APPENDIX H

WATER QUALITY

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Introduction

The Cypress Basin is located in Northeast Texas and is a sub-basin of the Red River Basin. The Basin, which is primarily rural, drains to Big Cypress Bayou which flows through Caddo Lake at the Texas-Louisiana border. The total basin drainage area in Texas is 2,812 square miles. The surface water resources have been extensively developed by the construction of many reservoirs including Lake Cypress Springs, Lake Bob Sandlin, Ellison Creek Reservoir, Lake of the Pines, Cross Lake, and several smaller impoundments. Caddo Lake is a shallow natural lake to which a Corps-operated spillway has been attached to control lake level. An additional water reservoir, Little Cypress Creek, was permitted but was deauthorized in 1993. Lake of the Pines is a Corps of Engineers project, while Caddo Lake is a combination non-Federal and Corps of Engineers project. The other reservoirs are owned and operated by non-Federal interests.

Surface waters of the Basin are used for municipal, agricultural, industrial, thermo-cooling, and recreation. Major population centers in the Basin include the Cities of Mount Pleasant, Pittsburg, Atlanta, Daingerfield, Linden, Gilmer, Jefferson, Marshall, Houghes Springs, Winnsboro, and Waskom. Mount Pleasant is the largest municipality in the Basin with a population of less than 13,000 during the 1990 census. Activities of these cities and industry are the primary threats to water quality in the Cypress Basin. The primary industries in the Basin are livestock production, agriculture, silviculture, and mining of oil, gas, clay, lignite coal and iron ore. Manufacturing and steam-electric power generation currently account for the major portion of the water demands.

Although nutrient levels in surface waters of the Cypress Basin are generally elevated, water is considered to be of good quality. Problems with water quality arise occasionally and are most likely the result of treated wastewater discharge during the period of thermal stratification, a time when stream flows are slow, surface temperatures elevated, and aeration rates low coupled with a high biological oxygen demand.

A number of federal, state, and local governmental agencies have compiled data regarding water quality parameters of the Cypress Basin for various purposes since the mid 1900's. There has been a lot of variation in sampling regimes and procedures implemented by these agencies. The purpose of this report is to make a comprehensive evaluation of existing water quality data for the Cypress Basin and to identify practical means of improving water quality if necessary.

Agencies Involved in Water Quality Issues

Texas Agricultural Extension Service (TAES). Although this agency is not involved in water quality sampling and data collection, the local and state staff provide information and technical assistance for a wide range of subjects to the people of each county. TAES provides relevant and applicable agricultural pollution control research results and recommendations for agricultural pollution prevention.

Texas Natural Resource Conservation Commission (TNRCC). Under Chapter 26 of the Texas Water Code, the TNRCC operates the Texas water quality protection programs. The TNRCC maintains the Surface Water Quality Monitoring (SWQM) database with the purpose of making information available from the agency's Surface Water Monitoring Program. This program was established in 1967 and is used by the TNRCC to monitor the impact of municipal, industrial, and agricultural discharges on water quality. Additionally, this agency works in cooperation with the U.S. Environmental Protection Agency (EPA) to administer the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

Texas Parks and Wildlife Department (TPWD). This agency manages and protects fish and wildlife and their habitat and also acquires and manages parklands and historic areas. TPWD also works to protect sensitive ecological habitats as well as endangered plants and animals. The Resource Protection Division, created in 1985, investigates pollution that may cause loss of fish or wildlife, and provides other government agencies with information and recommendations for protecting fish and wildlife. The division reviews permits proposed by the TNRCC for wastewater discharge and hazardous-waste disposal and participates in administrative and judicial proceedings concerning action that may affect fish and wildlife.

Texas Railroad Commission (TRC). TRC regulates the oil and gas industry to prevent the waste of resources and to protect property rights and the environment. They also regulate trucks and buses in intrastate service; natural gas utilities and safety; natural gas distribution systems; propane, butane and compressed natural gas safety; and surface mining for coal, uranium, and iron ore, including reclamation of the land after mining. The Oil and Gas Division of the TRC has authority to regulate oil field waste disposal into or adjacent to water and disposal by well injection.

Texas State Soil and Water Conservation Board (TSSWCB). The TSSWCB has been given the responsibility for planning, implementing, and managing programs and practices for abating agricultural and silvicultural non-point source pollution pursuant to Section 201.026 of the Agricultural Code of Texas.

Texas Water Development Board (TWDB). This agency maintains a network of stream gages which measure streamflows and selected parameters of water quality. Additionally, the TWDB, in cooperation with groundwater districts, measures water levels and samples water quality for selected parameters in a representative set of water wells. This monitoring system was established in the 1920's. The data is available for use in planning, managing, and operating water facilities and systems.

U.S. Department of Agriculture; Natural Resource Conservation Service (NRCS). Formerly the Soil Conservation Service, this agency is not directly involved in water quality data collection, however, it does provide technical assistance to farmers and ranchers of each county about ways to reduce soil erosion and ways to conserve water. These programs are important to water quality management, particularly with respect to sediment and associated elements that may be transported by runoff into streams and aquifers.

U. S. Environmental Protection Agency (EPA). The purpose of the EPA is to protect and enhance our environment under the laws enacted by Congress. Three federal water quality programs administered by the EPA are: 1) the Clean Water Act of 1972, which states that no one has the right to pollute navigable waters of the United States; 2) the Safe Drinking Water Act of 1974, designed to achieve uniformly safe and high quality drinking water in the United States; and 3) the Resource Conservation and Recovery Act of 1976, directed at providing safe management and disposal of hazardous and solid wastes. Additionally, the EPA is responsible for administering and enforcing CERCLA and has the authority to issue permits under the Natural Pollution Discharge Elimination System (NPDES).

U.S. Fish and Wildlife Service (USFWS). The USFWS is the principal agency for implementing the Endangered Species Act. One of the responsibilities of this agency is to review applications for discharge of pollutants under the state and Natural Pollution Discharge Elimination System (NPDES) permitting processes.

U.S. Army Corps of Engineers (USACE). The USACE has been regulating activities in the nation's waters since 1890. Until the 1960's the primary purpose of the regulatory program was to protect navigation. Since then the program has been broadened so that it now considers the full public interest for both the protection and utilization of water resources. The USACE issues permits under Section 10 of the Rivers and Harbors Act of 1899 which prohibits the obstruction or alteration of navigable waters of the U.S., and Section 404 of the Clean Water Act of 1972 which prohibits the discharge of dredge or fill material into waters of the U.S., including wetlands.

U.S. Geological Survey (USGS). The USGS maintains a network of stream monitoring stations which survey streams for flow and selected water quality parameters and makes the information available for use in water planning, management, and administration.

Local efforts. Additional persons or agencies which may act locally to assess water quality would be Councils of Government, university researchers, municipal water departments, and citizen monitoring groups.

Factors Affecting Water Quality in the Cypress Basin

The Cypress Basin is an agricultural and timber production area with significant industrial, manufacturing, and mineral production facilities. Its population was 125,500 people in 1990. The largest population center in the Basin is the City of Mount Pleasant, with a 1990 population of 12,291. Based on 1990 estimates of population, 42% of the people in the Cypress Basin lived in incorporated cities of greater than 1,000 population. The Texas Water Development Board estimates that the population of this area will increase by nearly 80% to 230,940 people by the year 2040.

In the Cypress Basin in Texas, there are 91 water rights permits with a total quantity of permitted water use of approximately 540,058 acre-feet annually. Of the total, 35 percent is for municipal purposes, 60 percent is for industrial uses, and the remaining 5 percent is allotted to mining, irrigation, flood control, and recreation. The outfalls are concentrated in the northwest quadrant of the Basin and along the course of Big Cypress Bayou.

Thirty-two Municipal Wastewater Discharge permits are issued in the Cypress Creek Basin in Texas (Figure 1). Of these, seven are no-discharge permits. The total volume of permitted flow is 8.54 million gallons per day (MGD).

There are 33 Industrial Wastewater Discharge permits issued in the Cypress Creek Basin in Texas (Figure 1). Of the total, 23 are non-discharge permits. The largest discharge is from electric power generation for cooling water which accounts for 85 percent of the one billion gallons per day of discharge that is permitted

Approximately ten municipal landfills throughout the Cypress Basin are impacted by the Subtitle D Regulations of the Resource Conservation and Recovery Act (RCRA) of 1983, as amended (Figure 1). RCRA regulates management and disposal of hazardous materials and wastes currently generated, treated, stored, disposed of or distributed, while Subtitle D deals with state or regional solid waste plans. Regional Councils of Government are responsible for developing plans for regionalization of landfills and achieving compliance with Subtitle D.

Five EPA designated Superfund sites are located in the Cypress Basin (Figure 1): Double R Plating located in Cass County, and Fabsteel, Marshall Wood Preservatives, Longhorn Army Ammunition, and Steinco all located in Harrison County. Superfund is the common term for the program operated under the legislative authority of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended, and the Superfund Amendments and Reauthorization Act (SARA), as amended, that funds and carries out solid waste emergency and long-term removal remedial activities at hazardous waste sites. Sites are placed either on the CERCLA list or the National Priority List (NPL). Because funds are limited, only the highest ranking sites make the EPA's NPL. The USEPA and TNRCC jointly administer CERCLA in Texas.

There are numerous abandoned and existing oil wells within the Cypress Basin, each having a brine pit associated with it. A pit is needed to hold the concentrated brine which is mined along with crude oil for evaporation or removal . Each pit is a potential source of chloride contamination resulting from a spill caused by either failure of the pit containment, or more commonly, overflow due to intense rainfall. Most oil well permits are located in the southern half of the Basin.

Many industrial applications require various facilities to effectively prevent contamination, erosion, and general degradation of stormwater flows, all of which eventually enter navigable waters. Stormwater permits were developed with the goal of encouraging the maintenance of consistent and

manageable technology for on-site control of stormwater runoff. Some of these permits are maintained permanently, while others are temporary due to the type of industrial activity taking place at a particular site.

Non-point source (NPS) pollution generally results from land runoff, atmospheric deposition, drainage, or seepage of contaminants. Major sources of non-point pollution include runoff from agriculture, urban areas, and silvicultural operations. Silt and nutrients are the pollutants responsible for most of the non-point source impact to the Basin's surface waters. An estimate of non-point source pollution from land runoff can be made using the Universal Soil Loss Equation (USLE). The USLE is a model that provides insight into the processes of soil loss and identifies those locations that may be at risk for erosion under certain conditions. Parameters considered in the model are rainfall intensity, soil erodibility, length of slope, degree of slope, cropping management, and soil conservation practices. These diffuse sources are often harder to identify, isolate, and control than traditional point sources. The potential sources of non-point source pollution in the Cypress Basin are from cities, industries, agricultural and silvicultural activities, and on-site wastewater disposal communities. There is also a basinwide non-point source pollution problem resulting from oil field operations and urban and rural stormwater runoff.

Aquatic Pollution

The natural state of the aquatic environment can be adversely affected by human activity. Parameters which tend to be most affected are temperature, dissolved oxygen, hydrogen ion (pH), conductivity, turbidity, suspended solids, dissolved solids, alkalinity, nutrients, biochemical oxygen demand, and metal concentration. Additional areas of concern resulting from municipal and industrial contamination are elevated populations of bacteria and chemical pollutants. Some contaminants which contribute to pollution of waters and sediments will be discussed briefly in this section.

<u>Enrichment With Nutrients</u>: Nutrient enrichment of an aquatic environment is commonly referred to as "eutrophication". Nitrogen and phosphorus are the most common nutrients contributing to enrichment, and while eutrophication is a natural, slow process that occurs as bodies of water age, the process can be grossly accelerated through human activity. Nutrient enrichment is exacerbated through additions of urban runoff, agricultural runoff, and industrial and sewage effluent (point and non-point sources). Enrichment creates the potential for severe environmental problems which include: an increase in primary production (algae and plants), blooms of nuisance and/or toxin producing bluegreen algae (cyanobacteria), and reduction in summer water clarity. Increased biomass due to enrichment is the primary cause of summer oxygen depletion and resulting fish kills.

Phosphorus enters fresh waters from atmospheric precipitation and from groundwater and surface runoff, and enters a lake with inflowing water and leaves with outflowing water and by sedimentation. The loading rates of phosphorus vary greatly with patterns of land use, geology and morphology of the drainage basin, soil productivity, human activities, pollution, and other factors. The range of total phosphorous in fresh waters is large, from
<0.005 mg/l in very unproductive waters to >0.1 mg/l in highly eutrophic waters. Most uncontaminated waters contain between 0.01 and 0.05 mg total phosphorous per liter.

Phosphate and essential inorganic micronutrients, particularly iron and manganese, form highly insoluble compounds and precipitate from the water column into the sediments. Rooted aquatic macrophytes often obtain phosphorous from the sediments and can release large amounts into the water both during active growth and upon senescence and death. In shallow lakes with large areas of vegetation, phosphorus release from sediment sources is much greater than in lakes that are deeper and more strongly stratified.

Nitrogen is an important macronutrient for all organisms as a major component of proteins, nucleotides, and amino acids. Major sources of nitrogen to surface waters are surface land drainage, groundwater, and atmospheric nitrogen in the form of precipitation, dry fallout, and N_2 fixation by bacteria and cyanobacteria (bluegreen algae). Enrichment occurs as a result of agricultural fertilization, loading from sewage and industrial wastes, and atmospheric pollutants. The range of nitrogen compounds in fresh waters is large, with concentrations of nitrite ranging from undetectable

levels to 1 mg/l, and concentrations of ammonia nitrogen and nitrate ranging from 0 to 10 mg/l (Wetzel, 1983).

Metals Contamination: Metals are introduced into aquatic systems as a result of the weathering of soils and rocks, from volcanic eruptions, and from a variety of human activities involving the mining, processing, or use of metals and/or substances that contain metal contaminants and burning of fossil fuels. Some metals such as manganese, iron, copper, and zinc are essential micronutrients, while others such as mercury, cadmium, and lead are not required even in small amounts by any organism. Virtually all metals, including the essential metal micronutrients, are toxic to aquatic organisms as well as humans if exposure levels are sufficiently high (Laws, 1993). The following table lists the maximum permissible concentrations in water recommended by the EPA for the protection of human health.

Maximum Permissible Concentrations of Various Metals in Natural Waters for the Protection of Human Health

	Maximum Permissible Concentration	
Metal	mg m^{-3}	Φmoles m^{-3}
Mercury (Hg)	0.144	0.72
Lead (Pb)	5	24
Cadmium (Cd)	10	89
Selenium (Se)	10	127
Thallium (Tl)	13	64
Nickel (Ni)	13.4	228
Silver (Ag)	50	464
Manganese (Mn)	50	910
Chromium (Cr)	50	962
Iron (Fe)	300	5372
Barium (Ba)	1000	7281

Source. EPA (1987): Federal Register 56(110):26460-26564 (1991).

Aluminum is the third most abundant element on earth, and is commonly found in natural waters as a soluble salt. It was not listed in the original priority metals list developed by the EPA, although it has been added and is being studied as a potential agent in Alzheimer's disease.

The State of Texas has set standards for concentration of metals in fresh waters. The following table lists the criteria which are used for assessment of metals in surface waters.

Comparison of Metal Criteria

Metals	Low Aquatic Life Criteria (µg/L)	Primary Drinking Water Standards (µg/L)	Screening Value Concern or Possible Concern
Aluminum	991	none	991
Arsenic	50	50	190
Barium	1000	2000	1000
Cadmium (dissolved)	2.33	5	varies by segment[1]
Chromium (dissolved)	50	100	varies by segment[2]
Copper (dissolved)	28	1300	varies by segment[3]
Lead (dissolved)	5	15	varies by segment[4]
mercury	1.3	2	1.3
Nickel	342.29	none	247
Selenium	5	50	5
Silver	50	none	.49
Zinc (dissolved)	230.38	none	varies by segment[5]

[1] .020 to 0.62 [2] 33.75 to 110.28 [3] 1.93 to 6.63 [4] 0.19 to 1.20 [5] 16.23 to 55.26

Priority pollutants: The term "priority pollutants" refers to a list of 126 pollutants contained in industrial wastewater for which the EPA has developed test procedures. The priority pollutant list includes base, neutral and acid (BNA) compounds and volatile organic (VOA) compounds as listed below.

BNA Compounds

Phenol	Acenaphthene	bis (2-Chloroethyl) Ether
2,4-Dinitrophenol	2-Chlorophenol	4-Nitrophenol
1,3-Dichlorobenzene	Dibenzofuran	1,4-Dichlorobenzene
2,4-Dinitrotoluene	Benzyl Alcohol	2,6-Dinitrotoluene
1,2-Dichlorobenzene	Diethylphthalate	2-Methylphenol
4-Chlorophenyl-phenylether	N-Nitorso-di-n-Propylamine	
Fluorene	Isophorone	4-Nitroaniline
2-Nitrophenol	4,6-Dinitro-2-Methylphenol	
2,4-Dichlorophenol	N-Nitrosodiphenylamine	
Benzoic Acid	4-Bromophenyl-phenylether	
bis (2-Choroethoxy) Methane	Hexachlorobenzene	2,4-Dichlorophenol
Pentachlorophenol	1,2,4-Trichlorobenzene	Phenanthrene
Naphthalene	Anthracene	4-Chloroaniline
Di-n-Butylphthalate	Hexachlorobutadiene	Fluoranthene
4-Chloro-3-Methylphenol	Pyrene	2-Methylnaphthalene
Butylbenxylphthalate	Hexachlorocylopentadiene	
3,3'-Dichlorobenzidine	2,4,6-Trichlorophenol	Benzo(a)Anthracene
2,4,5-Trichlorophenol	bis(2-Ethylhexyl)Phthalate	
2-Chloronaphthalene	Chrysene	2-Nitroaniline
Di-n-Octyl Phthalate	Dimethyl Phthalate	
Acenaphthylene	3-Nitroaniline	Benzo (b) Fluoranthene
Benzo (k) Fluoranthene	Benzo (a) Pyrene	Indeno (1,2,3-cd) Pyrene
Dibenz (a,h) Anthracene	Benzo (ghi) Perylene	

VOA Compounds

Chloromethane	Bromomethane	Vinyl Chloride
Chloroethane	Methylene Chloride	Acetone
Carbon Disulfide	1,1-Dichlorethane	1,1-Dichlorethene
1,2-Dichloroethene (total)	Chloroform	1,2-Dichlorethane
2-Butanone	1,1-Trichlorethane	Carbon Tetrachloride
Vinyl Acetate	Bromodichloromethane	1,2-Dichloropropane
Trans-1,2-Dichloropropene	Trichloroethene	Dibromochloromethane
1,1,2-Trichloroethane	Benzene	cis-1,3-Dichloropropene
2-Chloroethylvinylether	Bromoform	4-Methyl-2-Pentanone
2-Hexanone	Tetrachloroethene	1,1,2,2-Tetrachloroethane
Toluene	Chlorobenzene	Ethylbenzene
Styrene	Total Xylenes	

Pesticides: These compounds include insecticides (insect killing), herbicides (plant killing), or fungicides (fungi killing). Intensive pesticide use is undertaken for reasons of public health, agricultural production, or silviculture. Synthetic chemical pesticides generally fall into one of the following categories:

Chlorinated organics: A class of persistent, broad spectrum insecticides that linger in the environment and accumulate in the food chain. Among them are DDT, aldrin, dieldrin, heptachlor, chlordane, lindane, endrin, mirex, and toxaphene. Other examples include TCE, used as an industrial solvent.

Organophosphates: Chemicals that contain phosphorus, used to control insects, that are short lived and not associated with food chain transfer problems, but are toxic to almost all other organisms when first applied. Malathion and parathion are examples of organophosphates.

Carbamates: An organic hydrocarbon derivative of carbamic acid containing the functional group: R-COO-NH_2. These compounds are biodegradable and nonpersistent, although they are toxic to birds and bees when first applied. Aldicarb and carbofuran are examples of carbamates.

Pyrethroids: An insecticide containing synthetic compounds similar to pyrethrin compounds which occur in pyrethrum flowers (chrysanthemum). These compounds are toxic to beneficial insects and fish. Allethrin and dimethrin are examples of pyrethroids.

Polychlorinated biphenl (PCB): The chemical structure of PCBs is similar to some pesticides, however these compounds were used primarily as a component in electrical transformers, capacitors, heat transfer systems, and hydraulic fluids. To a much smaller degree, they were used in paints, adhesives, caulking compounds, plasticizers, inks, lubricants, carbonless copy paper, sealants, coatings, and dust control agents. PCBs are known to accumulate in the tissues of aquatic organisms and have been found to be as toxic as some pesticides to certain organisms. An important concern over PCBs has been their high degree of persistence in the environment. It has been estimated that they are 50-300 times more persistent than DDT residues. Because of their apparent toxicity and persistence, the manufacture of all PCBs was voluntarily terminated by the manufacturer in 1977. The EPA, under authorization of the Toxic Substances Control Act, banned the manufacture, processing, distribution in commerce, and use of PCBs in the United States effective July 2, 1979. Presently, most PCBs discharged into aquatic systems are considered either to be degraded in the water column or buried in the sediments (Laws, 1993).

Oil: Oil contains carcinogenic compounds including benzene and polynuclear aromatic hydrocarbons (PAHs). Most human exposure to benzene comes from inhalation of automobile exhausts and cigarette smoke, while exposure to PAHs are more likely to occur through contaminated fish, shellfish,and other food items. Human exposure to PAHs through water, fish and shellfish is probably minimal, since the taste of the food item becomes unsavory at concentrations far below levels associated with chronic toxicity (EPA, 1976).

Other Pollutants: Additional sources of contamination to the aquatic environment include the manufacture of explosives, bacterial contamination (primarily fecal coliforms) through inadequate sewage treatment, and thermal pollution generated predominately by power plants.

Water and Sediment Testing in the Cypress Basin

Parameters involved in water quality sampling generally include *in situ* measurements of temperature, dissolved oxygen (DO), pH, conductivity, and turbidity; physio-chemical measurements of suspended and dissolved solids, biochemical oxygen demand (BOD), and total and dissolved nitrogen and phosphorus; and enumeration of bacterial coliforms. Routine water and sediment sampling can involve testing for contaminants, such as metals, priority pollutants, pesticides, PCBs, PAHs, and explosives.

The State of Texas has established surface water quality standards, which vary by segment, for most major streams, rivers, reservoirs, and estuarine waters which are at the core of several TNRCC water pollution control programs. Classified waters in the state, including waters in the Cypress Basin, are assessed for attainment of these standards. A listing of the Texas Surface Water Quality Standards (TSWQS) for the Cypress Basin follows.

Texas Surface Water Quality Standards

Parameters	Criteria Range and/or Standard
Dissolved Oxygen	>5.0 mg/l
Maximum temperature	32-34°C
pH	6.0 - 8.5 (7.0 Neutral)
Chloride	35-100 mg/l or less
Sulfate	35-100 mg/l or less
Total dissolved solids	150-300 mg/l or less
Fecal coliforms	200 colonies/100 ml

mg/l = milligrams per liter
ml = milliliter
Source: TWC 1991

Historical data indicate that water quality in the Cypress Basin is generally good. Occasional exceedances of chloride, sulfate and heavy metal water quality criteria have been reported. DO levels have occasionally been recorded below minimum standards. Samples having parameter levels outside the recommended standards are usually taken during the summer months, when waters are stratified. However, the exceedances do not restrict the use of these waters for recreation or public water supply. Past studies indicate that sediments in some locations of the study area may be contaminated with heavy metals, PCBs, TNT derivatives, and PAHs.

No new testing was performed for the purpose of this report. The information outlined here is based on historical data, TNRCC data, and water and sediment investigations completed in 1992 by the USGS and the USACE Waterways Experiment Station.

Segments of the Cypress Basin

The status of the water within the Cypress Basin is reported every two years in the Texas Water Quality Inventory (WQI), which is prepared by the TNRCC in accordance with Section 305(b) of the Clean Water Act. The WQI report is based on the most recent four years of monitored surface and ground water quality data. It provides an overview of water quality trends, the extent to which surface water quality standards are attained, and the relative impacts of pollutants from various sources. Surface water quality data are summarized for individual stream, river, and reservoir segments. This report will review the available water quality data as it applies to these segments, based on TNRCC designation.

The TNRCC designations divide the Cypress River Basin into nine segments which consist of 181 stream miles and four major reservoirs that encompass 58,394 acres. Major tributaries to Cypress Creek are Black Bayou, James' (Jim's) Bayou and Little Cypress Creek. The nine segments are:

Segment 0401: Caddo Lake
Segment 0402: Big Cypress Creek Below Lake of the Pines
Segment 0403: Lake of the Pines
Segment 0404: Big Cypress Creek Below Lake Bob Sandlin
Segment 0405: Lake Cypress Springs
Segment 0406: Black Bayou
Segment 0407: James' (Jim's) Bayou
Segment 0408: Lake Bob Sandlin
Segment 0409: Little Cypress Bayou (Creek)

The segments will not be referred to by segment number in this report, only by segment name. All other waters in the Cypress Basin are not TNRCC designated segments
and are considered as unclassified. Most available data has been collected from classified segments.

Twelvemile Bayou: Located below the Caddo Lake spillway, a fair amount of historical data is available for Twelvemile Bayou. The USGS has collected *in situ* data since 1943. Limited water chemistry data collection was initiated in 1965 for conservative ionic constituents like calcium and chloride. Nutrient, metals, and pesticide data have been collected semiannually by USGS since 1979. The result of these studies indicates that water quality in Twelvemile Bayou varies considerably on a seasonal basis. The water quality is generally good when water is flowing over Caddo Lake Dam. During the summer and fall, water releases from Caddo Lake are minimal, and the water quality is significantly reduced. The dissolved mineral content increases and the conductivity can exceed 2,000 micromhos per centimeter (µmhos/cm). The source of the dissolved solids (primarily sodium chloride) is Black Bayou which drains the area northeast of Caddo Lake. In addition to seasonally high dissolved solids, Twelvemile Bayou frequently has high levels of dissolved iron and manganese and occasional high levels of dissolved copper. High mean levels of fecal streptococci and fecal coliform bacteria have been reported. Past studies have found trace amounts of TNT derivatives in

the surface water and sediments of Twelvemile Bayou (USACE, 1985). Because Twelvemile Bayou is in Louisiana, this segment has no water use or water quality status designation by the State of Texas.

A joint study by USGS and the USACE in 1991 and 1992 of water and sediments in this area indicated that Twelvemile Bayou has high levels of nutrients and coliform bacteria in the water column. Phosphorus was reported as having an average concentration of 0.08 mg/l, and average coliform bacteria levels exceeded the criteria of 200 colonies per 100 ml at the lower end of the bayou. Iron exceeded the domestic water supply criteria occasionally, but no other exeedances of water quality criteria were reported.

Sediment samples from the 1991-92 survey indicated that heavy metals, BNA and VOA compounds, PAH, PCB, and explosives contamination was not present in this segment. One pesticide, p'p'DDE, was detected in the sediments of Twelvemile Bayou at a concentration of 0.029 mg/kg.

Caddo Lake: Caddo Lake is an impressive baldcypress swamp and was designated as a Ramsar Wetland of International Importance in October 1993. The State of Texas designates water uses of Caddo Lake as contact recreation, high quality aquatic habitat and public water supply. There are two permitted domestic outfalls and four permitted industrial outfalls (a total of 6 outfalls) in this segment The TNRCC reports that dissolved oxygen, temperature, and pH measurements fall outside criteria in nine percent of samples from this segment.

Within the Cypress Basin, Caddo Lake is the best studied. The Environmental Protection Agency (EPA), the State of Texas, and the U.S. Army Corps of Engineers (USACE) have conducted studies in the basin. Additional investigations involving water quality have been made by several consulting firms and have been the subject of at least four masters theses. The waters have generally been found to be good for water supply, but occasionally State and Federal water quality criteria have been exceeded. The lake waters have exceeded the Texas drinking water criteria for chloride and the DO has dropped below the freshwater fish criteria of 5.0 mg/L. Low DO is found in the swampy region in the northwestern part of the lake and near the bottom in the main lake. The EPA's maximum contamination level (MCL) for copper, iron, and manganese have also been exceeded.

Among the past studies on Caddo Lake is a 1983 masters thesis, "Physico-chemical Limnology of Caddo Lake, Texas and Louisiana", by A.A. Hartung. The thesis examined the physio-chemical limnology of Caddo Lake and evaluated the possible affect of off-shore oil production on the lake's water quality. Mr. Hartung collected *in situ* and chemistry data over a one year period from nine stations throughout Caddo Lake. He concluded that the lake was eutrophic due to high levels of nitrogen and phosphorus. In addition, he attributed the high sediment organic content to oil production within the lake.

A 1985 water supply study by the Vicksburg District reported trace levels of several trinitrotoluene (TNT) derivatives in the surface waters of Caddo Lake. The Longhorn Ammunition Plant in Karnack, Texas, used TNT extensively in the 1940's. The drainage from the ammunition plant enters Caddo Lake through Goose Prairie and Harrison Bayous. Although TNT was not detected in Caddo Lake sediments, the study recommended that any future studies look for TNT and its derivatives in the waters and sediments.

The Texas Water Quality Board (TWQB) reported the first sediment and water samples at Caddo Lake in 1977. These data were examined in document #IMS-50, "Intensive Surface Water Monitoring Survey for Segment 0401". This survey reported that data collected in the Texas portion of the lake was indicative of good water quality and reported no significant water quality problems in Caddo Lake. Water samples were not analyzed for heavy metals or pesticides.

The sediments collected in 1977 by the TWQB from Caddo Lake were reported to be rich in organic material and frequently contained slight hydrogen sulfide odors. Concentrations of chromium, mercury, and nickel were below those reported for natural soils. Arsenic, cadmium, copper,

manganese, and silver only slightly exceeded the average levels reported for natural soils and were comparable to levels observed in other Texas reservoirs. Reported concentrations of lead and zinc exceeded average levels observed in natural soils. Pesticides were not detected in the sediments. PCB's were the only organic contaminants reported in the sediments. The highest sediment PCB concentration was 115 micrograms/kilogram (µg/kg) and the mean was 48.3 µg/kg. The report stated that this was the second highest PCB concentration for any of the lakes tested in Texas.

In August 1982, three sediment and water samples were collected by the Texas Department of Water Resources (TDWR). Ten additional sediment and water samples were collected by the USACE, Fort Worth District, in December 1982. Of the three stations sampled by the TDWR, only one station detected any PCB's. This station was located in the upper portion of Caddo Lake and contained the highest concentration ever reported in the lake, 676 µg/kg. Of the ten samples collected by the USACE, four reported detectable levels of PCB's. The four stations were scattered throughout Caddo Lake. The station reporting the highest concentration, 23.4 µg/kg, was in Goose Prairie Bayou. PCB's were reported only twice in the water column (5.06 and 0.17 µg/L) from sampling by TDWR and the USACE in 1982.

The 1991-92 USGS and USACE study of water and sediments in this area indicated that exceedances of temperature, pH, and DO criteria occurred occasionally in Caddo Lake. DO profiles frequently reported readings near saturation at the surface, with concentrations quickly falling below the criteria of 5.0 mg/l below the water surface. Phosphorus concentrations were high, with average values of 0.05 to 0.06 mg/l. No priority pollutants were detected in the water column, and, with the exception of iron, no metals were found to exceed drinking water standards in Caddo Lake.

The 1991-92 sediment analysis of Caddo Lake indicate that lead, mercury, nickel, and zinc are present in low levels and may be of some concern. No BNA compounds, PCBs or explosives were detected in the sediments, however trace amounts of several PAHs and the pesticide p'p'DDT were found. The VOA compound, toluene was detected at one site in Caddo Lake at a concentration of 0.39 mg/kg.

Lignite coal power plants located upwind from Caddo Lake release mercury into the air which is then deposited into the lakes via precipitation events or surface runoff. Data from the TPWD shows elevated levels of mercury in fish tissue in Caddo Lake. The USFWS is currently conducting a contamination investigation which focuses on the disposition of mercury in biotic and abiotic samples within the Cypress River Valley in order to evaluate the risk to fish and migratory birds.

A fossil fuel burning power plant owned by Southwest Electric Power Company of Shreveport, is located on the north shore of Caddo Lake near the town of Mooringsport, LA. The plant operation time fluctuates with weather conditions so that peak operating times correspond to extreme temperatures. Thermal pollution of waters can contribute to low DO levels in the summer months, while death of organisms due to thermal shock is possible in the winter months. Death by thermal shock is only likely to happen when a sudden start-up or shut down occurs. There have been no reports of fish kills due to the effects of heating from this power plant.

The shallow upper end of Caddo Lake is densely populated with aquatic plants (macrophytes). Four groups of aquatic macrophytes can be distinguished on the basis of morphology and physiology. These groups are: 1) emergent 2) rooted, floating-leaved; 3) submersed; and 4) freely floating (Wetzel, 1983). All of these forms are present in Caddo Lake. While many of the aquatic plants found here are native species, many are exotics that have been introduced (either accidentally or purposefully) to the lake. Water quality problems associated with dense growth of aquatic macrophytes include low DO, nutrient release to the water during active growth and senescence, and loading of organic matter to the environment. Additionally, the canopy of macrophytes becomes so thick in Caddo Lake during the growing season that access to some areas of the lake is restricted. Further discussion on the aquatic macrophyte condition of Caddo Lake is contained in Attachment A.

Big Cypress Creek Below Lake of the Pines: The State of Texas designates water uses of this segment as contact recreation, high quality aquatic habitat, and public water supply. There are 4 permitted domestic outfalls and 3 permitted industrial outfalls (a total of 7 outfalls) in this segment. The TNRCC reports that dissolved oxygen, pH, and fecal coliforms fall outside State criteria in 23-31 percent of samples from this segment. Additionally, low aeration rates and natural organic loads create a naturally stressed condition.

The State of Texas collected water quality data on Big Cypress Creek at Karnack from 1976 to 1988. They collected *in situ* and nutrient data approximately every 2 months and twice annually respectively. No metals or pesticide data were collected from the water column. Two sediment samples were collected in 1976 and 1978 and analyzed for pesticides, PCB's, and heavy metals, with no high levels reported. Comparing the available data to the Texas water quality criteria for drinking water, the water quality was good. There have been no reported exceedances of the water quality criteria in this segment. A comparison of historical data with more recent reports indicates that phosphorus concentrations in this segment have decreased since 1980 from an average concentration of 0.1 mg/l to 0.05 mg/l.

The USGS/USACE 1991-92 survey indicates that this segment of Big Cypress Creek has a high average concentration of phosphorus (from 0.03 to 0.05 mg/l), and extremely high levels of coliform bacteria (average values of 4,500-6,000 colonies/100ml) in the water column. The DO and pH occasionally fall below the minimum criteria. Iron and manganese were found to have average values exceeding the domestic water supply criteria of 300 and 50 Φg/l, respectively. No priority pollutants were detected in the water column in this segment.

Sediment samples from 1991-92 indicate that the BNA compound n-nitrosodimethyl amine was found in trace amounts at one site, but no VOA compounds, PCBs, PAHs, pesticides, or explosives were detected.

Lake of the Pines: The State of Texas designates water uses of Lake of the Pines as contact recreation, high quality aquatic habitat, and public water supply. There are 4 permitted domestic outfalls and no permitted industrial outfalls in this segment. The TNRCC reports that dissolved oxygen and pH measurements fall outside State criteria in only 8 percent of samples from this segment, and that there are no significant water quality problems.

Water quality data has been collected in Lake of the Pines by a number of agencies since 1975. The U.S. Geological Survey (USGS) collected water quality data in Lake of the Pines from October 1975 through September 1984. Analyses of the samples included water temperature, specific conductance, sulfate, chloride, dissolved oxygen (DO), hydrogen ion (pH), dissolved solids, nitrate, ammonia-nitrogen, silica, fluoride, total and non-carbonate hardness, sodium, potassium, iron, manganese, total phosphorus (TP), carbonate, alkalinity, and carbon dioxide. Bacteriological analysis for fecal coliforms was also performed. The water quality was generally good, with the water meeting the Texas criteria for potable water. Occasional exceedances of the Texas criteria for chloride, sulfate, and dissolved oxygen were observed. During the winter, average concentrations of DO throughout the lake are more than 10 mg/L. During the summer months, average DO concentrations ranged from 0.3 mg/L near the dam to 2.0 mg/L near the headwater at the bottom of the lake. In addition, the Environmental Protection Agency's (EPA) maximum contaminant levels (MCL) were occasionally exceeded for the following metals: cadmium, chromium, copper, iron, lead, manganese, mercury, and zinc. High concentrations of iron and manganese were reported near the dam. In the deeper portion of the lake, near the bottom, iron and manganese were much higher than mean concentrations at the surface. Fecal coliforms were in compliance with the Texas Surface Water Quality Standards of 200 colonies/100 ml (log average). No previous studies on Lake of the Pines have analyzed water samples for priority pollutants. The Texas Natural Resources Conservation Commission (TNRCC) analyzed sediment samples for polychlorinated biphenyl compounds (PCBs) and pesticides and detected PCBs in one sample.

In 1991-92 the USGS and USACE survey indicated high average concentrations of phosphorus (0.02-0.10 mg/l) in Lake of the Pines. The average coliform bacteria concentration was well above the criteria at the upper end of the lake, with the concentration substantially declining

toward the dam. Manganese had a high average value (exceeding domestic water supply criteria) at the upper end of the lake, with the concentration declining toward the dam. No other exceedances were reported.

Sediment data from 1991-92 show that lead and zinc were at concentrations indicating contamination, and that arsenic, cadmium, and mercury were at concentrations of possible concern. PAHs are present in the sediments in the most upstream reaches of Lake of the Pines and may exist for at least 0.5 mile downstream of the Lone Star Boat Ramp. Trace amounts of the pesticide p'p'DDT were detected in this segment. No BNA or VOA compounds, PCBs or explosives were found.

Big Cypress Creek Below Lake Bob Sandlin: The State of Texas designates water uses of this segment as contact recreation and intermediate quality aquatic habitat. There were a large number of permitted outfalls in this segment as of 1992, including 9 permitted domestic outfalls and 15 permitted industrial outfalls (a total of 24 outfalls).

Periodic dissolved oxygen violations occur in this segment due to hydrologic modifications, extremely sluggish velocity and point discharges. This segment does not meet the contact recreation criterion due to elevated levels of fecal coliform bacteria. Average nitrogen and phosphorus levels are elevated and contribute to dense phytoplankton growths as evidenced by elevated levels of chlorophyll *a*. Levels of pH have been recorded outside the minimum and maximum criteria. The discharge of treated wastewater appears to be the most significant source of nutrients and the cause of periodic depressed dissolved oxygen in the segment. Depressed dissolved oxygen levels are further aggravated by low stream discharge rates, sluggish stream velocities, high turbidity and high sediment oxygen demand.

A waste load evaluation for this segment was completed by the Texas Water Commission (TWC), now the TNRCC, in August 1988 and advanced waste treatment was recommended. A use attainability analysis was done in 1984. Due to naturally low dissolved oxygen levels, the aquatic life use was changed to "intermediate" and the criterion lowered to 4.0 mg/L.

The percentages of values outside State criteria for this segment include dissolved oxygen (24 percent of samples), temperature (2 percent of samples), pH (17 percent of samples), chloride (8 percent of samples), total dissolved solids (2 percent of samples), and fecal coliforms (25 percent of samples).

Lake Bob Sandlin: The State of Texas designates water uses of Lake Bob Sandlin as contact recreation, high quality aquatic habitat, and public water supply. There are 3 permitted domestic outfalls and 2 permitted industrial outfalls (a total of 5 outfalls) in this segment. The TNRCC reports no water quality problems in this segment, with no values occurring outside the State criteria in this segment.

Lake Cypress Springs: The State of Texas designates water uses of Lake Cypress Springs as contact recreation, high quality aquatic habitat, and public water supply. There are no permitted outfalls in this segment. Values outside the State criteria have not been measured, indicating that there are no water quality problems in this segment.

Black Bayou: The State of Texas designates water uses of this segment as contact recreation, intermediate quality aquatic habitat, and public water supply. There was only 1 permitted domestic outfall in this segment in 1992, and no permitted industrial outfalls.

Dissolved oxygen levels are known to vary widely and have been measured in violation of the criterion. These conditions are caused by algal photosynthesis and respiration. Treated wastewater is the most significant source of pollutants; however, naturally sluggish stream flow and the low assimilative capacity of the bayou contribute to the low dissolved oxygen levels.

A waste load evaluation was done by the State in 1974 and revised in 1988 using recent and more complete water quality and stream hydraulic information. A use attainability analysis was done

in 1984. Due to naturally low dissolved oxygen levels, it was recommended that the aquatic life use category was changed to "intermediate" and the criterion be lowered to 4.0 mg/L. Advanced treatment was recommended to maintain a dissolved oxygen concentration of 4.0 mg/L.

Values falling outside the State criteria are dissolved oxygen (33 percent of samples), and fecal coliforms (15 percent of samples).

James' (Jim's) Bayou: The State of Texas designates water uses of this segment as contact recreation, intermediate quality aquatic habitat, and public water supply. There were 3 permitted domestic outfalls in 1992 in this segment, and no permitted industrial outfalls.

Depressed dissolved oxygen and pH levels have been observed, largely due to the sluggish nature of the stream and low rates of aeration. The low dissolved oxygen levels prevent attainment of the intermediate aquatic habitat life use. Values measured outside State criteria include dissolved oxygen (40 percent of samples), pH (20 percent of samples) and fecal coliforms (40 percent of samples).

Little Cypress Bayou (Creek): The State of Texas designates water uses of Little Cypress Bayou as contact recreation, high quality aquatic habitat, and public water supply. There were 5 permitted domestic outfalls and 9 permitted industrial outfalls (a total of 14 outfalls) in this segment in 1992.

Naturally low dissolved oxygen levels prevent attainment of the high quality aquatic life use in this segment. Average levels of nitrogen and phosphorus are elevated. A draft waste load evaluation has been completed by the State. The TNRCC reports that values outside State criteria occur for dissolved oxygen in 96 percent of samples.

Little Cypress Bayou has been routinely monitored by the USGS near Jefferson, TX since 1968. Between 1968 and 1984 the average phosphorus concentration was high (0.1 mg/l), and dissolved oxygen levels were reported below the 5.0 mg/l standard in 15 percent of samples. Metal concentrations were low, exceeding the water quality standards only three times, once each for cadmium, lead, and mercury. No manmade organics were found in the water column during this period, however, PCBs and some pesticides (including chlordane) were detected at low levels in the sediments.

Sediment analysis by the USACE in October 1991 indicated the presence of the pesticide chlordane at a concentration of 0.073 mg/kg. No other contaminants were reported for this location.

Summary

Monitoring of water quality parameters began in the Cypress Basin in the mid 1900s. The water quality data suggest that elevated nutrient levels occur throughout the Cypress Basin, with many of the segments being classified as eutrophic, based on average phosphorus levels. A comparison of historic with more recent data indicates that phosphorus levels may have decreased in some areas over the last 10-15 years. Occasional exceedances of water quality criteria occur for temperature, dissolved oxygen, and pH. Coliform bacteria have been found at levels exceeding the domestic water supply criteria in some parts of the basin. Metals such as iron and manganese are found in concentrations exceeding water supply criteria in numerous locations throughout the basin. Although exceedances of water quality criteria develop on occasion, water quality in the Cypress Basin is considered to be good.

Metals such as arsenic, cadmium, lead, mercury, nickel, and zinc have been found at concentrations of concern in the sediments. Some PAHs and pesticides have been identified in sediments within the basin, however, the highest levels were reported in sediments 8 to 12 inches below the water/sediment interface and should not pose any problems to aquatic life as long as they remain undisturbed. No detectible amounts of BNA or VOA compounds, PCBs, or explosives have been reported in the sediments in recent data.

Conclusions/Recommendations

Clearly, there are water quality issues which need to be addressed in the Cypress Basin. Sources of pollution, both point and non-point, need to be identified and an effort should be made to minimize or reduce further degradation of the environment. A basin-wide assessment of the need for wastewater treatment should be conducted. Recently, as part of the Caddo Lake Initiative, the Bureau of Reclamation (BOR) completed a report entitled "Water/Wastewater Engineering Appraisal Report" which describes options for future water supply and wastewater treatment in the Caddo Lake area of Harrison County, Texas, which includes the communities of Karnack, Uncertain, Pine Island Point, Mossey Acres, Cypress Village, Taylor Island, and Longpoint. The report identifies specific options which address the future supply, treatment and conveyance of potable water and would improve wastewater services to reduce or eliminate continued contamination of Caddo Lake caused by improperly treated sewage. The options include a variety of alternatives which would involve upgrading/expanding existing facilities or the construction of new regional facilities.

Future water quality monitoring may help determine whether there are pollution problems resulting from agricultural activities, urban stormwater runoff, and inadequate wastewater treatment. Only a very specific, well designed and costly water quality monitoring program for each segment or station can conclusively determine a cause and effect relationship between the concentrations of contaminants in solution and the sources of the contamination. Consistent collection and use of analytical methods would produce invaluable information for the future protection and enhancement of the environment

Non-point sources of pollution derived from agricultural and silvicultural practices are generally categorized by the activities on the land that can generate pollutants. Pollutants from these activities are discharged into waters almost always as a result of rainfall runoff. Runoff collects and transports sediments, through surface erosion, to which herbicides, pesticides, and fertilizers can become attached and, to some extent, become dissolved in the water. Therefore, a key component of non-point source pollution control of fertilizers and potentially toxic chemicals used in these practices is the proper management of land to minimize erosion.

Methods to control phosphorous input to surface waters include restrictions of the use of cleaning products that contain phosphates, removal of phosphate at sewage treatment facilities discharging effluent into such water, and control of drainage from feedlots, agricultural areas, septic tanks, and other diffuse sources of phosphorous. Point sources of such inputs should be identified and eliminated as soon as possible.

Non-point sources contributing to the elevated nutrient concentrations and high coliform bacterial counts in the basin are numerous existing septic tank communities along the shores of the lakes. Monitoring for specific indicators of septic tank pollution and developement of treatment facilities is recommended.

Improper use and disposal of certain materials commonly found in households can be a source of water pollution. Even a very small quantity of common pesticides, such as chlordane, can toxify a city's wastewater system or an urban waterway if the chemical is improperly disposed. An educational program should be developed to inform the public of inherent or potential problems existing in the household, how they can impact the environment, and how to properly dispose of household hazardous waste. The use of more environmentally safe products should be encouraged and a household hazardous waste collection plan should be developed by local municipalities.

Funding and assistance for the development of water management programs/facilities can be obtained through various Federal agencies, such as the EPA, BOR, and USACE. Programs such as the USACE Partners for Environmental Progress Program (PEP) are designed to encourage greater private sector investment in water dependent environmental infrastructure which has typically been publicly financed. These infrastructure investments include water supply, treatment and distribution, all aspects of waste water management and other critical water dependent infrastructure support facilities.

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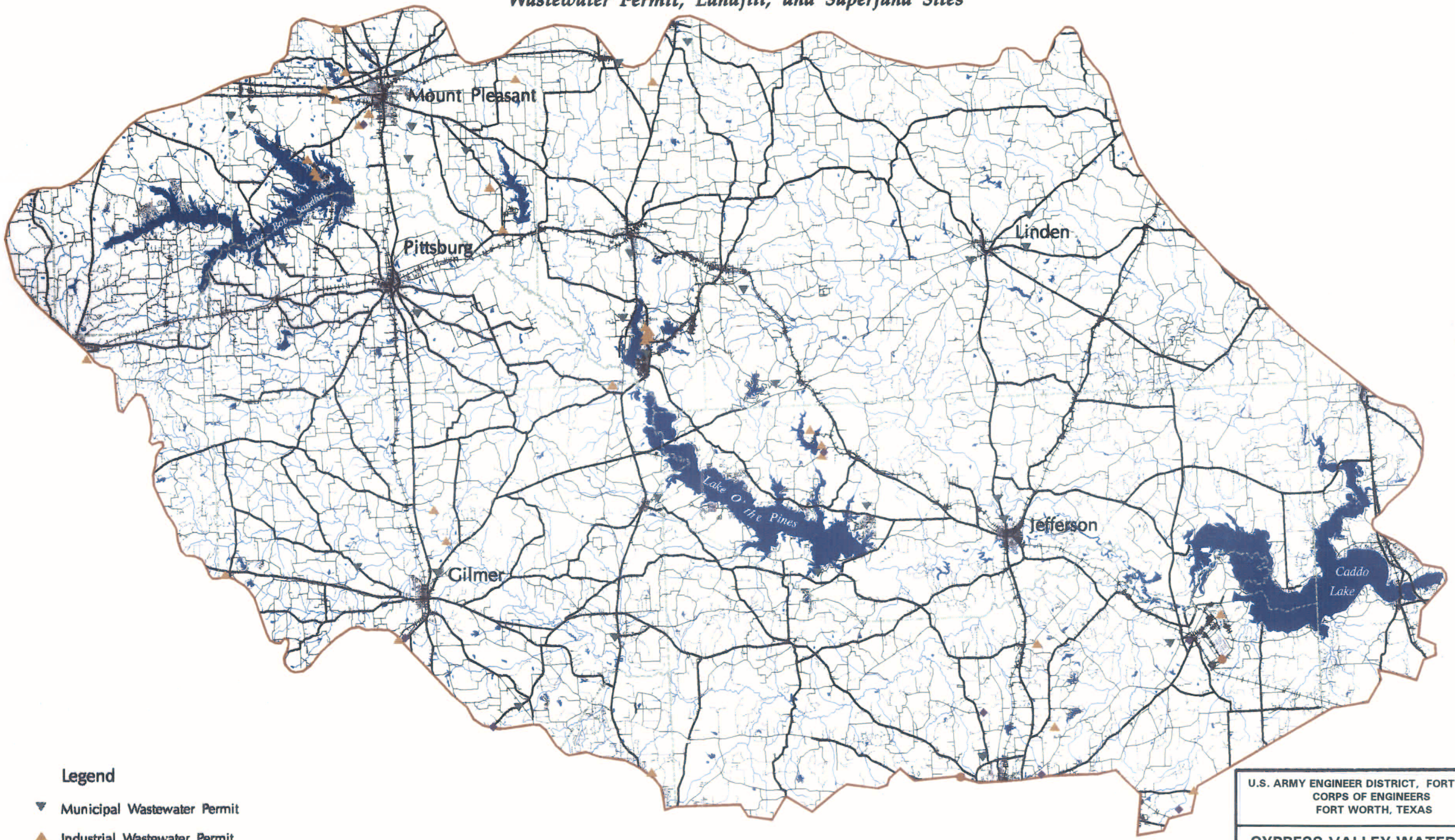
Cypress Bayou Watershed Study

Wastewater Permit, Landfill, and Superfund Sites



Legend

- Municipal Wastewater Permit
- Industrial Wastewater Permit
- Solid Waste Landfill
- Superfund

N

Note:
* Locations are approximate.
* Sites falling outside the study area are not shown.

U.S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS

CYPRESS VALLEY WATERSHED
TEXAS

FIGURE 1

APPENDIX I

CULTURAL (HISTORICAL)

RESOURCES

APPENDIX I

CULTURAL (HISTORICAL) RESOURCES

A Cultural Overview of Texas:

Introduction

Claimed by Spain, Texas was the subject of several Spanish expeditions prior to any serious attempts at colonization. Alonzo Alvarez de Pineda mapped the Gulf coast of Texas in 1519. Based upon Pineda's favorable reports, Spain tried, unsuccessfully, to establish settlements at the mouth of the Rio Grande. Alvar Nunez Cabeza de Vaca, one of several survivors of a failed attempt to explore the Gulf coast in 1528, journeyed across South Texas in an effort to reach Mexico. Exploration of the Panhandle area of Texas occurred when Francisco Vasquez de Coronado passed through in 1541. Seeking treasures of gold and silver, he crossed the Texas plains to Palo Duro Canyon and beyond before returning to Mexico in disappointment. The expedition of Hernando de Soto, travelling west from Florida, entered East Texas and the Cypress Valley Watershed in 1542. While in the area, the starving Spaniards looted the granaries of the Caddo Indians. It is believed that de Soto's *entrada* came within 300 miles of Coronado (Fehrenbach 1969:26).

De Soto's chronicles describe the Caddoan people. The Caddo were one of several native American societies encountered by the Spanish west of the Mississippi River, in the direction of New Spain. The Caddoan societies shared basic similarities in behavior, material culture, and custom. They spoke a different language from those previously encountered by the Spanish, so de Soto's men did not have a translator with them. The Caddo were described as successful maize agriculturalists as well as bison hunters.

The Caddo which inhabited the Cypress Valley Watershed and surrounding area were of the southern Caddoan-speaking group. At that time they lived between the Arkansas and Red River valleys and south into East Texas, within the present-day states of Texas, Oklahoma, Louisiana, Arkansas, and Missouri. The Caddoan family may be derived from the northern Caddoan-speaking groups, which include the Pawnee, Arikara, and Wichita, who lived on the Great Plains of North America. The southern group is believed to have consisted of the Kadohadacho, the Hasinai, and the Adai.

According to T.J. Prewitt, the Caddo had "a large population represented by many small settlements scattered within particular resource areas; a reliance upon horticulture as one of the primary means of subsistence; differentiated and undifferentiated mound/habitation sites with structurally differentiated mound classes (producing an apparently hierarchic division of places on the landscape); differential treatment of the dead reflective of a system of ranking; indications of long-term cooperation in disposal of the dead by groups represented by some of the archeological units" (Perttula 1992:7). What may be described as the Caddo culture is believed to have emerged around A.D. 800 (Perttula 1992:13). Caddo cultural traditions are very similar to the Mississippi period cultural traditions as defined in eastern North American archaeology. Many Caddoan archaeologists, however, believe the Caddo culture evolved relatively independent of the influence of Mississippi period developments in the eastern North American region.

The Spanish explorers kept records which provide a wealth of information on aboriginal inhabitants. As New Mexico was settled, traders and trappers entered Texas, adding to the knowledge of the area. Later expeditions focused on West Texas as the line of settlement in northern Mexico pushed slowly toward the Rio Grande. Despite these early explorations of the region, Texas remained the exclusive domain of native Americans, such as the Caddo, until the close of seventeenth century.

Spaniards in East Texas

As it was throughout the history of Texas, Spain took an interest in the area only when others did. The Spanish came to regard Texas as a buffer between their colonies in Mexico and French settlements in the Lower Mississippi Valley. The first Spanish missions in Texas were a reaction to French activity in the region. In 1685 Spanish authorities learned of a French outpost on the Texas coast. Several expeditions were launched into Texas before the ruins of Fort Saint Louis were found by Alonso de Leon in 1689. Spanish concern about French intrusions in Texas resulted in the decision to establish missions and presidios in East Texas to discourage further French encroachment.

De Leon returned to Texas in 1690 with Fray Damian Massanet and three other priests. Their expedition established the missions of San Francisco de los Tejas and Santisima Nombre de Maria in East Texas among the Hasinai, or Tejas, of the Caddo Confederacy. Located on or near San Pedro Creek, a western tributary of the Neches River, the missions were shortlived. Following an outbreak of smallpox, severe flooding, an epidemic that killed most of the cattle, and worsening relations with the Caddo, the missions were abandoned by the Spanish in 1692.

French activity in Texas renewed Spanish interest in the region. In 1714 the Frenchman Louis Juchereau de Saint-Denis arrived at San Juan Bautista on the Rio Grande. Much to the chagrin of Spanish authorities, Saint-Denis had ascended the Red River in 1713, established the post of Nachitoches in Louisiana, and traveled across Texas to the Rio Grande. As a result of this, the Spanish decided to reestablish a presence in East Texas. The expedition of Captain Domingo Ramon and Fray Francisco Hidalgo arrived in East Texas in 1716. They established a line of six missions and two presidios from the Neches River to present-day Robeline, Louisiana. San Antonio was founded in 1718 to serve as a way station between the Rio Grande and the East Texas missions.

Spain went to war with the Quadruple Alliance of Austria, France, Britain and the Netherland in 1718-1719. A large French force entered East Texas in 1719 and caused the Spanish to abandon their missions. After the war, a major Spanish expedition was sent in 1721 to reopen the East Texas missions and establish a permanent presence. Led by Marques de San Miguel de Aquayo, the group reestablished six missions and two presidios, including the Presidio de los Adaes, which was designated capital of the province. Three of the missions and the Presidio de los Tejas were abandoned 1729-1730.

The French threat to Texas ended in 1762 when, in order to keep Louisiana from being acquired by the victorious English, Louisiana was ceded to Spain during the Seven Years War. Transfer of control was ratified at the close of the war in 1763. With a secure eastern border, the king of Spain implemented "New Regulations of the Presidios" in 1772. This resulted in all missions and presidios in Texas being abandoned except for those at San Antonio and La Bahia. Settlers in East Texas were removed to San Antonio to strengthen the town against Comanche raids. Some of these settlers returned to East Texas and founded a village at the site of the old presidio of Nacogdoches in April 1779 (Fehrenbach 69).

Official Spanish attempts to settle East Texas ceased until another foreign power took an interest in Texas. In 1800 Spain was forced by Napoleon to cede Louisiana back to France, which promptly sold it to the United States in the 1803 Louisiana Purchase. Spain viewed the United States, and the westward surge of Anglo frontiersmen from the former British colonies, as a threat to Spanish hegemony.

Spanish Texas in 1803

At the time of the Louisiana Purchase, Texas was a large, mostly unpopulated region located between the Nueces and Red rivers. After over a century of Spanish occupation, there were only three small settlements with approximately 4000 inhabitants: San Antonio de Bexar, La Bahia del Espiritu Santo (renamed Goliad in 1829), and Nacogdoches (Fehrenbach: 73). Texas was "a feeble thrust against foreign powers in the lower Mississippi. . . " lacking in substance (Meinig, p. 23). Texas was held together loosely by the Camino Real, which stretched across Texas from San Antonio and Goliad to Nacogdoches. The first two villages were located on the southern edge of Texas, adjacent to the San Antonio River on a strip of well-watered prairie and open brush country. They were between the

sandy plains south of the Nueces River and the broadening woodlands beyond the Guadalupe River. It was an excellent ranching area, well-suited for colonization by centuries-old Spanish traditions. At San Antonio and Goliad the missions, presidios, and pueblos were arranged in standardized plans, and land was distributed to settlers according to their rank.. The highly-organized political establishment distributed water resources, regulated the economy, and maintained civil order. The population of San Antonio and Goliad consisted primarily of colonists recruited from established areas of Mexico.

Although it was located in Spanish Texas, there was very little to suggest that Nacogdoches was a Spanish village. The population at Nacogdoches was not colonized in the usual Spanish fashion. The missions founded here previously were abandoned, and the town was a later development. It had grown, since 1779, into heterogenous village consisting of drifters, refugees, and adventurers who had arrived here from different countries. The majority came from Louisiana. Nacogdoches had Spanish officials, but it was not formally designated as a presidio or pueblo. The surrounding land was not apportioned to settlers. It was loosely occupied by squatters, traders, and smugglers. There was little of the cohesion and stability usually found in the civic and social life of a Spanish colony.

Because of its topography and location, adjacent to a troublesome frontier and far away from the nearest Spanish colony, settlers were difficult to recruit. Large, dense forests full of swamps and mosquitoes were not appealing to those familiar with the high, dry plateaus of Mexico. Nacogdoches was over one-hundred miles from the nearest prairie opening, so ranching in the Spanish sense was impossible. Nacogdoches was very different from the typical Spanish colonial town of northern Mexico.

These three towns were the focus of settlement in Texas. Texas was linked to Mexico by a pair of desert roads from San Antonio to Monclovia and Saltillo. There were no Texas ports on the Gulf of Mexico because foreign trade was tightly controlled by Spanish authorities. Veracruz was the only authorized port for Texas and the entirety of Mexico. Nacogdoches served as the sole legal portal by land. Its role as portal and its strategic location adjacent to Louisiana was, according to Meinig, the reason for its existence and the source of its character. (Meinig Note)

Spanish Texas, therefore, consisted of two different regions and cultures which had their own landscape, people, purposes, and problems. San Antonio and Goliad were normal extensions of Spanish colonization, bounded by Spanish customs and oriented toward Coahuila and the rest of Mexico. Nacogdoches' population was oriented towards Louisiana. The inhabitants had little allegiance to anyone.

Spain Responds to the American Threat

There were two possible responses by Spain to the Louisiana Purchase. The first was to withdraw to what many considered the only portion of Texas worth inhabiting: the fine ranching country in the vicinity of San Antonio and Goliad. This area could be used as a buffer for Mexico against the Comanches. The other alternative was to retain control of East Texas in order to stem the advance of the United States and to control immigration, trade, and contacts with natives. The decision was made by the Crown to hold the line in East Texas. To strengthen Spanish control of Nacogdoches and provide a substantial Spanish presence in Texas, Governor Antonio Cordero authorized in 1805 the establishment of settlements along the Camino Real at the crossings of the San Marcos and Trinity rivers. The colonies were short lived because of Indian raids and the decline of Spanish power. Spain failed to colonize the timbered areas of Central and East Texas because authorities did not want the only colonists who would live there. Authorities maintained rigid control over immigrants, allowing only Spanish subjects, such as those from Louisiana, to immigrate to Texas. Few Mexicans desired to inhabit those areas, and Anglo-Americans, were considered politically unreliable. Spain finally implemented a systematic recruitment of foreign colonists under very careful controls, the *empresario* system, to settle Texas. The Mexican Revolution, however, interrupted the Spanish effort. It would be up to the new Republic of Mexico to utilize the *empresario* system.

The Republic of Mexico and the *Empresario* System

Mexico gained independence from Spain in 1821. The Republic of Mexico was highly successful in colonizing the empty lands between San Antonio and Nacogdoches by utilizing the *empresario* system. This system was one in which an individual was granted a large tract of land contingent upon its settlement by a specified minimum number of families. The colonies of Austin, DeWitt, DeLeon, and others were responsible for settling large numbers of immigrants.

In a relatively short time, Mexico succeeded in accomplishing what Spain could not do in over 100 years. After a decade of *empresarios*, there were approximately 25,000 settlers and their slaves in Texas. The only problem for Mexico was that Anglo-American settlers outnumbered the Spanish-speaking inhabitants of Texas by 5 to 1. Efforts were made from 1830 to 1834 to strengthen the Mexican-Indian presence in Texas and to recruit European settlers. American immigration was halted in the Decree of April 6, 1830. Texas was divided into the departments of Bexar, Brazoria, and Nacogdoches with the intent of establishing new garrisons in these departments and introducing large groups of Mexican settlers. Through the *empresario* system, the Republic of Mexico altered Texas from a land of two cultures into a land of three cultures. The newly-created departments were highly-representative of the three cultures.

The Department of Bexar was Hispanic in character. It was a ranching culture, "a cohesive, hierarchical structure of Spanish, *Mestizo*, and Indian--Catholic and formal, authoritarian and conservative; a typical society of officials, soldiers and priests, ranchers and foremen, vaqueros, carters, and peons" (Meinig: 33). On the opposite end of the spectrum was the Department of Nacogdoches. During the Republic of Mexico period the two areas differed even more than before. The town, plaza, streets, and municipal organization of Nacogdoches displayed some Spanish influence, but the inhabitants did not. Mexican independence coincided with an increase in the westward-moving population of the American frontier, and American newcomers dominated the area. The earlier heterogenous group of Nacogdoches was relegated to the bottom of the social order, regarded by both Mexican officials and Americans as ignorant and shiftless. Many of the newcomers; debtors, fugitives smugglers, adventurers, drifters and speculators, were lured by the security and opportunities of a poorly-policed border zone. There was no cohesive civic society, but this antithesis of Bexar was for many the attraction of Nacogdoches. Nacogdoches and the new town of San Augustine had a total population of around 6000 in their vicinities.

The Department of Brazoria, which was between Bexar and Nacogdoches, was American in character and Mexican in framework. Its difference with Bexar lay in its American population. Mexican institutions, in particular the empresario system, differentiated it from Nacogdoches. Brazoria was the area which was granted to the empresarios. Settlers were carefully recruited and allocated land. Brazoria, therefore, contrasted with the uncontrolled folk-movement infiltration that occurred in Nacogdoches and East Texas. Colonists of high quality and often ample means were attracted by the opportunity to easily acquire large quantities of good land. Stephen F. Austin inspired confidence in the settlers and set an example by giving allegiance to Mexico and its laws. Society was stable as the new inhabitants sought to improve their holdings. As in Nacogdoches, little emphasis was placed on developing the towns of Brazoria. Characteristic of American frontiersmen, a town was not a "primary, formal, and administrative creation but was a secondary, speculative response to commercial opportunity" (Meinig 1969).

The Decree of April 6, 1830 was finally voided by Mexico because there was not a sufficient amount of soldiers or settlers available to make the colonization effort successful. Anglo-American immigration to Texas was once again allowed. The decree is evidence that the Mexican government recognized the threat of allowing large-scale immigration into Texas from an adjacent nation. The American immigrants were of a different race, religion, language, and political tradition. These cultural differences and the isolation of Texas from the Mexican government, both politically and geographically, resulted in the Texas Revolution.

American Immigration to the Republic of Texas

Although land allotments were decreased, immigration to Texas increased when it became independent in 1836. The quality and price of land encouraged many to come, mostly from the South. Three general streams of westward movement from the Atlantic seaboard have been identified.

Going back two or more generations, the northern stream started in southeast Pennsylvania, western Maryland, and Virginia and moved to Kentucky and the Ohio Valley, touching southern Indiana and Illinois, and continuing on to Missouri and Arkansas. The middle stream started in Virginia and the Carolinas and crossed into Tennessee and then Arkansas. The southern stream crossed from the Carolinas to Alabama, Mississippi, and Louisiana. The typical East Texan was descended from the back-country folk of the Carolinas and immigrated to Texas from their homes in Tennessee or Alabama. The new inhabitants usually migrated a long distance rather than from Arkansas or Louisiana (Meinig: 43).

Converging on Northeast Texas, the three streams of migration usually entered Texas through either Fulton, Arkansas; Jefferson; or Nacogdoches, and flowed into separate districts, forming northern, middle, and southern areas within Texas according to their Southern source regions. These were not rigid channels of movement, and there was some intermingling, especially as settlements moved west. A fourth line of migration entered directly from the Gulf of Mexico via New Orleans and Europe. European immigrants entered through the Gulf ports of Texas, and, though relatively small in numbers, heavily impacted Texas with their distinct cultures.

Most of these migrations were unorganized folk movements, but the threat of Indian raids resulted in the establishment of frontier colonies, in the tradition of the empresarios, in the last years of the Republic of Texas. The Peters Colony at the headwaters of the Trinity, the Castro Colony west of San Antonio, and a large German colony west of Austin were efforts to settle large numbers of colonists on the frontier in a short amount of time. They brought security and served as a nucleus for further expansion.

In 1836 the Blackland Prairies from Bexar to the Red River was scarcely inhabited. By 1845 the Indians had been removed from the Eastern Cross Timbers, and settlers were entering the region by the droves. The Hill Country was being explored on the south, and a line of forts, including Fort Worth and Fort Duncan, was erected from the Red River to Rio Grande. From 1835 to 1860 the general limits of settlement in Texas were doubled.

The Development of the Cypress Valley Watershed: 1830-1860

By 1814 Anglo-Americans were settling in the Red River Valley in a manner characteristic of the Upper South frontier movement of the time. Exploration and transitory settlements founded by trappers and traders would be followed by families, who would build a cabin, cultivate a patch of vegetables, keep a few hogs, and hunt game. The first exclusively Anglo-American settlement was founded in Northeast Texas in 1815 when Posey Benningfield, James Burkham, and two other families settled south of the Red River on the present-day Bowie-Red River county line. A ferry and the town of Jonesboro was later established on the south bank of the Red River. Jonesboro served as the northern gateway to Texas for many years. David Crockett and Sam Houston entered Texas at Jonesboro and followed Trammel's Trace to Nacogdoches.(Meinig p. 35). An organized effort to settle the area occurred when General Arthur Wavell received an empresarial contract in 1826 for the colonization of a large part of Northeast Texas, which included all of present-day Harrison County. The United States protested that this area was part of the United State as stipulated by the Adam-Onis Treaty of 1819, so Mexican authorities cancelled the contract. The Mexican Land Commissioner issued twenty-two special land patents, mostly averaging 4000 acres, in 1835. No titles to this land were issued until after Texas gained independence because of a boundary dispute with the United States (Peter 1990:13).

Immigrants continued to trickle into Northeast Texas from the South, and by 1830 settlements extended from the Red River bottoms into the rolling hills and prairies to the south. Although Mexico claimed this area, no one exerted control over it. East Texas, in general, was Mexican by soil and Anglo-American in culture. The population, which was oftentimes nothing more than squatters, was ". . . rural, egalitarian, independent, individualistic, aggressive, and adaptable, it was, in some localities, through the selective process of the political border, volatile and conspiratorial as well" (Meinig, p. 35).

Immigration to Northeast Texas and the development of the Cypress Valley Watershed was greatly facilitated by Captain Henry M. Shreve in April 1835. At that time Captain Shreve, Superintendent of Western River Improvements for the U.S. Army Corps of Engineers, cleared the Great Raft from the Red River as far as Twelve Mile Bayou, near the future site of Shreveport. The raft was a mass of logs, debris, and silt that blocked the river. Its removal allowed navigation to Caddo Lake, via Twelve Mile Bayou. Within five years, steamboats would be travelling across Caddo Lake to Port Caddo.

Large numbers of settlers began arriving in the Caddo Lake area around 1837, as part of a new wave of immigration initiated by the creation of the Republic of Texas. Marshall and Harrison County were founded in 1839, and by 1840 a substantial number of settlers lived on the shore of Caddo Lake. The village of Smithville, the furthest navigable point west on Caddo Lake, was in existence by 1841. Some of the early arrivals brought their slaves and purchased large tracts of land, intent on transplanting the cotton culture of the South in Texas. In addition to cotton, the settlers raised cattle and engaged in subsistence farming. Several large cotton plantations northeast of Marshall began harvesting their first crop in the fall of 1841. It was not long before hundreds of bales of cotton were being shipped annually from the Caddo Lake area to Shreveport and New Orleans. According to Jacques D. Bagur, "The rapid growth of steamboat activity on Cypress Bayou and Caddo Lake was intimately related to the inception and expansion of cotton production."

The first settlers arrived at the town site of Jefferson shortly after Big Cypress Bayou was cleared for navigation in December 1844. Prior to the establishment of Jefferson, many immigrants travelled by boat to Shreveport and then crossed overland to Marshall and the rest of East Texas. River transportation was, however, the desired mode of transportation prior to the arrival of the railroad, because of the difficulty of overland travel. The first steamboats bearing immigrants to Texas began arriving at Jefferson in the spring of 1845.

Located at the furthest navigable point west on Big Cypress Bayou, Jefferson prospered as a regional transportation center for Northeast Texas with direct access to Shreveport and New Orleans. Due to its strategic location, Jefferson contributed greatly to the early growth and development of Dallas and Northeast Texas. Jefferson prospered as steamboats arrived with settlers and manufactured goods and departed with heavy loads of East Texas cotton. The large cotton plantations of Harrison County and Northeast Texas made Jefferson a major shipping point. By 1850 the number of steamboats calling at the port of Jefferson surpassed the number travelling to Port Caddo.

In 1846 the population of the area was sufficient to create Upshur County from a portion of Harrison County. A permanent county seat for Upshur County was established with the founding of Gilmer in 1849. Harrison County was the largest town in Northeast Texas and the second-largest cotton producer in Texas in 1849. The *Texas Republican* of 17 May 1854 noted that there were "9,000 bales of cotton in the warehouses of Jefferson, and large stocks of hides, peltries, and bois d'arc seed, awaiting shipment." In 1859 the county ranked third in the state in cotton. The *Texas Almanac* reports that Jefferson exported 25,000 bales of cotton that year. By 1860 the population of Jefferson had reached 1000.

Texas in 1860

Because it controlled an emerging railnet, Houston was the chief inland port in Texas by 1860 (Meinig 1968:59). The first railroad line was established in 1855 and by 1860 five lines extended from Houston. Other major areas of circulation included South Texas and Northeast Texas. San Antonio trade flowed mostly through the ports of Indianola and Port Lavaca in South Texas. Texas had a strong Galveston Bay/Gulf of Mexico orientation with the only important divergence being routes in Northeast Texas, such as Cypress Bayou/Caddo Lake to the Red River. According to Meinig, "in 1860 Texas displayed a fairly well integrated and very largely isolated circulatory system, connected to the outer world chiefly through Galveston, secondarily through land and river portals in the northeast
corner" (Meinig 1969:61).

By 1860 Texas had developed into four broad, discernable regions, which Meinig calls "provinces." According to him, these areas should be thought of as "gross generalizations rather than distinct entities, but are nonetheless essential to any characterization of Texas culture" (Meinig 1969:46-56). These areas denote a definite, over-all geographical pattern. Between Texas independence and the War Between the States, Texas had evolved, in twenty-five years, into a highly individual place with a very distinctive people. The diversity of Texas is evidenced by the governor's message and reports of the 1861 secession convention, which were officially issued in English, German, and Spanish.

East Texas

East Texas no longer provided sanctuary for those fleeing the law when it became a state. By 1845 the area had developed into a stable and homogenous region. Although isolated pockets of hunters and squatters still existed in the swamps and piney woods, the inhabitants could be described as "small farmers, small slave owners, raising a little cotton, and a few head of livestock., living in some contact with one another and within reach of at least a county-seat hamlet" (Meinig 1968:47). With good soil and transportation, cotton production blossomed. By 1860 the area was roughly two-thirds Anglo-American and one-third African-American, most of whom were transplanted from Alabama and other Gulf states. East Texas was a western extension of the older Deep South. It evolved in accordance with patterns of its source region. Formerly a backwoods frontier, East Texas became a society of poverty and prosperity with its foundation in the cotton culture. Slaves were important elements of the economic and social structure. It was a rural society focused on agrarian ideals where towns developed as shipping points for agricultural commodities. The economy of East Texas was based upon cotton, corn, cattle, and hogs.

North Texas

North Texas was a new region emerging in 1860. It was different and distinct, but not a sharp contrast from the rest of the state. This region is defined as the area located beyond the headwaters of Sabine, extending southward, in a narrow band along the Blackland Prairies. North Texas was settled by immigrants from the Border South. This group consisted mostly of Missourians, with strong representation from Tennessee and Arkansas, and a significant number of settlers from Illinois. There were few slaves and little cotton in East Texas. Agriculture was diversified with an emphasis on wheat and oats rather than corn. Settlements were more compact and towns were more important to social organization than in East Texas. The differences between rich and poor were less apparent. The differences between East and North Texas were similar to those of Alabama and Kentucky**.**

Central Texas

Central Texas consisted of the old Department of Brazoria with an extension into the western hills. This area was centered on the early Austin Colony with its eastern boundary the Trinity River, which is regarded as the traditional boundary between East and Central Texas. There was less of a cultural divide between East and Central Texas because an influx of Lowland Southerners came to both areas. The significance of Mexican institutions waned as differences between inhabitants became more subtle. Central Texas attracted men of capital with its rich and accessible coastal plain and fertile bottomlands located upriver. Alabamians and others came with slaves and tools and money to buy land. In some districts, slaves accounted for 50-80 percent of the population

The Brazos River was the cultural divide in 1860. To the east everything was of Southern origin, either Anglo-American or African-American. To the west of the Brazos, European settlers were a conspicuous part of the social geography. By 1860 Germans comprised nearly 25% of the population over a broad area. A German settler who visited Austin Colony in 1831 is attributed with causing the great immigration of Germans. Through his letters to family in Germany he is credited with recruiting a small group of Germans who settled west of San Felipe, between the Brazos and Colorado, by 1836. They were attracted to this area of low rolling woodlands and prairies. Large numbers of Europeans entered under the Republic of Texas group colonization program. Henry Castro settled 2000 settlers from the Franco-German borderlands, and a much larger effort was undertaken by a German company which was granted a large tract in the Hill Country. The company founded Carlshafen, or Indianola, and a way station was established in 1845 by the name of New Braunsfel, which had a population of 1500 by the end of its first year.

Coming from German-ruled homelands were Bohemians, Moravians, Sorbians, and Silesian Poles in the 1850s. They maintained their separate identities in Texas just as they had in Europe. Central Texas displayed a cultural variety that North and East Texas did not have. The Southerners and Germans both worked tracts with cotton, corn, and livestock, but the differences in approach by the two groups were obvious. The Southerners owned large plantations, planted in cotton with little diversification and worked by slaves. German efforts were smaller, family-operated, diversified farms with fields, pastures, gardens, orchards, and vineyards. Few Germans used slaves. The German market-centered town differed from the Southern crossroads hamlet or county seat. In Central Texas there was a definite contrast between a "strongly rural, militantly independent, mobile, and aggressive people nurtured on the frontier, and a strongly community-minded people drawn from the rigidly ordered country-sides and villages of Europe who came in groups and clung together as an alien minority" (Meinig 1969:54).

South Texas

The Mexican past was most evident in South Texas. Anglo Americans had acquired most of the desirable ranch land north of the Nueces River by 1860. Mexican Americans in this area, most of whom were found living along the Indianola-San Antonio Road, were the vaqueros who worked the ranches. Cotton and cattle were the mainstays of South Texas, and the plantation and the hacienda were institutions controlled by the Anglo. The former was worked by the black slave while the latter was worked by the mestizo vaquero.

There were few Hispanics east of Victoria in 1860. Those who had not fled in 1836 were driven out by the Mexican-American War. Hispanics and Anglos living west of Victoria either lived in separate towns or were physically adjacent and socially separate in the same town. Victoria was the largest town in the Nueces country and culturally diverse, with equal proportions of Anglos, Germans, African Americans, and Hispanos.

In South Texas the line of settlements extended from Corpus Christi on the Gulf of Mexico to Uvalde at the Balcones Escarpment. Approximately one-hundred miles of dangerous wilderness existed south of the Nueces country to the Rio Grande. Settlements along the Rio Grande were mostly Hispanic. Anglos sought to control this area as they did with the Nueces country, but the Hispanics had a greater solidarity. There was less disorganization following the wars of 1836 and 1845.

The Development of Texas: 1861-1901

Texas escaped the ravages of an invading foreign army, unlike most of the South, during the War Between the States. East Texas was an important area to the Confederate Trans-Mississippi Department, which functioned as a subunit of the government following the fall of Vicksburg in 1863. Jefferson and Marshall were ordnance, supply, and transportation centers which fed the Confederate war effort. The last invasion attempt by Federal troops was heroically thwarted at the Battle of Mansfield, Louisiana in 1864. The heaviest impact to the status quo in Texas was the abolition of slavery.

Refugees from a war-impoverished South begin pouring into Texas in 1865. During the postwar period Texas was the great Southern frontier. This was a time of immigration, growth, and geographical expansion. Texas experienced tremendous growth from 1860 to 1900: the population increased fivefold. Immigration rose from over a million in the early 1870s to over 3 million by 1900. Immigration was especially heavy in the 1870s and early 1880s.

Patterns remained the same as immigrants from the Gulf states continued settling in East Texas. The influx from Arkansas, Missouri, and Tennessee continued into the Blackland Prairie and Cross Timbers of North Texas. Central Texas was still an area of energetic growth and cultural diversity. Migrants from Germany, Bohemia, and Moravia entered Central Texas and settled in areas already dominated by their countrymen. The crisis of revolution in the 1840s was replaced by European wars of the 1860s and 1870s as impetus from their immigration. Immigration from south of the Rio Grande reinforced the Hispanic character of South Texas. The removal of the Indians from West Texas was almost complete by 1875. This opened a new area, representing half of the area of the state, for settlement.

Texas became an important supplier of cattle to the rest of the nation following the Civil War. Due to short supply, the northern states became a large market for Texas beef. Cattle were driven up such famous trails as the Chisholm, Great Western, and Shawnee to rail lines in Dodge City, Wichita, and Sedalia. The first railroads reaching into Texas from the North were built along cattle trails. By the mid-1880s the railroads completely replaced the big cattle drives. The cattle trails of the late 1860s were the first important commercial links from Texas to the rapidly-growing industrial centers of the nation.

It was after the Civil War that railroads became accessible to most Texans. Rail lines extended from Galveston and Houston, paralleling the Gulf, and took all but local traffic from the smaller Gulf ports. The railroads entered East Texas along some of the older pathways, from St. Louis and Memphis

and from Vicksburg and New Orleans. Jefferson was enjoying its "Golden Era" of prosperity and growth following the Civil War when the railroad arrived in 1873. The railroad robbed Jefferson of its importance as a major regional transportation link. The railroad afforded a safer, more dependable, and more convenient transportation source than the steamboat. Navigation to Jefferson was oftentimes difficult, and sometimes impossible, depending on the time of year. Because of the railroads, Texarkana and Shreveport replaced Fulton and Jefferson as portals to East Texas.

Whereas railroads contributed to the commercial demise of Jefferson and other towns, railroads arriving from the North caused the rapid growth of Dallas as a railroad junction. It grew from 3000 in 1870 to 10,000 in 1880 to 42,000 by 1900. Dallas developed as the center of North Texas, and Fort Worth grew as the gateway to West Texas.

By 1900 the Texas economy had been integrated, but not assimilated, into the Union on a colonial basis. Texas wealth was derived from primary production: cattle and baled cotton sent east for processing. Lumber from the vast forests of East Texas began reaching a national market in 1890s. Significant events occurred in 1901, however, that directed the development of Texas in the twentieth century.

Twentieth Century Texas

In January 1901 an enormous pool of oil in a salt dome south of Beaumont was struck by wildcat drillers. Spindletop and other major oil discoveries not only added oil to the list of primary products and exports from Texas, they also created a need for tools, supplies, and transportation. Local refineries spawned numerous allied industries. Oil became a tremendous economic multiplier for Texas. Large amounts of money flowed into the state. Local wealth was generated and controlled by Texans, who invested in Texas. Oil created a new rich class and empowered Texas with financial independence.

Later in 1901 two of the nation's large meat-packing companies made agreements with the local community to build large plants in Fort Worth. The construction of the Armour and Swift plants was the first direct entry of major national firms lured by Texas raw materials (Meinig 1969:81). Companies came to Texas to process the raw materials found in the state, use Texas labor, or assemble products for the growing Texas market. Texas was transformed from a primary producer into a diversified manufacturer. Texas was no longer a "colonial" economy exploited by a distant industrial region, but an integrated part of the national industrial complex.

These new variables in the Texas equation, oil and industry, greatly effected the regional cultural geography. Continued development and immigration have resulted in the creation five new areas and caused variations to the four initially identified by Meinig.

The Gulf Coast

The Gulf Coast is a new area which was created by the oil boom that has had such a profound effect upon twentieth-century Texas. From Sabine Pass to Corpus Christi, this area is more bound to coastal developments than to the interior. Historically, the flat wet prairies and sheltered bays were sparsely inhabited. At some river mouths and bays small settlements developed, each serving its own area or region. Cities which grew on the coast were merely expressions of the developing interior. Spindletop initiated a new pattern. New centers and industries developed, and the areas bordering Sabine Lake and Galveston Bay were connected by pipelines, railroads, and shipping. Additional discoveries of oil further down the Coastal Plain extended this type of network and development. Since World War II the growth of an enormous chemical industry spawned economic and social patterns that make this area a distinct region of Texas. The population has increased with an influx of new residents from within and without Texas. The area has a considerable amount of agriculture as well as industry.

Southwest Texas

Anglos and Hispanics share this area, which is a broad Mexican border zone including the Edwards Plateau and almost all of the Trans-Pecos. There is no oil and very few agricultural or industrial prospects. It is a land of Anglo ranchers and Hispanic cowboys and herders. The population is small over a large area, and towns exist as ranch supply centers, county seats, or railroad or highway service centers. As the sole metropolis in the area, El Paso is an exception to the region. Its history, population, industries, and commerce make it more related to New Mexico in form and function. With political ties to Texas, it has more ties to the country beyond the state borders.

West Texas

West Texas is a region of farms and ranches. It can be defined in area as a broad region from the Western Cross Timbers to the Pecos Valley, between the Red River on the north and the Concho River on the south. West Texas includes several belts of the lower plains, a broad, flat elevated block of the Southern High Plains, and the edge of the Edwards plateau. Farmland is scattered and farms are smaller and diversified on the eastern side. Cotton is dominant in the small, level basins of fertile soil located further west. Irrigated cotton and grain sorghums are the main crops in the large and very productive High Plains. Ranching is found on the lower plains and the semi-arid open plains on the south and west. Oil is the economic difference between West Texas and Southwest Texas. Every West Texas county can produce oil, and oil was the sole reason for the transformation of Midland and Odessa from small towns into cities.

The Panhandle

A large number of Middle Westerners came to the Texas Panhandle making this the only area in Texas which does not have strong Southern antecedents. Located beyond the northern limits for cotton cultivation, this area of wheat production has a very small minority population. Due to its geography and transportation patterns, the Panhandle is more connected with Kansas City and the East than with Fort Worth and the Gulf. According to Meinig, "Panhandle communities, farm towns, oil towns, and Amarillo as well, have a homogeneity and a political and social outlook which makes them more like those of Kansas than those in other Texas regions. . . the region as a whole constitutes a border zone of Texas society" (Meinig 1969:107).

German Hill Country p. 102

The German Hill Country is a compact block of half dozen counties centered on Fredricksburg, bordering West Texas. German colonists settled this area over 100 years ago. This area is distinct because colonists and descendants were successful in making a living out of marginally productive land. They maintained a strong social cohesion and local identity because no oil or other source of wealth has attracted outsiders. The German Hill Country is relatively homogeneous, bound by tradition. German Methodists, Lutherans, and Roman Catholics are the dominant denominations. The area has few African Americans and less Hispanics than areas to the south and west. Whereas there are more Germans in Central Texas, the German Hill Country is homogeneous.

Central Texas

Central Texas has remained an area of great diversity. Anglos of many backgrounds, African Americans, Hispanics, and several European groups give this area a variety which is found nowhere else in Texas The topography is also varied with woods, prairies, plains, and hills. There is an economic balance between agriculture, industry, and oil in Central Texas.

South Texas

This area is located between the Nueces River and the Rio Grande. Sandy plains are utilized as cropland and rangeland, but the availability of water determines use. Oil production occurs In half the counties of this area. South Texas is a bi-cultural area where Hispanics constitute the majority. The inhabitants are economically interdependent but socially segregated.

North Texas

North Texas serves as a link between East Texas and West Texas. It is a region of cotton, grain, and livestock on the Blacklands Prairie, containing small industrial cities, dominated on the whole by the metropolitan influence of Dallas. It consists mostly of Anglos, lacking the diversity of the southern regions. There are less African Americans here than in East Texas.

East Texas

East Texas consists of Eastern Timbers with rolling red hills and the piney woods. It is roughly defined as Texas east of the Trinity. It is a distinct region. Its patterns of society are so pervasive as to preserve its integrity. In its rural areas it is an extension of the Old South. It has a stable bi-racial society that is conservative and fundamentalist. Cotton was once the sole cash crop in the northern part of the region. It is gone now. Average acreage is small and density is high. There has been a continuous migration to other regions. Corn, hogs, and poultry, electricity, tractors, and trucks have been means of renewal.

Anglo and Negro form a bi-racial, but homogenous, society. Blacks are a quarter of the regional population. Few Europeans, Mexicans, or Northerners live in East Texas. The East Texas Oilfield created Kilgore, in essence, and transformed Tyler and Longview into small cities in the 1930s. Lone Star steel works broadened the industrial base in the 1940s. Lufkin is the lumber, pulp, and paper center of the piney woods. A combination of economic change and social continuity, marked by slow evolution of a single, solid, deep-rooted tradition. East Texas is unique in the state of Texas. The Cypress Valley Watershed is an important part of Northeast Texas and Northwest Louisiana. There are many opportunities with the Cypress Valley Watershed Study to preserve and enhance the heritage of this unique region.

Recommendations for the Development of a Rich Heritage

HERITAGE AREA: THE CYPRESS VALLEY WATERSHED

The Cypress Valley Watershed (CVW) is a unique region within the states of Texas and Louisiana. An excellent way to protect and enhance its unique cultural heritage, while encouraging development and economic growth, would be to designate it as a heritage area. This has already been done with the Los Caminos del Rio Heritage Project (LCRHP), which focuses on the area along the border of the United States and Mexico. A joint effort between the two countries, LCRHP promotes the area while preserving the heritage corridor along the Rio Grande.

The methods applied in the LCRHP can be applied to the CVW. Such a heritage area in Northeast Texas would broaden the experience of visitors. Those visiting the watershed for recreational purposes would also have the opportunity for heritage tourism. This would contribute to the economic development of the area and enhance regional community pride. Developing the CVW as a heritage

area, as was done along the Rio Grande, would combine history, ecology, and recreation activities. Opportunities would be increased by presenting a full range of activities for visitors. Such activities as birding, visiting nature preserves, boating, fishing, and antique hunting would be combined with heritage tourism to increase the number of potential visitors,

DESIGNATION AND INTERPRETATION

One of the first objectives would be to delineate the CVW. The best way to define this area would be to utilize the county boundaries for all counties located in the watershed. The ten county and one parish area would be identified with directional highway signs. The signs would be uniform, displaying, perhaps, the logo for the CVW. The Cypress Valley Center, which is currently being planned by the firm Inside/Outside, would be an excellent starting place for a tour of the heritage area. Brochures, audio cassettes, and/or tour guides would be available for tourists to help them plan their stay and select activities. Appropriate interpretive media, such as roadside pavilions, would be placed throughout the heritage area to identify important sites.

THEMES OF THE CYPRESS VALLEY WATERSHED

An in-depth historical study of the CVW would assist in identifying and interpreting a variety of regional themes. These themes, such as Native Americans, early Anglo Settlements, Agriculture, and River Transportation, would help to characterize the distinctness of area. Thematic landmarks, sites, and structures could then be identified for preservation. With interpretive media, the historic resources would orient the visitor and tell the story of the CVW within a coordinated, thematic framework.. Local museums or area offices could direct visitors to landmarks within the heritage area..

The area's historic properties and distinct cultures would be used to illustrate major themes of the region, such as early settlement, river commerce, and agriculture. Properties would be developed into a coordinated tourism experience to acquaint visitors with region's cultural resources. Part of the focus would be on the cultural continuity within the CVW Heritage Area between Louisiana and Texas that transcends political boundaries. Several preservation scenarios should be developed utilizing high-priority properties throughout the CVW as focal points. By developing these resources as focal points, secondary developments would occur. These tourism-related entrepreneurial efforts, such as hotels, restaurants, and shops, would provide economic development to the communities in which they occur.

REGIONAL AND LOCAL ORGANIZATION

A regional non-profit organization should be created to oversee the project. The board would consist of local residents that would help establish and achieve goals. A number of issues would be addressed by the board, such as cultural resource preservation, tourism and other economic development, environmental protection, and transportation. A permanent staff would be employed by the board to provide professional consultation. The staff would administer the organization, provide technical assistance to local communities, develop preservation ordinances and historic zoning for interested communities, and coordinate marketing efforts. Public and private funding would support the organization. The organization, staff, and board would work together to promote the CVW as a visitor destination and heritage area.

THE HERITAGE AREA CONCEPT

The heritage area concept complements a holistic, multi-disciplined regional approach. The U.S. Fish & Wildlife Service and the Wildlife Corridor Task Force are currently addressing this concept. Tours of the bayou and lake would address heritage as well as wildlife conservation and water quality. Heritage education would instill local students with regional pride, and restored landmarks, in addition to attracting tourists, would be living examples of their heritage and the need to preserve it. Archeological sites, from prehistoric villages to shipwrecks in the bayou, would add to the knowledge of the region's historical development. Restoration work in the region might encourage an interest in arts & crafts of the past. Artist colonies might foster the local production of historical crafts, which would educate residents and visitors about arts, crafts, of folklore. An artist-in-residence program could be started for the region.

LCRHP

Public agencies that helped with the LCRHP include The Rivers, Trails and Conservation Assistance Program of the National Park Service, Secretaria de Turismo (SECTUR) in Mexico, and the Texas Parks and Wildlife Department (TPWD). Los Caminos del Rio, Inc. and A.C., a binational non-profit organization was created to serve as regional grassroots advocate of the project. A State Interagency Task Force was created in 1990 by the Governor of Texas by Executive Order to undertake LCRHP activities. Included in the task force were Texas Historical Commission (THC), TPWD, Texas Department of Transportation (TXDOT), the Department of Commerce, NPS, U.S. Fish and Wildlife Service, SECTUR, Instituto Nacional de Antropologia e Historia (INAH), & Los Caminos del Rio, Inc. and A.C.

All of these agencies working together accomplished a lot. In 1991 and 1992 the THC conducted research and gave technical assistance. Landmark status from the National Register of Historic Places went to several properties. The THC also provided plans and cost estimates for the restoration of Our Lady of Refuge Church in San Ygnacio. Insurance and grant money paid for the work.. TPWD did a feasibility plan for San Ygnacio

In 1992 the NPS began a Heritage Plan. The plan studies the resources of the area and their linkage. Heritage is examined in terms of native wildlife, natural, scenic, and recreational resources. Cultural heritage of the region, including architecture, archeology, folklore, and arts and crafts are assessed. Infrastructure and transportation are also study components. The plan identifies community-supported, long-term, cost-effective strategies for resource conservation and examines how to combine such efforts with sensitive tourism development. Completed in early 1994, the Heritage Plan also has recommendations for partnership management of the heritage area by agencies, organizations, and individuals committed to the LCRHP.

In January 1992 NPS began the plan by sending questionnaires to key individuals and organizations. A study trip was undertaken in April 1992 by a 28-member team representing 15 disciplines. The team made on-site evaluations throughout the area during a five-day period. They examined management, infrastructure, conservation, and economic development issues. Results of the trip were published by THC and NPS in *The Cultural and Natural Resources of Los Caminos del Rio: An Interdisciplinary Evaluation.* Six public workshops were held by the NPS and Governor's task force in July 1992 to relate public opinion with the interdisciplinary team's findings. Representatives from Mexican federal agencies also drafted recommendations. The Mexican and American plans were formalized in the "Agreement to Collaborate on Los Caminos del Rio Heritage Project" signed on October 30, 1992. This agreement made the project a binational effort.

During the planning and organizing, project partners were involved with specific sites in the area. THC held the Certified Local Government Conference in Brownsville. The project was discussed as well as issues involving conservation, tourism, and public/private partnerships. Since fall 1992 the project staff has focused on heritage education. *A Teacher's Companion Activities and Resource Book* to accompany the second edition of *A Shared Experience* was prepared for junior high school students. The book has ideas for lessons about the area's cultural and natural heritage. Activities in 1993 included a clean-up and awareness day at the historic site of Guerrero Viejo and building

restoration projects at Laredo, Hidalgo, and Roma. Efforts in 1994 focused on preparing documentation on the area for designating it a National Heritage Area.

RECOMMENDATIONS FOR THE IMMEDIATE FUTURE

Many of the lessons of LCRHP can be applied to CVW. The following recommendations are based upon the vision and initiative of LCRHP:

1. Planning--A master plan for the CVW should be developed which integrates tourism, community and land-use planning, transportation, and historic site management.

2. Inventory and Protection--County surveys should be undertaken to identify tourist attractions in the CVW, such as historic and natural landmarks and sites. Potential threats should be identified and efforts should be made to insure the protection of these valuable resources.

3. Promotion--A touring map should be developed for the CVW which would guide tourists and interpret heritage sites.

4. Designations--Resources in the CVW should be designated, when applicable, as regional, state, and national landmarks. This would include the nomination of historic properties to the National Register of Historic Places, designation of historic districts, county-wide historic resource surveys, and research for National Historic Trail and National Historic Landmark designation. Efforts should be made to have the area designated as a National Scenic Byway. The CVW offers visitors and residents quality natural, scenic, cultural, and recreational resources.

5. Inter-governmental Coordination--a task force should be created which would coordinate agency activities, assist in project development, and encourage partnering.