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ENVIRONMENTAL ASSESSMENT

MAS

Geothermal Energy Geopressure Subprogram

DOE
Sweet Lake No.1

CAMERON PARISH, LOUISIANA

FEBRUARY 1980

U.S. DEPARTMENT OF ENERGY

Assistant Secretary for Resource Applications
Washington, D.C. 20461

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GLOSSARY AND ABBREVIATIONS

point of drilling	the location of the well bore
well site	the 2 ha area on which support facilities, including separators, cooling towers, tanks and laboratories will be located; includes point of drilling
Sweet Lake Prime Prospect Area	a rectangular area considered by DOE to be the most desirable zone for geopressured-geothermal resource exploration and development at this time
Frio Formation	the wedge of clastic sediments composed of numerous overlapping deltaic and interdeltaic systems which were built into the Gulf geosyncline (Tertiary age Oligocene series)
A-F/yr	acre-feet per year
API	American Petroleum Institute
cfs	cubic feet per second
bbls	barrels
BPD	barrels per day
BWPD	barrels of water per day
dBA	A-weighted sound levels taken with a sound level meter and expressed as decibels on the scale. The "A" scale approximates the frequency response of the human ear
Eh	redox potential
ERDA	Energy Research and Development Administration
FHWA	Federal Highway Administration
FIA	Federal Insurance Administration

hm^3/yr	cubic hectometers per year
Kh	permeability in millidarcies
md	millidarcy
mgd	millions of gallons per day
MMSCF	millions of standard cubic feet
ug/m^3	micrograms per cubic meter
ppt	parts per thousand
PRDA	Program Research and Development Announcement
psi	pounds per square inch
SCS	Soil Conservation Service
Tcf	trillions of cubic feet
TDS	total dissolved solids
USACE	U.S. Army Corps of Engineers
USDI	U.S. Department of the Interior
USGS	United States Geological Survey

CONVERSION FACTORS

Symbol	When you know	Multiply by	To find	Symbol
μ	microns	0.00003937	inches	in
mm	millimeters	0.0393701	inches	in
m	meters	3.28084	feet	ft
m	meters	1.09361	yards	yd
km	kilometer	0.621371	miles	mi
ha	hectares	2.47105	acres	acre
m^2	square meters	10.76	square feet	ft^2
m^2	square meters	1.19599	square yards	yd^2
km^2	square kilometer	0.3861	square miles	mi^2
m^3	cubic meters	35.31	cubic feet	ft^3
ml	milliliter	0.033818	ounces	oz
l	liter	1.05669	quarts	qt
mg	milligrams	0.00003527	ounces	oz
g	grams	0.03527	ounces	oz
kg	kilograms	2.30462	pounds	lb

SUMMARY

A Program Research and Development Announcement (PRDA) was issued by the Division of Geothermal Energy (DGE) of the Department of Energy's predecessor agency (ERDA) to acquire data on the characteristics of the geothermal geopressure resource in the Louisiana-Texas Gulf Coast Region. DGE received five responses to the PRDA and found the Sweet Lake No. 1 Well proposal to be superior to the other proposals based on technical, managerial, economical, and environmental criteria. This environmental assessment was prepared to further evaluate the environmental effects of the proposed actions prior to its initiation.

The proposed action will be the development of a test site consisting of three well sites (one geothermal fluid well for intermittent production testing of 300 days over a 26-month period and one or more injection wells will be drilled) and required access preparation. The test well will be drilled to a total depth of 4758 m (15,600 ft). One disposal well will initially be drilled to provide disposal of lower volume fluids produced during the initial 60-day test. If necessary, one or more additional disposal wells will be drilled, logged, completed, tested, and operated to provide for injection of high volume fluid. All surface facilities will be within .8 km (.50 mi) of the proposed well. Surface facilities will be constructed and installed on a 2 ha (5 ac) area. Extensive tests will be conducted on the physical and chemical composition of the fluids, their temperature, the nature of flow, fluid disposal techniques, and the reliability and performance of equipment. The objective of the proposed action is to determine the economic viability of the geopressured resource.

The test site is located approximately at latitude 30°01'N and longitude 93°08'W in Cameron Parish of southwest Louisiana. The northern two-thirds of the Prime Prospect Area is Pleistocene Prairie Terrace, the southern third is Recent coastal wetlands. The entire area is of low elevation and low relief. The sands of the Frio Formation to be tested occur at a depth of 4575 m (15,000 ft) below the well site. Surface hydrology on the Pleistocene Terrace is controlled by the levees and canals used in rice cultivation. Sheetflow is found on parts of the wetland, but canals and levees have channelized regional water movement. The proposed site is located on the prairie, not the wetland. Groundwater is used for domestic water supplies. Wildlife and natural habitat are concentrated in the Recent coastal wetlands.

Within the Prime Prospect Area is the community of Sweet Lake. The nearest large town is Lake Charles, 23 km (14 mi) to the northwest, while the nearest city is Beaumont, 72 km (45 mi) to the west. Homes and some businesses are in a linear settlement pattern along the two major highways, LA 27 and LA 384, across the Prime Prospect Area. However, the overall character of the Prime Prospect Area is rural as most of the land use is rice or soybean fields and pasture on the Pleistocene surface. There is only one known archeological site (in the wetlands) and no known historic or National Register sites in the Prime Prospect Area.

Construction of the proposed action will change the land use of 2 ha (5 ac) for the test well and each of the injection wells from agriculture to resource exploration. Lands will be cleared and erosion and runoff will result. During operation of the well test, the only expected impacts are from venting of gases or flaring of gases and noise. After the tests are completed, the area will be restored as much as possible to its natural condition by revegetation programs using native species. All sources of pollutants will be collected and disposed in environmentally acceptable ways. Accidents may result from this proposed action; however, numerous safeguards will be installed to reduce the probability of such an occurrence to an approved level.

If a blowout should occur, the environment may be polluted. Groundwater and surface water may be contaminated by the geothermal brines. Vegetation and possibly some wildlife will be destroyed. Homes, businesses, and churches may be temporarily evacuated, depending on the severity of the accident. Evacuation procedures will be coordinated with local law enforcement agencies. The air quality around the well site will contain H_2S and other gases which are harmful in too great a concentration to the ecosystem.

CHAPTER ONE - DESCRIPTION OF THE PROPOSED ACTION

1.1 Introduction

The Sweet Lake Number 1 Well proposal was selected using a competetive procurement process. A Program Research and Development Announcement (PRDA) was issued with the objective of acquiring data concerning the characteristics of the geothermal geopressure reservoirs in the Louisiana-Texas Gulf Coast Region as part of the Geopressure Subprogram. Environmental issues related to the Geopressure Subprogram were identified and analyzed in the Environmental Impact Assessment Geopressure Subprogram (EIA/GE/77-3, July 1977). Five responses were received which identified nine alternative sites in the Louisiana-Texas Gulf Coast Region. Six sites were located in Louisiana: two in Cameron Parish, one in Calcasieu Pairsh, one in Jefferson Davis Parish, one in Acadia Parish, and one in Terrebonne Parish. Three sites were loacted in Texas: one in Waller County, one in Harris County, and one in either Harris, Brazoria, or Fort Bend County. The confidentiality of the procurement process prevents identification of the specifics of these alternative sites. After a lengthy review, eight of the proposed sites were rejected and the Sweet Lake Number 1 site was selected because it was found to be superior to the other proposals based on technical, managerial, economical, and environmental criteria. This environmental assessment was prepared to further evaluate the environmental effects of the proposed action prior to its initiation.

This Environmental Assessment (EA) has been prepared to assess the environmental implications of the Department of Energy's (DOE's) proposal to drill, complete, and test one geopressure well located in Cameron Parish on a 2 ha (5 ac) test site, 23 km (14 mi) southwest of Lake Charles, Louisiana (Fig. 1-1). The test well is herein referred to as DOE Sweet Lake No. 1. One or more disposal wells will be located within .8 km (.50 mi) of the

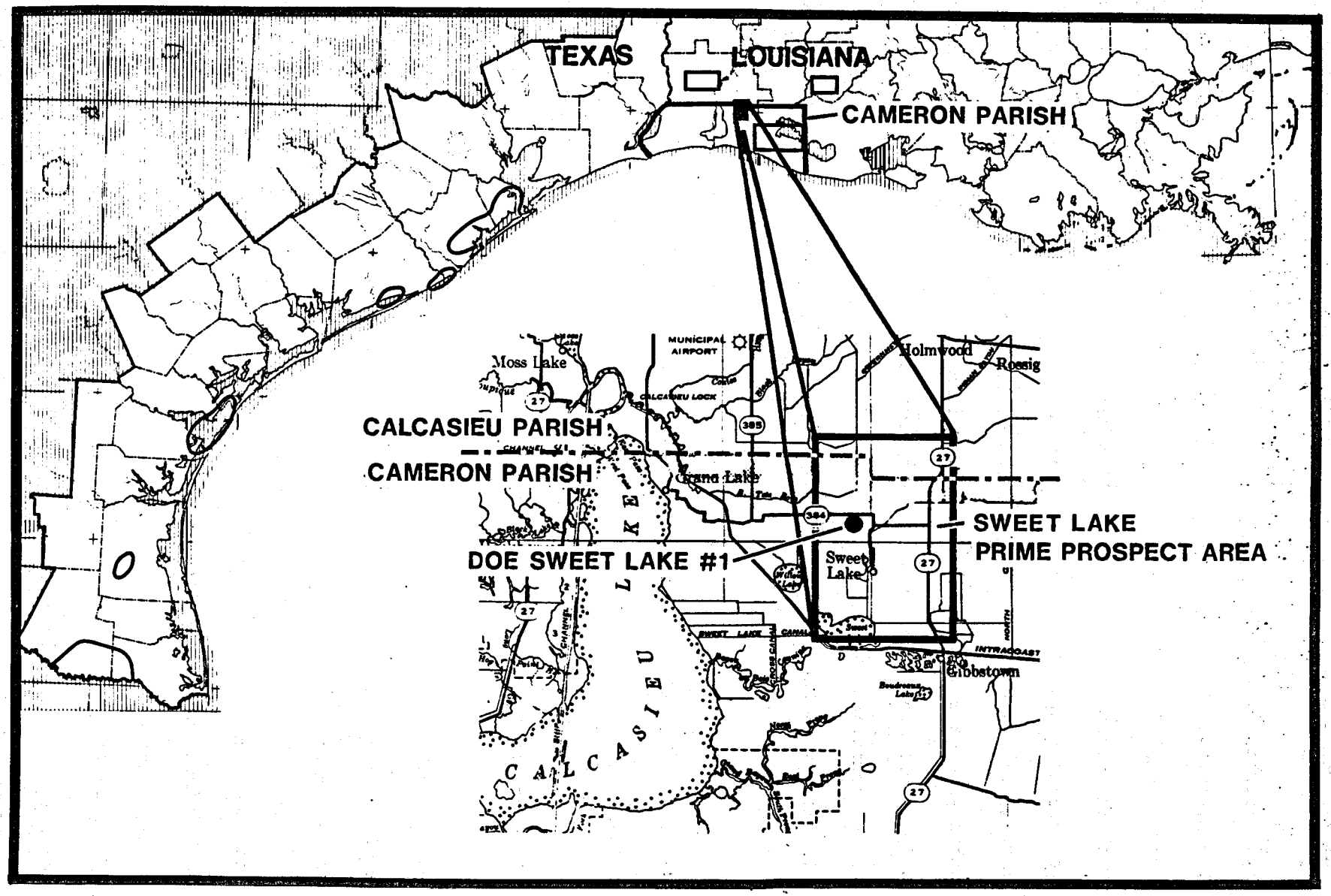


Figure 1-1. Location of the Sweet Lake Prime Prospect Area in relation to the Gulf Coast region.

proposed well. The Department of Energy (DOE) and the State of Louisiana through the State University system proposes to operate the test facility for 26 months to evaluate the geopressure potential of the subsurface. Tests to be conducted include flow rates, fluid composition, temperature, gas content, geological characteristics, and the land subsidence potential for subsequent production. This EA evaluates the impacts of the proposed action on the Prime Prospect Area.

This EA activity falls under the broad subprogrammatic Environmental Impact Assessment, Geopressure Subprogram, EIA/GE/77-3, July 1977, Division of Geothermal Energy, Energy Research and Development Administration; the activity associated with the Frio Fromation of Texas and Louisiana.

1.2 Site Location and Surface Features

1.2.1 The Region

The proposed action is located in southwest Louisiana in a promising zone for evaluating the physical and chemical characteristics of the resource (Fig. 1-1, 1-2, 1-3). The well will be drilled into the Lower Frio Formation to a depth of approximately 4758 m (15,600 ft). Net sand thickness in this area is on the order of 122 m (400 ft).

1.2.2 Site Selection

The well site was selected for resource analysis on the basis of four parameters: sand thickness (122 m [400 ft]), temperature (151 to 157°C [305 to 315°F]), porosity (22%), and environmental suitability (Pleistocene Terrace) for the proposed action and eventually possible full commercial exploitation.

1.2.3 Description of the Prime Prospect Area (Fig. 1-2 and 1-3)

All development of surface facilities and injection wells will take place

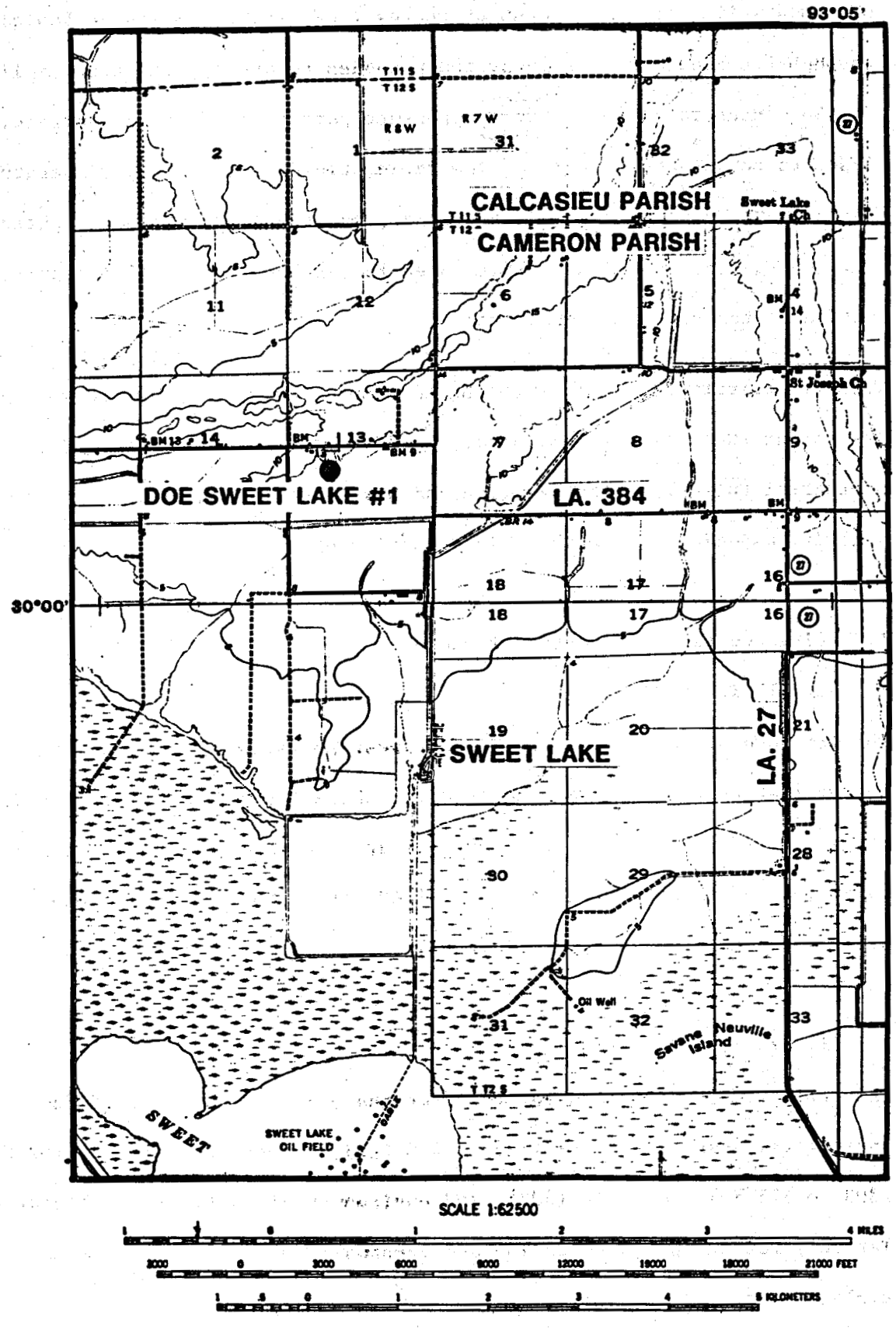


Fig. 1-2. A topographic map of the Sweet Lake Prime Prospect Area (USGS 15'Quadrangles, Sweet Lake, Louisiana, 1955, and Lake Charles, Louisiana, 1955.)

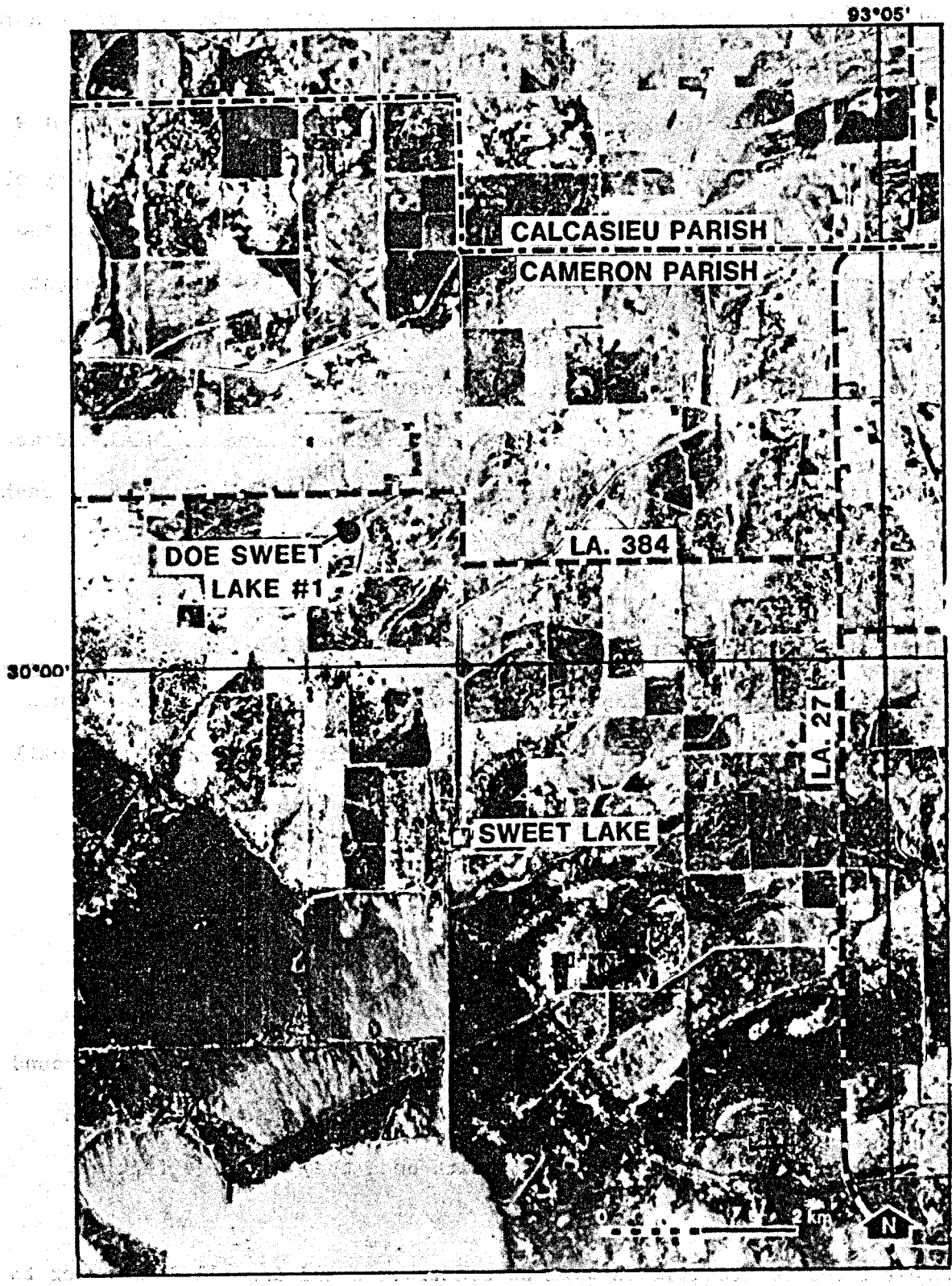


Fig. 1-3. An aerial photograph of the Sweet Lake Prime Prospect Area (Color IR, BIN No. 7AJ5, Frame 34, Photo ID 628900140ROLL).

within .8 km (.50 mi) of the point of drilling. All of the land to be used by this test is in private ownership, but is leased to the Gulf Magma Corporation. The Prime Prospect Area is centered on the latitude 30°01'N and longitude 93°08'W. Within the Prime Prospect Area is the community of Sweet Lake. The nearest large town is Lake Charles, 23 km (14 mi) to the northwest, while the nearest city is Beaumont, 72 km (45 mi) to the west. Homes and some businesses are in a linear settlement pattern along the two major highways, LA 27 and LA 384, across the Prime Prospect Area. However, the overall character of the Prime Prospect Area is rural, and most of the land use is rice or soybean fields and pasture. Wetlands and fresh-water marsh form the southern third of the Prime Prospect Area.

1.3 Project Description

The proposed action will consist of the drilling of one geothermal fluid well for production testing and two or more injection wells. A test well will be drilled with a 21.6 cm (8.5 in) borehole to a total depth of 4758 m (15,600 ft). One disposal well will be drilled to provide disposal of lower volume fluids produced during initial loop testing. If necessary, one or more additional disposal wells will be drilled, logged, completed, tested, and operated to provide injection for high volume fluid. The U.S. Environmental Protection Agency (EPA) Underground Injection Control Program proposed rules apply to both geothermal and injection wells and will be complied with once they become effective.

Required surface facilities will be constructed and installed in order to conduct the extensive resource tests. Over a 26 month period the test will assess the economic viability of the geopressure geothermal resource. Surface stream sampling of the produced fluids and the second phase is for full-scale processing of the produced geothermal fluids.

Phase 1 facilities would provide for full stream production directly into a disposal well (Fig. 1-4). Assuming a normal pressured sand in a 1952 m (6,400 ft) disposal well would have a formation pressure of only ±3,000 psi, it can be assumed that great quantities of water can be injected with surface flowing pressures derived from the producing well without assistance of pumps.

The producing well would be allowed to establish a stabilized flow-rate into the disposal well by regulation of an adjustable choke. After stabilization is established through the 20 cm (8 in) bypass, air-operated valves would rapidly close off a sample in the 20 cm (8 in) bypass and divert the full stream through the main 20 cm (8 in) line to the disposal well. Pressure, temperature, and flow rates would be continuously recorded. The trapped-sample (approximately 6 bbls) in the bypass would be cooled to desired temperature, reduced to desired pressure, and the gas samples withdrawn into evacuated vessels. Liquid samples under pressure would be purged from the bypass by assistance of high-pressured nitrogen.

Should the disposal well fail to take maximum desired flow rate, a booster centrifugal pump or an additional well could be added to the system.

Gas samples will be analyzed for mole percent concentrations of CO_2, C_1-C_5, and C_6+ by a mass spectrometer. Hydrogen sulfide and other volatile inorganic or organic sulfur compounds will be determined by gas chromatography and a flame photometric detector.

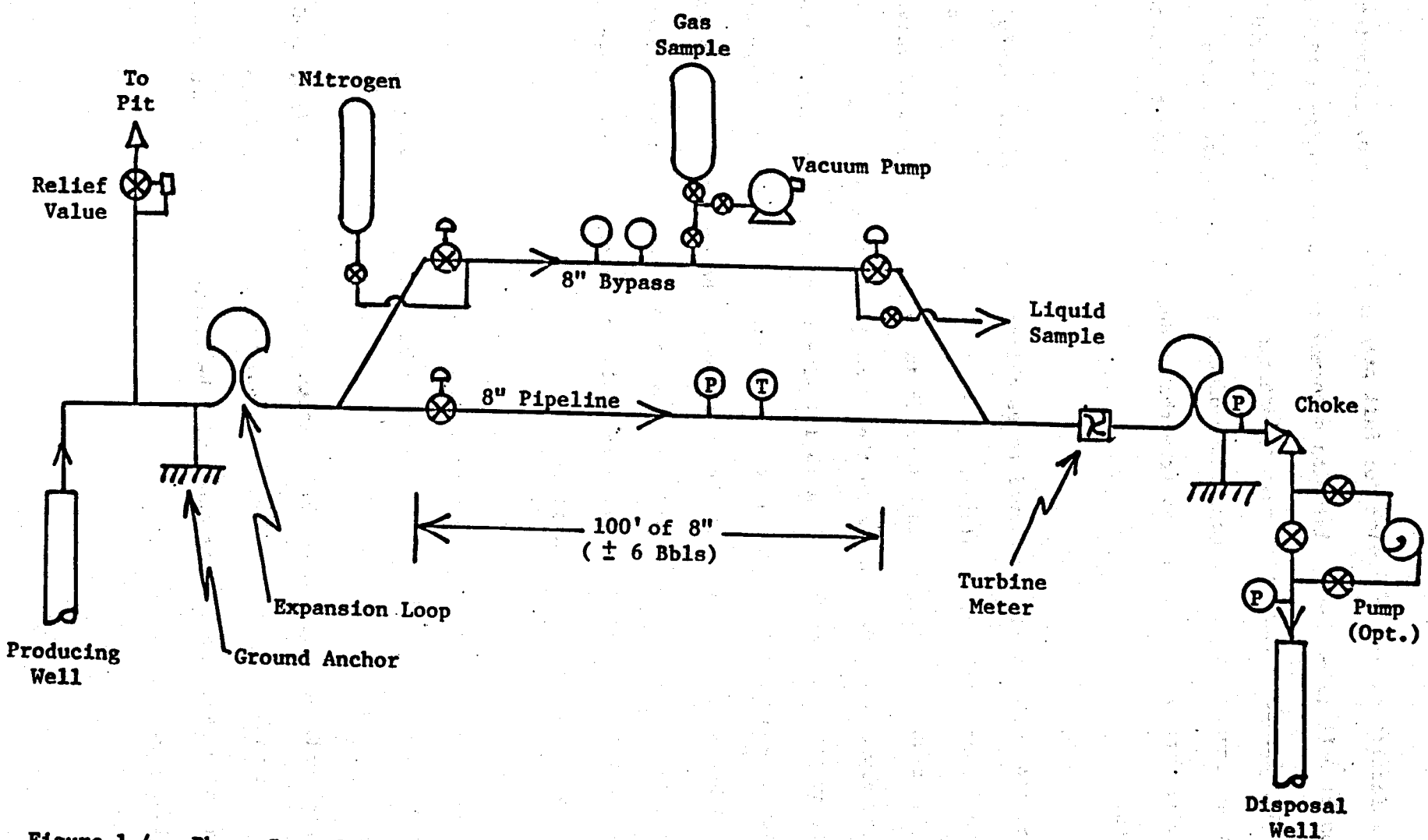


Figure 1-4. Phase I surface facility.

Liquid samples will be analyzed for hardness, solids, carbonates, chloride, silicates, barium sulfate, iron, arsenic, boron, cadmium, and other metallic species. Dissolved and total solids will be determined gravimetrically. The fluids conductivity and pH will be measured with flow line electrodes.

Corrosion and scale-formation properties of geothermal waters are expected to be different from those of waters having wells. The high salinities, Cl concentration, and high temperatures increase the corrosivity of geothermal waters by facilitating dissolution of iron at anodic sites. At reduced temperatures and pressures, these waters are expected to precipitate great quantities of oxyhydroxides of iron, carbonates, of Ca, Sr, and Ba, along with some sulfate of barium. Corrosion and scale probes inserted into the produced stream should be continuously monitored. Control and reduction of the fluids pH may be necessary before injection into the disposal well. Since most geothermal waters at temperatures of 26°C (79°F) are expected to be supersaturated with $BaSO_4$ and other compounds, it is desirable in the Phase #2 process facility to maintain some yet unknown temperature and pressure in order to maintain supersaturation prior to injection into the disposal well.

Due to the above uncertainties and anticipated problems, design criteria need to be gathered in Phase #1 prior to designing the permanent facilities of Phase #2. Figure 1-5 presents a generalized and probable flow diagram for the permanent facility. Alternatives to this flow diagram might include such items as aerial-forced draft coolers, filters, chemical injectors,

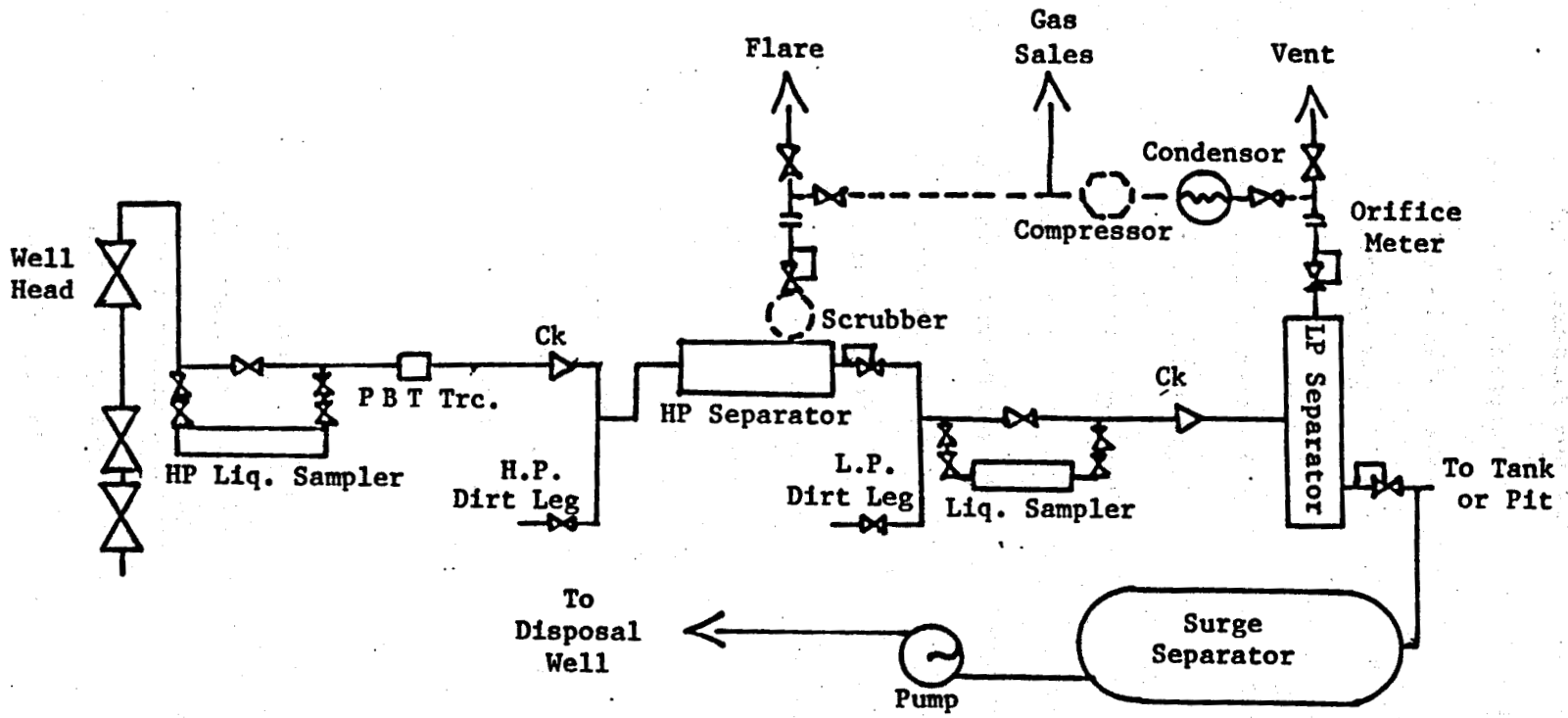


Figure 1-5. Phase II surface facility.

atmospheric storage tanks, and/or large, earthen pits. A cooling tower may be required to reduce the flow temperature before the disposal stream enters the pump station and is injected into the formation. Normally, this type of cooling device is small, about the size of an outside air conditioner. The impacts of a cooling tower(s) will be from noise and heat emissions and will be minimal. Presently it appears that the most likely permanent system will maintain the fluids above some minimum temperature 21-27°C (70°-80°F) and will not expose them to atmospheric pressure.

The decision of whether or not to proceed to the 240-day flow test phase of the project will be based on several engineering and environmental factors. The engineering factors are related to the productivity of the well and are interrelated (i.e., it is usually poor ratings in several of these factors rather than in just one that would cause the test to be cancelled). The environmental factors are significant impacts which cannot be mitigated. The general engineering and environmental factors are presented below:

<u>Engineering Factors</u>

rate of flow of the well (pressure fluctuations)
reservoir parameters (e.g. drawdown)
temperature of the fluid
total dissolved soilds concentration (TDS)
gas/water ratio

<u>Environmental Factors</u>*

violations of air quality standards
violations of water quality standards
subsidence
seismicity
significant impacts outside of the range of those defined in the EA
significant new impacts not defined in the EA

*The environmental factors are incorporated in the environmental monitoring program which will be implemented as part of the project.

This EA evaluates the environmental impacts of drilling, developing, and testing of the Sweet Lake No. 1 well. It does not evaluate the impacts associated with activities at the site beyond the 240-day test period. Additional documentation will be prepared at the appropriate time to support the decision of whether or not to continue DOE activities at the site beyond the 240-day test period.

An environmental monitoring program (Appendix A) will be implemented as part of the project. The purposes of the monitoring programs are to determine what impacts will result from the project and the levels of significance of these impacts. The information obtained by monitoring will be used to identify mitigation measures and corrective actions to be implemented to minimize the impact of the project. If significant impacts cannot be mitigated, DOE will evaluate continuation of the project.

1.3.1 Construction and Drilling

The construction phase of the proposed action includes site and access preparation. Drilling includes both well drilling and testing.

1.3.1.1 Site and Access Preparation

Drilling activities require the construction of access roads and level drilling pads for the production well and the injection wells on the higher ground. Where possible, the access road will be constructed to disturb a minimum area by using existing roads when available, by following the natural topography, and by avoiding cut and fill operations. The plank road will be approximately 4.2 m (14 ft) wide with a disturbed area of 0.4 ha/km (1.7 ac/mi) of roadway.

The proposed points of drilling will each be cleared, leveled, and compacted for an area of up to 100 cm^2 (.25 ac) to provide drill pads. As many as 1.6 ha (4 ac) will be used with minor disturbances for other equipment and laydown areas at each site. A ring levee will be constructed around the entire drill pad. Clam shells will be used as surface material to convert the site and road to permanent facilities.

1.3.1.2 Well Drilling and Testing

The initial disposal well will be 153 m (500 ft) north of the proposed geopressure well site along the access road. If a second disposal well is drilled, it will be 153 m (500 ft) south of the geopressured well. Figure 1-6 is a diagram of the disposal wells. The disposal wells will be drilled and operated in compliance with pertinent current regulations of the Louisiana Department of Natural Resources. The EPA Underground Injection Control (UIC) Program will be complied with when it becomes effective.

The geopressured well will be drilled to a total depth of approximately 4758 m (15,600 ft). A 14 cm (5.5 in) production liner will be set and perforated in the producing sands.

Testing will be during two periods: the first is planned for a 60-day period (Table 1-1) and the second is for a 240-day test period (Table 1-2). Phase 1 has been planned to consist of an initial shut-in period of three days followed by a series of four tests, each lasting twelve days. During each of these tests, the initial flow rate will increase by 10,000 BPD for three

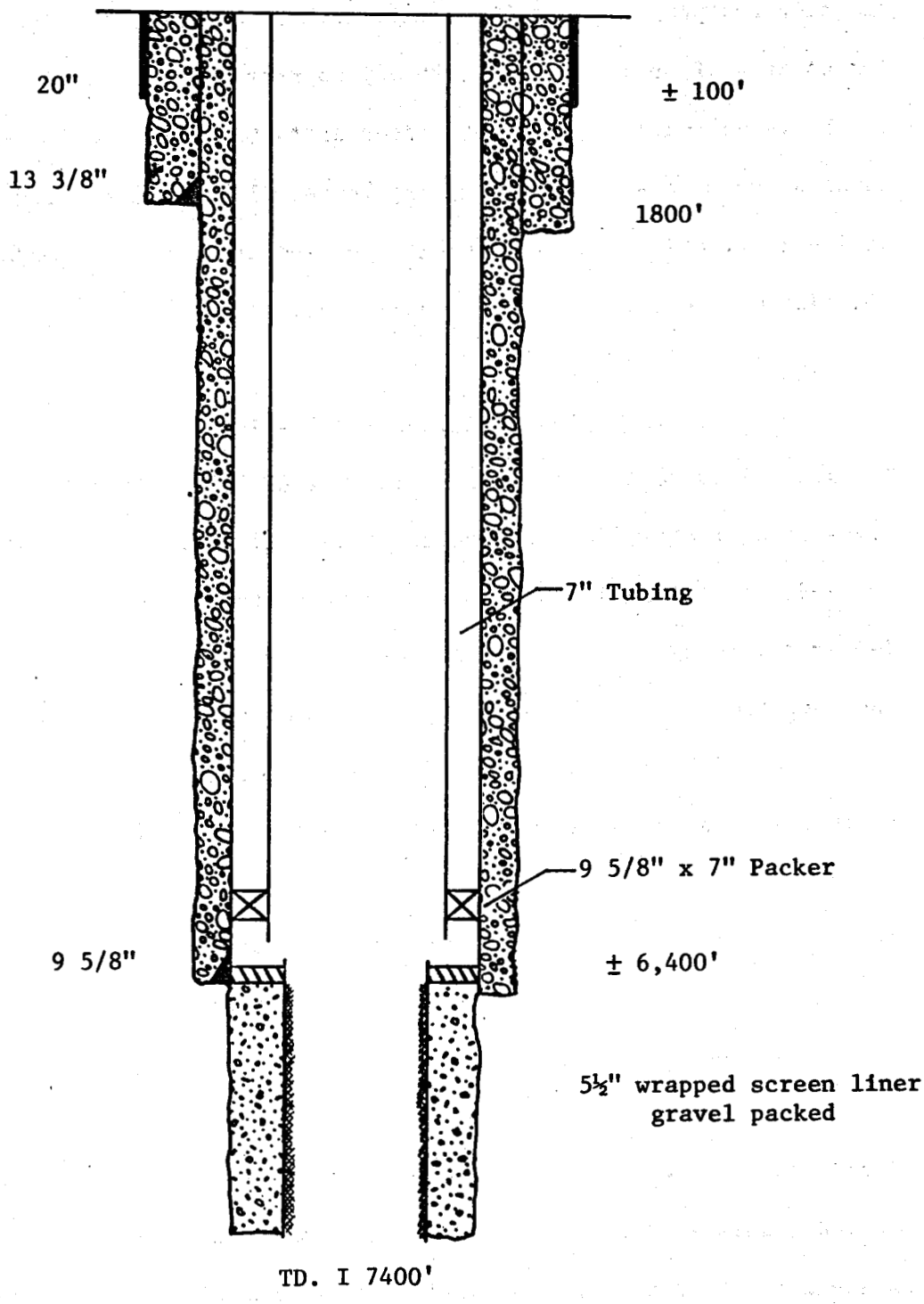


Figure 1-6. Sweet Lake disposal well diagram.

Table 1-1. Schedule for 60-Day Test (DOE, 1979).

Test Period	Test Duration	Cumulative Test Time (End of Period)	Test Rate BPD	Cumulative Fluid Production M Bbl
Initial State	3 days	Day 3	0	0
Dynamic				
Phase 1a	3 days	Day 6	0-10,000	15
Phase 1b	9 days	Day 15	10,000	105
Phase 2a	3 days	Day 18	10,000-20,000	150
Phase 2B	9 days	Day 27	20,000	330
Phase 3a	3 days	Day 30	20,000-30,000	405
Phase 3b	9 days	Day 39	30,000	675
Phase 4a	3 days	Day 42	30,000-40,000	780
Phase 4b	9 days	Day 51	40,000	1,140
Final Static	9 days	Day 60	0	1,140

Table 1-2. Schedule for the complete well testing program at DOE Sweet Lake No. 1 (DOE, 1979).

	By Days	By Months	By Quarters
1. Production Well--drill and complete	1- 90	1- 3	1st
2. Initial Disposal Well--drill and complete	100-130	4- 5	2nd
3. Test Loop--develop, fabricate, install	1-180	1- 6	1st & 2nd
--60 day test	181-240	7- 8	3rd
4. Permanent Test Facilities--design, deliver, install	210-510	7-17	3rd - 6th
5. Second Disposal Well	400-430	14-15	5th
6. Permanent Test Facility--240 day test	510-750	18-25	6th - 9th
7. Plug and Abandon and Start Site Restoration, or	750-770	26	9th
a. Continue DOE activities, or			
b. Transfer responsibility for the well to a responsible party in accordance with state laws.			

days and then remain at the cumulative rate (40,000 BPD) for nine days. At the end of these tests the well will be shut-in for the remaining nine days. The 240-day test will be designed based on the results of the 60-day test.

If the decision is made either not to continue DOE activities at the site beyond the 240-day test, or to transfer responsibility for the well into commercial production, the well sites will be abandoned. The wells will be plugged according to the regulations and permits of the Louisiana Department of Conservation.

If a developable resource is found, additional environmental documentation will be prepared to support the decision of whether or not to continue activities at the site beyond the 240-day test period. As stated previously, this EA only addresses the impacts of drilling, developing, and testing the Sweet Lake No. 1 well.

All surface facilities will be removed; all refuse, garbage, and toxic materials will be cleaned from the area; and the sites will be returned to a condition similar to their original condition before the drilling program.

1.4 Known Environmental Issues and Mitigating Measures

The DOE has planned the proposed action to have a minimal adverse impact on the physical, cultural, and economic environment. A summary of these mitigation measures is presented under Section 1.4.

1.4.1 The Physical and Biological Issues - A Summary of Adverse Impacts

(1) Upgrading or construction of roads to provide access to the test site will destroy vegetation and/or aquatic communities which constitute habitats for a variety of wildlife. In some cases the vegetation removed will be wildlife, waterfowl or fish habitat, or nursing grounds. Mitigation measures to be used to minimize adverse impacts include use of existing roads so as not to impact new areas, restriction of upgrading avenues of access to essential activities, and limiting activities to seasons when wildlife or land uses would be least affected.

(2) Installation of a reinjection well will require clearing of space for a drill pad. The area required will be kept to a minimum by using the smallest feasible drilling rig and facilities configuration.

(3) Removal of vegetation and construction activities will result in increased runoff, erosion, and sediment concentration in streams. Drill pads and roads will be surfaced with shell where appropriate to retard runoff. Barriers will be installed to contain runoff and prevent erosion.

(4) Contaminants such as lubricants from vehicles and equipment and chemicals from spills and accidents will be introduced into the environment. The degree of impact will depend on the type, amount, and duration of the spill or accident. Some species of flora will not be able to tolerate these occurrences and may be destroyed. Toxins may be picked up in the food chain and

passed to herbivores and carnivores. Portable sanitary facilities will be provided for construction crews and construction wastes will be disposed of at suitable spoil sites. Gases will be flared, blowout preventers will be installed, high pressure pipes and valves will be used, and a spill prevention control and counter-measure plan will be devised.

(5) Wildlife may be displaced by the human activity, noise, or accidents. However, the disturbances of wildlife will be held to a minimum by the installation and maintenance of safety equipment and plans.

(6) Blowouts or other accidents may introduce chemical and thermal pollutants into surface and groundwaters. However, blowout preventers, high pressure pipes and valves, and a spill prevention control and counter-measure plan will be installed and maintained to reduce the possibility of blowouts and accidents. Casings will be cemented completely from the formation to the surface to provide greater stability to ensure sealing of aquifers.

(7) Leakage from around casings may contaminate aquifers with chemical and thermal pollutants. But the Department of Energy will use high pressure pipes and valves and will seal aquifers in accepted federal and state manners to prevent their contamination.

(8) Well testing may result in land subsidence, but is considered improbable.

(9) Air quality will be adversely affected by the introduction of dust, vehicular emissions, and motor emissions associated with the well test program. To reduce adverse impacts, roads and the drilling pads will be surfaced with boards and shell. Newer

vehicles will be used which employ advanced pollution control devices for emissions.

(10) There is the possibility of air pollution in the vicinity of the test site should a blowout occur. The intensity of pollution depends on the nature and volume of the emitted fluids and gases. The Department of Energy will attempt to minimize the possibility of a blowout by installing and maintaining blowout preventers, high pressure pipes and valves, and using weighted mud and high pressure mud pumps capable of injecting mud into the well to control pressures.

(11) Noise from machines and vehicles operating at the test site will raise the ambient noise level. This will be kept to a minimum by muffling as many machines and engines as feasible.

(12) There will be an odor associated with the release of H_2S into the atmosphere.

1.4.2 The Cultural Issues - A Summary of Adverse Impacts

(1) Some land use changes may occur as a result of the well test. The area used for the reinjection well will be modified from its present status to an energy related use. However, the extent of changes will be kept to a minimum by good planning before actual work begins.

(2) Noise from the drilling and testing operation will affect the use of surrounding areas. Mufflers will be installed and maintained on all engines and vehicles to minimize impacts.

(3) If there should be residue left from operations or accidents at the site, selected future land uses may be limited. The chances of this will be minimized by removal of pollutants.

(4) The aesthetic value of an area will be reduced by the presence of a drilling operation.

1.4.3 The Economic Issues - A Summary of Adverse Impacts

Adverse economic impacts will occur if there should be an accident or a massive spill of some pollutants. Should either of these events occur, there may be a resulting land use change or contamination of a water supply. However, the Department of Energy is implementing every feasible precaution to prevent such accidents from occurring. Blowout preventers will be installed and high pressure pipes and valves will be used. Weighted mud and high pressure mud pumps capable of injecting mud into the well will be employed and a counter-measure plan will be used at the test site. Portable sanitary facilities will be provided for construction crews and construction wastes will be transported to suitable disposal facilities.

U.S. Department of Energy (DOE), Analysis of Cameron Parish Geopressured Aquifer Phase II Proposal Drilling and Testing Production Well, Sweet Lake Prospect, Contract No. ET-78-C-08-1561, Nevada Operations Office, 1979.

CHAPTER TWO - EXISTING ENVIRONMENT

2.1 Introduction

All development of surface facilities and injection wells will take place within .8 km (1/2 mi) of the point of drilling. All of the land to be used by this test is in private ownership, but is leased to Magma Gulf Corporation. The Prime Prospect Area is centered on latitude 30°01'N and longitude 93°08'W. Within the Prime Prospect Area is the community of Sweet Lake. The nearest large town is Lake Charles, 23 km (14 mi) to the northwest, while the nearest city is Beaumont, 72 km (45 mi) to the west. Homes and some businesses are in a linear settlement pattern along the two major highways, LA 27 and LA 384, across the Prime Prospect Area. However, the overall character of the Prime Prospect Area is rural; most of the land use is rice or soybean fields and pasture. Wetlands (freshwater marsh) form the southern third of the Prime Prospect Area. The following sections describe the existing environment of the Prime Prospect Area in sufficient detail to permit a discussion of impacts of the proposed action on the environmental systems.

2.1.1 Physiography

The Prime Prospect Area is divided into Pleistocene Prairie Terrace in the northern two-thirds and Recent coastal wetland in the southern third. The Pleistocene Prairie Terrace is a low altitude, low relief gently sloping plain. Maximum elevation in the Prime Prospect Area is between 4 and 6 m (15 to 20 ft) along a ridge trending northeast to southwest across the area. Maximum relief is along the same ridge (3 m or 10 ft) and across the stream bottoms. The Prairie Terrace slopes toward the Gulf of Mexico at approximately .29 to .38 m/k (1.5 to 2 ft/mi) (Jones et al., 1956).

The surface was deposited as part of the Red River Pleistocene floodplain (Jones, et al., 1956). The ridge crossing the Prime Prospect Area is probably the natural levee of one of these ancient channels. Because they are better drained, these levees have become the locations for roads and houses. LA 384 (Fig. 1-2) follows one of these levee systems. Pimple mounds characterize the terrace in this region of the state. The mounds are circular, 9 to 15 m (30 to 50 ft) in diameter and .3 to 1.5 m (1 to 5 ft) high. Fisk (1948) believes they are of erosional origin because of their alignment in parallel rows. However, no studies have been made which explain all occurrences (Jones et al., 1954). A Pleistocene outlier forms Savane Neuville Island in the southeast part of the Prime Prospect Area.

The Recent coastal marsh forms the northern fringe of the Chenier Plain of southwest Louisiana. This chenier plain marsh is a fresh deepwater marsh with standing water levels of 10 to 37 cm (4 to 15 in) (O'Neil, 1949). Sediment, deposited along the Pleistocene shoreline by longshore currents, is from the Mississippi River when it flowed along the west alluvial valley wall more than 5000 years ago (Frazier, 1967). Sweet Lake is a naturally occurring round lake characteristic of the Chenier Plain. The origin of these types of lakes is thought to be animal eatouts or fires; enlargement results from shore erosion by wind and storm generated waves.

2.1.2 Geology

The Sweet Lake Prime Prospect Area is in the northcentral section of the Gulf of Mexico coast of the United States. The region is dominated by the Gulf Coast geosyncline whose axis is just seaward of the shoreline (Fig. 2-1). Regional strike of geologic beds is east-west and they dip as a monocline toward the axis of the geosyncline (Bernard and Leblanc, 1965). The

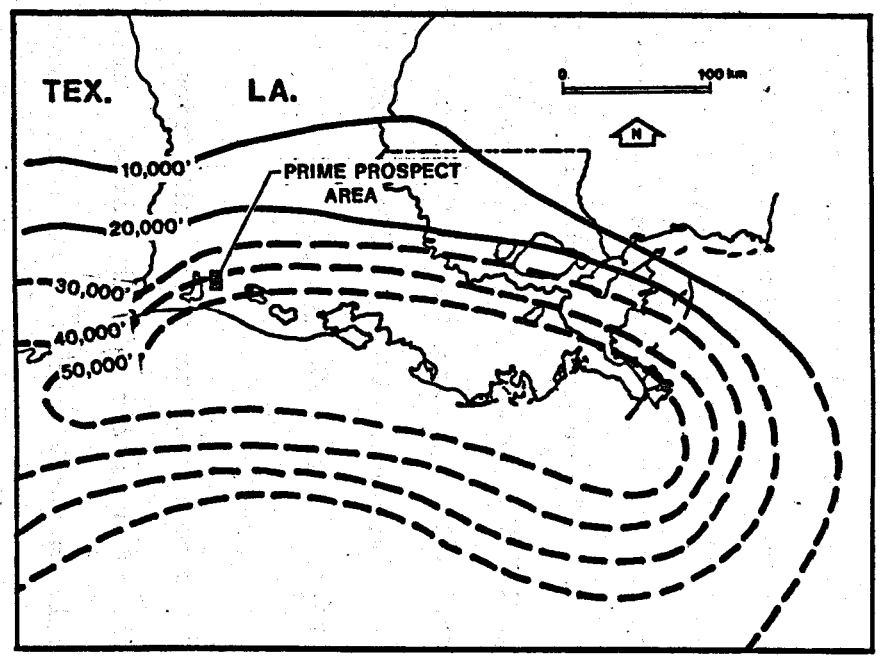


Fig. 2-1. Gulf Coast Geosyncline: approximate thickness of the Cenozoic of Louisiana (Modified from Hardin, 1962).

geosyncline is a huge prism of clastic sediments derived from the north and northwest. The beds dip and thicken into the geosyncline. Table 2-1 shows the geologic column for the Prime Prospect Area.

The Frio Formation is the geologic entity of concern for this project. The Frio extends across south Louisiana from Texas to Mississippi. The upper boundary is the Anahuacian Marginulina Zone and the base of the Frio is the "first occurrence of definite Vicksburgian fossils" (Warren, 1957). The Frio is composed of overlapping deltaic and interdeltaic systems which have built into the Gulf geosyncline. The formation displays an interfingering of sands, silts and clays deposited in the updip parts of the deltas. The downdip deposits are neritic environments and become more argillaceous farther south. The relation of the Frio Formation to geothermal activity along the Gulf Coast is described in detail by Bebout _et al_., 1976, Jones, 1968b, 1968c, 1969a, 1969b, 1970a, 1975, Jones and Wallace, 1973, and Wallace, 1969.

Figure 2-2 is a log from the center of the Sweet Lake Prime Prospect Area. The proposed test sands are 122 m (400 ft) thick. Table 2-2 shows the sand thickness for wells in the vicinity of the well shown. Figure 2-3 shows the location of the wells and the subsurface faults pattern across a part of the Sweet Lake Prime Prospect Area. The porosity of the proposed test sands average 22 percent (Durham, 1978). Temperatures in the proposed test sand range from 151°C (305°F) to 156°C (315°F). Fault A is downthrown to the south and has a displacement of 92 to 122 m (300 to 400 ft) between 3050 and 3355 m (10,000 and 11,000 ft) and 366 to 427 m (1200 to 1400 ft) between 3660 and 427 m (12,000 and 14,000 ft).

Table 2-1. Geologic Column for the Sweet Lake Prime Prospect Area

Age	Series	Group/Formation	
Quaternary	Recent	Undifferentiated	Alluvial and deltaic deposits
	Pleistocene	The Terraces	Deltaic and alluvial deposits
Tertiary	Pliocene	Citronelle	
		Fleming	Interfingering deltaic sands, silts and clays; brackish water silts and clay
	Miocene	Catahoula	Massive deltaic sands, non-marine siltstone
		Chickasawhay	Silty clays, lenticular sands, silty clays
	Oligocene	Anahuac	Transgressive marine deposits, shales, marls
		Frio	Massive deltaic and marginal marine sands
		Vicksburg	Sandy shales and lignitic clays
	Eocene	Jackson	Brackish water shales and sands and marls
		Claiborne	Marine clays, marls to channel sands, lignitic silts.
		Wilcox	Thick channel sands and shales

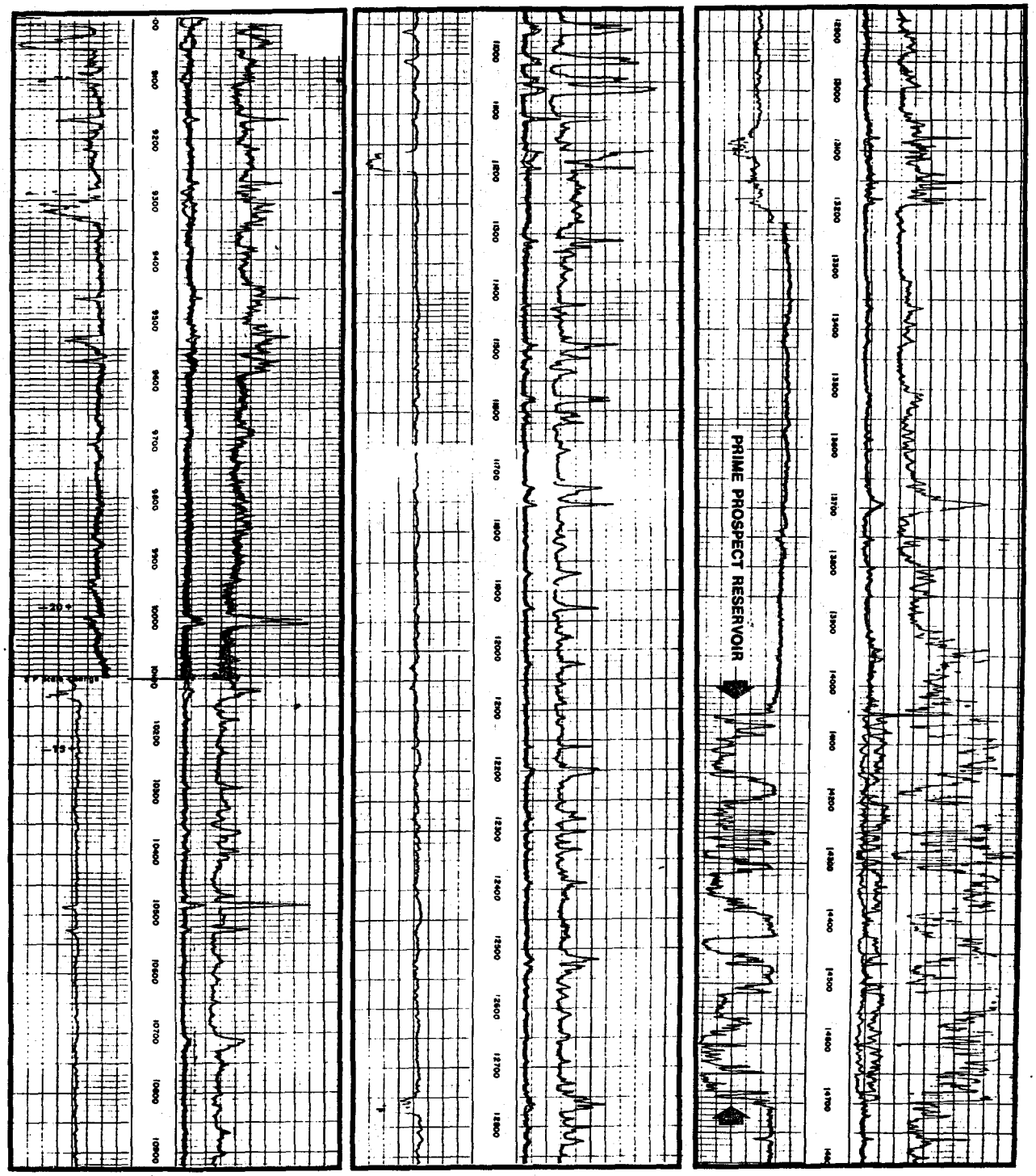
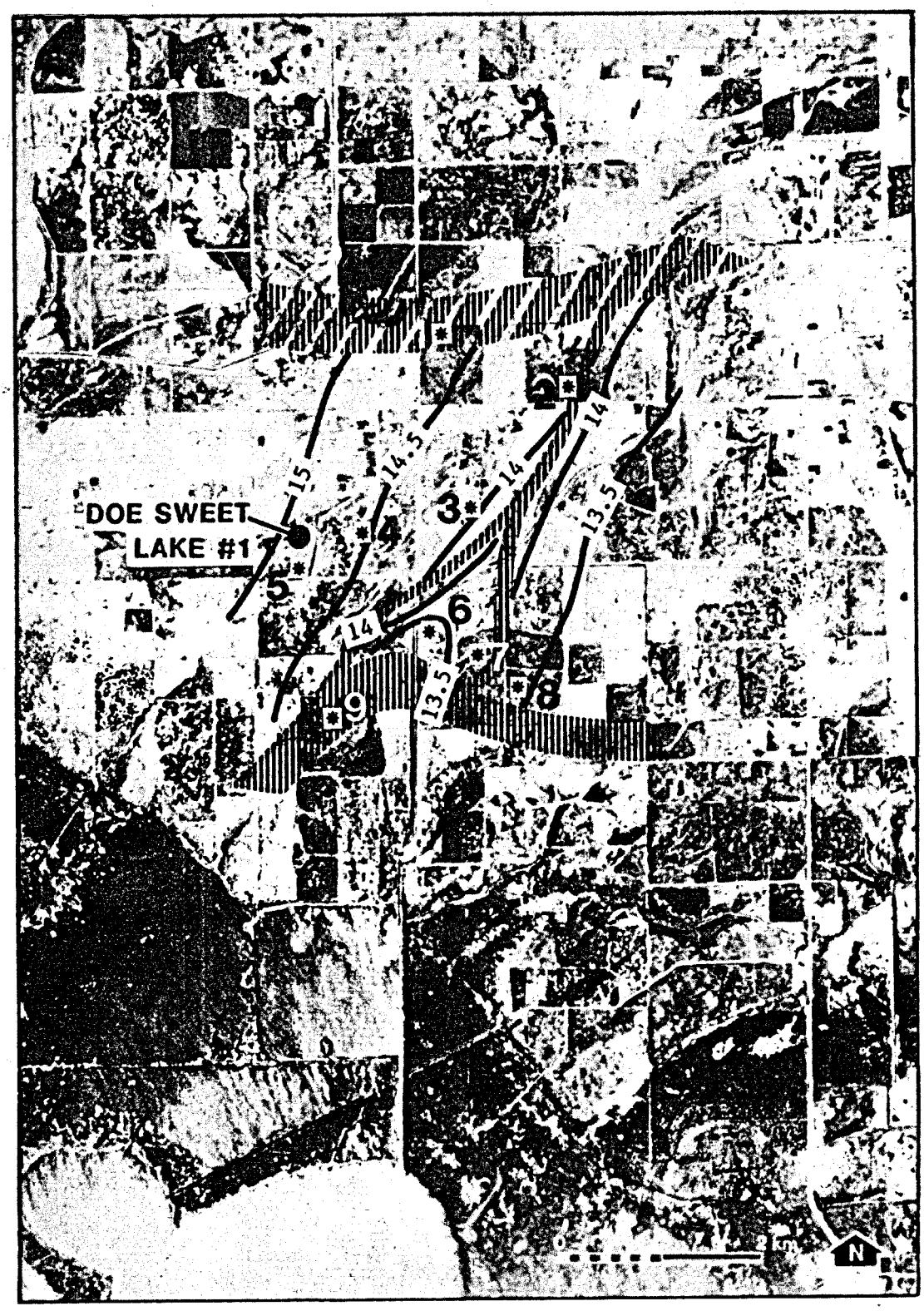


Fig. 2-2. Log of a well in the Prime Prospect Area. Well is located in Section 7, Township 12 South, Range 7 West (Louisiana Department of Natural Resources, Office of Conservation, 1978).

Table 2-2. Depths to Top and Base of Prospective Sands under the Sweet Lake Prime Prospect Area (Durham, 1978).

Well	Top Sand	Base Sand	Thickness
1	Not reached		
2	14,100		370+ (base not reached)
3	14,050	14,700	650
4	14,470	15,035	565
5	14,830	15,530	700
6	13,360	13,860	500
7	Not reached		
8	13,680	14,400	720
9	Faulted out		



KNOWN FAULT

14 TOP OF PROSPECTIVE SAND (THOUSANDS OF FEET)

HYPOTHESIZED FAULT

1* WELLS

Fig. 2-3. Fault map and contours of the top of the prospect sands (After Durham, 1978).

Fault B is downthrown to the south but is only indicated by seismic data. No information on displacement is available yet. The two small faults, C and D, have displacements of between 34 and 76 m (110 and 250 ft).

2.1.3 Land Subsidence

Land subsidence is the result of any one or a combination of three causes: tectonic adjustment, fault movement, or human impact. The Prime Prospect Area is undergoing land subsidence at present due to two of these causes. Tectonic subsidence due to general compaction of sediments is occurring at approximately 4 mm (16 in) per year (Holdahl and Morrison, 1974). Fault movement as a result of differential compaction and slippage is proceeding at an undetermined rate. However, Durham (1978) records throws of 92-122 m (300-400 ft) between 3050-3355 m (10,000-11,000 ft) and 366-427 m (1200-1400 ft) between 3660-4270 m (12,000-14,000 ft) in wells in the Prime Prospect Area indicating movement of the faults. There is no known man-caused subsidence in the Prime Prospect Area from either groundwater withdrawal of oil extraction, but the project will be closely monitored to determine the impact of flow testing on subsidence. It may be difficult to distinguish, however, between natural and induced subsidence.

2.1.4 Tectonic Activity

Figure 2-4 shows the regional tectonic setting around the Sweet Lake Prime Prospect Area. The Prime Prospect Area is to the northeast of the Calcasieu collapse-fault system (Seglund, 1974). Collapse-fault systems result from the weight and the rapid subsidence of accumulated sediment causing the intrusion of salt stocks and shale diapirs into the overlying sedimentary beds. The faults are downthrown toward the center of salt withdrawal areas, in this case centered just east of Calcasieu Lake (Seglund, 1974). The Sweet Lake Prime Prospect Area is crossed by an

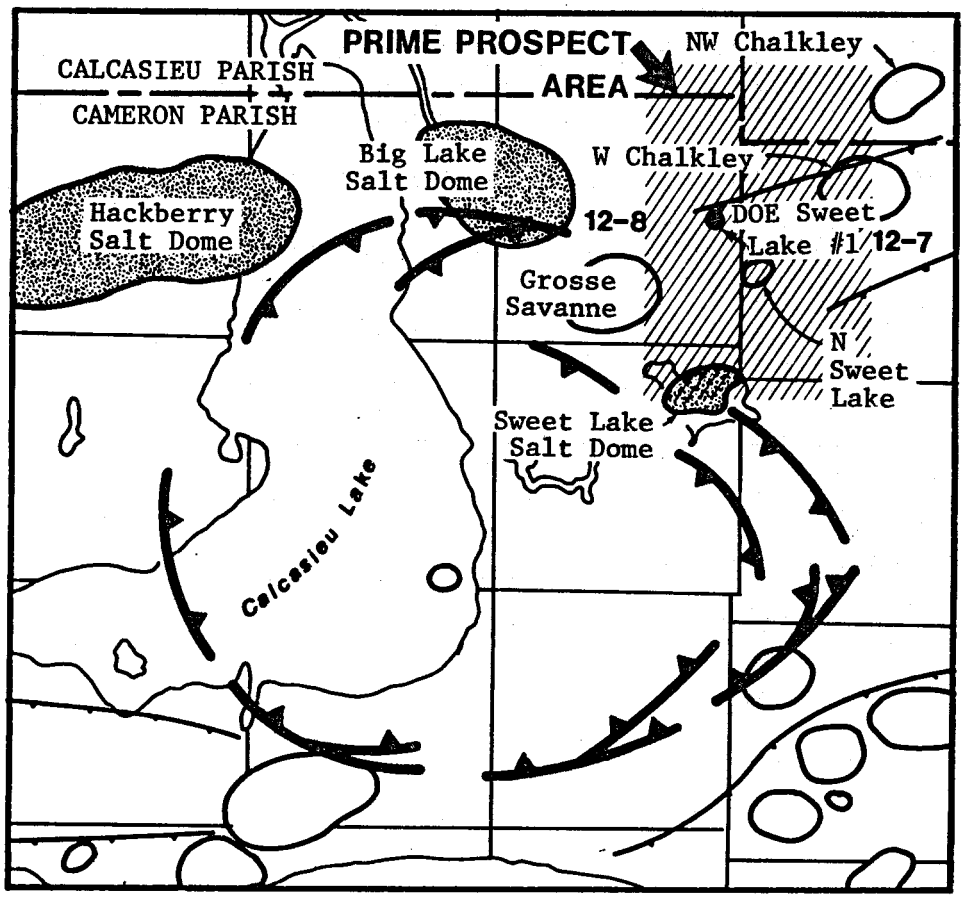


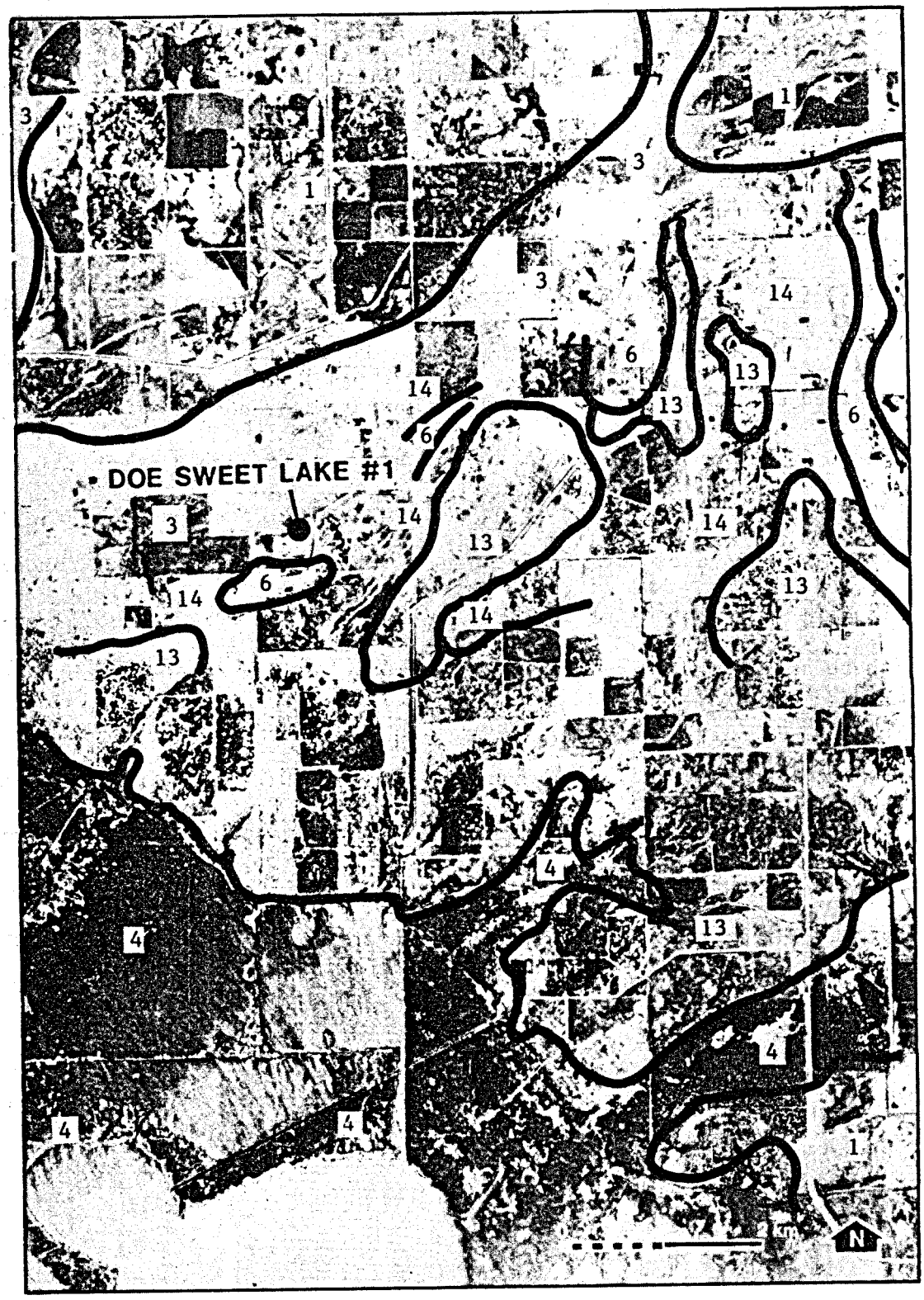
Fig. 2-4. Regional tectonic setting in the vicinity of the Sweet Lake Prime Prospect Area. (The dominant fault pattern is the Calcasieu Collapse Fault System. Regional faults trend east to west through the Prime Prospect Area.) (Modified from Seglund, 1974)

east to west trending regional fault which is downthrown toward the Gulf. Beds associated with these growth or contemporaneous faults are thicker on the downthrown side.

Seismic hazard in the study area is very low to non-existent (Algermissen, 1969; Algermissen and Perkins, 1976). Potential for seismic risk is described on a scale of 0 to 3 where Zone 0 means no damage, Zone 1 means minor damage, Zone 2 means moderate damage, and Zone 3 means major damage. Such a scale is based on historical data which considers only the intensity of the earthquake, not the frequency. The Sweet Lake Prime Prospect Area has a seismic potential of zero (Algermissen and Perkins, 1976) even though there have been two recent earthquakes in Louisiana. On October 19, 1930, an intensity VI [Modified MERCALLI (MM) Scale] earthquake was centered south of Donaldsonville at approximately 30° N Latitude and 91° W Longitude or 212 km (132 mi) east of the Prime Prospect Area. Some brick chimneys were cracked or the tops knocked down in Gonzales, Louisiana, 24 km (15 mi) north of the epicenter. A second earthquake occurred on November 19, 1958, in Baton Rouge, Louisiana, 137 km (85 mi) east of the study area. An intensity of V (MM scale) is estimated for this earthquake which shook houses and rattled windows. The Baton Rouge fault is active and has moved 6 cm (.20 ft) per year from 1959 to 1969 (Wintz et al., 1970).

2.1.5 Soils

Figure 2-5 shows the soils of the Prime Prospect Area. The northern two-thirds of the Prime Prospect Area are Pleistocene surfaces deposited by an ancient course of the Red River. The Crowley soils of silt loams with a silty clay subsoil are somewhat poorly drained. The permeability is very



1	MOREY-BEAUMONT ASSOCIATION	2	BEAUMONT
		6	CROWLEY
3	MOWATA-MOREY- CROWLEY ASSOCIATION	13	MOREY
4	FRESH WATER MARSH	14	MOWATA

Fig. 2-5. Soils of the Sweet Lake Prime Prospect Area (Ezernack, 1978; SCS, 1971).

slow and the surface runoff is slow. The Mowata clay loams are poorly drained flats or low depressions that have a very slow permeability. The Morey loam occurs in broad and level to slightly depressed areas. Slow permeability and very slow surface runoff characterize the soil. The Crowley-Morey-Mowata Association is soil of nearly level silt with clayey and silty subsoils. The Crowley soils make up the low ridges across the study area and the Morey and Mowata soils make up the lower areas. The remainder of the study area is Morey-Beaumont Association of nearly level clayey and silty soils. The association is poorly drained with the Morey soils forming the higher elevations and the Beaumont soils the lower elevations.

The Recent deposits across the southern third of the Prime Prospect Area of the Freshwater Marsh-Harris Association. Soils composed of minerals and organic freshwater peats are at or near sea level. The area is flooded most of the time except where dyked and pumped.

The general characteristics of the soils of the Prime Prospect Area are shown in Table 2-3. The Soil Conservation Service has defined the following terms which appear in the table. Permeability is the quality of the soil horizon that enables water or air to move through it. The acidity or alkalinity of the soil is expressed in pH values. The descriptive terms in this pH column are:

Extremely acid	below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5

Table 2-3. Characteristics of the Soils in the Sweet Lake Prime Prospect Area.

Soil Description	Type Land	Runoff	Flood Hazard	Permeability	pH	Dominant Use	Suitability for Pond Reservoir Area	Suitability for Buildings and Roads
Crowley silt loams to silty clay loam	Prime	Slow	None	Very Slow	Strongly to slightly acid	Crop land, rice soybeans	Slight	Severe - wetness, shrink-swell, low strength
Mowata silt loam	Prime	Slow	None	Very Slow	Medium and to moderately alkaline	Cropland-rice	Slight	Severe - wetness, shrink-swell, low strength
Morey sandy silt loam	Prime	Slow	None	Slow	Strongly acid	Crop land-rice, soybeans, white clover	Slight	Severe - wet
Beaumont clay	Prime	Slow	Low areas flood	Very slow	Strongly acid	Crop land and pasture	Slight	Severe - high shrink swell, low bearing capacity
Harris (undrained) clay		Very Slow	Flooded	Very severe	Mildly alkaline	Wildlife	Severe	Severe - high shrink swell
Harris (drained) clay		Slow	High potential	Very slow	Mildly alkaline	Pasture, crop land	Slight	Severe - high flood shrink
Crowley-Morey-Morante Association	Prime	45% Crowley; 25% Morey; 20% Mowata; 10% Beaumont						
Morey-Beaumont Association	Prime	70% Morey; 15% Beaumont; 15% Crowley, Mowata and Harris						

Freshwater marsh - Harris Association = 75% freshwater marsh, peat; 10% Harris (undrained); 10% Harris drained; 5% Beaumont, Morey and Mowata

Definitions of Degree of Limitations:

Slight - The limitation is not serious and is easily tolerated or overcome.

Moderate - The limitation needs to be recognized, but it can be tolerated or overcome.

Severe - The limitation cannot be easily tolerated or is difficult or costly to overcome.

Very Severe - The limitation is so restrictive that the stated use is generally impractical.

Source: SCS, 1971, Esernack, 1978

Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

The shrink-swell potential is the relative volume to be expected of soil material which changes in moisture content; that is, the extent to which the soil shrinks as it dries or swells when it gets wet. Amount and kind of clay affects the extent of swelling and shrinking.

2.1.6 Prime and Unique Farmland

The Soil Conservation Service (Ezernack, 1978) has determined that the following soils are Prime Farmland in the Prime Prospect Area:

Crowley silt loams to silty clay loams

Mowata silt loam

Morey sandy silt loam

Beaumont clay

Crowley - Morey - Mowata Association

Morey - Beaumont Association

These soils comprise approximately 66 percent of the Prime Prospect Area, 12 percent of Cameron Parish, and 1 percent of Calcasieu Parish. The well sites and facilities will require 2 percent of a square mile. There are 461 sq km (178 sq mi) of Prime Farmland in Cameron Parish and 1134 sq km (438 sq mi) of these Associations in Calcasieu Parish.

2.2 Hydrology and Water Use

2.2.1 Groundwater

2.2.1.1 Occurrence

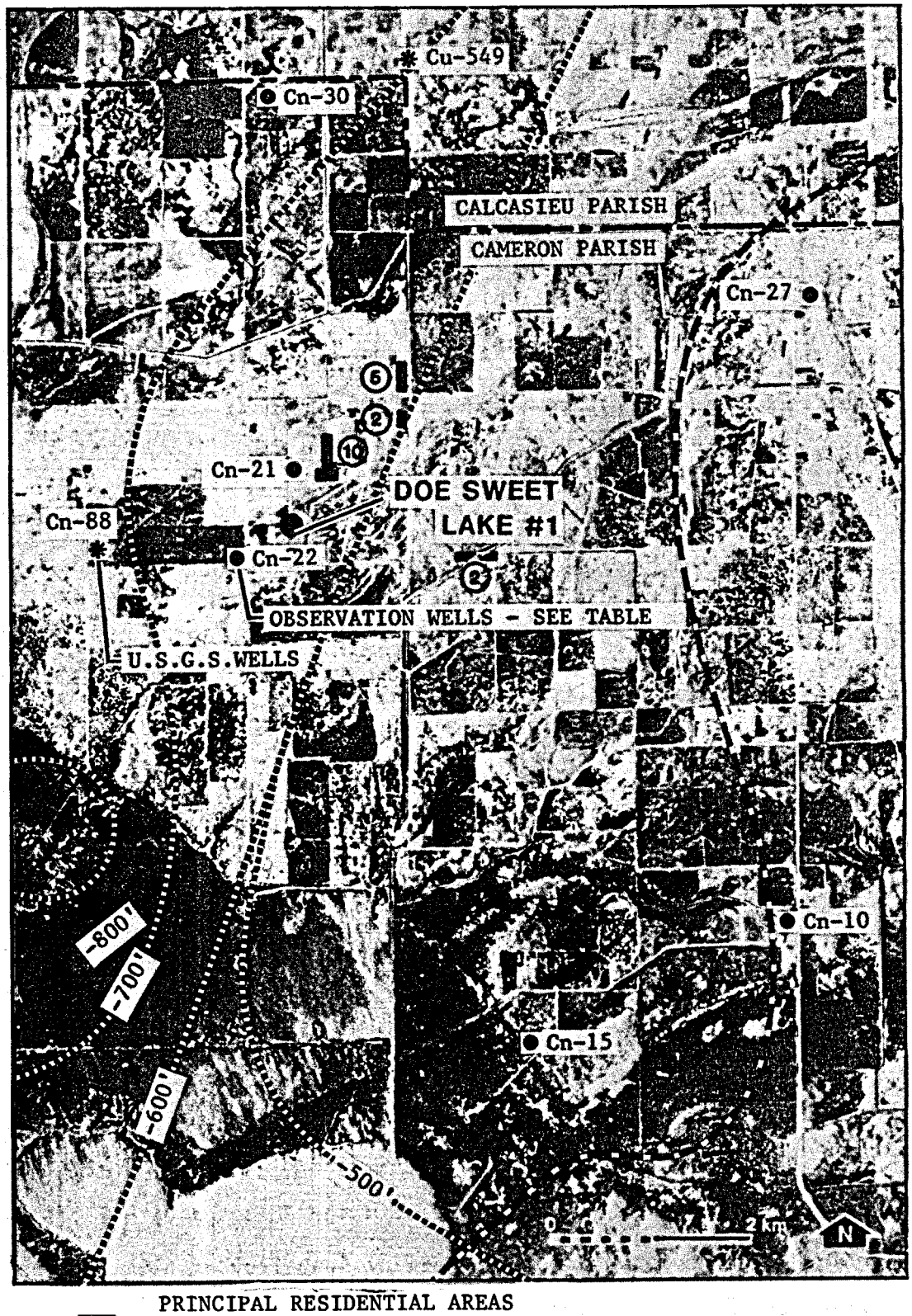
Under the Prime Prospect Area, fresh groundwater occurs only in the Chicot aquifer, the principal source of groundwater for southwestern Louisiana. The Chicot aquifer is a gulfward dipping and thickening wedge of Pleistocene clays, sands, and gravels which extends into Texas to the west and to the Atchafalaya Basin to the east. Recharge occurs from rainfall and stream infiltration in the outcrop area 48 to 68 km (30 to 40 mi) north of the prospect. Southward from the outcrop area, the aquifer is overlain by fine-grained sediments and Recent age silts and clays of the coastal marsh. This relatively impermeable cover creates artesian conditions in the aquifer, i.e., wells completed in the Chicot aquifer have water levels that rise above the top of the aquifer and in some cases rise above the land surface.

Extensive clay beds separate the massive sand and gravel beds of the aquifer into three main units named on the basis of their depth of occurrence in the Lake Charles industrial area. These are the "200 foot" sand, the "500 foot" sand, and the "700 foot" sand (Jones, Turcan and Skibitzke, 1954). In some areas the clay separation is missing, permitting the sands to be hydraulically interconnected.

Before development of the Chicot aquifer for municipal, industrial, and agricultural purposes in southwestern Louisiana, groundwater levels were above land surface and the natural groundwater flow direction was from the outcrop area coastward. The saltwater originally

deposited with the Chicot sands was flushed southward and replaced by freshwater (less then 250 ppm Cl) which is present in the "200-foot" and "500-foot" sands in the Prime Prospect Area to a depth of more than 244 m (800 ft) (Fig. 2-6). Slightly saline water [1000 to 3000 mg/l (1 to 3 ppt) dissolved solids] extends to between 305 and 336 m (1000 and 1100 ft) below the surface (Winslow, Hillier and Turcan, 1968). The position of the freshwater/saltwater interface varies among individual sand units but generally the position is increasingly northward with increasing aquifer depth. Thus, the interface is south of the Prime Prospect Area in the "200-foot" sand (Fig. 2-6). In the "500-foot" sand the toe of the saltwater wedge extends a few kilometers north, although the upper portion of the sand yields freshwater (Figure 2-7). And the interface in the "700-foot" sand is several kilometers north of the Prime Prospect Area, providing only saline water in this sand at the Prime Prospect Area (Fig. 2-8).

Extensive development of the groundwater resources for industrial and municipal use in the Lake Charles area and for rice irrigation in parishes north of the Prime Prospect Area have lowered water levels in the Chicot aquifer producing a north-northwestward groundwater flow direction at Sweet Lake. Based on a potentiometric slope (the slope defined by water level differences in wells completed in the Chicot aquifer) of .38 m/km (2 ft/mi) to the north and an average permeability of 61,119 l per day per m^2 (1500 gallons per day per ft^2) (Harder et al., 1967) the groundwater flow rate is computed to be 28 m per year (92 ft per year).



PRINCIPAL RESIDENTIAL AREAS
NUMBER INDICATES ESTIMATED NUMBER OF DOMESTIC WATER WELLS.

NORTHERN LIMIT OF SALTWATER (250 ppm Cl^-) IN THE "200-FOOT" SAND OF THE CHICOT AQUIFER. (HARDER, et al., 1967)

ALTITUDE OF BASE OF FRESH GROUNDWATER (250 ppm Cl^-) CONTOUR INTERVAL 100 FEET. (HARDER et al., 1967).

Fig. 2-6. Groundwater distribution under the Prime Prospect Area.

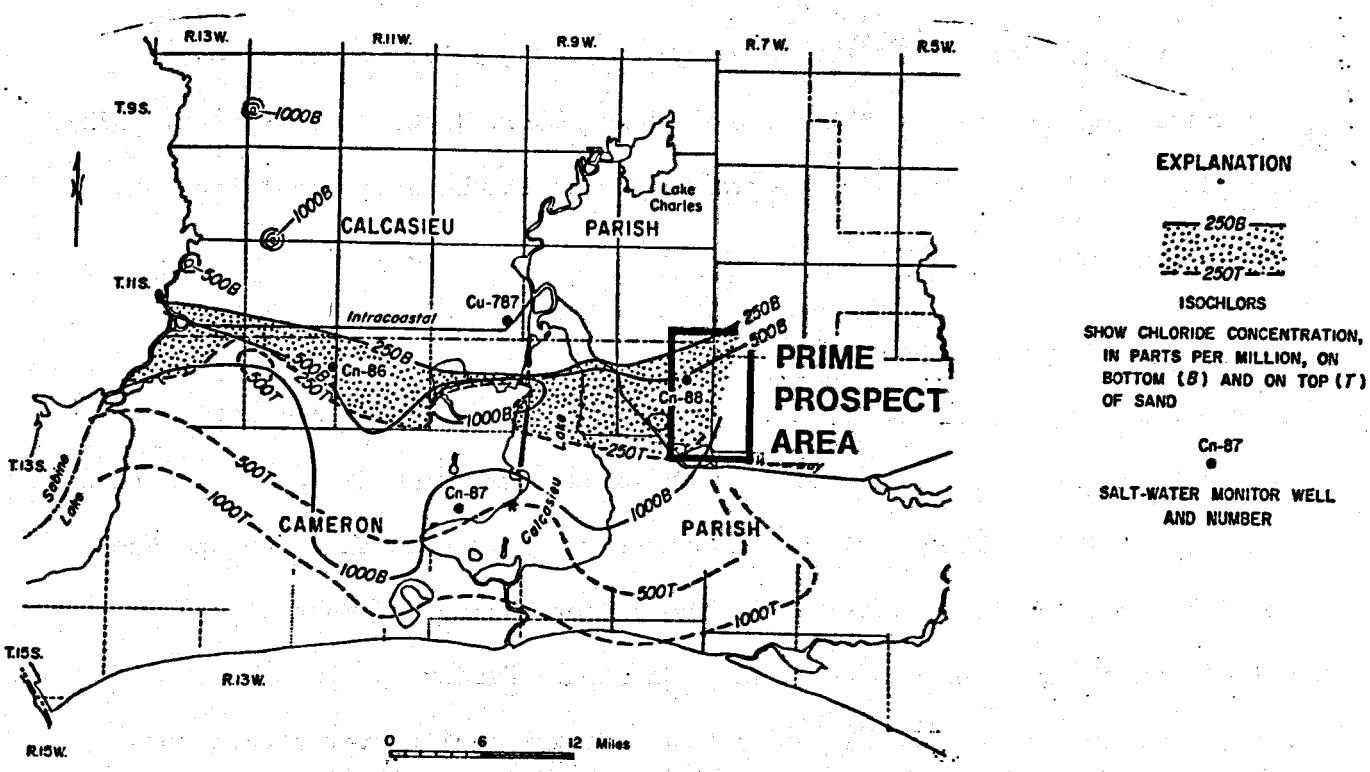


Fig. 2-7. Freshwater / saltwater interface in the "500-foot" sand (Harder et al., 1967).

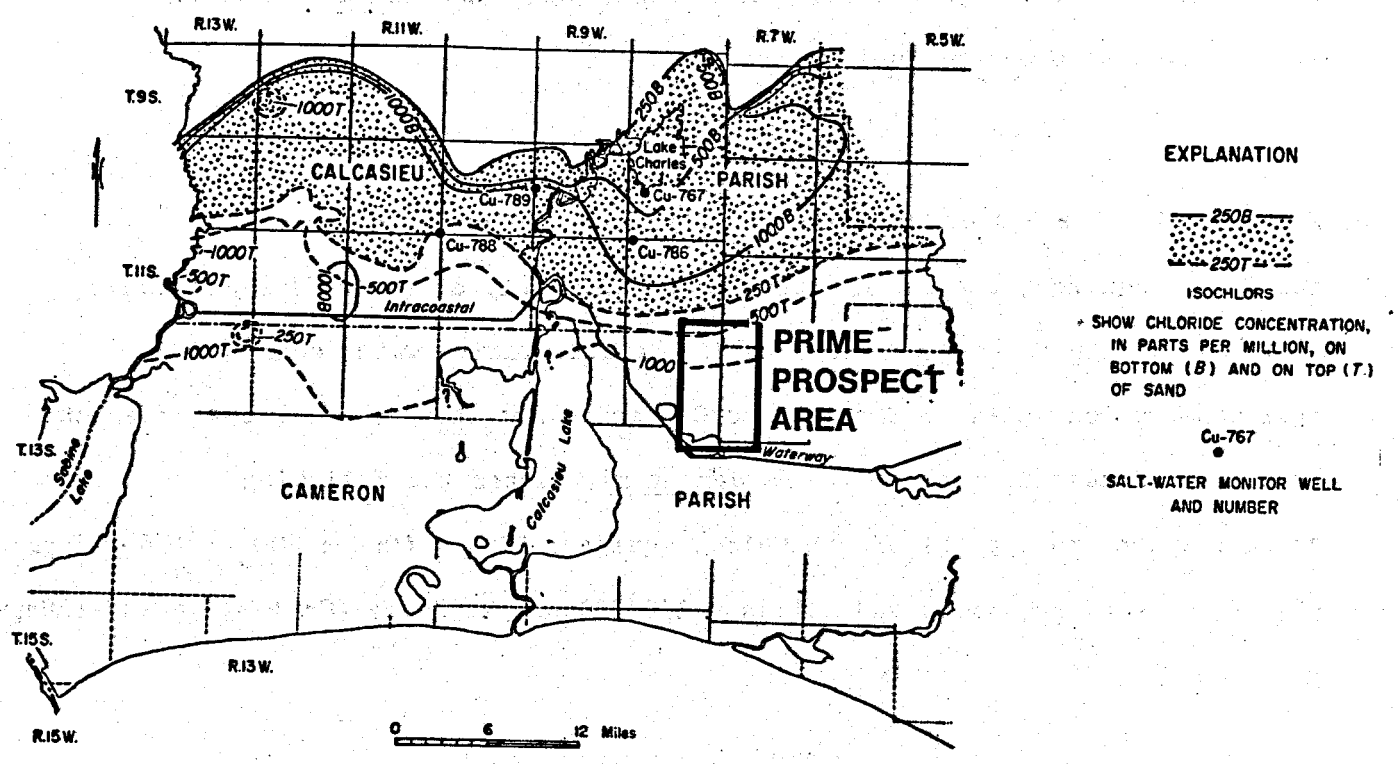


Fig. 2-8. Freshwater / saltwater interface in the "700-foot" sand (Harder et al., 1967).

Water levels are currently 12 to 18 m (40 to 60 ft) below the surface in the Chicot aquifer in the Prime Prospect Area (La. Dept. Public Works, 1975). Records of water levels from observation wells in the area maintained by the USGS are given in Table 2-4.

2.2.1.2 Quantity

In the Prime Prospect Area fresh groundwater is present to 244 m (800 ft) below the surface. Wells yield as much as 63 l/sec and 126 l/sec (1000 and 2,000 gpm) (Rollo, 1960). Although groundwater is abundant, pumpage has resulted in water level declines in the Chicot aquifer of more than 31 m (100 ft) in the pumping center at Lake Charles. Harder et al., 1967, determined that the weighted average water level decline for the Chicot aquifer in southwestern Louisiana for the period 1944-1965 was only 6.7m (22 ft) with an average annual withdrawal rate of 927 billion liters (245 billion gallons). They concluded that groundwater use could be increased without excessive water level declines.

2.2.1.3 Quality

North of the freshwater/saltwater interfaces in the various sands of the Chicot aquifer, the fresh water is predominantly of the sodium-calcium-bicarbonate type (Harder et al., 1967). Representative water analyses from observation wells in Cameron and Calcasieu Parishes in the Prime Prospect Area are included in Table 2-5. Harder et al. listed the following concentrations as typical of the Chicot aquifer: SiO_2 = 40ppm; HCO_3 = 175-225ppm; CO_3 =0; Cl = 45ppm; dissolved solids = 230-280ppm; hardness (Ca + Mg) = 100-150ppm; pH = 7.4.

Table 2-4. Records of Water Level Fluctuations in Wells in the Sweet Lake Prime Prospect Area (See Fig. 2-6 for locations)

CN-88U. U.S.GEOL.SURVEY. (SEC. 14, T. 12S., R. 8W.) DRILLED OBSERVATION ARTESIAN WELL IN CHICOT AQUIFER OF PLEISTOCENE AGE, DIAM 4 IN, DEPTH 666 FT, SCREENED 656-666. MP TOP OF 1/2-IN PIPE, 2.68 FT ABOVE LSD.
LSD 8.86 FT ABOVE MSL.
HIGHEST WATER LEVEL 39.97 BELOW LSD, APR. 13, 1965,
LOWEST WATER LEVEL 63.71 BELOW LSD, JULY 15, 1974.
RECORDS AVAILABLE: 1964-74.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
OCT. 13, 1964	45.86	AUG. 23, 1966	47.89	SEP. 26, 1968	52.63	MAR. 27, 1971	51.69
DEC. 9	43.82	SEP. 30	48.32	NOV. 13	50.72	APR. 30	54.63
FEB. 9, 1965	41.33	OCT. 28	48.98	JAN. 8, 1969	48.82	JUNE 7	59.65
MAR. 1	40.44	NOV. 29	45.74	JAN. 29	48.29	JULY 21	62.25
MAR. 23	40.35	JAN. 3, 1967	44.37	MAR. 3	47.52	SEP. 2	61.35
APR. 13	39.97	FEB. 2	41.74	MAR. 12	47.27	DEC. 1	57.71
APR. 29	40.87	FEB. 21	43.40	MAR. 25	47.05	JAN. 12, 1972	55.82
MAY 26	44.66	MAR. 20	42.96	APR. 23	46.87	FEB. 21	54.91
JUNE 14	46.26	APR. 11	43.86	JUNE 4	49.12	FEB. 29	54.67
JULY 1	50.30	APR. 25	43.99	JULY 18	58.20	MAR. 29	53.88
JULY 30	53.06	MAY 22	46.34	AUG. 29	57.04	APR. 25	54.90
AUG. 11	51.57	JUNE 29	51.72	OCT. 6	55.59	MAY 15	56.24
SEP. 2	51.09	AUG. 1	52.12	OCT. 21	55.04	JUNE 26	62.95
OCT. 5	49.10	AUG. 15	52.63	NOV. 21	54.26	JUNE 27	62.95
OCT. 19	48.16	SEP. 29	50.97	JAN. 8, 1970	52.59	AUG. 5	63.29
NOV. 5	47.34	OCT. 26	49.77	FEB. 24	51.55	MAR. 13, 1973	54.94
NOV. 29	47.00	DEC. 4	49.27	MAR. 11	51.20	APR. 11	54.52
DEC. 15	45.76	JAN. 10, 1968	46.47	APR. 2	50.72	JUNE 8	56.35
DEC. 29	45.27	FEB. 2	46.08	MAY 12	52.30	SEP. 18	62.98
JAN. 26, 1966	43.87	FEB. 27	45.48	JUNE 22	55.46	FEB. 26, 1974	56.72
FEB. 25	42.77	APR. 1	45.02	JULY 29	60.60	MAR. 18	56.18
MAR. 8	42.75	APR. 29	44.34	SEP. 1	58.93	APR. 23	56.13
MAR. 21	42.36	MAY 28	48.79	OCT. 6	56.70	MAY 28	58.65
MAR. 31	42.21	JULY 2	51.37	OCT. 23	55.71	JULY 15	63.71
APR. 27	41.75	AUG. 5	53.78	NOV. 19	55.30	SEP. 30	63.29
MAY 27	43.50	SEP. 4	53.05	JAN. 4, 1971	55.49	NOV. 4	59.60
JUNE 28	45.59	SEP. 18	52.58	FEB. 17	52.22	DEC. 2	59.34
JULY 28	49.25						

CALCASIEU PARISH 93

CU-549. PRAIRIE CANAL CO. (SEC. 30, T. 11 S., R. 7W.) DRILLED IRRIGATION ARTESIAN WELL IN "200-FT" SAND OF CHICOT AQUIFER OF PLEISTOCENE AGE, DIAM UNKNOWN, REPORTED DEPTH 360 FT, SCREENED INTERVAL UNKNOWN. MP LOWER LIP OF DISCHARGE PIPE, 5.09 FT ABOVE LSD.
LSD 6.81 FT ABOVE MSL.
HIGHEST WATER LEVEL 25.67 BELOW LSD, APR. 29, 1958,
LOWEST WATER LEVEL 55.31 BELOW LSD, AUG. 27, 1963.
RECORDS AVAILABLE: 1958-74.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JAN. 17, 1958	29.06	SEP. 11, 1961	46.56	SEP. 2, 1965	53.65	FEB. 24, 1970	40.75
APR. 29	25.67	MAR. 26, 1962	26.22	MAR. 21, 1966	32.16	FEB. 17, 1971	38.98
SEP. 4	39.45	MAR. 29, 1963	29.33	AUG. 29	47.13	SEP. 10	53.28
SEP. 9, 1959	37.09	AUG. 27	55.31	MAR. 20, 1967	32.64	FEB. 21, 1972	40.98
APR. 21, 1960	25.90	MAR. 24, 1964	30.62	MAR. 4, 1968	34.92	FEB. 27, 1973	40.81
AUG. 31	45.50	AUG. 24	48.51	MAR. 5, 1969	35.92	FEB. 26, 1974	41.63
MAR. 21, 1961	26.25	MAR. 22, 1965	30.45				

Source: Louisiana Department of Public Works, 1975

Table 2-5. Selected Chemical Analyses of Groundwater in the Sweet Lake Prime Prospect Area.*

Well No.	Date	Screen Depth	Total Iron	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Sulfate	Chloride	Dissolved Solids	Hardness as $CaCo_3$
			CAMERON PARISH									
			"500-foot" Sand									
Cn-88-L	2-10-64	242-245 m (794-804 ft)	.01	5.2	26	396	3.1	297	0	520	1130	120
	10-?-71	" "	--	--	--	--	--	--	--	540	--	--
Cn-88-U	10-01-64	200-203 m (656-666 ft)	--	--	--	--	--	--	--	170	--	--
	3-19-74	" "	--	--	--	--	--	--	--	160	--	--
			"700-foot" Sand									
Cn-88-A	2-11-64	291 m (953 ft)	1.4	3.4	35	865	7.0	301	0	1270	2400	154
			CALCASIEU PARISH									
			"500-foot" Sand									
Cu-549	5-16-55	229 m (750 ft)	--	--	--	--	--	--	--	34	--	--

*Additional chemical analyses for these wells and other wells are on file at the USGS Branch in Baton Rouge, Louisiana.

2.2.1.4 Use

Wells shown in Figure 2-6 are listed by use and completion depth in Table 2-6. However, because this data was collected by the USGS as early as 1943, it is likely that many of these wells are no longer in use. Today, the principal groundwater use in the Prime Prospect Area is rural domestic supply as most of the irrigation water is supplied by surface canals traversing the area. As a rule, each household in the area is served by a single domestic well completed within 153 m (500 ft) of the surface in the "200-foot" sand. Where houses are closely spaced, one well may serve two houses. The principal residences and estimated number of wells in the Prime Prospect Area are shown in Figure 2-6.

2.2.2 Surface Water

The occurrence, quantity, and quality of surface water in the Prime Prospect area is closely related to both physical and cultural features of the landscape. Excess precipitation runs off over the land surface, creating the regime of streams. Climatic and geomorphic factors determine the expected range and character of surface water activity, establishing predictable hydrologic responses in a natural setting.

Surface flow in the Louisiana coastal region is hard to assess not only becuase of the complex nature of the physical environment, but also because of an equally complex set of cultural features. Canals, levees, weirs, spoil deposits, and other control structures interact with natural drainage patterns on the Pleistocene "upland" surfaces

Table 2-6. Water Wells Recorded with the USGS in the Prime Prospect Area

Well No.	Depth (Meters)	Depth (Feet)	Use	Date of Record	Aquifer
Cu-549	110	360	Irrigation	1946	"500-foot" sand
Cn-30	-	-	Irrigation	1949	- -
Cn-21	117	383	Irrigation	1943	"200-foot" sand
Cn-22	118	388	Irrigation	1946	"200-foot" sand
Cn-27	149	490	Irrigation	1947	- -
Cn-88	200-291	656-953	USGS observations	1964	"500 and 700-foot" sands
Cn-10	115	376	Irrigation	1950	"200-foot" sand
Cn-15	126	411	Industrial	1945	"200-foot" sand

Source: Jones et al., 1954.

and in the wetlands areas to produce a distinctive set of regional hydrologic processes and responses. This section describes the resulting surface water characteristics of stream regime, water quality, and water resources development as they pertain to the proposed action in the Sweet Lake Prime Prospect Area.

2.2.2.1 General Basin Hydrology

The Prime Prospect Area is located in the Calcasieu River Basin, a drainage area about 10,632 km^2 (4105 mi^2) which encompasses both Pleistocene and Recent surface environments (La. Stream Control Comm., 1978). Flatness of terrain and the ubiquitous canals of the lower part of the basin around the Prime Prospect Area assure much cross-basin transfer of surface water, and thus an indeterminate drainage pattern for most of the Prime Prospect Area. Surface drainage through the Prime Prospect Area is generally north to south in response to a southerly surface slope. Therefore drainage is sluggish as both confined (channel) and unconfined (sheet) flow. Additionally, the presence of the Chenier ridges in the southern part of the basin disrupt the north-south flow. The ridges generally parallel the coast in an east-west orientation.

Details of the surface drainage patterns within the Prime Prospect Area are shown in Figure 2-9. On the Pleistocene surface, transportation systems and irrigation canals dominate the existing natural stream network to the extent that little uncontrolled surface flow can be detected. The proliferation of roadbeds, diked fields, canalized streams, and ditches, and other manmade hydrologic features control overland runoff from the terrace to the wetlands.

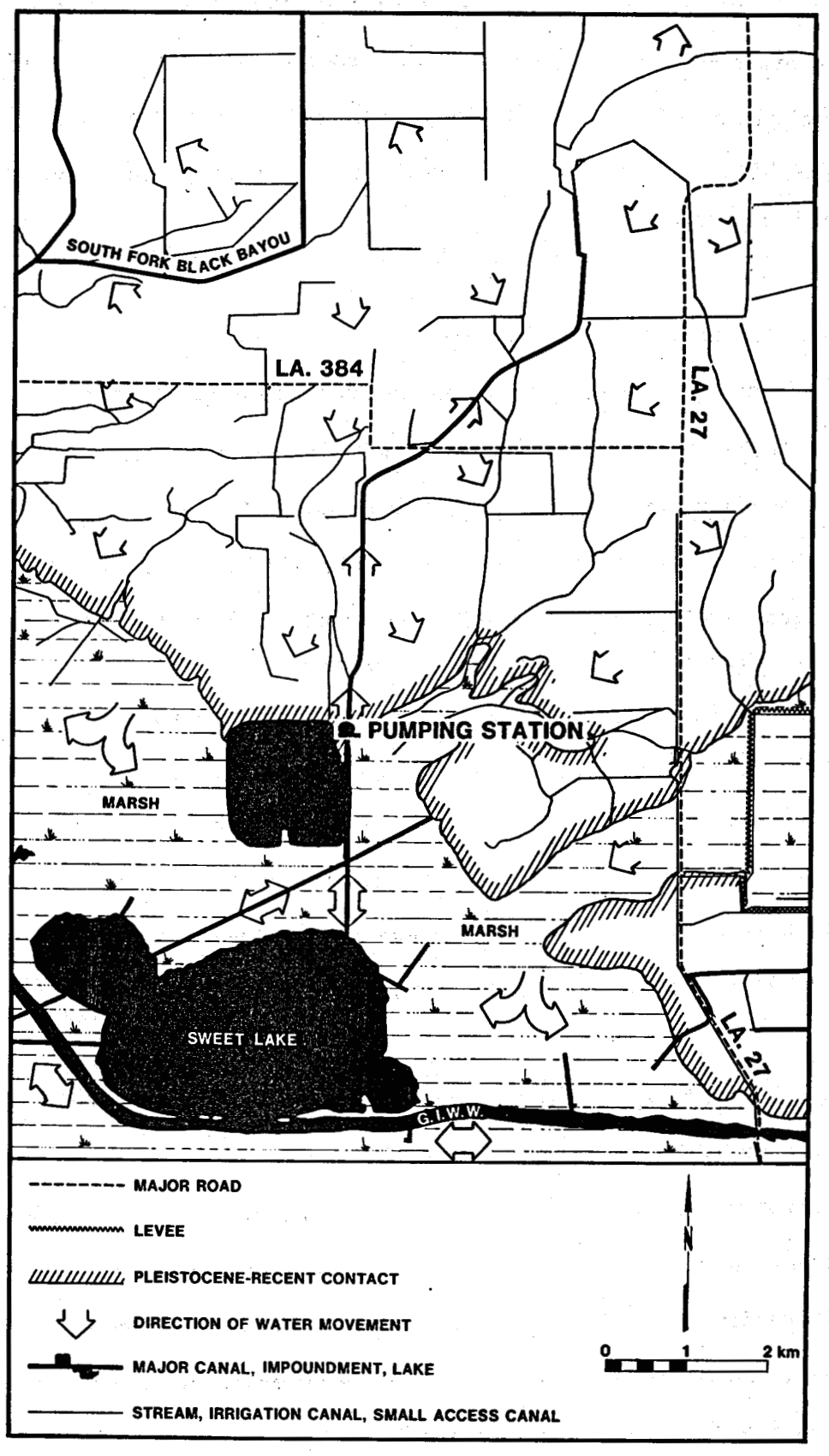


Fig. 2-9. Generalized surface water movement in the Prime Prospect Area.

Drainage divides in the Prime Prospect Area, such as La. Highway 27 on the east (Fig. 2-9), tend to confine and direct surface drainage to some extent, but all restricting features are breached by one or more streams or canals. Seasonal use dictates the direction of flow in irrigation canals as well as the amount of surface water pumped and stored in canals, diked fields, and other impoundments. Notwithstanding these alterations, the general drainage patterns are indicated by arrows in Figure 2-9.

Surface drainage in the wetlands is regulated by the combined effects of runoff from the upland surfaces, tidal oscillations, and weather events. Southerly winds pile Gulf waters up against the coastline causing inland flow and flooding of the wetlands. Northerly winds have the opposite effect, at times almost emptying the marshes. Drainage patterns, water levels, and salinities in marshes and hydrologically connected streams and canals are thus caused to fluctuate on an hourly or daily basis. Furthermore, the GIWW has crosscut the natural drainage pattern in the southern part of the study area, forming an intercept for all southward-flowing runoff. Water levels and direction of water movement in the GIWW are controlled, but are also subject to frequent fluctuations.

Excessive rainfall, river flooding, and tropical cyclones which elevate Gulf waters (storm surge) inundate portions of Louisiana's low-lying coastal region. Though relatively rare, the tropical cyclone is a

dangerous part of the natural environment of the Prime Prospect Area. Precipitation in excess of 760-890 mm (30 - 35 in) is not unusual during the duration of these storms, and the probability of hurricane-force storms in any year is about 7 - 8% in the Prime Prospect Area (USACE, 1976).

2.2.2.2 Physical Characteristics of Area Hydrology

A hydrograph of nearby Calcasieu River can be used to illustrate the anticipated regime of stream flow in the geographic region of the Prime Prospect Area (Fig. 2-10). The data show that streams in the Prime region are, on the average, highest in the spring and lowest in fall. Average discharge for the stream is high (71 m^3/s; 2493 cfs), but the range of discharge (1393 m^3/s; 49,200 cfs to 6 m^3/s; 195 cfs) more clearly points out the nature of surface flow in the basin. The list of mean yearly discharges in the figure also shows the highly variable regime of streams in this region owing to yearly climatic variability. Heavy rainfall can cause spectacular rises in streams and consequent localized flooding throughout the study area, whereas periods of drought can cause extremely low flows in streams and low water levels in marshes.

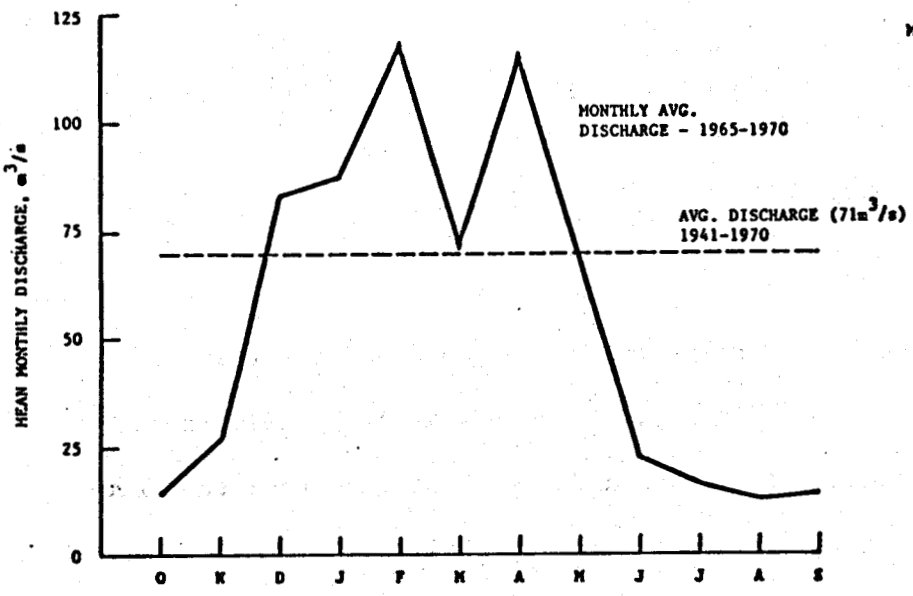
Average annual runoff is estimated at 1.2-1.3 hm^3/km^2 (989-1032 A-F/mi^2) (Muller, 1975). Runoff characteristics are governed by soil type, vegetation, and land use in the Prime Prospect Area. Average runoff from various land uses is shown in Table 2-7 and would generally apply to this area. The soil type, vegetation, and land use sections of this assessment explain the distribution and relative importance to surface runoff of these differences in the Prime Prospect Area.

CALCASIEU RIVER NEAR KINDER

AREA = 4403 km^2 (1700 mi^2)

MAX. DISCHARGE = 1393 m^3/s (49,200 cfs) } 1965-70

MIN. DISCHARGE = 6 m^3/s (195 cfs) }



MEAN YEARLY DISCHARGE (m^3/s)

1951	37.4
1952	55.7
1953	129.3
1954	41.6
1955	73.9
1956	41.4
1957	59.4
1965	38.3
1966	70.9
1967	55.1
1968	60.5
1969	56.0

Fig. 2-10. Mean monthly discharge, 1965-1970, and mean yearly discharge, selected years, Calcasieu River near Kinder, Louisiana (USGS, 1966-1971).

Table 2-7. Runoff as a Percent of Precipitation on Various Surfaces

Surface	% RUNOFF
Urban residential	
single houses	30
garden apartments	50
asphalt or concrete pavement	85-100
Forested areas (depending on soil type)	5-20
Parks, farmland, pasture	5-30

Source: Linsley and Franzini, 1972

Elevation in the Prime Prospect Area ranges from less than 1 m (3 ft) to over 4 m (15 ft). This relatively low elevation creates a significant flood hazard for much of the area; the exact flooding potential is illustrated in Figure 2-11.

2.2.2.3 Water Quality Characteristics

The Calcasieu River Basin has a history of water quality problems. Six of the thirteen segments within the basin have been declared "water quality limited", primarily for oxygen depletion, high bacteria counts, taste, and odor (La. Stream Control Comm., 1978). Concentrations of industry and population along the Calcasieu River and its tributaries are the main problems in the basin. Around the Prime Prospect Area, in the southeastern portion of the basin, the main water quality problems are pesticides' loading and saltwater intrusion (USACE, 1976). These problems are related to withdrawal of surface waters and extensive management of surface waters for agriculture and transportation.

1 ABOVE PROJECT FLOOD STAGE

2 ABOVE 100-YEAR FLOOD STAGE, BELOW PROJECT FLOOD STAGE

3 BELOW FLOOD STAGE OF 100-YEAR FLOOD

Fig. 2-11. The 100-year and 500-year floodplains in the Prime Prospect Area (Pyburn and Odum, 1970).

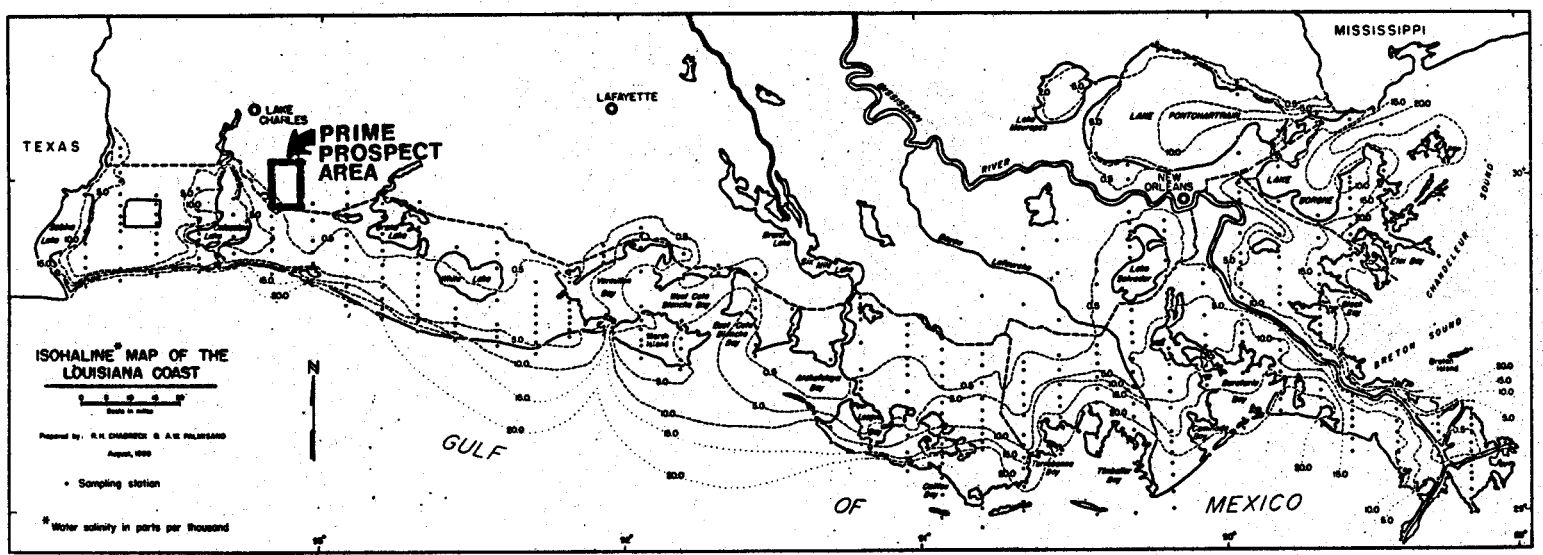


Fig. 2-12. Isohaline map of the Louisiana coast (Chabreck, 1972).

Salinity conditions in the lower part of the basin are some of the important environmental factors affecting distribution of plants and animals and water use for agricultural purposes. Vegetation and wildlife resources and soils adjust to a range of water quality conditions produced by fluctuating salinities and water levels. Figure 2-12 shows the average distribution of surface salinities in the Louisiana coastal zone. On the average, surface salinities in the Prime Prospect Area range between 0.5 and 4.0 ppt (parts per thousand) in the open marshes. The area is considered a freshwater habitat (USACE, 1974). Seasonal saltwater intrusion has resulted in salinities up to 3.4 ppt in the irrigation canal south of the Sweet Lake pump (Coody, 1978). This condition results from seasonal low water levels, heavy pumping for irrigation, and improper regulation of the Calcasieu locks on the GIWW (Coody, 1978).

Table 2-8 summarizes available information on water quality, and Table 2-9 summarizes available water quality criteria for stream segments in the vicinity of the Prime Prospect Area. Location of the water quality sampling sites and the stream segments may be found in Figure 2-13. Comparison of the water quality standards (Table 2-9) and observed water quality data (Table 2-8) indicates that most water quality standards were violated during the periods of observation. If these data are assumed to be representative of regional water quality, it is evident that surface waters around the Prime Prospect Area are often below acceptable standards. More site-specific data are needed in order to document that assumption, however.

Table 2-10 summarizes and compares levels of pesticide concentrations measured in the GIWW at site #6 (Fig. 2-13) with EPA recommended criteria (EPA, 1976). Only those parameters in violation of their respective criteria are shown. The sources of these pesticides are the agricultural fields in the area. The GIWW crosses numerous streams in the area without locks to prevent lateral flow of water, allowing drainage from the fields to enter the canal.

Table 2-8. Water Quality Data (Ranges of Values in mg/l)

Parameter	Sampling Stations*					
	1 (1975-77)**	2 (1976-77)	3 (1975-77)	4 (1976-77)	5 (1976-77)	6** (25Mar77)
TDS	48-5558	-	-	-	-	-
CI	4-2770	8.6-6600	-	5600-15,000	14-1000	-
SO_4	0-385	4-890	-	750-3600	-	-
DO	2.7-9.1	3.7-10.8	3.0-7.0	6.6-12.8	-	8.52
pH (units)	5.9-7.5	6.2-7.8	6.6-8.8	6.7-8.4	-	7.5
Temperature (^{o}c)	8-30.5	10-24	9.5-34	8-26	6-31.5	21.0
Conductivity (micro-ohms)	-	58-18,800	-	1890-40,200	-	195

* See Figure 2-13 for locations
** Observations during water years 1975, 1976, 1977
*** One-time sample

Source: U.S.G.S., 1976-77; La. Stream Control Comm., 1978; USACE, 1976.

Table 2-9. Water Quality Standards (Selected Parameter) and Water Use Designations (Selected Stream Segments).

Segment	Water Uses* A	B	C	D	Cl (mg/1)	SO_4 (mg/1)	DO (mg/1)	pH (range)	TDS (mg/1)	Temp. (°c)
Calcasieu R. (Headwaters to Lake Charles)	A	B	C		62	35	5.0	6.0-8.5	225	32
English Bayou (Headwaters to Calcasieu R.)	A	B	C		250	75	5.0	6.0-8.5	300	32
Calcasieu R. (Lake Charles to Moss Lake-tidal)	A	B	C		N/A	N/A	4.0	6.0-8.5	N/A	35
Calcasieu R. (Moss Lake to Gulf of Mexico -tidal)	A	B	C		N/A	N/A	4.0	6.0-8.5	N/A	35
Lacassine Bayou (Headwaters to Mermentau R.)	A	B	C		90	30	5.0	6.0-8.5	260	32
GIWW (Calcasieu Lock to Vermilion Lock)		B	C		250	75	5.0	6.0-8.5	500	32
Mermentau R. (Grand Lake to Gulf of Mex.-tidal)	A	B	C		N/A	N/A	4.0	6.5-9.0	N/A	35

* A= Primary contact recreation
B= Secondary contact recreation
C= Propagation of fish and wildlife
D= Domestic raw water supply

** Chemical parameters and temperature= max. values
Dissolved oxygen= min. values

Source: La. Stream Control Commission, 1978

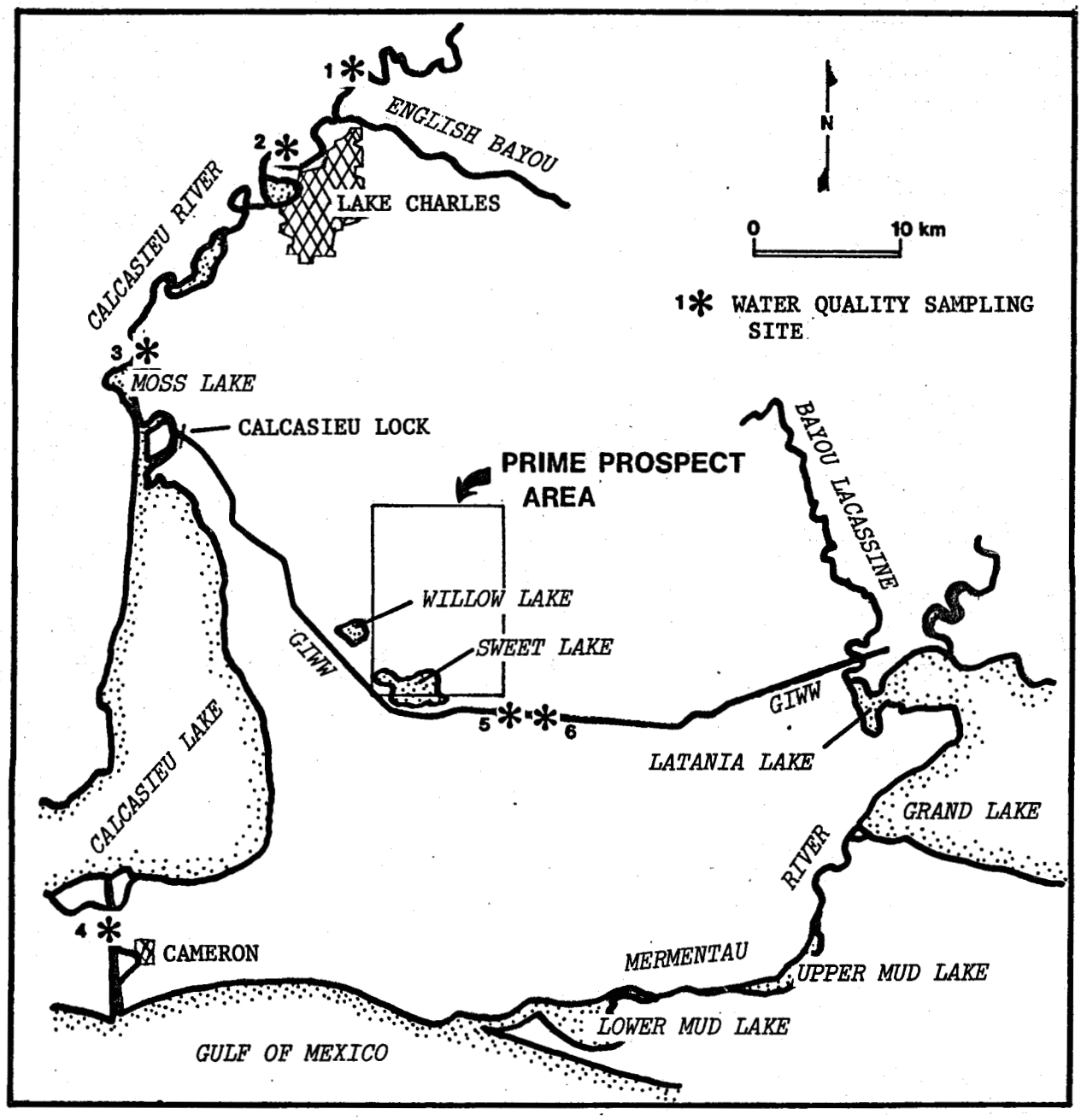


Fig. 2-13. Location of surface water quality sampling sites (Table 2-8) and water use designation stream segments (Table 2-9) (Louisiana Stream Control Commission, 1978).

Table 2-10. Comparison of Pesticide Concentrations in the GIWW with EPA Maximum Recommended Concentrations.

Pesticide	Recommended MAX (μg/l)	Observed Concentration (μg/l)
Lindane	0.02	0.055
Heptachlor	0.01	0.029
Chlordane	0.04	0.830
Dieldrin	0.005	0.190
DDT	0.002	0.031
DDD	0.006	0.0095

Source: USACE, 1976

2.2.2.4 Water Resource Development

No known municipal or domestic water supply is taken from surface water sources in the Prime Prospect Area, but most stream segments are classified as suitable for "primary" and "secondary contact recreation" and for "propagation of fish and wildlife" (Table 2-9). Extensive surface water management practices are conducted for rice irrigation, livestock ranching, navigation, drainage, flood control, and saltwater intrusion problems.

Specific lists of municipal and industrial users, amounts of surface water used for irrigation, and point sources of municipal and industrial discharges are available for the region around the Prime Prospect Area (Engineer Agency for Resources Inventories, 1973; Office of Water Planning and Standards, 1974). In the Prime Prospect Area (Fig. 2-9) there are no listed users or discharges except for irrigation purposes. No wild, natural and scenic, or recreational waterways have been designated in or near the project site (La. Wildlife and Fisheries Comm., 1976).

The main sources of surface water irrigation used in the Prime Prospect Area come from water bodies to the south: Sweet Lake, Willow Lake, and GIWW. The water is pumped northward into the area from Sweet Lake via a navigation canal by a major pumping system located at the community of Sweet Lake (Fig. 2-9). Two pumps at this site pump 45,000 gpm each for 24 hours a day for 4 months (April through July) during the rice irrigation season (Coody, 1978). The Mermentau and Calcasieu Rivers also supply additional irrigation waters to fields in the upper portions of the Prime Prospect Area (Coody, 1978).

2.3 Flora and Fauna of the Prime Prospect Area

The Prime Prospect Area is located in southwestern Louisiana (Fig. 2-14). On a regional basis the area consists of two major natural ecosystems: the prairie (located on the Prairie or Pleistocene Terrace) and wetlands (located on the Chenier Plain) (Fig. 2-14). The biota of the Prairie Terrace is mostly terrestrial with an associated aquatic system (canals and natural waterways). Most of the wetlands are composed of marsh and open water. The proposed site is on the prairie and not on the wetland.

Both the prairie and wetlands have been subjected to man-made and natural events that have greatly altered the composition and distribution of vegetation. Agricultural enterprises greatly expanded into western Louisiana during the late 19th century and early 20th century, destroying the native prairie and substituting grazed pastures and grain crops (Brown, 1972; Bauman et al., 1979). The prairie was ideally suited to rice production and today western Louisiana provides most of the rice produced in the United States (LSU, n.d.a, n.d.b; Bauman et al., 1978). By the mid 20th century, some former rice fields in this area were being planted in soybeans. However, rice production did not decrease because new rice fields were constructed in the wetlands south of the prairie region (Bauman et al., 1978). Both successful and unsuccessful agricultural reclamation projects in the coastal wetlands have altered the native vegetation. In the successful attempts, the drained wetlands support agriculture or pasture while the unsuccessful attempts have led to replacement of drained marshes by open water bodies. It should be noted that the square lake, southwest of the community of Sweet Lake, is not an unsuccessful marsh reclamation project but a former brine disposal pit (Old Salt Water Pit) constructed by Pure Oil in the 1930's (Racco, 1978). It

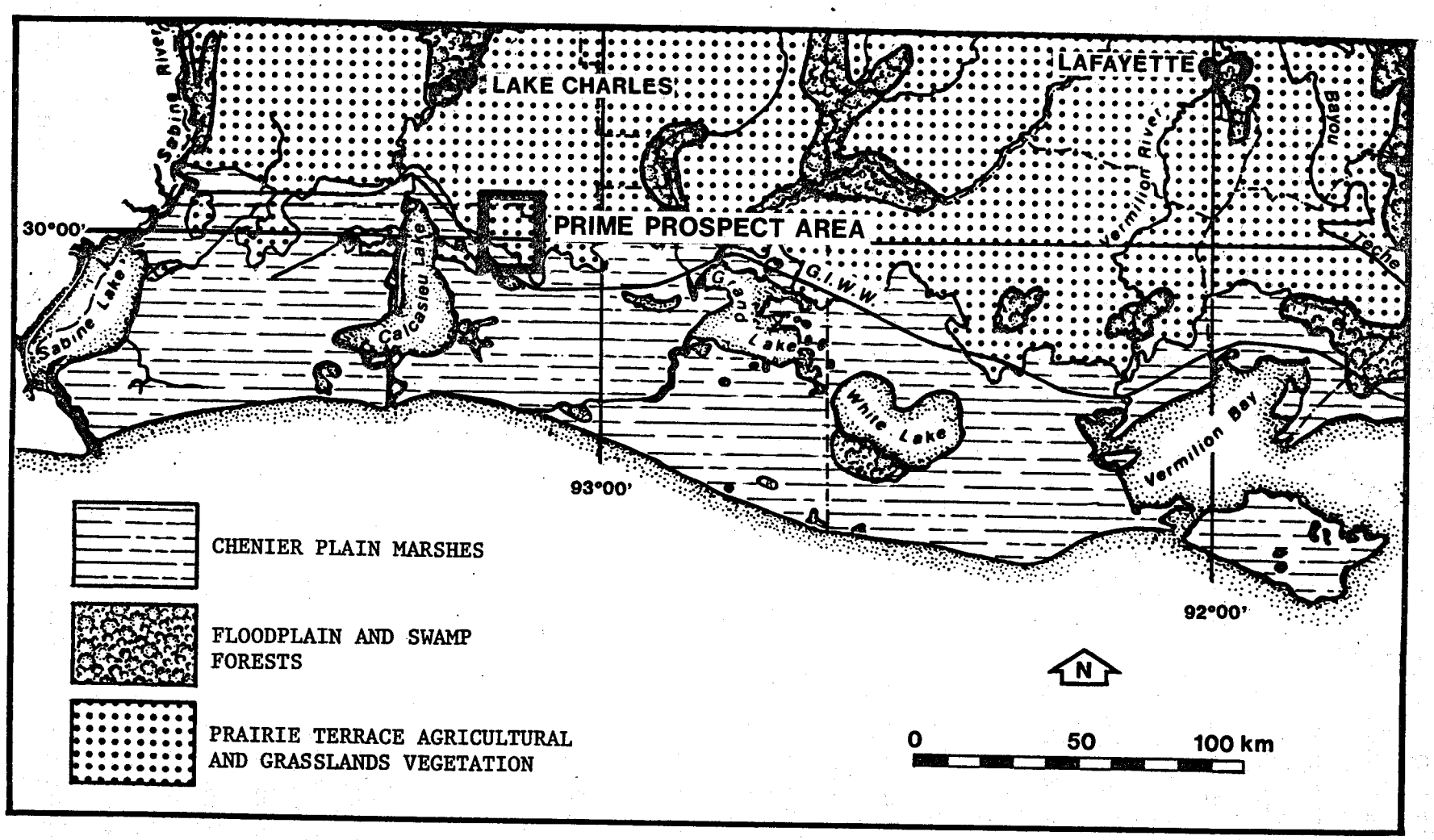


Fig. 2-14. Regional vegetation of southwestern Louisiana (DOE, 1978).

was abandoned in the 1960's and today water levels in the lake average about 43.2 cm (18 in) deep. Some submerged freshwater aquatics grow in the lake but hyacinth and alligatorweed mats have not become established because of the periodic influx of slightly brackish water (up to 3.4 ppt) (Racco, 1978; Coody, 1978).

The prairie and wetland habitats support a variety of faunal species (Appendix B, Tables 1-4) some of which are among Cameron Parish's more important resources. It supports a dense nutria (Myocastor coypus) population, the most important furbearing animal in Louisiana (the leading fur producing state in the U.S.) (O'Neil and Linscombe, 1977). The offshore menhaden and shrimp fisheries of Cameron Parish are important components of Louisiana's fish industry, also the largest of any state in this country.

Another of the unique faunal features of Cameron Parish is its bird life. This parish, and the entire state, lie at the bottom of the great Mississippi Valley Migratory flyway. The spring and fall mass movement of northern nesting species brings incredible numbers of birds into the state (Lowery, 1974b). Cameron Parish receives a high percentage of these individuals as is evidenced by its being the spring meeting place for the Louisiana Ornithological Society, its having one of the highest national Audubon Christmas Bird Counts, and the highest number of waterfowl harvested annually.

The Sabine National Wildlife Refuge Christmas Bird Count is perennially a leader in the number of species seen. On 18 December 1977, about 56,787 birds representing 171 species were tallied during the count (Newman, 1977). Although most of these species winter in south Louisiana, a much larger number of trans-gulf migrants pass through the parish each fall and spring.

Of particular recreational and economic importance are the vast numbers of ducks and geese that winter in Cameron Parish. Most of the dabbling ducks and geese rest and preen in coastal marshes and feed in rice and soybean fields to the north (Brown, 1978). The high concentrations of wintering waterfowl are an extremely important resource. This resource allowed Cameron Parish hunters to annually harvest an average of 172,702 ducks and 36,978 geese between 1961 and 1970. Only one other county or parish in the United States annually harvests more ducks or more geese (Carney et al., 1975). Although duck stamp sales in Cameron Parish are rather low, Calcasieu Parish (directly north of Cameron Parish) sold 11,556 waterfowl stamps during the 1975-76 fiscal year, the sixth highest of any parish or county in the United States (Carney et al., 1978). Because Calcasieu Parish has a relatively low waterfowl harvest, it might be assumed that many of the Cameron Parish hunters come from other parishes or states and buy their waterfowl stamp in the more populated Calcasieu Parish.

Major vegetation systems within the Prime Prospect Area are related to man's agricultural practices and natural or man-influenced water regimes (Fig. 2-15). The most extensive one (covering approximately two thirds of the site) is the agricultural ecosystem (predominantly rice, soybeans and improved pasture) which replaced former prairie grasslands (on the Prairie Terrace) and some of the preexisting marshlands (on reclaimed Chenier Plain marshlands). A smaller wetlands ecosystem consists of freshwater lakes, marsh ponds, and marsh vegetation covering approximately one third of the southern portion of the Prime Prospect Area. This is classified as a freshwater marsh because the average salinity is less than 1.5 ppt even though the range may go from 0 to 4.0 ppt (USCE, 1976) (Fig. 2-15).

1 FRESH WATER MARSH

2 FRESH WATER

3 AGRICULTURAL VEGETATION

PLEISTOCENE - RECENT CONTACT

0.5 ppt SALINITY READING (CHABRECK, 1972)

Fig. 2-15. Major vegetation ecosystems of the Prime Prospect Area.

2.3.1 Terrestrial flora and fauna

Historically, the prairie vegetation consisted of grasses, sedges, herbs, and a few trees on the flanking benches of streams and on the floodplains (Penfound, 1944; Brown, 1972; Jones *et al.*, 1954; St. Amant, 1959; USDA, S.C.S., 1971; 1969, Wackerman, 1929). More recently, most of this region has been changed for agricultural use and is neatly segmented by man-made networks of irrigation canals that have obliterated the few pre-existing drainage networks.

Vegetation within the fields is controlled through planting of desired crops (various varieties of rice and soybeans)(Table 2-11) and herbicide spraying to remove undesirable weeds (Coody, 1978; LSU, n.d.a., n.d.b). Wildlife species occurring in these areas have adapted to man's agricultural practices. Vegetation and wildlife commonly occurring within agricultural fields, field borders, canal banks, and road shoulders are included in Appendix B, Table 5. Additional ornamentals near houses include mimosa (*Albizzia julibrissin*), fig (*Ficus carica*), redbud (*Cercis canadensis*), Japanese plum (*Eriobotrya japonica*) and satsuma (*Citrus reticulata*). About 15 to 20 years ago, a limited number of pine windbreaks were planted in linear stands near houses and pastures through the efforts of the Soil Conservation Service (Coody, 1978).

Table 2-11. Common Rice Varieties and Approximate Days to Maturity.

Medium Grain		Long Grain	
Saturn	-120	Starbonnet	-130
Nato	-120	Labelle	-103
Vista	-115	Lebonnet	-109
Nova	-120	Bluebelle	-109
Brazos	-118	Belle Patna	-103

(LSU Coop. Ext. Ser., n.d.b)

2.3.2 Aquatic flora and fauna

Aquatic habitat within the Prime Prospect Area can be generally classified as either agricultural canals or marsh. Each of these habitats is characterized by certain species.

Because of their steep banks, frequent cleaning, and turbid condition, the agricultural canals support few submerged and rooted aquatic plants. Most species existing in this habitat are capable of existing in inconsistently flowing water with periods of low oxygen and high turbidity. Associated with these stress periods is a reduction in species diversity, most noticeable in the floral and faunal micro-organisms at the base of the flood chain.

The vegetation that does grow within the irrigation ditches is undesirable to agricultural interests since it interferes with movement of irrigation waters. It is therefore destroyed annually either manually, mechanically, or chemically (Coody, 1978). Aquatic vegetation and wildlife either observed in July, 1978, or expected to occur in uncleared canals or in roadside ditches are listed in Appendix B, Table 6.

The wetlands south of the Prairie Terrace were deep, freshwater marshes (under 9.6 to 36.0 cm [4 to 15 in] of water). The dominant vegetation around the middle of the 20th century is included in Appendix B, Table 6. Flora and fauna either observed in July, 1978, or expected to occur in the marshes of the Prime Prospect Area are also included in Appendix B, Table 6.

2.4 Endangered Species

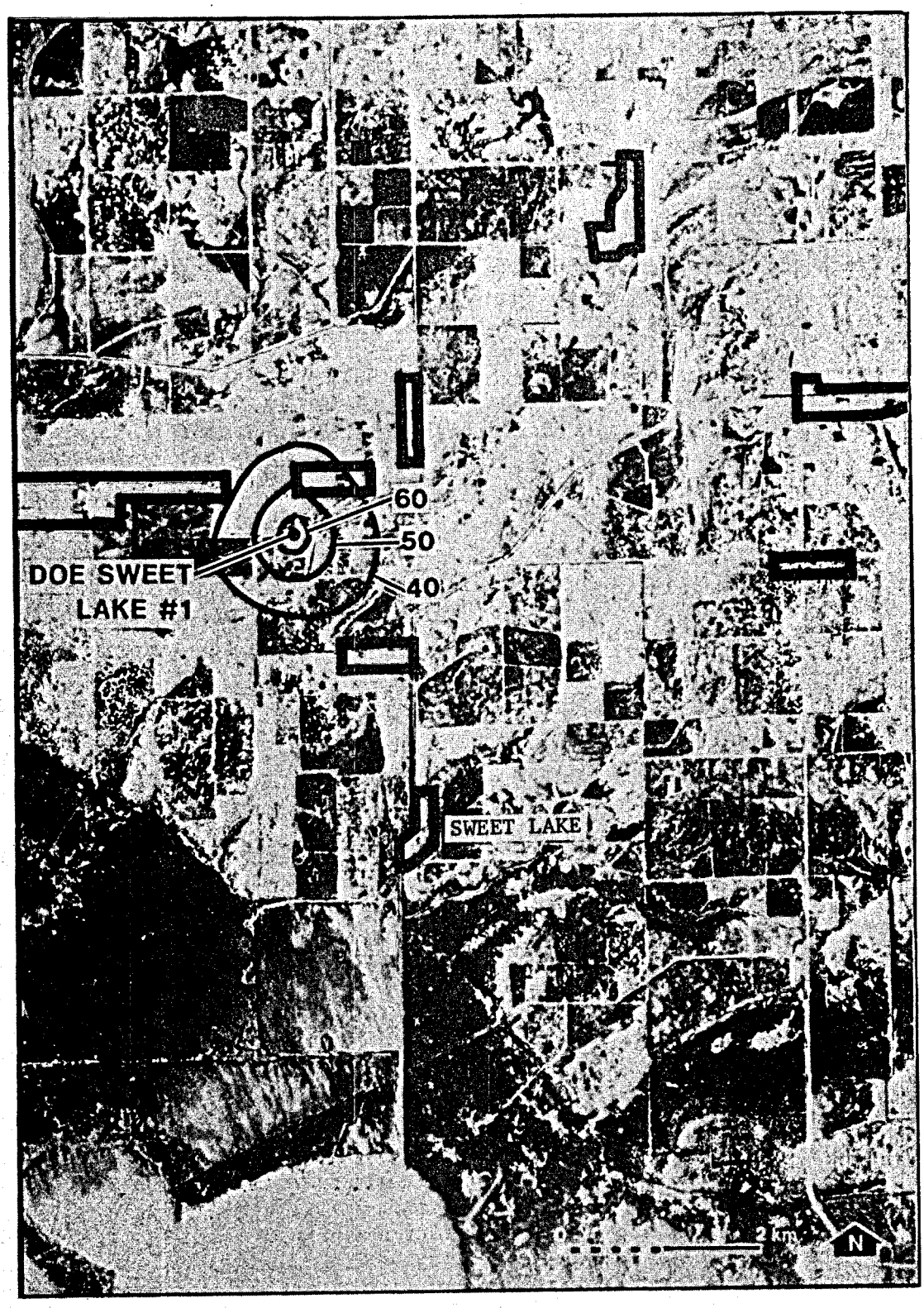
The Prime Prospect Area is included in the present or historical range of several endangered or threatened species. Those species so classified whose range currently includes the project area are awnless bluestem (Bothriochloa exaristata) and the American alligator (Alligator mississippiensis). The Southern Bald Eagle (Haliaeetus leucocephalus) and the Peregrine Falcon (Falco peregrinus) may also pass through the area or spend a limited amount of time there while searching for food. The Whooping Crane (Grus americana), Brown Pelican (Pelecanus occidentalis), and red wolf (Canis rufus) historically occurred in the Prime Prospect Area but neither exist there now nor are they likely to reinhabit the area. A listing of each of the threatened or endangered species is included in the Appendix C.

2.5 Noise

2.5.1 Ambient Noise

The ambient, or normal, daytime noise level for the rural area near the Prime Prospect Area has been recorded as about 50 dBA (unpublished LOH data). Nighttime levels will reach as low as 35-40 dBA depending upon atmospheric conditions and nighttime noises. Individual receptors are scattered throughout the study area; however, there are concentrations of receptors as shown on Fig. 2-16. These receptors include churches, businesses, and residences.

Noise has been defined as any unwanted sound. Sound is actually a pressure level which fluctuates through various media, such as air,



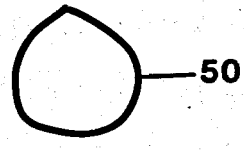


Fig. 2-16. Concentrations of receptors in the Sweet Lake Prime Prospect Area. Noise contours resulting from normal operation of a drilling rig (Radian Corporation, 1979).

buildings, etc. It is based on a reference pressure of 2×10^{-5} Newtons per square meter, and quantified in terms of decibels, a logarithmic scale of pressure levels. Since the human ear does not hear high and low frequencies of sound as well as the mid-range, the "A" filter is used when recording noise as a function of human response. The noise levels are therefore expressed as A-weighted decibels, or dBA. Table 2-12 shows the common sound levels associated with selected activities which may occur in the Prime Prospect Area.

2.5.2 Regulations

There are no specific state standards applicable to noise from geothermal activity within Louisiana. In the absence of state standards, at lease four Federal regulations may apply to the well site. The first, Geothermal Resources Operational Order No. 4 (USDI, 1975), allows a maximum noise level of 65 dBA for all geothermal related activity, as measured at the lease boundary line or 0.8 km (0.5 mi) (Overlay) from the source, whichever is greater. This level applies in the absence of any more restrictive criteria and may be exceeded under emergency conditions or with the permission of all residents within 0.8 km of the source.

The second regulation is applicable to the workers at the well site who are covered under the Occupational Safety and Health Administration (OSHA) guidelines (1971). The following levels (Table 2-13) are recommended as maximums for exposure without hearing protection. The United States Environmental Protection Agency (EPA, 1974) has established more restrictive guidelines (Table 2-14). These guidelines are based on land use and activity.

Table 2-12. Common Sound Levels

Sound source	dBA*	Response criteria	Intensity (W/m^2)
Carrier deck jet operation	150		10^9
	140	Painfully loud; limited amplified speech	10^8
	130		10^7
Jet takeoff (200 ft)		Maximum vocal effort	
Unmuffled geothermal well			
	120		10^6
Discotheque			
	110		10^5
Jet takeoff (2000 ft)			
Shout (0.5 ft)			
	100		10^4
Heavy truck (50 ft)		Very annoying, hearing damage (8 hr)	
	90		10^3
Pneumatic drill (50 ft)		Annoying	
	80		10^2
Freight train (50 ft)			
Freeway traffic (50 ft)		Telephone use difficult; intrusive	
	70		10^1
Air conditioning unit (20 ft)			
	60		1
Light auto traffic (50 ft)		Quiet	
	50		10^{-1}
Living room			
Bedroom			
	40		10^{-2}
Library			
Soft whisper (15 ft)		Very quiet	
	30		10^{-3}
	20		10^{-4}
Broadcasting studio		Just audible	
	10		10^{-5}
		Threshold of hearing	
	0		10^{-6}

*Typical A-weighted sound levels taken with a sound level meter and expressed as decibels on the scale. The "A" scale approximates the frequency response of the human ear.

Source: Council on Environmental Quality, 1970.

Table 2-13. Permissible Noise Exposures

Duration per day, hours	Sound level (dBA)
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼ or less	115

Source: OSHA , 1971

Table 2-14. Levels of Environmental Noise.

TO PREVENT	LEVEL	AREA
HEARING LOSS	Leq* (24) ≥ 70dBA	All areas
Outdoor Activity Interference and Annoyance	Ldn** ≥ 55dBA	Outdoor residential areas and farms and other outdoor areas where people spend widely varying amounts of time, and other places in which quiet is a basis for use.
	Leq (24) ≥ 55dBA	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor activity interference and annoyance	Ldn ≥ 45dBA	Indoor residential areas
	Leq (24) ≥ 45dBA	Other indoor areas with human activities such as schools, etc.

*Leq- the equivalent noise level, is a summation of all the sound pressure levels over a given time period, which is then averaged out for that period of time to give a single sound level which is representative of all the various fluctuations. Leq (24) is a 24 hour equivalent level.

**Ldn - the day/night noise level, is an Leq(24) with a 10dBA penalty added to the nighttime hours.

Source: EPA, 1974

Finally, the United States Department of the Interior (1975) has published the following noise criteria not to be exceeded for geothermal-related activities.

LAND USE	DAYTIME (dBA)	EVENING (dBA)	NIGHT (dBA)
Industrial & Geothermal	70	65	60
Business & Commercial	65	60	50
Residential-Urban	60	55	45
Residential-Suburban	50	45	35
Residential-Rural	45	40	30
Agricultural	70	65	55
Recreational	45	40	30
Uninhabited or Rangelands	70	65	60

The above regulation will be the most difficult to meet, particularly in light of the 30 dBA nighttime level set for the rural-residential land uses in the Prime Prospect Area.

2.6 Atmospheric Conditions

2.6.1 Regional Climatology

There are no meteorological measurements within the Sweet Lake Prime Prospect Area. Because the terrain in the southwestern section of Louisiana is located on the same flat level coastal plain as Lake Charles, it is applicable to use the long-term National Weather Service Station at Lake Charles as a first approximation to the Prime Prospect Area. The meteorological data are given in Table 2-15.

The general climatical classification of the region is humid subtropical with a strong maritime character. The climate is influenced to a large degree by the amount of water surface in the form of lakes, bayous, and flooded rice fields and by the proximity of the Gulf of Mexico. Throughout the year these water bodies modify the relative humidity and temperature, decreasing the range between extremes. When southerly winds prevail, these effects are increased, imparting the characteristics of a marine climate. The summer months are consistently quite warm, but maximum temperatures rarely exceed 38°C (100°F) because of the uniformly high humidity of the dominant maritime tropical air mass, and the moderating effects of cloudiness and the scattered convective showers and thunderstorms which are a primary feature of the weather during these months. The Prime Prospect Area is also subject to infrequent but important polar influences during winter, as masses of cold air periodically move southward across the plains states and out over the Gulf of Mexico. The winter months are normally mild with cold spells usually of short duration.

Prevailing wind flow is from a southerly direction during most of the year. The flow of air from the Gulf of Mexico helps to temper extremes

Table 2-15. Meteomlogical Observations at Lake Charles, Louisiana

Month	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Temperature[a] °C	11.3	12.8	15.7	20.5	24.0	27.1	28.0	27.9	25.8	21.1	15.7	12.4	20.2
Precipitation[a] mm	103	114	98	110	129	128	166	121	105	88	104	145	1409
Wind direction[b]	N	S	S	S	S	SSW	SSW	SSW	ENE	ENE	ENE	NE	S
Wind speed[b] m/s	4.6	4.7	4.9	4.6	4.0	3.3	2.9	2.8	3.3	3.4	4.2	4.2	3.9
Relative humidity[c] %	81	75	77	77	78	77	80	81	80	77	77	81	78
Thunderstorm days[d]	3	3	4	4	8	9	14	15	9	3	3	3	77
Mixing height[m]	520	740	870	1050	1130	1280	1300	1250	1320	1200	840	590	1008
Solar Radiation[f] Ly/day	200	315	400	435	520	565	475	465	430	390	297	193	390

a. Normal for 1941-1970 period
b. Two year record for prevailing wind direction and 16 years for mean wind speed
c. 13 year record
d. 16 year record; mean number of days with thunderstorms
e. From Holzworth (1964); mean mixing heights
f. For 1963-1973 period

Source: National Climatic Center, 1977 and other years.

of summer heat, shorten the duration of winter cold spells, and provides a source of abundant rain. Winds are usually rather light. Almost 80 percent of hourly wind speed observations during the year are 6 m/s or less.

Rainfall is heavy with the normal annual total near 1409 mm (55 in). Amounts are substantial in all seasons, although there is an early autumn minimum in October. All other months except March produce an average of more than 100 mm (3.9 in) with the July total often more than 166 mm (6.5 in). Almost all rainfall is of the convective and air mass types, showery and brief, except occasionally during winter when nearly continuous frontal rains may sometimes persist for a few days.

Summer relative humidity exceeds 80 percent for about 12 hours per day. High humidity may be experienced at any hour, but occurs mainly at night; 90 percent or more of the hours from late evening through early morning have relative humidity of 80 percent or higher. Readings of 50 percent or less occur about two hours per day usually during afternoons; from 25 to 40 percent of midafternoon hours have had relative humidity of less than 50 percent.

Thunderstorms occur each month. They are most frequent in July and August with almost one-half of the days in each month reporting thunder. The fewest days with rain are in October. Severe local storms, including hailstorms, tornadoes, and local windstorms, have occurred over small areas in all seasons, but most frequently during the spring months. Since

1900 the centers of four hurricanes have passed very near Lake Charles. The area has been affected by several others and also by a number of tropical storms which did not attain hurricane intensity. The strongest wind reported from 1940 through 1971 was 36 m/s from the SE in 1957. However, Lake Charles is in the region where a mean recurrence interval of 50 years gives a standardized extreme wind speed of 46 m/s (90 mph).

2.6.2 Meteorology Near the Prime Prospect Area

As described in the previous section (2.6.1), the meteorology near the Prime Prospect Area may be approximated by observations made at Lake Charles since the Prime Prospect Area has no meteorological observations and is located on the same flat coastal plain and not very far from the National Weather Service Station at Lake Charles. Table 2-15 gives important parameters related to the meteorology in the region. A description of meteorological and climatological conditions has already been given in 2.6.1. Since the table is self-explanatory, it will not be discussed in detail. Note that, however, for air quality studies, both solar radiation and mixing height are added in the table in addition to those basic parameters. They will be used later in the impact analysis.

The atmospheric stability class is very important in the diffusion calculation; therefore Table 2-16 gives the pertinent information as a first approximation to be used in the impact computation in-so-far as the air quality due to the proposed action is concerned. Note that stability Class A represents extremely unstable conditions, B unstable, C slightly unstable, D neutral, E slightly stable, F moderately stable, and G extremely stable (Slade, 1968). It is evident from the table that the combination of neutral and slightly stable conditions (D & E) occupied about 62% of the year.

Table 2-16. Percent Frequency and Wind Speed for Stability Classes as Averaged Between Taft, Louisiana and Houston, Texas.

Stability Class	Percent Frequency	Average Wind Speed, m/s
A	6.4	4.0
B	2.4	4.3
C	4.8	4.2
D	32.2	4.1
E	29.4	3.0
F	14.3	1.7
G	10.5	1.3

Source: DOE, 1978

2.6.3 Air Quality

Since the Prime Prospect Area has no air quality measurements and is located on the same flat coastal plain as the nearby Lake Charles, the air quality for the Prime Prospect Area may be approximated from the observations made at the Lake Charles area as a first approximation. Table 2-17 summarizes the existing air quality in the general area compared to the National Ambient Standards. For comparison purposes, measurements of carbon monoxide at Nederland and West Orange, Texas were also included in the Table since these two areas are located in the same Air Quality Control Region, i.e., 106, as Lake Charles and Prime Prospect Area (EPA, 1978). From Table 2-17 it can be seen that, except for ozone and nonmethane hydrocarbons, other pollutants as listed and regulated by Federal and State agencies were within the primary standards.

The impacts on air quality due to drilling, maintenance, and flow testing of the proposed well will be discussed in detail in Chapter 3. Furthermore, impacts on air quality due to accidents and blowouts will be calculated in Chapter 5.

2.7 Unique Resources

2.7.1 Recreational Areas Existing and Proposed

Cameron Parish offers numerous opportunities for outdoor recreation especially hunting and fishing. Extensive marsh areas and natural and man-made bodies of water are used for recreational purposes.

Table 2-17. Summary of Air Quality Data Observed in the Lake Charles Area as Compared to National Ambient Standards.

Pollutant	Average Time	Primary Standards[a]	Lake Charles Area
Particulate matter	Annual (Geometic mean)	75	55[c]
	24-hour[b]	260	154[c]
Sulfur oxides	Annual (Arithmetic mean)	80	26[c]
	24-hour[b]	365	108[c]
Carbon Monoxide	1-hour[b]	40	5.7[d], 8.4[e], 7.5[f]
Nitrogen dioxide	Annual (Arithmetic Mean)	100	42[c]
Photochemical Oxidants, O_3	1 hour[b]	235	282[c]
Hydrocarbons (Nonmethane)	3 hour (6 to 9 a.m.)	160	185[g]

a. Units are in $\mu g/m^3$ except for CO which is in mg/m^3

b. Not to be exceeded more than once per year.

c. For the year of 1976 (data source: EPA, 1978)

d. Measured by Louisiana Dept. of Highways at Westlake opposite industries about 200m from I-10 on Feb. 10, 1976 during Jan.-Feb. 1976.

e. Nederland, Texas, same as c, for comparison only

f. West Orange, Texas, same as e.

g. Measured by Louisiana Dept. of Highways at Cameron Evacuation Route in Cameron Parish at 11 a.m. on January 20, 1976.

The Lacassine National Wildlife Refuge offers 12,869 ha (31,776 ac) for outdoor recreation. Sport fishing is allowed on a seasonal basis. It is also a haven for waterfowl, furbearers and other wildlife. The Refuge is 13 km (8 mi) to the east of the Prime Prospect Area (Fig. 2-17).

The Sabine National Wildlife Refuge encompasses 57,853 ha (142,846 ac) with about 13,487 ha (33,300 ac) of water including 210 km (125 mi) of canals and waterways averaging about 15 m (50 ft) wide and 1-2 m (3-7 ft) deep. The Refuge is open to public sport fishing, crabbing and bird watching. Public duck and goose hunting is also permitted on a seasonal basis by the U.S. Fish and Wildlife Service. The Refuge is 35 km (22 mi) to the west of the Prime Prospect Area.

The Rockefeller State Wildlife Refuge within its 23,670 ha (58,445 ac) has many shallow water impoundments 0-.3 m (0-14 in) deep and many canals and bayous averaging about 12 m (40 ft) wide and 1.5 m (5 ft) deep. This State Wildlife Refuge also offers opportunities for sport fishing on a seasonal basis. Saltwater fish species such as red fish, drum and speckled trout abound. The Refuge is 40 km (25 mi) to the southeast of the Prime Prospect Area.

There are neither National or State Parks nor any scenic rivers within the boundaries of the Prime Prospect Area.

Near the Prime Prospect Area lies the Gulf Intracoastal Waterway (GIWW) which offers recreational opportunities and fair sport fishing. Sweet Lake, located in the Prime Prospect Area, encompasses 810 ha (2000 ac) of water.

Its fresh-to-brackish waters (it presents slight saltwater pollution occasionally) offer fair sports fishing and private boat launching facilities.

All along Creole Canal following State Highway 27 and south of the GIWW crabbing and fishing are popular among local people and people from within the immediate surrounding parishes.

Directly south of the Prime Prospect Area and facing the Gulf of Mexico lies Ruthersford Beach which offers Gulf-oriented recreation. It is administered by the Louisiana State Parks and Recreation Commission. Private camps are also found here extending for about 1.6 km (1 mi) along the beach area (Fig. 2-17).

Hunting and fishing in Cameron Parish are popular outdoor recreational activities within the area. More than 50 percent of the private lands in the parish are leased for hunting. Within the Prime Prospect Area most of the hunting rights are leased to individual hunters and private hunting clubs. Much of the same land is leased to trappers during trapping season.

A recreational center is located on Louisiana Highway 384 near the Grand Lake High School, approximately 1.6 km (1 mi) west of the Prime Prospect Area. A baseball field, a recreation field, and a rodeo arena are also located in the Prime Prospect Area (Fig. 2-18).

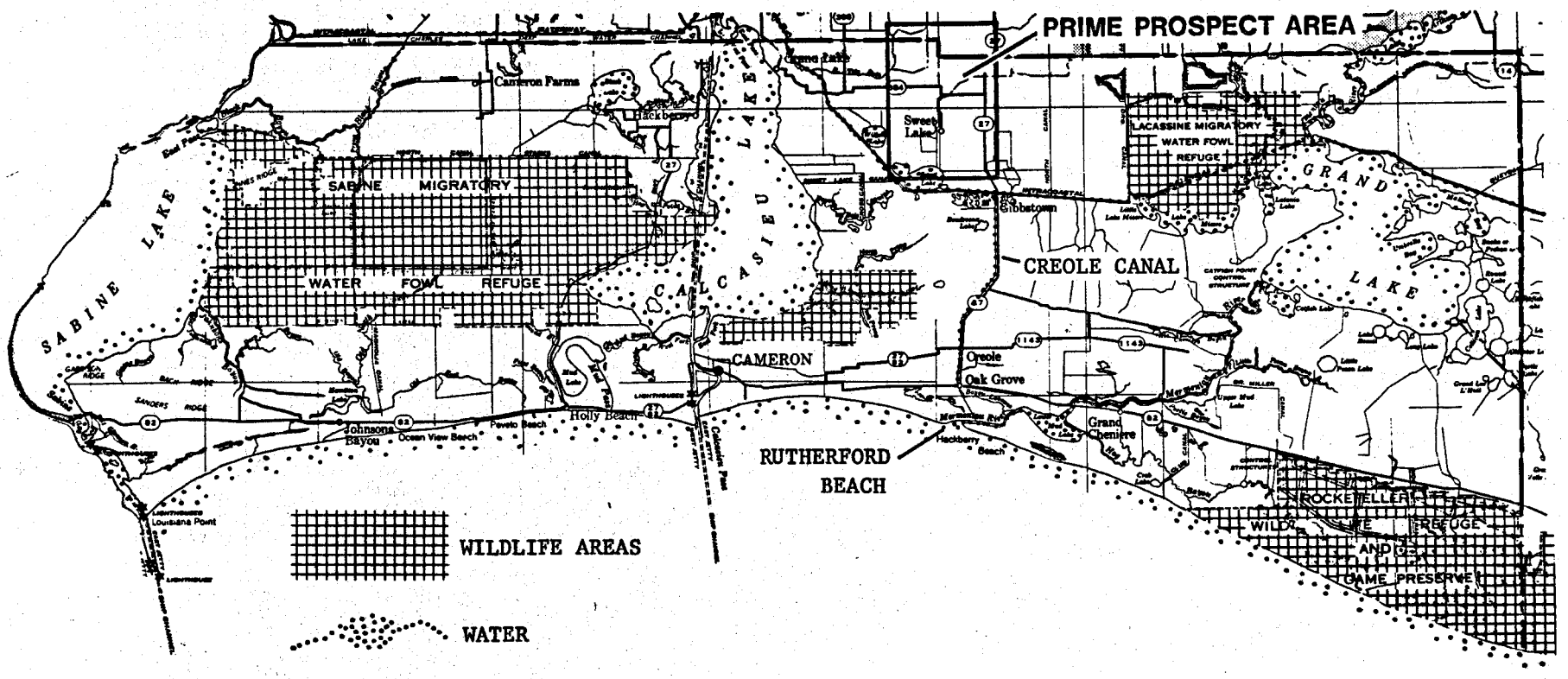
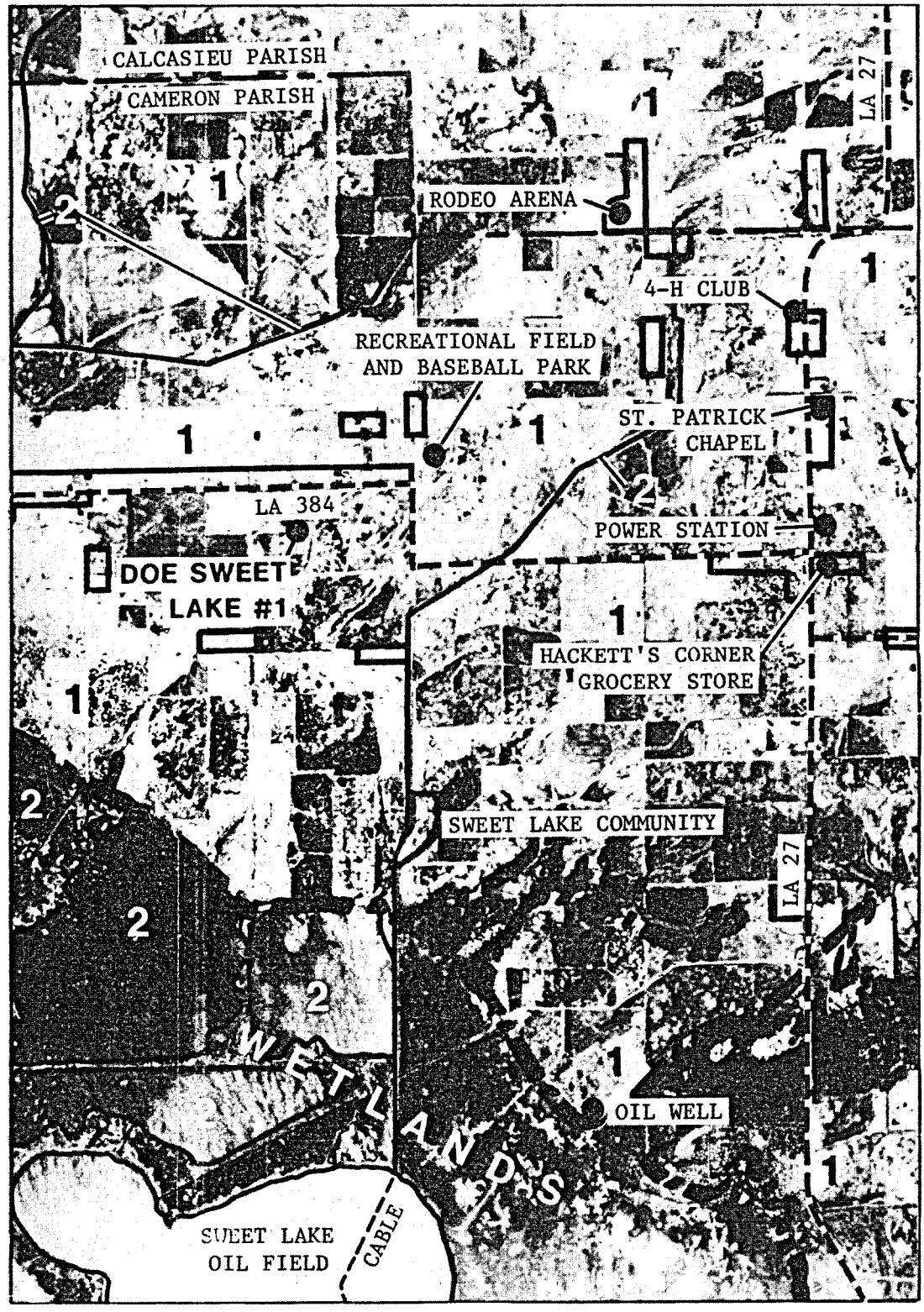


Fig. 2-17. Recreational and wildlife areas in relation to the Prime Prospect Area (ICRPDC, 1975).



URBAN AND BUILT UP LANDS (STRIP SETTLEMENT)

1 AGRIGULTURAL LANDS

2 WATER

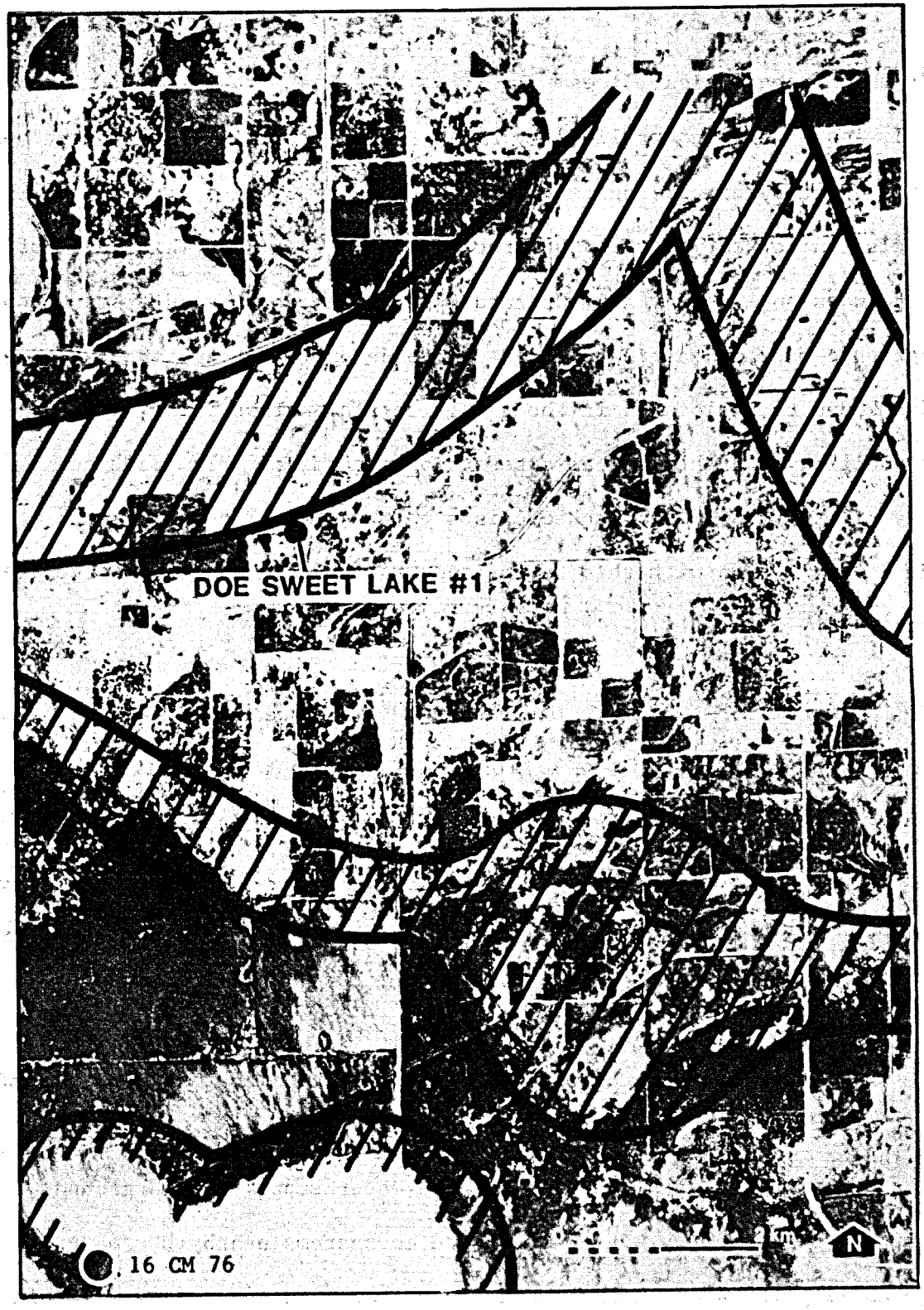
Fig. 2-18. Land use in the Prime Prospect Area.

2.7.2 Archeological Sites

A Level I, Assessment and preliminary Field Survey (Fricker, 1978; Department of Culture, Recreation and Tourism, 1978) was performed by a professional archeologist in connection with the preparation of this EA. This level of survey includes an archival and literature review as well as an examination of topographic maps and aerial photographs to determine if any archeological sites are known to be located in the area. It also allows areas with a high probability of archeological sites to be determined. In addition, a one day visit by qualified archeologists to the Prime Prospect Area was made in connection with this EA to study the terrain and to observe the high probability areas.

One archeological site, 16 CM 76, located on the northwest shore of Sweet Lake (Fig. 2-19) is in the Prime Prospect Area. Shell and pottery scattered for 15 m (50 ft) were found along the shore of the lake. One other archeological site (16 CM 1) is located along the shore of Sweet Lake but it is just out of the Prime Prospect area. If a site is found during drilling or excavation, DOE will contact the State Historic Preservation Officer.

Several high probability areas were identified from examination of maps. High probability areas are areas where sites are expected due to past or present geomorphic features, vegetation, and water supply. High ground overlooking a water supply with two or more ecosystems nearby has a very high probability for archeological and historical site occurrence. Within the Prime Prospect Area this situation is found twice (Fig.2-19), once along the southern edge of the Pleistocene Terrace and along relict Red River stream channel. Prior to 5000 B.C. (Frazier, 1967) the southern edge of the Pleistocene Terrace was a coastline. As such it provided marine and terrestrial



HIGH PROBABILITY AREAS

ARCHEOLOGICAL SITE

Fig. 2-19. Known archeological sites and high probability zones for archeological sites in the Prime Prospect Area.

aboriginals' subsistence. Sites were probably located near a source of fresh water such as a stream or river. After Holocene sediments were deposited, two ecosystems remained, the low marshy areas and the drier Pleistocene Terrace.

The second high probability area is the two relict stream scars on the Pleistocene Terrace (Jones et al, 1954). The natural levees of the stream are excellent habitation sites, especially if a smaller stream occupied the channel after it was abandoned by the Red River.

2.7.3 Historical Sites

There are no sites listed or nominated to the National Register of Historic Places in the Prime Prospect Area. A Level I Cultural Resources Survey (Department of Culture, Recreation, and Tourism, 1978) was performed prior to well installation and facilities construction to determine if any historical structures eligible for nomination to the National Register of Historic Places would be affected by the proposed action. The report of this work was submitted to the State Historic Preservation Officer. No sites of historical importance were found at the proposed well site (Appendix D).

2.8 Demographic and Socio-Economic Setting

2.8.1 Demography

Cameron Parish has a 100 percent rural population. In 1975 its population was 9,009 persons; the population has grown 20.1% since 1970 when 8,194 persons resided in the parish. The Prime Prospect Area is within Ward 4 of Cameron Parish which had a population of 1,218 in 1970, a 16.8 percent increase over 1950 population. Population of Cameron Parish by Wards for 1950, 1960, and 1970 is shown in Table 2-18.

Table 2-18. Cameron Parish - Population by Wards for the Years 1950, 1960, and 1970.

Ward	1950	1960	1970
1	514	611	566
2	904	879	1,166
3	2,276	2,721	3,205
4	1,012	1,036	1,218
5	330	479	704
6	1,208	1,183	1,335

Source: PAR, 1973.

Population statistics for white and non-white persons for the years 1950, 1960, and 1970 are presented in Table 2-19, which shows a low non-white minority population. There are no existing non-white concentrations or settlement groups within the Prime Prospect Area.

Table 2-19. Cameron Parish - Population Composition by Race for the Years 1950, 1960, and 1970.

	WHITE		NON-WHITE	
	NO.	%	NO.	%
1950	5,661	90.7	583	9.3
1960	6,470	93.6	439	6.4
1970	7,627	93.1	569	6.9

Source: PAR, 1973

Population within Cameron Parish is expected to increase slowly or moderately within the next decade. Table 2-20 shows population projections up to the year 1990 according to the Imperial Calcasieu Regional Planning and Development Commission (ICRPDC, 1974).

Table 2-20. Cameron Parish - Population Projections - 1980, 1985 and 1990.

Existing Population

1975	1980		1985		1990	
9,009	High	Low	High	Low	High	Low
	11,900	9,300	13,300	10,000	14,100	10,600

Source: ICRPDC, 1974

The town of Grand Lake is the only area of population concentration near the Prime Prospect Area. Population for Grand Lake in 1970 was 1,218 persons. Projected population for this community is shown on Table 2-21.

Table 2-21. Projected Population for Grand Lake - 1980, 1985, and 1990

	1980	1985	1990
Grand Lake	1,400	1,491	1,582

Source: ICRPDC, 1974

The figures presented in the table also reflect a slow to moderate rate of growth.

The majority of the population within Cameron Parish in 1970 was between 15 and 64 years of age representing 58.1 percent of the total population. The trend since 1940 is for a steadily growing population in the age group between 45 and 64, and of elderly people (over 65 years of age). A decrease in the age group between 15 and 44 is also notable indicating a possible migrating trend.

2.8.2 Ethnic Groups

The first white settlers came into the area in the mid-nineteenth century and were largely Anglo-Saxon. Later in the nineteenth century French Canadians

arrived in the parish (Public Affairs Council of La., Inc., 1973), becoming hunters and trappers. The French Canadian influence is dominant in Cameron and Calcasieu parishes today, and the area is considered to be part of Acadian Louisiana (Bertrand, 1976).

2.8.3 Socio-economic Characteristics

The principal basis of Cameron Parish's economy is agriculture and petroleum extraction, though services including government represent the biggest major industrial employer (Table 2-22). Examination of statistics reveals a decrease in agricultural employment from 1950 when agriculture was the leading employer. Petroleum extraction was the main major industry employer in 1960 (22.7%) but declined by 1970 (16.0%). In 1970, manufacturing represented the third major industry employer with 11.8 percent of the total labor force.

Median family income for 1969 was $7,726.00 for Cameron Parish making it 17th among other parishes. Forecasted median family income for 1980 is $11,500, for 1985 is $13,000 and for 1990 is $14,600 (ICRPDC, 1974). Rural farm family income for 1969 was $8,905.

Per capita income in Cameron Parish for the year of 1972 was $2,691, representing a 24.5 percent increase over the 1970 personal income of $2,161.

2.8.3.1 Agricultural Economy

The principal crops in Cameron Parish and in the Prime Prospect Area are rice and soybeans.

While the number of farms has decreased since 1954 (See Table 2-23), the average size of farms has steadily increased.

Table 2-22. Percentage of Persons in Cameron Parish Employed by Major Industry, 1950, 1960, 1970.

Employed by Major Industry	1950 Number	1950 Percent	1960 Number	1960 Percent	1970 Number	1970 Percent
Total	1,861	100.0	1,887	100.0	2,601	100.0
Agriculture, forestry & fisheries	678	36.5	306	16.2	336	12.9
Petroleum Extraction	285	15.3	429	22.7	416	16.0
Construction	194	10.4	198	10.5	219	8.4
Manufacturing	128	6.9	138	7.3	306	11.8
Furniture	0		0		0	
Primary and fabricated metal	0		0		0	
Machinery	3		0		12	
Elec. Machinery	1		0		0	
Motor vehicles	0		0		0	
Transport Equip.	7		18		34	
Other durables	0		0		9	
Food & kindred	59		69		144	
Textile mill and apparel	0		0		3	
Printing, publishing	1		4		10	
Chemical	47		21		27	
Other nondurable	10		26		67	
Railroad	0		0		6	0.2
Trucking service	19	1.0	8	0.4	9	0.3
Other Transport	90	4.8	76	4.0	164	6.3
Communications	4	0.2	8	0.4	17	0.7
Utilities & sanitary	4	0.2	20	1.1	84	3.2
Wholesale trade	22	1.2	16	0.9	95	3.7
Food & dairy	48	2.6	41	2.2	22	0.8
Eating & drinking	61	3.3	61	3.2	122	4.7
Other retail	49	2.6	151	8.0	45	1.7
Finance, ins. & real est	4	0.2	17	0.9	29	1.1
Business & repair serv.	33	1.8	54	2.9	101	3.9
Private households	21	1.1	47	2.5	38	1.5
Other personal service	24	1.3	32	1.7	33	1.3
Entertainment	8	0.4	5	0.3	15	0.6
Hospitals	8	0.4	13	0.7	50	1.9
Education	76	4.1	113	6.0	136	5.2
Other Prof. Service	11	0.6	29	1.5	63	2.4
Public administration	54	2.9	62	3.8	111	4.3
Other	40	2.2	63	3.3	184	7.1

Table 2-23. Number of Farms and Average Size of Farms in Cameron Parish.

	No. of Farms	Land in Farms	Average Farm Size	
1954	649	N.A.*	158 ha	(391 ac)
1964	462	284,585	250 ha	(616 ac)
1969	423	287,385	275 ha	(679.3 ac)
1974			302 ha	(746 ac)

*Not Available

Sources: ICRPDC, 1974, Public Affairs Research Council of La., Inc., 1973, USACE, 1976

In the year of 1974, there were 26,606 ha (65,693 ac) of total cropland in the parish. Harvested cropland accounted for 9403 ha (23,217 ac). Cropland in pasture were 16,127 ha (39,820 ac) and 1076 ha (2,656 ac) had other cropland. Cattle are also raised in the Prime Prospect Area. A common practice is to rotate a year of rice with two years of pasture or two years of rice with three years of pasture.

2.8.3.2 Petroleum Extraction

Cameron Parish is the leading parish in natural gas and oil production of the five parishes that make up the planning district of the Imperial Calcasieu Regional Planning and Development Commission. The parish accounted for more than half of the total production for 1970, as shown in Table 2-24.

In order of value, the minerals produced in Cameron Parish are: petroleum, natural gas, natural gas liquids, and sand and gravel. Other minerals produced in the parish are salt and shell.

Table 2-24. Cameron Parish Oil and Natural Gas Production

	Crude Oil Barrels	Condensate Barrels	Casinghead & Natural Gas - Mcf
Cameron Parish	16,275,000	9,807,400	905,452,000
Total Planning District	28,160,000	16,270,300	1,187,289,000

Source: ICRPDC, 1974

Five petroleum fields are located within or near the Prime Prospect Area: Sweet Lake, 1215 ha (3,000 ac) which in 1975 produced 735,828 barrels of crude oil and 321,200 MCF of casinghead gas; Sweet Lake North, 32 ha (80 ac) which in 1975 produced 18,045 barrels of crude oil, 14,904 barrels of condensate and 123,990 MCF of dry gas and 30,962 MCF of casinghead gas; W. Chackley, 81ha (200ac) which was inactive in 1975; N.W. Chackley, 421 ha (1,040 ac) which produced 399,065 MCF of dry gas in 1975; and Grosse Savanne, 65 ha (160 ac) which was inactive in 1975.

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3.1 Impacts Due to Drilling and Maintenance

3.1.1 Geology

Effects of hydraulic rotary drilling and well construction on the physical geology of well sites can be divided into two classes:

1) Effects related to well construction procedures, practices, or methods and well maintenance, and
2) Effects attributable to fluid withdrawal rate, depth, and duration, in production operations.

Most of the effects of well construction on the physical geology of the site are local, and can be measured in meters or tens of meters from the borehole. Only two procedures, hydraulic fracturing and squeeze (high-pressure) cementing may have effects observable at distances of hundreds, or even thousands of meters, from the borehole. Both of these downhole operations are highly specific with regard to depth and geologic setting; hydraulic fracturing is done to improve the permeability of a sandstone, by filling pressure-induced fractures with sand grains larger than those of the fractured formation; and squeeze cementing is done to seal off a fluid-producing zone in a permeable formation. In some areas, these procedures have been known to produce measurable uplift of the land surface, and even to result in observable fractures, but in the areas considered here, where hydraulic fracturing and pressure cementing in oil-test and production wells is a common practice, no such effects have ever been known to occur.

Well maintenance, in terms of procedures that might be employed to preserve or enhance the yield characteristics of geothermal production wells, might include acidizing or hydraulic fracturing, or both. Again, these procedures have not produced observable changes at the land surface, where properly employed.

3.1.2 Physiography

Drilling and maintenance of the proposed action will have no significant adverse impact on the Prime Prospect Area. The Pleistocene Terrace is essentially level and is easily shaped to conform to desired pad configurations. There are no geologically unique areas in the Prime Prospect Area.

3.1.3 Soils

Drilling and maintenance of the proposed action will not have significant adverse impact on the soils of the Prime Prospect Area. Erosion may be expected from installation of the test well; however, it is not expected to increase overall soil loss from the land because the Pleistocene Terrace is agricultural. Crops of rice, soybeans, and pasture are rotated throughout the area and have resulted in sediment input into watercourses.

3.1.4 Groundwater

A groundwater well may be required to provide water during drilling operations. No measurable impacts are expected due to the limited duration of the activity and the limited volume of water required. Because groundwater needs are negligible, impacts such as surface subsidence and saltwater intrusion are not expected to result from any of the drilling or maintenance operations.

It is likely that some brine, drilling muds, and possibly hydrocargons (fuels and lubricants) will be lost to the surface at the drill site by inadvertent spills. Surface spills will permeate the soil, especially during dry periods, but only to some shallow depth due to the limited volumes likely to be spilled. Whether a spill is brine or fluid hydrocarbon, the effect will be

long-lasting and difficult or impossible to remove. However, the impact will be small because the depth of contamination will be limited to near the surface and the area of the spill should be limited to the drill site. Fresh groundwater resources of the Chicot aquifer, separated from the surface by more than 46 m (150 ft) of fine-grained deposits, should not be affected.

Subsurface impacts of drilling under normal operating conditions will be negligible because of the surface casing program required by rules and regulations of the Louisiana Department of Conservation to seal off and protect the freshwater aquifers with properly cemented casing to be certified by pressure testing and geophysical logging.

3.1.5 Surface water

Potential impacts to surface water from drilling and maintenance are those associated with any construction project and any development in an area. Land clearing and leveling, road and drill pad construction, increased vehicular traffic, and other activities associated with development and maintenance of the well will cause increased runoff and erosion rates, increasing turbidity locally, thereby degrading water use desirability or plant and animal habitat. Runoff from the construction site will contain oil and grease from vehicles and equipment and chemicals from drilling muds. Existing drainage patterns may be further altered by road or levee construction, or by resulting channel sedimentation. The nature and intensity of surface water use for agriculture around the proposed site will make containment of such potential pollutants especially important. Contaminants will be contained by levees surrounding the well which will be constructed in accordance with state regulations.

The test site is above the 100-year flood level (Fig. 2-11). Localized catastrophic flooding could wash toxic materials into irrigation canals and drainage canals which cross the rice fields. The nearest major waterway is the Gulf Intracoastal Waterway (GIWW), approximately 6 km (3.6 mi) to the southwest.

3.1.6 Wildlife and Vegetation

Expected impacts are dependent upon such factors as:

1) standard procedures involved in well drilling and maintenance,
2) well siting,
3) care taken in drilling and maintenance operations, and
4) mitigation measures incorporated into the drilling program.

The major impact expected from well drilling will be loss of habitat. Installation and maintenance of a geothermal well site within the Prime Prospect Area will require a commitment of up to 0.4 ha/km (1.7 ac/mi) for roads, and 1000 m^2 (¼ ac) for drill pads. An additional 1.6 ha (4 ac) will be temporarily committed for the combined use of equipment storage and laydown areas during installation. Vegetation and, therefore, existing wildlife habitat will be lost in these areas. Wildlife presently existing on these proposed transportation corridors will be lost or displaced.

Road construction and eventual road usage can also be expected to generate dust, especially during dry weather conditions. Dust coating the leaves of nearby vegetation can impair growth and reduce photosynthetic activity by reducing CO_2 exchange (Treshow, 1970). A slightly lower aquatic production in nearby water bodies may also result from increased surface water turbidity due to soil erosion.

A prompt surfacing of roads and other work areas will lessen the amount of dust generated. However, all of the soils in the Prime Prospect Area (Table 2-5) show a severe limitation to road building activities due to a high shrink-swell index and low strength of bearing capacity. Thus, even during a short well test period, road repair work may be necessary and thereby generate additional dust.

Drilling muds and their associated chemicals are to be reinjected before the site is abandoned. However, if any toxic materials are left in the area of the well site, they may remain at the site, since the clay subsoil would prohibit their leaching from the soil. They could then percolate to the surface, be taken up by vegetation and thereby be incorporated into the local food web.

The hunting recreation currently provided in most of the Prime Prospect Area will probably be curtailed for some distance around the well site. The well construction and maintenance may also decrease hunter success and the quality of the recreational outing.

3.1.7 Land Use

Direct impacts will be associated with the removal of Prime Farmland (as designated by the SCS) from production for the development of the proposed action. About 0.4 ha (1.7 ac) for each kilometer (0.6 mi) of access road constructed and 1000 m^2 (0.25 ac) for each drilling pad will be removed as a result of the proposed action. An additional 1.6 ha (4 ac) per drill site will be removed, adjacent to each well, during well drilling.

This is about .001% of the Prime Farmland in the Prime Prospect Area. The areas affected are scheduled to be converted to their previous (pre-project) conditions after plugging and abandoning each well. Therefore, this does not constitute an irreversible commitment of Prime Farmland to other uses. In order to minimize land use changes and environmental impacts, pipelines going to the injection wells will be laid next to the access roads or canals. The use of Prime Farmland will be minimized by keeping the test site as small as possible and by restoring it to the pre-project condition.

3.1.8 Socio-economic

The expected working force for the proposed action will consist of about 30 to 50 persons at any given time. The majority of them are expected to come from the more urban and industralized area of Lake Charles (neighboring Calcasieu Parish), during the time of construction and testing operations (approximately 10 to 11 months in total).

Due to the small size of the operation and its short duration, impacts on public services will probably be non-existent, and economic impacts, if any, are not expected to be significant.

3.1.9 Air quality

Construction-related impacts on air quality will result from dust, exhaust emissions from construction machinery, and noncondensable gases released from geothermal fluids during preconstruction flow-testing. Since the land will be disturbed in connection with construction of additional drill pads, access roads, pipelines, and other related activities, dust will

inevitably be generated. Because the area to be disturbed and exposed to erosion is small (.4 ha/km [1.7 ac/mi] of roadway and 100 m^2 [.25 ac] for drill sites), and the road surface and site will be covered with clam shells to provide a protective cover, it is not likely that emissions from land disturbance will significantly affect air quality. If dust becomes a nuisance, the site and road will be wetted down periodically.

Exhaust emissions from drilling and construction machinery will include SO_2, NO_X, CO, hydrocarbons, and particulates. Diesel drives for the drilling rigs typically consume 2000 liters/day (550 gal/day) of fuel, resulting in emissions of approximately 23 Kg/day of CO, 9 Kg/day of exhaust hydrocarbons, 107 Kg/day of NO_X, 7 Kg/day of SO_X, and 7.5 Kg/day of particulates (ERDA, 1976). The emissions associated with the operation of diesel-powered equipment for 5 days to prepare a well pad would be equivalent to those associated with a single day of drilling. A small amount of polluting emissions will also result from the operation of delivery trucks and private vehicles. These releases are expected to be minor, short-term, and should be readily dispersed because about 62 percent of the time the atmospheric stability classes are in D and E (Section 2.6.2). The accumulated level of impacts due to exhaust emission from drilling and construction machinery is negligible.

Noncondensable geothermal gases will be released during drilling (ERDA, 1976). Although the weight of the drilling mud should prevent a large release of gases to the surface during drilling, the mud will carry some gases to the surface. These gases will be released to the atmosphere from the water/steam separator at the well, from the drilling-mud cooling tower, and

from the liquid sump. Maintenance of sufficient pressure within the well to protect against blowouts should result in acceptably low levels of gaseous emissions during drilling. Impact on air quality due to blowout will be discussed later. Because the exact chemical characteristics and magnitude of the gaseous releases are unknown, an air quality monitoring program will be implemented during the 60-day test. The resulting data will provide information to support the decision on whether or not to continue with the project.

3.1.10 Recreation, Archeological, and Historical Data

No direct or indirect impacts associated with drilling and maintenance upon recreational, archeological, and historical sites are expected from the proposed action. A detailed site survey has been conducted and no archeological or historical sites or artifacts were identified (see Appendix B).

3.1.11 Federal, State, Regional, and Local Land Use Programs

None of the responding agencies see any conflicts with the proposed action. Therefore it is assumed that there will be no adverse impact on their land use programs.

The SCS (Ezernack, 1978) did identify the Pleistocene Terrace in the Prime Prospect Area as Prime Farmland.

3.1.12 Noise

Noise levels observed by the Radian Corporation (1979) for the Bureau of Economic Geology, the University of Texas at Austin in 1978, on a 2100 horsepower drilling rig are anticipated to be generated by the

drilling of the wells at the Sweet Lake proposed well site. Noise levels generated by the drill rig were loudest perpendicular to the engine exhaust, not in the direction of the exhaust. During a two-hour time period, they found the loudest noise from the drill rig to be as follows:

at 31 m (100 ft)	89 dBA
at 91 m (300 ft)	78 dBA
at 183 m (600 ft)	65 dBA
at 275 m (900 ft)	56 dBA

Figure 2-16 depicts the anticipated noise level produced by the drilling rig in the Ldn metric as derived from the Radian Corporation data. Because no data are available concerning the precise orientation of the drill rig exhaust, the worst case was assumed in Figure 2-16, that is the case with the loudest direction pointing at the closest developed area.

All current noise regulations are based to some degree on the land use of the receptor area. Those land uses most likely to be affected by increased noise levels are called sensitive receptors. A sensitive receptor can be defined as a land use whose primary function is devoted to an activity where quietude is a critical factor of use. Such sensitive receptors could include churches, hospitals, rest homes, and certain parks. Some animals may also be considered sensitive receptors. However, a survey of the project area and current literature revealed no fauna in the study area known to be permanently affected by the noise. The nearest receptors, permanent residences, are .5 km (.3 mi) from the proposed well site. Those residents will temporarily be subjected to approximately 50 dBA during the period the well is drilled and vented.

3.2 Impacts Caused by Flow-testing or Operation of the Proposed Action

3.2.1 Geology

The possible environmental impacts of geopressured geothermal resources development have been identified as: 1) land subsidence and 2) contamination of, or hydraulic effects upon, (a) the surface environment in the vicinity of the well site; or (b) the subsurface environment, consisting of aquifer systems, both fresh and saline, in the vicinity of the well site. All such impacts would be of a secondary nature, occurring as a consequence of fluid withdrawal, or fluid escape, from formations in the geopressure zone.

Land-surface subsidence as a result of fluid production from the subsurface is a complex hydrodynamic phenomenon related to the drainage function of fine-grained sediments, mainly swelling varieties of clay, which is closely controlled by the geometry of sediment facies distribution in the zone of hydraulic stress, the salinity and temperature of formation waters set in motion by the hydraulic stress, and the effects of structural deformation, mainly faults, as subsurface hydraulic barriers. Faults in the Louisiana Gulf Coastal Plain reflect natural hydrodynamic effects, their location and the movement on them being mainly the consequences of differential compaction of sandy sediment facies and adjacent clayey sediment facies, in response to progressive compressive stress due to increasing overburden load, concurrent with continuing prograding deltaic deposition. Movement on such faults is likely to be renewed if the pressure of interstitial fluids in the fine-grained sediments is reduced, resulting in effective stress differentials greater than any the sediments have previously experienced. Reactivation of movement on existing faults as a consequence of compressive stress induced by removal of

fluids from the subsurface by wells is common in the Gulf Coastal Plain of Texas, and is evident in a few localities in Louisiana. All such movements are attributable to fluid pressure declines in reservoirs of the hydropressure zone only.

Susceptibility of any locality to land subsidence as a consequence of fluid withdrawal from reservoirs in the hydropressure zone is related to the hydrologic history of the locality, and of the region in which it occurs. If the deposits in a coastal area have been preconsolidated by loading stress, either as a consequence of Pleistocene lowering of sea level, deep trenching by rejuvenated coastal streams, and lowering of the water table by several hundreds of meters below its present "static level"; or by natural water level decline before fluid withdrawals through wells, then there will be no subsidence of the land surface until the head of water in these deposits is lowered by pumping below the level reached in the geologic past. The Holocene deposits, which overlie the Pleistocene deposits, have not been pre-stressed by natural drainage, and are highly susceptible to compaction as a result of fluid withdrawal and consequent head decline. Land subsidence from fluid withdrawal is common where Holocene deposits are affected.

Deposits in the geopressure zone occur within a natural pressure vessel; interstitial fluid pressure reflects part, or all, of the weight of overlying deposits. Beneath a regionally extensive "seal," now mapped in considerable detail in the Gulf Coastal Plain, geopressure conditions extend downward thousands of meters - perhaps to the zone of rock metamorphism at depths of 10,675 to 12,200 m (35,000 to 40,000 ft). The depth to the top of the geopressure zone ranges from about 2,440 to 5,490 m (8,000 to 18,000 ft) in south Louisiana. It is at a depth of about 2,745 m (9,000 ft) in the vicinity of the Prime Prospect Area, and about 3,660 m (12,000 ft) in the vicinity of the LaFourche Crossing

prospect. Sandbed aquifer systems occur in the geopressure zone thousands of meters below the pressure seal, and fluid pressure declines resulting from large-scale withdrawals from such aquifers commonly reduce reservoir pressures to hydrostatic, or below. However, the fluid pressure "envelope" in which these zones of low fluid pressure occur is unbroken, and no upward transmission of the zone of pressure relief is yet apparent. There is no well-documented example of land subsidence in coastal Louisiana resulting from withdrawal of fluids from reservoirs in the geopressure zone -- some 6,600 of which have produced some 6 Tcf of natural gas each year, for more than a decade. Some of these reservoirs have also produced millions of barrels of saltwater with the gas.

If production wells are properly constructed, negative impacts are not likely on the physical geology in the vicinity of the well site. (These improbable negative impacts could be contamination, or hydraulic effects upon the land surface or the subsurface environment). Pressure relief as a function of fluid production tends to close, rather than open, fault planes; well design will preclude serious thermal effects on the near-surface rock environment; and suitable disposal wells will return spent brines to regional salaquifer systems.

Effects of flow testing on the physical geology of the well sites are those resulting from fluid pressure changes in the reservoirs tapped by the wells. Flow tests involve relatively small total volumes of produced fluids, by comparison with the volumes of fluid withdrawn during commercial operations on an annual basis, for example. Detailed records for wells and well fields which have produced from geopressured reservoirs comparable to the ones to be flow tested in the Sweet Lake area, indicate that no

adverse environmental consequences should result from flow testing. Geopressured zone reservoirs are known to have produced more than 100 million barrels of liquid equivalent (at 1,000 cubic ft of gas equals one barrel of liquid) over periods as great as 10 years with no measurable subsidence. Wallace (1962) provides records of production, Pz (where P = Pressure, and z = coefficient of expansion of the gas) versus cumulative production, and cumulative water production, for numerous geopressured gas reservoirs in south Louisiana -- some of which developed reservoir pressures less than hydrostatic without observable land subsidence.

3.2.2 Physiography and Soils

Because there will be no adverse impact on the geology of the Prime Prospect Area there will be no adverse impact on the physiography or soils.

3.2.3 Groundwater

During normal operating conditions, groundwater would not be impacted by flow testing with the exception of normal amounts of surface contamination of soils from inadvertantly lost brine. The impacts will be limited in area and not affect fresh groundwater in the Chicot aquifer.

3.2.4 Surface water

Impacts to surface water from this stage of the proposed action could result from disposal of the fluid brought to the surface, and from possible elevational and drainage gradient changes brought about by land surface subsidence or seismic activity. Thermal and chemical pollution could alter surface water quality. Elevation changes could alter surface flow patterns, disrupting irrigation and navigation uses or environmental systems

dependent upon existing gradient flows and water regimes. Additionally, such changes could increase saltwater encroachment in the wetland areas or in irrigation supply sources, canals, or impoundments.

3.2.5 Wildlife and vegetation

Potential impacts directly generated from flow testing and operation include liquid and gaseous effluents and noise. Potential impacts indirectly generated include dust, exhaust, and noise from increased automotive traffic to and from the well site. There are no known endangered or threatened species within the project area.

Geothermal effluents are extremely hot, saline to brine, and may contain concentrations of toxic elements in solid, liquid, or gaseous form. If released into the environment, any of these properties could cause adverse biological impacts. However, proper containment, insulation, and disposal (reinjection into saline aquifers) of geothermal products during normal operations should assure a minimal effect on the plant and animal life.

It may, however, be necessary to flare uncondensable geothermal gases instead of reinjecting them. This may cause local increases in H_2S, SO_x, or CO_2 levels. If the H_2S is in high concentration, it may lead to acidification of water which may in turn solubilize the trace heavy metals (Schieler, 1976).

The sulfur oxides and H_2SO_4 can be highly toxic to vegetation and aquatic communities. If wind conditions are light and these substances remain in the atmosphere near the ground or are washed onto ground surfaces by rainfall,

the soils and surface waters could become more acidic, and less conducive to plants and aquatic life. The impact will vary because plants and animals have differing tolerances to pH. For example, legumes can tolerate some degree of acidity. However, soybeans produce highest yields in soils having a pH of 6.5 to 7.0 (Peevy, 1972) and a lowering of pH as a result of acidification of the soils can be expected to lower crop yields. The most critical areas would be those with soils already somewhat acidic like Crowley silt loam, Morey sandy silt loam, and Beaumont clay with crops of soybeans or clover. A test of short duration should mitigate this hazard.

Noise, another direct product of the proposed action, should have no effect on plants and cause only temporary movements of animals away from the well site.

During periods of flow testing and operation, vehicular traffic to and from the well site is expected to increase. Automotive exhaust and dust may decrease vegetative productivity, especially for those individuals close to the roads but should not cause permanent damage.

If the well is tested or operates during the waterfowl hunting season, noise generated from the well operation and traffic moving to and from the well site may lessen the quality of the outdoor experience and decrease hunter success near the well site.

3.2.6 Land Use

There are no expected impacts on land use from the flow-testing and operation of the proposed action other than the commitment of land for the drilling of the proposed action.

3.2.7 Socio-economic

The socio-economic character of the Prime Prospect Area will not be affected by the flow-testing and operation of the proposed action.

3.2.8 Air Quality

Well-testing will result in the direct release of steam and a variety of other gases and particulates for approximately 70 days (ERDA, 1977a). The contaminant of greatest concern is hydrogen sulfide. No data is presently available on the hydrogen sulfide concentration in the Frio Formation in this project area. Hydrogen sulfide concentrations for the Frio along the Gulf Coast in Texas range from .32 mg/l to 1.6 mg/l (Kharaka et al., 1977). Concentrations from geopressured zones in the Frio in Vermilion Parish east of the Sweet Lake Prime Prospect Area range from .4 mg/l to .5 mg/l (Kharaka et al., 1979). The H_2S concentrations at the project will probably be between those values shown in Table 3-1. Hydrogen sulfide levels will be monitored in order to determine if a significant impact will occur. No Louisiana or Federal air standards for hydrogen sulfide presently exist. The H_2S odor threshold is .002 mg/l. Other gases that may be emitted are CO, NO_X, NH_3, CH_4, N_2, and H_2, based on typical noncondensable gas content for pressure fluids. Particulates released with the geothermal fluids or raised by equipment should not add

Table 3-1. Hydrogen Sulfide Concentrations in the Frio Formation.

Well	Field	County or Parish	H_2S Concentration mg/l
Kitchen #1	Chocolate Bayou	Brazoria, Tex.	1.6 [a]
Cozby #2	Chocolate Bayou	Brazoria, Tex.	.85 [a]
Gardiner #1	Chocolate Bayou	Brazoria, Tex.	.32 [a]
Rachel #66	East White Pt.	San Patrizio, Tex.	1.0 [a]
St. Un. A #9	Weeks Island	Vermilion, La.	.4 [b]
Edna Delcambre No. 1	Tigre Lagoon	Vermilion, La.	.5 [b]

Source: [a]Kharaka et al., 1977
[b]Kharaka et al., 1979

significantly to the background level of particulates in the proposed test site area. The short duration of these emissions makes it unlikely that the air quality will be significantly affected outside of the immediate area of the well.

The impact of flaring the gases from a single plume is expected to be small based on the experiences from similar geothermal well tests (ERDA, 1977a). Operational monitoring will identify the percentage reduction of the various pollutants resulting from flaring. This particular project is miniscule when compared to the many flares which exist in major refineries in the Lake Charles area where the air quality is still within standars (see Section 2.6.3).

The impact of the cooling tower, if required, is expected to be negligible because of the small size required for the single well operation. A possible impact would be the increased occurrence of fog (or the formation of "steam fog" during freezing temperatures in winter; but the frequency for this is small, since the mean number of days with temperature equal

or less than 0°C [32°F] as observed at Lake Charles is approximately 13 days per year).

3.2.9 Recreational, archeological, and historical sites

There will be no adverse impact on the known recreation or archeological or historical sites in the vicinity of the well site.

3.2.10 Federal, state, regional, and local land use programs

There will be no adverse impact on the known Federal, state, regional, and local land use programs in the vicinity of the well site.

3.2.11 Noise

Noise from engines may impact selected receptors in the vicinity of the proposed well site. However, it is not expected to exceed engine noises normally experienced along the nearby Louisiana highway.

3.3 Unavoidable Direct and Indirect Impacts

3.3.1 Impacts from Drilling and Maintenance - A Summary

The unavoidable impacts from drilling and maintenance may be summarized as follows:

1) Approximately 2 ha (5 ac) of Prime Farmland will be removed from productivity during the duration of the proposed action.
2) The Pleistocene surface is already modified by agricultural practices. Soil erosion is expected during the preparation of the road or canal to the site and at the well site, but this will not exceed what is already happening in the agricultural fields.
3) Small amounts of brine, drilling muds and hydrocarbons will be spilled during normal drilling and maintenance operations. However,

the impacts will be limited in areal extent and depth and not affect the fresh groundwater resources of the Chicot aquifer.

4) Roads will alter existing drainage patterns. Runoff will increase turbidity in watercourses and degrade water-use desirability and natural habitat.

5) The greatest impact due to drilling and maintenance of a well will be the loss of habitat for drill pads and access routes. Biotic productivity in and near roads used for access to the well site may be reduced. Hunter success and the quality of the outdoor experience near the well site may be reduced.

6) Because the concentration of total suspended particulate in the air is within standards at the Lake Charles area, the added impact on air quality due to construction is small. The accumulated level of impacts due to exhaust emission from drilling and construction machinery is also negligible.

7) There is potential for noise impact from the proposed action in the Prime Prospect Area. However, because of the rural character of the Prime Prospect Area, the impact will not affect a large number of people.

3.3.2 Impacts from Flow-testing and Operation - A Summary

The unavoidable impacts from flow-testing and operation may be summarized as follows:

1) In all probability, some brine will be lost to the soil but the impact will be local and will not effect groundwater resources.

2) Gaseous releases, noise, and increased traffic either directly or indirectly generated during testing and operation of a geothermal well may cause adverse biological impacts.

3) Well-testing will result in the direct release of steam and a variety of other gases and particulates for about 2 to 3 months. The short duration of these emissions makes it unlikely that the air quality will be significantly affected outside of the immediate area of the well. However, due to the noxious odor of H_2S, inhabitants within a 3.2 km (2 mi) radius of the well should be informed. This will require notifying approximately 265 people.

The impact of flaring the gases from a single plume is expected to be small; monitoring will provide more accurate measurement of effluents.

The impact of the cooling tower, if required, is expected to be negligible due to its small size. (However, it may cause a localized "steam fog" during freezing temperatures, but the frequency of such temperatures is only 13 days per year in the Prime Prospect Area.)

4) Some noise impact is expected from the operation of the flow-testing and operation of the proposed action. Such noise emissions will not affect a large number of people because of the rural character of the Prime Prospect Area.

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CHAPTER FOUR - PROBABLE CUMULATIVE AND LONG-TERM ENVIRONMENTAL EFFECTS

4.1 Adverse

4.1.1 Geology

Unless the test well blows out and craters, or flows out of control for a long time (months or years), there will be no long-term environmental effects. Geopressured zone reservoirs commonly show rapid fluid pressure recovery to conditions very close to initial reservoir pressure, following long periods of production at very large flow rates (Wallace, 1962). If the target reservoir of the Sweet Lake prospect is as described, its return to initial conditions following tests should be rapid, and no subsidence or fault activation is expected.

4.1.2 Physiography and soils

There should be no cumulative and long-term environmental effects on the physiography in the vicinity of the well site.

During normal operations, cumulative and long-term adverse impacts will be limited to soil contamination by small amounts of drilling fluids, fuels, lubricants and brine. Soil contamination by such fluids can have long-term effects, but the volume of brine leakage should be small and the impact would be limited to the production well, pipelines, and disposal well sites.

4.1.3 Groundwater

The Chicot aquifer should not be adversely impacted.

4.1.4 Surface water

There will be a change of water circulation patterns by roadbeds and other constructed impediments to surface flow. There is a possibility of water quality alteration from chemical and thermal pollution and from runoff containing lubricants and other toxins introduced into this environment by development of the proposed action. Finally, local water resources may be consumed for developmental or operational purposes.

4.1.5 Wildlife and vegetation

The probable cumulative and long-term effects are similar to those of most oil and gas well operations in Louisiana.

The chronic low level discharges of oil, bleed water, machine lubricants, and drilling muds from prolonged drilling activities may have a long-term, cumulative effect on biological productivity in the vicinity of the well. Coating of vegetation and sediments by oil-emulsion drilling muds, if used, could lead to the imparting of an oily taste to animals that feed on these materials. Drilling muds will render dabbling ducks inedible.

Localized biological deserts are common sites around tank batteries, separators and similar facilities (St. Amant, 1972). If brine discharges are present, salt accumulation on heavy soils would retard if not totally prohibit reestablishment of vegetation for many years (Coody, 1978; Landry, 1978).

4.1.6 Land use

Prime Farmland will be removed from production by the installation of the proposed action. The amount of Prime Farmland needed is .001 percent of the prairie farmland in the Prime Prospect Area.

4.1.7 Socio-economic

Due to the short construction and testing time period, and to the fact that there will not be a large influx of workers or specialized personnel into the Prime Prospect Area, no adverse cumulative and long-term environmental effects are expected to occur.

4.1.8 Air quality

There are no known long-term or cumulative impacts on the air quality of the Prime Prospect Area.

4.1.9 Recreation, archeological and historical sites

The only long-term effect on culture resources would be the damage to archeological and historical sites that could be induced by the greater accessibility to those sites near the access roads. Vandalism is a major problem and is irreparable. Structures associated with the proposed action may impair the visual integrity of a historic structure.

4.1.10 Federal, state, regional, and local land use programs

There will not be any adverse cumulative and long-term environmental effects upon institutional factors as a result of the proposed action.

4.1.11 Noise

The test site will be able to meet Federal noise regulations if positioned correctly and adequate mufflers are maintained. Since the majority of the noise produced by the operation will be during drilling, this effect will only be of short duration. Therefore, no negative long-term cumulative effects are anticipated from this project.

4.2 Beneficial

4.2.1 Geology

Beneficial effects to the physical setting, in terms of geology or subsurface hydrology, might include the creation of a relatively shallow reservoir of low-grade heat, formed by the waste-water disposal operation. This would be inconsequential if the volumes produced and disposed are small.

4.2.2 Physiography and soils

No known cumulative or long-term impacts on the physiography and soils of the well site area will result from the proposed action.

4.2.3 Groundwater

Testing and producing a geothermal well at the proposed location is not expected to produce beneficial effects for the local groundwater resources.

4.2.4 Surface water

If the constituency of the produced fluids allows, the produced waters could be used as a supplement to irrigation waters presently being used exclusively in the Prime Prospect Area. However, this is not planned at the present time, but could occur should circumstances warrant.

4.2.5 Wildlife and vegetation

Whenever land use changes occur, habitat for existing vegetation and wildlife is destroyed while habitat is created for other species. Land disturbances or changes in elevation, soil moisture, and soil or water chemistry will benefit species more tolerant of the newly created habitats.

4.2.6 Land use

There are no known beneficial impacts which may result from the proposed action in the vicinity of the well site.

4.2.7 Socio-economic

The beneficial economic benefits, if any, will be of a short duration. The expected working force will be small and will be probably commuting for only the time involved in the construction and testing operation. Should the project prove the resource feasible for development, there may be a great deal of economic activity in the future, but not necessarily from Federally funded projects.

4.2.8 Air quality

There are no known beneficial impacts to the air quality in the vicinity of the well site as a result of the proposed action.

4.2.9 Recreation, archeological, and historical sites

An intensive survey of the well site has been conducted and no sites have been identified (see Appendix D).

4.2.10 Federal, state, regional, and local land use programs

Local governmental agencies may develop and adopt rules and regulations regarding geopressured and geothermal resources exploration and exploitation, as they will realize the existing potential of these resources within their area of jurisdiction. No other beneficial cumulative and long-term environmental effects are expected as a result of the proposed action.

4.2.11 Noise

There are no known beneficial impacts from the noise of the proposed action on the well site or surrounding areas.

REFERENCES

Coody, Wayman, personal communication, Sweet Water Land and Oil Company, Belle City, Louisiana, 1978.

Landry, D. P., personal communication, Agricultural Extension agent, Thibodaux, Louisiana, 1978.

St. Amant, L.S., Louisiana Wildlife Inventory and Management Plan, Pittman-Robertson Section, Fish and Wildlife Division, Louisiana Wildlife and Fisheries Commission, New Orleans, Louisiana, pp. 92-95; 100-101, 1959.

Wallace, W. E., Water Production from Abnormally Pressured Gas Reservoirs in South Louisiana, Gulf Coast Association Geological Society, Transactions, v. 12, pp. 187-193, 1962.

CHAPTER FIVE - ACCIDENTS

As of the preparation of this document, there are no known detailed studies of well blowouts or other accidents associated with geothermal-geopressured wells in the Gulf Coast area. However, EPA conducted studies on two well blowouts in the wetlands of south Louisiana which indicate the possible areal extent of contamination from such accidents. These two well accident studies were on the Edna-Delcambre #4 well in Vermilion Parish, Louisiana (ERDA, 1976) and the McCormick Oil and Gas Well 1.6 km (1 mi) south of Intracoastal City, Louisiana (Castle, 1975). The Edna-Delcambre well blew fluid into the air approximately 30 m (100 ft). As a result of winds, brine fallout occurred at a maximum distance of 610 m (2000 ft) from the well site. At the McCormick Oil and Gas Well, maximum drift of fluid discharge was approximately 1828 m (6000 ft). Major contamination extended out 1525 m (5000 ft) and covered an area of 269 ha (665 ac) (Castle, 1975). The type of fluid and amount of discharge will depend on the character of individual wells. Some indication of what may be found in the Prime Prospect Area (Tables 5-1, 5-2, and 5-3) is available from other studies (Hankins et al., 1977; Wilson et al., 1977; Karkalits and Hankins, 1978). These estimates of components and concentrations were used to estimate the potential adverse impacts resulting from the proposed action.

OSHA guidelines protect worker health and welfare at the site of the proposed action. These programs are well defined and are the responsibility of the driller. The Department of Energy is directly concerned with reducing the potential of an accident which results in the uncontrolled release of heated brines and other fluids and gases into the environment. In order to reduce the

Table 5-1. Summary of Water Analyses from an Edna Delcambre Well.

Component	Sand #3	Sand #1
	Concentration, mg/l	
Total Dissolved Solids	115,000	133,000
Total Hardness (as $CaCO_3$)	6,100	6,800
Chloride	67,000	80,000
Silicate (as SiO_2)	58	57
Bicarbonate (as $CaCO_3$)	1,100	1,100
Calcium	1,700	2,100
Magnesium	160	180
Iron	7	11
Zinc	<1	1
Strontium	290	400
Boron	60	63
Sodium	43,000	46,000
Potassium	290	290
pH	6.2	6.1

Source: Hankins *et al.*, in press

Table 5-2. Range of Concentrations Reported for Louisiana Geopressured Waters.

Component	Concentration, mg/l Minimum	Maximum	Number of Analyses Reported
Total Dissolved Solids	200	345,000	64
Sodium	10	103,000	65
Potassium	50	1,100	45
Calcium	8	33,000	65
Magnesium	0	24,000	63
Chloride	10	201,000	66
Sulfate	0	407	61
Bicarbonate	0	2,500	65
Lithium	2	18	46
Strontium	3	265	10
Barium	4	1,000	34
Bromine	14	213	44
Iodine	5	74	45
Boron	18	67	38

Source: Wilson *et al.*, 1977

Table 5-3. Typical Gas Analysis from Delcambre Test Well

Component	Mole %	
	Sand #3	Sand #1
CO_2	1.08	2.03
N_2	0.29	0.13
CH_4	92.78	95.36
C_2H_6	3.47	1.73
C_3H_8	1.12	0.37
i-C_4H_{10}	0.42	0.09
n-C_4H_{10}	0.32	0.09
i-C_5H_{12}	0.14	0.05
n-C_5H_{12}	0.09	0.04
C_6's	0.09	0.02
C_7 plus	0.20	0.09

Source: Karkalits and Hankins, in press

possibility of such an accident, blowout preventers will be installed, high pressure pipes and valves will be used, and casings will be cemented into place and overlapped. Annular space of each well will be cemented completely from the formation to the surface to provide greater stability to ensure sealing of aquifers. A spill prevention control and countermeasure plan will be devised. Weighted mud and high pressure mud pumps capable of injecting mud into the well to control pressures will be used during the proposed action. Well design and drilling plans will be reviewed by the Louisiana Department of Natural Resources as a prelude to their issuance of a permit to drill.

5.1 Accidents During Site Preparation and Access Construction

5.1.1 Geology

Negligible effects on geologic conditions may be expected as a consequence of accidents during site preparation and access construction.

5.1.2 Physiography and soils

Accidents may cause spillage of oils or other toxic fluids into the Prime Prospect Area. The extent and severity of such an occurrence will depend on the type of spillage.

5.1.3 Groundwater

Contamination may result from the spillage of oils or other toxins. The degree of impact will depend on the amount of spill and the location of the spill.

5.1.4 Surface water

Accidents during preparation and access construction would be those common to any construction or industrial development requiring use of heavy machinery, vehicles, and petroleum or other toxic products. Leaking or overturned lubricant tanks would introduce pollutants into surface drainage. Fire and explosion could have the same effect. Toxins in drilling muds and other materials being brought to the site represent a potential impact if they are, by accidental leak or collision, allowed to mix with surface waters.

In the particular setting of the proposed action, construction activities could accidentally close drainage ditches or breach levees, dikes, or other retaining structures. The effect would be to alter established surface flow patterns, allowing otherwise segregated water sources to mix.

5.1.5 Wildlife and vegetation

Accidents having the greatest probability of occurrence during site preparation and road construction include spills and fire. Accidental spills directly on vegetation of lubricants, fuels, drilling muds or chemicals would probably kill exposed plants. When washed into aquatic systems, they could damage the habitat for food chain organisms and higher aquatic forms. A list of some common constituents in drilling muds and their relative toxicities are listed in Table 5-4. Such spills should be contained to assure a minimum of damage.

The extent of damage would also depend upon the clean-up procedure. Surfactants might prove more harmful to vegetation than the original spill (Cowell, 1969). Burning might remove a major portion of the hydrocarbons, and while it would

Table 5-4. Some Constituents Used in Drilling Fluids and Muds and Selected Toxicities

CONSTITUENT[1]	COMMENTS[2]	CONCENTRATION IN MUDS[2] (ppm)	96 hr. TLm[3] Fish	96 hr. TLm[3] Sea	TLV[4] (mg/m³)
X Quebracho extract	Biodegradable	6,000-15,000	135	158	
x Lignosulfonates, calcium and chrome derivatives		12,000	7,800	12,000	10.0
Acrylonitrites (such as hydrolyzed polyacrylonitrite)					
Sodium salts of meta and pyrophosphoric acid					
Natural gums					
Tannins					
Molecularly dehydrated phosphates					
Subbituminous products					
Protocatechuic acid					
Barite					
Lignins (such as humic acids)					
Bentonite		15,000-105,000	14,500	100,000	<10.0
Sugarcane fibers					
Lime	irritating to skin and eyes	1,500-6,000			5.0
Granular material, such as ground nutshells		6,000-90,000			
Corn starch					
Saltwater					
Soluble caustic/lignin product					
Carboxy methyl cellulose					
X Crude oil					
X Sulfonated crude oil					
X Oil emulsions					
X Sodium chromate	must not be discharged to environment	750-6,000			0.5
Anionic and nonionic surfactants					
Organophylic clay		1,500-6,000	3,000	8,600	10.0
X Soaps of long-chain fatty acids		66,000-120,000	570	140	10.0
Phospholipids (e.g., lecithin)					
X Asbestos	very toxic	15,000-30,000			2 fibers/cc
Unisteam					

X = Greatest potential adverse impact on local vegetation and fauna

Source: 1) Collins, 1975, p. 463
2) O.P.G.E.E., 1977
3) 96 hr. TLm: the ppm required to kill 50% of the organisms in 96 hours
4) TLV: Level of pollutant below which a worker could be subject for 8 hours a day for 5 days a week.

destroy existing vegetation, reestablishment of perennials should not be retarded. Burning as a clean-up operation for major oil spills is currently practiced in coastal Louisiana and has the support of the Louisiana Wildlife and Fisheries Commission (St. Amant, 1972; Castle, 1975). In other instances, plowing under in agricultural areas or pick up from water bodies would be the most suitable cleaning procedures and should be used when and where possible. Spills due to site and road preparation and construction would probably be localized and minor, and not necessitate major clean-up operations.

Depending on moisture conditions at the time, accidental fires could spread through the area until extinguished or until reaching waterways of sufficient size to stop the fire. Fires should have little impact on the vegetation of the immediate area since the area is currently maintained in early successional stages through normal agricultural practices or common marsh management techniques, i.e., burning (O'Neil and Linscombe, 1977). However, fires should be controlled as soon as possible, especially in agricultural areas to prevent loss of agricultural crops during the growing season.

5.1.6 Land use

In case of an accident during site preparation or road construction, further prime agricultural lands could be removed from or permanently damaged for production. Accidents involving trucks or vehicles with volatile fuel cargoes could affect settlements or recreational areas depending on the proximity of the accident to the site of the proposed action and the extent of the accident. The level of activity and risks involved with delivery of volatile fuel cargoes is similar to that for typical drilling operations by oil companies on the Louisiana-Texas gulf coast.

5.1.7 Socio-economic

There may be an adverse impact to the individual should an accident occur, but in general there will be no overall impact on the socio-economic character of the region.

5.1.8 Air quality

During site preparation and access construction, the impacts on air quality will result from dust, exhaust emissions from construction machinery, and noncondensable gases released from geopressured fluids during preconstruction flow-testing. These releases are expected to be minor, short-term, and should be readily dispersed because about 62 percent of the time the atmosphere stability classes are in D and E (Section 2.6.2).

5.1.9 Recreation, archeological and historical sites

Accidents during site preparation and access construction would have little or no effect on recreation, archeological or historical sites.

5.1.10 Federal, state, regional, and local land use programs

There will be no long term impact on any Federal, state, regional, and local land use programs. Should the accident occur near one of these activities, such as a state highway, there may be disruption of service until the accident is controlled.

5.1.11 Noise

There should be no long-term noise impact resulting from accidents.

5.2 Accidents During Drilling and Operation

The DOE will initiate precautionary measures which will reduce the potential for accidents. These measures are discussed in Section 5.1.

5.2.1 Geology

Accidents that might have serious impacts on the geologic conditions and subsurface hydrology are (1) blowout with cratering, or (2) uncontrolled flow at very high rates. When a blowout occurs, the producing formation may be seriously damaged by erosion, collapse, and structural deformation in the vicinity of the well bore, with similar and even more widespread effects in overlying formations. With destruction of well casing by explosive movement of water and sand upward, cratering begins. Blowout craters more than 610 m (2000 ft) in diameter, with boiling hot water and mud discharging steam, have been formed in South Louisiana in several oil drilling accidents where wells penetrated the geopressure zone. Craters have boiled for months before killing themselves, or being brought under control by wells drilled nearby to kill them.

Although the petroleum industry has developed sophisticated blowout prevention equipment against any known eventuality, malfunctioning equipment, human error in judgment, or negligence occasionally can lead to blowouts. A detailed description is available of drilling risks and mitigating measures unique to geopressured zones in the Gulf Coast region (Energy Research and Development Administration, 1977). While the probability of a blowout in geopressured

zones has not been studied in detail, and information on blowout rates is presently unavailable, it is known to be substantially higher than that for the oil industry as a whole (the majority of oil wells are drilled in normally pressured reservoirs). The oil industry, however, has frequently drilled into the geopressured zone and has prevented blowouts in all but the most exceptional cases. The significant impact of a major blowout is evidenced by the few instances when one did occur. Factors which reduce the potential for blowouts are knowledge of the subsurface, expertise of the driller, use of proper blowout prevention equipment (BOPE), properly weighted drilling muds, properly selected and installed casing strings, and proper completion practices (all of which are reviewed by the Louisiana Department of Natural Resources prior to their issuance of a permit to drill).

Accidents during drilling can permanently damage target reservoirs and all prospective overlying reservoirs, by physical disruption as well as long-lasting hydrologic effects. However, the geologic damage is likely to be local in extent. The hydrologic and hydrodynamic effects could be widespread and long-lasting, especially if dissolved gas is released in vapor phase in several overlying aquifers, as appears to have occurred as a consequence of the Tigre Lagoon blowout in 1969. Cross flow of saline waters and the contamination of shallow freshwater aquifers as a result of blowout are likely to be local in effect.

5.2.2 Physiography and soils

Contamination of soils may result from a blowout of the well during the drilling phase of the proposed action.

5.2.3 Groundwater

Significant threats to the quality of local groundwater could arise as a result of accidents which would cause deep formation brines to enter freshwater aquifers during drilling and operation of the geopressured well and the associated brine disposal wells. Fresh groundwater could become permanently contaminated with brine high in NaCl and other constituents such as boron (Gustavson and Kreitler, 1976). Possible groundwater contamination mechanisms include:

*Surface brine spills from uncontrolled well blowouts
*Subsurface blowouts
*Lost circulation zones encountered during drilling
*Loss of brine due to hydraulic fracturing of the disposal aquifer or the casing cement
*Brine loss through leaky or inadequately plugged abandoned well casings
*High pressure hazards to future drilling into disposal formations

The former three mechanisms -- surface blowouts, subsurface blowouts and lost circulation -- could occur with both production and brine disposal wells. However, because production wells will penetrate geopressured reservoirs and brine injection wells will be completed in normally pressured sands within a few thousand meters of the surface, blowout hazards should be limited to production wells.

The latter three mechanisms --hydraulic fracturing, brine loss through abandoned wells and pressure build-up disposal sands -- are potential problems limited to the brine disposal well operations.

Of all the hazards, the most immediate is a blowout of the deep production well. Problems associated with excessive pressures developed during brine disposal are unlikely in view of experience in brine disposal operations in the Sweet Lake area. The Louisiana Department of Conservation (1976) reported

that a total of 86.85 million barrels of brine had been injected into saline aquifers at the Sweet Lake Field by 1975. A geopressured well producing 20,000 barrels of brine daily would flow for 11.9 years to produce this volume. Brine disposal wells at Sweet Lake Field include one completed in a 46 m (150 ft) thick sand at -610 m (-2000 ft) capable of injecting 40,000 bbl per day at surface pressures less than 350 psi. Similar favorable conditions for brine disposal are anticipated for the region of the well site.

In normal drilling operations the weight of the mud column in the hole is higher than the encountered formation fluid pressures. Hence, fluids do not flow from the formation into the well. If the weight of the mud column is less than formation pressure, an uncontrolled vertical flow of formation fluid can result in a blowout.

Drilling into deep, geopressured reservoirs requires all reasonable preventive measures be taken to maintain control of the well. Operational blowout preventers are required by the rules and regulations of the Department of Conservation. Drilling mud programs can take advantage of formation pressure data obtained from wells already drilled into the geopressured resource to assure that adequate mud weight is maintained.

If equipment malfunctions or other accidents result in a well blowout, drilling muds and formation fluids spilled on the surface would contaminate the soils and shallow sediments. The extent of contamination is dependent on the volume of fluid produced and the length of time the well is out of control. Limited volumes of fluid can be impounded at the well site to control the area of impact. High flow rates could result in contamination over a larger area, but drainage from

the Pleistocene Terrace to the coastal marsh to the south would remove much of the brine, reducing the impact to local arable soils. Groundwater resources in the Chicot aquifer are not likely to be affected by a well blowout at the surface.

Blowouts can occur totally below the surface if fluid from one formation (not necessarily geopressured) is lost to another formation of lower fluid pressure. In the worst case, a brine flow could be established from a deep saline aquifer into the fresh groundwater aquifer around the well bore. Such an occurrence should be prevented by the required surface casing and cementing program which is designed to seal off the freshwater resources. Should a subsurface blowout occur, a large volume of brine could be introduced into the Chicot aquifer and local domestic wells may be adversely affected. The "slug" of contaminating brine could be partially removed from the aquifer, if it could be located, by a system of specially designed wells.

During drilling, drilling muds and other fluids can enter the fresh groundwater aquifer in zones of "lost circulation" where the aquifer is highly permeable (gravel zones) and the pressure exerted by the column of drilling mud is greater than the fluid pressure in the aquifer. Lost circulation can usually be corrected by varying mud weight and viscosity or ultimately casing-off the problem zone. Aquifer contamination from this source is expected to be insignificant because the amount of fluid lost before circulation is reestablished will be small (a few barrels perhaps) and the fluid will likely be freshwater based mud.

Brine must be injected into saline sands which are under hydrostatic pressure (i.e., formation pressure is equal to the pressure produced by a column of water of height equal to the depth of the aquifer concerned). If injection pressure approaches or exceeds geostatic pressure (the weight of the overburden, about 1 pound per foot of depth), the area around the well bore and the formation can be fractured. Vertical flow paths could be created and brine could be forced into shallow freshwater aquifers.

Hydraulic fracturing is unlikely in normal brine injection operations because injection pressures are maintained well below fracture pressures. Aquifers of adequate volume for safe containment of the required volume of brine disposal, similar to the disposal sands at Sweet Lake Field, are expected to exist.

Brine injection will undoubtedly increase the formation pressure in the receiving formation. Although the increase is expected to be localized around the well and to dissipate when injection is stopped, it is possible that abandoned wells cased through the same disposal reservoir have leaky, inadequately plugged casings which provide vertical flow paths for release of injection pressure build-up. Injected brine or native formation brine could be displaced through shallower casing leaks into saline sands, freshwater aquifers or even to the surface. Subsurface leaks are unlikely to be detected. Abandonment records of all wells near the planned disposal wells should be checked to insure an adequate plug exists below the base of fresh groundwater.

If brine disposal aquifers are totally confined, they will permanently retain the pressure increase produced during brine injection. It is possible the pressure could be higher than that anticipated in future drilling ventures in the area. Future operators must be aware of any unnatural formation pressures created in previously normally pressured formations so that back-flows and blowouts can be avoided.

Brine disposal experience at Sweet Lake Field indicated that the creation of permanently pressured disposal reservoirs is unlikely. Such a possibility can be avoided by monitoring the disposal well to assure that the aquifer volume is sufficient to receive the brine without excessive pressure increase.

5.2.4 Surface water

Accidental discharge of geopressured fluids to the surface poses the greatest potential impact to surface water. High temperatures and pressure of the geopressured resource increase the possibility of accidents during drilling. Blowouts, thermal wellhead and casing cracks, scaling and clogging of injection wells, leaks, spills, and human errors could all result in venting of the produced fluids to the surface where they could be introduced into surface waters by drainage, seepage, or flooding.

Dorfman and Deller (1976) list these impacts from surface disposal, whether routine or accidental:

1) Contamination of shallow aquifers and soils from leaks or flooding;
2) destruction of non-salt-tolerant vegetation adjacent to water courses;

3) interruption of animal migration patterns;

4) disruption of food chains and ecological balance in estuarine waters; and

5) thermal pollution.

Produced geopressured fluids range in temperature from 150°C to 260°C (302°F to 500°F) (Drofman, 1976). The highest recorded temperature in the Gulf Coast region is 273°C (523°F) at a depth of 5859 m (19225 ft) (Dorfman, 1976). Chemical composition of the produced fluids varies from formation to formation. Sabadell and Axtmann (1975) report a high probability of environmental pollution by trace metals from geothermal sources.

Table 5-5 lists tolerance levels suggested by EPA (1976) for selected constituents. The range of relative hazard of constituents for which data are available can be evaluated by comparing the listed tolerance levels with levels of constituents found in Louisiana geopressured fluids. The range of relative hazard is calculated by dividing the observed maximum and minimum concentrations by the appropriate limit (Schieler, 1976). This gives a number which indicates how much, if any, a given concentration exceeds maximum allowable concentrations (Table 5-6).

On the basis of these available data, barium, TDS, and chloride are the constituents which appear to present the greatest potential hazard. However, unknown hazards from toxic trace elements whose concentrations

Table 5-5. EPA Suggested Water Quality Criteria.

Constituent	Domestic	Aquatic
Alkalinity ($CaCO_3$)	20 mg/l	
Ammonia	0.02 mg/l	
As	50 µg/l	
Ba	1 mg/l	
Be	1100 µg/l	
B	750 µg/l	
Cd	10 µg/l	
Chlorides	250 mg/l	
Cr	50 µg/l	100 µg/l
Cu	1 mg/l	0.1 96-hr.LC_{50}*
Cn	5 µg/l	
total dissolved gasses	110% saturation value	
Fe	0.3 mg/l	1 mg/l
Pb	50 µg/l	100 µg/l
Ma	50 µg/l	100 µg/l
Hg	2 µg/l	0.1 µg/l
Ni	0.01 96-hr. LC_{50}	
N	10 mg/l	
Phenol	1 µg/l	
P	0.01 µg/l	
Se	10 µg/l	0.01 96-hr.LC_{50}
Ag	50 µg/l	0.01 96-hr.LC_{50}
Sulfates	250 mg/l	
TDS	500 mg/l	
Turbidity	limit 10% reduction in photosynthetic activity point	
H_2S	2 µg/l	
Temperature	a) increase in weekly average no greater than 1 C (1.8 F) b) daily cycle not altered in amplitude or frequency, summer maximum not exceeded	
Zn	5000 µg/l	0.01 96-hr.LC_{50}

*LC_{50} - the concentration of a toxicant which is lethal (fatal) to 50% of the organisms tested in a specified time.

Source: EPA, 1976

are unknown and for which no tolerance limits have been established may prove to be far more hazardous.

Table 5-6. Range of Relative Hazard of Known Geopressure Fluid Constituents

Constituent	Range of Concentration (ppm)	Tolerance Level for Domestic Supply (ppm)	Range of Relative Hazard
TDS	200-345,000	500	0.4-690
Chlorides	10-201,000	250	0.04-804
Sulfates	0-407	250	0-1.6
Barium	4-100	1	4-1000
Boron	18-67	0.750	24-89
Sodium	10-103,000	270	0.04-381

All species of fish and other aquatic life must tolerate a range of dissolved solid concentrations in order to survive. Estuarine and marsh species tolerate changes from fresh to brackish to seawater. Abrupt changes in these aspects of water quality resulting from accidental discharge of geopressure fluids into surface waters could eliminate desirable habitat and cause plasmolysis of leaves and stems in vegetation. The following limits in salinity variation have been recommended to protect wildlife habitat (EPA, 1976):

Natural Salinity (ppt)	Variation Permitted (ppt)
0-3.5	1.0
3.5-13.5	2.0
13.5-35.0	4.0

Agricultural uses of water are also limited by dissolved solids concentrations. The following general classification of salinity hazards for irrigation water has been prepared (EPA, 1976):

Dissolved Solids Hazard for Irrigation Water (ppt)

Water from which no detrimental effects will usually be noticed.....0.5

Water which can have detrimental effects on sensitive crops.....0.5-1.0

Water that may have adverse effects on many crops and requires careful management practices.....1.0-2.0

Water that can be used for tolerant plants on permeable soils with careful management practices.....2.0-5.0

Table 5-7 lists tolerance limits for agricultural water use of known constituents in geothermal fluids. The table considers water uses for irrigation and livestock watering, pointing out known results of excessive concentrations of the constituents.

Undetected or accidental venting of effluents through surface or subsurface faults could occur for several reasons. Faulty installation of casing, choice of hydraulically unsuitable disposal aquifers or reinjection well sites, and wells improperly plugged during abandonment could allow the fluids to escape undetected at some distance from the well site through faults or land lenses with surface outcrops. Contamination of soils, reduction of water quality, and consequent threats to terrestrial and aquatic biota could result.

Table. 5-7. Agricultural Use Criteria for Constituents in Geopressured Fluids

Constituent	Criteria	Remarks
Ammonia		No criteria suggested.
Arsenic	0.1 mg/l	Toxicity to some crops at 0.5 mg/l; no livestock criteria suggested.
Barium		No criteria suggested.
Beryllium	.001 to .500 mg/l	Crop toxicity acidity dependent; no livestock criteria suggested.
Boron	0.75 mg/l	Toxic to sensitive plants, e.g. citrus at <1 mg/l; no livestock criteria suggested.
Cadmium		Reduced crop yields at 1 mg/l; crop accumulation related to zinc concentrations; no livestock criteria suggested.
Chromium		No criteria suggested.
Copper		Toxicity for plants begins at 0.1 mg/l; no livestock criteria suggested.
Iron		No criteria suggested.
Lead		Toxic to plants at <30 mg/l; no criteria suggested.
Manganese	0.2 mg/l suggested for acidiphilic crops	Toxicity to plants increases with decreasing pH; no livestock criteria suggested.
Mercury		Bio-accumulation but no criteria suggested.
Nitrates		No criteria suggested; nutrient for crops.
Phosphorus		No criteria suggested; nutrient for crops.
Selenium		No criteria suggested.
Silver		No criteria suggested.
H_2S		No criteria suggested.
Zinc		Toxic to some crops at 0.4 to 25 mg/l may cause iron deficiency in plants; no livestock criteria suggested.
Total Dissolved Solid (TDS)	5,000-15,000 mg/l suggested	Osmotic effects in plants; variable harm to both plants and animals.
Sodium		Toxic to certain plants; ratio to other cations important; no criteria given.

Source: EPA, 1978

5.2.5 Wildlife and vegetation

Accidents induced from blowouts, cracks in the well head or pipes, human error, or natural hazards (i.e., hurricanes, floods, subsidence, fault reactivation) could cause release of toxicants into the environment. The range and seriousness of the resulting impacts are dependent on the type, composition, quantity and length of exposure of the biologically degrading material released and various environmental factors such as wind speed and direction, light and atmospheric moisture.

Of these accidents, the blowout will probably have the most detrimental effect on the surrounding vegetation and fauna. The constituents of geopressured effluents and their concentration will determine their toxicity. Some of the expected constituents of geopressured brines are listed in Table 5-8. Comparison of concentrations in brine and acceptable standards are shown and those substances considered to be a hazard are marked with an X.

Sodium, potassium, calcium and magnesium are all necessary nutrients for plants. An elevated sodium level resulting from a blowout would be high for domestic use but is expected to be diluted before it enters streams or aquifers.

Chloride ion is the single most prevalent ion in brine. It can be detected by animals at low levels. Any increase in chloride, hardness or TDS levels in an area must be compensated for by increased respiratory demand of the local fauna and flora. The tolerance level of rice and soybeans is 1,500 ppm (Coody, 1978) for TDS. The salts may "sterilize" the soil for 10-25 years or more (Coody, 1978; Landry, 1978). Lower levels of TDS would impair productivity but not cause long-term damage. The major effects would probably be within 300 m (984 ft) of the well, and in agricultural areas could probably be confined to a single field. All of the

Table 5-8. Constituents in Geopressured Brines of Environmental Concern (ppm).

Hazard (X)	Component	Geopressured Waters of Louisiana[1] minimum	Geopressured Waters of Louisiana[1] maximum	Edna Delcambre No.1 Well[2] minimum	Edna Delcambre No.1 Well[2] maximum	Acceptable Standard[7]
X	Total dissolved solids	200	325,000	115,000	133,000	
	Total ($CaCO_3$) hardness			6,100	6,800	300[5]
X	Chloride	10	201,000	67,000	80,000	250[5]
	Silicates (SiO_2)			57	58	
	Bicarbonate	0	2,500	1,100	1,100	
	Calcium	8	33,000	1,700	2,100	
	Magnesium	0	24,000	160	180	
X	Iron			7	11	1.0
X	Zinc			<1	1	0.009-0.4[6]
X	Strontium	3	265	290	400	
X	Boron	18	67(75[10])	60	63	0.5-1.0
X	Sodium	10	103,000	43,000	46,000	270[5]
	Potassium	50	1,100	290	290	*[9]
	pH			6.2	6.1	
	Iodine	5	74			
X	Sulfate	0	407			250[5]
X	Lithium	2	18			0.1[9]
X	Barium	4	1000			50.0
X	Bromine	14	213			
	CO_2			1.08[3]	2.03[3]	
	N_2			.29[3]	.13[3]	
X	H_2S	3.1[4]				0.3-3.0[8]
	CH_4			92.78[3]	95.36[3]	
	Other Hydrocarbon gases			0[3]	3.47[3]	

Sources:
1) Wilson et al., 1977.
2) Hankins et al., (in press).
3) Karkalits and Hankins, (in press).
4) CSCPC, 1970.
5) Tolerance level for domestic supply, using 7.
6) .01 of the 96-hour TL_{50} for fresh water fish fry or eggs
7) EPA, 1976.
8) Thompson and Kats, 1977.
9) Trashow, 1970. * indicates a toxic substance but no levels specified.
10) Gustavson and Kreitler, 1976.

soils in the Prime Prospect Area have a high clay content whose cation exchange capacity could extend the persistence of salinity problems.

Increased hardness (Mg, Ca) due to geopressured well effluents, while exceeding drinking water standards, may actually be beneficial since calcium and magnesium are necessary nutrients for plants. Increased water hardness raises the tolerance level of plants and animals to other toxic metals.

Heavy metals have been commonly found in geopressured waters and have been cited by many authors in the geothermal literature (Axtmann, 1975; Collins, 1975; Schieler, 1976; Balashov, 1975; Schmidt, 1973; Sabadell and Axtmann, 1975; and Koons et al., 1977). Similarly, Gulf Coast brines have been found to include significant levels of several heavy metals (Wilson et al., 1977; Hankins et al., 1977; Mayer and Ho, 1977), particularly zinc, boron, lithium, iron, strontium, barium, and bromide (Table 3-1).

Zinc may be a pollution problem in Gulf Coast brines (Table 3-1). It was found to be toxic to Pacific oyster larvae at 0.2 ppm even over a short period (Brereton et al., 1973) and to be harmful to freshwater fish fry or eggs within 96 hours (EPA, 1976). The levels of zinc in soluble and exchangeable forms and, hence, its availability to marsh plants and cultivated rice have been reported to increase with a reduction in pH and an increase in oxidation-reduction conditions (Cambrell et al., 1977a, 1977b; Jugsujinda, 1975). It would be most harmful on upland acidic soils under a dry condition.

A secondary effect of zinc contamination is to cause a shortage of manganese uptake, noted especially in soybeans, which lowers productivity and yield (Treshow, 1970).

Boron levels are very high in geopressured brines, sometimes over 75 times the maximum suggested by EPA (1976). Its effects are ameliorated on neutral to alkaline soils of high adsorption capacities (Biggar and Fireman, 1960), such as the fresh marsh. The upland areas would be most sensitive to boron additions where over 0.5 ppm would cause inhibition of flowering, chlorosis and lowered plant production (Treshow, 1970). Lithium, similarly, causes chlorosis, burning, and impaired plant growth at the levels present in geopressured brines. Iron, strontium, barium, and bromine may be in excess of tolerable limits to freshwater fauna and terrestrial and aquatic flora. Their uptake will probably be greatest under reduced oxygen conditions, such as those present in the marsh or flooded rice fields.

In summary, the availability of heavy metals to plants and ultimately the rest of the food chain is dependent on Eh, pH, and other constituents of the soil. The alternating of reduced and oxidized conditions such as is present in a terrace rice field makes these locations ideal for complexing and then solubilization of heavy metals. Thus, a spill during a flooded period would cause metals to be complexed under reduced conditions to form sulfide precipitates or to be surface absorbed onto organic matter or clays. A dry period or dredging could oxidize and break these complexes allowing a pulse of heavy metals to be released.

H_2S gas has been measured in the field near a geopressured site blowout at levels toxic or harmful to plants (Coastal States Gas Producing Co., 1970). This is probably a very localized phenomena.

In conclusion, there are many constituents in geopressured brines which can have detrimental impacts on flora and fauna. Toxicities are compounded by the high salt concentration of the brine and by high temperatures (Anderson, 1973), both of which may cause toxicity to occur at lower concentrations than under normal conditions. Fauna surviving the spray will avoid areas where vegetation has been destroyed. Fish kills can be anticipated in adjacent and downstream aquatic systems. Contamination of irrigation waters or agricultural fields may make hazardous the use of food produced there. It may be necessary to take those areas out of production. Measures should also be taken to discourage wildlife usage of the contaminated fields.

It is possible that a blowout may occur while drilling through an oil or gas formation. In such a case oil or gas could fall on the surrounding areas and may cause local damage and fires. The seriousness of such a spill would be dependent on the type of hydrocarbon, the dosage received, the physiography of area, weather conditions at the time of the spill, the type of local biota, the season of year, the previous exposure of the area to oil or other pollutants and the type of clean-up treatment implemented (Straughan, 1972).

Damage to flora would be most severe where the leaves are coated with oil. Vegetation with oiled leaves will probably be killed (Baker, 1971). Perennial plants with underground storage structures will be most likely to survive (Baker, 1971). However, annuals may not repopulate the contaminated area in the immediate future following a spill.

Continued oilings may increase mortality of plants and even animals, especially in aquatic systems (Cowell, 1971). The time of year in which a blowout occurs has a direct bearing on survival of the biota (Cowell, 1969; Baker, 1971) with the greatest damage occurring during the reproductive seasons. The time of year least damaging to plants would be winter.

Hydrocarbons may migrate down into the soil (Dietz, 1973) and persist there for years (Blumer and Sass, 1972; Whelan et al., 1976) since the oxygen required for their microbial degradation (Zobell, 1973) may be limiting. An oil sheen on the sediment and leaf surfaces may reduce oxygen diffusion into the soil and lower vegetation productivity even though death does not ensue (Gebhart, 1973). Oxygen deprivation and toxicity may cause drastic reductions in aquatic animal life. The effects of such a spill would be to eliminate oil sensitive species, thereby changing the community structure (Burk, 1976). The significance of this to the productivity and diversity of the biotic community will depend upon the importance of the adversely affected species within the community (Treshow, 1970).

An oil slick resulting from a blowout could attract birds and would be most harmful during migrating periods when bird populations in south Louisiana are high (Erickson, 1963). Oil ingested during preening could line the alimentary tract and give lethal or sublethal doses of toxins to birds (Hartung and Hunt, 1966).

Aromatic compounds in oil are water soluble which increases their biological accessibility. They are also more toxic than other oil fractions (Resource

Tech. Corp., 1972). Their dispersal will depend on the area's physiography, air and water temperature, and weather conditions. Oils would be least likely to disperse rapidly in the winter and/or under calm wind and water conditions.

Clean-up operations might include burning, plowing, physical removal, surfactants, etc. The practices least likely to harm the area would include controlled burning and plowing under of fields on the terrace. The terrace areas are already diked and ditched and drainage is controlled for irrigation purposes. Oil pollution of a field or of irrigation waters could be easily contained with minimum environmental impact if rapid action is taken immediately following an accident. Mechanical removal of oil from the irrigation ditches and burning of agricultural crops or plowing of contaminated fields would only result in short-term productivity losses.

Subsidence, earthquakes or fault reactivation are considered very unlikely occurrences. Fire, either accidental or from controlled burning during spill clean up, will have the least impact on low, wet areas. On the terrace, agricultural crops can be replanted. Fire should have little long-term effect if promptly controlled.

5.2.6 Land use

In case of an accident during drilling or a well blowout, hypersaline geopressured fluids could spill onto agricultural areas. The impact of such an accident would result in the destruction of all vegetative cover which came in contact with the fluids. Agricultural productivity of the affected lands could be hindered for a long period of time. Past experiences with brine spills (over 3.5 ppt) into rice fields have made these fields unproductive even 10 years after the time of the accident (Coody, 1978). Brine

fall-out is documented to have occurred, as a result of wind action, as far out as 1830 m (6000 ft) from the well site (Castle, 1975).

Because of the proximity of the test site to a strip development and local recreational site, disruption of domestic or recreational activities may take the form of evacuation. Damage to the exterior of building structures is possible.

5.2.7 Socio-economic

A blowout and uncontrolled discharge of brines and gases will cause the evacuation of all houses, businesses, and churches in the area of impact. In the Tigre Lagoon accident, brines were carried a distance of approximately 610 m (2000 ft) (ERDA, 1976). At the McCormack Oil and Gas Well, maximum drift of fluid was approximately 1830 m (6000 ft). In total, a relatively few number of people will be adversely affected by such an accident because of the rural character of the region. Fields will also be polluted by the spill and will not be available for agricultural production for an undetermined period.

5.2.8 Air quality

By standards of normal oil field operation, extraordinary precautions will be taken in the proposed project to prevent blowout of the test well. Yet the possibility of a blowout should be considered in view of the high pressures anticipated in the geopressured zone. Some documentation exists on blowout occurrences at various geothermal fields (ERDA, 1976).

Since the emission rate of H_2S due to possible blowout from the proposed project is not known, one may calculate the impact on air quality as the result of the oxidation from H_2S to SO_2 from the experience gained by Edna Delcambre #4 well (ERDA, 1976).

The computation of SO_2 is based on the following assumptions:

A. Emission height is assumed to be about 30 m (100 ft). This is based on data that during both the first and second blowout of Edna Delcambre #4 well, saline formation fluid was blown about 30 m (100 ft) vertically into the air.

B. Emission rate of H_2S is assumed to be about 6.8 Kg/hr. This is based on a Union Oil Co. well testing, which produced a total flow of 22,500 Kg/hr., of which 3% was noncondensable gases. Ninety-nine percent of this was CO_2. If the remaining percent is assumed to be entirely H_2S, the total emissions of H_2S would equal 6.8 Kg/hr.

C. Atmospheric stability is assumed to be F, the moderately stable condition commonly used as the air pollution computation for safety analysis.

D. Wind speed during stability F, which occurs about 14% per year, in the Prime Propsect Area is 1.7 m/s. This is given in the Section 2.6.2.

E. Blowout will result in the burning of the gas, which in turn will result in oxidation of the H_2S to SO_2. Available data showed that 620 grams of H_2S would produce 1136 grams of SO_2.

On the basis of the preceding information, the maximum concentration of SO_2 may be computed from standard EPA techniques to be about 192 $\mu g/m^3$. The distance of this maximum concentration is expected to be about 1.6 km (1 mi) downwind from the blowout well. Although the concentration of SO_2 is below air quality

standards, because of the noxious order of H_2S, the area within 3.2 km (2 mi) radius from the blowout well should be warned and necessary precautions taken.

In summary, the impacts of the proposed project on air quality are insignificant during construction and operation. However, should blowout occur, the most important pollutant will be SO_2, and its maximum concentration is below national ambient air quality standards. No adverse effect on air quality is anticipated even under conservative estimates during stable atmospheric conditions. The effect of inversion layer is also small, because the minimum height of that layer is about 520 m(1706 ft) above ground (see Section 2.6.2).

5.2.9 Recreation, archeological, and historical sites

There are no archeological or historic sites on the well site to be affected by the proposed action.

5.2.10 Federal, state, regional and local land use programs

A well blowout may result in the closing of state highways.

5.2.11 Noise

With the possible exception of explosions, the loudest accidental noise level from the well site would be if the well were venting in an unmuffled condition. Anticipated noise levels produced by this occurrence have already been discussed in Section 3. Accidents of this type may result in broken windows in buildings at the well site.

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CHAPTER SIX - COORDINATION WITH FEDERAL, STATE, REGIONAL AND LOCAL AGENCIES

6.1 Programs and Permits

At present there are several Federal, state and local agencies which have programs, regulations or permits pertaining to geothermal activities, or to activities involved in geothermal exploration and development (Harrell et al., 1978).

Several agencies at all levels of government were contacted and asked to identify any rules or regulations that they may have affecting the proposed testing of a well site in Cameron Parish for geothermal resources. A list of the agencies contacted appears in Appendix E of this report. An asterisk identifies those that responded.

6.1.1 Federal

The accompanying Table 6-1 shows agencies at the Federal level which have rules, permits or programs concerning geothermal activities. Executive Orders which may affect the proposed action are also identified. Table 6-2 identifies major Federal legislation pertaining to particular valuable resources.

For more extensive data covering Federal programs, rules and regulations pertaining to the geothermal and geopressured resources, see Department of Energy (DOE), 1978.

6.1.2 State

In Table 6-3 state agencies which have rules, regulations, permits or programs related to the exploration and development of geopressured or geothermal resources in Louisiana are identified.

Table 6-1. Matrix of Federal Action on Geopressured-Geothermal Well Testing Activities and Related Oil Activities.

FEDERAL AGENCIES	Coastal Const. Activities	Navigable Water	Mineral Leasing on Public Lands, O.C.S Oil, Gas, Other Mining Leases, Permits & Other Act. Management Programs	Dredging and Filling Disposal of Dredge Material	Activities on Marine Sanctuary-Coastal Zones	Noise & Air Emissions	Effluent Disch. & Water Quality & Water Resources	Oil Pipelines (Interstate)	Fish & Wildlife Resources	EIS Review	Historic Sites Bldg. & Objects National Register	
Bureau of Land Management Dept. of the Interior			* ✓							X		43 USCA p. 1 et seq. OCS Land Set, 43 USCA pp 1331-1342
Bureau of Outdoor Recreation (Dept. of the Interior										X		16 USCA p. 460, 1; 16 USCA p. 460 1-4
U. S. Army Corps of Engineers	*✓	*✓		* ✓				* ✓		X		33 USCS sec. 408 (1960): 33 USCS sec. 404 (1960): FWPCC sec 404-33 USCS: Sec. 1344 (Supp 1976).
Dept. of Commerce Coast & Geodetic Survey, NOAA	* ✓				✓ *					X		Coastal Zone Management Act (1972) P.L. NO. 92-583, 86 Stat. 1280, & U.S.C.pp. 1431 et seq.; 15 USCA pp. 311, 330a: 15USCA p.1501 et seq.
Environmental Protection Agency		* ✓		* ✓		✓ *	✓* ✓			X		FWPCA Sec. 402 (1976) 42 USCA Sec. 1857. 1858, 3521 et seq. 4901 et seq.: 21 USCA p. 346a; 33 USCA pp. 1251 et seq; 1[illegible]11 7
Federal Power Commission								*✓		X		USC p. 135 et seq. 16USCA pp. 791-825r:49 USCA pp 1671-1684: 15 USCA p. 717 et seq
Geological Survey			*✓							X		43 USCA p. 1334, 1337: 43 USCA p. 31 et seq. : 30 USCA p. 351 et seq.
Interstate Commerce Commission								*✓				49 USCA p. 1 et seq. ; 49 USCA p. 302 35 seq.; 49 USCA pl 901 et seq. 49 USCA p. 1001 et seq.
U. S. Coast Guard	*✓	*✓							✓	X		33 USCA p. 1221; 46 USCA p. 526; 33 USCA p. 14d; 33 USCA p. 1002; 14 USCA p. 81 et seq.: 14 USCA p. 1 et seq.
U. S. Fish & Wildlife Service (Dept. of the Interior)			✓	✓					*✓	X		16 USCA pp. 742a-742k: 16 USCA p. 1361 et seq.
Water Resources Council							✓			X		42 USCA p. 1962 et seq: Fed. Non-nuclear Energy Res. & Dev. Act, 1974 Sec. 13
Energy Research and Development Administration (ERDA)			*✓							X		42 USCA p. 5812 et seq.42 USCA p. 2011 et seq.: Fed. Non-Nuclear Energy Res. Dev. Act. 1974, Sec 3, 30 USCA pp. 66[illegible]-668
Advisory Council on Historic Preservation										X	*✓	16 USCA 461-67 USCA 470-470m as ammended, 1973: 42 USCA 4321 et seq.1970
Executive Orders												
Floodplain Mgmt.												Executive Order 11988. May 24, 1977
Protection of Wetlands												Executive Order 11990. May 24, 1977

* Agencies Requiring Permits

✓ Agency Reviews EIS and EA or Reviews Applications

x Agency has Rules and Regulations Applying to Action

Table 6-2. Major Federal Legislation Pertaining to Valuable Resources

Resources	Federal Legislation
Water	Federal Water Pollution Control Act
Air	Clean Air Act
Endangered Flora and Fauna	Endangered Species Act
Floodplains and Erosion Hazard Areas	Flood Insurance Act
Barrier Island and Beaches	Coastal Zone Management Act
Historic and Cultural Resources	National Historic Preservation Act
Wildlife Refuges and Reserves	Pitman-Robinson Act; Dingall-Johnson Land and Water Conservation Fund Act
Areas of Unique Cultural Significance	National Historic Preservation Act
Minerals	Mineral Leasing Act
Prime Agricultural Lands	Homestead Act
Forests	National Forest Management Act
Living Marine Resources	Fisheries Conservation and Management Act; Marine Mammal Protection Act
Coastal Resources	Federal Consistency Provisions of the Coastal Zone Management Act
Prime Farmlands	Section 302 Rural Development Act

Note: For more extensive data concerning Federal programs, rules and regulations pertaining to geothermal and goepressured resources, see Department of Energy (DOE), 1978.

Source: Federal Register, 1978a, 1978b; SCS, 1978.

Table 6-3. Matrix of State Actions of Geopressure-Geothermal Well Testing Activities and Related Oil Activities .

State Agencies Louisiana	Drainage of Noxious or Poisonous Subst. into Nat. W.W. & Canals	Coastal Activities (CZMP)	Mineral Leasing State Public Lands	Geothermal Leasing Public State Lands	Public Lands Right-of Ways. Highway Access	Activities in Scenic River & Streams	Oil, gas and geotherm. regul. Geol. or geophysical exploration	Effluents discharge (oil & gas, & geotherm). Water quality	Air emissions	Brine disposal	Fish & Wildlife Resources	Dredging & filling activities	Activities in or on archaeological landmarks. Cultural resources	Flood control, drainage, pipelines crossing waterways	Permit Reviews and/or EIS Review	Authorization
State Land Office			*x	*x	*x							*x				La. R.S. 41:1173-1174 Dec. 31, 1974; La. R. 41:1262-1268 Ammended by Acts 1970, No. 59: Acts 1974, No. 611; Title 30, p. 171-179.14
Louisiana Wildlife and Fisheries Commission			x			*x		*x							✓	Ch. 8 of Title 56, La. Rev. Stat. 1950, R.S. 56:1841-56:1849. Title 41, p. 12640
a) La. Stream Control commission								*x		x		x			✓	La. Rev. Stat. 56:1433; La. Rev. Stat. 56: 1431-56:1446 Div. of Wat. Pollution Contr. of L.W.&F. Comm.
b) Office of Coastal & Marine Resources	*x									*x					✓	La. R.S. 56:1453 et seq.,1950; La. R.S. 56: 1461-63; La. R.S. 56:1464-1464.4
c) Office of Wildlife											x					Administers wildlife refuges, and programs of research on wildlife
La. Dept. of Transportation and Development																Senate Bill 930. Act 361. July 14, 1978. Submitted to the Secretary of Commerce for its approval.
a) Coastal Zone Mgt. Prog.		x														
b) Office of Highways					x											L.S.A. - 48; 344
c) Office of Public Works														*x		
La. Archaelogical Survey and Antiquities Commission													*x		✓	L.R.S. 41:1601-1603 as ammended by Act 37? of 1974 La. standards for cultural resourc surveying is in draft form.
La. Air Control Comm.									*x						✓	Title 40 Sec. 2204 of Title 40 of La. Rev. State, 1950. Title 40, Sec. 2201 et seq. A 259 of 1964. Has given auth. to La. Dept. Health to administer regul. applying to an source of air emissions.
a) La. Dept. of Health								*x	*x.							R.S. 40:2204(A) Title 40 Sec. 2201 et seq., 259 of 1964
State Mineral Board			*x	*x			*x									Title 30, Ch. 3 Sec. 211-216, La. Rev. Stat of 1950 as ammen. by Act 175 of 1954. Titl 30. p. 121-129, p. 151-159, p. 171-179.14
Dept. of Urban & Community Affairs															✓	Executive Order 60 A-95 Review
La. Dept. Office of Natural Resources (Office of Conservation)							*x			*x		x				Title 30, Order 29-E Act 134, Act 735; Ord. 25 B. La. Geothermal & Geopressured Energy & Dev. Act, 1975. Title 30, Ch. 7 (Act 73: 1975): Ch. 8 (Act 784: 1975). Statewide or 29-P. July 20, 1978

* Agencies Requiring Permits ✓ Agency Reviews EIS and EA or Reviews Applications x Agency has Rules and Regulations Applying to Action

On July 20, 1978, rules and regulations governing the drilling for and production of geothermal resources in the State of Louisiana became effective. These rules and regulations are compiled under Statewide Order No. 29-P. They are available at the State of Louisiana Office of Conservation, Baton Rouge, Louisiana.

In Table 6-4 a summary is presented of the forms that must be submitted in the State of Louisiana for the drilling and production of geothermal resources.

6.1.3 Regional and local

The only regional or local governmental agency with executive and legislative authority in Cameron Parish is the Parish Police Jury.

The Parish has an ordinance providing land use and control measures which complies with Federal guidelines and makes the Parish eligible for flood insurance under the National Flood Insurance Act of 1968, as amended 1971, and the Flood Disaster Protection Act of 1973, as amended (Emmer, 1977).

No comments have been received from the Parish Police Jury pertaining to the proposed action, which leads to the assumption that they do not have any rules or regulations affecting the proposed action.

The Imperial Calcasieu Regional Planning and Development Commission sees no conflicts with the proposed action.

ble 6-4. Forms that Must be Submitted in the State of Louisiana for the Drilling and Production of Geothermal Resources.

ency	Office	Form No.	Description
pt. of Natural source	Conservation (District Office)	GR-10	Applications for permits to drill wells for geothermal development below the fresh water sands
"	"	GR-4	Applications for permits to repair or workovers
"	"	WH-GR	Well History & Work Resume Report
"	District Manager original to Office of Conservation Baton Rouge	GR-Operator's Monthly Rept.	Monthly Production
"	District Manager Office of Conservation	GR-4 and WH-GR	Directional drilling
"	District Manager Office of Conservation	GR-10-A (Application for Amended Permit to drill for Geothermal Resources)	Change of Operator
"	"	GR-5PD	Well off production or no longer in use as a service well
"	"	GR-4 Work Permit	Intention to plug any well or wells

6.2 Land Use Plans

Federal, state, regional and local agencies were contacted by letter dated July 10, 1978, requesting information on identification of conflicts that might result from the proposed action with any active and proposed plans which they may have. The list of the agencies contacted appears in Appendix E.

6.2.1 Federal

The Gulf Intracoastal Waterway (GIWW) is a channel built and maintained by the U.S. Army Corps of Engineers and is the closest federal project to the well site.

The only known Soil Conservation Service project is the "Cameron Watershed Project" (SCS, 1978) (Fig. 6-1). Some of the area affected by this project lies very near the Prime Prospect Area. Increased agricultural utilization of this area may be expected as a result of this SCS project.

As far as the Maritime Administration is concerned, the only potential conflict that could occur from the proposed action is if it interferes with waterborne commerce on a navigable waterway.

It is assumed that other agencies contacted which have not replied have no identifiable conflict regarding the proposed action.

6.2.2 State

A list of state agencies contacted regarding conflicts of their plans and the proposed action is included in Appendix E. None of the state agencies which responded see any conflicts with their plans.

6.2.3 Regional

The Imperial Calcasieu Regional Planning and Development Commission (ICRPDC) is the regional agency in charge of the Imperial Calcasieu Planning District which comprises the five southwestern Louisiana parishes of Cameron, Calcasieu, Allen, Beauregard and Jefferson Davis.

Cameron Parish is the largest parish in the Imperial Calcasieu Planning District (ICRPDC, 1974). Due to its extensive swamps and marsh areas, development is concentrated along cheniers and high ridges alongside existing roads and highways. There are no incorporated cities or towns in Cameron Parish. Main utility and petroleum lines are shown in Figure 6-1.

Agricultural lands consisting of rice fields, soybean fields and pasture are mainly formed in the northern parts of the parish. Table 6-5 shows a land use summary of Cameron Parish.

Existing and projected land use plans developed by the IRCPDC depicts the study area and its vicinity mainly as an agricultural area with built up lands representing the community of Grand Lake and some strip development (ICRPDC, 1975). Wetland areas encompass the southern portion of the Prime Prospect Area. Present land uses are depicted in Figure 2-18. The majority of the land is in rice fields, soybean fields and pasture. Built up areas are along LA 384 and LA 27 (the major transportation arteries across the Prime Prospect Area), in a strip development. Churches, schools, a power station and the main recreational facilities in the Prime Prospect Area are also depicted in Figure 2-18.

Slow or moderate growth within the next decade is expected to take place along existing highways in the form of strip development. Low lying areas

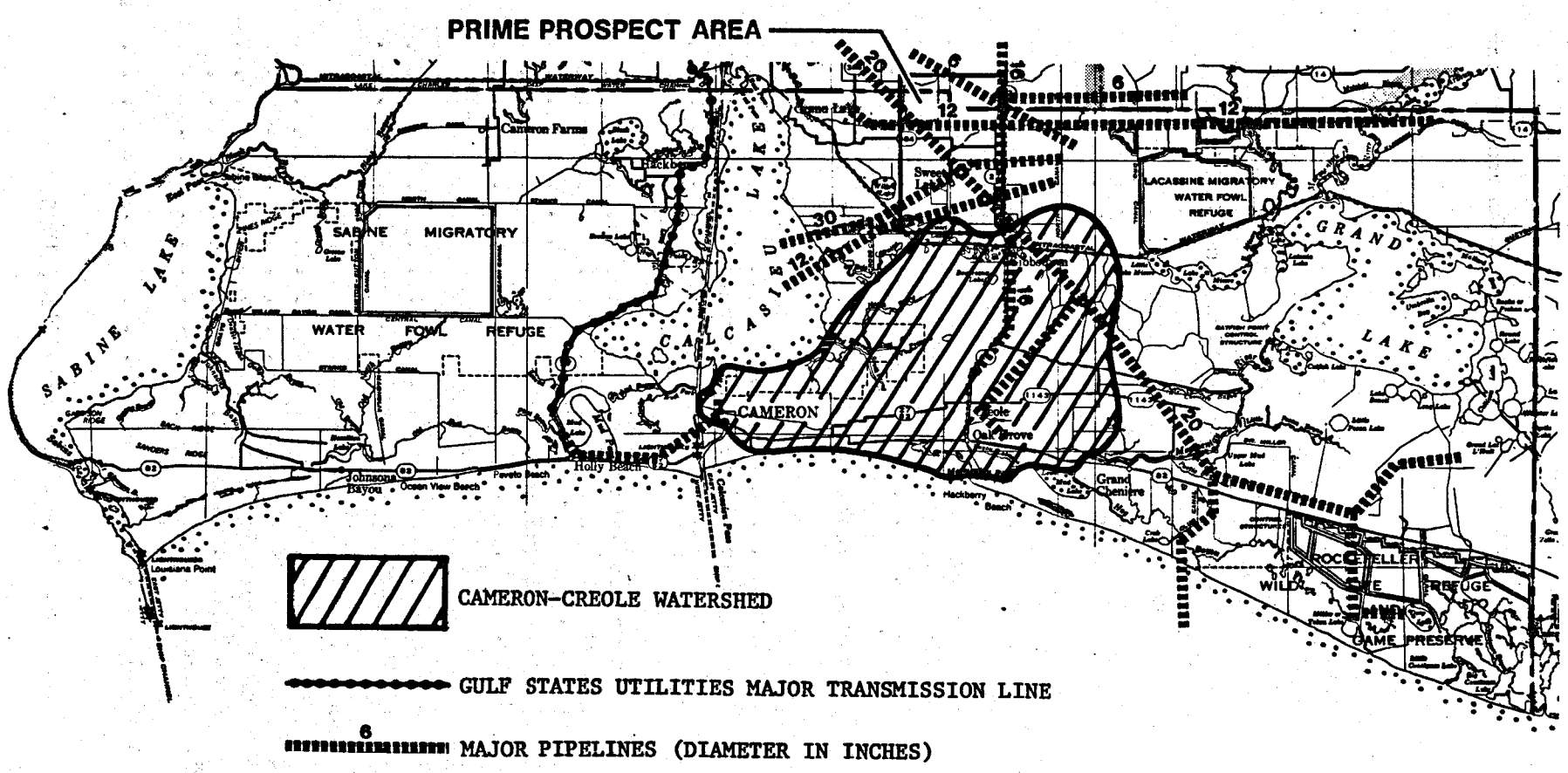

Fig. 6-1. Federal programs and utilities in the Prime Prospect Area (ICRPDC, 1976 and Department of Conservation, 1973).

Table 6-5. Summary of Existing Land Use - Cameron Parish

LAND USE CATEGORY	ACRES
Urban and Built-up Land	
11. Residential	494
12. Commercial and Services	-0-
13. Industrial	247
14. Extractive	9,139
15. Transportation, Communications and Utilities	247
16. Institutional	247
17. Strip and Clustered Settlement	741
18. Mixed	-0-
19. Open and Other	-0-
Agricultural Land	
21. Cropland and Pasture	106,704
22. Orchards, Groves, Bush Fruits, Vineyards and Horticultural Areas	-0-
23. Feeding Operations	-0-
24. Other	-0-
Rangeland - Not Applicable	
Forest Land	
41. Deciduous	-0-
42. Evergreen (coniferous and other)	-0-
43. Mixed	-0-
Water	
51. Streams and Waterways	17,043
52. Lakes	180,557
53. Reservoirs	-0-
54. Bays and Estuaries	-0-
55. Other	187,226
Wetland	
61. Forested	1,729
62. Nonforested	841,282
Barren Land	
71. Salt Flats	-0-
72. Beaches	-0-
73. Sand Other than Beaches	-0-
74. Bare Exposed Rock	-0-
75. Other	4,446
TOTAL ACREAGE	1,350,102

Source: Louisiana State Planning Office, 1975.

with potential for flooding limit expansion outside higher grounds. The nearby community of Grand Lake is expected to slowly expand southeast along LA 384 (ICRPDC, 1975).

Industrial uses are expected to occur in the future south of the study area along the Gulf Intracoastal Waterway and near the area where LA 27 crosses the GIWW (ICRPDC, 1975).

Developed areas for the year of 1976 and projected development areas for 1985 according to ICRPDC are presented in Table 6-6.

6.2.4 Local

There are no known Parish land use plans for the Prime Prospect Area. However, Cameron Parish is eligible for the National Flood Insurance Program (Emmer, 1977), an indirect form of land use control. The flood-prone zones of the Prime Prospect Area are shown in Figure 2-11.

Table 6-6. Cameron Parish Existing and Projected Urban Acreages, 1976 - 1985.

	PRESENT ACRES	PROJECTED ADDITIONAL ACRES NEEDED	
	1976*	1980	1985
Residential	1,422	328	491
Commercial-Service	20	7	10
Industrial	426	163	244
Extractive	9,300	263	135
Outdoor Games	9	40	42
Swimming	9	-0-	-0-
Picnic	1	11	11
Boating	Indeterminate	-0-	-0-
Camping	5	15	16
TOTAL	11,602	888	1,041

*Base year was from 1972 USGS Land Use Maps, Louisiana Land Use Data Analysis (LUDA) information, field surveys, and existing plans.

Source: ICRPDC, 1976

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CHAPTER SEVEN - ALTERNATIVES

7.1 Delay

This project is designed to drill a well into a geopressure reservoir to evaluate the reservoir potential over a sustained period of flow testing. A previous well test in Louisiana was in an abandoned oil well, and although it provided important data, it was not in the optimum location. The delay of this project will restrict the availability of geopressure reservoir data on geopressure exploration techniques and severely restrict the amount of information available on the geopressured resource.

7.2 No Build

The No Build alternative is not consistent with Congressional mandate as directed by the Geothermal Energy Research, Development and Demonstration Act of 1974 (U.S. Congress, 1975). This act directs the Federal Government to encourage and assist private industry in the development and demonstration of practicable means of producing energy from geothermal resources in an environmentally sound manner. This assistance is to include resource assessment and research and development projects.

7.3 Alternative Approaches

The DOE through the geopressure subprogram is evaluating alternative methods for obtaining the necessary chemical and physical data on the geopressure resource. One method is to conduct a literature search of published and

unpublished reports or data. A second method is to redrill oil wells after they have been abandoned and the rigs are moved from the location. The literature search has not provided the necessary data in a form which is required to evaluate the resource. Schmidt (1973), Hankins (1977), Wilson et al., (1977), and Karkalits and Hankins (1977) provide some basic data, but not in sufficient quantity or in the optimum location for future development of the resource. Redrilling of abandoned oil or gas wells is economical but the wells do not always occur in optimum resource areas. It becomes a decision, then, of whether to expend limited funds for projects which may never be developed because of physical, cultural, or economic constraint.

There is serious doubt that the results of short-term flow testing would encourage industry to develop long-term flow testing on their own initiative because of 1) a lack of data on reservoir performance, 2) unlikely commercial development in the near-future, and 3) uncertainty regarding institutions and/or regulatory barriers to full scale commercialization.

7.4 Location

As stated previously, nine alternative sites were identified in response to the PRDA. Six sites were located in Louisiana: two in Cameron Parish, and one each in Calcasieu, Jefferson Davis, Acadia, and Terrebonne Parishes. The remaining three sites were located in Texas: one each in Waller and Harris County, and one in either Harris, Brazoria, or Fort Bend Counties. The confidentiality of the procurement process prevents identification of the specifics of these alternative sites.

A specific well site was selected within the study area. Well site selection is based on geologic, economic, and environmental consideration. The selected well site location is known to have adequate sand thickness and high temperature at drillable depth. Furthermore, a lease for mineral rights is available. In an environmental study of six prime geopressured-geothermal prospects of Louisiana (Newchurch et al., 1978), the Pleistocene Terrace area was judged to have the lowest impact on ecosystem, surface water, land use, and the lowest vulnerability to natural hazards (flooding). In this study, the upland prospect areas (Sweet Lake and Lafourche Crossing) were judged to be best suited environmentally for the geopressured test program. Impact on marshlands and wildlife refuges (high priority environmental issues) is considered also, especially since an upland site is possible which satisfies the objectives of the program.

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APPENDIX A

DRAFT ENVIRONMENTAL MONITORING PLAN:

SWEET LAKE NO. 1

DRAFT ENVIRONMENTAL MONITORING PLAN: SWEET LAKE NO. 1

INTRODUCTION

A DOE contractor will manage environmental baseline and monitoring studies for geopressured test well activities. The drilling and testing operations associated with the Sweet Lake geopressured well will be conducted within the scope of this Environmental Assessment (EA).

ENVIRONMENTAL BASELINE AND MONITORING STUDIES

The purpose of collecting environmental baseline data is to provide a description of selected physical, chemical, and biological conditions against which later environmental monitoring data can be compared. This comparison will provide a basis for determining the net environmental change attributable to test well operations at any subsequent time.

The following data shall be collected to establish the baseline of ambient conditions prior to fluid production:

<u>Air Quality</u>

existing air quality conditions
local meteorological characteristics
noise level monitoring

<u>Water Quality</u> (surface and subsurface)

existing water quality conditions
water resource usage
hydrologic patterns, surface and ground-water levels

<u>Subsidence</u>

subsidence history
leveling surveys

Seismicity

Microseismic surveys

Ecosystem Quality

biological surveys

In order to avoid duplication, information presented in this EA for the well test shall be incorporated where possible in the environmental baseline evaluation. For example, very little additional work may be required to establish existing ecosystem quality.

An environmental monitoring program designed to provide comparative data during drilling and production phases will include the studies listed below. The asterisk indicates the studies that are contingent upon the occurrence of environmental changes (e.g., changes in air quality and/or standards violation in the case of air quality) and are not considered in the base scope of work.

Air Quality

air quality monitoring
pollutant dispersion modeling*
continuous wind speed, wind direction, temperature, and precipitation
noise level monitoring

Water Quality

water quality monitoring
water level monitoring

Subsidence

repeated leveling surveys
tiltmeter surveys (maybe)

Seismicity

continuous microseismic surveys

Ecosystem Quality

biological surveys*
bioassays*

Monitoring studies may be increased if environmental conditions, either natural or as a result of test well activities and geopressure fluid analysis, require such adjustment.

The combined scope of environmental baseline and monitoring studies which are planned during the first year include the air quality, water quality, subsidence, seismic, and ecological studies described below.

1. Air Quality. Air quality studies will be performed to: 1) determine ambient air quality prior to possible disturbance from test well activities; 2) identify any substance potentially derived from the geopressured fluid that may have an adverse effect on the environment, and establish baseline concentrations for these substances; 3) collect locally available meteorological data necessary for understanding dispersion and conversion patterns; and 4) provide baseline data compatible with later measurements needed to assure compliance with state and Federal air quality standards.

   Air quality monitoring will be performed to determine changes in air quality which may be related to well testing activities. Sampling and analysis for hazardous substances will be from a fixed automated monitoring unit located approximately 1.6 km (1 mi) northwest of the test site (prevailing winds are from the southeast). Analyses will include continuous measurement of sulfur dioxide, hydrogen sulfide, total hydrocarbons, and methane. Meteorological data from continuous recorders shall include wind speed, wind direction, temperature, and precipitation. In the event of significant atmospheric pollutant emissions, dispersion characteristics will be determined.

Analytical procedures for air quality monitoring will be consistent with designated Reference or Equivalent Mehtods published by the U.S. Environmental Protection Agency (EPA), Monitoring and Research Laboratory, Research Triangle Park, North Carolina, November 3, 1978. Analyzer performance shall conform to specifications for automated methods as described in 40 CRF, Parts 50 and 53.

A baseline ambient noise level survey will be conducted prior to site development. Additional noise level surveys will be reported as decibels on the A-weighted sound level scale. Noise surveys will provide both the sound level exceeded 10% of the time during each measurement period, L_{10}, and the equivalent continuous level, L_{eq}. Noise level meters will conform to Type 2-General Purpose specifications for accuracy established by the American National Standards Institute (ANSI, S1.4 - 1971).

2. Water Quality. Water quality baseline studies will be conducted to determine: 1) ambient water quality conditions in local bayous and canals and in shallow groundwater prior to possible disturbance from test well activities; 2) baseline conditions for substances potentially present in the geopressured fluids; and 3) water resource usage and baseline concentrations for substances and physical properties for which state standards have been established.

Water quality monitoring studies will be performed so that changes in chemical and physical properties of surface and groundwater can be determined. Surface water samples will be collected monthly; surface water levels will be recorded at the time of sample collection.

Laboratory analyses to be conducted for each sample will include Na, K, NH_3. SO_4, Cd, Mn, Ca, Cl, Ba, Pb, As, B, Hy, total hardness (calculated), and total organic carbon. Field measurements shall include pH, specific conductance, turbidity, temperature, and dissolved oxygen.

Three or four observation wells will be drilled approximately 62 m (200 ft) into the zone of fresh groundwater. Groundwater samples will be collected each month. Field and laboratory analyses to be performed on groundwater samples will be the same as for surface waters. Water level in the observation wells will be reported monthly.

Ground- and surface water sample collection, handling, preservation, and analysis will be consistent with methods published by the EPA, "Manual of Methods for Chemical Analyzers of Water and Wastes" (1974), and the U.S. Geological Survey (USGS), "Recommended Methods for Water Data Aquisition" (1977).

3. Subsidence. Subsidence baseline studies will include an initial leveling survey to establish relative surface elevations, and an examination of historic leveling data and topographic maps to determine subsidence history in the vicinity of the test well.

The initial leveling survey shall consist of First-Order precise leveling. Leveling profiles will be tied to National Oceanic and Atmospheric Administration (NOAA) elevation benchmarks which are located beyond the area of potential subsidence impact. Procedures to be used in establishing benchmarks in the vicinity of the test will be in accordance with guidelines provided in the NOAA

publication, "Specifications to Support Classification, Standards of Accuracy, and General Specifications of Geodetic Control Surveys" (1978).

Subsidence monitoring will consist of first-order releveling surveys which will be conducted at 12-month intervals during production to document the occurrence of land-surface subsidence, if any, near the well site, or of differential surface movement along reactivated faults. First-year subsidence studies will include one leveling survey which will be conducted prior to the production of geopressured fluids.

4. Seismicity. Microseismic surveys will be performed to 1) determine background microseismic activity prior to disturbance from fluid production, and 2) monitor microseismic activity during fluid production. Baseline microseismic studies will include an initial reconnaissance survey to determine sources and levels of background microseismic activity. Data from this survey will be used to identify locations for permanent monitoring installations which will be least influenced by natural and cultural background noise.

Continuous microseismic monitoring will be performed using seismometers emplaced in sealed boreholes at least 3 m (10 ft) below ground surface. Microseismic monitoring studies will provide the origin time of local seismic events, their estimated locations, and their relative magnitudes. The microseismic monitoring net will be operative approximately 6 months prior to fluid production.

5. Ecosystem Quality. Baseline ecological studies will rely on existing published and unpublished data to establish ranges and populations of plant and animal species in the vicinity of the test well. Additional biological surveys will be conducted in the event of significant impact to plant or animal life, but are not considered part of the base scope of work.

ENVIRONMENTAL PROGRAM MANAGEMENT

The management of environmental monitoring will include insuring that data collected is compiled, analyzed, and reported to the U.S. Department of Energy (DOE) on a quarterly basis, or more frequently if necessary. The DOE contractor will provide for contractual arrangements with firms for performance or selected field and laboratory studies. Overall data interpretation and impact assessment will be performed by LSU investigators. The DOE contractor will be responsible for determining if Federal, state, and local environmental quality standards are being met, and will inform DOE in the event of non-compliance, as well as informing DOE when an increase or decrease in baseline monitoring studies are required.

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APPENDIX B

WILDLIFE

Table 1. Freshwater Fish Whose Range Includes the Sweet Lake Prime Prospect Area (After Douglas, 1974).

Common Name	Scientific Name
spotted gar	Lepisosteus oculatus
Longnose gar	Lipisosteus osseus
alligator gar	Lepisosteus spatulata
bowfin	Amia calva
gizzard shad	Dorosoma cepedianum
threadfin shad	Dorosoma petenense
redfin pickerel	Esox americanus
carp	Cyprinus carpio
golden shiner	Notemigonus crysoleucas
blacktail shiner	Notropis venustus
river carpsucker	Carpoides carpio
smallmouth buffalo	Ictiobus bubalus
bigmouth buffalo	Ictiobus cyprinellus
blacktail redhorse	Moxostoma poecilurum
channel catfish	Ictiobus natalus
pirate perch	Aphredoderus sayanus
blackspot topminnow	Fundulus olivaceus
mosquitofish	Gambusia affinis
sailfin molly	Poecilia latipinns
brook silverside	Labidesthes sicculus
sunfish	Lepomis spp.
largemouth bass	Micropterus salmoides
white crappie	Pomoxis annularis
black crappie	Pomoxis nigromaculatus

Table 2. Amphibians and Reptiles Whose Range Includes the Sweet Lake Prime Prospect Area (After Conant, 1975)

Common Name	Scientific Name
American alligator	Alligator Mississippiensis
alligator snapping turtle	Macroclemys temmincki
common snapping turtle	Chelydra serpentina serpentina
stinkpot	Sternotherus odoratus
razor-backed musk turtle	Sternotherus carinatus
Mississippi mud turtle	Kinosternum subrubrum hippocrepis
Mississippi map turtle	Graptemys kohni
southern painted turtle	Chrysemys picta dorsalis
Mobile cooter	Chrysemys concinna mobilensis
Missouri slider	Chrysemys floridana hoyi
red-eared turtle	Chrysemys scripta elegans
three-toed box turtle	Terrapene carolina
ornate box turtle	Terrapene ornata
western chicken turtle	Deirochelys reticularia miaria
midland softshell turtle	Trionyx muticans
pallid spiny softshell	Trionyx spiniferus
green anole	Anolis carolinensis
ground skink	Leiolopisma laterale
five-lined skink	Eumeces fasciatus
broad-headed skink	Eumeces laticeps
western slender glass skink	Ophisaurus attenuatus attenuatus
broad-banded water snake	Natrix fasciata confluens
yellow-bellied water snake	Natrix erythrogaster flavigaster
diamondback water snake	Natrix rhombifera
green water snake	Natrix cyclopion cyclopion

Table 2 (Continued)

Common Name	Scientific Name
gulf glossy water snake	Natrix rigida sinicola
Graham's water snake	Natix grahmi
eastern garter snake	Thamnophis sauritus sauritus
Gulf Coast ribbon snake	Thamnophis proximus orarius
brown snake	Storeria dekayi
Mississippi ringneck snake	Diadophis punctatus
eastern hognose snake	Heterodon platyrhinos
rough green snake	Opheodrys aestivus
western mud snake	Farancia abacura reinwardti
Texas rat snake	Elphe obsoleta lindheimeri
Louisiana milk snake	Lampropeltis triangulum amaura
prairie kingsnake	Lampropeltis calligaster calligaster
speckled kingsnake	Lampropeltis getulus
western cottonmouth	Agkistrodon piscivorus leucostoma
southern copperhead	Agkistrodon contortrix contortrix
pygmy rattlesnake	Sistrurus miliarus
western lesser siren	Siren intermedia nettingi
three-toed amphiuma	Amphiuma tridactylum
central newt	Notophthalmus viridescens
small-mouthed salamander	Ambystoma texanum
marbled salamander	Ambystoma opacum
dwarf salamander	Eurycea quadridigitata
eastern narrow-mouthed toad	Gastrophryne carolinensis
Gulf Coast toad	Bufo valliceps
northern spring peeper	Hyla crucifer crucifer

Table 2 (Continued)

Common Name	Scientific Name
green treefrog	*Hyla cinerea*
squirrel treefrog	*Hyla squirella*
northern cricket frog	*Acris crepitans*
bronze frog	*Rana clanitans*
pig frog	*Rana grylio*
bull frog	*Rana catesbeiana*
southern leopard frog	*Rana utricularis*

Table 3. Mammals Whose Range Includes the Sweet Lake Prime Prospect Area (After Lowery, 1974a).

Common Name	Scientific Name
Virginia opposum[1]	Diadelphis virginiana
least shrew	Cryptotis parva
red bat	Lasiurus borealis
seminole bat	Lasiurus seminolis
northern yellow bat	Lasiurus intermedius
nine-banded armadillo	Dasypus novemcinctus
eastern cottontail[2]	Sylvilagus floridana
swamp rabbit[2]	Sylvilagus aquaticus
plains pocket gopher	Geomys bursarius
marsh rice rat	Oryzomys palustris
fulvous harvest mouse	Reithrodontomys fulvescens
hispid cotton rat	Sigmodon hispidus
common muskrat[1]	Ondatra zibethicus
roof rat	Rattus rattus
Norway rat	Rattus norvegicus
house mouse	Mus musculus
nutria[1]	Myocastor coypus
coyote[1]	Canis latrans
red fox[1]	Vulpes fulva
northern racoon[1]	Procyon lotor
North American mink[1]	Mustela vison
spotted skunk[1]	Spilogale putorius
striped skunk[1]	Mephitis mephitis
Neartic River otter[1]	Lutra canadensis
white-tailed deer[2]	Odocoileus virginianus

Table 3 (Continued)

[1] Commercially important furbearer in Louisiana (O'Neil and Linscombe 1977)

[2] Recreationally important game species in Louisiana

Table 4. Important Game Birds Whose Range Includes the Sweet Lake Prime Prospect Area (After Carney et al., 1975 and Brown, 1978).

Common Name[1]	Scientific Name[1]
White-fronted goose	Anser albifrons M[2]
snow goose	Chen caerulescens M
fulvous tree-duck	Dendrocygna bicolor R[3]
mallard	Anas platyrhynchos M
mottled duck	Anas fulvigula R
gadwall	Anas strepera M
northern pintail	Anas acuta M
green-winged teal	Anas crecca M
blue-winged teal	Anas bicolor M
cinnamon teal	Anas cyanoptera M
northern shoveler	Anas clypeata M
American wigeon	Anas americana M
wood duck	Aix sponsa R
ring-necked duck	Aythya collaris M
canvasback	Aythya valisineria M
lesser scaup	Aythya affinis M
bufflehead	Bucephala albeola M
ruddy duck	Oxyura jamaicensis M
American coot	Fulica americana M
king rail	Rallus elegans R
Virginia rail	Rallus limicola R
sora	Porzana carolina M
yellow rail	Coturnicops noveboracenis R
purple gallinule	Porphyrula martinica R

Table 4 (Continued)

Common Name	Scientific Name	
common gallinule	Gallinula chloropus	R
mourning dove	Zenaida macroura	R
bobwhite	Colinus virginianus	R

[1] Common and scientific names are after Lowery 1974b.

[2] M = migratory, does not normally nest in the project area.

[3] R = resident, although the species may be migratory, individuals normally nest in the project area.

Table 5. Vegetation and Wildlife Commonly Occurring Within Agricultural Fields, Field Borders, Canal Banks, and Road Structures Within the Sweet Lake Prime Prospect Area.

PRAIRIE TERRACE

Habitat Type	Listing of Plants	
	Common Name	Scientific Name
Agricultural Fields[1]	rice	Oryza sativa
	soybeans	Glycene max
	alligatorweed	Alternanthera philoxeroides
	barnyard grass	Echinochloa colonum
	signal grass	Rachiaria platyphylla
	dayflower	Commelina communis
	eclipta	Eclipta alba
	sesbania	Sesbania exaltata
	birdeye	Caperonia castanaefolia
	nut sedge	Cyperus esculentus
	joint vetch	Aeschynomeni virginica
	chocolate Weed	Melochia corchoirfolia
	rice flatsedge	Cyperus iria
Field Edges, Canal Banks, Roadsides	mud plaintain	Heteranthera limosa
	rattlebox	Daubentonia texana
	spotted spurge	Euphorbia nutans
	verbena	Vervain sp.
	yankeeweed	Eupatorium capillifolium
	foxtail grass	Setaria sp.
	sesbania	Sesbania macrocarpa
	broom sedge	Andropogon virginicus
	black-eyed susan	Rudbeckia sp.
	wooly croton	Croton capitatus
	dandelion	Taraxacum officinale
	Johnson grass	Sorghum halepense
	sunflower	Helianthus spp.
	smutgrass	Sporobolus poirettii
	nightshade	Solanum sp.
	coffeeweed	Sesbania exalta
	smartweed	Polygonum spp.
	cocklebur	Xanthium spp.
	buttonweed	Diodia virginiana
	peppergrass	Lepidium virginicum
	milkweed	Asclepias spp.
	ironweed	Vernonia spp.
	thistle	Cirsium spp.
	giant ragweed	Ambrosia trifida
	blackberry	Rubus spp.
	grape	Vitus spp.

Table 5 (Continued)

Habitat Type	Listing of Plants	
	Common Name	Scientific Name
Field Edges, Canal Banks, Roadsides (cont'd.)	peppervine	Amelopsis arborea
	poison ivy	Rhus radicans
	deer pea	Vigna luteola
	morning glory	Ipomea spp.
	passion flower	Passiflora incarnata
	hackberry	Celtis laevigata
	blackwillow	Salix nigra
	chinese tallow	Sapium sebiferum
	catalpa	Catalpa bignonioides
	cottonwood	Populus deltoides
	loblolly pine	Pinus taeda
	prickly-ash	Zanthorylum clava-herculis
	red maple	Acer rubrum
	live oak	Quercus virginiana
	bald cypress	Taxodium distichum
	wax myrtle	Myrica cerifera
	elderberry	Sambucus canadensis
	common privet	Ligustrum sinense
	eastern baccharis	Baccharis halimifolia
	Listing of Animals	
Agricultural Fields, and Associated Field Edges, Canal Banks, and Roadsides	(Reptiles and Amphibians)	
	western cottonmouth	Agkistrodon piscivorus leucostoma
	green anole	Anolis carolinensis
	green tree frog	Hyla cineria
	American alligator	Alligator mississippiensis
	water snakes	Natrix spp.
	(Birds)	
	Common Grackle	Quiscalus quiscula
	Brown-headed Cowbird	Molothrus ater
	Red-winged Blackbird	Agelaius phoeniceus
	Bobwhite	Colinus virginianus
	Mourning Dove	Zenaida macroura
	Purple Gallinule	Porphyrula martinica
	numerous waterfowl species (Appendix B, Table 4).	

Table 5 (Continued)

Habitat Type	Listing of Animals	
	Common Name	Scientific Name
Agricultural Fields, and Associated Field Edges, Canal Banks, and Roadsides (cont'd.)	(Mammals)	
	least shrew	Cryptotis parva
	rabbits	Sylvilagus spp.
	marsh rice rat	Oryzomys palustris
	fulvous harvest mouse	Reithrodentomys fulvescens
	nutria	Myocastor coypus
	northern raccoon	Procyon lator
	Listing of Plants	
Canals and Roadside Ditches	alligatorweed	Alternanthera philoxeroids
	water hyacinth	Eichornia crassipes
	cattail	Typha spp.
	pickeralweed	Pontederia cordata
	pennywort	Hydrocotyle spp.
	rushes	Juncus spp.
	cyperus	Cyperus spp.
	three-cornered grass	Scirpus spp.
	lippia	Lippia spp.
	sawgrass	Cladium jamaicense
	elephant's ear	Colocasia esculenta
	roseau cane	Phragmites communis
	parrot feather	Myriophyllum brasiliense
	yellow pond lilly	Nuphar luteum
	primrose-willow	Ludwigia decurrens
	water hyssop	Bacopa monnieri
	duckweed	Lemna spp.
	Listing of Animals	
	(Fish)	
	garfish	Lepisosteus spp.
	shad	Dorosoma spp.
	mosquito fish	Gambusia affinis

[1]Common plants of agricultural fields are after Louisiana Cooperative Extension Service, n.d.

Table 6. Flora and Fauna Expected to Occur in the Marshes of the Prime Prospect Area.

MARSH

Habitat Type	Listing of Plants	
	Common Name	Scientific Name
Fresh Marsh (Historically)[2]	maidencane	Panicum hemitomon
	cattail	Typha spp.
	bull tongue	Sagittaria falcata
	spikerush	Eleocharis quadrangulata and Eleocharis cellulosa
	yellow cutgrass	Zizaniopsis miliacea
	sawgrass	Cladium jamaicense
	roseau cane	Phragmites communis
	bullrush	Scirpus californicus and Scirpus validus
Fresh Marsh (Present)	Bull tongue	Sagittaria falcata
	maidencane	Panicum hemitomon
	alligatorweed	Alternanthera philoxeroides
	wiregrass	Spartina patens
	horned bladderwort	Utricularia cornuta
	mudbank paspalum	Paspalum dissectum
	white waterlily	Nymphaea odorata/tuberosa
	American lotus	Nelumbo lutea
	spikerush	Eleocharis spp.
	watershield	Brasenia schreberi
	Carolina bacopa	Bacopa caroliniana
	joint vetch	Aeschynomene virginica
Spoil Banks and Higher Sites	black rush	Juncus roemerianus
	cattail	Typha spp.
	cypress	Taxodium disthicum
	wooly croton	Croton capitatus
	eastern baccharis	Baccharis halimifolia
	black willow	Salix nigra
	Chinese tallow	Sapium sebiferum
	matgrass	Lippia nodiflora
	morning glory	Ipomea spp.
	rattlebox	Daubentonia texana
	salt marsh-mallow	Kosteletzyka virginica
	sensitive briar	Schrankia spp.
	smartweed	Polygonum spp.
	spikerush	Eleocharis spp.
	water hyssop	Bacopa monnieri
	wire grass	Spartina patens
	wax myrtle	Myrica cerifera

Table 6 (Continued)

Habitat Type	Listing of Animals	
	Common Name	Scientific Name
Fresh Marsh	(Fish)	
	garfish	Lepisosteus spp.
	largemouth bass	Micropterus salamoides
	(Reptiles and Amphibians)	
	American alligator	Alligator mississippiensis
	water snakes	Natrix spp.
	western cottonmouth	Agkistrodon piscivorus leucostoma
	brown snake	Storeria dekayi
	(Mammals)	
	common muskrat	Ondatra zibethicus
	rabbit	Sylvilagus aquaticus
	northern raccoon	Procyon lotor
	white-tailed deer	Odocoileus virginianus
	(Birds) (See Appendix A, Table 4)	

[2]Dominant vegetation around the mid-1900's after O'Neil, 1949.

REFERENCES

Brown, B. W., Personal Communication with Refuge Manager, Lacassine National Wildlife Refuge, U.S. Department of Interior, Fish and Wildlife Service, letter of July 21, 1978.

Carney, S. M., M. F. Sorensen, and E. M. Martin, Distribution in States and Counties of Waterfowl Species Harvested During 1961-70 Hunting Seasons, U.S. Department of Interior, Fish and Wildlife Service, Special Science Report, Wildlife No. 187, p. 132, Washington, D.C., 1975.

Conant, R., A Field Guide to the Reptiles and Amphibians of Eastern and Central North America, Houghton Mifflin Company, Boston, Mass., p. 429, 1975.

Douglas, N. H., Freshwater Fishes of Louisiana, Claitor's Publishing Division, Baton Rouge, Louisiana, p. 443, 1974.

Louisiana Cooperative Extension Service, Better Rice for Bigger Profits, Publication No. 1236, pp. 14, n.d.

Lowery, G. H., Jr., Mammals of Louisiana and Its Adjacent Waters, Louisiana State University Press, Baton Rouge, Louisiana, p. 565, 1974a.

_____. Louisiana Birds, Louisiana State University Press, Baton Rouge, Louisiana, p. 651, 1974b.

O'Neil, Ted, The Muskrat in the Louisiana Coastal Marshes, Louisiana Wildlife and Fisheries, New Orleans, Louisiana, p. 152, 1949.

O'Neil T. and G. Linscombe, The Fur Animals, The Alligator, and the Fur Industry in Louisiana, Louisiana Department of Wildlife and Fisheries, New Orleans, Louisiana, pp. 68, 1977.

APPENDIX C

ENDANGERED SPECIES

Awnless bluestem, a prairie grass, would be expected to possibly exist in the Prime Prospect Area. A site biological survey was conducted and the awnless bluestem was not found.

The American alligator was originally classified as endangered throughout its range. However, with strict enforcement and adequate habitat, the species has become very common in Cameron Parish and several adjoining parishes where it has been reclassified as threatened (Federal Register, 1975). The reptile's abundance in this area has made it an important source of income for local trappers who participate in a special alligator season. In 1976, buyers paid $16.50 per foot or an average of $118.80 per hide (O'Neil and Linscombe, 1977).

When abundant, large numbers of the endangered Whooping Cranes concentrated in the prairies and marshes of southwest Louisiana in the winter. However, their population has since dramatically declined due to loss of prairie habitat, human habitations, natural disasters, and low reproductive potential. Today, Aransas National Wildlife Refuge in Texas is the center of wintering activity for the whoopers. The last Whooping Crane was reported in Louisiana on 2 December 1949 (Lowery, 1974). Due to the alteration of the natural landscape by man, it is highly unlikely that Whooping Cranes presently use the area as a wintering site.

The Brown Pelican is a coastal species whose population has declined remarkably since 1955. The apparent cause for the decline was ingestion of chlorinated hydrocarbons, chemicals widely used in pesticides. Through the process of

biomagnification, pelicans accumulated lethal amounts of the toxic chemical in their fatty tissues. Accumulation of chemicals caused massive dieoffs of these fish-eating birds during stress periods when fatty tissue was the only food source. The pesticides were also found to be the cause of eggs having shells too thin to be incubated. Because of its status as Louisiana's state bird, several attempts have been made to reestablish it in coastal Louisiana. However, no attempts in western Louisiana (Rockerfeller Refuge) have been successful (Lowery, 1974).

Peregrine Falcons are endangered due primarily to pesticide poisoning. In winter they are present in coastal Louisiana where large numbers of shore-birds or waterfowl are found. Therefore they may pass through the Prime Prospect Area in search of food (Lowery 1974).

The Southern Bald Eagle has also become endangered due largely to pesticide poisoning. Although several nesting territories are known in Louisiana, none exist in or near the project area. Because eagles are primarily fish eaters, they are usually near aquatic habitats and could pass through the Prime Prospect Area.

The only endangered or threatened mammal whose range extends into Cameron Parish is the red wolf. Land use changes have restricted the wolf's historical range by encouraging invasion by coyotes and dogs with which red wolves interbreed. The easternmost edge of the red wolf range is west of Calcasieu Lake or 21 km (13 mi) southwest of the Prime Prospect Area (Carley, 1978). However, coyotes, coyote x red wolf hybrids, or dog x red wolf hybrids are often incorrectly called "wolves" by local people.

REFERENCES

Carley, C. J., Personal Communication with Project Leader, Federal Wolf Recovery Team, U.S. Fish and Wildlife Service, Beaumont, Texas, Letter of July 6, 1978.

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Lowery, G. H., Jr. Louisiana Birds, Louisiana State University Press, Baton Rouge, Louisiana, p. 651, 1974.

O'Neil, T. and G. Linscombe, The Fur Animals, The Alligator, and the Fur Industry in Louisiana, Louisiana Department of Wildlife and Fisheries, New Orleans, Louisiana, pp. 68, 1977.

Endangered Or Threatened

Species Correspondence

Coastal Environments, Inc.

January 4, 1980

Dr. Rod E. Emmer
Coastal Environments, Inc.
1260 Main Street
Baton Rouge, Louisiana 70802

RE: Endangered Plant Species Survey

Dear Dr. Emmer:

On 21 December 1979, Diane Wiseman and I met with representatives from Magma Gulf and Technadrill who led us to the Sweet Lake Geothermal Well Site. The site is located in Cameron Parish, Louisiana just south of Louisiana Highway 384 approximately 4 miles (6.4 km) west of the intersection of 384 with Louisiana Highway 27. The site is located in a rice field farmed by Mr. Charles Precht who gave us permission to walk over and examine the area.

The site consisted of an area of approximately 5 acres (2 ha) of flat topography interspersed with small levees necessary in rice culture irrigation. The field was last farmed in 1978. A proposed endangered plant species, awnless bluestem (Bothriochloa exaristata), has been found to occur in Cameron Parish. However, inspection of the area revealed that this plant does not occur in the area of the well site. Plants present included typical fallow field species such as solidago (Solidago sp.), broomsedge (Andropogon virginicus), cockleburr (Xanthium sp.), panic grass (Panicum sp.), flatsedge (Cyperus sp.), and yankee weed (Eupatorium sp.). Because the field will again be farmed in 1981, occurrence in the area in the future of the proposed endangered plant is not likely.

Sincerely yours,

Donny J. Davis

Donny J. Davis
Biologist

DJD/ree

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United States Department of the Interior
FISH AND WILDLIFE SERVICE
75 SPRING STREET, S.W.
ATLANTA, GEORGIA 30303

JAN 29 1980

Mr. Bennie G. DiBona
Director, Department of Energy
Division of Geothermal Energy
Washington, D.C. 20461

Dear Mr. DiBona:

We have received your letter of January 11, 1980, concerning the proposed geothermal well test in Cameron Parish, Louisiana. We have also reviewed the letter of January 4, 1980, from Mr. Donny J. Davis in which he stated that an on-site field inspection of the well site was conducted and that no evidence of the awnless bluestem (Bothriochola exaristata) was found.

Although the awnless bluestem was proposed as an endangered species, its status as such was cancelled in November 1979, as a result of the 1978 Amendments to the Endangered Species Act. At present, it is a species of concern to the Fish and Wildlife Service, but formal consultation on projects which may impact the species is not required. However, we appreciate and encourage your concern and actions to prevent adverse impacts to this and other formerly proposed species.

Based on the above, we concur that adequate measures have been taken to avoid adverse impacts to this species. Our Jackson Area Office is in agreement with this determination.

Sincerely yours,

Frank D. Richardson

Regional Director

1 JAN 1980

Mr. Kenneth E. Black
Regional Director
U. S. Department of the Interior
Fish and Wildlife Service
75 Spring Street, S.W.
Atlanta, Georgia 30303

Dear Mr. Black:

In accordance with provisions of the National Environmental Policy Act of 1969, the U. S. Department of Energy is preparing an Environmental Assessment for a geopressured geothermal well test project at the Sweet Lake No. 1 site in Cameron Parish, Louisiana.

Due to concern that a proposed endangered species, awnless bluestem, might exist in the proposed project area, a field survey of the well site area was conducted on December 21, 1979.

The enclosed letter describes the results of that survey, and states that the species awnless bluestem does not occur in the area of the well site, and is not likely to occur there in the future.

Your concurrence that adequate measures have been taken to avoid adverse impacts with respect to this proposed endangered species would be appreciated.

Sincerely,

BGD

Bennie G. DiBona, Director
Division of Geothermal Energy

Enclosure

APPENDIX D

Archaeological And Historic Preservation Correspondence

STATE OF LOUISIANA
DEPARTMENT OF CULTURE, RECREATION AND TOURISM
OFFICE OF PROGRAM DEVELOPMENT

EDWIN W. EDWARDS
Governor

E. BERNARD CARRIER, PhD
Assistant Secretary

J. LARRY CRAIN, PhD
Secretary

January 22, 1980

Mr. Bennie G. DiBona, Director
Division of Geothermal Energy
Department of Energy
Washington, D.C. 20461

Re: An Evaluation and Field Survey of Cultural Resources at the Proposed Sweet Lake #1 Geothermal Well Site, Cameron Parish, Louisiana

Dear Mr. DiBona:

My staff in the Division of Archaeology and Historic Preservation has reviewed the above referenced cultural resources survey report. We concur with your archaeological consultant's findings that no significant cultural resources appear to be affected, and this letter may be considered as my clearance for the project. If cultural remains are encountered during construction, however, this office should be notified immediately.

If you have any further questions, please contact my staff in the Division of Archaeology and Historic Preservation.

Sincerely,

E. Bernard Carrier

E. Bernard Carrier
State Historic Preservation Officer

EBC:GHM:fmr

cc: Coastal Environments, Inc.

DIVISION OF ARCHAEOLOGY AND HISTORIC PRESERVATION
P. O. Box 44247 Baton Rouge, La. 70804 504 342-6682

JAN 1 1 1980

Dr. R. Bernard Carrier
State Historic Preservation Officer
Office of Program Development
Division of Archeology and Historic Preservation
P. O. Box 44247
Baton Rouge, Louisiana 40804

Dear Dr. Carrier:

The U.S. Department of Energy is considering a project to drill, complete, and test a geopressure well located in Cameron Parish, Louisiana. In the process of preparing an Environmental Assessment for this project, an evaluation and field survey of cultural resources at the proposed site (Sweet Lake No. 1 Geothermal Well Site, Cameron Parish, Louisiana) was completed on December 21, 1979.

The enclosed report describes that evaluation and survey, and indicates that "no cultural resources were found to occur within the project area, and therefore no resources potentially eligible for nomination to the National Register of Historic Places will be affected by the proposed well."

Your concurrence in this finding will be appreciated.

Sincerely,

Original signed by
Bennie G. DiBona

Bennie G. DiBona, Director
Division of Geothermal Energy

Enclosure

bcc:
M. Rogowsky, GC
S. Greenleigh, GC
F.A. Leone, EV/NAD
R. Stern, EV/NAD
DGE Rdg File
RA-233:REOliver:bem:633-8755:1-11-80

DOE FORM AD-3 (12-77)

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APPENDIX E

AGENCIES CONTACTED

APPENDIX E

Agencies Contacted During the Preparation of the Environmental Assessment

U.S. DEPARTMENT OF THE INTERIOR
HERITAGE, CONSERVATION AND RECREATION SERVICE
18th and 5th Street C
Washington, D.C. 20240

U.S. WATER RESOURCES COUNCIL
2120 L Street, Suite 800
NW Washington, D.C. 20037

U.S. DEPARTMENT OF THE INTERIOR
Geological Survey
Reston, Virginia 22092

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Plaza Tower, 1001 Howard Avenue
New Orleans, Louisiana 70113

ADVISORY COUNCIL ON HISTORIC PRESERVATION
1522K Street, Suite 510
NW Washington 20055

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Herring Plaza Box # 4377
Amarillo, Texas 79101

U.S. DEPARTMENT OF COMMERCE -NOAA
NATIONAL MARINE FISHERIES
Duval Building
9450 Candy Boulevard
St. Petersburg, Florida 33702

U.S. DEPARTMENT OF COMMERCE
MARITIME ADMINISTRATION
Central Region Office
Number 2 Canal Street
New Orleans, Louisiana 70130

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
P.O. Box 1630
Alexandria, Louisiana 71301

FEDERAL ENERGY REGULATORY COMMISSION
Fort Worth Regional Office
819 Taylor Street, Room 9A05
Fort Worth, Texas 76102

NUCLEAR REGULATORY COMMISSION
1717 H Street, NW
Washington, D.C. 20555

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)
Region 6 - First International Building
1201 Elm Street
Dallas, Texas 75270

U.S. ARMY CORPS OF ENGINEERS
New Orleans District
P.O. Box 60267
New Orleans, Louisiana 70160

DEPARTMENT OF TRANSPORTATION
U.S. COAST GUARD - EIGHT DISTRICT
Hale Boggs Federal Building
500 Camp Street
New Orleans, Louisiana 70130

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Water Resources Division
Federal Building
300 East 8th Street
Austin, Texas 78701

U.S. DEPARTMENT OF THE INTERIOR
NATIONAL PARKS SERVICE
Southeast Region Office
1895 Phoenix Boulevard
Atlanta, Georgia 30349

U.S. DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
P.O. Box 44753
USL, Lafayette, Louisiana 70504

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
7981 Eastern Avenue
Silver Spring, Maryland 20910

DEPARTMENT OF WILDLIFE AND FISHERIES
Wildlife and Fisheries Building
400 Royal Street
New Orleans, Louisiana 70130

STATE OF LOUISIANA STREAM CONTROL COMMISSION
P.O. Drawer FC
University Station
Baton Rouge, Louisiana 70893

LOUISIANA AIR CONTROL COMMISSION
325 Loyola Avenue
P.O. Box 60630
New Orleans, Louisiana 70160

STATE OF LOUISIANA DEPARTMENT OF CULTURE, RECREATION AND TOURISM
OFFICE OF STATE PARKS
P.O. Box 44426
Baton Rouge, Louisiana 70804

DEPARTMENT OF COMMERCE
LOUISIANA OFFICE OF COMMERCE AND INDUSTRY
P.O. Box 44185
Baton Rouge, Louisiana 70804

DEPARTMENT OF HEALTH AND HUMAN RESOURCES
OFFICE OF HEALTH SERVICES AND ENVIRONMENTAL QUALITY
P.O. Box 60630
New Orleans, Louisiana 70160

DEPARTMENT OF NATURAL RESOURCES
LOUISIANA GEOLOGICAL SURVEY
P.O. Box G
Baton Rouge, Louisiana 70893
LSU Geology Building

DEPARTMENT OF NATURAL RESOURCES
OFFICE OF MINERAL RESOURCES (State Mineral Board)
P.O. Box 2827
Baton Rouge, Louisiana 70821
Natural Resources Building

DEPARTMENT OF NATURAL RESOURCES
OFFICE OF CONSERVATION - GEOLOGICAL OIL AND GAS DIVISION
P.O. Box 44006 - Capitol Station
Baton Rouge, Louisiana 70804

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
OFFICE OF PUBLIC WORKS
P.O. Box 44155
Capitol Station
Baton Rouge, Louisiana 70804

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
OFFICE OF COASTAL RESOURCES PROGRAM
Hoover Building Annex
2156 Woodale Boulevard
Baton Rouge, Louisiana 70804

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
OFFICE OF HIGHWAYS
P.O. Box 44245 Capitol Station
Baton Rouge, Louisiana 70804

LOUISIANA DEPARTMENT OF COMMUNITY AFFAIRS
OFFICE OF STATE CLEARING HOUSE
626 North 4th Street
Baton Rouge, Louisiana 70802

LOUISIANA STATE PLANNING OFFICE
P.O. Box 44425
Baton Rouge, Louisiana 70804

SOUTH CENTRAL PLANNING AND DEVELOPMENT COMMISSION
P.O. Box 846
Thibodaux, Louisiana 70301

IMPERIAL CALCASIEU REGIONAL PLANNING AND DEVELOPMENT COMMISSION
P.O. Box 3164
Lake Charles, Louisiana 70601