JAN '77

SUMMARY

STATEMENT TYPE: ( ) Draft (X) Final Environmental Statement

PREPARED BY: The Strategic Petroleum Reserve Office, Federal Energy Administration, Washington, D.C. 20461

1. Type of Action: ( ) Legislative (X) Administrative

2. Brief Description of the Proposed Action:

The Federal Energy Administration is considering the implementation of Strategic Petroleum Reserve (SPR), Title I, Part B of the Energy Policy and Conservation Act of 1975 (P.L. 94-163) through the development of a 58 million barrel crude oil storage facility at the Bryan Mound salt dome. The purpose of the SPR is to mitigate the economic impacts of any future interruptions of the petroleum imports. Under the initial phase of the SPR, referred to as the Early Storage Reserve (ESR), one hundred fifty million barrels of oil will be stored by 1978. Of the different types of storage facilities, existing solution-mined salt dome cavities are among the most attractive for petroleum storage because of the relative low cost of bulk storage and the extreme geological stability of rock salt masses. The Bryan Mound site, a salt dome with existing cavities located in Brazoria County, Texas, has been identified as a candidate site for the ESR because it offers the advantage of large storage capacity, easy access to the distribution network, and a relatively short preparation period.

3. Summary of Environmental Impacts and Adverse Environmental Effects

This site-specific EIS analyzes the environmental impacts caused by site preparation and operation. Construction and preparation of the storage cavities, dock facilities and pipelines would degrade water quality by increasing the amount of suspended particulates, toxic sulfides, heavy metals, arsenic, pesticides and other toxic hydrocarbons. Marine operations (loading, unloading and transporting crude oil) create the risk of oil spills which have the potential to disrupt fish and shellfish production, destroy non-mobile aquatic organisms and birds, and damage marsh vegetation. Loading and unloading operations would also cause evaporative hydrocarbon emission which would temporarily exceed the Federal standard.

Because of characteristics of Freeport Harbor the disposal of ballast water extracted from tankers during unloading could create a concentration of oil in the harbor which would have the same potential of disrupting the aquatic ecosystem as oil spills. The loading and offloading of crude oil from barges and the hydrocarbon vapor losses from oil storage tanks would increase the amount of hydrocarbon (in the form of volatile vapors) released to the atmosphere in the Freeport area. Hydrocarbon emissions to the atmosphere could cause increased photochemical reactivity and ozone concentrations in the Freeport area.

Beneficial impacts include the economic gains associated with additional employment and income in the Gulf region, as well as protection from economic losses that result from petroleum supply interruptions.

4. Alternatives Considered:

Alternative Storage Sites

Bayou Choctaw Salt Dome
Cote Blanche Island Mine
Weeks Island Mine
West Hackberry Salt Dome

Alternative Facility Components

Alternative Distribution Facilities

Alternative Brine Disposal Facilities

Alternative Displacement Water Supplies

No Action

5. Comments on the Draft Statement have been received from the following:

Advisory Council on Historic Preservation
Department of the Army, Corps of Engineers
Environmental Protection Agency
Nuclear Regulatory Commission
Texas Department of Agriculture
Governor's Energy Advisory Council (Texas)
Texas Parks and Wildlife Department
Texas Water Development Board
Texas Water Rights Commission
Velasco Drainage District
Dow Chemical Company
LOOP, Inc.
Seaway Pipeline, Inc.

6. Date made available to CEQ and the Public:

The draft statement was made available to the Council on Environmental Quality and the public in September 1976. This final statement was made available to the Council on Environmental Quality and the public on January 7, 1977.

TABLE OF CONTENTS

LIST OF FIGURES

Figure		Page
3.2	Location of Bryan Mound SPR Crude Distribution Components	3-26
3.3	General System Layout - Bryan Mound	3-28
3.4	Estimated Frequency Per Trip of Crude Oil Spilled from Accidents During Transport by Tankship	3-55
3.5	Distribution of Value of Cargo Loss Per Incident from Tank Barge Accidents	3-61
3.6	Estimated Distribution of Amount of Oil Spilled in Accodents Involving Barges . . .	3-62
3.7	Estimated Distribution of Amount of Oil Spilled in Accidents Involving Tankships .	3-66
3.8	Estimated Distribution of Amount of Oil Spilled in Accidents Involving Offloading or Loading Tankships and Barges	3-72
3.9	Typical Storage Wells	3-85
7.1	SPR Distribution Network	7-2
8.1	Factors Influencing Growth, Brazoria County, Texas	8-4
8.2	Future Urbanization Pattern, Brazoria County, Texas	8-7

LIST OF TABLES

1. DESCRIPTION OF PROJECT

1.1 BACKGROUND

This document is a final site specific Environmental Impact Statement (EIS) for the proposed storage of crude oil at the Bryan Mound salt dome located in Brazoria County, Texas. This project is part of the Strategic Petroleum Reserve (SPR) program currently being planned by the Federal Energy Administration (FEA). Creation of the SPR was mandated by Congress in Title I, Part B of the Energy Policy and Conservation Act of 1975, P.L. 94-163 (the Act) for the purpose of providing the United States with sufficient petroleum reserves to minimize the effects of any future oil supply interruption. The Act requires that within seven years the SPR contain a reserve equal to the volume of crude oil imports during the three consecutive highest import months in the 24 months preceding December 22, 1975 (approximately 500 million barrels). The Act further requires the creation within three years of an Early Storage Reserve (ESR) of 150 million barrels as the initial phase of the SPR to provide early protection from near-term disruptions in the supply of petroleum products.

A draft programmatic EIS (DES 76-2) addressing the effects of the SPR program as a whole was filed with the Council on Environmental Quality and made available to the public on June 25, 1976. The final programmatic EIS was filed on December 17, 1976. That statement considers several different types of storage facilities, including the use of existing solution-mined cavities in salt formations and conventional mines, the construction of new solution-mined cavities and conventional mines, the use of existing and the construction of new conventional surface tankage, and the use of surplus tanker ships. The draft programmatic EIS should be consulted for a description of each of these storage methods and the potential impacts which might result from its use. The programmatic EIS also assesses the cumulative impacts which could be expected from use of various combinations of the different facility types.

Because of the severe time constraints placed upon the ESR completion schedule by the Act, FEA will use sites which have existing capacity that may be converted to oil storage for this initial phase of the SPR (see Early Storage Reserve Plan, FEA, April 1976). Potential ESR sites include existing solution-mined cavities in salt domes, and existing conventional mines which can be converted into storage facilities in a realtively short time. A total of eight candidate ESR sites have been selected by means of a screening process involving the application of a series of six criteria.* Of these eight candidate sites, only five are alternatives to one another for the purpose of selecting ESR storage sites to supply oil to refineries on the Gulf Coast, on the East Coast, and in the Caribbean. The other three candidate sites can only supply the inland refineries.

In addition to the Bryan Mound salt dome, the four other alternative candidate sites able to supply the Gulf Coast, East Coast and Caribbean market areas, include the West Hackberry salt dome (Cameron Parish, Louisiana), the Bayou Choctaw salt dome (Iberville Parish, Louisiana), the Cote Blanche salt mine (St. Mary Parish, Louisiana), and the Weeks Island salt mine (Iberia Parish, Louisiana). Section 7.1 includes a more detailed discussion of the rationale supporting the selection of the five alternative sites and a brief summary of the impacts associated with each of the other four sites besides the Bryan Mound salt dome. Draft Environmental Impact Statements on all five alternative candidate sites (DES 76-4 through DES 76-8, September 1976) were filed with the Council on Environmental Quality and made available to the public on the same day so that the environmental impacts associated with the possible use of these sites could be compared with one another. EISs are also in preparation for the other three sites and will be made available prior to any subsequent site selection, as described in Section 7.1.

*These criteria are capacity, distribution accessibility, technical feasibility, potential environmental concerns, ease of acquisition and cost. Section II.E.1 of the programmatic EIS describes in detail how the criteria were applied to approximately 300 salt domes and approximately 300 existing mines to select 32 candidate SPR sites, including the eight candidate ESR sites.

1.2 PROPOSED FACILITIES

1.2.1 Concept for Storage in Salt Domes

The use of salt domes for petroleum storage is attractive because of both the relative low cost of such bulk storage and the extreme geological stability of rock salt masses. In addition, being deep underground provides security from natural catastrophes or sabotage. In the Gulf Coast region, over 50 salt domes, both onshore and offshore, appear feasible for development (see Figure 1.1).

Salt domes are a major source of brine feedstock for chemical and salt industries in the Gulf region. Cavities are formed by dissolving the salt with circulating water and pumping out the resulting brine (see Figure 1.2). The process requires a large volume of leach water (about 7 barrels fresh water or about 8 barrels seawater for every barrel of space created). Some of these cavities are currently used to store a number of petroleum products. In the U.S., the products stored are primarily LPG products such as propane, ethylene, etc., as well as some fuel oil. Although crude oil storage in solution cavities does not present particular technical problems, it has been done principally in other countries.

Both existing salt dome cavities and new cavities to be developed are being considered for the Strategic Petroleum Reserve. Salt domes with existing cavities have been identified as candidates for the Early Storage Reserve (ESR) because they require less time to prepare for oil storage. Approximately 900 cavities with a total capacity of 300 million barrels are known to exist in salt domes and bedded salt formations. In some cases it is feasible to enlarge existing cavities or to leach additional cavities at selected sites.

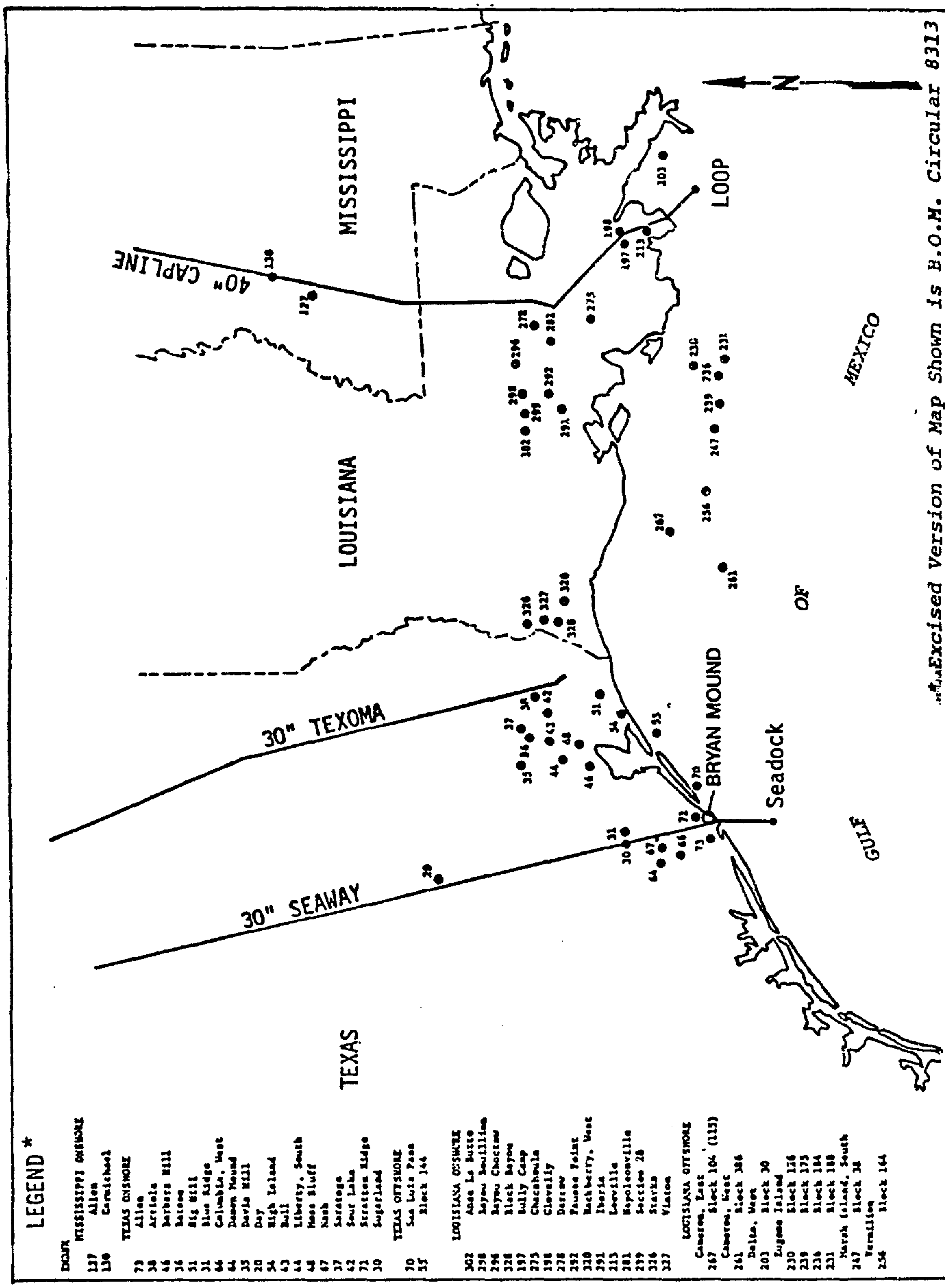


Figure 1.1. Gulf Coast Region Salt Domes

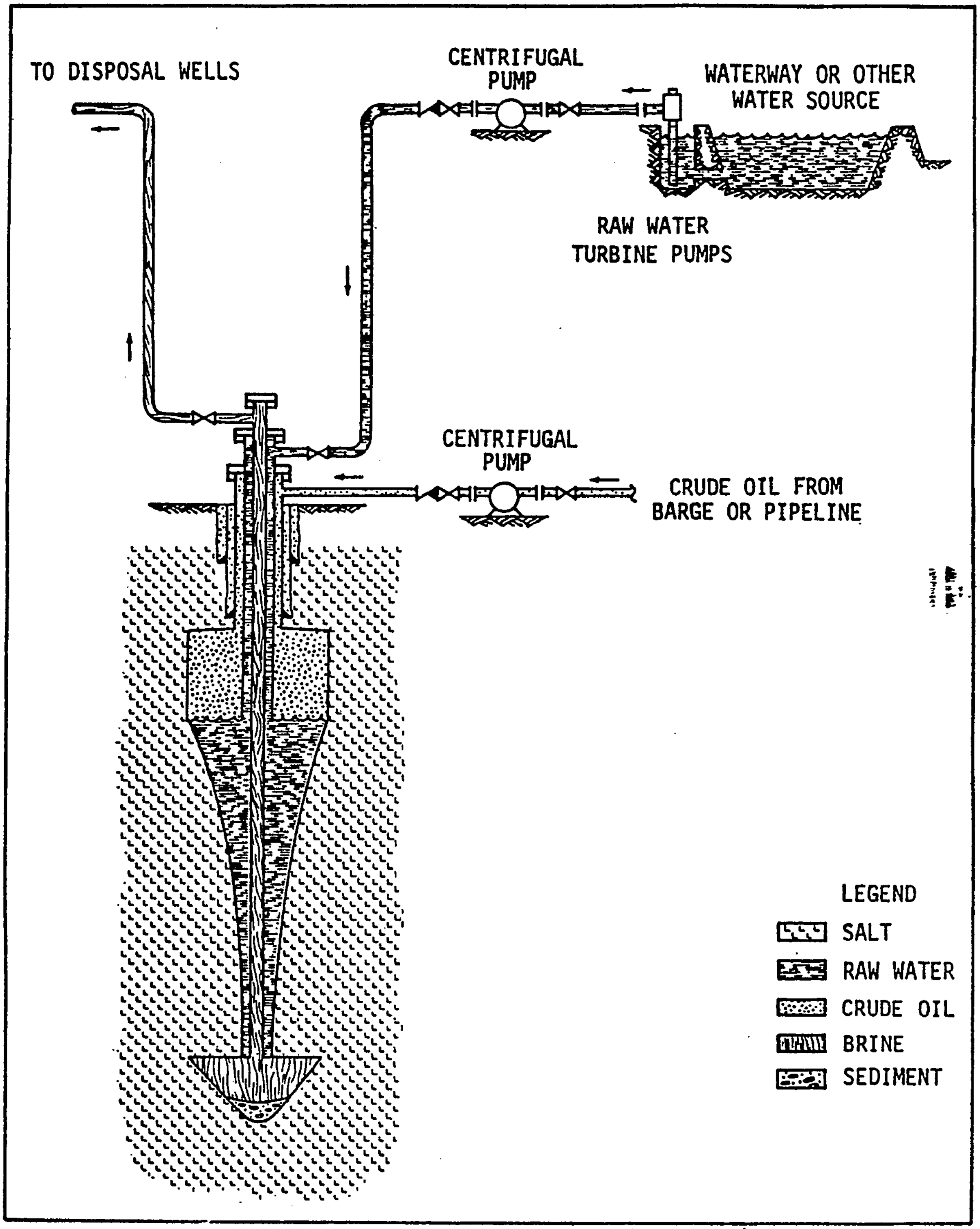


Figure 1.2 Typical Solution Cavity in Salt Formations

1.2.2 Proposed Storage Site

The Bryan Mound Strategic Petroleum Reserve facility is currently designed to store about 58 million barrels of crude oil in the Houston/Seaway storage region. The site was chosen as a candidate site because of its proximity to dock facilities at Freeport and the Seaway Tank Farm 4-miles to the west. Through the Freeport dock facilities, crude can be delivered to Bryan Mound for storage and later transported to any production area serviced by port facilities. In addition, Bryan Mound crude can be delivered to the Seaway system through its tank farm.

It will take an estimated 1-1/2 years (including property and materials acquisition, regulatory approvals, etc.) to construct the storage facility at Bryan Mound, after which crude oil could be accumulated at the rate of up to 385,000 barrels per day. The facility's full storage capacity is expected to be reached in approximately 2-1/4 years.

1.2.3 Location

The Bryan Mound dome is in the southwestern part of Brazoria County, Texas. It lies about 3 miles southwest of the city of Freeport, 65 miles south of Houston and 45 miles southwest of the Texas City/Galveston area (Figure 1.3). The dome site itself is bordered on the West by the Brazos River Diversion Channel, which was diverted in the 1940's to provide a suitable harbor in the old River for the Brazos Port area. The dome is located just north of the Intracoastal Waterway (ICWW) and the Gulf of Mexico lies only 2 miles south (Figure 1.4).

Protective levees lace the entire Freeport area. Some of these levees form a protected triangular area south of the city of Freeport. At the southwestern vertex of this protected triangular area lies Bryan Mound, a

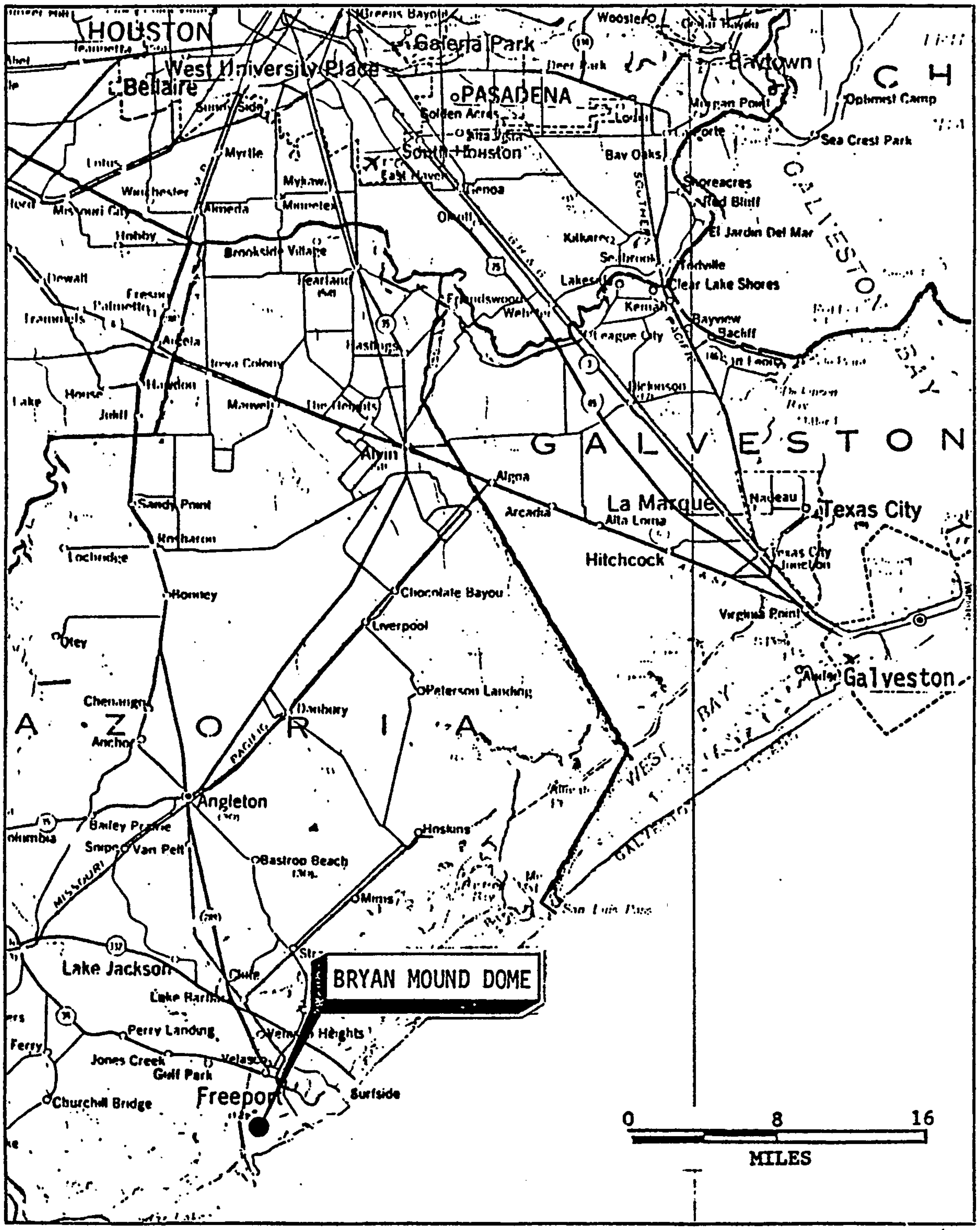


Figure 1.3 Location Map - Bryan Mound Dome

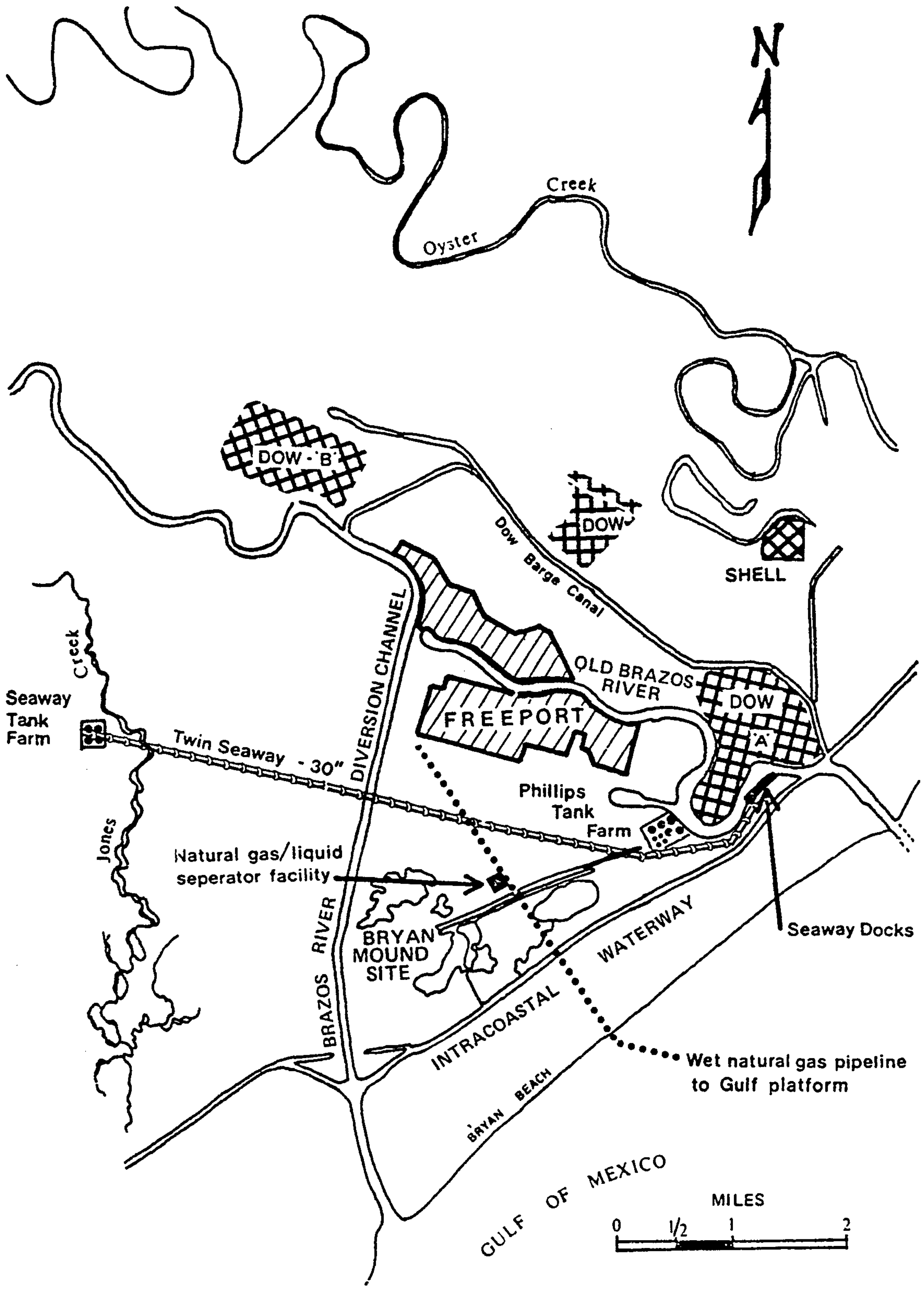


Figure 1.4 Petrochemical Facilities Near Bryan Mound

surface expression above the salt dome rising about 15 feet above the surrounding marshland. The protective triangle of which Bryan Mound is a part encompasses some 3.4 square miles which is drained of excess surface water by two large pump stations; however, the protected triangle still contains several small lakes covering about 0.4 square miles.

A paved road leads from the city of Freeport, along the top of the levee beside the new Brazos River Channel, past the entrance to the storage site. Shell roads provide access to the facilities at the site, including the wellheads of the 4 cavities of interest to the Strategic Petroleum Reserve program. A shell road continues along the southern leg of the levee that parallels the Intracoastal Canal, and joins another paved road that leads back to Freeport.

1.2.4 Development Capacity

During the proposed project life, it is assumed that there would be five fill and withdrawal cycles. This process would cause additional leaching of the existing storage cavities. A total of 70 percent to 86 percent enlargement is expected, depending upon actual solubility conditions. Although the cavity enlarges, it is presently planned that only the volume of crude oil withdrawn during a given cycle would be replaced during the fill operations. Although there are no plans at this time either to enlarge the present cavities or to develop new cavities, it would be possible to place up to 10 cavities each of 10 million barrels capacity in the Bryan Mound dome.

1.2.5 General System Description

The general physical plant for the proposed Strategic Petroleum Reserve facility at Bryan Mound consists of storage cavities, pipeline connections to a central pumping and control facility, holding tanks at the site, a crude oil distribution network, a raw water supply system, and a brine disposal system. This system is schematically illustrated in Figure 1.5.

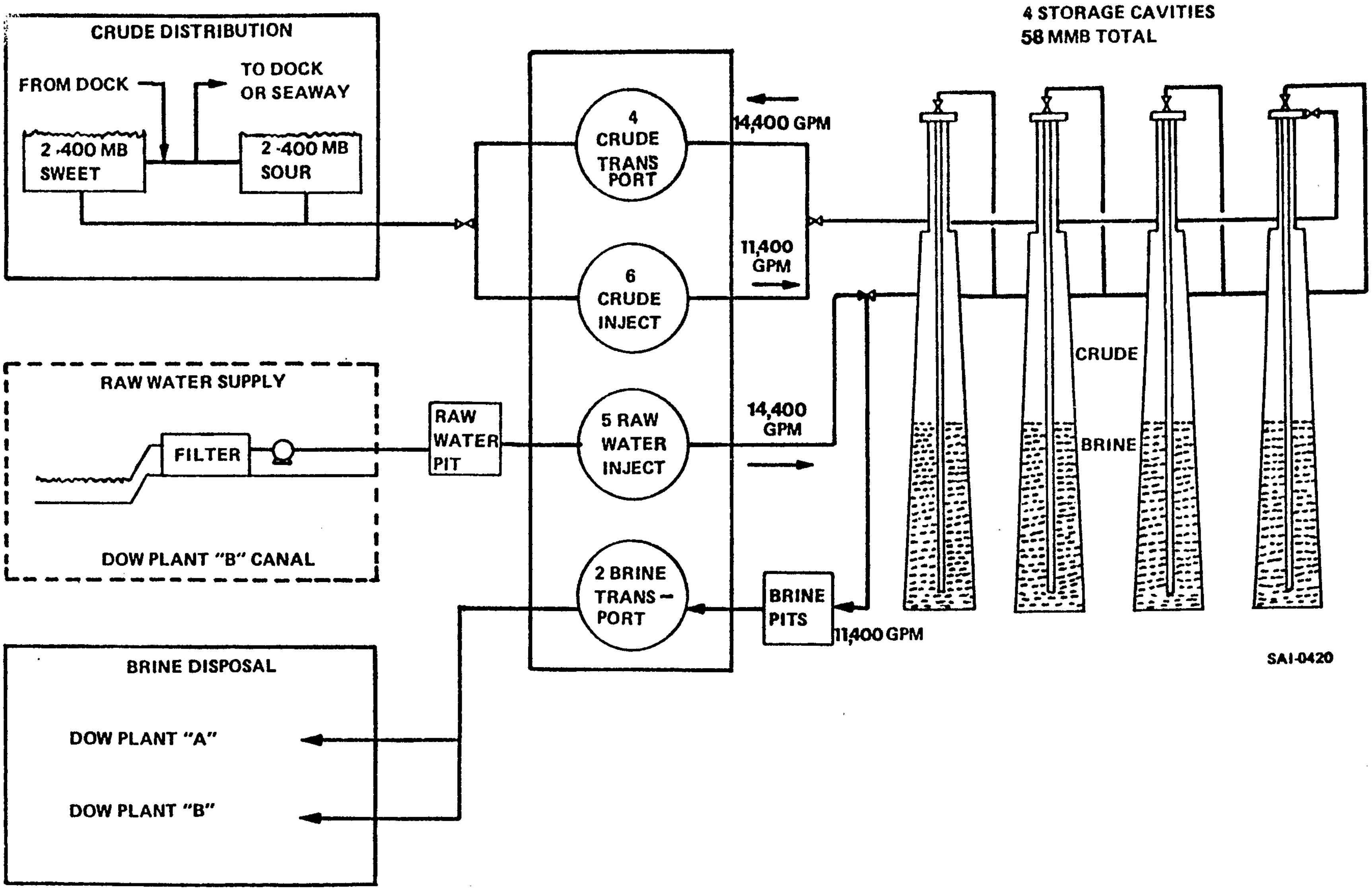


Figure 1.5 Schematic of Bryan Mound Strategic Petroleum Storage Facility

Five cavities have been generated within the dome by brine solution mining. Of these 5 cavities, 4 (those labeled 1, 2, 4, and 5 by Dow Chemical Company) have been identified by Dow as being appropriate for crude storage. Cavern number three is too large to be used for crude oil storage. It would become potentially unstable after five cycles of filling and withdrawing oil. The location of the wells of these 4 cavities are shown in Figure 1.6, and pertinent data on the cavities are presented in Table 1.1. The total capacity of these cavities is 66.6 million barrels; however, about a 10 percent volume loss in roof pocket sumps, and a retained brine safety layer is assumed in computing the space available for SPR Program storage. Therefore, storage of only 58 million barrels is being planned.

Crude oil pipelines would run from the dome site to the Seaway Docks in the Old Brazos River harbor and from the site to the Seaway Tank Farm (see Figure 1.7). Four 400,000-barrel holding tanks would be located at the dome site.

Raw water to be used for crude displacement during withdrawal would be supplied by Dow Chemical Company from their private reservoirs.

Brine displaced from the cavities during crude filling operations would be used as production feedstock by Dow Chemical Company's Plants "A" and "B." It would be transported to the plants through existing pipelines.

1.3 SITE DEVELOPMENT AND CONSTRUCTION

1.3.1 Physical Facilities

The storage site layout (Figure 1.6) presents both existing and planned facilities. Existing facilities include roads, brine lines to plants, brine and other pits, and Dow pump houses. New wells would be drilled to the existing cavities and new oil, brine, and water lines would be constructed between the wells and the new pump house. A new fresh water line from Plant "B" would be required. The oil distribution system on the site is

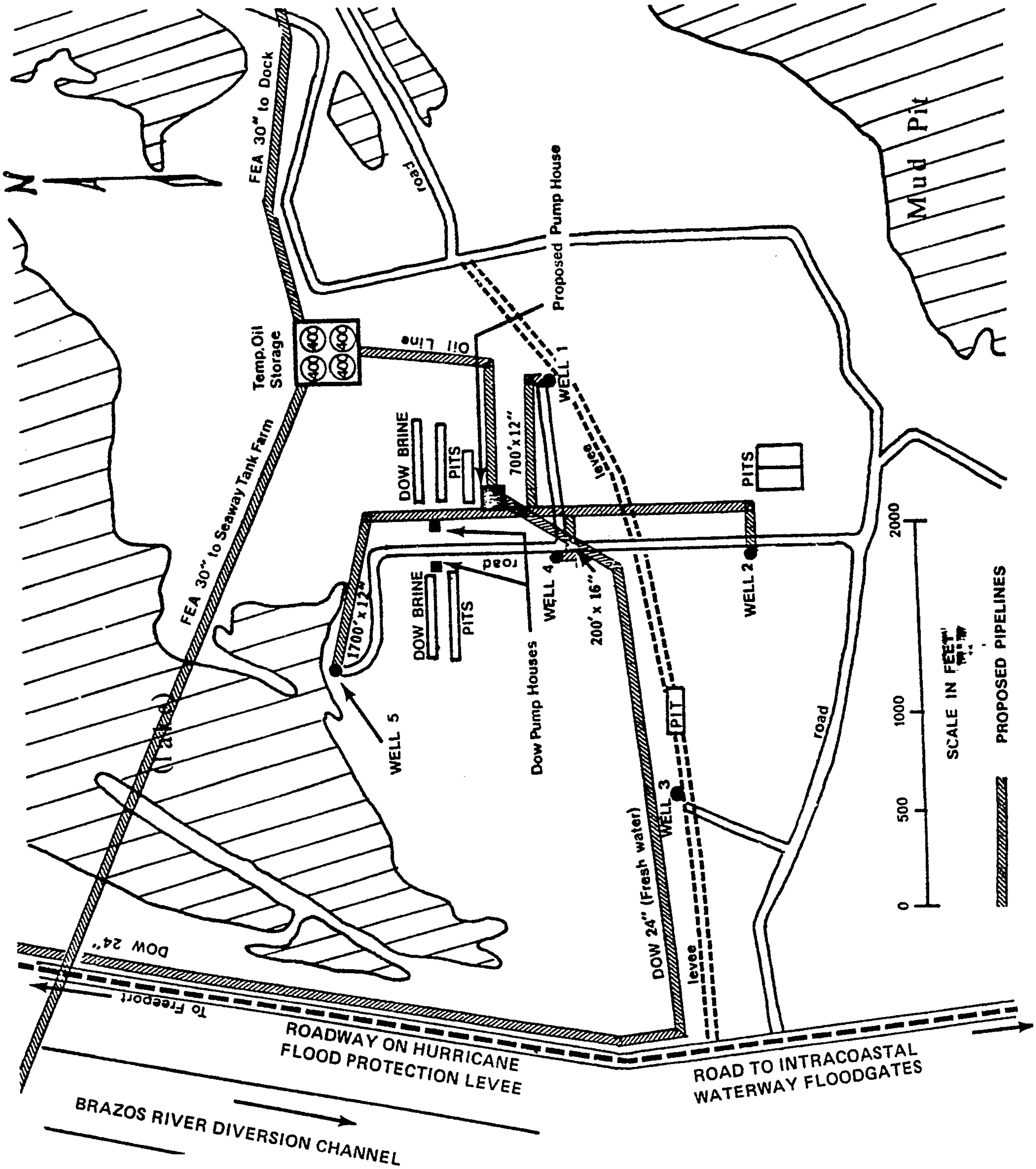


Figure 1.6 Detailed Bryan Mound Site Layout

Table 1.1 Bryan Mound Cavity Data †

Cavity No.	Cavity Depth (ft) Top	Cavity Depth (ft) Bottom	Approximate Radius (ft)	Volume (MMB)
1	2,425	2,862	175	7.5
2	1,465	1,679	220	6.6
4	2,551	3,140	230	17.3
5*u	2,140	2,697	180	10.2
5*l	--	--	--	25.0
				66.6

† Data received from Dow Chemical Company

* #5 Cavern consists of upper(u) and lower (l) caverns.

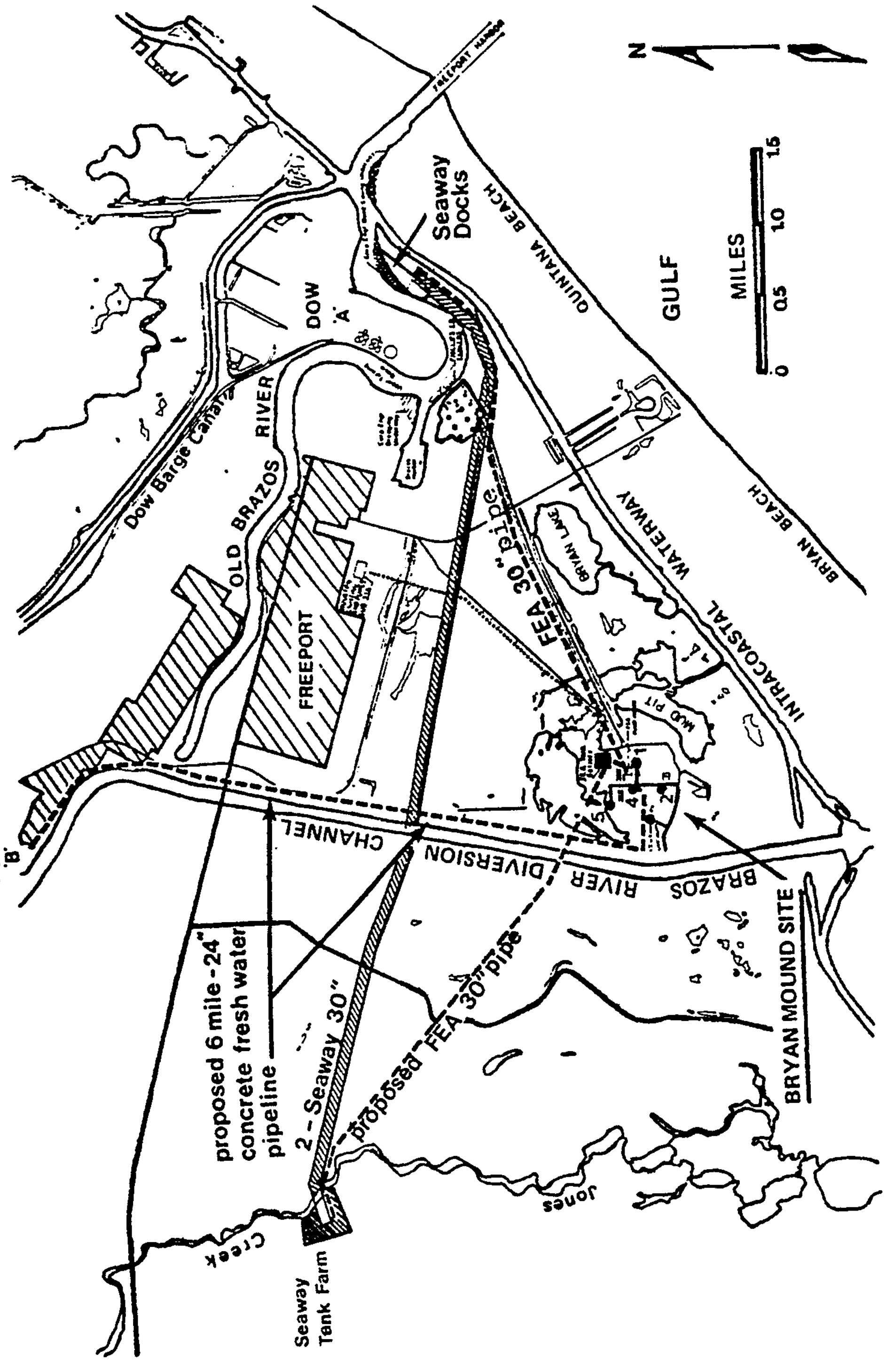


Figure 1.7 Location of Bryan Mound Distribution Components

new, and includes the 4 holding tanks, the 30-inch lines to the dock and the Seaway Tank Farm, and the lines between the temporary storage tanks and the new pump house. All oil, brine, and water lines would be buried.

An engineering layout of the storage facility (Figure 1.8) shows the various major components and their interfaces. Design requirements associated with the various components such as volume of tanks, pump horsepower, maximum flow rates, and anticipated line pressures are also given.

Cavity Preparation

New well holes would be drilled to the 4 existing cavities to accommodate pipe strings of appropriate sizes to obtain the required water/brine and crude flow rates into and out of the cavities. These new well holes would be drilled within about 50 feet of the existing holes by drilling rigs that Dow Chemical Company uses in its brine operations. If required by the schedule, Dow would drill two of these new holes simultaneously. Typical motors associated with the drilling operation at a well include a 820 horsepower generator used for the drilling and 500 horsepower to 730 horsepower motors for the mud pumps. The mud used would be retained onsite in above ground steel tanks during drilling operations, then removed from site afterwards.[1]

Prior to the drilling operations, the area around the new well sites would probably have to be gravel-filled and shell-covered in order to assure support for the drilling equipment.

The wellheads for the new holes would be designed to support the required casings and pipe strings. The well-heads would be cemented into the surface. The high flow rate requirements dictate casing sizes that are larger than usually found in oil field operations. A 30-inch surface casing would be cemented to the top of the caprock and a 24-inch casing would be cemented into the salt dome. The crude string would be a 20-inch pipe cemented into the top of the cavity, while the brine string of 13-3/8-inch pipe would be lowered to near the bottom of the cavity.[1]

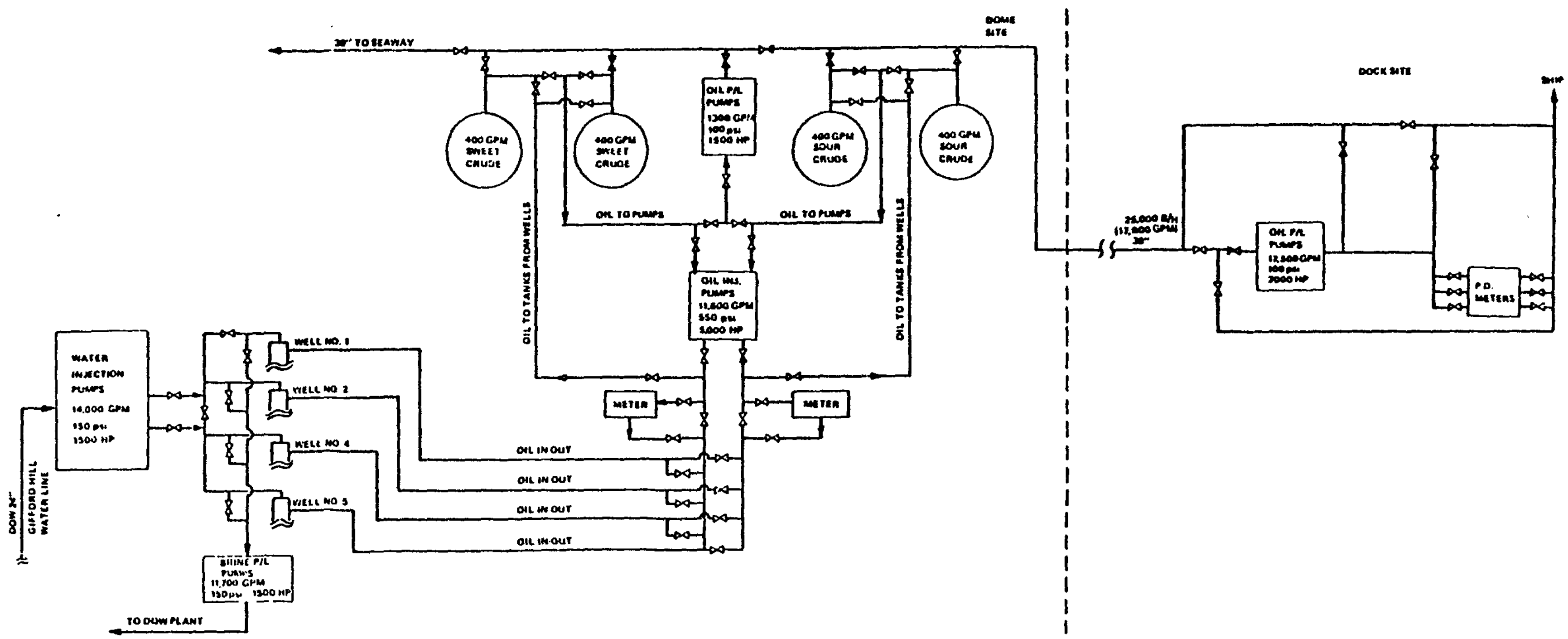


Figure 1.8 Bryan Mound SPR Facility Engineering Layout

Buildings, Dock Facilities, and Harbor

One new building required on the dome site is a pump house. This structure would be about 65 feet by 100 feet in size and would house all of the electrical equipment such as starters, breakers, meters, and pumps. The pumps to be housed in this building at the dome site are listed in Table 1.2.

It is anticipated that the pump house buildings both at the dome site and at the dock would be steel framed buildings with corregated tin sides and roof. The buildings would rest upon concrete slab foundations with raised concrete pads for the pumps.

In addition, a ballast water treatment facility, to be located at the dock site, would be required to process the ballast water that is withdrawn during the loading of the tank ships. The facility would consist of: (1) two 50,000 barrel separation tanks in which the ballast waste will settle for 2 or 3 days, (2) a 15,000 barrel emulsion treating facility with steam and aeration treatment capability, (3) a 10,000 barrel slop tank for the temporary storage of oil wastes removed from the ballast water, and (4) two oilfield type separators for additional oil removal through baffling just prior to ballast water disposal. This facility would reduce the oil content in the ballast water to a maximum monthly average of 7 ppm prior to disposal. As currently planned the treated water would be discharged into the Freeport Harbor (see Figure 1.7).

The proposed plan is to use the Seaway, Inc. docks, presently under construction. The facilities at the dock would consist of a small structure (approximately 30 feet by 50 feet) to house the pumps, meters, and other electrical equipment required at dockside, as well as a small office to handle crude transfer transactions. The dock would be capable of loading or unloading tankers of up to 50,000 DWT. Tanker size determines the pump (Table 1.2) and hose sizes (10-, 12-, and 16-inch) at the docks. The monitoring system located at dockside

Table 1.2 Bryan Mound Pump Data

Pump Description	Location	Number	Type	Size (HP) System	Size (HP) Each Pump	Flow Rate (gpm) System	Flow Rate (gpm) Per Pump	Pressure (PSI)
Crude Pipeline	Dome	6	Electric	2100	500	26,000	6,500	100
Crude Injection	Dome	10	Electric Centrifugal	5000	500	11,700	1,170	550
Crude Pipeline	Dock	4	Electric	1500	500	17,500	5,800	100
Water Injection	Dome	3	Electric Centrifugal	1150	500	13,000	4,300	100
Brine Pipeline	Dome	3	Electric	1400	500	11,700	3,900	150
* Water Pipeline	Plant "B"	4	Electric	1150	300	14,000	3,500	100
Transfer Pumps (Primer Oil)	Dome	8	Electric	640	80	26,000	3,300	75
Transfer Pumps (Primer, Fresh H_2O)	Dome	4	Electric	400	100	13,000	3,300	75
Transfer Pumps (Primer, Brine)	Dome	3	Electric	300	100	11,700	5,800	75

* Values estimated.
Part of Dow Chemical Company's operations - not directly a part of this Storage Facility.

would consist of two 16-inch positive displacement (P.D.) meters, two associated 16-inch deaerators, and a single 8-inch P.D. meter with an 8-inch deaerator. Each 16-inch deaerator/meter system would be capable of handling 13,000 barrels per hour (9,100 gallons per minute) while the 8-inch system would handle 2,300 barrels per hour (1,610 gallons per minute).

When the dredging for the Seaway facilities (currently under construction) is complete in early 1977, the harbor will be able to handle up to 50,000 DWT tankers, light loaded (so the maximum draft would not be exceeded). Therefore, no further dredging of the harbor or its entry is anticipated.

Steel Surge Tanks

The four 400,000 barrel floating roof tanks are constructed onsite, adhering to American Petroleum Institute (API) and American Society of Mechanical Engineers (ASME) construction codes. They all will have adequate spill retention dikes, fire prevention systems, and security fences.

Displacement Water Supply

The proposed displacement water, which would be required to withdraw crude from the cavities, would be supplied by Dow Chemical Company. A 24-inch pipeline capable of handling the required 480,000 barrels per day (14,000 gpm) would be laid between Bryan Mound and Dow's Plant "B" along the protected side of the levee adjacent to the Brazos River. Within Dow's Plant "B," water would be taken from a canal which brings water a distance of 15 to 25 miles to both Plants "A" and "B" from two reservoirs, Brazoria Reservoir and Harris Reservoir, developed and owned by Dow Chemical Company. The water for these reservoirs is purchased from the Lower Brazos River Authority during high water stages.

Brazoria Reservoir is located just north of the Brazos River at a point 6 miles northwest of the Brazoria County Airport in Lake Jackson, while Harris Reservoir is 8 miles northwest of Angleton on Dry Bayou.

Each of these reservoirs has a surface area of 5,000 to 6,000 acres, and a depth of at least 10 feet.[1] Therefore, the volume of each of the reservoirs is at least ten times the projected displacement water requirement for a crude withdrawal.

The 5-mile long pipeline between Dow Plant "B" and Bryan Mound is to be concrete-reinforced pipe. This line would be laid along an existing Dow right-of-way to the mound.

Surge capability for the displacement water supply system would be handled through existing pits at the dome site. Water would flow into the pit from the 24-inch line; then, as required, the water would be pumped into the cavities by the appropriate onsite pumps (see Table 1.2) to displace the crude. The onsite water lines are shown in Figure 1.6. These lines double as brine lines during the fill process.

Brine Disposal

The proposed system is designed so that Dow Chemical Company Plants "A" and "B" can use all of the brine forced from the cavities during crude fill operations. The system would have a maximum brine generation rate of about 16,700 barrels per hour (11,700 gallons per minute). As the brine is forced from the cavities, it would flow through various pipes into open brine pits on the dome site (see Figure 1.6). These pits act as surge tanks. The brine would be pumped from these pits to the Dow plants through existing seamless, steel pipelines by pumps located in the onsite pump house (see Table 1.2). Three 8-inch lines go to Plant "A," while two 8-inch lines and one 12-inch line go to Plant "B." The 8-inch lines have transported brine in the past; however, the 12-inch line has been the leach water line during previous dome operations. It would be converted to a brine line for the Strategic Petroleum Reserve Program. All of the lines are rated for over 300-psi operations while operating pressures during this project should be near 150 psi. Routes of these brine lines are indicated in Figure 1.7.

Receipt and Distribution of Crude Oil

The cavities would be filled with crude which would be brought to the dome by tankers. These tankers would unload the crude at the dock facilities and the crude would be metered before being pumped to surge tanks at Bryan Mound site via a 30-inch pipeline. The route of this 30-inch line is shown in Figure 1.7. The maximum flow along this line, dictated by the design of tanker loading or unloading within 18 hours, is 25,000 barrels per hour (17,500 gallons per minute).

At the Bryan Mound site four 400,000 barrel steel surge tanks are proposed to temporarily store sweet crude and sour crude. This temporary storage would allow continuous brine supply to the Dow plants during period of filling. Several tankers are expected to be unloaded at the rate of approximately one each 24 hours with an actual pumping period of 18 hours per vessel. Likewise, it would allow a smooth scheduling of tanker loading during a drawdown cycle.

The pump house operations at the site would allow the crude from the dock either to go directly to a desired cavity through the onsite metering system, or to be temporarily stored in the appropriate tanks prior to cavity injection. This onsite metering system would consist of two 12-inch deaerator and P.D. meter sets, each having the ability to handle 6,000 barrels per hour (4,200 gallons per minute). The size of the various onsite crude lines are shown in Figure 1.6.

1.3.2 Land Requirements

The Bryan Mound Strategic Petroleum Reserve Facility would require 30 acres of land for site construction and 3 acres for docking facilities. A right-of-way that would include approximately 45 acres would be necessary for the pipeline which would connect the storage site with the docking facilities. A right-of-way that would include 54 acres would be necessary for the pipeline which would connect the site with the Seaway Tank Farm. Approximately 15 acres would be disrupted in the laying of a new 24-inch fresh water line to Dow's Plant "B". The new pipe would follow Dow's existing right-of-way.

The surface rights and mineral rights to the land directly over the center of the dome are leased by Dow Chemical Company from Freeport Minerals, which owns most of the land over the dome. Surface rights at the dock are controlled by Seaway, Inc.

1.3.3 Road Construction and Other Grading

The Bryan Mound dome site has a number of existing shell roads including those to each of the cavities being considered. Since new well holes would be drilled into each of the cavities to allow properly sized access for the Strategic Petroleum Reserve project, it is possible that slight extensions to these roads may be required.

An asphalt roadway exists atop the entire protective levee along which lie the fresh water line and brine lines between Dow Plant "B" and the dome site. The lines that would carry brine to Dow Plant "A" already exist, and sufficient access to these lines exist to perform surveillance. Therefore, no additional roadways would be required for these lines.

The land through which the crude pipelines would be laid is sufficiently firm during most of the year to allow construction, surveillance, and maintenance without supportive roadways.

Safety dikes would be constructed around each of the crude oil surge tanks to contain any spilled crude should a leak occur. This would consist of bulldozing about 20 acres to a depth of approximately 2 feet below the surface and using the dirt to construct a dike at least 7 feet above the original surface plane.

1.3.4 Pipeline Construction

The general pipeline construction technique employed in this marsh area is the push ditch method. A ditch approximately 5 to 10 feet wide is dug along the pipeline right-of-way. This ditch automatically fills with water because the natural water table is at the surface. The pipe joints, each about 40 feet long, are assembled at a convenient push site and the pipeline is pushed forward into the ditch as the length of another joint is attached.

The pipeline fabrication process consists of welding the joints of pipe together and applying appropriate corrosion protection material. A vehicle travels along the ditch with the front of the pipeline, guiding the line and aiding with the starting and stopping of the assembly as the process continues. After the pipeline is assembled and in its desired location, it is filled with water to sink it to the bottom of the ditch. Finally, the ditch is filled, the surface of the right-of-way smoothed, and the pipeline route marked.

Four types of special areas exist along the proposed pipeline rights-of-way: Protective levees, roadways, the Brazos River Diversion Channel crossing, and the Jones Creek crossing. The procedure employed at the protective levees is to bore a hole under the levee at the proper depth. A breather casing is placed through this tunnel and the levee fill is repacked around this casing. Then, the pipeline is drawn through the breather casing. The purpose of the breather casing is to allow ready pipeline leak detection and to allow any eventual pipeline replacement without again affecting the levee. Cut-off collars with compacted backfill will be installed at the points at which the pipeline both enters and leaves the levee. Once the line is in place, the levee must be tested to assure design integrity per U.S. Corps of Engineers regulations. Pipelines are placed under roadways in a fashion similar to that used for the levee crossing except that the integrity check is not required.

A U.S. Corps of Engineers' construction permit is required whenever a pipeline crosses a navigable waterway. The pipeline laying process across the Brazos Diversion Channel requires dredging a ditch with a depth of at least six feet to bury the pipeline. Approximately 15,000 cubic yards of naturally occurring clays and silts would be excavated, placed on the banks, and contained for use as backfill. After the line is placed in the ditch, it would be connected to the onshore pipelines. Pneumatically operated block valves will be installed on both sides of the diversion channel, so that if a leak occurs in the under channel section, it can be quickly isolated. The ditch will be backfilled with dredged material. The bottom will be smoothed and the ground surface, including the bank and surrounding marsh, will be restored to as near original condition as possible.

The Jones Creek pipeline crossing will be carried out using the same procedures. Approximately 950 cubic yards of naturally occurring clays and silts will be excavated and backfilled.

1.3.5 Power Requirements

Most of the pumps and other equipment used onsite would be electrical. It is anticipated the power required to operate the various facilities at both the dome and the dock would be obtained from the Houston Power and Light Freeport Substation which is about 2.5 miles from the dome. This would involve the installation of a 3 phase 12 kilovolt-ampere power circuit.

1.4 OPERATION AND MAINTENANCE PROCEDURES

1.4.1 Operating Procedures

1.4.1.1 Storage Phase

The storage phase is that relatively dormant time period between when the cavities are filled to design capacity and when the crude is needed for a national emergency. During this interim period, the only activities would be security and maintenance checks. However, readiness for activation during an emergency may require keeping some trained operations personnel available and familiar with the site.

Security Measures

Security measures for the Strategic Petroleum Reserve facility are those standard for petroleum storage facilities. The main storage site is fenced and properly lighted. All wellheads have pneumatic gate valves on brine and crude lines to allow for remote control. These controls plus all electrical equipment are housed in a security building. Also, all pipelines are monitored with pressure switches at each end of the line for early detection of leaks. The facility maintains standard fire prevention systems and warning devices.

Equipment Testing and Maintenance

During this storage period, all equipment is serviced and tested on a regular basis to ensure proper working order. Pumps, pressure valves, and safety equipment are lubricated and operated at least once a month. Maintenance crews are on duty on a 24-hour basis.

1.4.1.2 Extraction Phase

The Strategic Petroleum Reserve program requires an emergency deliverability of stored oil over a 5 month period. Thus, average delivery rates for a 58 million barrel facility are 385,000 barrels per day (11,230 gallons per minute); however, considering that delivery through tankers might be required, the system is designed for simultaneous delivery of 13,000 gallons per minute to tankers at Seaway docks and 13,000 gallons per minute to the Seaway Tank Farm. The facility's systems are designed to handle this maximum delivery rate.

Recovery Process

Crude oil stored in each salt cavity is recovered by pumping raw water into the bottom of the cavity, thus displacing the oil through the concentric tubing at the top of the cavity. A total system raw water maximum injection rate of 14,000 gallons per minute is required to meet the crude delivery rate; the raw water injection rate at each cavity depends on cavity volume and operational configuration at the time. The oil leaves each wellhead at a pressure of about 100 pounds per square inch, a pressure capable of transporting the oil by pipeline to the distribution system surge tanks.

Distribution

Both the Seaway dock at Freeport Harbor and the Seaway pipeline through the Seaway Tank Farm are anticipated distribution systems for the Bryan Mound facility. (See Figure 1.7) Crude shipped through the dock facilities would be loaded on up to 50,000 DWT tankers for transportation to coastal refineries in PAD 1 or III or in the Caribbean. PAD stands for a Petroleum Allocation District. The crude distributed through the Seaway system would reach refineries in PAD II or IV.

1.4.1.3 Refill Phase

After an oil supply interruption has ended, refill of the Strategic Petroleum Reserve stroage facility is planned, provided that supplies are stabilized and crude is available for additional storage reserves. The rate of fill depends upon the availability of crude.

Refill Process

The refill process is the reverse of the recovery process. The crude oil is injected into the top of the storage cavity, thus displacing the brine which in turn goes to the Dow plant. The brine disposal systems and distribution system is sized to handle a fill rate equal to the extraction rate, i.e., 11,230 gallons per minute or 385,000 barrels per day for a 5-month period.

Refill Capacity

Five fill and withdrawal cycles are designed for the Strategic Petroleum Reserve system. Although the cavern capacity enlarges during each cycle, only the original design capacity for each cavity would be refilled. This reduces somewhat the continued leaching process.

1.4.2 Safety Precautions

1.4.2.1 Protective Control Devices

All storage cavity wellheads would be equipped with (1) hydrocarbon detection devices to protect against overfill, (2) pneumatic gate valves on crude and brine wellhead openings with high-low pressure switches for remote control of safety valves, and (3) valve limit switches, signal devices and alarms.

Pump control and protective devices would be installed on all major pumping equipment to monitor critical operating variables and to automatically shut down the affected equipment in the event that an unsafe operating condition develops.

Pump station emergency shutdown systems would be installed at all stations to allow the shutdown and isolation of the pumping station in the event of an emergency. Pipelines would have meter bases and pressure switches monitored at each end as a precaution against leaks. Pressure relief valves would be installed on piping, equipment, and pressure vessels as needed to prevent these systems from exceeding safe limits.

1.4.2.2 Fire Protection

Pump stations and meter stations would be provided with portable fire extinguishers installed, classified, rated, and selected in accordance with applicable standards of the National Fire Protection Association.

Surface oil holding tanks at the distribution terminal would be equipped with standard sprinklers and foam fire prevention systems.

1.4.2.3 Corrosion Protection

All buried portions of the pipelines would be externally coated with a protective coating. Where required, the pipeline would be installed in breather casings at highway, or levee crossings with insulators and spacers to electrically isolate the pipelines from the casing.

1.4.2.4 Protection from External Damage

All electrical equipment, pumps, and control systems would be housed in buildings and placed on concrete pads for protection against most flooding. Protection of the pipelines from external damage would be provided by burying them and by marking their location. Additional mechanical protection for that portion of the pipelines in areas of swamp or marsh and at waterway crossings would be provided by the external coating of wire mesh reinforced concrete.

1.4.2.5 Protection of Local Surface Environment

Points in and around pumping stations, where oil may be drained from the system during normal or emergency operations or maintenance, would be appropriately diked and provided with waste sumps. Waste oil collected in this manner would be returned periodically to the storage system.

All surface tanks are required to be enclosed in adequate retention dikes to protect the area environment from leakage of crude. This is consistent with the Spill Prevention Control and Countermeasures Plan requirement of 40 CFR 112-7.

1.4.2.6 Security

The construction and maintenance of the proposed Bryan Mound SPR facility would require 30 acres of a 150 acre piece of land that Dow Chemical currently leases from Freeport Minerals. This 150 acres is presently enclosed by a 3 or 4 strand, barbed wire fence which keeps cattle that are grazing in the general area from entering the site. This fence may be replaced by a more secure one, for example, a 9-foot chain link fence. Other fencing would be needed around high-voltage areas or other danger zones. Since the facility operates on a 24-hour basis, personnel would be on duty at all times. All fenced facilities would have warning signs posted conspicuously to warn the public of the nature of the facility.

REFERENCES

[1]Ed Williams, personal communication, Dow Chemical Company, Freeport, Texas, Mar. 1976.

2. DESCRIPTION OF THE ENVIRONMENT

The regional environmental setting of the project encompasses the entirety of Brazoria County, Texas. Located on the Texas Gulf Coast, Brazoria County lies in a coastal plain environment comprised mainly of coastal prairie and marsh. The coastal prairie represents 412,700 acres and the marsh 84,000 acres of the total 962,276 acres (including water bodies) within the county.

Brazoria County is a part of the Gulf Coastal Plane Physiographic Province. This province is characterized by flat featureless plains, bordered along the Gulf of Mexico by shallow bays, barrier islands and beaches. Brazoria County lacks the large bays and barrier islands that generally characterize Texas coastal areas. A poorly developed drainage pattern, characterized by many marshes and swamps, exists in the coastal area. Surface drainage is into the Gulf of Mexico.

Most of the Texas coast is made up of recently derived Holocene sediments overlying sediments of Pleistocene origin. Pleistocene sediments outcrop near the site and include clays, shells, and concretions indicative of their marine origin. This unique beach front extends only from Freeport, Texas to the Colorado River (a distance of about 50 miles) forming the parent material for the various environmental units which have become established along this portion of the Texas coast. Elevations within the county range from sea level along the coast to a maximum of 60 feet above mean sea level in inland areas. The Bryan Mound site rises to about 15 feet above mean sea level. The San Bernard and Brazos Rivers are used to a limited extent for rice farming irrigation. The San Bernard River receives relatively large amounts of industrial effluent and is high in salt content. Within the county neither river is potable.

The environment which may be affected by the construction and operation of a Strategic Petroleum Reserve (SPR) facility at the Bryan Mound salt dome includes the areas of the storage site, pipeline rights-of-way, and tanker dock facilities. Brine displaced by oil during filling of the cavities would be used by the Dow Chemical Company. This section of the report identifies and describes those factors of the environment which may be affected by the project.

2.1 LAND FEATURES AND USES

2.1.1 Evolution of Salt Domes

The Bryan Mound salt dome is one of nearly 450 salt domes in the Gulf Coast region of the United States and Mexico. The salt in these domes was originally deposited in a broad shallow sea during Jurassic time (130 to 200 million years ago). Since then the salt basin was buried to depths of 15,000 to 35,000 feet by pelagic sediments of the Cenozic age. In general the salt was deposited in horizontal beds, but due to alternating periods of deposition and erosion the surface of the salt had topographically high areas. Since the mechanism of initiating salt dome growth is one of isostatic adjustment, it was some of these topographic highs that began to rise first and eventually formed the nucleus of present day salt domes.[1] The salt begins to rise because the overlying sediment has an average density that is greater than the density of the salt (2.164 gm/cm^3). The sediment overlying the topographic high has a lower density than the sediments overlying the salt on all sides of the high; consequently the salt flows laterally and up toward the area of least resistance, namely the topographic high. Approximately 4,000 feet of overburden is needed to exceed the density of the salt, and a sediment depth greater than that will cause upward movement of salt.[2]

It was the size and shape of the original surface irregularities of the salt that controlled the early rates of vertical movement. This in part explains the differences in the present day size of salt domes.

As the salt rises, sediment stretching and normal block faulting occurs in the overlying sediments. The increasing permeability along the fault planes allows the relatively easy descent of meteoric water. This water combined with existing ground water leaches the upper leading edge of the salt dome, leaving various insoluble residues: primarily anhydrite, with minor amounts of dolomite, calcite, barite, pyrite, quartz, and sulphur.[3] The continuing rise of the salt further fractures the caprock, allowing deeper water percolation and additional salt leaching, and hydration of the upper anhydrite layers. The result is a thickening of the caprock and the formation of gypsum. These residues are the prime constituents of the salt dome caprock.

2.1.2 Regional Geology

The Bryan Mound salt dome lies within the Gulf Coast geosyncline which, in the area of the dome, is characterized by about 15,000 feet of poorly consolidated Miocene and younger sands and shales. The dome is located north of the geosynclinal axis which during early Miocene time had a west southwest trend. The monoclinal strata of the geosyncline, through which the salt is rising, dip in a southeasterly direction. The Miocene sediments are faulted by normal dip slip faults that strike northeast and are down thrown on the basin side.

Little surface expression of regional geological structure exists. A geological map of the country (Figure 2.1) shows a simple outcrop pattern which is related to the regional dip. Some of the salt domes of the area have produced mounds or sinks in the surface although many have no surface expression of faults.

The softness of the rock underlying the area permits deformation to take place without brittle fracture, consequently seismic activity in the Gulf Coast region is very low. The National Oceanic and Atmospheric Administration (NOAA) has classified the United States into four zones with differing degrees of expected seismic risk. These subdivisions are based upon the recorded history of past seismic activity. Zone 0 covers areas having no reasonable expectancy of surface earthquake damage; Zone 1, expected minor damage; Zone 2, expected moderate damage; and Zone 3, possible major destructive earthquakes.

The Bryan Mound dome project area lies within the boundary of seismic risk Zone 0. However, in order to acquire more specific information, an earthquake data search was requested from the NOAA seismic information service. This NOAA office has catalogued the records of all known tremors occurring since the mid 1800s. The data search was requested to cover the rectangle from 28°55' north to 30°19' north, and from 90°10' west to 95°45' west. The results of the search indicated that no earthquakes have been recorded in the Bryan Mound area.

2.1.3 Local Geology

The Bryan Mound salt dome diapir is the principle structural element of the local geology. The summit of the dome rises from an elongated mass of salt at a depth of 15,000

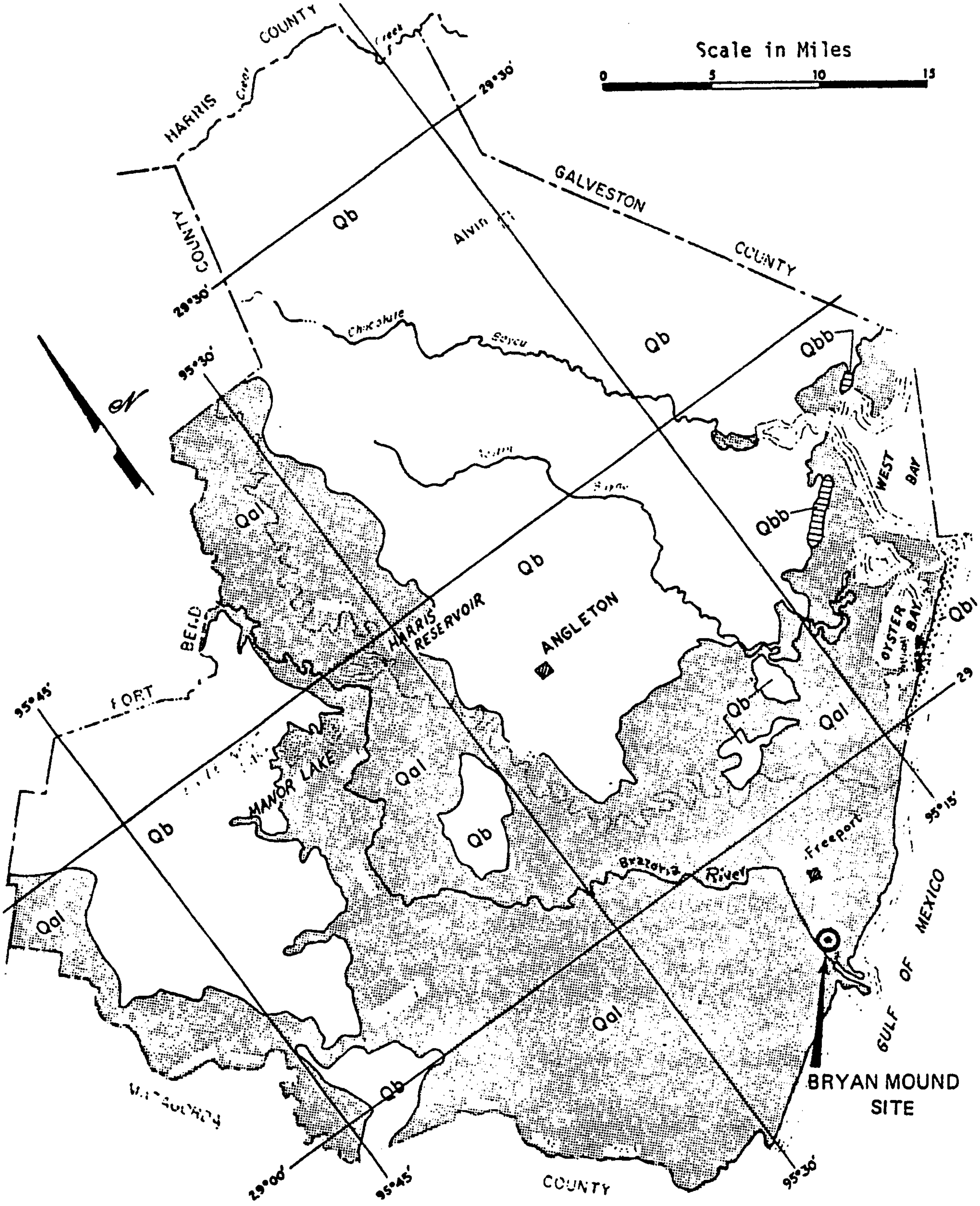


Figure 2.1. Geological Map of Brazoria County, Texas showing location of Bryan Mound Dome. (Legend on next page.)

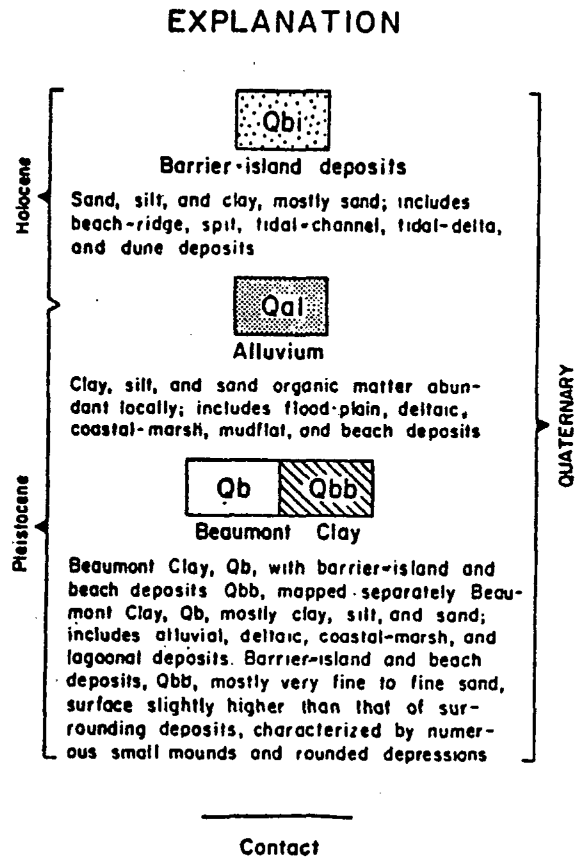


Figure 2.1 (continued). Legend for geological map of Brazoria County, Texas showing location of Bryan Mound Dome.

feet (Figure 2.2). Deformation caused by the combination of upward movement of the salt and settling and compaction of the sediments has produced a system of subsurface faults and flexures over the flanks of the diapir. Away from the dome the sedimentary rock formations have a gentle to moderate dip toward the southeast.[3] Unconsolidated and partially consolidated muds, sands, and shales of Recent, Pleistocene, and Pliocene age overlie the central portion of the dome (see Figure 2.3).[4,5,6,7,8] Unconsolidated and partially consolidated sands and shales of Pliocene and Miocene age extend to a depth of 15,000 feet on the flanks of the dome. Above the dome, the sediments have been forced upward by the salt, forming a mound with an elevation of 15 feet above mean terrain.

Surface Waters

Bryan Mound is surrounded by marshland and numerous bodies of water. On the edge of the site are two natural ponds. These waters are predominantly brackish or saline. Their salinities vary up to 15 ppt depending on the season and flood stage of the Brazos River. The dredged Brazos River channel runs just west of the dome. In the project area, Jones Creek is 1.25 miles west of, and runs parallel to the Brazos Diversion Channel. Mud Pit (Lake), on the southeast corner of the dome, lies just outside of the storm protection levees.

Subsurface Waters

Geologic units containing fresh or slightly saline water in Brazoria County are the Goliad sand, Willis sand, Bentley formation, Montgomery formation, and the Quaternary alluvium. These formations are generally of similar composition consisting of sand, silt, and clay or shale. The units range in age from Pliocene to Holocene (Figure 2.3).

In general, each aquifer contains fresh water in its higher portions and saline water where it dips to greater depths. Over much of the county the water table is declining because of high rates of pumping. Ground water overdraft has caused land surface subsidence in the Freeport area.[8]

2.1.4 Soil

Soil series in the vicinity of the Bryan Mound dome include the Harris-Veston-Galveston Association (nearest the Gulf) and the Moreland-Pledger-Norwood Association (along the Intracoastal Waterway and lower Brazos and San Bernard

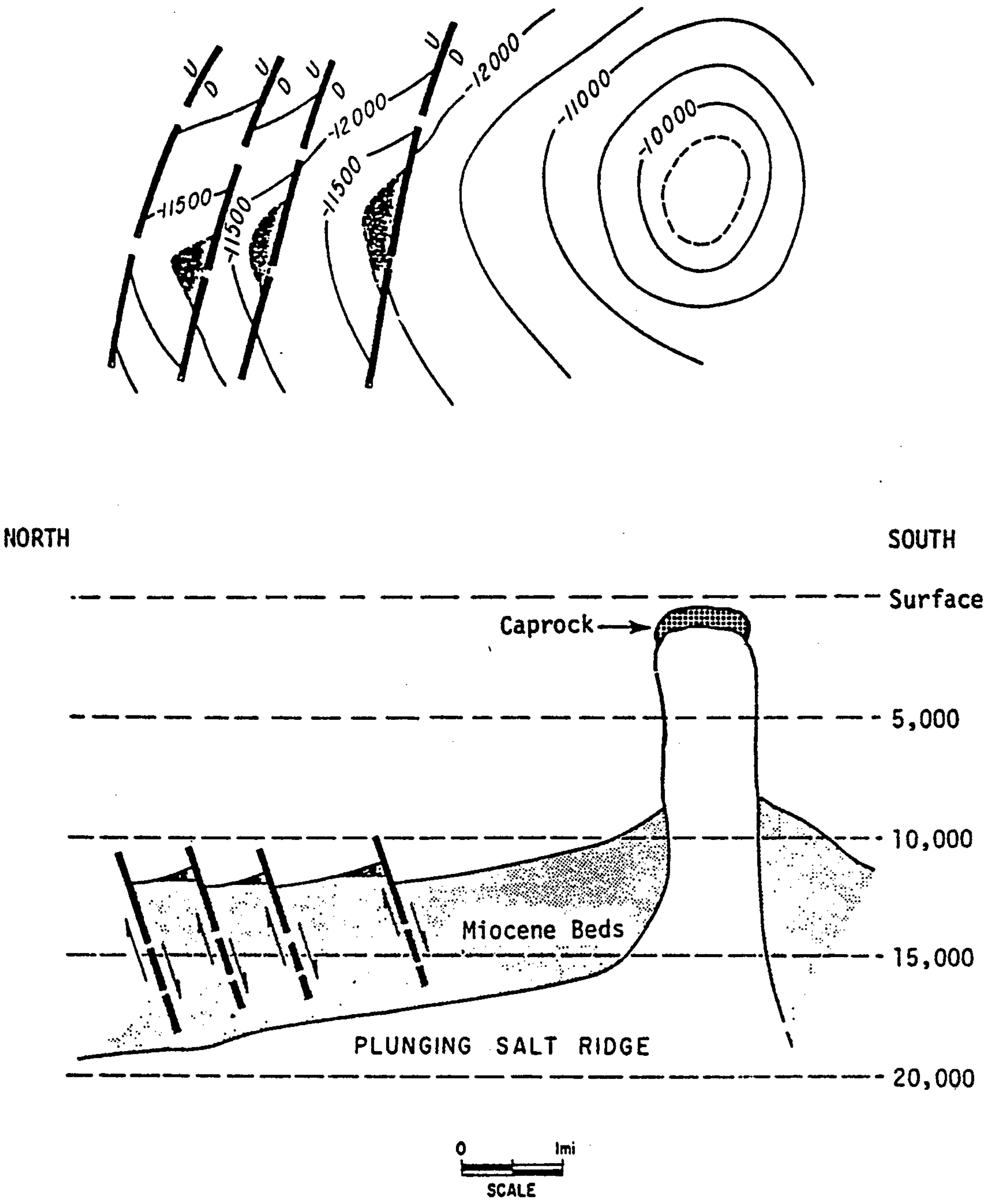


Figure 2.2. Generalized cross section and structure contour map of the Bryan Mound Dome.

GEOLOGIC CLASSIFICATION			Lang, J.W. and Winslow, A.G. (1950) [4]	Wood, L.A. and Gabrysch, R.K. (1965) [5]	Hammond, W.W., Jr. (1969) [6]	Petitt, B.M., Jr. and Winslow, A.G. (1957) [7]	Sandeen, W.M. and Jesselman, J.B. (1973) [8]	
System	Series	Stratigraphic Unit	(Houston District)	(Houston District)	(Matagorda County)	(Galveston County)	Aquifer	Unit
QUATERNARY	Holocene	Quaternary alluvium	Recent	Confining layer	GULF COAST AQUIFER: Heavily pumped zone	Recent	CHICOT	Upper
	PLEISTOCENE	Beaumont clay	Beaumont clay			Beaumont clay		
		Montgomery Formation				Alta Loma Sand of Rose (1943)		Lower
		Bentley Formation						
TERTIARY(?)	PLIOCENE (?)	Willis Sand	Alta Loma Sand of Rose (1943)	Alta Loma Sand of Rose (1943)				
TERTIARY	PLIOCENE	Goliad Sand	Zone 7	Heavily pumped layer	(approximate limits of beds considered)	Lissie Formation (approximate limits of beds considered)	EVANGELINE	(approximate base of beds mapped in this report)
			Zone 6					
			Zone 5					
	MIOCENE	Fleming Formation	Zone 4					
			Zone 3					

Figure 2.3. Near surface geologic column for Brazoria County

Rivers).[9,10] Much of eastern and northern portions of Brazoria County contains the Lake Charles-Edna-Bernard Association.[10] Along both the Brazos and San Bernard Rivers in the northern part of the county, the Miller-Norwood-Pledger Association is found.[9,10] The Lake Charles-Edna-Bernard Association is classified as a "Vertisol" while the other three associations in the county are grouped in the soil order known as "Mollisols."[10] From the beach-gulf interface to the low marshland south of the Intracoastal Waterway, the Harris-Veston-Galveston Association exists. Soils in this Association vary from the clayey Harris series in old tidal flats, through a loamy Veston series, to sandy Galveston soils which occupy the highest elevations.[9] The Harris soils are largely montmorillonite clay, while the Veston soils are intermediate between Harris and Galveston soils and are loamy in texture. These soils are derived from marine and deltaic sediments and are near neutral to alkaline (calcareous) in the surface layer. Many soils in the Bryan Mound vicinity of the Harris-Veston-Galveston Association are classified as saline-sodic and have an extremely high salinity which limits plant growth.[9] Many of the areas covered by these soils are subjected to frequent inundation by seawater.

The Bryan Mound dome along with much of the Gulf Coast Prairie is situated in an area of the Moreland-Pledger-Norwood Association. Soils in this association are calcareous, clayey, and loamy in texture. They were derived from recent flood plain alluvium.[9] These soils also are mixed with a considerable amount of montmorillonite and are moderately alkaline and calcareous to neutral in the surface layer or present a moderate surface salinity hazard to plants while subsoils are much higher in salinity.

Soils along the Brazos and San Bernard Rivers in the northern part of Brazoria County are developing as a Miller-Norwood-Pledger Association. Soils in this association also are clayey, loamy, and calcareous with an appreciable amount of montmorillonite. They present no surface salinity limitations to plant growth, but have a high salinity hazard in the subsoil. Fluvial woodlands are located on these soils in the northern part of the county. Table 2.1 presents a brief summary of soil characteristics for the soil associations of the site and for the region (Brazoria County). Typical vegetation found on these soils also is given.

Table 2.1 Soil Characteristics of Four Soil Associations Found in Brazoria County and at the Bryan Mound Dome

Soil Association	Annual Rainfall on Soil	Setting: Regolith	Setting: Relief	Mineral and Chemical Properties	Typical Vegetation	Limitations and special Features	Land Uses
Lake Charles - Edna - Bernard	25-50 inches	Clayey and loamy; deltaic sediments	Level to nearly level	Montmorillonite; strongly acid to moderately alkaline in surface layer; increasing alkalinity with depth	Tall grasses, live oak	Wet; high shrink-swell potential; very slow permeability; high corrosion potential; high sodium in lower layers; severe residential foundation problems	Crops, irrigated crops, pasture, range, wildlife, urban
Harris - Veston - Galveston	25-55 inches	Clayey to sandy; marine and deltaic sediments	Level to gently undulating	Montmorillonite and mixed; neutral in surface layer; salinity common	Cord grasses and other bunch grasses, sedges	Wet, high corrosion potential; high shrink-swell potential	Range, urban, recreation, wildlife
Miller - Norwood - Pledger and Moreland - Pledger - Norwood	38-45 inches	Clayey and loamy; calcareous recent flood plain alluvium	Level	Mixed with montmorillonite; moderately alkaline and calcareous to neutral in surface; moderately alkaline and calcareous below	Hardwood forest; shade tolerant tall grasses	High shrink-swell potential; occasional flooding; high corrosion potential	Crops, irrigated crops, pasture, urban, parks

2.1.5 Land Usage Characteristics

Caprock and Sulfur Production

The Bryan Mound salt dome has an overlying caprock at a depth of 680 feet and is composed primarily of anhydrite with some limestone. The caprock is a maximum of 480 feet thick and contains abundant sulfur deposits. Over 5 million tons of sulfur were extracted from the caprock during the period 1912 to 1935. Over 900 test and production wells were drilled into the caprock during sulfur production.[3] A thickness of 305 feet of salt exists between cavern No.2 and the bottom of the caprock, with a barrier from 3 to 4 times as thick over the other caverns. Since the wells are drilled only into the caprock, they do not affect the integrity of the caverns.

Salt Characteristics

The Bryan Mound dome is circular as viewed from above. The depth to the salt is 1,136 feet[3] (Figure 2.2). The halite is coarsely crystalline with individual crystals averaging about one centimeter in size. About 3 percent of the mass of the dome consists of anhydrite, with traces of other minerals including calcite, dolomite, barite, pyrite, quartz, celestite, iron minerals, and sulfur.[3]

Oil and Gas Production

Oil production began at Bryan Mound in 1949, but production has always been low. Less than 11,000 barrels of crude oil were produced as of 1965, and no active oil operations presently exist on the dome.

Existing Land Use

Patterns of land use in Brazoria County in 1970 were documented by the Texas Highway Department based on an extensive field survey and review of current aerial photography, tax, and property records.[11] To maintain a common denominator for land use inventory among adjoining counties, the Texas Highway Department used the Houston City Planning Commission's simplified standard land use classification, which has 10 categories:

- Single family residential
- Multiple family residential
- Commercial and service
- Industrial
- Educational
- Open space (including national wildlife refuges)
- Water
- Resource production
- Undeveloped land (including agriculture and oil well production)
- Highway right-of-way

Figure 2.4 indicates the distribution of land use in the county (as of 1970) in each category. Undeveloped land exceeds all categories (861,011 acres) while water (57,138 acres), open space (21,635 acres), and residential (12,362 acres) uses follow. Industrial use comprises 5,284 acres in the county.

Under present land use activity, Brazoria County is strongly characterized by urbanization that is relatively cohesive in and about the various cities. The primary exceptions to this pattern are a lineal residential and commercial development following State Highway 288 between Angleton and Lake Jackson, and residential development along county roads in the triangular area formed by Sweeny, West Columbia, and Brazoria.

Industrial activities are concentrated in a few large operations, principally: Dow Chemical north and south of Freeport; Monsanto Chemical and Amoco Chemical on Chocolate Bayou north of Farm Road 2004; and Phillips and Allied Chemical Refineries near Ocean on the western boundary of the county. The Bryan Mound site is located in the heart of the industrial area owned by Dow Chemical.

Hurricane flood protection measures have been taken in the area around Bryan Mound. Work was performed under the Freeport and Vicinity, Texas Hurricane Flood Protection Project. This is a program of strengthening existing levees and constructing new levees and related drainage systems in the Brazosport Area. The Project was authorized by the Federal Flood Control Act of 23 October 1962, House Document No. 495, 87th Congress. Project funding is 70% by the Federal Government and 30% by local interests, represented by the Velasco Drainage District as Local Sponsor.

As part of the Project, certain improvements were made relating directly to Bryan Mound and the adjoining area to the north of the mound and south of the developed area of the City of Freeport. (See Figure 1.7).

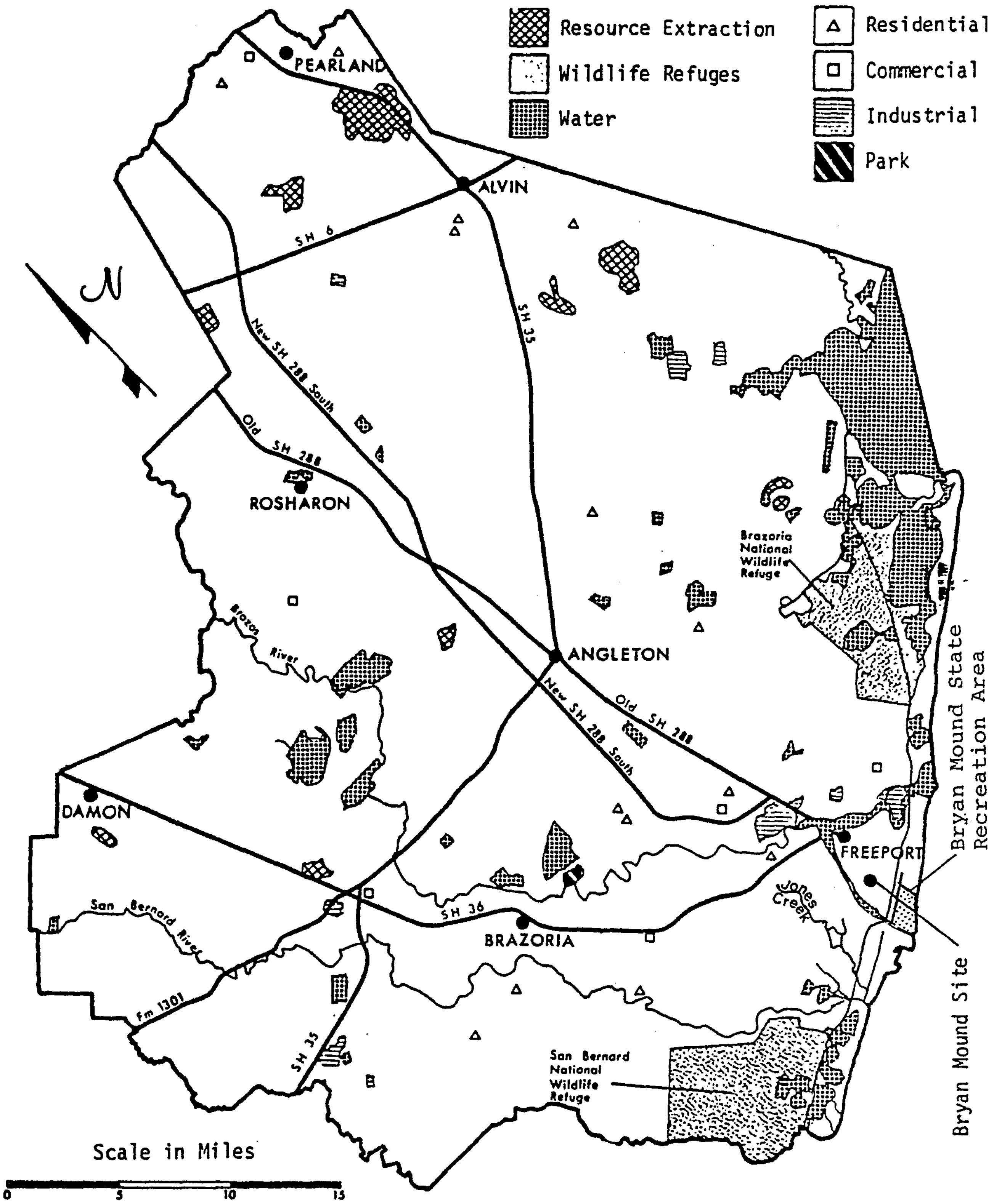


Figure 2.4. Prominent land uses and distribution in Brazoria County, Texas.

- The South Frontal Levee, running from the high ground at Bryan Mound to the south side of the existing Phillips Terminal, has been strengthened and raised to protect the area against the Standard Project Hurricane. The levee parallels the route of the proposed FEA 30" pipeline, (Figure 1.7).

- Similarly, the East Bank Brazos River Diversion Channel Levee has been strengthened and raised. It extends from the high ground at Bryan Mound northerly, and parallels the proposed 6 mile 24" concrete fresh water pipeline indicated on Figure 1.7.

- Similarly, protection of the area against flooding from the north is afforded by the levees at the Phillips Terminal, Brazos Harbor and the Old Brazos River.

Consequently, the entire area south of the City of Freeport to the South Frontal Levee is enclosed by a ring levee system and protected against flooding from the Standard Project Hurricane.

Turning to the interior drainage facilities, rainfall runoff is removed from the enclosed area by the following:

- The West End Pumping Station located at the southwest corner of the developed area of the City of Freeport, Figure 1.8. The station contains three pumps with a total capacity of 450,000 gallons per minute.

- A grated gravity drainage structure through the South Frontal Levee. The structure consists of two 7' by 5' concrete boxes.

A second pumping station, the Pine Street Pumping Station transfers runoff from the developed area of the City of Freeport over a lower interior levee southerly into a channel running westerly to the West End Pumping Station. The lower interior levee formerly was the storm protection levee for the city, now afforded by the South Frontal Levee. Accordingly, the Pine Street station contains four pumps with a total capacity of 200,000 gallons per minute.

When the total protection project was planned, the Galveston District, Corps of Engineers, concluded that additional runoff discharge capacity through the South Frontal Levee was not justified, based on the then current stage of development. Based upon a brief review of the project outlined in the Draft Environmental Impact Statement, and assuming that a sensitive facilities are sited on the high ground of Bryan Mound, no significant flood damages are foreseen.

2.2 WATER ENVIRONMENT

The Bryan Mound dome is adjacent to the Brazos River Diversion Channel and about 1 mile north of where the river crosses the Intracoastal Waterway and 2 miles north of where the river empties into the Gulf of Mexico.

The Bryan Mound SPR facilities, including most of its pipeline routing, lie in a marsh area that is transitional from salt water to fresh water conditions. Its poorly draining soil readily allows surface collection of rain and Gulf storm surge water. Most of the area between the dock facilities and the dome site is drained of surface water by two pump stations in the surrounding levee. The present system design includes the supply of displacement water from Dow Chemical Company reservoirs and the utilization of displaced brine by Dow plants.

There is some interaction between the project and the Brazos River since this is the water source for the Dow reservoirs. Descriptions of these water systems and their present conditions are presented in Subsection 2.2.1.

The shallow coastal waters of the Gulf of Mexico represent an alternate brine disposal site. A description of that portion of the Gulf is provided in Subsection 2.2.2. Although current design does not involve use of subsurface waters either as water supply source or as a disposal site, some understanding of the ground water system is necessary in order to provide basic information necessary in considering alternatives and accidents. Such a description is provided in Subsection 2.2.3.

2.2.1 Surface Water System

The surface water system consists primarily of the Brazos River Diversion Channel, the Old Brazos River which runs through the city of Freeport, the Intracoastal Waterway, and Jones Creek. In addition to these bodies of water, there are a number of canals, ponds, reservoirs and small lakes in the vicinity of the site. The general arrangement of the surface water system is shown in Figure 2.5.

The Brazos River

The Brazos River basin has the largest drainage area of any of the Texas River basins. Its area encompasses about 15 percent of the land area in Texas and totals approximately 44,000 square miles. However, about 9,240 square miles of the basin area normally do not contribute to surface runoff due to a combination of surface geologic characteristics and precipitation patterns. The total length of the river is about 1,210 river miles.[12] The tidal portion of the river extends from the Gulf of Mexico as far upstream as Brazoria, a distance (along the river

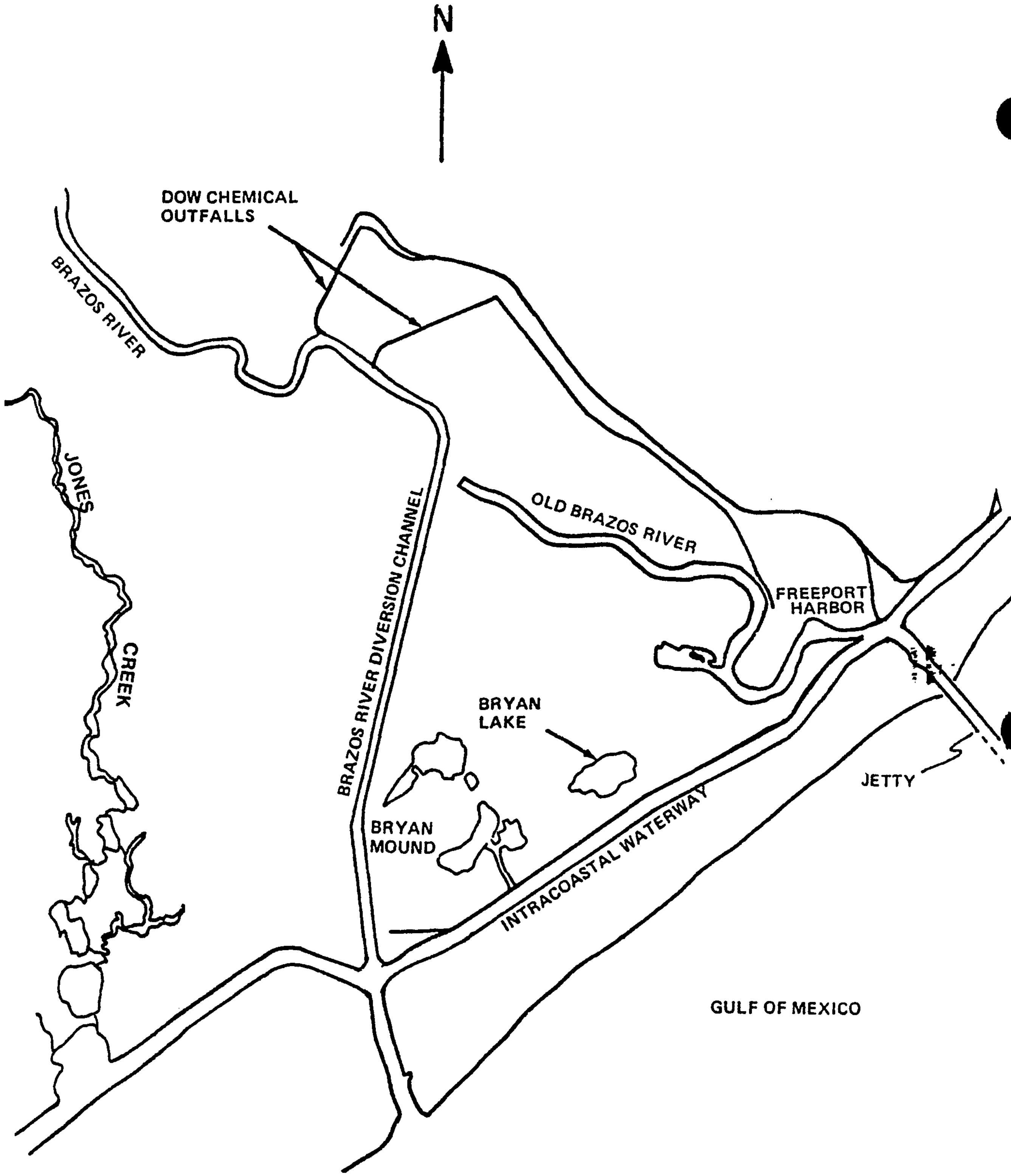


Figure 2.5 Surface Water System in the Vicinity of Bryan Mound

flow path) of about 25 miles. The diurnal tide of the river mouth is 1.8 feet.

The waters of the Brazos River have not been intensely developed for municipal and industrial use because they are often too saline. Most of the salt load is due to the accretion of brine from salt domes, springs, and seeps from the upper river basin. Several large reservoirs have been built in the basin, but use of the stored water has been limited due to relatively high salinity. However, the water is generally suitable for irrigation.[12]

Most of the reservoirs are located in the middle part of the basin. There are 23 major reservoirs above Brazoria County. About 1/6 of the population (almost 2 million people) in Texas inhabits the basin, and much of the land is used for agricultural purposes. It follows that there is a significant amount of waste water entering the river from municipal sewage treatment plants and agricultural runoffs which probably contain significant quantities of pesticides and fertilizers during certain time periods. These waterborne wastes probably are interspersed throughout the concentrations under most circumstances.

The Brazos River estuary is a unique body of water for the Texas Gulf Coast in that it empties directly into the Gulf of Mexico. The Lower Brazos River was diverted in the early 1940s, when the Dow Chemical Plant B was constructed, to provide a suitable harbor in the old river for the Brazos Port area. The diverted channel, now called the Brazos River Diversion Channel, is about 6 miles long from the point of diversion to the Gulf of Mexico. It is fairly straight and typical of a dredged, altered channel. There is some widening of this channel upon entrance into the Gulf and the channel is fairly shallow at this point (approximately 3 to 4 feet deep). The Intracoastal Waterway crosses the Diversion Channel about 1 mile upstream from the Gulf (see Figure 2.5). The U.S. Army Corps of Engineers operates a set of locks in the Intracoastal Canal, one on each side of the Diversion Channel. The purpose of these locks is to keep detritus and silt from entering the Intracoastal Waterway during periods of higher river flows.

When the locks are closed, very little water can pass through them; therefore, most of the river water goes directly into the Gulf. However, when the locks are either inoperative or open due to heavy boat traffic, there is evident mixing of waters from the Brazos River and the Intracoastal Waterway.

The USGS data collection station nearest to the potential withdrawal sites for the Dow Chemical Company reservoirs is located near Rosharon, Texas. The monthly mean flow rates at this station from October 1971 to September 1974 are given in Table B.1-1 of Appendix B.1. During the 3 year period covered by the data, the flow rates ranged from 483 to 27,870 cubic feet per second. In comparison, the maximum raw water flow rate designed for SPR Project at Bryan Mound is only about 21 cfs and even this is buffered from the river by the Dow Company reservoirs.

The Federally approved Texas water quality standards classify the tidal portion of the lower Brazos River as suitable for both contact and noncontact recreation and for propagation of fish and wildlife. The Brazos River water above tidal range to Whitney Dam is classified as suitable for all of the above plus for domestic raw water supply. The water quality criteria set by the Texas Water Quality Board (TWQB)[12] are presented in Table B.2-1 in Appendix B.2.

The TWQB standards for temperature, sulfate, chloride, total dissolved solids, and DO were easily met for all samples. The October 12, 1973 sample with a pH value of 6.0 was outside the TWQB standard range. The fecal coliform count often ran above the TWQB criteria with readings as high as 780 in May 1974 and September 1974.[58] The most recent detailed analysis of water quality in the tidal portion of the Brazos River was conducted by the Texas Water Quality Board (TWQB) in 1971.[59] A total of six sampling locations were chosen as indicated in Figure 2.6.

Data gathered by the TWQB at each of the sampling stations are presented in Appendix B.3. These data include: average surface and bottom dissolved oxygen (DO), temperature; conductivity; water clarity; average surface and bottom alkalinity, hardness pH, and biological oxygen demand; percent fixed and volatile solids content of the bottom sediments; bottom sediment mercury, arsenic, calcium and calcium carbonate content; and total and fecal coliform concentrations. A comparison of these data with the TWQB standards, given in Appendix B.2, shows that:

- At Stations 1 and 1A, the DO level at both the surface and the bottom were too low, especially at the bottom of Station 1A. This is probably because of the direct influence of the oxygen demand of Dow Plant B waste water.

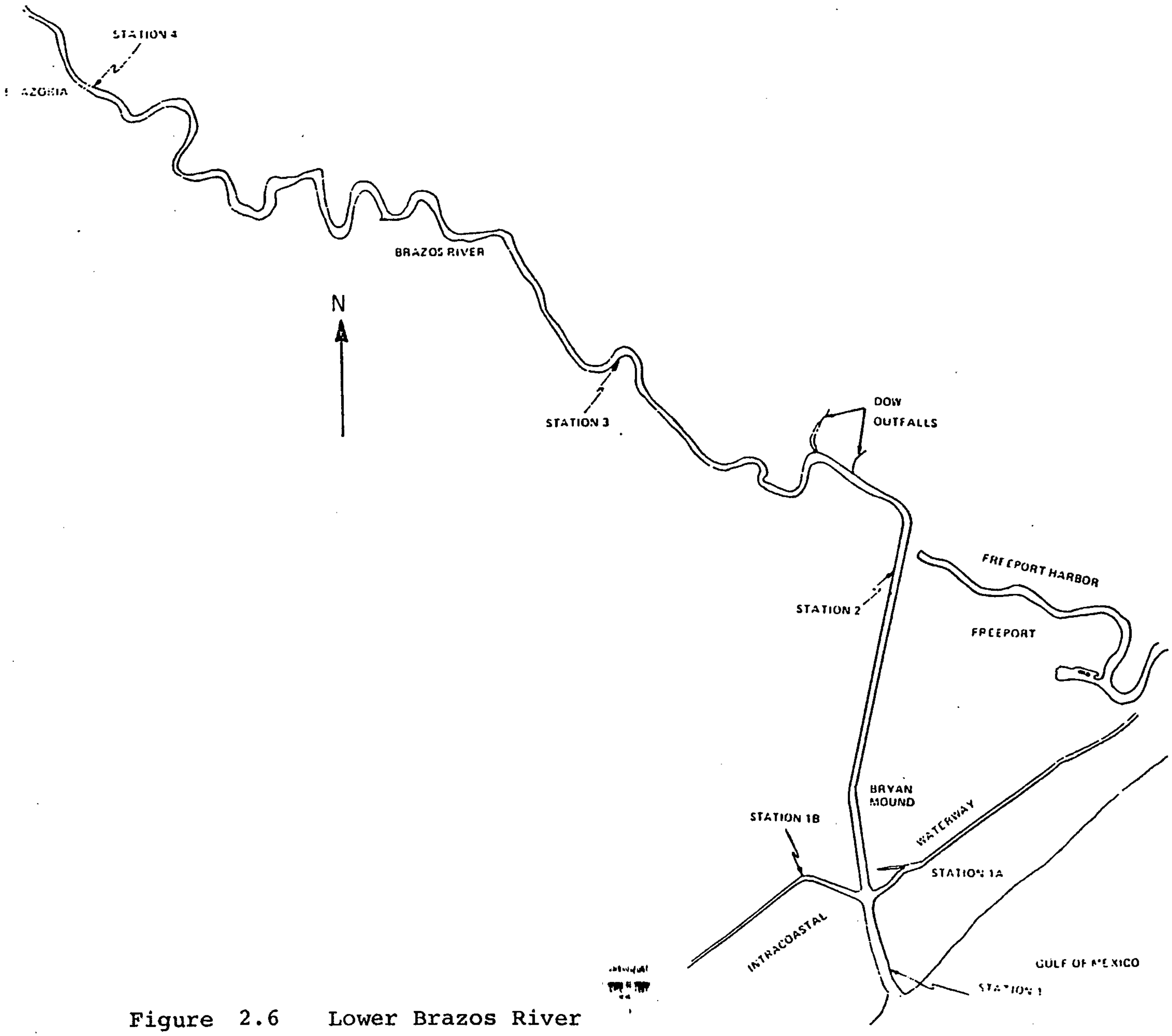


Figure 2.6 Lower Brazos River

- At Station 3, the DO level was only an average of 1.6 mg/l at the bottom. This is probably caused by the relatively stagnant salt water intrusion wedge at the bottom of the river at this station where there is little vertical mixing.

- The pH values were on the high end of the acceptable range throughout the entire sampling area. This poses a potential problem for the growth and maintenance of most marine organisms.

- The temperatures of all the recorded samples were well under the TWQB criterium; however, temperatures of 36°C have often been recorded at Station 2 during periods of low river flow rates in mid and late summer.[2]

The data taken at Station 4 are probably just upriver of the Dow Chemical Company's raw water stations for Brazoria Reservoir. Water at this sampling station met all Texas water quality standards except the fecal coliform standard of not more than 200 MPN/100 ml. The average fecal coliform count in April 1971 was 330 MPN/100 ml.

In summary, data show that the Brazos River estuary is subject to wide variations in water quality. These changes are primarily a function of river flow rate, although tidal interactions are also an important factor. A somewhat naturally occurring salt water wedge, which generally has very little dissolved oxygen (DO), exists in the lower strata water in the upper portion of the estuary. This "dead salt water wedge" is frequently subject to changes in position.

Dow Chemical represents the major industrial installation utilizing the Brazos River both as a source of water and as a waste water receiving stream. During high water stages for the river, Dow purchases fresh water from the Lower Brazos River Authority. The water, as noted in Section 1.2.3.3, is stored in Brazoria and Harris Reservoirs from which it is transferred to Dow Plants "A" and "B" by canal. The annual volume of fresh water transferred to the Dow Plants ranges from 42 billion to 84 billion gallons (1-2 billion barrels).[13] The City of Freeport obtains approximately 1.5 million gallons per day of fresh water through Dow from the same 2 reservoirs. This represents approximately 550 million gallons annually.[14] In addition to this fresh water Dow also utilizes approximately 467 to 509 billion gallons of salt water annually. This salt water is pumped to the facility from the Gulf by special canals. Waste water from the Dow installation enters the Brazos River by means of two canals as indicated in Figure 2.5. The total discharge rate averages about 1.05 million gallons per minute or 2,340 cubic feet per second.[15] Comparison with the data given in Table B.1-1 of Appendix B.1 reveals that this flow rate is of the same order of magnitude as the flow rate of the Brazos River. All available water quality data for this discharge is presented in Table B.3-2 of Appendix B.3.

Freeport Harbor and Intracoastal Waterway

As noted previously, the original channel for the Lower Brazos River has been modified to provide a harbor for the city of Freeport. Freeport Harbor is a Federally maintained deep draft navigation project that extends from deep water in the Gulf of Mexico through a jettied entrance to Freeport, Texas, a distance of about 7 miles. The present harbor components are pictured in Figure 2.7, while their maintained dimensions are presented in Table B.4-1 in Appendix B.4. An easing of the bend from Station 65 to Station 139 and a widening the entrance to the Brazos Harbor Channel were approved by the U.S. Army Corps of Engineers in 1975, with construction beginning later that year. Further, through the River & Harbor Act of 1970, authorization has been given to deepen the 36 foot channels and turning basins to 45 feet and the Brazos Harbor Channel to 36 feet. The impact of these approved modifications on the harbor dimension is also shown in Table B.4-1. The maintenance dredging requirements associated with the existing harbor as well as the modification are summarized in Table B.4-2 of Appendix B.4.

As a deep draft port, Freeport complements other ports on the Gulf Coast in handling exports, imports, and coastal shipping. Over 7 million tons of cargo were carried over the harbor channels in 1973. Most of this trade volume consisted of crude petroleum, petroleum products, and basic chemicals.

Freeport Harbor and the Intracoastal Waterway are tidal from the Gulf to the diversion dam. The diurnal tide in Freeport Harbor has a mean range of about 1.8 feet, and the mean high water is about 1.0 foot above mean sea level. During prolonged periods of strong north winds in the winter, the

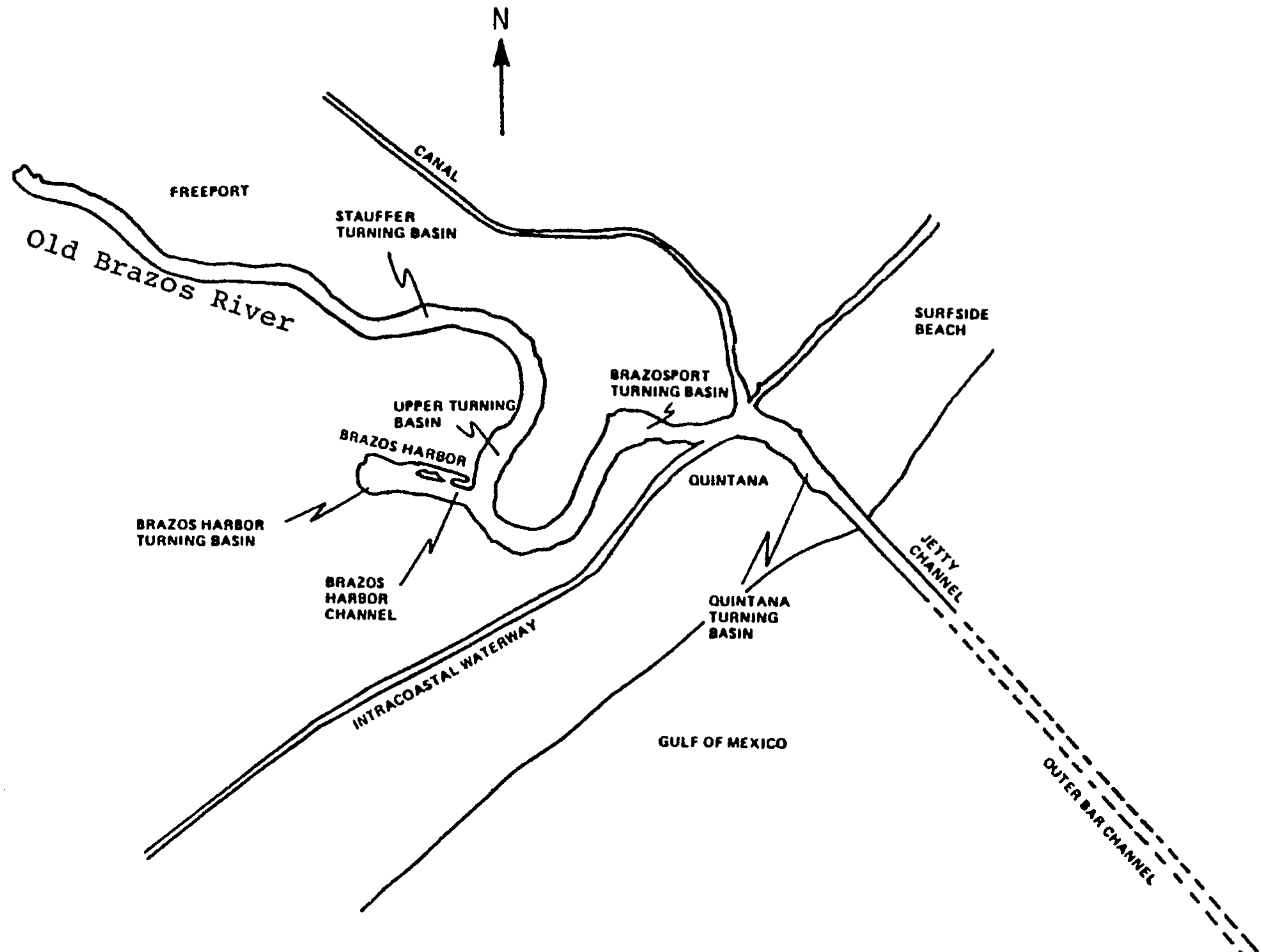


Figure 2.7 Components of Freeport Harbor

water surface may be depressed as much as 3.5 feet below mean sea level. Sustained south and southeast winds during the summer have the opposite effect. Extreme fluctuations in water levels are caused by tropical storms and hurricanes.

The Freeport Harbor maintenance and modification dredging by the Corps of Engineers over the past several years have generated fairly complete water and sediment quality data for Freeport Harbor and the Gulf Intracoastal Waterway between the Harbor and the Intracoastal junction with the Brazos Diversion Channel. Data from the various studies and monitoring programs are presented in Appendix B.5.

Comparisons of these data for Freeport Harbor with the TWQB criteria as given in Appendix B.2, reveals general conformance, with the possible exception of high pH levels. Comparison with the proposed EPA numerical criteria for water quality, marine water constituents (aquatic life), provided in Appendix B.2, reveals the harbor water contained low values of dissolved oxygen* and high values of pH. In addition, the levels of zinc, copper, and possibly lead were high.

It is significant to note that according to an existing EPA ruling[16] dredged spoil from the harbor must be dumped in confined disposal areas and cannot be released into the Gulf.

Jones Creek

Jones Creek, which interconnects numerous small ponds and lakes and which discharges into the Intracoastal Waterway, flows in a southeasterly direction to the west of the Brazos River Diversion Channel (see Figure 2.8). Jones Creek shows tidal influence with saltwater intrusion as far upstream as State Highway 36. Water quality samples for Jones Creek have been collected on only one date, July 10, 1975.[62] Three points along Jones Creek were sampled (see Figure 2.8). This data indicates that salinity at Station J-1, the sampling area furthest upstream, was 0.5 ppt which is the upper ppt limit for freshwater classification.

The water samples were taken by SEADOCK, Inc. during the preparation of the Environmental Report for the SEADOCK Deepwater Port Project. Table 2.2 summarizes the water quality data which was obtained. TWQCB Standards[60] for the San Bernard River were selected as a point of reference because of the proximity of the San Bernard to Jones Creek, and because no standards have been established exclusively for Jones Creek.

*PL 91-611, House Document 93-289, 93rd Congress, 2nd Session.

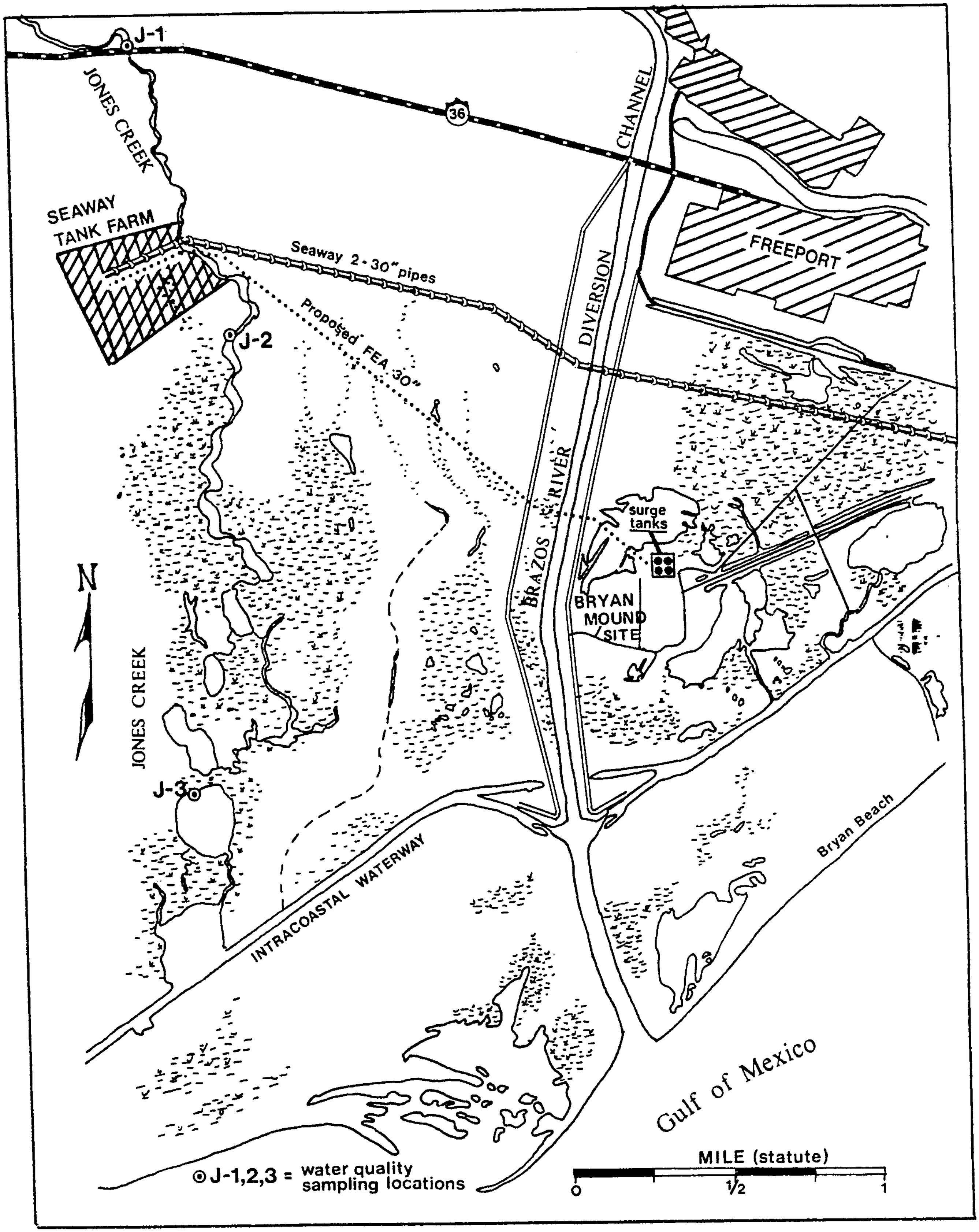


Figure 2.8 Location of Water Quality Sampling Stations on Jones Creek

Table 2.2 Physical Water Quality Data, Jones Creek July 10, 1975*

PARAMETER	STATION J1	J2	J3	TWQCB STANDARDS[a]
Temperature (°C)	26.9	26.0	26.8	Not to exceed 4°F rise above natural conditions
Specific Conductance (μmhos/cm)	690	700	3,090	-
Transparency (cm)	2.5	4.5	6.0	-
Turbidity (JTU)	60	53	38	-
Dissolved Oxygen (ppm)	4.9	5.2	8.5	Not less than 5
Salinity (ppt)	0.5	0.6	2.0	-
pH	8.1	7.9	8.3	-
Total Suspended Solids (mg/l)	64	39	54	-
Total Dissolved Solids (mg/l)	420	450	2,200	Not more than 25,000
Biochemical Oxygen Demand (mg/l)	8	13	8	Not more than 5
Chemical Oxygen Demand (mg/l)	41	26	26	-
Total Organic Carbon (mg/l)	23	25	18	-
Oil and Grease (mg/l)	2	2	2	Substantially Free
Chloride (mg/l)	80	115	1,130	Not more than 12,000
Sulfate (mg/l)	5	13	130	-
Sulfide (mg/l)	N.D.[b]	N.D.	N.D.	-
Fecal Coliforms (MPN/100 ml)	≤2,400	1,100	1,100	Not more than 1,000

[a] Standards established by TWQCB (Texas Water Quality Control Board), for San Bernard River River Tidal, 1972[60]

[b] None detected

*Source: "Seadock Environmental Report," prepared for the Seadock, Inc., Austin, Texas, in part by Dames and Moore, Houston, Texas; Institute for Storm Research, Houston, Texas and Evans Hamilton, Inc., Houston, Texas, Supplementary Information, December 15, 1975.

The information presented in Table 2.2 indicates that Jones Creek is an organically polluted stream. The biological oxygen demand (BOD), and the Fecal Coliform Count exceeded TWQCB (1972) standards for the San Bernard River. High Fecal Coliform counts are probably caused by inadequate sewage treatment. The community of Jones Creek is not serviced by public sewage treatment facilities. Individually owned septic tanks could be the cause of high BOD as well as high Fecal Coliform counts. Decaying vegetation from surrounding marshes could also contribute to the observed high BOD.

Water flow data and sediment and elutriate sampling data are not available for Jones Creek. There is no additional information on Jones Creek available from either the Texas Water Quality Control Board Criteria for 1976[12] or from the USGS "Water Resources Data for Texas-Water Quality Records," 1974.[58]

2.2.2 Coastal Waters of the Gulf of Mexico

The shallow coastal waters of the Gulf of Mexico southeast of the Bryan Mound site constitute a brine disposal alternative. To attain the necessary 20 to 25 foot depth for disposal, a site would be between 0.8 and 1.0 miles offshore.[17] The bottom composition in this area is sand.[18]

The salinity of the Gulf in the potential brine disposal area is affected by the discharge of rivers along the Texas coast, as well as by tides, currents, and precipitation. No detailed salinity data for the immediate area are available. However salinity and other water quality data are available for the existing dredge disposal area which is located 3.5 miles to the northeast of the Alternate Brine Disposal Zone, (See Figure 2.7). These data are provided in Appendix B.6. As noted in this appendix, the salinity ranged from 28 to 29 ppt in this region. Bottom sediment data is available in the immediate vicinity of brine disposal site, as provided in Appendix B.6.

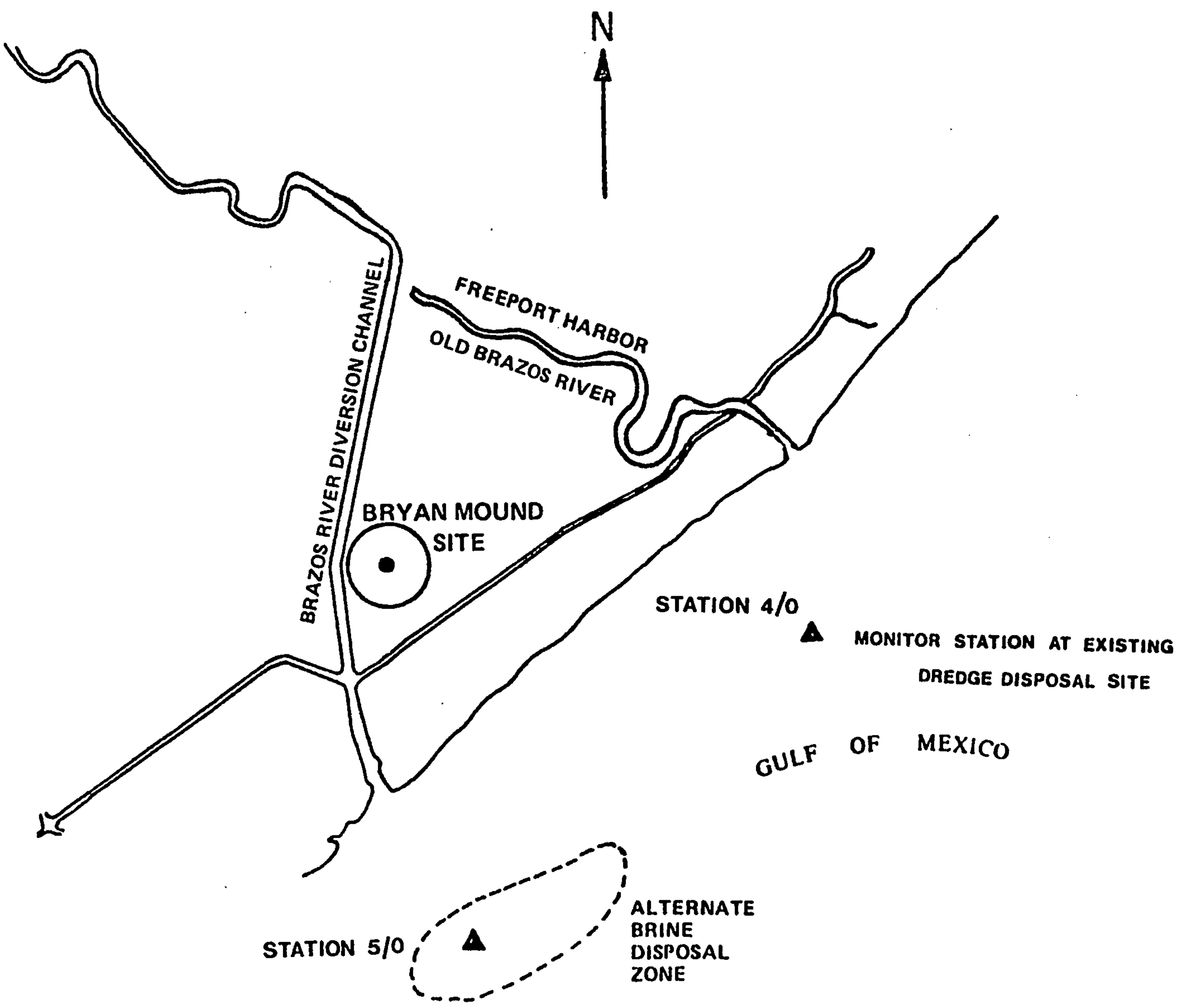


Figure 2.9 Location of Alternate Brine Disposal Zone

Surface currents in the area are variable, being strongly affected by winds, tides and the flow of the Brazos River. Mean surface currents 30 miles southwest of the brine disposal site are presented in Figure 2.10 As indicated in the figure, the most probable current sets to the northeast with a drift of 0.6 knots or to the west with the same drift.[19]

2.2.3 Subsurface Waters

Current design for the Bryan Mound site does not call for the use of the shallow subsurface waters aquifer as a source of displacement water, or the deep subsurface aquifer as a brine disposal site. Because both water systems represent alternatives to the existing design, however, they are described in the following subsections.

Shallow Subsurface Aquifer

The uppermost aquifer in the vicinity of Bryan Mound is known as the Chicot aquifer and extends from about 150 to 1,100 feet beneath the surface. Chicot is subdivided into two units. These subdivisions are designated the upper unit and the lower unit. In most places, the two units are separated by clay. In Brazoria County, the upper unit is either a water table or artesian aquifer; the lower unit is an artesian or leaky artesian aquifer. The relationship between the Chicot aquifer and other geologic classifications of the region is summarized in Figure 2.3.

Upper Unit of Chicot Aquifer

The most widespread fresh water aquifer in Brazoria County and the only aquifer containing fresh water in the vicinity of Bryan Mound is the upper unit of the Chicot aquifer. The upper unit consists of the interconnected shallower sands that are generally present between the surface and a depth of 100 to 300 feet, including the alluvium in the river valleys. The aquifer dips southeastward at about 2 feet per mile. As shown in Figure B.7-1 of Appendix B.7, in the vicinity of Freeport, the base of the upper unit occurs at a depth of about 300 feet while at Bryan Mound the depth is about 250 feet. Near Freeport the thickness of sands in the upper unit is about 180 feet as indicated in Figure B.7-2, while at Bryan Mound, the sand thickness is much less (about 75 feet).

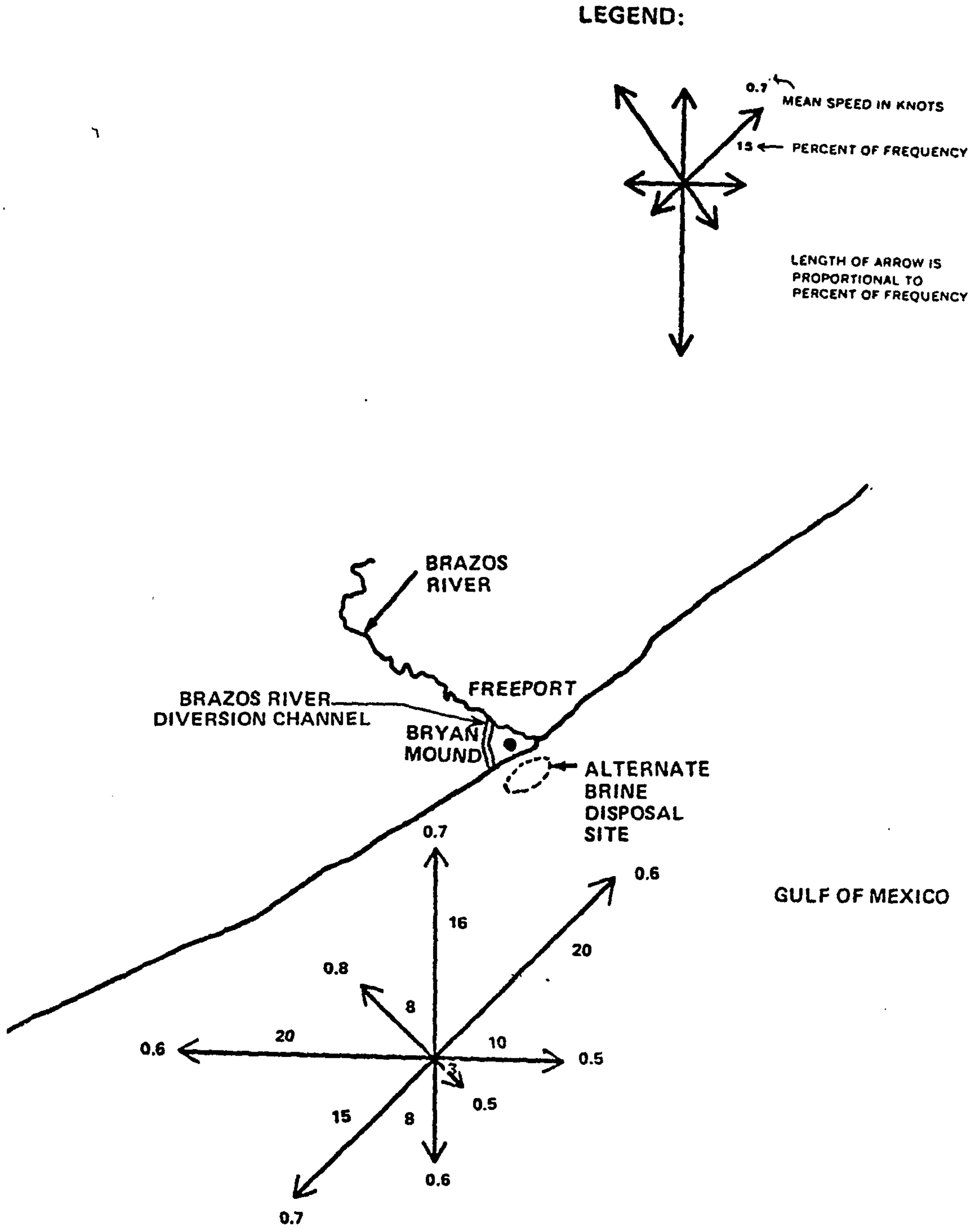


Figure 2.10 Current Rose in the Gulf of Mexico near Bryan Mound

Source: Outer Continental Shelf, Western Gulf of Mexico, Upland Soils, Bottom Sediments, Visual No. 3, U.S. Dept. of Interior, Bureau of Land Management.

Fresh water occurs in the top portion of the aquifer. Near Freeport, fresh water occurs at depths of about 200 to 250 feet or less while at Bryan Mound no fresh water occurs below about 75 feet. It is important to note that, as shown in Figure B.7-5, a layer of saline water (1 to 3 ppt) approximately 40 feet thick overlies the fresh water in the aquifer in the vicinity of Freeport.[8]

Near Bryan Mound dome fresh and saline water are found interbedded. The quality of ground water in this area is deteriorated by one or both of two processes: (1) the water dissolves salt from the dome, or (2) water from deeper, high pressure, saline water bearing sands flows up into the overlying aquifer through flow ways formed along the sides and across the tops of the dome.

The clay that overlies the sands of the upper unit of the Chicot in much of Brazoria County is replaced by sands of the Quaternary alluvium in the Brazos River system. Thus the Chicot aquifer is in hydraulic continuity with the surface. The layer of saline water in the top portion of the Chicot in this region may result from the salt water wedge, which penetrates upstream in the Brazos River, causing saline water to seep through these sands into the top of the Chicot.

The hydraulic characteristics of the Chicot aquifer in parts of Brazoria County were determined by aquifer tests. The field coefficient of transmissibility was as much as 66,000 gallons per day per foot for the upper unit. The maximum permeability for the sand exceeded 1,000 gallons per day per square foot while the minimum permeability was 130 gallons per day per square foot.

Fresh water wells in the vicinity of Freeport yield 1,000 to 3,000 gallons per minute, while in the vicinity of Bryan Mound, the yield is from 500 to 1,000 gallons per minute. The aquifer supplies 25 percent of the water for public supply and domestic use as well as part of the water used by industry in the Freeport area. The city of Freeport draws 500 thousand gallons of water daily from the upper unit via 8 wells at a depth of about 250 feet.[14] The City of Surfside Beach draws 150,000 gallons per day from 6 wells at depths between 165 and 500 feet.[20] Because of the large drawdown in the area, combined with the relatively thin section of fresh water sand, and the proximity of water of proven quality, the aquifer appears overdeveloped in the Freeport area.[8]

Lower Unit of Chicot Aquifer

The basal bed of the Chicot aquifer is the massive sand described as the "Alta Loma" sand in Galveston County,[21] and the Alta Loma Sand of Rose[22] in the Houston District.[23]

The Alta Loma Sand and the sands above it which show similar water level fluctuations are included in the lower unit of the Chicot aquifer. The basal sands of the Chicot aquifer can be distinguished on most electrical logs because they usually display a higher range of resistivity than the sands of the Evangeline aquifer which lie at greater depths.

As shown in Figure B.6-3, Appendix B-7 the base of the lower unit (which corresponds to the base of the Chicot aquifer) occurs at a depth of about 1,200 feet in the vicinity of Freeport. Near Bryan Mound dome, as expected, the lower unit is encountered at shallower depths (about 1,000 feet). In both areas, the sands in the aquifer are about 370 feet thick as shown in Figure B.6-4. The lower unit dips southeast at about 10 feet per mile.

With respect to hydraulic characteristics, the field coefficients of transmissibility were as much as 275,000 gallons per day per foot with a maxinum permeability in excess of 1,000 gallons per day per square foot.

The lower unit of the Chicot aquifer contains a large amount of slightly saline water. Large (10,000 gallons per day), sustained withdrawals of this water could be made without excessive drawdown. Large wells (3,000 gallons per minute or more) producing saline water can be constructed anywhere in Brazoria County where the lower unit of the Chicot contains 100 feet or more of saline water bearing sand. Wells that produce slightly and moderately saline water from this unit have been constructed and used by industry in the Freeport area.

Deep Subsurface Aquifers

Beneath the Chicot aquifer lies the Evangeline aquifer which consists of Pliocene and Miocene formation. At greater depths lie the additional Miocene sands. The relationship between the Evangeline aquifer and other geologic classification in the region is shown in Figure 2.3. These subsurface water bodies represent alternate sites for brine disposal.

Evangeline Aquifer

The Evangeline aquifer is a sequence of alternating sands and clays that thicken from about 2,000 feet at the northern edge of Brazoria County to more than 3,500 feet at the southern edge. At most locations in the county, there is more sand than clay in the Evangeline. Although some sands and clays are continuous throughout much of the area, most units vary considerably in thickness from location to location. Thicknesses of individual beds of sand and clay generally range from a few feet to about 100 feet.[8]

The Evangeline aquifer is present in the subsurface everywhere in the county except for small areas where the salt domes pierce through the Evangeline and into the overlying Chicot beds. The average dip of the fresh water bearing beds is approximately 30 feet per mile to the southeast. Over geologic structures, the dip approaches zero and may even be reversed to the northwest. Locally, dips away from the structures are more than 30 feet per mile.

The hydraulic properties of the Evangeline aquifer in Brazoria County have not been determined. However, the values determined from tests of the heavily pumped layer in the Houston District probably approximate those for the aquifer in Brazoria County. Wood and Gabrysch[23] report that the coefficients of transmissibility measured by pumping tests generally are in the range of 75,000 to 150,000 gallons per day per foot in the Houston District. The average permeability of the heavily pumped layer in the Houston District is about 250 gallons per day per square foot. The Evangeline aquifer has individual beds of sand as much as 230 feet thick containing slightly saline water. However, this thickness is a local occurrence. No large thick beds containing slightly saline water have been found in this aquifer.

In the vicinity of Freeport and Bryan Mound the characteristics of the aquifer are not well defined. It would appear, however, to contain a large quantity of saline water in the depth interval from about 1,200 to 4,900 feet.

Lower Miocene Sands

Beneath the Evangeline aquifer, Miocene sands continue to a depth of 6,500 feet. Very little data is available concerning these sands, but based on the analysis of a single well log 15 miles to the northeast these sands probably occur in layers from 70 to 120 feet thick, interspersed with layers of clay.[24] The sands should contain saline waters. In the Miocene formations below 6,500 feet, the composition is mostly silt and clay with no sands encountered.

2.3 METEOROLOGICAL CONDITIONS

2.3.1 Climatical Conditions

The climate of the Bryan Mound area is classified as humid subtropical with strong marine influences. Seasonal fluctuations are moderate,* varying from short mild winters to long hot summers. The summer days are generally hot and humid, broken occasionally by tropical storms, with little variety day-to-day.

In Galveston, January through March are the foggiest months, with an average of 4.1 percent of the days per month having heavy fog that restricts visibility to less than a half mile.[25] March through May and September are usually the windiest, with mean wind speeds of 12 to 15 mph at Freeport, with something less than 2 percent of the winds less than 2 mph.[26] This same January through March period is typically the coldest with temperatures in the upper 50°'s to low 60°'s, ranging from average minimum temperatures of 49° in January to maximum of 67° in March. The driest period is from January to June with between 2.7 and 3.3 inches of rain each month. The normal rainfall on a monthly basis at Freeport is plotted in Figure 2.9. The average annual rainfall at Freeport is 45 inches, and the annual lake evaporation losses are roughly 53 inches.[26] May through September are usually the hottest and have the highest thunderstorm activity. Temperatures between 70° and 85°, as seen in Figure 2.12, dominate the

---

*The following data are not site specific in that the nearest weather monitoring stations are 5 to 25 miles away. Data presented are from the nearest station to Bryan Mound, with the exception of Corpus Christi (approximately 135 miles down the coast) data.

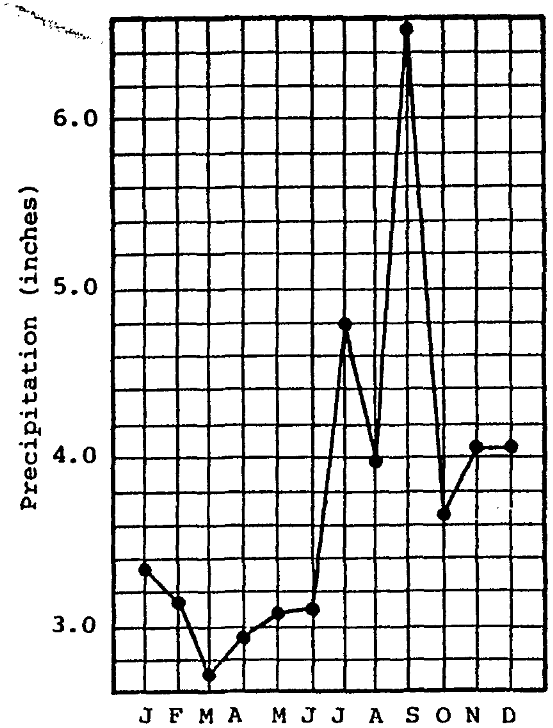


Figure 2.11 Average Monthly Precipitation at **Freeport**[26] (38-41 Years of Record)

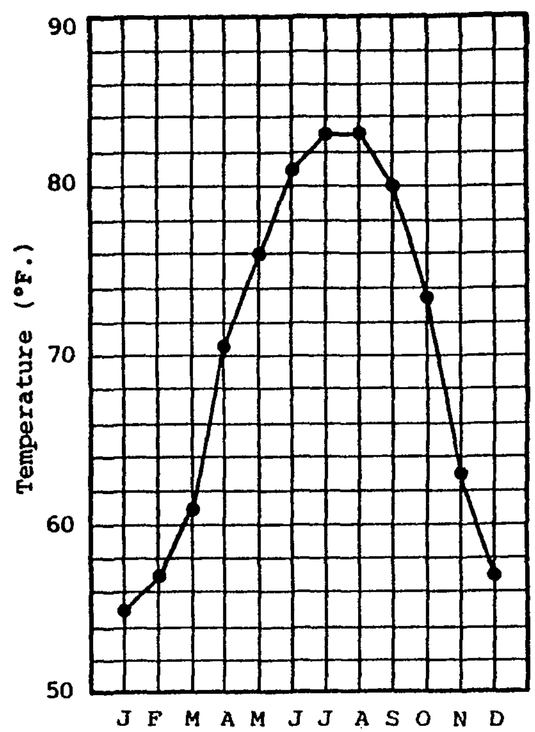


Figure 2.12 Monthly Temperatures at Galveston, Texas [26]

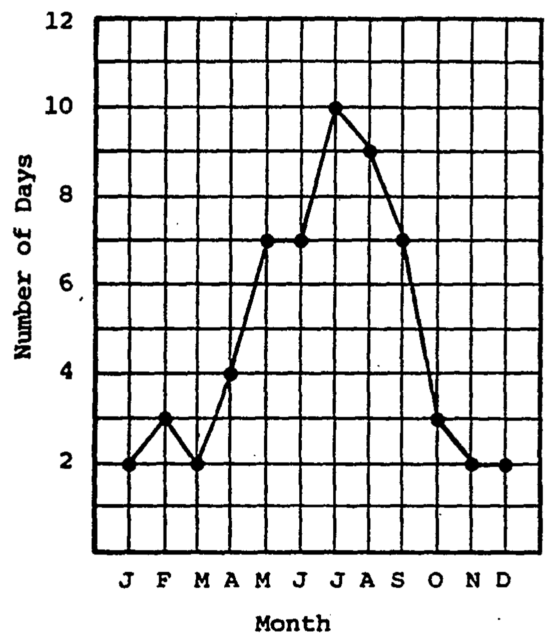


Figure 2.13. Average Number of Days per Month with Thunderstorms at Houston, Texas (Hobby Field) for 1939-1968 [26]

summer months. The mean annual temperature is 70°. The average length of the growing season is 275 days. The humidity varies little on an annual basis; it is approximately 82 percent in the morning dropping to 72 percent in the after noon and evening.[16] Thunderstorm activity in the area is greatest in July and August, with an approximate mean annual number of days with thunderstorms being 58 days. The monthly distribution of thunderstorms is seen in Figure 2.13.

The nearest wind rose data are from Galveston and Victoria, Texas. Figures 2.14 and 2.15 show these patterns and Figure 2.16 gives a general profile of the wind rose patterns for the Gulf Coast. The annual percent frequency of wind by speed groups for Galveston and Corpus Christi shows similar characteristics:

Wind Speed Groups	Galveston[27]	Corpus Christi[28]
0- 3 mph.	4%	4%
4- 7 mph.	13%	14%
8-12 mph.	39%	28%
13-18 mph.	33%	37%
19-24 mph.	10%	12%
25-31 mph.	2%	3%
32-38 mph.	1%	0.5%
Mean Speed	12.5 mph.	12.9 mph.

Eighty nine percent of the winds at Galveston are less than 18 mph. Extreme winds at 30 feet above ground with a 50 year recurrence interval are around 95 mph and with a 100 year recurrence interval, around 100 mph.[29]

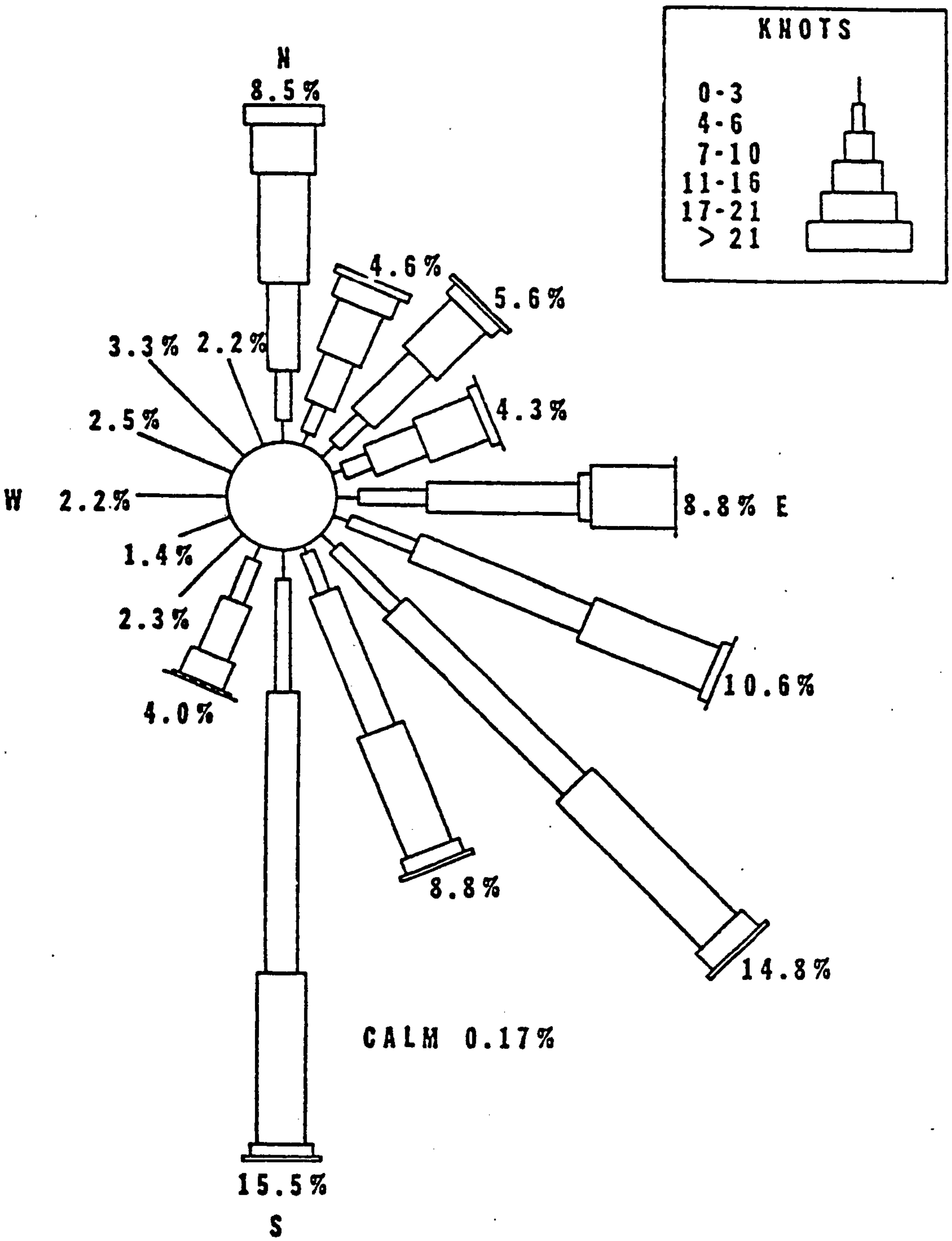


Figure 2.14. Annual Wind Rose, Galveston, Texas covers period 1959 - 1963.

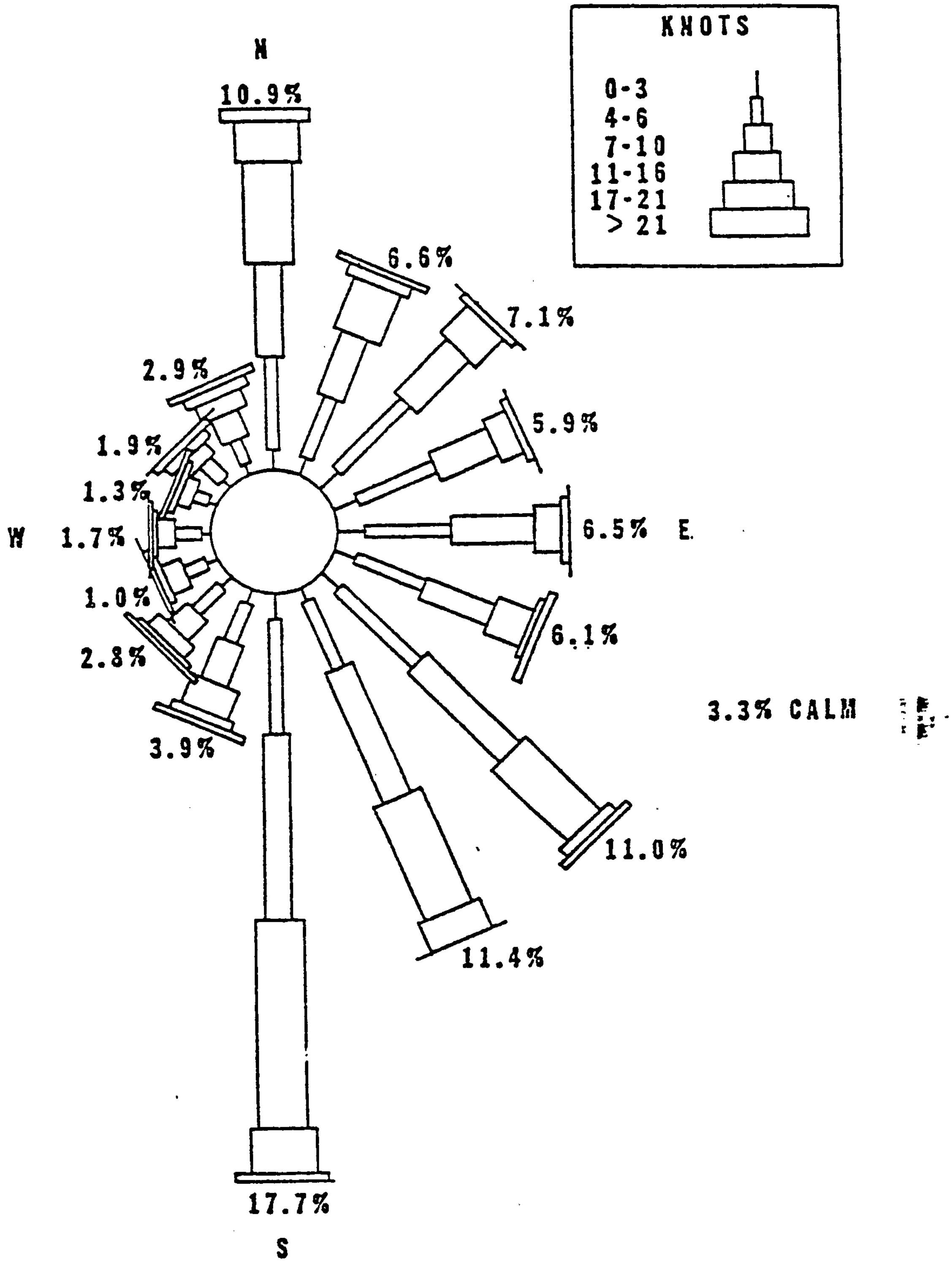


Figure 2.15 Annual Wind Rose, Victoria, Texas covers period 1964 - 1973.

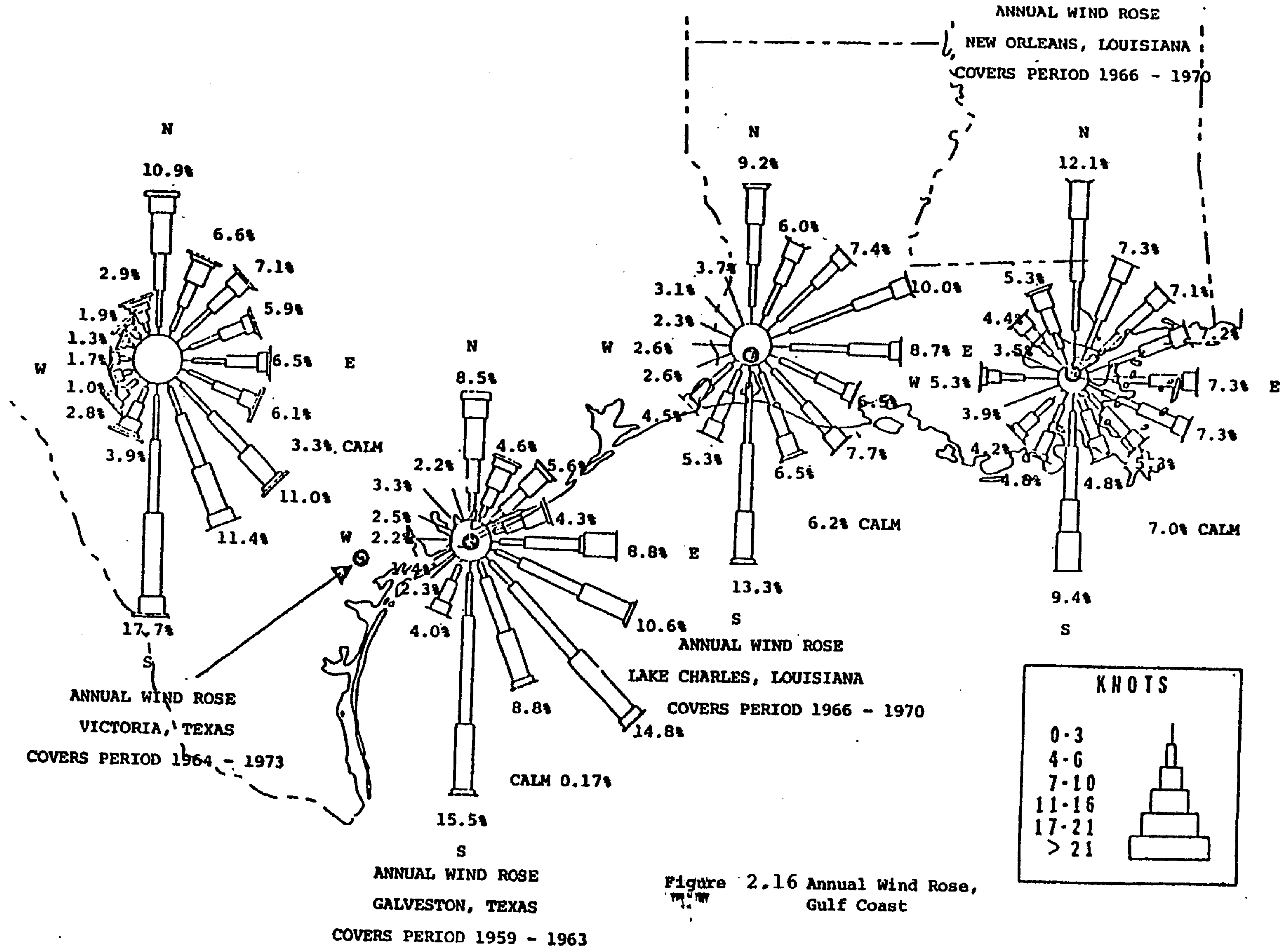


Figure 2.16 Annual Wind Rose, Gulf Coast

Severe storm statistics on the three 50 nautical mile strips (57.6 statute mile strips) of Texas coastline surrounding Bryan Mound from San Antonio Bay to south of Beaumont reveal these details:

Number of Tropical Cyclones Reaching the Mainland 1886-1970*

	Southwest	Central	East
All Tropical Cyclones	10	15	17
All Hurricanes	8	12	10
Great Hurricanes	3	3	3

Number of Years Between Tropical Cyclone Occurrences
(Average for Period 1886-1970)

	Southwest	Central	East
All Tropical Cyclones	8	5	5
All Hurricanes	10	7	8
Great Hurricanes	28	28	28

Risk of Tropical Cyclones**

	Southwest	Central	East
All Tropical Cyclones	12%	18%	20%
All Hurricanes	9%	14%	12%
Great Hurricanes	4%	4%	4%

*Southwest: 57.6 miles of coastline from San Antonio Bay to Matagorda (approximately 37 miles down the coast from Freeport).
Central: 57.6 miles of coastline from Matagorda to San Luis Pass (approximately 20 miles down the coast from Galveston), of which Bryan Mound is roughly in the center.
East: 57.6 miles of coastline from San Luis Pass to just south of Beaumont.

Definitions:

Tropical Cyclone	39-73 mph.
Hurricane	74-124 mph.
Great Hurricane	More than 125 mph.

**Risk equals the probability (%) that a tropical storm, hurricane or great hurricane will occur in any one year in a 50 nautical mile segment of coastline.

Because of the proximity of the Bryan Mound salt dome to the coast, the secondary weather disturbances induced by offshore tropical storms must be reviewed. Table 2.3 shows the size and intensity of tropical storms observed within 300 miles of the Seadock proposed offshore Superport site, as reported by Seadock, Inc. It can be seen that tropical storm activity offshore is more intense than activity that reaches the mainland.

Atmospheric stagnation periods are minimal because of the Gulf Coast winds. The total number of forecast days of high meteorological potential for air pollution is minimal because of the relatively constant winds off the Gulf. The seasonal inversion frequency as percent of total hours is reported to be approximately 37 percent for winter, 20 percent for spring, 15 percent for summer, 30 percent for fall, with the annual inversion frequency of 25 percent.[31]

The normal tidal fluctuations in the Freeport-Galveston area are small, with the Freeport diurnal range of 1.8 feet. Further, tides in this area are erratic. It is important to note that wind and storm acitivity off the coast have a strong effect on variations in water heights. As reported by the U.S. Army Corps of Engineers, during strong northwesterly winds, water levels can drop to as low as -4.0 feet and during hurricanes the high levels could be +15.0 feet.[32] Variations in salinity levels in the bays and estuaries are also influenced by the direction and strength of the winds as well as by the amount of rainfall associated with high wind and storm activity. Reference 32 states that the average fluctuation in salinity is about 15 ppt, with maximums seldom exceeding 32 ppt.

2.3.2 Existing Air Quality

In compliance with the Federal Clean Air Act, the state of Texas has initiated its Implementation Plan which provides for the implementation, maintenance and enforcement of the Federal Air Quality Standards promulgated by the Environmental Protection Agency (EPA) on 30 April 1971 (36FR8186). The Texas standards are identical to the federal standards as listed in Table 2.4, with a few additions. The additions pertinent to the SPR Program activities are listed in Table 2.5.

In order to characterize the existing air quality of the Bryan Mound site, three air monitoring surveys in the near vicinity were considered sufficient, thus excluding any need

Table 2.3

Size and Intensity Distribution of 143 Tropical Storms Observed Within 300 Nautical Miles of the Proposed Offshore SEADOCK Support Facilities.[25]

Intensity (max. wind speed, mph)	Size of Storms: Small*	Medium**	Large***	Total
Extreme (>135 mph)	3	7	2	12
Major (101-135 mph)	3	9	3	15
Minimal (74-100 mph)	19	21	1	41
Minor (<74 mph)	49	26	0	75
Total	74	63	6	143

* average radius of 20 mph winds = 100 nautical miles
** average radius of 20 mph winds = 200 nautical miles
*** average radius of 20 mph winds = 300 nautical miles

Table 2.4 Federal Ambient Air Quality Standards

Pollutant	Primary Standard	Secondary Standard
Particulates:		
Annual Geometric Mean	75μg/m³	60μg/m³
24-hour Maximum	260μg/m³	150μg/m³
Sulfur Dioxides:		
Annual Arithmetic Mean	80μg/m³ (0.03 ppm)	60μg/m³ (0.02 ppm)
24-hour Maximum	365μg/m³ (0.14 ppm)	260μg/m³ (0.10 ppm)
3-hour Maximum	-	1300μg/m³ (.5 ppm)
Sulfur Acid Mist and/or Sulfur Trioxide:		
24-hour Maximum	12μg/m³	
1-hour Maximum	30μg/m³	
Carbon Monoxide:		
8-hour Maximum	10mg/m³ (9 ppm)	10mg/m³ (9 ppm)
1-hour Maximum	40mg/m³ (35 ppm)	40mg/m³ (35 ppm)
Photochemical Oxidants:		
1-hour Maximum	160μg/m³ (0.08 ppm)	160μg/m³ (0.08 ppm)
4-hour Maximum	98μg/m³ (0.05 ppm)	98μg/m³ (0.05 ppm)
Hydrocarbons (non-methane):		
3-hour Maximum	160μg/m³ (0.24 ppm)	160μg/m³ (0.24 ppm)
Nitrogen Dioxide (NO_2):		
Annual Arithmetic Mean	100μg/m³ (0.05 ppm)	100μg/m³ (0.05 ppm)

μg/m³ = Micrograms per Cubic Meter

mg/m³ = Milligrams per Cubic Meter

Table 2.5 Texas Ambient Air Quality Standards (as specified in conjunction with the Federal Ambient Air Quality Standards)

Suspended Particulates:	
5-hour average	100μg/m^3
3-hour average	200μg/m^3
1-hour average	400μg/m^3
Visible Emissions:	
5-minute period	not to exceed 20% opacity
(for any stationary flue constructed after 31 January 1972)	
Sulfur Dioxide (SO_2):	
30-minute average	net ground level concentration*
Orange, Jefferson Counties	0.32 ppm
Harris, Galveston Counties	0.28 ppm
All other counties	0.40 ppm
Hydrogen Sulfide (H_2S):	
30-minute average	net ground level concentration*
(1) downwind concentration effecting property used for residential, business or commerce purposes	0.08 ppm
(2) downwind concentration effecting property used for other than the above specified land uses; e.g. vacant land, range land, industrial property	0.12 ppm

*net ground level concentration is the downwind concentration minus the upwind concentration.

for further monitoring. Two of these surveys are fairly extensive. The data provided by the Texas Air Control Board (TACB) were collected for the year September 1974 to September 1975 at Clute, which is approximately 7 1/2 miles north of Bryan Mound and is listed in Appendix D. Summaries of the results of brief surveys taken by the Southwest Research Institute (Houston) for Seadock, Inc., at Jones Creek (5 1/2 miles northwest of Bryan Mound), and at the proposed Seaway Tank Farm facility (4 1/2 miles northwest of Bryan Mound) are included also in Appendix D.

The conclusions of these surveys show that the air quality around Bryan Mound is very good with the exception of high non-methane hydrocarbon concentrations and oxidant concentrations. Concentrations of carbon monoxide (CO), sulfur dioxide (SO2) and nitrogen dioxide (NO2) are minimal, in some cases at or below the minimum detectability limits. Particulates are low, characteristic of rural areas subject to reasonably consistent winds due to the flat terrain and winds off the Gulf.

Concentrations of non-methane hydrocarbons are very high, approximately 30 percent of the time they are higher than the National Ambient Air Quality guidelines as recorded by the Southwest Research Institute. At Clute, the TACB records show high levels of non-methane hydrocarbons. Seventy-four and five tenths percent to 98 percent of the hours recorded showed concentrations higher than the 0.24 ppm federal guidelines for the year, September 1974 to September 1975.[33] Hourly oxidant concentrations measured at Clute for this same period show that national one hour standards were exceeded frequently.

2.3.3 Noise

Noise at the site and in the near vicinity of Bryan Mound is typical of a reasonably remote, essentially flat marshland area. In the winter and spring, the contributing noise sources are wind, periodic bird calls, the rustle of the grasses and brush, and maritime traffic on the Brazos River and the Intracoastal Waterway. The day-night A-weighted sound levels are around 49 dB on reasonably calm days (winds less than 10 mph).[34] In the summer, because of the high humidity and warmth, the marshland noise is dominated by the buzz of mosquitoes and other insects, frogs, crickets, bird calls and the noise of the foliage on the brush, as winds blow through. On a normal summer evening the noise levels can be as much as 10 to 15 dB higher than winter levels because of the activities of native creatures and insects.

The Bryan Mound site is characterized by remote area noise patterns. Local activity on roads nearby and Dow's brine operations are the only significant noise intrusions.

In preparation of the environmental impact report for the proposed Seadock offshore superport, Seadock, Inc. performed a brief ambient noise survey in the area of Jones Creek where the Seaway Tank Farm facilities will be located.[25] While this study is not precisely site specific for Bryan Mound, the area is only a few miles away and the ambient levels and spectra can be assumed to be representative of noise sensitive areas around the site. Figures 2.17 and 2.18 show the daytime, evening, and nighttime octave band spectra for two sites chosen by Seadock, Inc. on the basis of their sensitivity to interruption by noise. The first is approximately 2,000 feet from a running creek, the second is at a small community roadside. These spectra were taken in early March when any deciduous trees are still barren, and insect populations are relatively low. Figure 2.19 is the ambient spectrum taken from a Department of Transportation noise survey of the Florida Everglades.[35] This spectrum is a little "quieter" than the Jones Creek area daytime spectra because of the lack of human activity (road traffic in particular) in the everglades.

The A-weighted* levels range from a low of 40 dB (nighttime) to a high of 48 dB (daytime). In the summer, these ambient levels may be as high as 50 dB in the evening. The closest noise sensitive sites near Bryan Mound, such as Jane Long School and West End Church (Freeport), are approximately 2

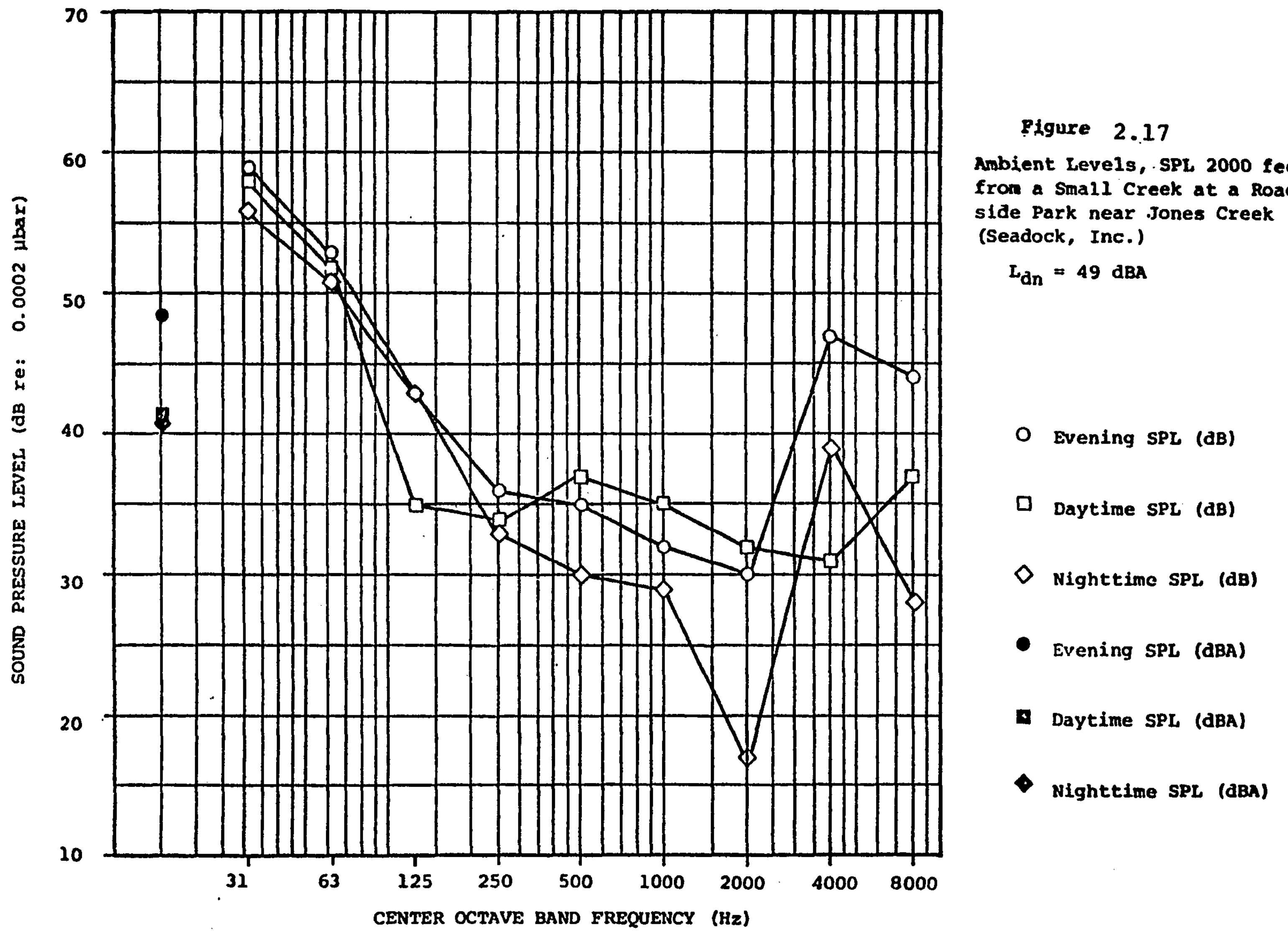


Figure 2.17

Ambient Levels, SPL 2000 feet from a Small Creek at a Roadside Park near Jones Creek (Seadock, Inc.)

L_{dn} = 49 dBA

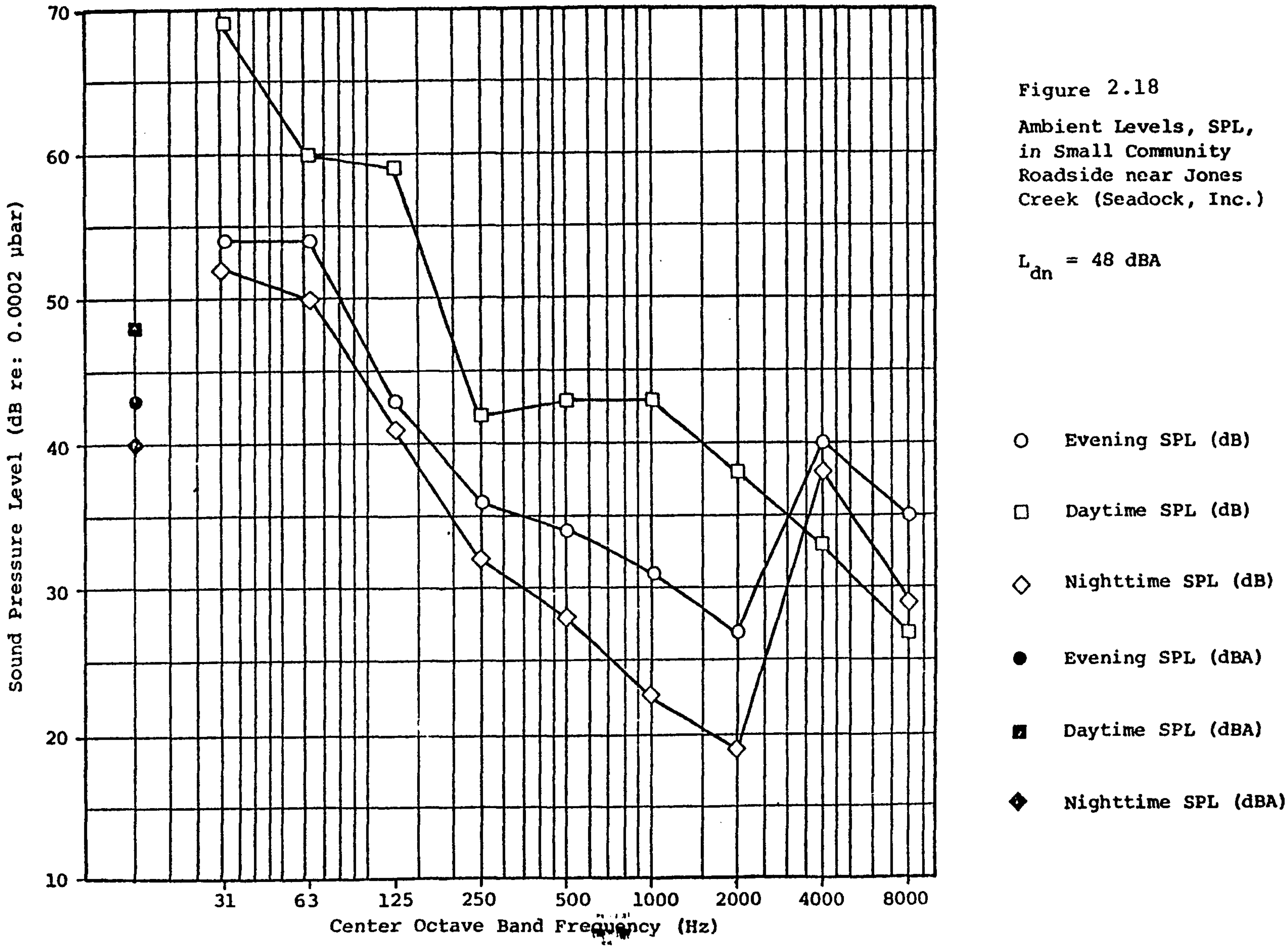


Figure 2.18

Ambient Levels, SPL, in Small Community Roadside near Jones Creek (Seadock, Inc.)

L_{dn} = 48 dBA

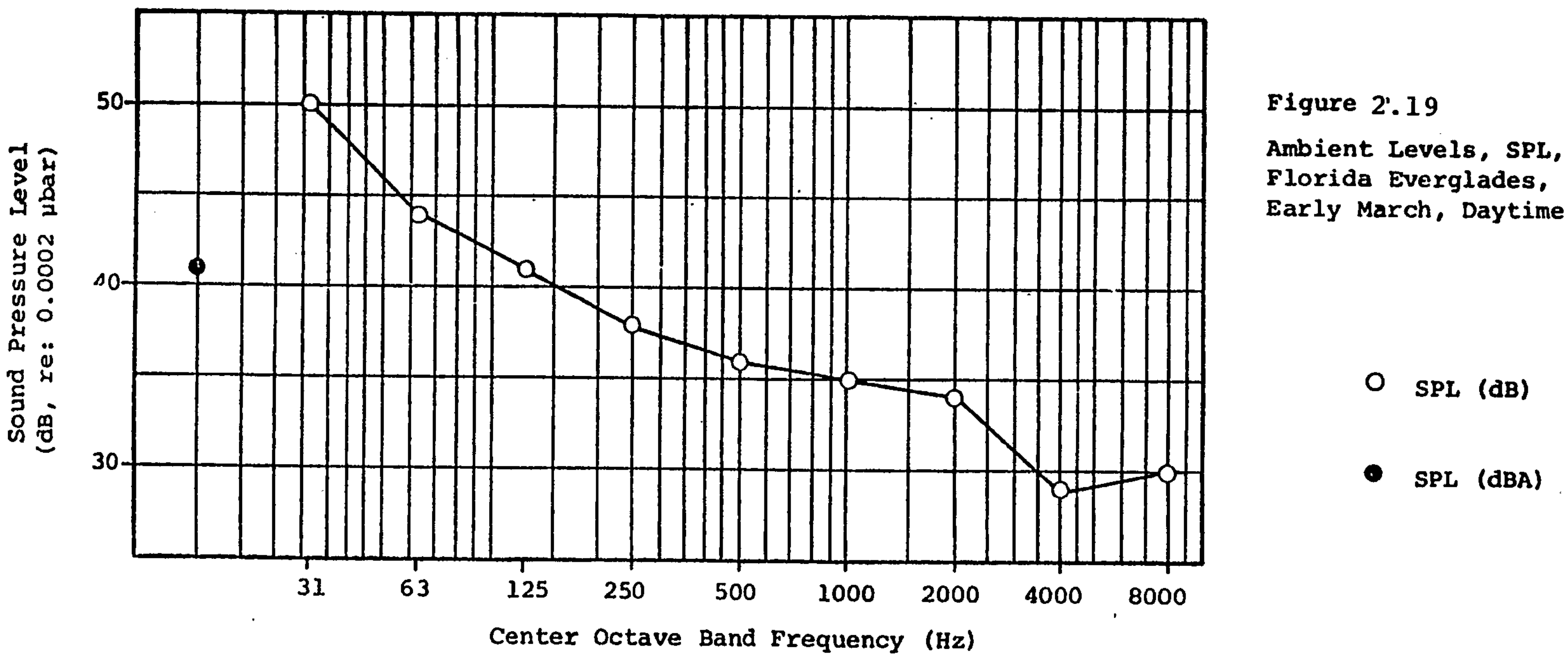


Figure 2.19

Ambient Levels, SPL, Florida Everglades, Early March, Daytime

miles north of the site, with 2 miles of marshland between the site and the church and the school.

2.4 SPECIES AND ECOSYSTEMS

2.4.1 Ecosystems

For this report, 3 major natural environments or ecosystems have been identified corresponding to units used in the Environmental Geologic Atlas of the Texas Coastal Zone-Galveston-Houston Area.[36] The major natural environments are:

- o marshlands and coastal prairies
- o cleared lands
- o coastal and inland waters.

Characteristic flora and fauna of these 3 ecosystems as well as their vegetation type subdivisions are summarized in Table 2.6. A map showing the distribution of vegetation types comprising these ecosystems is provided as Figure 2.20.

Marshlands and Coastal Prairies

Marshes extend from the Gulf Coast throughout much of the county and cover 84,000 surface acres. All three marsh types, saline, brackish, and freshwater, are found within Brazoria County with salinities decreasing northward. In the saltwater marsh, smooth cordgrass (Spartina spp.) predominates.[34,37] Saltgrass, glasswort, Salicornia spp., batis (Batis maritima), and salt matrimony vine (Lycium carolinianum) may also occur. Hardstem bulrush (Scirpus olneyi) and saltgrass (Distichlis spicata) are the most common grasses in brackish marshes. Saltwater marshes (salinities may range up to 40 ppt) and brackish marshes provide excellent habitat for overwintering, migratory waterfowl. Geese predominate while egrets, gulls, ibises,

Table 2.6 Typical Fauna and Flora of Ecosystems and Biosystems of Brazoria County, Texas

Environment	Marshlands			Coastal Prairies	Cleared Lands		Coastal and Inland Waters	
Environmental Subcategory	Freshwater Wetland	Intermediate and Brackish Wetland	Saline Wetland		Urban and Suburban	Crops and Future Lands	Freshwater	Saline
Biotope	Freshwater Marsh		Salt Marsh					Planktonic Bays
Typical herbs, grasses and trees	Maiden cane cordgrass sedges water hyacinth pennywort	smooth cordgrass soilbind morning glory fiddle leaf morning glory sea purslane	smooth cordgrass salt grass shore grass glasswort salt matrimonyvine batis Carolina wolfberry bulrush Harstem bulrush	gulf cordgrass bunchgrass Indian grass switchgrass bluestem liveoak huisatch ragweed prairie pleatleaf	Various resendential species	rice soybeans prairie grass	NA	NA
Typical mollusks and crustaceans	snails mussels clams	snails crabs clams shrimp oysters	fiddler crabs mud crabs clams snails shrimp	snails	NA	NA	clams snails	clams shrimp crabs snails
Typical amphibians and reptiles	Western diamondback rattlesnake	Gulf salt marsh snake Western diamondback rattlesnake	Gulf salt marsh snake	ornate box turtle leopard frogs Western diamondback rattlesnake	NA	NA	frogs water snakes	NA
Typical fish	minnows crappie sunfish catfish gar	killifish	killifish cyprinids immature mullet spot	NA	NA	NA	crappie catfish gar shad buffalo-fish	mullet anchovy silver-sides cyprinids menhaden
Typical mammals	opossum rabbits raccoon	rabbits hispid cotton rat	rabbits hispid cotton rat	cattle hispid cotton rat rice rats rabbits	domesticated animals	cattle rabbits hispid cotton rat	NA	NA
Typical birds	Gulls Terns Black Skimmer Barn Owl Eastern Meadowlark Red-Winged Blackbird Killdeer Willet Sanderling	Common Gallinule American Coot Yellowlegs Sandpipers Terns Boat-Tailed Grackle Eastern Meadowlark Seaside Sparrow	Plovers Geese Great Blue Heron Little Blue Heron Egrets Least Bittern Ibis Roseate Spoonbill Ducks Clapper Rail	Sparrows Hawks Eastern Meadowlark Egrets Vultures Kites	Blackbirds Robins Starlings	Blackbirds Hawks	Ducks Gulls	Frigate Birds Gulls Terns Ducks

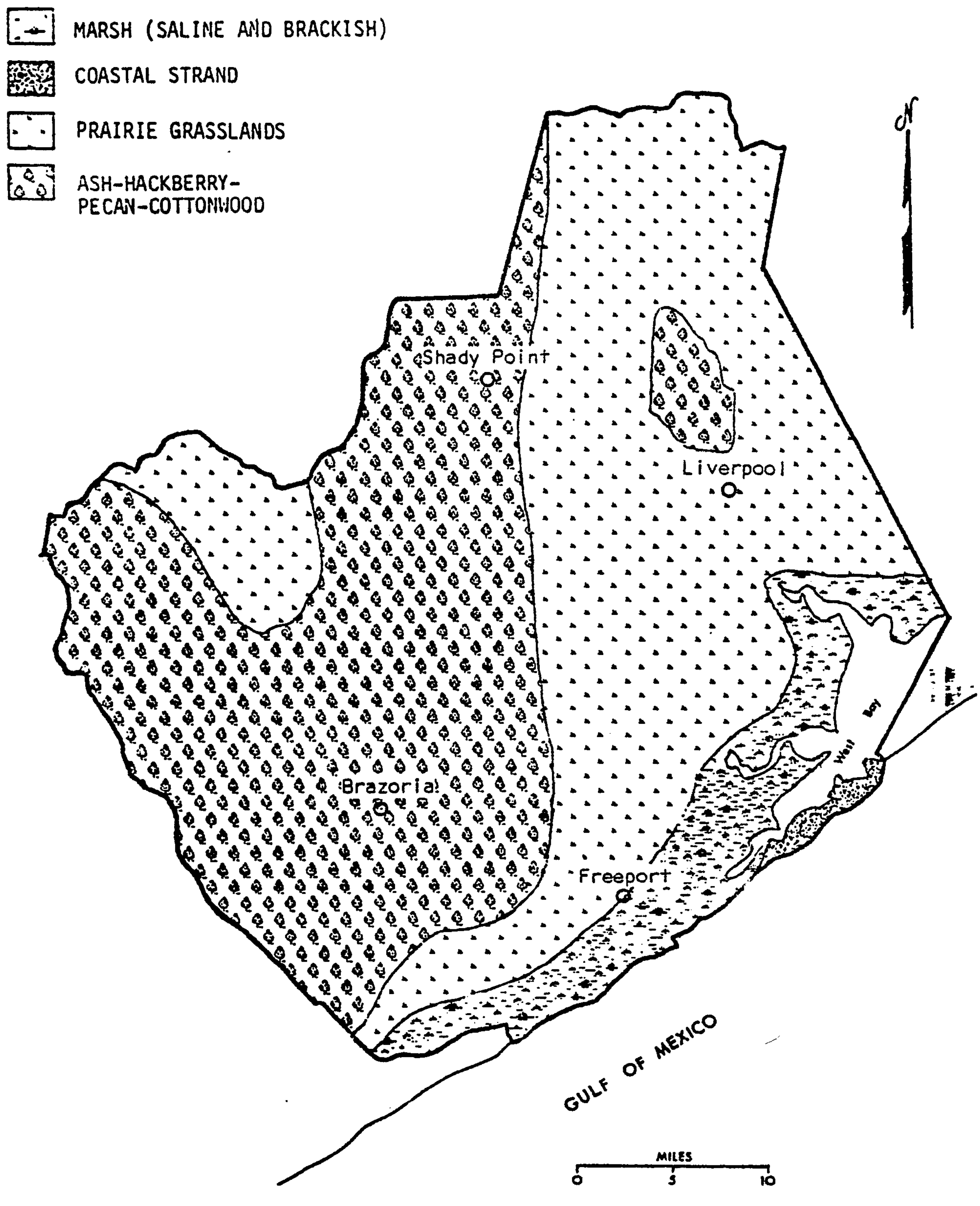


Figure 2.20 Distribution of vegetation types in Brazoria County, Texas

herons, plovers, and sandpipers are also common in these marshes. Hispid cotton rats (Sigmodon hispidus), eastern cotton tail rabbits (Sylvilagus floridanus), are prominent mammals, while the gulf salt marsh snake (Natrix sipedon clarki) is the common reptile. (See Table 2.6).

Typical emergent vegetation of fresh water marshes include maidencane (Panicum hemitomon), pennywort (Hydrocotyle sp.), and water hyacinth (Eichornia crassipes). Fresh water marshes are utilized by waterfowl as feeding sites. Avifauna commonly sighted are terns, Sanderling, Killdeer, red-winged blackbirds, and gulls. The most abundant reptile is the western cottonmouth and the most typical mammals include opossum rabbits, and raccoons. White-tailed deer also are found in Brazoria County.

Gulf Coast Prairie covers 412,700 acres in Brazoria County. Prairie areas subject to occasional saline inundation are dominated by gulf cordgrass (Spartina spartineae). In grazed areas, the western ragweed (Ambrosia psilostachya) is more common. Prairie pleatleaf (Nemastylis geminiflora), bunchgrasses, Indian grass, and switchgrass are also commonly found on the prairie. Members of the prairie avifauna are the Savannah, Vesper, Whitecrowned and Song Sparrows, Mockingbirds, Eastern Meadowlark, Cattle Egrets, Turkey Vulture and Black Vultures, and the Marsh Hawk. Common mammals include domestic cattle, hispid cotton rats, rice rats, and the eastern cottontail rabbits. The western diamondback rattlesnake and the ornate box turtle are prevalent reptiles of the gulf coast prairie.

Cleared Lands

Approximately 44,127 acres of cleared lands are located within the county as a result of crop cultivation (rice), the planting of high nutrient pasture grasses, industrial/refinery activity, residential areas, educational facilities, open space, and highway rights-of-way. The remaining acres (not classified as woodlands, marshlands, and coastal prairies, or cleared lands) are categorized as either water bodies or undeveloped land.

Wildlife which frequent cleared land are varied depending on pressures of land use. The fauna tends to include species immigrating from surrounding ecosystems. Residential areas have predominantly domesticated animals and song birds whereas other areas provide habitat for furbearers and predators such as coyotes. Rice fields are favorite feeding grounds for geese in winter months. For this reason, these areas are used quite often for hunting activities.

Coastal and Inland Waters

Estuaries and the Gulf Intracoastal Waterway

Estuarine waters within Brazoria County are primarily limited to the extreme lower and extreme upper coastline of the county (outside of immediate project impact site). These waters include Cedar Lakes, Christmas, West, and Chocolate Bays. Circulation is generally poor within these semi-enclosed lakes and bays. Species diversity tends to be low therein with high population densities. The lower portion of West Bay near San Luis Pass is tidally influenced. This area has good circulation, species diversity is high, and population densities are generally low, thus indicating a more stable, well balanced biological system. Salinities in Gulf Intracoastal Waterway are expected to equal those in estuarine waters. The biotic components would be similar to those occurring in the brackish to saline waters already discussed.

Biological productivity of the estuarine area is generally high and it provides habitat suitable for the development of commercially important species. Diatoms are the most abundant type of phytoplankton in the inshore areas. Genera normally encountered in samples include *Melosira*, *Navicula*, *Nitzschia*, and *Chaetoceros*. Dinoflagellates (*Ceratium* and *Peridinium*) are the second most common phytoplankton. In the brackish and saline coastal waters, zooplankton populations are dominated by copepods with *Acartia tonsa* being the most common copepod.[38]

In brackish and saline waters, nematodes, copepods, amphipods, ostracods, mollusks, and polychaetes are the predominant benthic animals.[39] The marsh clam, (*Rangia cuneata*,) the American oyster (*Crassostrea virginica*), and the blue crab, (*Callinectes sapidus*) are abundant commercial species.

Coastal ichthyofauna (fish) of Texas is generally abundant and diverse. The finescale menhaden (*Brevoortia gunteri*) reach their greatest abundance in the coastal areas. The bay anchovy (*Anchoa mitchilli*) is apparently a year-round resident of the estuarine waters while most of the ichthyofauna is comprised of seasonal transients such as the sea catfish, mullet, croaker, spot, seatrout, and red drum.

Three species of shrimp are commercially harvested in Texas, but the brown shrimp (Penaeus aztecus) is by far the most important. Larvae and juvenile forms are common in estuarine waters.

Rivers and Inland Waters

The most important water system within the county is the Brazos River. The river has been dammed, and the diversion channel passes to the west of the Bryan Mound site. The original channel now forms the Brazosport Harbor which lies to the east of the site. A large number of creeks, bayous, sloughs, and streams such as Redfish Bayou, Oyster Creek, and Jones Creek occur in the county. The San Bernard River, originally a small stream, has been dredged, and it now is utilized as a shipping channel. This channel enters the Gulf of Mexico east of the Cedar Lakes and lies beyond the scope of the study area. Reservoirs such as Harris and Brazoria Reservoirs are scattered throughout the county. Rivers and inland waters cover a total of 57,138 surface acres within the county.[40]

Dominant floral and faunal components of freshwaters in Brazoria County include green algae (Scenedesmus spp. and Staurastrum spp.), diatoms (Coscinodiscus spp., and Melosira spp.), and blue-green algae (Anabaena spp., and Oscillatoria spp.). Common macrophytes include the pondweeds (Potamogeton spp.), duckweeds (Lemna spp.), and water-lilies (Nymphaea spp.). Zooplankton samples include rotifers (Synchaeta spp., Asplanchna spp. and Brachionus spp.), copepods, cladocerans, and nematodes. Common benthic macroinvertebrates are the amphipods, corixids, larval dipterans, and Coleoptera. Predominant fishes of fresh waters include gizzard shad (Dorosoma cepedianum), carp (Cyprinus carpio), gar (Lepisosteus spp.), and sport fishes such as the largemouth bass (Micropterus salmoides), channel catfish (Ictalurus punctatus), and several species of sunfish (Lepomis spp.) and crappie (Pomoxis spp.).

2.4.2 Environmental Setting of the Bryan Mound Storage Site

The Bryan Mound site is located near the mouth of the Brazos River northeast of the Intracoastal Waterway and covers 216 surface acres. This project would provide for storage of about 58 million barrels of crude oil in four existing chambers in the Bryan

Mound salt dome. Surface development at the site would require the drilling of a new entry well for each chamber, and the installation of associated pipelines and pumping facilities on the mound. This would require 3 to 5 acres in addition to the use of an existing brine storage pond.

Four tanks for the temporary storage of crude oil during filling and recovery operations would be placed on the northern part of the area. The tanks and their associated safety dikes would occupy about 20 acres of the site. A total of about 30 acres would be required for on-site construction (Table 2.7). Access roads are already in existence.

The surface of Bryan Mound is considerably altered by the presence of buildings, structures, and equipment left by previous sulfur and on-going brine mining operations. Some areas have sulfur contamination which has stunted the vegetation. Where undisturbed, the mound is used extensively by cattle for grazing. The area is relatively poorly drained.

The Bryan Mound site is situated on Gulf Coast Prairie which is surrounded by brackish marsh. These communities are located in the Moreland-Pledger-Norwood Soil Association which is calcareous, clayey, and loamy in texture. Figure 2.21 depicts community types and physiographic features of the Bryan Mound dome and surrounding area. Gulf Coast Prairie is the climax vegetation of the area and is probably influenced more by elevation than by any other factor. Prairie subject to saline water influence is dominated by Gulf cordgrass (Spartina spartineae).

Herbivorous bird species, most common during the winter, such as, Savannah Sparrows, Vesper Sparrows, White-crowned Sparrows, and Song Sparrows are common on the open grassland of the site. Resident insectivorous birds of the gulf coast prairie include Common Nighthawks, Mockingbirds, Eastern Meadowlarks, and Seaside Sparrows. Cattle Egrets, also insectivorous, are numerous wherever cattle graze. Carnivores of the prairie include permanent residents, such as, Turkey Vultures, Black Vultures, White-tailed Kites, and Marsh Hawks, and winter residents such as Red-tailed Hawks, Sharp-shinned Hawks, and Swanson's Hawks.[34]

Table 2.7 Acres of each vegetation type affected by various components of the Bryan Mound SPR facility.

Facility Components	Community Type: Marsh	Coastal Prairie	Cleared Land
Bryan Mound Site (wells, roads and temporary storage tanks)	0	30	0
Pipelines	18	26	68
Dock Facilities	0	0	3
Water Sources and Brine Disposal	0	0	0
TOTAL	18	56	71

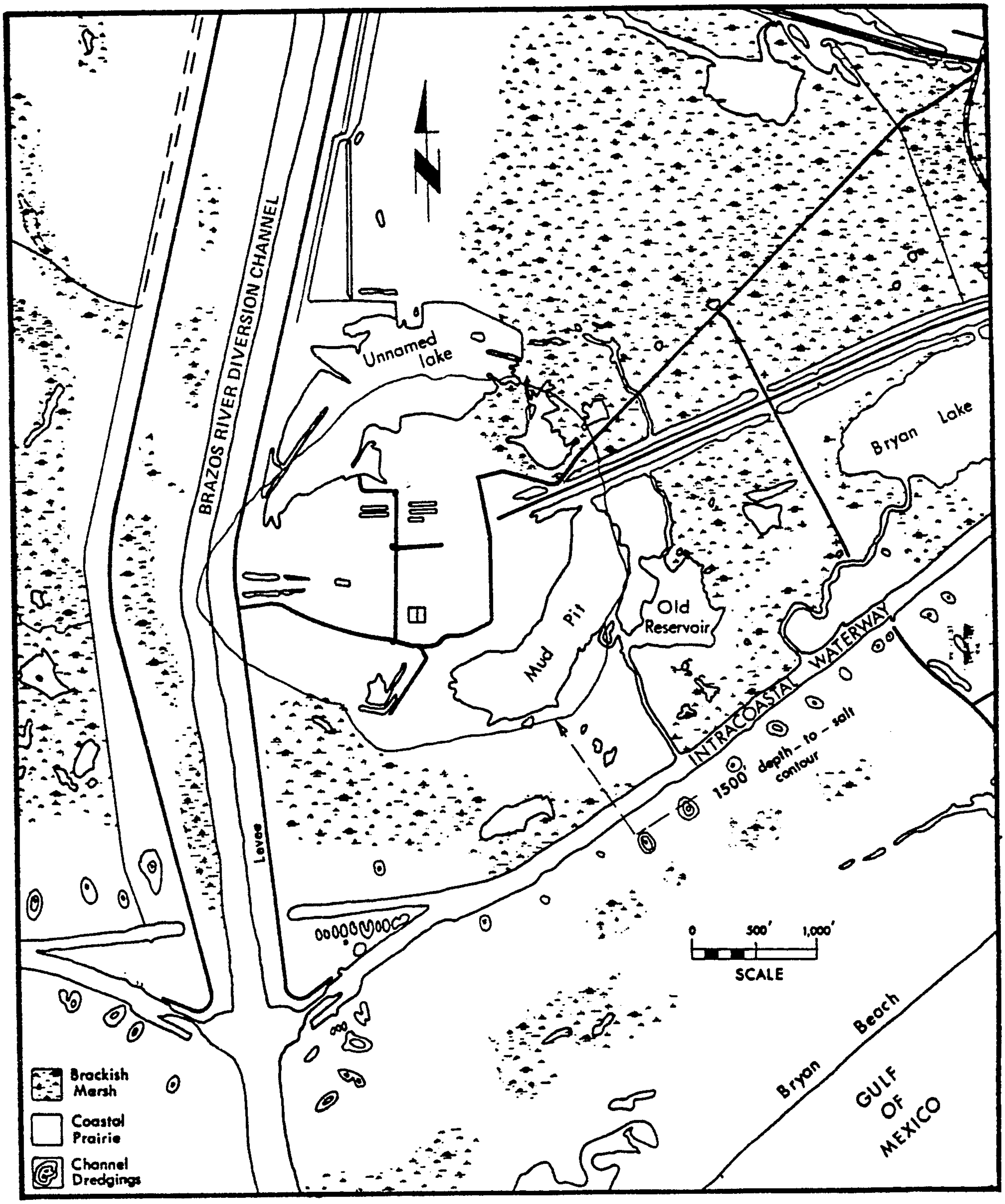


Figure 2.21 Community types and physiographic structures of the Bryan Mound Dome and surrounding area, Brazoria, Texas.

Cattle are the largest herbivores found in the area and probably consume the greatest amount of herbage of all mammals present. Hispid cotton rats, rice rats, and eastern cottontail rabbits are the most common mammals on the site, although other small mammals occasionally immigrate from surrounding areas to forage.[34]

The ornate box-turtle (Terrapene ornata ornata), a prairie inhabitant, is the most common primary consumer of the herpetofaunal group. The western diamondback rattlesnake is the most important carnivorous herpetofaunal species in the Gulf Coast Prairie. Southern leopard frogs (Rana sphenocephala pipiens) are considered important in the grassland ecosystem. They are quick breeders following rain storms, and this makes them potentially available in large numbers.[34]

On the periphery of the Bryan Mound site are two one quarter acre ponds. Only Mud Pit pond on the southeast corner lies outside of the storm protection levee. Salinities in these ponds are expected to vary between freshwater salinities and up to 10 to 15 ppt depending on the season and flood stage of the Brazos River.

In the fresh and slightly brackish waters pennate and centrate diatoms are generally common. However, from sampling in the Freeport area, green algae were the most abundant member of the plankton flora.[34] Only one filamentous algal species, the blue-green alga (Oscillatoria erythreae) is recurring and abundant. This species was absent in winter samples but made up 11 percent of summer samples. The dinoflagellates Ceratium and Peridinium were also abundant.

The University of Texas measured primary productivity of phytoplankton in Galveston Bay and reported average gross photosynthesis to be 2.25 mg-Carbon/liter/day in area canals.[4] This figure averaged 8 percent higher than values from marshes and 49 percent higher than values from the West Galveston Bay. Production in the brackish to saline waters at Bryan Mound is expected to approximate productivity values from the Galveston area canals and marshes.

Zooplankton of brackish to saline waters of Texas reportedly represents a relatively rich and diverse fauna dominated by the Euryhaline copepod Acartia tonsa.[42] Dames and Moore reported that samples from the Freeport vicinity were predominantly made up of nauplii and copepods.[34] Nauplii were present in all seasons but were particularly abundant in the summer in bay and estuarine stations. These organisms apparently utilize the low-salinity, nutrient-rich waters of the area to mature. Khromov reports a zooplankton density in nearshore waters southwest of Galveston of greater than 0.5 grams/cubic meter (g/m^3).[43] Such biomass values are reasonable for the saline to brackish waters of the site.

The benthos is influenced by the position of the saltwater wedge.[34] Most collections are dominated by polychaete genera (Amphitrite, and Clymenella). Gastropods inhabit these areas as well as pelecypods and crustacea. Ostracods are abundant on soft, muddy, organically rich bottoms.

In the coastal zone, aquatic plants abound. Particularly abundant are pondweeds (Potamogeton spp.), duckweed (Lemna minor), arrowheads (Sagittaria spp.), water milfoil (Myriophyllum spp.), and Spartina grasses. Brackish and estuarine vegetation areas with Spartina grasses provide important sources of organic matter to the water system and provide habitats for numerous invertebrates such as the Periwinkle (Littorina irrorata) and mussels.

Marshes are very productive in terms of numbers of animals caught when all species are combined. Most abundant in this area are brown shrimp (Penaeus aztecus), spot (Leiostomus Xanthurus), menhaden (Brevoortia sp.), silverside (Menidia beryllina), mullet (Mugil spp.), and cyprinids (Fundulus similis and Cyprinodon variegatus).

2.4.3 Environmental Setting of the Pipelines

Crude oil would be transferred to and from tankers by a 30 inch pipeline which would extend through marshland and filled and developed land to the dock facilities. The line would be buried using conventional techniques with the surface returned to its original contour. The pipeline would cross the Freeport Storm Protection Levee, Highway 1495, two secondary roads, and one pipeline. The final mile of the eastern end of the line would parallel the existing Seaway pipeline.

A similar 30-inch pipeline would connect the storage area with the Seaway storage facility which is located on the west bank of Jones Creek. This line would extend, in a 100-foot right-of-way, northwest from the site, cross the Brazos Diversion Channel, and continue across approximately 2.75 miles of marshland and coastal prairie. The pipeline would meet the existing Seaway 30-inch pipeline approximately 0.25 miles east of the Jones Creek crossing (see Figure 1.7). The new pipeline would parallel the existing pipeline route which runs across Jones Creek and into the Seaway Tank

Farm. The Jones Creek area and adjacent marshes (see Figure 2.8), which the pipeline would traverse is a highly productive biological area. Typical of marsh-estuarine systems, vegetation acts as an energy transfer mechanism in converting mutrients transported by adjacent rivers, marshes, and grasslands to food for bacterial and fungal decomposers. The decomposers convert the plant material to food for higher tropic consumers. Many of these secondary consumers are important for commercial and sporting purposes and include young Brown and White Shrimp, Blue Crab, Gulf Menhaden, Atlantic Croaker, Sea Trout, Black Drum, and Spot.[62]

In July 1975 water quality data were taken at three points along Jones Creek (see Section 2.2.1). Figure 2.8 indicates the location of these sampling points. At point J-1 located in a ponded area under State Highway 36, the shore vegetation was observed to be dominated by *Scirpus* sp., and *Lemna minor* was observed floating on the water.[62] *Spartina* sp. dominated the shore vegetation at point J-2 and samples at location J-3 were collected form a zone of *Spartina alterniflora*.[62] The bottom substrate at all locations consisted of soft muds which at location J-3 was covered by a layer of organic detritus.

During the operational phase of the project, displacement water would be required to remove the stored oil. A new pipeline would be placed along an existing right-of-way which extends for 5 miles just inside the Brazos River flood levee. Two miles (12 acres) of the pipeline corridor are in the coastal prairie system, and the other 3 miles (18 acres) are within the developed area of the Dow complex.

The pipelines would traverse marsh, coastal prairie, or disturbed, and cleared areas. The saline and brackish marshes provide excellent habitat for migratory waterfowl that overwinter along the coastal areas. Snow, White-fronted, and Canada Geese account for more than 60 percent of the waterfowl population observed on the marshes and salt flats during a 1973 survey.[34] Waterfowl use the marshes in the vicinity primarily for feeding; the birds move into the area during the day and feed on the Olney bulrush and saltgrass. The goose population of these marshes was estimated at 80,000 birds during a later winter survey, while the duck population was estimated at 2,000 to 3,000 ducks, with Northern Shovelers being the most numerous of 10 species.[34]

Hispid cotton rats, eastern cottontail rabbits, armadillos, and canid (Canis spp.) species are found on the low marsh and salt flats areas. The gulf salt marsh snake (Natrix sipedon clarki) is found in the saline marshes of the area, feeding primarily on fish.

Marshes of the area are inundated at least part of the growing season and range from brackish to saline. No specific vegetation relationship can be attributed to a specific soil type, as vegetation here is influenced by salinity from seawater from the Gulf of Mexico. Hardstem bulrush (Scirpus olneyi) and saltgrass (Distichlis spicata) are common species of the brackish marsh, while the saline marsh and salt flat are dominated by smooth cordgrass (Spartina spp.). Surface salinities in the Brazos River diversion channel, range from 4 to 18 ppt while bottom salinities probably range from 10 to 25 ppt.[44]

In brackish to saline areas where marsh grasses provide the source of organic matter and habitats, benthic invertebrates, the perwinkle (Littorina irrorata), horse mussels (Modiolus spp.), bacteria, and scavengers are commonly collected. Where aquatic vegetation is more sparsely distributed or in the main channel, benthic collections contain gastropod molluscs, bivalve molluscs and the crustacea.[34,42]

It is certain that the Brazosport turning basin does not possess a unique nektonic community. Most of the fishes expected to appear in samples from the basin would be transient adults from the marine environment or larval and juvenile stages of migratory fish. The planktonic community is dominated by pennate and centrate diatoms. The dinoflagellates Ceratium and Peridinium also are collected, but generally dinoflagellates are less numerous than diatoms in euryhaline conditions.[34] Zooplankton samples from Texas bays and lagoons, which tend to be relatively rich and diverse, are probably dominated by the copepod Acartia tonsa.

In the intertidal zone, the dominant benthic organisms are young and adult insects, polychaete worms, bivalve molluscs (particularly Donax variabilis), and a few crustaceans such as the mole crab and ghost crabs. Periwinkles (Littorina sp.) and isopods (Ligia spp.) are commonly found on exposed rocks and pilings.[45] Dames and Moore reported that ship channel benthic stations in the Freeport area showed a divergent community structure.[34] No specific taxonomic group predominated in the samples; several groups were equally represented in their collection.

2.4.4 Environmental Setting of the Dock Site

Transfer of crude oil to and from tankers would be accomplished utilizing the Seaway dock facilities. The construction of the ballast treatment system would disturb approximately 3 acres of land (all of the area is cleared). Section 2.4.2 discussed the floral and faunal constituency of this land, which is determined to a great extent by human activity. The area in the vicinity of the dock site and the ballast treatment system has been disturbed recently during construction of the Seaway Dock and pipeline.

2.4.5 Environmental Setting of the Water Sources and Brine Disposal

Since the storage chambers are already in existence, there is no requirement for a supply of leach water or pipelines for the project. No brine excess would be produced during the site preparation and construction phase. Brine evolved during facility operation would be processed through existing brine ponds and transported by existing pipelines to the Dow Chemical plant. This brine would be used by Dow operations in lieu of brine from wells at other locations.

When it becomes necessary to withdraw crude oil from storage, displacement water would be supplied from the Dow industrial water supply system. This system withdraws water from the Brazos River during periods of high flow and stores it in two reservoirs (Harris and Brazoria). Water would be withdrawn from a canal near Dow's Plant "B" and carried via a new 24 inch pipeline to the dome. Any water used during displacement would subsequently be returned as brine to the Dow system during the ensuing fill operations. This brine would be used by Dow in lieu of brine from other salt leaching operations.

No site specific data have been found regarding the aquatic communities of Harris and Brazoria Reservoirs. According to several Dow Chemical employees, Brazoria provides excellent bass fishing opportunities to the sport fisherman. The dominant floral and faunal components of these reservoirs are expected to be similar to those found in other reservoirs of Texas.[46]

Common macrophytes in fresh waters of the Texas Gulf Coastal prairies include pondweeds, duckweeds, waterlilies, and arrowheads. Important components of the nektonic community are the gizzard shad (Dorosoma cepedianum), carp (Cyprinus carpio), and gar (Lepisosteus spp.). These fishes are generally considered undesirable to sport fishermen who prefer angling for sport fishes such as largemouth bass, crappie, catfish, and sunfish. Certain of the hybrid sunfish (such as the green redear) are considered excellent panfish. Buffalo fish are found in most of the Texas freshwater lakes and streams, and they contribute 90 percent of the commercial inland freshwater catch statewide.[47]

Green algae (Chlorophyta) are expected to dominate the phytoplankton samples with diatoms (Coscinodiscus spp., Melosira spp., and Pleurosigma spp.) and blue-green algae being important constituents. Often zooplankton samples from reservoirs are numerically dominated by rotifers. Copepods may be the second major zooplanktonic constituent with cladocerans and nematodes following in importance. Aquatic larval stages of the insects Diptera (flies) and

Coleoptera (beetles) generally dominate samples collected from submerged logs and aquatic plants. Amphipods (scuds) and Corixidae (water boatmen) are also common. Abundant macroinvertebrates in the profundal zone are the Chironomidae, Ceratopogonidae, oligochaetes, and bryozoans.

2.4.6 Rare and Endangered Plants and Wildlife

A considerable number of rare and endangered species have been identified in the Texas coastal zone. However, because of the proximity of the Bryan Mound site to human habitation, relatively few species are found within the area.

Three plant species included in the Texas Organization for Endangered Species (TOES) are found within the general area of Freeport.[48] Sea-oats (Uniola paniculata) have been sighted southeast of the Bryan Mound Site between Old Reservoir and Bryan Lake.[34] Sea-oats provide habitat for much of the terrestrial wildlife in dune areas as they generally grow in thick clumps associated with other vegetation. Spartina alterniflora (smooth cordgrass or oystergrass) has been observed growing along the Old Intracoastal Waterway.[34] The third plant species, black walnut (Juglans nigra), occurs approximately 8 miles northwest of the Bryan Mound site.[34]

The U. S. Department of Interior, Fish and Wildlife Service designates rare and endangered wildlife.[49] Within the region, wildlife included on the national list are the Peregrine Falcon, Brown Pelican, Southern Bald Eagle, red wolf, and American alligator. Because of the wide ranging mobility of the Peregrine Falcon and its attraction to open areas, there is a reasonable chance that the bird may traverse the area of the site. In 1969, a Brown Pelican was sighted at Freeport by the Audubon Society. Because their numbers are extremely low, it is unknown if any are within the project region at this time. The Southern Bald Eagle is known to nest in the area, and is generally declining in population throughout the south due to reproduction failure.[50] The Reddish Egret (considered by TOES to be rare) has been sighted in the region.[34]

The red wolf formerly ranged over much of the Southeastern United States, but it is now restricted to a few southeastern counties of Texas (one of which is Brazoria County) and Cameron Parish, Louisiana. Human activities, hunting, and parasites appear to be major limiting factors of the red wolf.[51]

The American alligator, which has been protected for several years, also is likely to be found within the region. The Texas horned lizard (Phrynosoma cornutum) which is considered by TOES to be rare has been sighted in the region.[34] Marine reptiles such as the Atlantic Ridley Turtle (Lepidochelys kempi) and the leatherback turtle (Dermochelys coriacea) are considered endangered by the U. S. Department of Interior.[49] All of these species have been recorded in Brazoria County, but are not expected to be affected by the project.

2.4.7 Commercially Important Species

Agriculture

Commercially important vegetative species in Brazoria County are limited generally to rice, grain, and sorghum production. Brazoria is one of 13 coastal Texas counties which account for 30 percent of the nation's rice harvest. Although sorghum is considerably less important than rice, in county-wide farm production (1969) 171,172 bushels were harvested from 7,574 acres of land.[52] Overall farm land within the county used for crop production in 1969 was 95,616 acres, approximately 10 percent of the total county acreage. No commercial timber is harvested within the county and pecan production is not commercially profitable.

Wildlife

Commercially valuable wildlife within the region include racoons, opossums, foxes, and nutrias. Hunting of migratory waterfowl along coastal Texas in winter provides income to the county through hunting lease sales and associated hunting expenditures.

Aquatic Organisms

Estuarine waters, river mouths, and passes along the Gulf Coast provide excellent nurseries for juvenile shrimp and fish. Although Brazoria County lacks the large bay system more characteristic of other Texas coastal counties, the importance of all estuaries and marshlands along the coast cannot be overlooked. This county is important considering the coastal zone as a whole. In 1968 Freeport landed 9,171,700 pounds of shrimp for a value of $8,295,814 which is 17.5 percent of the entire Texas coast catch in pounds.

Commercial fishing is a multimillion dollar business along the Texas coast. Landings for 1971 totaled 167.1 million pounds for a value of 69.8 million dollars. The 1972 landings were smaller at 115.2 million pounds, but are still impressive on a national basis. Table 2.8 presents pounds of total Texas landings of finfish and shellfish.

The major commercial species on the Texas Gulf Coast are shrimp, oyster, menhaden, blue crab, and several common sport fish. The bays and estuaries are biologically very important areas since the marshes serve as the nursery grounds for most of the commercially important species on the Texas coast. In almost all cases, specimens collected from marsh areas are juveniles. The greatest species diversity and population densities occur at passes and river mouths within the Brazoria County area.[34]

Members of the croaker family (including the seatrout, drum, and Atlantic croaker)are the most numerous fishes collected in Texas coastal waters. These migrant species move into the saline waters of the Gulf in October through December. Most fishes return to the bays from February to April.[54] Other important commercial fishes whose migratory behavior brings the young into estuarine waters include menhaden (*Brevoortia* spp.) and mullet (*Mugil* spp.).

Shrimp are the single most valuable marine product in Texas. Shrimp landings in the state amounted to 92 percent of the total dollar value of finfish and shellfish in 1970 and 1971.[52] From 1966 to 1971, Texas landings have accounted for 37 percent of the Gulf state shrimp catches. Brown shrimp (*Penaeus aztecus*) is the most abundant shrimp in Texas waters and tends to be concentrated in the intermediate zone from Galveston to the Rio Grande.[39]

Although many species of crabs are collected in Texas coastal waters, the blue crab (*Callinectes sapidus*) is the only crab extensively exploited by man. Contrasted to the shrimp, adult blue crab populations are fished in nearshore bays as well as on the inner shelf of open Gulf waters.

The American oyster (*Crassostrea virginica*) occurs in estuaries and passes with salinities ranging from 10 to 30 ppt. Most of the production in the last few years has been

Table 2.8 Pounds of Total Texas Landings of Finfish and Shellfish in 1970 and 1971 [53]

Species	1970 Pounds	1971 Pounds	1972 Pounds
Crabs, Blue	5,525,400	5,809,600	6,444,680
Oysters, Meats	4,674,700	4,744,300	3,908,714
Shrimp (Heads-On)			
Brown and Pink	69,252,000	72,759,925	98,247,657
White	19,071,100	14,091,924	
Other	2,600	64,260	
Squid	9,700	9,500	5,610
Total Shellfish	98,535,500	97,479,509	108,606,661
Total Finfish and Shellfish	146,936,300	167,154,601	115,231,871

centered in Galveston, San Antonio, Matagorda, and Aransas Bays. None of these bays are within Brazoria County.

2.5 SOCIOECONOMIC CHARACTERISTICS

2.5.1 Population Density and Growth

The Bryan Mound project site is located just southwest of Freeport, Texas in Brazoria County. The county's population has increased from 76,000 in 1960 to 108,000 in 1970, and to an estimated 131,000 in 1976. This growth rate is the result of rapidly expanding industrial development in the area. A detailed examination of Brazoria County is given in Appendix F.

The area in the vicinity of the project, known locally as the "Brazosport" community includes the municipalities of Brazoria, Clute, Freeport, Jones Creek, Lake Jackson, Oyster Creek, Quintana, Richwood, and Surfside Beach. Unincorporated areas include Bryan Beach, Gulf Park, and San Luis Pass areas. In composite, they make up the area which in the past two decades has become known simply as "Brazosport." See Figure 2.22 for the location and size of these population centers relative to the Bryan Mound Site. Brazosport has a single consolidated school district, a single junior college district, country club, planning commission, chamber of commerce, and most of its civic, social, charitable, and cultural institutions are unified to represent the whole area. The area is primarily industrial and is the population center of Brazoria County. Brazosport has an estimated population of 55,650 in an area of 270 square miles.

Towns and Urban Areas

The cities included in the Brazoport community all operate within a single, complex community base. Home rule cities in Brazosport include Freeport, with the only mainland deep water port in Texas; Clute, at the geographic center; and Lake Jackson, the largest city in Brazoria County. The municipalities of Richwood, Jones Creek, Oyster Creek, Surfside (the historic city of Brazoria), and Quintana are part of this diverse community, as is the village of Havenwood, the Bryan Beach area, Lake Farms, and the various populated areas along Bastrop Bayou, Oyster Creek and on the Brazos and San Bernard Rivers.

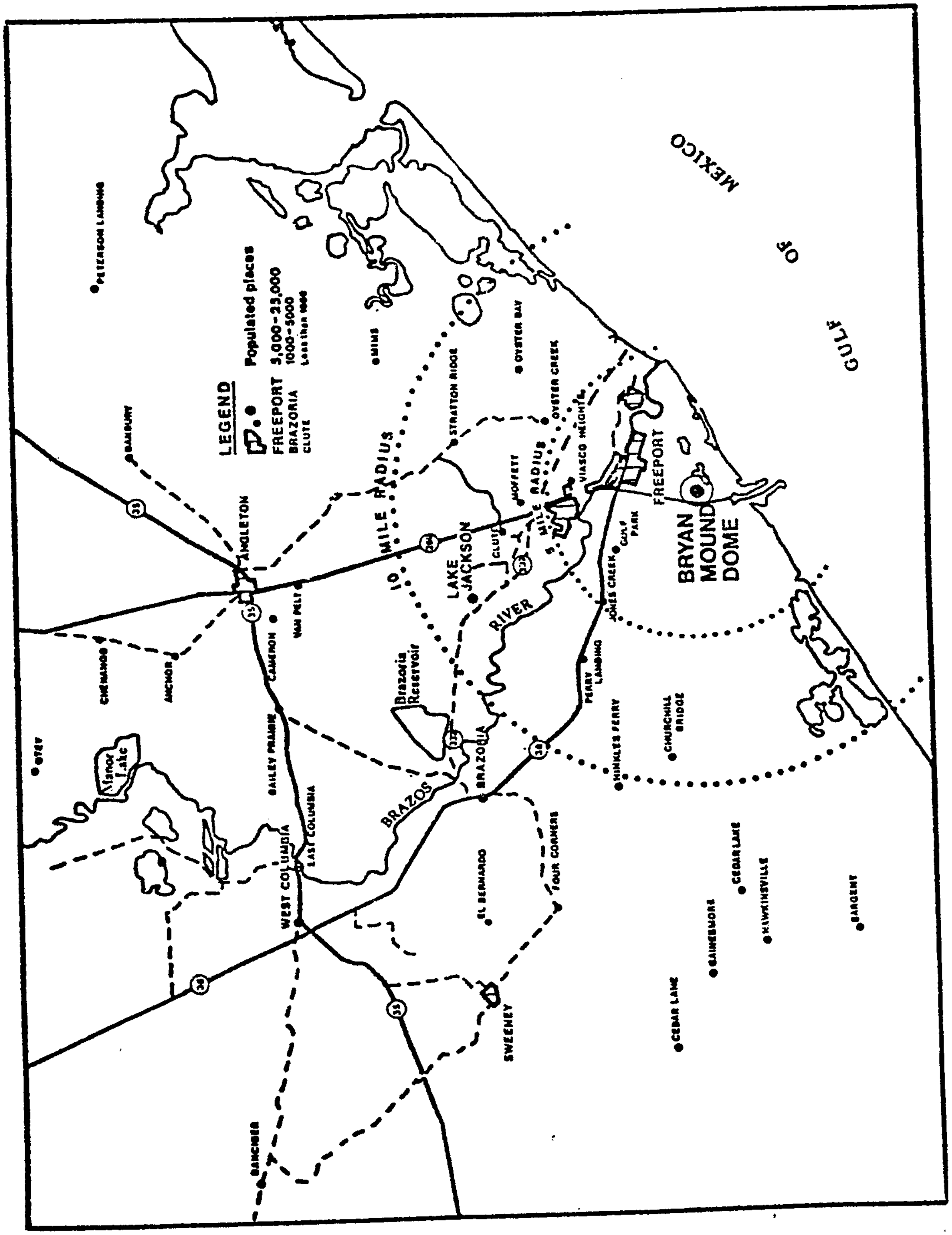


Figure 2.22 Population Centers in Relation to Bryan Mound Dome

Freeport

This city is the port city for Brazoria County with an estimated population of 13,500 in 1976. Freeport is the base of fire and police protection for the project. It is about 2 miles from the site by County Road 242. Freeport can be expected to provide some of the labor and much of the equipment and supplies for the project.

Brazosport Community

Located at the confluence of several waterways, Brazosport straddles the line between deep forest and Gulf floodplain, providing a variety of land types ranging from salt marsh to open grassland to dense big tree forest. In addition to the open sea at its doorstep, Brazosport has hundreds of miles of inland waterways. Both the Brazos and San Bernard Rivers meet the Gulf here. In close proximity are Oyster Creek, Jones Creek, Bastrop, Buffalo Camp, and East Union Bayous, several small waterways, the Brazos Harbor Channel, the port of Freeport, and the Gulf Intracoastal Canal. Through this maze are woven numerous industrial and commercial canals, several lakes of various sizes and shapes, and a string of large inland bays.

Historical Growth and Trends

For the past three decades, this complex community has shown outstanding expansion both industrially and recreationally to produce what probably has been the highest consistent growth rate among midrange communities in Texas. During the decade 1960-1970, for instance, Brazoria County's growth rate was over 40 percent, the highest in the eastern half of Texas, with the bulk of this growth in Brazosport.

Brazosport is closer to 100 foot deep Gulf water than any other point on the upper Texas coast and this proximity of deep water has had a profound effect on the area's development. This factor, combined with the natural waterway of the Brazos River, made this an important commercial area in the early days. In the 1940s Dow Chemical discovered an abundance of clean, fresh seawater close at hand, with access to a deep harbor which was created here a decade earlier by diverting the last few miles of the Brazos River. This played a major part in the location of the chemical industry. Dow's Texas Division is the economic cornerstone of the modern Brazosport community, providing economic weight and consistency to a diverse area. Both internal and external expansion of industry have been rapid and constant here, since the beginning of the area's industrial growth. Existing plants grow larger and new plants open at regular intervals.

The population growth of this area results largely from the development of natural resources: natural gas, oil, salt, seawater, oyster shell, sulfur, and a healthy, enjoyable year round climate for tourists. The entire area is a turmoil of construction and efforts to keep services apace with rapid development. Projects are built by the dozen: roads and highways, water transportation improvements, new industrial starts, new commercial and residential areas, technological advances, new economic base and growth of the existing base.

The frontal levee system protecting the area from storm tides has recently been increased to a 21 foot elevation. This system will be complete with installation of a gate on the harbor channel. Plans are underway now to widen and deepen the harbor, to a depth of 45 feet and a width of 1200 feet. Construction plans also are being finalized to build the nation's first "superport" 30 miles off Brazosport's shoreline. It is expected that the Seadock project will generate substantial onshore construction by a number of product-related companies.

2.5.2 Cultural Patterns

Past, present, and future share the spotlight in Brazosport which is both the oldest and the newest area in modern Texas. The first European explorers of Texas landed here in the 1500s. Later, the early Texas immigrants came to this point by sea to establish Stephen F. Austin's first colony. This was the site of the first armed conflict between Texans and Mexicans in the battle of Velasco in 1832, 4 years ahead of the Alamo.

Six national flags, and possibly a seventh, have flown over the soil of Brazosport: Spain, France, Mexico, the Republic of Texas, the Confederacy, and the United States all have claimed this area, as did a short lived government called the Republic of Fredonia. The original owners of the central Texas coast, a tribe of seven foot tall cannibal Indians called the Karankawas, were present long enough to see all seven flags. Now extinct, the fierce "Kronks" were recorded in the area as late as the early 1900s. The new residents are people from all over the United States and from other countries. A preponderance of people in the community were born, raised, and educated elsewhere and moved here as adults. According to the Brazosport Chamber of Commerce, persons of Spanish descent and American Negro are the only significant ethnic and minority groups in Brazosport community. Overall, both groups make up from 11 to 13 percent of the Brazosport population. Of these percentages, Negroes comprise about 40 percent and persons of Spanish descent about 60 percent of the minority grouping. According to the 1970 U.S. Census, Freeport had a population distribution of 10.7 percent Negro and 9.6 percent of Spanish descent.

Housing

All types of housing are in short supply in the Brazosport area. At least 700 new housing units are being constructed each year in the area but supply has not kept up with the demand. Most mobile home parks are filled to capacity. A large percentage of the work force are forced to commute from other areas, and even from as far as Houston (about 40 miles). This situation will probably continue for some time due to the rapid growth of the area.

Education

The educational attainment levels of the population 25 years of age and over in the Brazosport area is 2 years better than is the national average.

Brazosport has a single consolidated school district and a single junior college district. There are 16 public schools consisting of 2 high schools, 3 intermediate schools, and 11 grade schools with a total enrollment of 10,813 students. Brazosport College was established in 1968 and offers programs leading to associate degrees in many academic and technical vocational areas. The 1974 enrollment was 3,409 students with a faculty of 136. The college is located in Lake Jackson.

Police and Fire Protection

Police and fire protection for the project would be provided by the City of Freeport and the Brazoria County Sheriff's Office. Freeport has 19 full time police officers (including a chief), 5 dispatchers, and 7 police cars. Several deputies from the Sheriff's Department regularly patrol areas outside municipalities. Freeport has a paid full time fire department with 7 firemen and a chief. At the present time, 2 additional openings for firemen are unfilled. The fire department has 2 modern pumper trucks and 1 foam trailer for chemical fires. Additional fire fighting units and personnel are available from adjacent communities under an established and tested system for mutual assistance. A large number of trained volunteer firemen are available if needed.

Hospitals and Medical Personnel

There are three hospital districts and four hospitals in Brazoria County. The largest insitution, Community Hospital at Freeport, has but 129 beds and 5,850 annual patient discharges. The Texas Medical Center in Houston provides for major medical services to county residents and its access will be improved upon completion of Freeway 288. No increase in inpatient capacity in Brazoria is expected for the foreseeable future. Five small medical clinics are also located in the Brazosport area. There is a shortage of medical personnel in the area. An established system for emergency evacuation of seriously injured persons by helicopters and fixed wing aircraft exists. Injuries of large numbers of persons would cause serious problems for proper care and evacuation.

2.5.3 Economic Characteristics

Basic Economy of the Area

Chemicals

The largest basic chemical manufacturing complex in the world is in Brazosport, centered around the Texas Division of the Dow Chemical Company (5,000 plus employees). Local manufacturers include Nalco Chemical (50 to 99 employees), ShinTech, Inc. (50 to 99 employees), Hoffman-LaRoche, Schenectady Chemicals, Inc. (25 to 49 employees), Dow Chemical's new Brazosport Plant (8 to 24 employees), Dow Badische (250 to 499 employees), Rhodia, Inc. (100 to 249 employees), Shell Oil Buccaneer Plant, Dow's Oyster Creek Division (250 to 499 employees), Red Barn Chemicals (8 to 24 employees), all in the chemical field. A variety of diverse industries such as Rheem Manufacturing Company, Mallay Corporation, Maencor, Big Three Industries, and numerous small plants also are located in the area.

Fishing

The area is a seasonal home to one of the world's largest shrimp fishing fleets, producing as much as 15 million pounds of shrimp annually. The beaches, the sports fishing, and the recreation facilities of Brazosport attract an annual crop of visitors who outnumber the resident population by about five to one.

Employment Distribution

Unemployment is practically nonexistent in the Brazosport area, with a January 1976 rate of 2.1 percent unemployed, the greatest number being in the chemical or fishing industries. Other significant occupations are metal finishing, printing, machine shop, mattresses and upholstery, metal roofing and sheet metals, ships and boats, heavy marine construction, and food processing. A large proportion of local workers commute from other nearby areas because of lcoal housing shortages.

Income Distribution Patterns

A survey by Sales Management Magazine in 1974 provided the following information on households in Brazoria County:

Total Net Income	$515,896,000
Median Household Effective Buying Income (EBI)	$14,086
Average Household EBI	$14,782

Percent Households by EBI Groups

$ 0-2,999	8.9%
$ 3,000-4,999	5.7%
$ 5,000-7,000	9.1%
$ 8,000-9,000	6.6%
$10,000-14,999	25.2%
$15,000-& over	44.5%

2.6 UNIQUE FEATURES

2.6.1 Archaeolgoical and Historical Sites

The Texas coastal zone contains archaeological sites providing evidence that humans have inhabited the region for as long as 15,000 years.[55] The discovery and study of archaeological sites is essential to the understanding of man's cultural evolution in this part of the world. Brazoria County contains 37 sites. These sites are similar to many of those found in the coastal zone in that they contain middens of Ostrea and Rangia shells, and most are located on or near the strand.[55]

There is one historic site on the National Register in Brazoria County.[56] This site is the John McCroskey Cabin located 2 miles northeast of Cedar Lake on Stringfellow Ranch (approximately 17 miles west of Bryan Mound). Also, two sites have been chosen by the Texas State Board of Review for submission to the National Register. These sites are the Levi Jordan Plantation and the Varner-Hogg Plantation.[55] The Levi Jordan Plantation is located approximately 10 miles north of Bryan Mound dome and the Varner-Hogg Plantation is 10 miles northwest of the dome. The proposed project would not interfere with these sites in any way.

In compliance with Section 2(a) of Executive Order 11593, "Protection and Enhancement of the Cultural Environment" (May 13, 1971), a survey has been carried out to locate, inventory and nominate eligible historic, architectural and archeological properties to the National Register of Historic Places. The results of this survey showed that the proposed undertaking will not result in the transfer, sale, demolition or substantial alteration of eligible National Register Properties. As the project progresses, additional surveys will be carried out to determine that no additional eligible properties have been uncovered.

In compliance with Section 1(3) of Executive Order 11593 it has been determined that the proposed project will not result in the destruction or deterioration of non-federally owned districts, sites, buildings, structures or objects of historical, architectural or archeological significance.

2.6.2 Parks, Wildlife Refuges, and Scenic Areas

In Brazoria County there are two county recreation areas, two National Wildlife Refuges, one National Audubon Society

Sanctuary, and one State Park. Quintana-Bryan Beach and Surfside Beach are 157 acre and 304 acre recreational areas. Quintana-Bryan Beach is located 2 miles southeast of the Bryan Mound site and Surfside Beach is 5 miles east of the site. Both areas have playgrounds and are used primarily for swimming and surfing.[55] Bryan Mound Beach State Recreation Area is located approximately one mile south of Bryan Mound. This area was recently obtained by the Texas Parks and Wildlife Department and contains 877 acres. The recreational facilities are being planned for future public use.

The National Audubon Society owns several tracts of land in the Texas coastal zone which are used as wildlife refuges. Some of these are located near national wildlife refuges and serve to extend the sanctuary provided by these refuges. West Bay Bird Island is one such sanctuary located east of Brazoria National Wildlife Refuge in West Galveston Bay. Bird Island is managed primarily for the protection of ibises, Roseate Spoonbills, and egrets.[55]

The U. S. Fish and Wildlife Service administers five wildlife refuges on the Texas coast. Two of these (Brazoria and San Bernard) are within Brazoria County (see Figure 2.4). San Bernard National Wildlife Refuge, which was established in November of 1968, is Texas' newest wildlife refuge. The refuge contains 14,920 acres in Brazoria and Matagorda counties, approximately 6 miles southwest of the site, and is currently administered by the Angleton office of the U. S. Fish and Wildlife Service. The primary wildlife for this refuge are: geese, ducks, wading birds, shorebirds, and red wolves. The water fowl population averages about 3,000 Canadian Geese, 74,000 Snow Geese, and less than 20,000 ducks. Because the refuge was not staffed until September 1972, estimates of the populations for other wildlife species are not available. In 1970 the San Bernard National Wildlife Refuge received 538 visitors.[42,55,56]

Brazoria National Wildlife Refuge, located on the Coastal Plain of southeast Texas (17 miles southeast of Angleton), contains 9,530 acres of coastal marsh and prairie in Brazoria County, approximately 8 miles northeast of the site. Three-fourths of the refuge is less than 4 feet in elevation. Spoil bank knolls and windbreak plantings are the only breaks in the marsh vegetation. The primary wildlife of this refuge are: geese, ducks, red wolves, alligators, and muskrats. The refuge offers public hunting and fishing in limited areas, sightseeing, birdwatching, and nature photography. The refuge office, which also administers the San Bernard National Wildlife Refuge, is the smallest refuge on the Texas coast and had 524 visitors in 1970.[38,42,55,56,57]

2.6.3 Biologically Sensitive Areas

The coastal prairie and marshes of the upper Texas coast, of which Brazoria County is a substantial part, provide habitat for numerous species of wildlife. Several of these species of wildlife are endangered (see Section 2.4.6). Of all the nationally endangered species or subspecies which frequent the area, three of these (Southern Bald Eagle, American alligator, and red wolf) nest or permanently reside in the area and thereby rely heavily upon Brazoria County habitat.

The only remaining red wolf population in the United States is restricted to the southeastern region of Texas in the counties of Liberty, Chamber, Jefferson, Brazoria, Harris, and Galveston, and in Cameron Parish in southwestern Louisiana.[51] Apparently, two separate subspecies exist which are separated by Galveston Bay and the Houston Metropolitan area. Canis rufus rufus is the subspecies found in Brazoria County. Both populations are restricted to the coastal prairie and marsh habitat.[51]

The range of the American alligator, which includes Brazoria County, extends along the entire Texas Coast and throughout most of the eastern third of the state.

The Southern Bald Eagle is known to nest in Brazoria County.[55] Its nest is a large structure usually in a large tree near a body of water. Nesting in woodlands or Savannah of the area, the Southern Bald Eagle probably utilizes the open water bodies of the prairie and marsh areas of the County while foraging for fish, its main food.

The coastal prairie and marsh land is also important to waterfowl. Major concentrations of Texas' wintering waterfowl populations are found along the coast. Brazoria County supports a substantial proportion of these wintering populations, particularly in the San Bernard and Brazoria National Wildlife Refuges.

REFERENCES

[1] Ralph O. Kehle, Notes from a seminar on Gulf Coast Structure, Houston, Texas, 1968.

[2] ibid., based on "Geological Aspects of Abnormal Reservoir Pressures in Gulf Coast Louisiana" by George Dickinson, published in the "American Association of Petroleum Geologists Bulletin, Vol. 37, No. 2, pp 410-432, 1953.

[3] M. T. Halbouty, Salt Domes: Gulf Region, United States and Mexico, Gulf Publishing Company, Houston, Texas, 1967.

[4] J. W. Land and A. G. Windslow, "Geology and Groundwater Resources of the Houston District," Texas, Texas Board of Water Engineers, Bulletin 5001, 1950.

[5] L. A. Wood and R. K. Gabrysch, "Analog Model Study of Groundwater in The Houston District," Texas, Texas Water Commission, Bulletin 6508, 1965.

[6] W. W. Hammond, Jr., "Groundwater Resources of Matagorda County," Texas, Texas Water Development Board, Report No. 91, 1969.

[7] B.M. Pettit, Jr. and A. G. Windslow, "Geology and Groundwater Resources of Galveston County," Texas, U.S. Geological Survey, Water Supply Paper No. 1416, 1957.

[8] W. M. Sandeen and J. B. Wesselman, "Groundwater Resources of Brazoria County," Texas, Texas Water Development Board, Report No. 163, 1973.

[9] Texas A & M University, "Environmental Aspects of the Supertanker Port on the Texas Gulf Coasts," Prepared for TAMU Sea Grant Program in NCAA, TAMU-SG-73-201, 1972.

[10] Texas A & M University, "General Soil Map of Texas," Texas Agricultural Experiment Station, U. S. Soil Conservation Service, U.S. Department of Agriculture, 1973.

[11] Bernard Johnson, Inc., "Brazoria County Comprehensive Transportation Plan," Brazoria County Transportation Planning Commission, pp. 142, 1975.

[12] "Texas Water Quality Standards," Texas Water Quality Board, February 1976.

[13] E. Williams, private communication, Dow Company, Freeport Texas, June 4, 1976.

[14] B. Comeux, private communication, Municipal Water Works, Freeport, Texas, June 3, 1976.

[15] M. Moos, private communication, Texas Quality Board, Austin, Texas, June 3, 1976.

[16] A. W. Busch, Regional Administrator, Environmental Protection Agency, Dallas, Texas, letter to Colonel N. C. Rhodes, District Engineer, Corps of Engineers, Galveston, Texas, April 17, 1972.

[17] Nautical Chart 11233, Texas Intracoastal Waterway, Galveston, Bay to Cedar Lakes, U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Ed. 8, December 1974.

[18] Outer Continental Shelf, Western Gulf of Mexico, Upland Soils, Bottom Sediments, Visual No. 3, U. S. Department of Interior, Bureau of Land Management.

[19] Outer Continental Shelf, Western Gulf of Mexico, Surface Currents, Visual Graphic No. 7, U. S. Department of Interior, Bureau of Land Management.

[20] S. V. Standley, personal communication, Municipal Water Works, Surfside Beach, Texas, June 3, 1976.

[21] B. M. Petitt, Jr. and A. G. Windslow, "Geology and Ground Water Resources of Galveston County, Texas," U. S. Geological Survey Water Supply Paper 1416, 1957

[22] N. A. Rose, "Ground Water and Relation of Geology to Its Occurrence in the Houston District, Texas," American Association Petroleum Geologists Bulletin, v. 27, No. 8, pp. 1080-1101, 1943.

[23] L. A. Wood and R. K. Gabrysch, "Analog Model Study of Ground Water in the Houston District, Texas," Texas Water Commission Bulletin 6508, 1965.

[24] C. G. Smith, Jr., private communication, Louisiana State University, Baton Rouge, Louisiana, June 3, 1976.

[25] "Seadock Environmental Report," prepared for the Seadock, Inc., Austin, Texas, in part by Dames and Moore, Houston, Texas; Institute for Storm Research, Houston, Texas and Evans Hamilton, Inc., Houston, Texas, Section 10, 1974.

[26] <u>Climate Atlas of the United States</u>, U.S. Department of Commerce, Environmental Science Services Administration, Environmental Data Service, National Oceanic and Atmospheric Administration, June 1968.

[27] "Climatography of the U.S.", No. 82-41. Summary of Hourly Observations; Galveston, Texas, Municipal Airport. U.S. Department of Commerce, Decennial Census of the U.S. Climate, 1951-1960.

[28] "Summary of Meteorological Observations; Surface; Corpus Christi, Texas--1945-1972," prepared by Officer in Charge, Naval Weather Service Command, Environmental Detachment, Asheville, N.C., Job No. F2006 (N867).

[29] H. C. S. Thom, New Distributions of Extreme Winds in the U.S., J. of Structural Division, ASCE, Vol. 94, No. ST7, Procedure Paper 6038, July 1968.

[30] R.H. Simpson and M. B. Lawrence, Atlantic Hurricane Frequencies Along the U.S. Coastline, NOAA Technical Memorandum NWS SR-58, Fort Worth, Texas, Southern Region Headquarters, National Weather Service, June 1971.

[31] Charles R. Hasler, "Low Level Inversion Frequency in the Contiguous United States," Monthly Weather Review, 89 (9), September 1961.

[32] "Final Environmental Statement, Maintenance Dredging, Gulf Intracoastal Waterway, Texas Section. Main Channel and Tributary Channels," prepared by the U.S. Army Corps of Engineers, Galveston District, Volume I, 13 October 1975.

[33] "Continuous Monitoring Data," Clark Texas, Texas Air Control Board, September 1974-September 1975.

[34] Dames and Moore, "Environmental Analysis Louisiana Offshore Oil Port", prepared for Loop, Inc., New Orleans, Louisiana, 1974.

[35] "Measurement of Ambient Noise Levels in the Florida Everglades," Report No. DOT-TSC-OST-72-2, Technical Note, Department of Transportation, Office of Noise Abatement, September, 1971.

[36] W. L. Fisher, et al., "Environmental Geologic Atlas of the Texas Coastal Zone--Galveston-Houston Area," Bureau of Economic Geology, University of Texas, 91 pp., 1972.

[37] D. S. Correll and M. C. Johnston, Manual of the Vascular Plants of Texas, Texas Research Foundation, Renner, Texas, 1881 pp., 1970.

[38] U.S. Department of the Interior, "Directory of National Wildlife Refuges," U.S. Fish and Wildlife Service, Washington, D.C., 1972.

[39] J. W. Day, et al., Community Structure and Carbon Budget of a Salt Marsh and Shallow Bay Estuarine System in Louisiana. LSU Center for Wetland Resources, Publication No. LSU-SG-72-04, 79 pp., 1973.

[40] Bernard Johnson, Inc., "Brazoria County Comprehensive Transportation Plan", Brazoria County Transportation Planning Commission, 1975.

[41] C. H. Oppenheimer and K. G. Gordon, Texas Coastal Zone Biotopes: An Ecography, University Texas Mar. Sci. Inst., 1972.

[42] Texas A & M University, "Environmental Aspects of the Supertanker Port on the Texas Gulf Coasts", Report on the Environmental Aspects of a Supertanker Port on the Texas Gulf Coast, prepared for TAMU Sea Grant Program in NCAA. TAMU-SG-73-201, 72 pp., 1972.

[43] N. S. Khromov, Quantitative Distribution of Plankton in the Northwest Part of the Caribbean Sea and in the Gulf of Mexico, TR. VNIRO (Trane. All-Union Sci. Research Inst. of Sea Fish and Ocn.), Vol. 57, 1965.

[44] J. S. Kirkpatrick, Lower Brazos River Project Final Report, Texas Water Quality Board, Austin, Texas, 1972.

[45] University of Texas, "A Conceptual Report on the Management of Bay and Estuarine Systems, Phase I". Coastal Resource Management Program, 1972.

[46] Environment Consultants, Inc., An Environmental Appraisal of Big Brown Steam Electric Station, Part I., Findings and Recommendations, Dallas, Texas, 143 pp., 1974.

[47] R. McCune (Editor), Freshwater Fishes of Texas, Texas Parks and Wildlife Department, Austin, Texas, 1971.

[48] Texas Organization for Endangered Species.

[49] U.S. Department of the Interior, Fish and Wildlife Service, "United States List of Endangered Fauna," U.S.D.I., Fish and Wildlife Service, Washington, 1974.

[50] U.S. Department of Interior, Bureau of Land Management, "Final Environmental Statement, Proposed 1976 Outer Continental Shelf Oil and Gas General Lease Sale--Gulf of Mexico," O.C.S. Sale #41, Bureau of Land Management, 1975.

[51] G. A. Riley and R. T. McBride, "A Survey of the Red Wolf (Canis rufus)", U. S. Department Interior Fish Wildlife Service Bureau, Sport Fish, Wildlife Sp. Sci. Report Wildlife No. 162:1-15, 1972.

[52] R. E. Boykin, Texas and the Gulf of Mexico, Department of Marine Resources Information, Center for Marine Resources, Texas A&M University College Station, 1972.

[53] "Maintenance Dredging of Freeport Harbor," Texas, Final Environment Statement, U.S. Army Engineer District, Galveston, Texas, 10 July 1975.

[54] G. Gunter, Some Relationships of Estuaries to the Fisheries of the Gulf of Mexico in Estuaries, G.H. Lauff, (ed.), American Association Adv. Sci. Publication No. 83: 621-368, 1967.

[55] U.S. Department of the Interior, "Draft Environmental Impact Statement," Volumes 1, 2, 3, and 4, OCS Sale No. 37, Bureau of Land Management, 1974.

[56] U.S. Department of the Interior, "Public Use of National Wildlife Refuges," U.S. Fish and Wildlife Service, Washington, D. C., 1971.

[57] U.S. Department of the Interior, "Brazoria National Wildlife Refuge," U.S. Fish and Wildlife Service, Albuquerque, New Mexico, 1965.

[58] "Water Resources Data for Texas Water Quality Records," U. S. Department of Interior, USGS, 1974.

[59] "Lower Brazos River Project: Final Report," Texas Water Quality Board, January 1972.

[60] "San Bernard River Tidal Standards," Texas Water Quality Board, 1972.

[61] "Water Quality Requirements, Vol. II, Coastal Waters,; Texas Water Quality Board, 1972.

[62] "Seadock Environmental Report," prepared for the Seadock, Inc., Austin, Texas, in part by Dames and Moore, Houston, Texas; Institute for Storm Research, Houston, Texas and Evans Hamilton, Inc., Houston, Texas, Supplementary Information, December 15, 1975.

3. ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

3.1 LAND FEATURES AND USES

The localized environment that would be impacted by dike construction around the tanks and wellheads of the strategic petroleum reserve facility would encompass about 30 acres. Also, 112 acres are required for pipeline rights-of-way and 3 acres for proposed facilities at the Seaway tanker dock facility. Minor soil erosion would occur during the construction activities. This impact, however, is considered a temporary adverse effect.

Human activity in the past has altered natural drainage patterns by channel cuts, levees and road construction, and river diversions. Further construction would simply add to the already altered setting.

3.1.1 Geologic Impacts

Construction

One potential impact (subsidence) could produce cumulative effects on area geology. Subsidence has been measured in surrounding areas and in Freeport for over 30 years.[1] This subsidence is caused by compaction of subsurface aquifers following the pumping out of large quantities of ground water. However, leveling from wellhead to wellhead using surveying techniques has not identified active subsidence for a period of several years.[52]

Storing oil in cavities would not be affected by surface subsidence. However, because of the removal of sulfur from the caprock, the potential for subsidence on the site may be increased by construction of large (400,000 barrel) above ground storage tanks. The increased loading of the surface could result in aquifer compaction and subsidence in the immediate vicinity of the tanks. If subsidence due to the weight of the oil in the storage tanks did occur, stress would be placed on the pipelines leading to the tanks. Failure of the pipeline would depend on the amount of subsidence. The oil spilled if the pipeline did rupture would be minor and probably would be contained by the dikes surrounding each tank. Subsidence would possibly include the dikes but breeching of the dikes would not be likely because the area under the tank would probably be the point of greatest subsidence and the dikes would be on a contour of relatively equal subsidence. The design of the system calls for structural reenforcement of the tanks, but if an oil leak did develop during subsidence the subsidence "bowl" would serve as an additional containment for the oil.

Surface changes caused by drilling four new wells, forming gravel filled and shell covered drilling pads, constructing a retention dike, and laying pipelines would have minimal impacts on the already altered geology and be worthy of brief mention only. Except for small areas, the texture and chemical properties of the surface soils should in no way be altered.

Operation

The area around the Bryan Mound dome is considered to be in a seismic risk Zone 0; that is, no surface earthquake damage is reasonably expected. Fault zones in the area are apparently stable. Routine operation of the facility is not expected to result in any geologic effects.

The terrain that is altered for levee construction, well pads, and storage facilities would need to be maintained for the operational life of the project. These man made structures may slightly alter surface water runoff, but should not affect existing storm levees or their design capabilities.

Geohydrology

Under normal operations, impacts on the geohydrology of the area should be negligible. Since displacement water would be drawn from the Brazoria and Harris Reservoirs (not from subsurface aquifers) no direct impact on ground water quality should be observed.

Soils

Routine operating conditions are not expected to affect soil conditions significantly. Small amounts of fill dirt and shells would shift to immediately adjacent areas. During floods, larger quantities of fill may be transported to surrounding areas. The amounts and types of fill would not significantly change the character of nearby soils.

3.1.2 Land Use Impacts

Construction

The construction necessary for completion of the Bryan Mound dome storage facility would have an impact on land use in three areas: the dome itself, the dock facility, and the interconnecting pipeline system.

Storage Site

The construction of new entry wells, pumping facilities, temporary storage facilities, and other necessary structures would involve the use of about 30 acres of the 215 acre salt dome. This land area is already industrially developed.

Its use would continue to be restricted and is not likely to change because of the private ownership of the land. Any subsidance which occurs would be confined to the site and only buildings associated with the project would be affected.

Dock Facilities

The construction of ballast treatment tanks at the dock facilities would require 3 acres of land previously developed. For this reason their construction would have little effect on existing land use.

Pipeline System

Three new pipeline systems would be built. One system would be used for crude oil transportation between the Bryan Mound storage facility and the dock facility at Freeport. The second would provide for crude oil transportation between Bryan Mound storage facility and Seaway storage facility. The third system would be used for transporting displacement water to the Bryan Mound storage facility. Table 3.1 provides a brief summary of the mileage and acreages of each pipeline system relative to the environs each impacts.

The crude pipeline connecting Bryan Mound and the dock facility at Freeport would be 3.7 miles long and would require a 100 foot wide right-of-way. The construction of this pipeline would impact 45 acres of developed land, about half of which is adjacent to an existing storm levee. The remaining acreage is industrial land at Bryan Mound and in the Freeport Harbor area. This pipeline would have little impact on these previously disturbed areas.

Constructing the crude oil pipeline connecting Bryan Mound and Seaway storage facility would require 18 acres of marsh, 8 acres of developed land, and 26 acres of coastal prairie it also crosses the Brazos River. The pipeline would be 4.4 miles long and would require a 100 foot right-of-way. The developed land required for construction of this pipeline is all on Bryan Mound, and its use would not be impacted by pipeline construction. The 26 acres of coastal prairie vegetation disturbed during construction should return to previous conditions during the next growing season. The temporary disturbance of 18 acres of marsh habitat would be the most serious impact resulting from the pipeline construction and is likely to leave a noticeable alteration of the habitat over a longer time (See Section 3.4).

Table 3.1. Land Required for Pipeline Systems

Environs Impacted / Pipeline System	Bryan Mound to Dock Facility	Bryan Mound to Seaway Storage Facility	Bryan Mound to Displacement Water Source	Total
Marsh				
Acres	0	18	0	18
Miles	0	1.5	0	1.5
Developed				
Acres	45	8.4	15.0	68.4
Miles	3.7	0.7	5.0	9.4
Coastal Prairie				
Acres	0	26.4	0	26.4
Miles	0	2.2	0	2.2
Total				
Acres	45	52.8	15	112.8
Miles	3.7	4.4	5.0	13.1

The pipeline which would supply displacement water to Bryan Mound would be 5 miles long with a 25 foot right-of-way. A total of 15 acres of developed land along an existing right-of-way would be required to construct this pipeline. Construction would have little effect on land use of these 15 acres. Although vegetation would be temporarily disturbed it would return to its previous condition during the next growing season; however, occasional mowing on rights-of-way would continue to disturb vegetation for the life of the project.

Operation

Operation of the SPR program at Bryan Mound would require land at the storage site at the dock site, and for pipeline rights-of-way. The impact on land use is much greater during the construction phase than in the operational phase which is discussed here.

All land required for operation of the storage site and dock facility is industrially developed, privately owned land. The existing land use restrictions would be retained throughout the life of the project.

The interconnecting pipeline system involves 3 separate pipelines that would require a total of 112 acres of land. The 68 acres of developed land required would suffer no additional land use restrictions. The 26 acres of coastal prairie maintained as right-of-way would be allowed to return to its original state during the operation of the pipeline except for occasional mowing and so land use would therefore not be affected. The total of 18 acres of marsh required for right-of-way for the 2 crude oil pipelines would suffer the greatest land use impact. A semipermanent scar of 1.5 miles would probably result from maintenance of this right-of-way along the marsh.

3.2 WATER QUALITY

Site preparation and construction would involve dredging for the laying of a pipeline across the Brazos River Diversion Channel and across Jones Creek. The dredging operation would have a temporary impact on the environment. A considerable amount of earth moving will occur at the site during construction of dikes, roads, and pipelines. Such activity would also have some impact on the water environment. In addition, certain chemical and biological pollutants would be gnerated by the construction and must be taken into condiseration.

3.2.1 Impact of Dredging

The location of the dredging is indicated in Figure 3.1. Water quality degradation may result from (1) an increase in turbidity of the water; (2) the release of toxic sulfides; (3) the release of toxic heavy metals or arsenic; or (4) the release of pesticides or other toxic hydrocarbons trapped within the bottom sediments.

At the site of the dredging activity in the Brazos Diversion Channel, there would be an inevitable increase in turbidity as a result of the turbulence created by the dredge. If the bottom sediments are polluted, the release of a fraction of these pollutants during dredging cannot be avoided. Thus, the probable severity of the impact must be established. Most researchers have concluded that the dredging operation, using modern techniques, has little local effect on the water overlying the sediments.[2,3,4,5,6] This appears to be the case even when the sediments are highly polluted. These investigations report that some dredging activities increase water turbidity and other parameters to a very minor degree up to a mile from the dredge site under certain conditions. A significant increase in any parameter has been reported only within 200 feet of the dredge.

Probably the most significant impact observed would be the turbidity plume generated by the sediment discharged into the river channel. Previous studies of canal dredging in Louisiana have indicated that silt can be carried as far as 1,300 feet from a dredge discharge. However, at distances greater than a few hundred feet, turbidities did not exceed those often attained under natural conditions.[7] The amount of material drifting away from the dredge discharges was estimated to be only one percent of the total dredged material, and evidence of fine material in suspension was lost in the natural turbidities over distances of 1,000 feet.

Because of the very likely presence of currents and wave action in the river, the turbidity plume may extend over a larger region. The size and duration of this plume would depend upon the size of the dredge and the length of time during which dredging occurs. It is reasonable to expect a moderate increase in turbidity at distances as great as one mile from the dredging site when the current is strong.

In addition to turbidity, consideration must also be given to the possible pollutants which might be released from the bottom sediments. Because of the absence of standard elutriate samples for the lower Brazos River, it is difficult

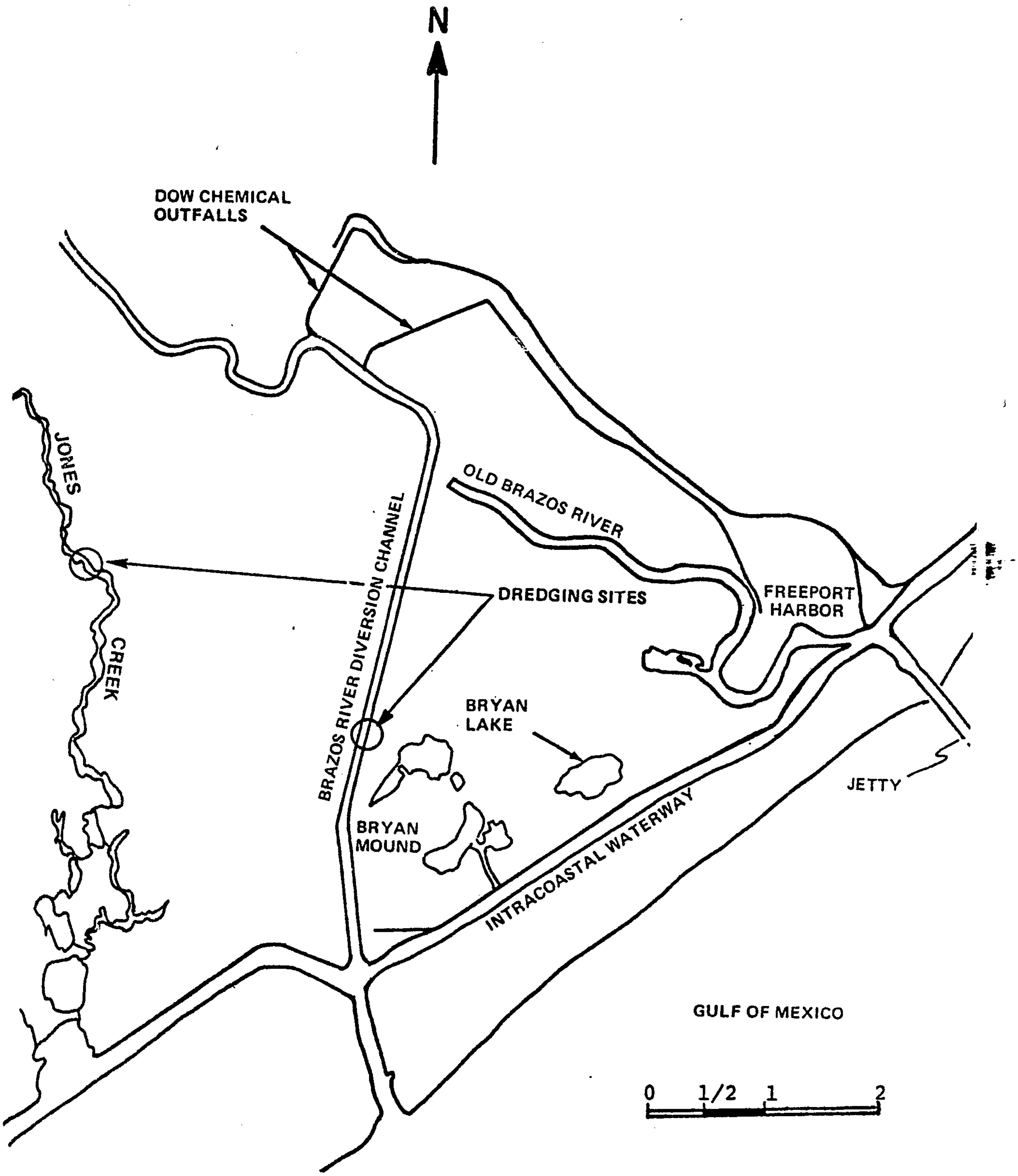


Figure 3.1 Location of Dredging Sites in the Vicinity of Bryan Mound

to predict the nature of such releases. A limited picture can be developed based on available water quality and sediment data provided in Appendix B-5. (See Section 3.4.2 for evaluation of the effect on species and ecosystems).

The pipeline would cross Jones Creek at a point approximately 4.5 miles north of where the creek discharges into the Intracoastal Waterway. Water quality data for this area is discussed in Section 2.2.1. Limited water quality data was obtained for Jones Creek in July 1975. Of the three points tested, location J-2 was the closest to the proposed pipeline crossing (see Figure 2.8).

It is expected that pipeline burial would cause an increase in suspended solids downstream of the dredging site. Lack of volumetric flow data and standard elutriate samples for Jones Creek make it difficult to estimate the composition and dimensions of the plume of suspended sediment that will be created during dredging.

The pipeline would cross Jones Creek approximately 4.5 miles north of where the creek discharges into the Intracoastal Waterway. The ecological setting of this area is described in Section 2.4.2. Pipeline burial will increase turbidity at the site and downstream from the site. Pipeline burial may also result in the release of dissolved nutrients. Because Jones Creek flows less rapidly than the Brazos River, the increase in dissolved nutrients could temporarily elevate the BOD downstream from the pipeline crossing.

The proposed disposals and transportation for disposal of dredged materials will be performed in accordance with all applicable Federal laws and regulations. (See Section 9.2).

3.2.2 Impact of Earth Movement

Sediment represents the major nonpoint source of water pollution on most construction sites, especially on those which require extensive grading. Sediment includes solids and organic materials detached from the ground surface by erosion and carried into the drainage system principally by runoff. The introduction of sediment into various natural bodies of water and the associated turbidity and solids deposition result in numerous adverse physical, chemical, and biological effects. Suspended sediment ultimately reduces the storage capacity of waterways, increases flooding hazards, foulds and destroys aquatic habitats, diminishes recreational and property values, and enhances the transport of other harmful pollutants such as human and anumal sanitary wastes, pesticides, and petrochemicals.

The site preparation and construction activity would involve a significant amount of earth movement. Approximately 64,500 cubic yards of earth would be displaced during this process, excluding the dredging operation. Associated with this movement of earth, approximately 20 acres of coastal prairie would be disturbed. (See Section 3.4.1 for evaluation of the effect of this activity on species and ecosystems).

3.2.3 Chemical and Biological Pollutants

Numerous solid and liquid products, both organic and inorganic, used in construction are a source of water pollution. The major sources of construction related chemical pollution can be broadly grouped under the following headings:

- Petroleum products
- Herbicides and pesticides
- Fertilizers
- Metals
- Soil additives
- Construction chemicals
- Miscellaneous wastes

Of these, petroleum products, herbicides and pesticides, and fertilizers appear to be the best known and the best documented sources of chemical pollution.

Pollution from petroleum products generally occurs from improper disposal of waste materials such as crankcase oil and various cleaning solvents, leakage of fuels and oil from storage facilities, and damaged or improperly maintained vehicles; fuel spills during equipment refueling operations; and the use of oils for dust control on roadways.

Herbicides and/or pesticides are used on some construction sites to control undesirable vegetation, insects, and rodents. The primary cause of pollution from the use is these chemicals are in the improper use, handling, and disposal of waste materials.

Fertilizers are extensively utilized in the revegetation of areas affected by grading operations. Like herbicides and pesticides, the primary causes of damaging pollution are improper use, i.e., applying too much fertilizer or improper preparation of the ground surface prior to application.

The biological pollutants which generally enter receiving streams and other water bodies as a result of construction activities are bacteria, fungi, worms, viruses, and other less prevalent organisms. Biological pollution is primarily a result of poor sanitary conditions at a construction site;

generally improper disposal of human wastes, garbage, and other organic material. The disturbance, exposure, and subsequent erosion of surface soils that contain bacteria and other organisms are also contributing factors. Regardless of their origin, biological pollutants of major concern are the pathogenic organisms associated with human wastes.

Prediction of the impact of such chemical and biological contaminants is quite difficult because of the human element involved.

3.2.4 Displacement Water

The freshwater supply required to displace crude oil from the cavities would be supplied by Dow Chemical Company through a new 24 inch fresh water supply system. Water taken during periods of high flow from the Brazos River is stored in 2 reservoirs developed and owned by Dow (Harris and Brazoria). Removal of water from the Brazos River would not affect quality of the river water. Water stored in the 2 reservoirs would be utilized for displacement at a maximum rate of about 14,000 gallons per minute.

This utilization is not expected to significantly affect either reservoir; furthermore, these reservoirs were designed and built for the purpose to which the displacement water is being applied, that is, pumping into the cavities of the dome for various reasons.

3.2.5 Brine Water Discharge

All brine produced from the cavities of the Bryan Mound Strategic Petroleum Reserve project would be used by Dow Chemical Company at their Freeport Chemical plant. Therefore, the discharge of brine would not affect any surface or subsurface waters.

3.2.6 Other Surface Water Effects

During the operational phases of the project, the Brazos River and Gulf Intracoastal Waterway would not be affected by oil passing through pipelines or by loading or unloading at dock facilities. Only in the event of an oil spill would the waterways be severely impacted. Accidental spills are discussed in detail in Section 3.7 (Effects of Accidents and Natural Disasters).

3.3 AIR QUALITY

The quality of the air at the Bryan Mound dome would be somewhat affected during site preparation and construction. The sources of emissions in general would be short lived and transient in nature. The principal pollutant of concern would be hydrocarbon emissions. Data indicate that present hydrocarbon concentrations in the vicinity of the proposed facilities at Bryan Mound are significantly higher than those of the national and Texas ambient levels.[8] This data is tabulated in Appendix D.

The quality of the air at the Bryan Mound Dome would not be seriously degraded during the storage phase of site operation. However, the emission of hydrocarbon vapors would be large during loading and unloading phases if mitigative measures are not taken. The concentrations of hydrocarbons in the area are historically higher than federal and state standards most of the time.[10]

3.3.1 Impact of Vehicles, Equipment and Paint Solvents

The quality of the air at the Bryan Mound site during construction would be affected by the following pollution sources:

- General Construction Vehicles
- Drilling Rig Motors
- Paint Solvent on Storage and Surge Tanks
- Fugitive Dust

The sources, the specific emissions, and quantities will be discussed in the following paragraphs.

General Construction Vehicles

During the site preparation phase, there would be clearing operations, land fill, and road construction. This phase would last seven months. A number of machines and heavy vehicles would be used. The gas and diesel engines would emit: Hydrocarbons, SO_2, CO, NO_2 and particulates.

The prediction of quantities of pollutants is difficult because it depends upon many factors including: number of vehicles, type of vehicles, model-year, duty cycle, speed, cold operation fraction, and ambient temperature. Typical average emission levels for light and heavy duty, gasoline and diesel vehicles are shown in Table 3.2.

The on-site vehicle sources are assumed to be 10 heavy duty gasoline vehicles plus 10 heavy duty diesel vehicles with a conservative duty factor of 2,000 hours/year [11] and speed of 10 miles per hour. The emission data are given in Table 3.3.

Drill Rig Equipment

Drill rig equipment includes, typically, three large engines and other smaller engines. These motors would be considered to total 2,000 horsepower and, as a worst case assumption, to be heavy duty diesels of miscellaneous construction type. The emission rate is listed in Table 3.3.

The drill rig equipment is assumed to operate at 50 percent load for about 7,000 hours/year. These emission rates are also given in Table 3.3. It is apparent that the estimated vehicle emissions are much smaller than the drill rig equipment emissions.

Paint Solvent on Storage and Surge Tanks

Four 400,000 barrel floating roof oil storage tanks would be constructed at the site. A 100,000 barrel stripping tank for treating ballast water and a small tank for storing salvaged oil would be located at the dock. All tanks would probably be spray painted with solvent-based paints. The solvent is composed of relatively volatile, light hydrocarbons. The quantity of paint required depends on several variables. Here it is assumed (for purposes of evaluating a "worst case") that one gallon would cover 100 square feet with 2 coats (the average of two estimates), that one gallon will weigh 15 pounds (the range is 10 to 15 pounds per gallon), and that half the weight is solvent (50 to 55 percent is normal).

The quantity of emissions from spray painting is estimated in the following way. It is assumed that a painting rate of 6,000 ft^2/day would be maintained for as long as necessary at the tanks. Sixty gallons of paint per day would be used at the site and the average hydrocarbon emission rate would be 1.18 grams per second (g/sec).

Table 3.2 Typical Average Emission Factors for Vehicles

Pollutant	Gasoline Light Duty 1970 g/mi	Gasoline Heavy Duty 1970 g/mi	Diesel Light Duty Pre-1973 g/mi	Diesel Heavy Duty Pre-1973 g/mi
CO	33.2	188.0	1.7	28.7
HC	4.8	13.8	0.46	4.6
NO_x as NO_2	5.2	12.6	1.6	20.9
Particulate	.54	1.3	0.73	1.3
SO_x as SO_2	.18	.36	0.54	2.8

Note: Low speed operation may increase emission levels by a factor of 2 to 4.

Source: Compilation of Air Pollutant Emission Factors. Second Edition, Supplement No. 5, U.S. Environmental Protection Agency, Dec. 1975.

Table 3.3 On-site Emission Rates During Construction

Pollutant	Vehicles[a] (g/sec)	Drill Rig[b] (g/sec)	Paint Solvent[c] (g/sec)
CO	.138	0.654	
Hydrocarbon	.0117	0.241	1.18
NO_2	.0211	3.42	
SO_2	.0020	0.216	
Particulates	.0019	0.209	

a 10 heavy duty gasoline vehicles plus 10 heavy duty diesel vehicles at a conservative duty factor of 2,000 hr/yr, each.

b Assuming 1 drill rig, 2000 horsepower operating at 50 percent load, 20 hours per day.

c Assuming 6,000 ft^2/day painting rate, 2 coats at 200 ft^2/gal/coat.

Source: Compilation of Air Pollutant Emission Factors, Second Edition, U.S. Environmental Protection Agency, March 1975.

The pollutant concentrations at several downwind distances from construction vehicles, drill rig equipment, and paint solvent are shown in Table 3.4. Note that all primary standards are met except for the hydrocarbon concentration for paint solvent out to 0.5 kilometers (1,640 feet).* Current ambient levels of hydrocarbons at Clute, seven miles north or the site, and at Freeport, four miles north of the site, frequently exceed primary standards.[10] It is probable that the hydrocarbon level at the site is also exceeded frequently. The concentrations listed in Table 3.4 are based on meteorological conditions which exist about 5 percent of the time in the Bryan Mound area. Therefore, for one or two days per month the paint solvent vapors would noticeably elevate the hydrocarbon levels for a distance of about one kilometer downwind within a strip 100 to 200 meters wide (Appendix A). During more typical days, the paint solvent vapors will be lower by a factor of 5. At these times, the hydrocarbon levels will not seriously elevate ambient levels which may be above standard levels. Painting is expected to last 90 days.

Fugitive Dust

Dust emissions would result from construction activities at the site. The dust would be associated with land clearing, excavation, cut and fill operation, and construction. The amount of dust would vary from day to day depending on the activity and the weather. A large portion of the dust would be due to equipment traffic over temporary roads.

Field measurements at apartment and shopping center construction sites yield an estimate of 1.2 tons of dust per acre of construction per month of activity.[12] This estimate is high for the Bryan Mound site because the estimate is for a semiarid climate. Dust emissions are often inversely proportional to the square of ground moisture, and ground moisture is 1.66 times the semiarid level at Bryan Mound.[12] Therefore, the dust emissions during construction are estimated to be 0.5 tons of dust per acre of construction per month of activity.

Dust emissions during facility operation would be due to vehicle travel over unpaved roads for the most part. Assuming an average vehicle speed of 40 miles per hour and a road surface silt content of 30 percent, the estimated dust emission is 0.24 pounds per mile of unpaved road traveled.

---

*Assuming total hydrocarbon emissions are non-methane levels.

Table 3.4 Pollutant Concentrations Downwind from Sources ($\mu g/m^3$)

Pollutant	CO	CO	HC	NO_2	SO_2	SO_2	Particulates	Particulates
Sample Time								
	8 hr.	1 hr.	3 hr.	1 yr.	24 hr.	1 yr.	24 hr.	1 yr.
Federal and State Primary Standards								
	10,000	40,000	160*	100	365	80	260	75
Construction Vehicles								
Downwind Distance (km)								
0.5	75	106	7	0	1	0	1	0
1.0	24	34	2	0	0	0	0	0
2.0	8	12	1	0	0	0	0	0
5.0	2	3	0	0	0	0	0	0
10.0	0	1	0	0	0	0	0	0
Drill Rig Equipment								
Downwind Distance (km)								
0.5	354	503	153	32	99	2	96	2
1.0	114	162	49	9	32	1	31	1
2.0	40	57	17	3	11	0	11	0
5.0	11	15	5	1	3	0	3	0
10.0	2	3	1	0	1	0	1	0
Paint Solvent								
Downwind Distance (km)								
0.5			749					
1.0			240					
2.0			85					
5.0			22					
10.0			4					

* Non-methane hydrocarbons only; levels calculated are total hydrocarbons.

The amount of dust-producing construction is relatively small for the proposed project because most of the on-site and access roads are paved. Most of the dust would settle within the site boundaries. The fugitive dust escaping the site will not seriously impact the environment.

Summary

The quality of the air near the site would be affected by the activities of site preparation and construction. During the start-up period, construction would take place at the site for about seven months and at the tanker terminal for about the same period. Emissions due to construction equipment, paint, and drill rigs would degrade the air with dust, CO, SO_2, NO_2, HC, and particulates. An estimate of the emissions based upon reasonable assumptions concerning number and types of sources is shown in Table 3.4.

The impact of these emissions depends on ambient air quality and the dispersal characteristics of the atmosphere. Ambient air quality has been discussed in Section 2.3. Atmospheric dispersion calculations were based on methods recommended by the Environmental Protection Agency[13] and averaged over appropriate time intervals as outlined in Appendix A.

3.3.2 Impact of Oil Storage and Handling

The quality of the air at the Bryan Mound site during operation will be affected by the following pollution sources:

- General Service Vehicles
- Valves, Pump Seals, and Gauges
- Crude Oil Tanks
- Tankers Loading and Unloading
- Fugitive Dust

Service vehicles and fugitive dust raised by vehicles would cause less impact than during the construction phase where it was estimated to be small. For this reason, attention would be focused on hydrocarbon emissions and the accompanying hydrogen sulfide.

Valves, Pump Seals, and Gauges

There would be a wide variety of valves, seals, and gauges associated with the pumping of crude oil through the pipelines between the dock facility and the individual cavities. Pipe flanges may be ignored because they are insignificant leakage sources. Valves may be classified in two categories;

flow control or pressure relief valves. Several types (gate, globe, angle, plug, etc.) exist in each category. A study of refineries in Los Angeles County showed that the average leakage of flow control valves in liquid petroleum service averaged 0.108 pounds per day per valve. The upper limit for one refinery was three times higher or 0.32 pounds per day per valve. The average leakage of hydrocarbons from pressure relief valves was 2.9 pounds per day per valve for all refineries. The maximum average for an individual refinery was about three times higher, or 9.1 pounds per day per valve.[14] A fraction of this leakage would evaporate into the atmosphere, perhaps 10 percent.

Pump leakage generally occurs through seals, which may be either mechanical or packed type. An EPA study found that centrifugal pumps with mechanical seals lose about 0.6 pounds per day while those with packed seals average 5.9 pounds per day. Reciprocating pumps with packed seals lose about 4.0 pounds per day.[14] An upper limit on average leakage of 6 pounds per day per pump is assumed.

The leakage rate of gauges is not known. In the absence of pertinent data, the average leakage rate of flow control valves is assigned to gauges and other instrumentation.

Site schematics show about 50 oil valves, 50 pressure indicators, and about 20 other gauges at the site. Assuming that 35 valves are flow control and 15 are for pressure relief, the upper limit on leakage should be:

35 x 0.32	flow control valves
15 x 9.1	pressure relief valves
70 x 0.108	gauges
8 x 6.0	pumps
194 pounds per day	

Most of this leakage would be collected but some, perhaps 20 pounds per day or .106 g/sec, would enter the atmosphere by evaporation. This hydrocarbon emission rate will cause little impact. If sour crude is being transferred, a maximum hydrogen sulfide emission rate would be 0.004 g/sec, or 3.8 percent of the hydrocarbon emission rate.[15] (See Table 3.5.

Emissions from leaks in valves, pump seals, and gauges do not appear to impact ambient air quality significantly. Even when they are considered as a point source, they contribute only 17 $\mu g / m^3$ at 0.5 kilometers.

Table 3.5 Operational Pollution Sources and Emission Rates (g/sec)

	Total Hydrocarbons	Hydrogen Sulfide
Valves, pump seals, and gauges	0.106	.0001 to .0040
Crude oil tanks (per tank)	0.63	.00063 to .024
Tanker Unloading *	242 (max)	.242 to 9.2
Tanker Loading	363	.363 to 13.8

* May be zero unless tanker is vented during unloading.

Crude Oil Tanks

The 1974 ambient non-methane hydrocarbon levels at three locations in this region were above Federal and state standards most of the time (sometimes by factors of 3 to 15). The sources of these pollutants are not known, but, directional data suggests the emissions may be coming from any or all of the large petrochemical complexes in the area and/or the city of Clute which is about six miles north of the site.[10]

Four 400,000 barrel floating roof surge tanks will be built on site. The evaporative hydrocarbon emissions from such storage tanks are estimated using a calculation of tank diameter, tank design, crude oil vapor pressure and density, and average meteorological conditions.[16] These tanks will be the standard 44 feet high (13.4 meters) and will be 108 feet in diameter (34 meters). Assuming these dimensions, a crude oil true vapor pressure of 1.8 pounds per square inch absolute, and oil density of 7.4 pounds per gallon, the estimated emission rate would be 120 pounds per day or 0.63 grams per second. Between 0.1 and 3.8 percent of this loss would be hydrogen sulfide, depending on the composition of the crude oil.

The hydrocarbon concentrations from emissions from the tanks tabulated in Table 3.6 are based on two tanks being used as storage tanks and two tanks being used as surge tanks. No tank separation has been included in this estimate. The downwind concentrations would be less than 160 $\mu g/m^3$ if the wind direction was perpendicular to the centerline of the two tanks. The worst-case values estimated in Table 3.6 are perhaps 3 percent probability values rather than the 5 percent quoted earlier for paint solvent emissions. The hydrocarbon emissions from crude oil surge tanks at the Bryan Mound site might elevate the ambient non-methane hydrocarbon levels within 0.5 kilometers downwind in the "worst case" situation analyzed. These concentrations would be reduced by a factor of 5 during more typical, but still conservative conditions as shown in Appendix A.

Vessel Loading and Unloading

It should be noted that not all hydrocarbon emissions are hazardous, nor do they all contribute to smog. It is difficult to determine what fraction of the emissions discussed here are in fact non-methane hydrocarbons (those specifically regulated and thought to be precursors to photochemical oxidant formation). One estimate might be made using the data collected for the immediate vicinity of

Table 3.6 Worst-Case Operational Downwind Pollutant Concentrations (ug/m^3)

Pollutant	Hydrocarbons	Hydrogen Sulfide (max)
Sample Time	3 hr.	30 min.
Federal & State Standard	160[a]	60 residential, business area
		90 vacant land, industrial area
Valves, Pump Seals and Gauges		
Distance (km)		
0.5	17.	1.
1.	8.	0.
2.	3.	0.
5.	1.	0.
10.	0.	0.
2 Tanks used as storage and 2 used as surge tanks at a given location		
Distance (km)		
0.5	186	10
1.	82	4
2.	35	2
5.	9	1
10.	4	0
Tanker Unloading without vapor recovery (Max)[c]		
Distance (km)		
0.5	38,500	2000
1.	17,700	920
2.	6,800	350
5.	2,100	110
10.	1,100	56
Tanker Loading without vapor recovery		
Distance (km)		
0.5	57,700	2980
1.	26,500	1380
2.	10,200	524
5.	3,100	166
10.	1,600	84

a - Non-methane hydrocarbons only; levels calculated are total hydrocarbons.

b - May be zero unless tanker is vented during unloading.

Bryan Mound and presented in the air quality Appendix D. Since the elevated hydrocarbon levels in the Freeport-Clute area are believed to be caused by the heavy petroleum industry in the area, it can be conservatively estimated that the composition of the existing levels is roughly similar to those emissions directly attributable to the Strategic Petroleum Reserve program. Based on this, and choosing the five days reported by Seadock to be those days with the highest ambient hydrocarbon levels (both total hydrocarbons and the non-methane fraction), an average fraction of non-methane levels were 42.2 percent of the total hydrocarbon levels.

The crude oil to fill the caverns would be delivered via tanker to the dock facility at Bryan Mound. Oil tankers of approximately 254,000 barrels would unload their cargo in 24 hours. During this time some emission of H_2S and hydrocarbons would take place. Presently, there are no reliable measurements of the emissions from unloading shipping vessels, but, there are some estimated values given by work done at the American Petroleum Institute[17] and compiled by EPA.[11] A vapor loss rate of 46,100 pounds per day or 242 g/sec is estimated for unloading a 254,000 barrel tanker in 24 hours. Depending on the unloading practices used at a given facility, some fraction of the vapors may enter the atmosphere. It is quite reasonable to assume that during unloading, air is drawn into the tanks allowing very few emissions to escape the tanks. If vapor recovery systems are implemented, only small amounts would enter the atmosphere.

The emissions resulting from tanker unloading, which are tabulated in Table 3.6, are based upon venting to the atmosphere those vapors formed in tanks during drawdown periods.

During withdrawal of oil from the facility, oil would be pumped to tankers at a rate of 385,000 barrels per day. The evaporative loss would be 70,500 pounds per day or 363 g/sec. The emissions noted under tanker loading in Table 3.6 are those that would be forced into the atmosphere by positive displacement unless a vapor recovery system is used. The higher levels are due to a higher loading rate into the tanker compared to the unloading rate into storage tanks.

The 1972 emissions inventory for Air Quality Control Region (AQCR) 216 (which includes Freeport) shows that approximately 4,351,000 pounds per day of hydrocarbons were being emitted from various sources within the region. Brazoria County contributed 826,000 pounds per day of the total. Therefore, the maximum losses from tanker loading (70,500 pounds per day) represents 2 percent of the total for the AQCR and 8.5 percent of the total for Brazoria County.

As shown in Table 3.6, the potential emissions from tanker loading and unloading during worst case conditions may be as great as 57,700 ug/m^3 (total hydrocarbons) at 0.5 kilometers. Industrial plants several kilometers away would experience high hydrocarbon levels under commonly occurring wind conditions. At certain times, undesirable high hydrocarbon concentrations (3,100 ug/m^3) may reach Freeport.

Another concern arising from emission estimates are the maximum 30-minute hydrogen sulfide (H_2S) concentrations. These levels represent the extreme worst case because for the sour crudes (with 3.8 percent H_2S at the well head), most, if not all of the hydrogen sulfide gas evaporates and is lost during transport. However, the analysis reflects the conservative assumption that all of the H_2S formed would be emitted to the atmosphere during transfer. If sour crude with this high level of H_2S is stored at the Bryan Mound site, the analysis shows a worst case concentration of 166 ug/m^3 in Freeport (a maximum rate applicable to the 150-day withdrawal period only).

Current Regulations

Neither vapor emissions from crude oil storage nor vapor emissions from ship loading and unloading activities are regulated at this time, but an interim strategy to attain the National Ambient Air Quality Standard (NAAQS) for photochemical oxidant by controlling reactive hydrocarbon emissions has recently been proposed by EPA for the Texas State Implementation Plan (SIP)*. Controls have been proposed for previously exempt crude oil emissions from storage tanks. Regulation of crude oil emissions from vessel loading and unloading is not anticipated at this time.

Floating roof storage/surge tanks are specified for the Bryan Mound site, and are considered by EPA to be the best available control technology. The technology for vapor control and recovery systems for marine terminal crude oil transfer operations has been developed, but there has been relatively little application of it. Since the SIP does not require such systems to be employed, the feasibility design upon which this EIS is based does not include them. This was done so that the document would reflect a worst case analysis of the impacts. However, the working designs for the facilities are still being formulated, and inclusion of a vapor recovery system for marine terminal operations is being considered.

*"Proposed EPA Revision to the Texas State Implementation Plan," Environmental Reporter, Current Developments, Volume 7, Number 29, November 19, 1976, pp 1065-1083.

Another requirement for SIPs to meet the NAAQS is new source review. The most recent ruling from EPA regarding new source review has established the trade-off system*. Under this provision, new sources are required to show that emissions from the new source plus SIP-required reductions from existing sources equal a net decrease in emissions. That is, the new source should not delay progress toward achieving the NAAQS in non-attainment AQCRs. The effects, if any, of this ruling on the SPR program remain uncertain at this time.

*"EPA Draft Preamble to Interpretive Ruling on New Source Review Requirements," Environmental Reporter, Current Developments, Volume 7, Number 29, November 19, 1976, pp. 1091-1094.

3.3.3 Noise

Construction activities associated with the Bryan Mound oil storage project and operation of the facilities upon completion of construction would create only minor and temporary noise impacts for residential, recreational, farming and other non-industrial land uses in the Bryan Mound-Freeport area. The construction activities are planned to take place over a period of approximately 10 months. The noise from construction and facility operation would occur at the following locations. (See Figure 3.2.)

Bryan Mound Storage Site Area

Contributing noise sources at the storage site area during site preparation would be air compressors, trucks, diesel engines, pumps, drilling rigs, impact equipment, concrete mixers, and general construction related equipment. Noise levels typical of this equipment are given in Table 3.7. An evaluation of the construction noise sources indicates that diesel engines would provide the most consistent source of noise and that impact and drilling equipment would create the peak sound levels. No noise sensitive land uses are located on or adjacent to the proposed storage site. (See Figure 3.3 for site layout and land usage.) The areas adjacent to the storage site are swamp or marshlands and are unpopulated.

After completion of the storage site preparation, fill operations would require the use of injection pumps and brine disposal pumps. These, together with other pumps which would be used for oil discharge operations, would be sheltered in a pumphouse at the storage facility. Although noise levels within the pump house can be expected to exceed 90 dBA, typical pump house construction should reduce exterior noise from this source to less than 70 dBA at 50 feet from the structure.

Additional noise at and near the storage facility would be caused by the slight increased vehicle traffic from maintenance and operating personnel. It is estimated that noise from all sources associated with fill/discharge operations would increase the noise levels less than 2 dB at the site perimeter.

Based upon the existing land use and the remoteness of the site from residential and other noise sensitive use areas, it is not anticipated that noise from storage facility operations would interfere with outdoor or indoor activities near the storage site.

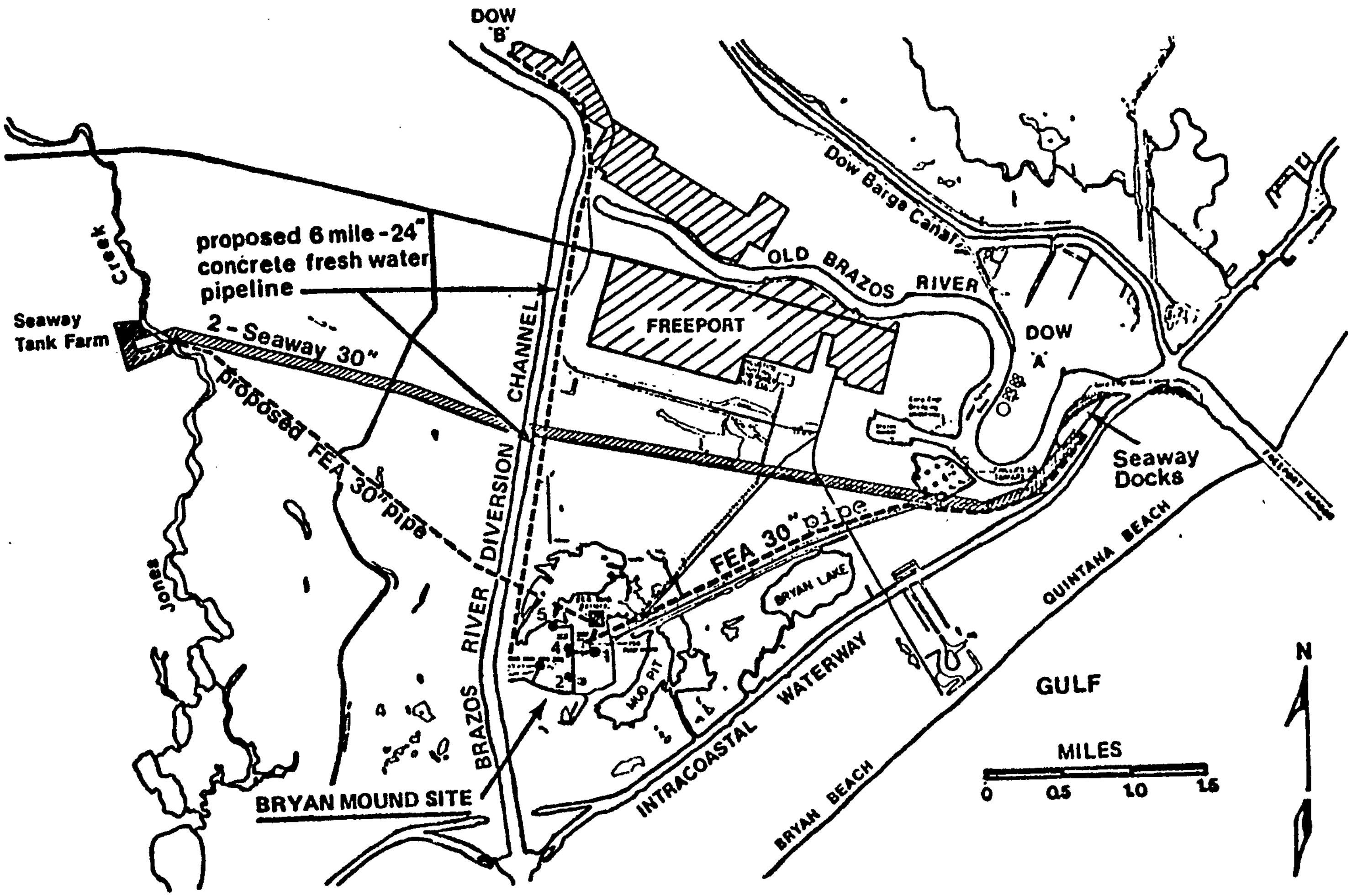


Figure 3.2 Location of Bryan Mound SPR Crude Distribution Components

Table 3.7 Construction Equipment Noise Levels

Equipment	A-weighted sound level at 50 feet (dBA)
Air Compressor	81
Backhoe	85
Concrete Mixer	85
Crane Mobile	83
Dozer	87
Generator	78
Grader	85
Pile Driver	101
Pump	76
Rock drill	98
Truck	88

SOURCE: "Noise Emission Standards for Construction Equipment Background Document for Portable Air Compressors," U.S. Environmental Protection Agency, EPA 550/9 - 76 - 004.

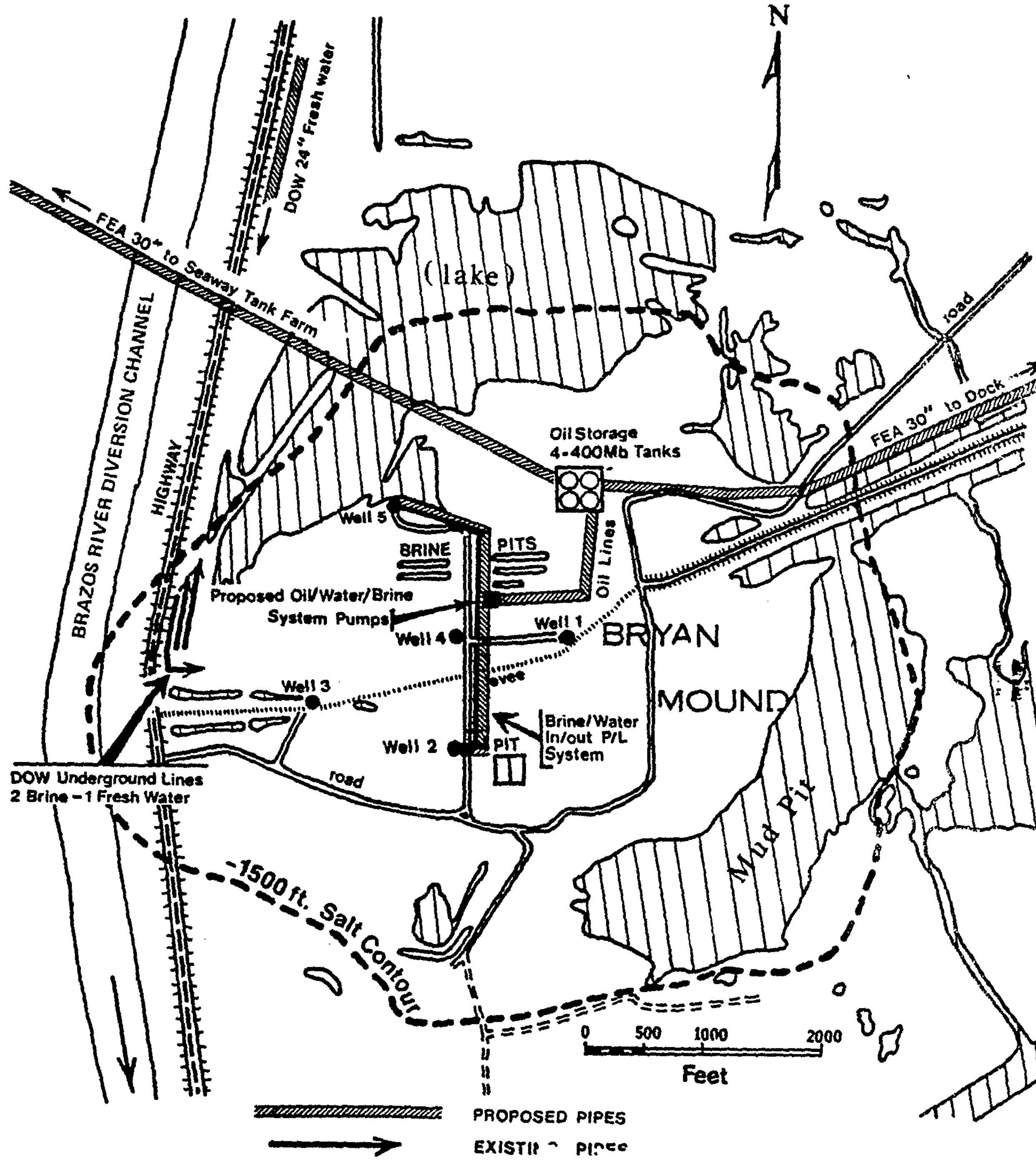


Figure 3.3 General System Layout - Bryan Mound

Pipeline Corridors

Two oil pipeline systems would be built in the Bryan Mound-Freeport area. One of approximately 3.7 miles would extend eastward to the Freeport docks; the other would extend 4.4 miles westward to the Seaway tank farm. As can be seen in Figure 3.2 these pipelines pass through undeveloped areas and are not expected to impact noise sensitive land use areas during their construction. The noise impact boundary is estimated to be L_{eq}= 55 dB at 500 feet from the pipeline construction (see Appendix C).

In addition to the oil pipelines a 5 mile 24" concrete pipeline for raw water supply would be laid between Bryan Mound and Dow Chemical Company's Plant "B". The construction of this proposed pipeline along an existing Dow right-of-way will pass through developed areas of Freeport along the Brazos River. It is possible that temporary noise impacts may occur in residential or commercial land use areas as the pipeline construction passes through the more developed areas. It is estimated that no noise impacts (L_{eq} >55 dB) on a daily basis would result beyond 500 feet from the pipeline construction. The annual L_{dn} levels along the pipeline construction are not expected to be affected because of the relatively short period of construction activity at specific sites.

Dock Area

Present plans are to use available docks and construct ballast water facilities at the Freeport Harbor. It is not anticipated that usage of the dock facilities during fill and discharge operations at Bryan Mound would significantly affect ambient levels for "normal" activities at the Freeport docks.

Summary of Noise Impacts

Noise impacts from the construction associated with the Bryan Mound site preparation are summarized in Table 3.8. During fill and/or discharge operations, there would be noise generated from the continuous operation of pumps at the storage facilities. The noise is expected to be continuous day and night for approximately 18 months during fill and 5 months during withdrawal, however, since the pumps would be enclosed in pumphouses, it is anticipated that there would be negligible noise impacts from the operations in the vicinity of these facilities (see Appendix C for Federal noise guidelines).

Table 3.8 Summary of Sound Level Contribution (dB) from Construction Activities

Construction Site	L_{eq}	L_{dn}	Distance from Center of Site
Storage Site Area	< 55	< 55	2500'
Pipeline Corridors*	< 55		500'

*No nighttime activity planned.

3.4 SPECIES AND ECOSYSTEMS

3.4.1 Impact on Storage Site Species

The oil storage site is located on a 216 acre tract consisting of poorly-drained coastal prairie with industrial buildings, roads, and equipment scattered throughout. Drilling of four new entry wells and construction of four crude oil holding tanks and a new pump house (on the northern part of the site) would require additional development of 20 acres of disturbed coastal prairie.

Clearing of land around the new storage wells and construction of the dikes around the tanks could cause temporary erosion with an associated increase in turbidity in the freshwater lake on the northwest side of the dome and in the brackish marsh northeast of the dome. Effects would be most evident if heavy rainfall occurs during or shortly after construction. If construction is completed relatively early in the growing season (approximately 275 days), a plant community would become established on the banks and cleared areas within several months. This vegetation would help retard runoff , thereby reducing soil erosion and associated turbidity. It would also serve as feeding grounds for birds, small mammals and other wildlife which frequent areas of human activity.

It is not expected that construction on the dome itself would reduce water quality in either the Brazos River or the Gulf Intracoastal Waterway. Suspended solids and nutrients which flow into the unnamed, low-salinity lake on the dome or into the surrounding marshlands are not expected to cause as severe changes as would be expected with dredging or pipeline burial. The overall net effect on primary production (photosynthesis and growth of phytoplankton, emergent and submergent aquatic macrophytes, and periphyton) would be a slight positive one unless light penetration is severely limited. This could occur at the marsh and lake margins following heavy rains, but impacts on aquatic organisms would be very short term and localized.

Maximum phytoplankton growth occurs in late winter and spring due to nutrient influx and warming followed by a summer minimum growth period. Aquatic macrophytes also grow more abundantly as the water warms in spring. Although no specific primary production data are available for the on-site lake, productivity estimates have been made for algal flats and salt marshes in the area.[18] Both estimates are approximately 600 pounds-carbon/acre/year (lb-c/acre/yr) as net production with that amount considered as a maximum for the shallow algal flats. It is doubtful that the primary productivity of the on-site lake is as high as 600 pounds-carbon/acre/year even though phytoplankton in such a lake would have a high reproduction rate. No significant increases or decreases in primary production are expected as a result of dome construction activities and any slight changes would not be evident within a month after construction because of rapid population changes in plankton and periphyton.

As a result of the possible slight enhancement of growth of aquatic vegetation, zooplankton, benthic invertebrates, and small filter-feeding fish may also experience subsequently increased food availability. In addition, detrital matter washed in from cleared areas may enhance the feeding of benthic invertebrates which consume detritus.

Approximately 20 acres of coastal prairie would be cleared and removed from biological productivity. Assuming that coastal prairie grass production on the site is 2,500 Kcal/m^2/yr,[19] a total loss of 2.02×10^8 Kcal/year of primary production would result. Using an estimated productivity for dense grass flats in southern Texas[18] (1,800 pounds-carbon/acre/year net production), a total loss of 36,000 pounds-carbon/year would be realized as a result of construction on the dome. Bulldozing 20 acres to a depth of two feet (Section 1), would obviously severely impact any small invertebrates in the litter and top soil. Populations of nematodes, mites, collembola (springtails), insect larvae, spiders and oligochaetes (worms) would be destroyed. Secondary productivity by these groups, while unknown for the site, is probably comparatively low due to the already disturbed nature of the habitat. Loss of primary and secondary production would be localized but permanent effects.

Noise and construction activity would discourage birds and other wildlife from using the site as feeding or nesting area. The following animals would emigrate from the area during construction: rats, rabbits, turtles, snakes, sparrows, hawks, meadowlarks, vultures, and egrets. Upon completion of construction some small mammals, birds and reptiles would return within several months. Only small portions of the 20 acres bulldozed would be available as habitat for these forms. Since this site already has a substantial amount of human activity, fill and withdrawal and maintenance operations would be slight, additional impacts to wildlife. The operations at the site and temporary storage facility would have little additional effect on the physical aspects of the site. However, minor adverse aesthetic impact and some noise and air quality degradation, associated with presence of the facilities and increased human activity, would be experienced.

3.4.2 Effects of Pipelines on Ecosystems

Construction of the Oil Pipeline to the Seaway Tank Farm

The 30" pipeline between Bryan Mound and the Seaway tank farm would extend on a 100 foot right-of-way, across the Brazos River Diversion Channel, to approximately 4.4 miles west of the dome. The right-of-way would require 6 acres of developed land on the mound, 18 acres of brackish marsh, 26.4 acres of coastal prairie, and 1.5 acres of river and creek bottom.

Impacts on the 6 acres of developed land of the dome (highly disturbed channel dredgings) would be negligible since this land supports only a relatively few individual transient species of wildlife from surrounding ecosystems. Noise and construction activities also would temporarily drive mobile wildlife (birds, reptiles, amphibians, and small mammals) from the pipeline corridor in the marsh and coastal prairie. These organisms would return as soon as vegetation becomes re-established. Their temporary displacement into the surrounding habitat would produce some stress on peripheral populations.

If it can be assumed that brackish coastal marsh productivity is approximately 1,518 g dry weight/m^2/year[20] and coastal prairie productivity is 2,500 Kcal/m^2/year,[19] the amounts of production lost for one year's growth due to pipeline burial in the marsh and coastal prairie are 1.10×10^8 g dry weight and 2.67×10^8 Kcal, respectively. Vegetation in the corridor is expected to return within one year, although mowing or other maintenance along the right-of-way may be required (based on personal observation of pipeline corridors in the study area). This production loss would result in a reduction of food availability for wildlife or fish.

Pipeline burial in the river would eliminate temporarily ½ acre of benthos habitat. Relatively immobile forms including some crabs, other decapods, barnacles, polytion. Background turbidity levels in the lower Brazos River are relatively high. Based on Seechi disk transparency determinations, light penetration varies from 0.2 to 1.0 feet depending on rainfall, river flow, and tidal influence.[21] Thus, pipeline burial should not produce significant changes in either dissolved solids or turbidity. Release of nutrients would produce minor measurable changes in their concentration. Because of the flow rate of the river and the absence of well defined plankton populations in most large rivers,[22] nutrients would be diluted, washed downstream, or adsorbed onto sediments without producing significant changes in plankton growth.

The pipeline would cross Jones Creek approximately 4.5 miles north of where the creek discharges into the Intracoastal Waterway. The ecological setting of this area is described in Section 2.4.2. Pipeline burial will increase turbidity at the site and downstream from the site. Pipeline burial may also result in the release of dissolved nutrients. Because Jones Creek flows less rapidly than the Brazos River, the increase in dissolved nutrients could temporarily elevate the BOD downstream from the pipeline crossing.

Pipeline burial in the river and creek would eliminate temporarily 1.5 acres of benthos habitat. Relatively immobile forms including some crabs, other decapods, barnacles, polychaete worms and mollusks would be eliminated at the immediate vicinity of pipeline burial. In comparison with the vast expanse of brackish water habitat in the nearby rivers and waterways, the loss of ½ acres of benthic invertebrates is inconsequential. The pipeline burial area would become repopulated by benthic organisms within 1 or 2 months after construction.

Construction of the Oil Pipeline to the Dock

As a result of constructing the 30 inch pipeline from the dock to the dome, 45 acres of mostly secondary regrowth vegetation would be affected. This area is presently disturbed and supports low numbers of transient organisms such as waterfowl, reptiles and small mammals from surrounding ecosystems. Revegetation in the pipeline corridor is expected to occur within a year.

Construction of the Pipeline for Displacement Water

The addition of a 24 inch pipeline for displacement water from the private Dow Chemical Company supply would consist of a new line between Bryan Mound and Dow's Plant "B" where water would be drawn from a canal. This new pipeline would require an additional 50 foot path along an existing right-of-way inside the Brazos River levee west of the dome. Impacts on aquatic communities in surrounding areas would be minimal. Unless heavy rainfall occurs during or shortly after construction, runoff into the lakes and marshes within the levee would cause negligible effects.

Two of the 5 miles of new rights-of-way would cross parallel an existing levee (6 acres utilized) while the remaining 3 miles would cross land developed for the Dow Chemical complex (9 acres). Clearing of vegetation on the 6 acres near the levee would result in a loss of productivity of 2,500 Kcal/m^2/year[19] for one year's growth. The importance of this loss is evaluated at the end of Section 3.4. As for the oil distribution pipeline, installation of the new displacement water line would temporarily disturb wildlife. Mobile birds, reptiles, amphibians, and small mammals would emigrate to surrounding areas. Any stress on surrounding populations would be minimal because the area involved is a long, narrow strip.

Maintenance of Pipelines

During the operational phase of the facility, the pipelines and storage activities would cause little environmental impact under normal operating conditions. Noise would probably cause the most impact as pump stations along the pipeline paths would create localized stress. Maintenance of the right-of-way by mowers would drive mobile organisms from the vicinity temporarily. The storage facility may be aesthetically unpleasant to some people and slight noise and air quality degradation associated with increased human activity in the area may be evident. Increased human activity around pump stations may cause an out-migration of birds and other wildlife. If pumping activities extend over a period of several months, impact on bird feeding and nesting may be severe enough to permanently prevent return of birds.

3.4.3 Impacts on Species at the Dock Site

An area of approximately 3 acres of dry land next to the Seaway docks on the south side of the Freeport Harbor, would be used for ballast treatment tanks. Construction of the tanks and treatment facilities would eliminate a small amount of coastal grassland permanently. Few trees would be removed and no critical wildlife habitat would be lost since only transient birds and small mammals and a few resident reptiles or amphibians would be affected.

The impact of releasing ballast treatment water with oil concentrations of the effluent not exceeding 14 ppm (mg/l) daily is dependent on the flushing regime of Freeport Harbor. Existing water quality (Appendix B.5, Tables B.5-1, B.5-2) near the discharge area has low ambient oil and grease levels in the water column (less than 1 mg/l). Computer simulations, which treated oil as suspended droplets emerging from a diffuser port in the middle of the harbor and one foot from the bottom, indicated rapid dilution with a water velocity of 1 foot per second. At 300 feet downstream only a trace (0.02 ppm) of oil above ambient remains. These are steady-state conditions and the flow characteristics of Freeport Harbor are more complicated with tidal flows reversing direction every few hours. As a worst case, it is possible for oil to be transported via tides or wind action into areas where it would become concentrated. One such potential area exists about 1.5 miles upstream where ambient oil and grease levels are 60 mg/l. Near the point of discharge a chronic pollution problem would exist and lower species diversity of many marine plankton and fish as well as lower productivity can be expected there. Effects would be localized and diffusion would limit the area affected. The effects would persist throughout each 150 day fill-withdrawal cycle. It should be noted that the State of Texas classifies Freeport Harbor as suitable for non-contact recreation only (Appendix B.2, Table B.2-1).

Shipping operations would affect the aquatic life in the Freeport Harbor. Ship passage may cause increased turbidity and shoreline erosion. Passage of a barge or tanker can resuspend sediments which require at least 2½ hours to settle.[23] The suspended sediments can clog or abrade gills of fish and macrobenthos or can suffocate mollusks. Also, additional turbidity can reduce plankton productivity, thus reducing the amount of food available to filter-feeding fish and mollusks. Light penetration in the proposed dock area is presently 1.3 to 4.8 feet, but this may be intermittently reduced by ship passage. In an active waterway, such as the Freeport Harbor, large ships are common. Therefore, impacts directly attributable to the tankers connected only with the Bryan Mound oil storage operation would be minor in comparison to the total impact from ship traffic within the Freeport Harbor.

3.4.4 Effects of Brine Disposal and Water Intake Systems

Brine Disposal

Brine extracted from the storage cavities when they are filled with oil, is to be processed through existing brine ponds and transported via existing pipelines to the Dow Chemical plant. Brine produced would be used by Dow operations in lieu of brine from wells at other locations, therefore, no terrestrial and aquatic communities would be impacted.

Displacement Water

Oil displacement during recovery would require a total water demand of 14,000 gallons per minute from surface waters to fill the 4 chambers. This water can be supplied from the existing Dow industrial water supply system storage reservoirs (Brazoria and Harris). Dow presently purchases 1800 million barrels of water per year from the lower Brazos River Authority and has an option to purchase an additional 620 million barrels. A single filling of the Bryan Mound storage cavities would require 58 million barrels or 3.2 percent of Dow's present lease capacity (2.4 percent when purchase option water supply is included). This 58 million barrel requirement also represents 7.5 percent of the capacity of the two reservoirs (See Section 1.3.1). Thus there is additional impact associated with the operation of the storage facility. A greater volume of water may be withdrawn during oil recovery operations than during Dow's normal leaching. Thus a relatively larger number of planktonic organisms would be eliminated over a short time span. Individual organisms would be sacrificed because of entrainment (organisms drawn in) in the intake structures and impingement (entrapment against the intake screen).

Organisms which would be entrained are the plankton (diatoms, other algae, copepods), larval fishes, benthic organisms, and aquatic insects. Virtually all organisms entrained in the intake water would be killed. Since these organisms form the basis of aquatic food webs, production losses would affect other species in the vicinity. Effects are expected to be localized near the vicinity of the intake structures.

The number of impinged organisms would depend on the size of the screen apparatus. Most intake systems are fitted with ½ inch mesh screen and intake velocity of the water would be 0.6 feet per second or less. It is doubtful that a severe impingement problem would occur. Large organisms incapable of passing through the screen presumably would be mobile enough to escape. Intakes are designed to minimize inflow velocity and thus prevent impingement. Frequent cleaning would prevent clogging which can create stronger currents across the intake screen.

3.4.5 Summary of Biological Impacts

At the Bryan Mound dome site 20 acres of disturbed coastal prairie would be permanently lost. Soil invertebrates would be eliminated and 2.02 X 10^8 Kcal/yr. production or 36,000 lbs of carbon production/yr. would be lost. This represents a localized loss which would, in addition, influence animal populations feeding and/or nesting at this site. Construction and human activity would force emigration of mobile wildlife.

Two oil pipelines are proposed. The pipeline between the dome site and the Seaway tank farm would impact 8 acres of developed land, 18 acres of brackish marsh, 26.4 acres of coastal prairie and .5 acre of Brazos River bottom. Biological impacts on dry land would be negligible; 1.10 x 10^8 g dry wt/year plant production (marsh) and 2.67 x 10^8 Kcal/year (coastal prairie) would be lost due to pipeline construction. If pipeline right of ways are maintained this amount of potential production can be assumed to be lost over the course of one year. This production loss would result in a reduction of available food for fish and wildlife. One-half acre of benthic habitat in the Brazos River would be disrupted and immobile organisms killed but populations of crabs, barnacles, worms and mollusks would re-establish in one to two months. The pipeline from the dock to the dome would cross 45 acres of predominately disturbed habitat. Construction and maintenance activities along both oil pipeline routes would reduce the numbers of organisms utilizing those areas as habitat.

Construction of a displacement water pipeline would impact 9 acres of developed land and 6 acres along the levee. Primary production losses from the 6 acres total 6.1 X 10^7 Kcal/yr. This represents a relatively small and localized production loss. Construction and maintenance activities would temporarily disturb wildlife with some birds, reptiles, amphibians and small mammals emigrating to surrounding areas.

Impacts on 3 acres of dry land which would be required for ballast treatment tanks would be very localized. The area is already highly disturbed. Shipping operations would produce a small additional impact to aquatic life in Freeport Harbor.

Severe but localized impacts on plankton, larval fishes and benthos would occur near the displacement water intake structures and losses of these organisms would affect local food webs. Impingement would not be a problem. Brine produced in facility operation would be used by Dow Chemical, thus no terrestrial or aquatic communities would be impacted by brine disposal operations.

There are no known populations of rare or endangered species resident in the immediate area of the dome, dock or along any proposed pipeline routes.

3.5 WASTE DISPOSAL

Discussions with Dow Chemical Company personnel have led to probable disposal techniques for the various types of wastes. During the site preparation and construction phase, generated wastes include surplus lumber and metal goods, paper, waste concrete, earth excavations, personnel sewage, and, possibly, formation water during the drilling process. All of these types of wastes are generated in the present Dow Chemical Company operations in the Freeport area.

Surplus lumber and scrap metal are normally sold to local dealers who handle such materials. On the other hand, disposal of waste paper, concrete, and other nonmarketable goods are usually contracted to a local private firm which disposes of them in the Brazoria County Precinct #1 Disposal Site located 2 miles east of Clute. Probably no more than a few thousand cubic feet of each of these types of materials would be generated during the entire project.

Most of the earth material excavated during project construction would be used within the project, for example, as dike material around various tanks.

Sewage treatment and disposal would probably be through the common portable septic tank system that can be rented from various contractors or through a more permanent system constructed in compliance with State regulations. Any formation water produced during the well drilling process would probably be reinjected into the well hole with the drilling mud or collected by drilling support tank trucks and processed in Dow's waste handling facilities.

The major waste product that is generated during system operation is the ballast water extracted from the tankers during unloading. An estimated upper limit on the amount of ballast water to be handled is 50,000 barrels per tanker of which as much as 5 percent or 2,500 barrels per tanker may be recoverable oil. To recover this oil, the ballast water would be processed through a ballast water treatment facility at the dock site. This facility would reduce the oil content of the waste water to a maximum monthly average of 7 parts per million (ppm) prior to discharging the water into the Freeport Harbor. No adverse impact is seen in disposing of the waste water in this fashion. On the other hand, the recovered oil would probably be injected into the cavities.

Similarly, the small amounts of waste oil generated by the pumping facilities and at other locations would be collected and probably processed through the ballast water treatment facility.

3.6 SOCIOECONOMIC EFFECTS

3.6.1 Manpower Requirements

Drilling and Construction

An estimate of the manpower requirements for drilling to the salt dome, construction of facilities on site, and laying of pipelines is shown on Table 3.9.

The labor distribution assumes that a primary contractor would be hired to coordinate operations. Subcontractors would be performing some tasks related to plant construction. A small core of personnel would supervise the overall operations, and additional supervisors would take care of component operations. Some of these supervisors generally do the work of skilled operators and have added responsibility for coordination and recordkeeping, thus they are not considered to be separate from the productive work force. It is assumed that drilling and plant construction operations would be conducted concurrently. Drilling would operate continuously, using three shifts of 10 men pér shift, or a total of 30 skilled workers. Laying of pipe on site and construction of surface structures other than tanks, would require about 50 workers. The construction of four 400,000 barrel steel tanks is expected to proceed along with other construction and requires about 25 skilled craftsmen in the welding and pipefitting trades.

Laying of Pipelines

A 30 inch crude oil pipeline would connect the project with dock facilities at Freeport about 3.7 miles east and with the Seaway Tank Farm about 4.4 miles west. A new 24 inch concrete raw water pipeline would be constructed from the project to Dow Plant "B" about 6 miles north. This construction would take place concurrently with drilling and tank construction. The labor force of 50 men assigned to laying of pipes and surface facilities on the site would probably be retained for construction of these additional pipelines.

Table 3.9. Manpower requirements for preparation and construction on the Bryan Mound Site

Operations:		Number of Workers*
Drilling**	10 men x 3 shifts	30
Plant Construction and Pipelines		50
Welders and Pipefitters for Tanks		25
Supervisors***		10

Total time required 10 to 12 months

* All workers are skilled workers
** Based on 24-hour operation
*** Includes an overlap of personnel among operations

Note: Administrative and clerical support not included because positions already exist and project will require no additional requirements.

Source: Mr. Ed. Williams, Dow Chemical Company, Freeport, Texas.

Operation of Facilities

At the most, 10 persons can handle all aspects of facility functions during storage. This would include equipment operators, maintenance, security, and administrative personnel.

During oil recovery procedures, a work force of up to 46 skilled laborers would be required for a period of 5 months. This estimate includes personnel to operate and monitor pumps and valves, and dock workers to load tankers with oil from the storage site. A similar level of manpower would be necessary when the cavities are refilled at the end of the petroleum storage period.

Summary

Drilling and construction of facilities at Bryan Mound, pipelaying operations, and tank construction would all be underway simultaneously. Total manpower requirements during the projected 10 months of construction could reach a peak of approximately 115 men. Because drilling crews would be working in shifts, the maximum number of workers on site during the day would be approximately 95. About 10 workers would be on site during each of the two evening drilling shifts. After construction, the labor force would be reduced to a maximum of 10 persons who would be permanent employees of the project.

3.6.2 Potential Sources of Labor and Supplies

The local availability of the required manpower, equipment, and supplies for the Bryan Mound project would depend upon the activity of other new industrial plant construction at the time. If the needs of this project produce a demand for these resources at a time when local competition for them is strong, it may be necessary to hire contractors from a considerable distance.

Industrial expansion has been taking place in the Bryan Mound area for the past 30 years. There is little unemployment but a steady influx of outside labor has been entering the area as jobs have opened up, and large numbers of skilled workers are available. The site is near the Houston metropolitan area. It is anticipated that most of the men would be drawn from Houston and from nearby locations in Brazoria County. Most workers would commute to the site. About 25 workers would be recruited from the immediate Freeport and Brazosport area. Some workers would live in mobile homes or seek temporary housing in the Brazosport area.

3.6.3 Effects on Community Services

The migration of workers to the area would produce little stress on community services. Since the area is geared to servicing large influxes of tourists on a regular basis, an additional 115 persons would cause little effect. All roads in the area are constructed for heavy equipment loads, but would require some additional maintenance.

The availability of standard housing is low in the Brazosport area. If an outside drilling or pipelaying contractor is used, and a trailer park is set up for 10 to 12 months to house employees in one of the communities near the site, some short term stress factors can be expected. Primary among these would be (a) providing a drinking water supply and sewage disposal facility, and (b) providing for the schooling needs of children in families that move with the workers. Since most residents of the area are recent migrants from other areas, there seems little chance of stress due to cultural differences between the established community and the migrant workers. There would be no problem absorbing up to 200 children into existing school systems in Brazosport. (Public school enrollment in 1976 for grades one through twelve was 10,813).[24]

The area comprising the project site and pipelines would be under the jurisdiction of the Brazoria County Sheriff's Department and the Freeport Police Department. Security forces supplied by the project would coordinate with these local law enforcement agencies in maintaining the protection of personnel, equipment, and supplies. Municipal police forces are well trained, well equipped, and accustomed to large influxes of people. The project site would have fire fighting equipment on hand. Auxiliary aid in containing fires that may spread into the surrounding areas is available from several local sources.

The area provides an adequate level of health services for the existing populace. Medical facilities can adequately provide for most injuries to workers onsite. Workers migrating to Brazosport may cause a slight strain on medical facilities. Any large scale disaster may cause serious problems because of requirements for evacuation to Houston medical facilities.

The area is geared to provide recreational facilities and services so any requirements by workers employed on the project would be no problem. In general terms, the impact of the project on community services would produce an increment of stress that is small compared to existing stresses resulting from the rapid expansion of the population in the area.

3.6.4 Economic Impact

Employment and Payroll

The major local benefits of the project would be the direct employment and payroll. It is anticipated that a number of local contractors would be hired for various phases of construction. Including the men detailed to the project by these contractors, the payroll for each of the phases would be approximately as follows:*

Drilling	$ 51,000 per month
Plant Construction	85,000 per month
Mechanical Construction (Tanks and Pipe Fittings)	42,500 per month
Supervision	20,000 per month
Total	$198,500 per month

Presuming some fluctuation in the number of men on the payroll, and some short term sequential projects (tank construction and pipe fittings), the payroll would be roughly between $150,000 and $200,000 per month for the first 12 months. These wage rates are on a par with those being paid by the construction industry in the area. Except for those employees who commute from Houston, the income received by workers would tend to circulate within the Brazoria County and Brazosport area.

Local Business and Industry

The petrochemical and chemical industry is a vital part of the economy of the area, and a large number of industries have been established that provide goods and services for these operations. Several local industries engage in maintenance and repair of offshore well equipment. Fabricated structural steel, sheet steel, steel and concrete pipes, and fittings are available in the local area. It is expected that local contractors would be augmented by contractors from the larger Houston labor market. Use of outside labor would not adversely affect current employment in the area. Because the duration of construction for the project is confined to 12 months, it is anticipated that no new businesses would be induced by it.

---

*Based on a wage rate of $1,700 per month for skilled workers, $2,000 per month for supervisors.

Tax Benefits

Sources of tax revenue for Texas and Brazoria County are (1) severance taxes (and royalties) from the extraction of oil and gas, (2) property taxes, and (3) sales tax (4% state tax on general goods and services). Severance tax would not apply to this operation. It is assumed that the site and rights-of-way would be leased, but new equipment and materials installed there would be federally owned and therefore exempt from property and sales tax. At present Dow pays approximately $15,000 in property taxes on the Bryan Mound site, and in the event that the site was purchased rather than leased, a like amount would be lost to the county. In the event that the oil is withdrawn from the salt cavities, the companies that purchase the oil would be exempt from state sales tax if they are registered wholesalers (most oil companies are registered). Tax benefit from the project would accrue indirectly from the income and purchasing exercise of the workers.

Costs

Costs to the community would be primarily those paid for public servies: electrical, water and sewage connection, trash collections, police and fire protection, schools, and health facilities. Costs would be attributable to the general growth of the communities and not incurred because of this specific project. Road maintenance in the vicinity of the site would be added costs directly attributable to the project.

Migration of workers to the area to meet required manpower needs may cause a period at the end of drilling and pipe-laying operations when replacement jobs are not available in sufficient number to employ these workers. This situation could place a burden on social welfare services if the workers decide to remain in the Freeport area. However, the present growth rate of general construction, heavy industrial, and the petrochemical industry in the area indicates that opportunities for reemployment of these workers would be available.

3.7 EFFECTS OF ACCIDENTS AND NATURAL DISASTERS

The potentiality of accidents and natural disasters is discussed in this section with particular emphasis on the possibility of crude oil or brine spills. The discussion is based on probabilities of occurrence contained in appropriate literature and applied to the specific facilities proposed for the strategic petroleum storage in the Bryan Mound dome.

The probabilities of occurrence were generated from historical accident or natural disaster data. Care has been taken to use probabilities generated for circumstances and environments similar to those existing for this project.

3.7.1 Pipeline Accidents

The available liquid pipeline accident or failure data gathered by the Department of Transportation covering the years 1968 through 1973 show fairly consistent statistics.[25] Analysis of these data performed in conjunction with the submission of the Louisiana Offshore Oil Port (LOOP) Project environmental impact assessment indicated that an accident rate of 0.00136 incidents occurred per mile/year.[26] However, taking into account the improvements in pipeline materials, manufacturing processes, construction, and testing procedures, reasonable accident/failure frequency was projected to be 5×10^{-4} per mile/year.[26] These probabilities include spills caused by external forces including natural disasters, corrosion, operational reliability, and better than a 10 percent contingency category.[26]

Using this accident/failure frequency, the expected frequency an incident per year for the various types of pipelines in this SPR Project is given in Table 3.10. Also present in this table are the lengths of each of the pipeline systems and the number of operational years associated with a program of 5 fill/withdraw cycles. The oil lines are assumed to be full for a projected 25 year life of the project.

Employing data from Table 3.10, the probability of a given number of spills from each of the types of pipelines during the life of the project may be computed. These probabilities are presented in Table 3.11. Note that in each case by far the most probable number of pipeline spills is zero. In fact, only about a 10 percent chance of a crude spill is projected and about a 5 percent chance of a brine spill. The brine spill analysis must be tempered by the fact that the probability data are based upon higher pressure oil lines. Even the crude spill probability must be tempered somewhat because the operating pressures for most of the crude pipelines at this site are relatively low (less than 200 psi), and galvanic protection is afforded to reduce corrosion.

The same data base that was used to compute an accident frequency rate projects the mean spill size to be about 1,000 barrels. Using this mean spill size, the annual crude

Table 3.10. Expected Accident or Failure Frequency

Type of Pipelines	Approximate Length (mi) [a]	Expected Accident/Failure Frequency (Events/Year)	Approximate Number of Operational Years [c]
Crude Oil	8.2	.00425	25 [d]
Brine [b]	25.0	.0125	5
Raw Water	6.0	.003	3.5

a. Includes approximately 1 mile of line on the dome site for each type.

b. Includes 3 lines each to Plants "A" and "B".

c. Assumes 18-month initial fill, five five-month withdrawals, and four ten-month refill periods.

d. Assumes oil pipelines are filled at all times.

Table 3.11. Probability of Pipeline Failure During Project *

Number of Crude Spills	Probability (%)
None	89.4
1	10.0
more than 1	0.6

Number of Brine Spills	Probability (%)
None	93.8
1	5.4
more than 1	0.8

Number of Raw Water Spills	Probability (%)
None	98.9
1	1.0
more than 1	0.1

* Assumes that pipeline integrity is tested prior to initiation of each withdrawal/refill cycle.

spill expectation volume is only 4.25 barrels, or the total crude spill volume expected over the life of the project is only 106 barrels.

The 30 inch crude oil pipeline runs east 3.7 miles to the dock from the site and west 4 miles to the tank farm. Each segment contains 20,000 barrels of oil during the life of the project. A major break during oil transfer would be detected by fail-safe monitoring. Minor leaks could go undetected for some time. The maximum credible oil leak during a storage period might take place as follows. Assume that the buried pipeline outside protective levees is punctured without a report of the incident being made. Oil would seep out under the small pressure head available until the pressure head went to zero, or a routine pressure test was made, or the escaping oil was reported and the leak isolated. The worst case would require (1) that the break occur in a low place (perhaps the crossing under the Brazos River), (2) that a surface valve was not tightly closed on the long leg of the line and (3) that pressure checks of pipeline integrity were not made at intervals. Under these circumstances a fraction of the 20,000 barrels would seep out until the oil surfaced. Eventually a serious leak would be noticed and traced.

The maximum credible oil spill during oil transfer would be caused by a complete break, perhaps due to a vehicle accident, while the maximum flow rate is 20,000 barrels per hour. The pressure sensors would soon cut off the pumps but several thousand barrels of oil could be released.

A large pipeline accident spill is unlikely because the pipeline is protected by burial along the entire route. Crude leaking from a buried line would be somewhat contained by the surrounding earth; further, over much of the crude pipeline route at the Bryan Mound facility, any crude that did reach the surface is prevented from reaching the open waterways by the levee systems in the area. Therefore, the damaged area would be limited and cleanup could proceed effectively. Similarly, the pipeline spills in the dock area would be constrained from directly reaching the Intracoastal Waterway by an existing levee, and that portion reaching the Freeport Harbor area should be contained by the dock site equipment or other accident equipment in the area.

The worst place for a bad spill would be under the Brazos River; however, the probability of a leak under the river during the life of the project is less than .002 and the probability of a large leak is much less than that. The levee system along the Brazos River would essentially prevent inland penetration of the crude oil. The point of the pipeline crossing is channeled as part of the six miles of "new river" dredged in the 1940's. Closing of locks at the junction of the Brazos River and Intracoastal Waterway would prevent oil transport into the waterway. Crude oil, if not quickly contained and cleaned up, would reach the mouth of the river and could contaminate sections of Bryan Beach and Quintana Beach. Since this area of the river is a dredged channel close to the ocean, biological communities are represented mostly by transient marine forms. Impacts on benthis and nektonic organisms would be similar to those described in Section 3.7.3 for marine forms.

The largest brine line to Dow's Plant "B" contains about 4000 barrels of brine. The smallest contains 1200 barrels of brine. Brine spills due to pipeline accidents are assumed to have about the same probability as oil spills from pipelines. The magnitude of the mean brine spill size is assumed to be about 1000 barrels as it is with oil spills.

Should an oil or brine leak occur within a diked area, the leaked material would be contained until it could be removed. A spill above ground in an undiked area would tend to flow to a lower level until trapped by features of the terrain or until it flowed into one of the nearby ponds or lakes. Some of the spill might soak into the ground and contaminate the upper layer of brackish ground water discussed in Section 2.2.

Oil which has leaked from a buried pipeline would tend to migrate to the surface. A brine leak under similar conditions might diffuse into and mix with the shallow brackish aquifers in the area. Contamination of the deeper fresh water aquifers is not expected.

3.7.2 Risk of Oil Spills During Marine Transportation

Introduction and Summary

This section presents estimates of both the probability and the size of oil spills arising from accidents during marine operations and transport. Marine operations considered include the voyage of the tankship through the Freeport Harbor Entrance Channel and associated waterways from the Gulf to the terminal, and loading and offloading operations at the terminal. Accidents include vessel casualties such as collisions and groundings, and mishaps at the marine terminal such as failure of a hose connector, overfilling a tank, opening the wrong valve, etc.

A detailed description of the estimated risk of oil spills from accidents is presented in the following two subsections. A summary is provided in the following paragraphs.

The estimates are based primarily on statistical analyses. The number of vessel casualties, which would result in the spill of oil, were derived from the Coast Guard's listing of Commercial Vessel Casualties for fiscal years 1969 through 1974. The count of ship traffic was obtained from "Waterborne Commerce of the United States," U.S. Army Corps of Engineers. Combined, these data yielded the expected frequency of spills per transit of a tankship from the Gulf to the terminal. Similarly, the frequency of spills for loading and offloading oil at the terminal was obtained from incidents reported by the Coast Guard's Pollution Incident Reporting System and Corps of Engineer traffic data, both covering the entire United States. The distribution of the quantity of oil spilled, with the number of spills, was developed from the Coast Guard Commercial Vessel Casualty data for losses from tank barges in Western Rivers* and the inland Gulf region. The quantities spilled are distributed log normally versus number of fraction of spills. This relationship was modified for application to tankship casualties and accidental spills during loading and offloading at the marine terminal.

The above methodology is based on the assumptions that the planned crude oil transport operation is essentially the same as that for which the accident experience has accrued and that the added ship traffic in the Freeport Entrance

*Primarily the Mississippi River system.

Channel does not in itself increase the likelihood of accidents. These assumptions seem justifiable. For the first assumption, the facilities, tankships and barges to be used will be nearly the same as those now used in the area. For the second assumption, it may be noted that traffic along the Channel is one way[27], movements in one direction at a time. Hence ship collisions have not been observed and the increased traffic caused by the movements of crude oil should have no effect on the accident rate of a ship.

The estimates of risk of accidental oil spills is summarized in Table 3.12. The expectation quantity of crude oil spilled per trip from vessel accidents, such as groundings, rammings (striking fixed objects, submerged or on or above the water surface), structural failure, fires and explosions, etc., is 0.59 barrels per trip for the tankships (254,000 barrels capacity). Accidents at the marine terminal, such as overfilling a tank, opening the wrong valve, etc., have an expectation quantity spilled of 0.86 barrels per trip for either barges or tankships. The total expected quantity of oil spilled during the transport of 58×10^6 barrels is 331 barrels for transport by tankship.

Figure 3.4 shows the frequency distribution of spill sizes for tankship accidents.

If barges rather than tankships are used to transport the crude oil, the expectation of spills and the amount of spill oil would be larger than 331 barrels. The reason for this is that the barges have a smaller capacity and hence must make a larger number of trips to transport the same quantity of oil. The spill frequencies per trip for barges and tankships are nearly the same.

As is well known, oil spilled onto water produces a very extensive slick. The following relationship between spill quantity and slick area or radius, assumes unhindered (no wind, currents, or surface obstacles) spreading and a circular-shaped slick:[28]

$$A = \pi r^2 = 2.52 \times 10^4 \ (V)^{3/4}$$

Where A is square meters, r is the radius of the slick in meters, and V the volume spilled in barrels.

These dimensions are achieved 24 to 48 hours after the spill. For the median spill quantities listed in Table 3.12. the ultimate slick dimensions were computed:

Table 3.12

Risk of Spills of Crude Oil from Marine Transport Accidents at the Bryan Mound Site

	Tankships
Frequency of oil spills from vessel casualties[b], spills/trip	$3.3x10^{-5}$
Median quantity of oil spilled from vessel casualties[b], bbl/spill	5300
Expectation quantity of oil spilled from vessel casualties[b], bbl/trip	0.59
Frequency of oil spills from accidents at the marine terminal, spills/trip	$7.3x10^{-3}$
Median quantity of oil spilled from accidents at the marine terminal, bbl/spill	18
Expectation quantity of oil spilled from accidents at the marine terminal, bbl/trip	0.86
Total expectation quantity of oil spilled for transport of $58x10^6$ bbl,	331[a]

[a] 228 tankship trips

[b] Groundings, rammings, structual failure of vessel, etc.

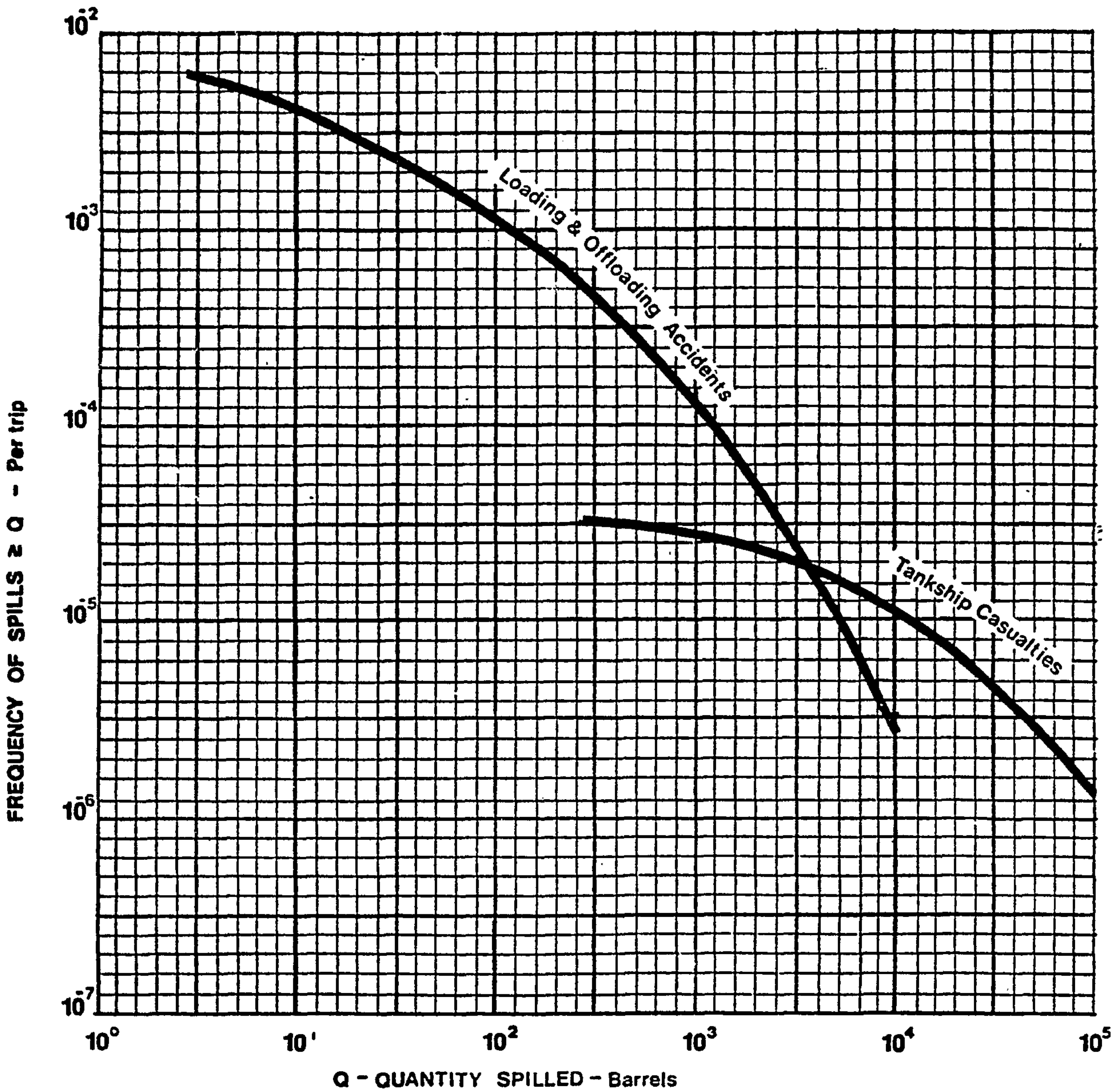


Figure 3.4 Estimated Frequency Per Trip of Crude Oil Spilled From Accidents During Transport by Tankship

Quantity Spilled (barrels)	18	5300
Slick area (m^2)	0.22×10^6	15.6×10^6
Slick radius (m)	469	2232

Freeport Harbor and its Entrance Channel are surrounded by firm banks or levies. Hence spills of oil would be confined to the waterways. Since winds are predominatly from the south through to the east, oil slicks would tend to move further into the harbor channel or westerly along the Intracoastal Waterway which intersects the channel about 3/4 of a mile inland from the Gulf. However, during times of a strong ebbing tide, part of the slick might be carried outside of the entrance jetty. Slicks from spills outside the jetty would be carried onto the beach, south of Freeport, by the strong westerly currents in the area.

Risk of Spills from Vessel Casualties

The estimation of the frequency of shipping accidents and spills of oil was based on the number of reported accidents to tankships and tankbarges compared with the number of trips these vessels made into U.S. ports along the Gulf Coast (Brownsville, Texas to Key West, Florida). The accident data was obtained from the U.S. Coast Guard Commercial Vessel Casualty Reporting System in which pertinent items of information have been recorded on magnetic tape. The data for the Gulf Coast area are summarized in Tables 3.13 and 3.14 for tank ships and tank barges respectively.

Only casualties which resulted in loss of cargo, i.e., rupture of at least one of the cargo tanks, were counted in the estimate of spill frequency. From the tables, only 1.4 percent of the reported tank ship casualties and 3.9 percent of the reported tank barge casualties were sufficiently severe to result in a spill of the cargo.

This data base is believed to be accurate and complete. The reporting system has been in effect for over 10 years, and by law, all vessel casualties with more than $1,500 total damages must be reported. Casualties sufficiently severe to cause the loss of cargo invariably involve total damages much greater than $1,500.

For all U.S. ports along the Gulf Coast, there were a total of 9,830 inbound tank ship trips and 76,856 inbound barge trips during calendar year 1974.[29] For a 6 year period corresponding to FY 1969 through FY 1974, it was estimated that there were 60,000 tank ship trips into Gulf Coast harbor during which liquid cargo was carried. Similarly for tank barges, the estimated 6 year count was 460,000 trips. These estimates are believed to be correct to within at least a factor of 2. The reason for this is that the count of outbound ships and barges very nearly equals the inbound count and it is likely that many, if not most, carry a liquid cargo.

In estimating the frequency of vessel casualties with cargo loss, the category "collisions" in Tables 3.13 and 3.14 was excluded from the accident count. According to the Captain of the Port (U.S. Goast Guard) for the area, the traffic in the entrance to Freeport Harbor is one way because it is so narrow (200 to 300 feet). Vessels traversing the channel in one direction must complete their

Table 3.13. Tankship Accidents In Inland Gulf Waters During Fiscal Years 1969-1974

Cause	Number of Vessel Casualties	Number of Vessel Casualties with Cargo Loss
Collisions (with other vessels)	81	1
Rammings (collisions with fixed, floating and submerged objects)	75	1
Groundings	14	1
Fires and Explosions	3	0
Structual Failures	24	0
Other (flounderings, capsizing, flooding, undetermined)	11	0
Total	208	3
Total (less collisions)	127	2

Table 3.14. Tank Barge Accidents In Inland Gulf Waters During Fiscal Years 1969-1974

Cause	Number of Vessel Casualties	Number of Vessel Casualties with Cargo Loss
Collisions (with other vessels)	712	25
Rammings (collisions with fixed, floating and submerged objects)	383	9
Groundings	122	8
Fires and Explosions	19	0
Structual Failures	25	4
Other (flounderings, capsizing, flooding, undetermined)	35	4
Total	1,296	50
Total (less collisions)	584	25

passage before vessels can commence a passage in the opposite direction.[27]

Accordingly, the frequency of casualties of cargo loss for tank ships becomes:

$$\frac{2 \text{ (losses in 6 years)}}{60{,}000 \text{ (transits in 6 years)}} = 3.3\times10^{-5} \text{ spills/transit.}$$

For tank barges, the same estimate becomes:

$$\frac{25 \text{ (losses in 6 years)}}{460{,}000 \text{ (transits in 6 years)}} = 5.4\times10^{-5} \text{ spills/transit.}$$

It should be noted that these frequencies of spills are an average for the entire inland Gulf Coast area. On the other hand, for Freeport Harbor and its entrance, there have been no spills from tank ship casualties during the 6 year period.

The Coast Guard Vessel Casualty data reports the dollar value of the cargo loss. These data for tank barge casualties in both the Gulf Coast region and on Western Rivers (mainly the Mississippi-Ohio River system) have been plotted in Figure 3.5. The cost of the material spilled in each incident is distributed log normally with the number of spills. The cumulative distribution curve in Figure 3.5 should be interpreted for any given percent of all spills as having cargo value equal to or less than the indicated value. Most of the spilled cargos consisted of crude oil and petroleum fuels, and at the time most of the spills occurred, it is assumed that the average value of these materials was $3.00 per barrel. Using this value, the data in Figure 3.5 were converted to a frequency distribution of quantity spill as shown in Figure 3.6. The curve in Figure 3.6 begins to bend over at spill quantities of 8,000 to 10,000 barrels and this reflects the fact that the capacity of many barges is between 10,000 to 20,000 barrels.

The median quantity spilled is approximately 1,100 barrels. From Table 3.15, the most common tank barge sizes are 1,500 2,750, and 3,000 tons. These barges will hold 15,000 to 21,000 barrels of oil in 6 tanks of 2,500 to 3,500 barrel capacity each. Hence the median spill represents approximately 1/3 the capacity of a typical barge cargo tank. The reasons only a fraction of the contents of a cargo tank is spilled are that the damage in a casualty is such that all the cargo cannot leak out, and that the outflows often are sufficiently slow to permit taking measures, such as transfer of the cargo to another vessel or tank, to limit the amount lost.

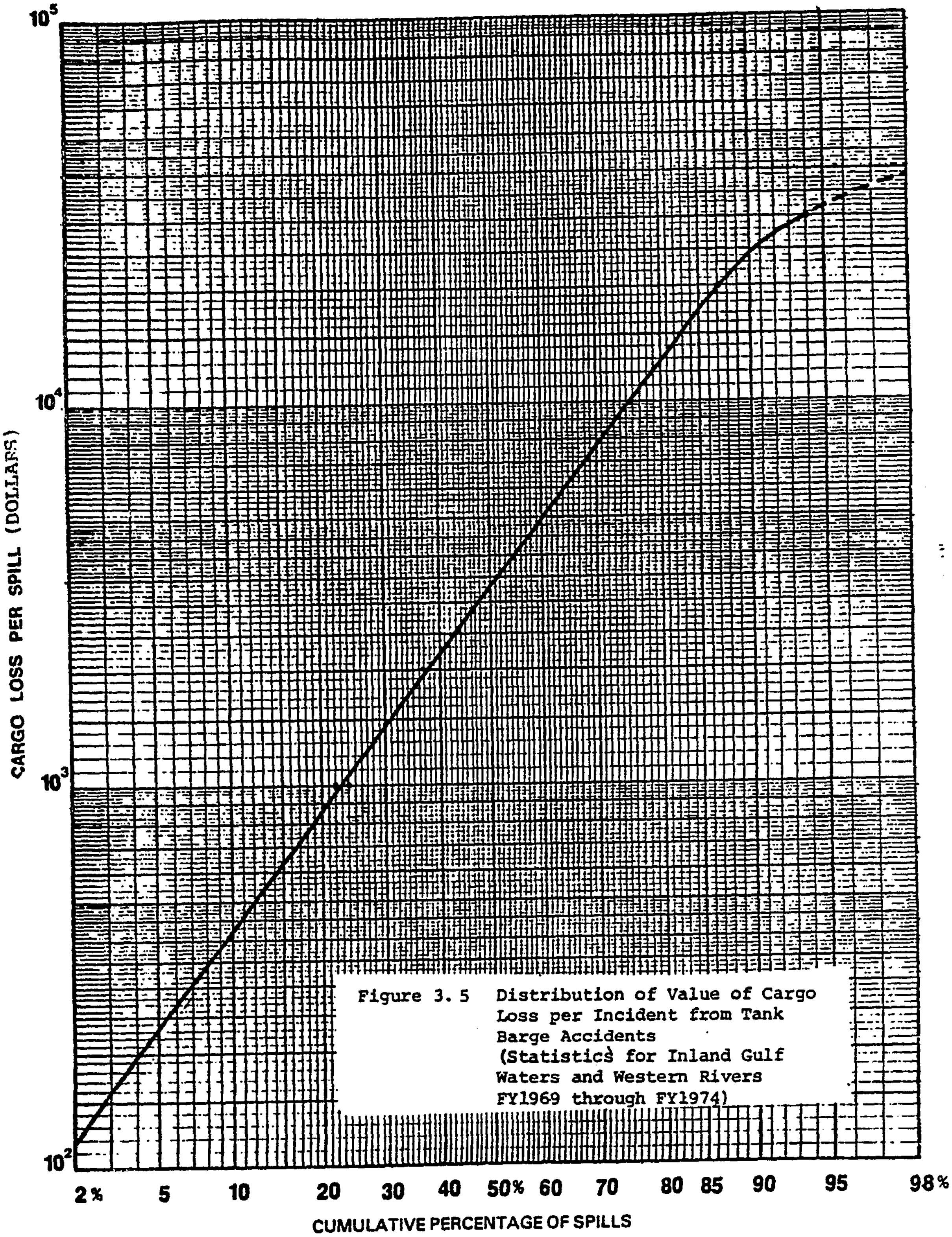


Figure 3.5 Distribution of Value of Cargo Loss per Incident from Tank Barge Accidents (Statistics for Inland Gulf Waters and Western Rivers FY1969 through FY1974)

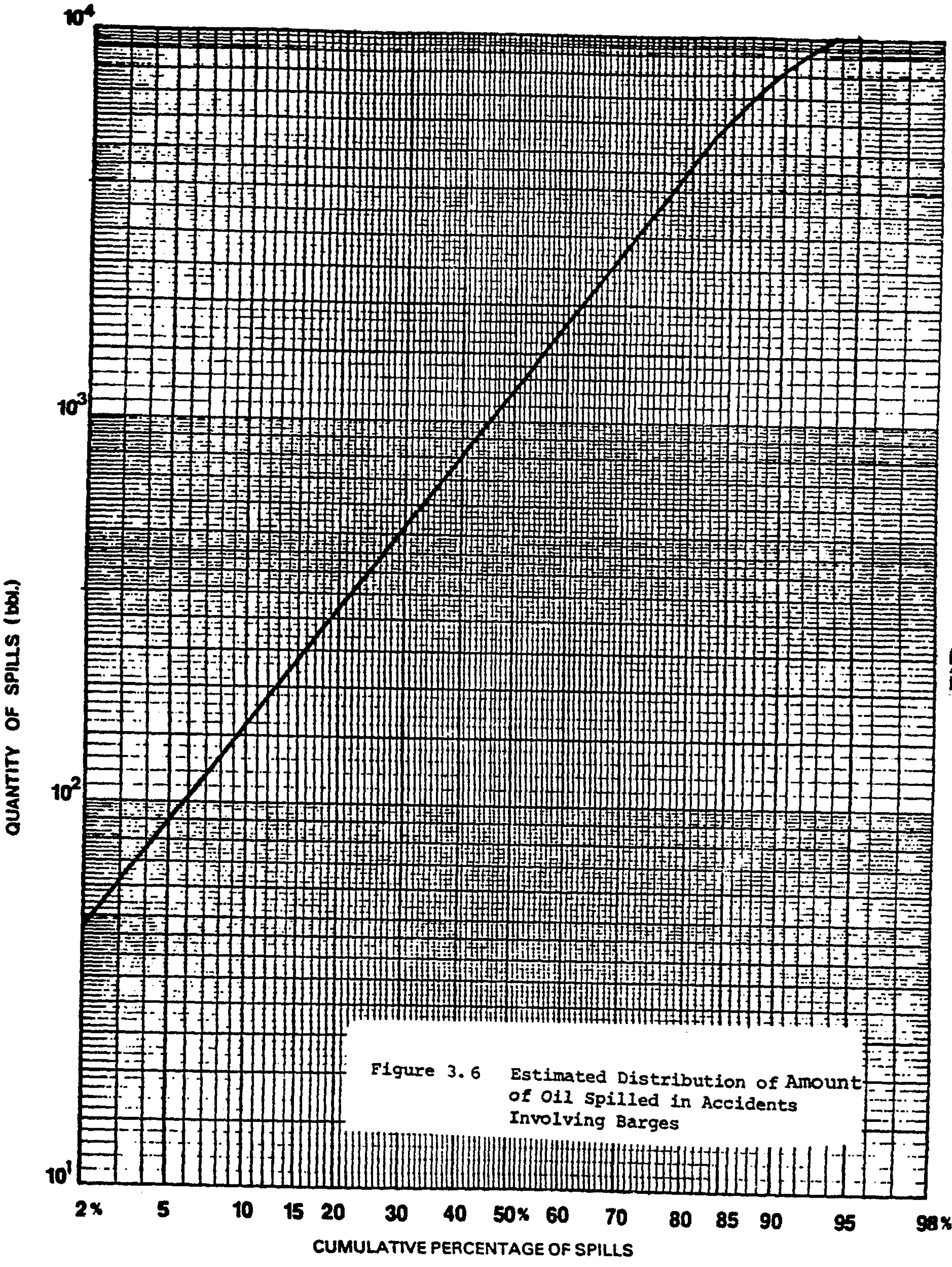


Figure 3.6 Estimated Distribution of Amount of Oil Spilled in Accidents Involving Barges

Table 3.15. Barge Size Distribution, Tank

Representative Barge Size (Dimensions in ft)	Draft Empty (ft)	Draft Loaded (ft)	Nominal Tons/Barge	Number of Barges
508 x 90	4.0	34.0	32425	1
340 x 54	2.5	11.0	4680	13
290 x 53	1.5	11.0	3000	520
240 x 50	2.0	9.0	2750	427
185 x 54	1.5	9.6	2100	154
220 x 40	1.5	9.0	2000	65
148 x 54	1.5	9.0	2000	99
195 x 35	1.5	9.0	1500	662
180 x 35	1.5	9.0	1300	105
135 x 40	1.5	6.0	1000	276
215 x 25	1.5	9.0	1200	3
175 x 26	2.0	9.0	1000	38
140 x 26	1.0	6.0	626	91
110 x 30	1.5	6.0	345	191

(Source: U.S. Army Corps of Engineers Waterborne Commerce Statistics Center, Transportation Lines on the Mississippi River System and the Gulf Intracoastal Waterway 1974 (Transportation Series 4)).

The barge spill distribution curve was modified to estimate the spill size distribution for tankship casualties. For reasons suggested above, it was assumed that the loss of 1/3 the volume of a single tank would be equivalent to the median spill from a tankship casualty. In addition, the slope of the tankship spill distribution (i.e. the variance) was assumed to be the same as for tankbarges. Table 3.16 shows the approximate characteristics of the tankship (32,000 DWT) to be used. It was estimated that a wing tank on this size vessel would contain 15,900 barrels, and that the median spill would be 1/3 of this or 5,300 barrels. Assuming the same slope as for the tank barge spill distribution, the spill size distribution for tankships, shown in Figure 3.7 is obtained.

Figure 3.7 also indicates the reasonableness of this estimated distribution. The distribution of spill sizes from all tankship casualties in U.S. inland coastal waters during fiscal years 1969 through 1974 is shown by the points plotted. These lie below the estimated curve for a 32,000 DWT tankship as expected since the casualties include a large number of smaller tankships. The available data indicate that the prediction gives a conservative estimate (tend to over-estimate the consequences).

Estimates of the expected spill size frequency from tank ship and barge casualties are presented in Tables 3.17 and 3.18, respectively. The per trip frequencies are simply the product of the spill frequency and the fraction of spills in the given size range from Figures 3.6 and 3.7. These data were used to help derive the estimates presented in Table 3.12 and Figure 3.4 discussed above. The expectation quantity of crude oil spilled is the sum of the products of frequency and quantity spilled (average of the ranges in Table 3.17) for all spill sizes.

Spills at the Marine Terminal

Spill frequency and size during operations at the tank ship terminal were estimated in a manner similar to that used for vessel casualties. A count was made of the total number of spills and quantity spilled at marine terminals during a single year, 1974. Next, an estimate was made for the total number of barges and tankships loaded or unloaded at these terminals. Spill frequency was obtained simply from the quotient of number of incidents and the number of loading and offloading operations. A spill size distribution was estimated by adjusting the distribution in Figure 3.6 such that the median equalled the size of the average spill. Data on the individual incidents were not examined and the actual size distribution could not be developed.

Table 3.16

Characteristics of Tankships

	60,000 DWT[a]	32,000 DWT[b]
Length Overall, feet	731	666
Beam, feet	105	84
Draft, feet	43	35
Gross Tonnage	32,000	-
Net Tonnage	23,000	-
Number of Wing Tanks	8	8[c]
Approximate Capacity of the Wing Tanks, bbls	27,500	15,900[c]
Number of Center Tanks	5	5[c]
Approximate Capacity of the Center Tanks, bbls	46,000	26,600[c]
Total Cargo Capacity, bbls	440,000	254,000

---

a "Offshore Petroleum Transfer Systems for Washington State," Oceanographic Institute of Washington, December 16, 1974, p. III-54.

b Maritime Administration, Office of Port and Intermodal Development, Report No. 1 on Support Task No. 6 for Strategic Petroleum Reserve Program, FEA, Draft, April 13, 1976.

c Estimated.

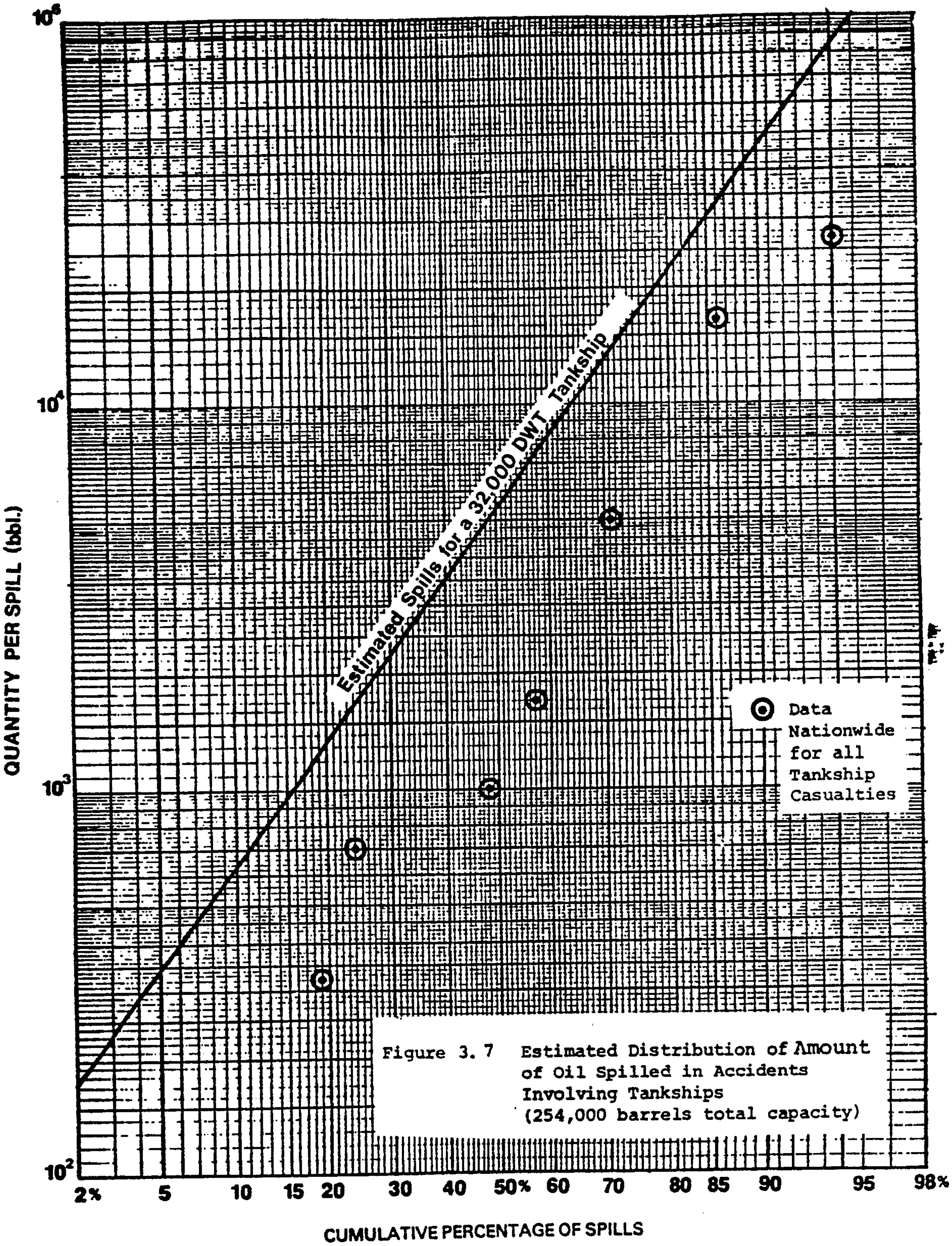


Figure 3. 7 Estimated Distribution of Amount of Oil Spilled in Accidents Involving Tankships (254,000 barrels total capacity)

Table 3.17

Estimated Spill Size Frequency
From Tankship Accidents
(Permanent Fill and Distribution System)

Spill Size (BBLS)	Frequency (Per Tankship Trip)	Frequency per Transport of 58 x10[6] BBLS[a]
<300	$1.45x10^{-6}$	$3.31x10^{-4}$
300-1,000	$3.83x10^{-6}$	$8.73x10^{-4}$
1,000-3,000	$6.77x10^{-6}$	$1.54x10^{-3}$
3,000-10,000	$9.41x10^{-6}$	$2.15x10^{-3}$
10,000-30,000	$6.60x10^{-6}$	$1.50x10^{-3}$
30,000-100,000	$3.63x10^{-6}$	$8.28x10^{-4}$
>100,000[b]	$1.32x10^{-6}$	$3.01x10^{-4}$

a 228 Trips
b Maximum quantity spilled is 254,000 bbls, the capacity of the tankship.

Table 3.18

Estimated Spill Size Frequency From Barge Accidents (Intermediate Fill System)

Spill Size (BBLS)	Frequency (Per Barge Trip)	Frequency per Transport of $58x10^6$ BBLS[a]
<100	$3.83x10^{-6}$	0.011
100-300	$7.61x10^{-6}$	0.021
300-1000	$1.41x10^{-5}$	0.039
1000-3000	$1.34x10^{-5}$	0.037
3000-10,000	$1.16x10^{-5}$	0.032
>10,000[b]	$3.62x10^{-6}$	0.010

a 2762 Barge Trips
b The maximum quantity spilled is 21,000 bbls, the capacity of the barge.

The data base for the number of spill incidents was the U.S. Coast Guard's Pollution Incident Reporting System (PIRS)[25] Data for the year 1974 are reported in summary form by the Coast Guard. The number of spills and the total amount spilled in the entire United States at marine terminals from the shore facility and from tankship and tank barges at the terminal have been accumulated and broken down by type of cause. These are reproduced in Table 3.19. It is not clear from this source if all these spills were associated with loading and unloading operations. However, from the nature of the causes listed, they could have been. The assumption made here is that they were. This is conservative in the sense that the number of spill incidents associated with loading and offloading may be overestimated. In this vein, a question arises concerning the completeness of the data. The requirements according to law are that all spills of polluting substances must be reported.[30] U. S. Coast Guard personnel feel that all of the larger spills eventually are reported. Therefore, the data base is deemed to be adequate.

The manner in which the number of loading and offloading operations were counted also tends to overestimate the frequency of spills. During recent years, there have been approximately 33,000 tank ship trips into all U.S. ports annually.[31] Tank barge trips into U.S. ports during 1974 were approximately 126,000 trips.[29] Also, during 1974, there were 34,000 east bound tank barge trips along the Intracoastal Waterway.[29] It is assumed that for each inbound trip into a port, a tank ship or tank barge makes at least one stop to load or offload a bulk liquid cargo. On the Intracoastal Waterway,, the assumption is made that the number of trips in one direction (only) corresponds to at least 2 loading/offloading operations (one at the origin and one at the destination). This adds to a total of 227,000 loading and offloading operations. Not included in this count is the appreciable tank barge traffic along the Mississippi River system. Therefore, a total of 2.3×10^5 loadings and unloadings of bulk liquid cargo are assumed to occur annually at marine terminals in the United States. Because of the count of operations left out, it is believed that the value 2.3×10^5 may be low by a factor of 2.

Table 3.19

Spills Loading and Offloading Bulk Cargo At a Marine Terminal

Cause	Shore Facility: Number of Incidents	Shore Facility: Total Barrels Spilled	Tankships and Tank Barges: Number of Incidents	Tankships and Tank Barges: Total Barrels Spilled
Tank Ruptures, Leaks	7	477	-	-
Pipe and Hose Ruptures and Leaks	82	921	117	296
Valve Failure	21	191	120	722
Pump Failures	9	1,742	18	19
Other Leaks and Equipment Failure	81	250	182	957
Tank Overflow	30	24,179	366	2,916
Personnel Errors	85	2,340	278	1,994
Intentional Discharges Including Bilge Pumping	6	73	112	1,016
Natural or Chronic Phenomenon	22	420	4	0
Unknown	21	28	116	7,647
Total	364	30,621	1,313	15,567
Average Spill	84 bbls/spill		12 bbls/spill	

Table 3.20

Estimated Spill Size Frequency From Accidents During Loading or Offloading at the Dock

Spill Size (BBLS)	Frequency (Per Operation)	Frequency per Transport of $58x10^6$ BBLS By Tankships[a]
<3	$1.15x10^{-3}$	0.26
3-10	$1.16x10^{-3}$	0.26
10-30	$1.74x10^{-3}$	0.40
30-100	$1.51x10^{-3}$	0.34
100-300	$7.99x10^{-4}$	0.18
300-1,000	$3.69x10^{-4}$	0.08
>1,000	$1.28x10^{-4}$	0.03

a 228 Tankship Trips

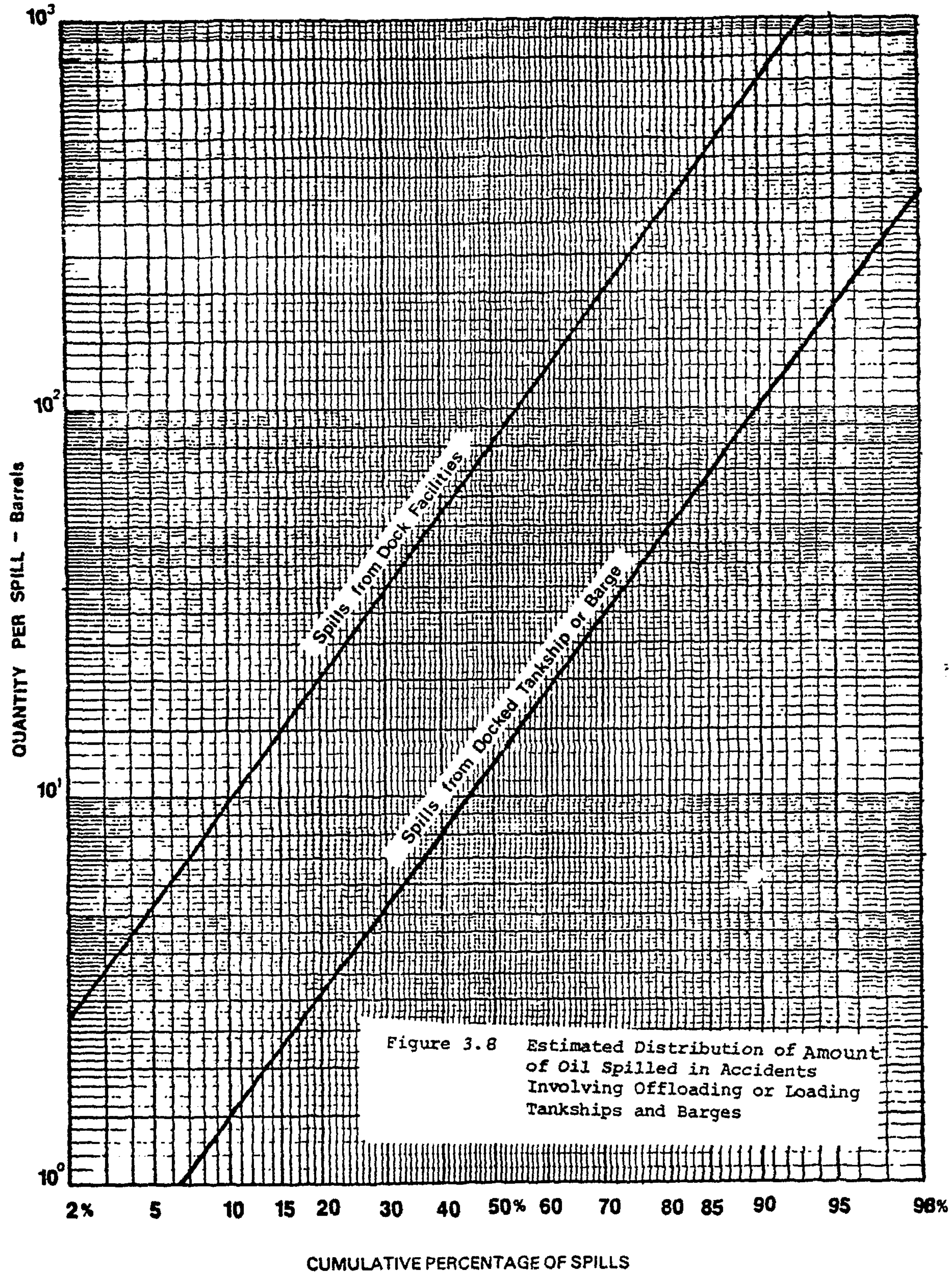


Figure 3.8 Estimated Distribution of Amount of Oil Spilled in Accidents Involving Offloading or Loading Tankships and Barges

Combining this value with the number of spill incidents listed in Table 3.19. the following spill frequencies are obtained:

$$\frac{364}{2.3\times10^{5}} = 1.58\times10^{-3} \text{ spills/trip}$$

from the terminal itself, and

$$\frac{1313}{2.3\times10^{5}} = 5.71\times10^{-3} \text{ spills/trip}$$

from the tankship or barge during loadings and offloadings at the marine terminal.

The estimated log normal distributions of the quantity of oil spilled are shown in Figure 3.8. As before, these were derived from the distribution in Figure 3.6 using the average spill sizes listed in Table 3.19 as the median values.* Finally, the frequency of spills in a given size range was calculated as the product of the spill frequency and the percent of spills in the size range. These are listed in Table 3.20 and were used to help construct Figure 3.4 discussed above. The data listed in Table 3.20 also were used to calculate the median spill size and expected spill quantities listed in Table 3.12 above.

*This tends to overestimate the size of the spills in the distribution since the median value in a log normal distribution is always less than the average value.

Ecological Impact of Oil Spills

The potential biological damage from oil spills in the dock area or between the terminal and the storage cavities in the salt dome is slight. Most of the pipeline between the dock and dome is confined in an entrapment basin formed by storm levees and higher ground. The lower part of the basin is a highly disturbed marsh without natural outlets. It is routinely drained by pumping. Some points on the dome are contaminated with sulfur. Vegetation in these places is stunted. Small oil spills in this area which did not contaminate the marsh water could be disregarded, with natural degradation allowed to take its course. Cleanup would be required with larger spills or if the water were contaminated. Proven cleanup services are readily available in the area. The only complication might be spills which occurred when there was any overflow, as during storms.

The channel to the dock area and other water channels nearby have a greatly impoverished biota because of the continuing disturbance from shipping and other water traffic and the maintenance of channel dimensions by dredging. Pesticides, fertilizers, industrial chemicals, and sewage effluents may also have an influence even though the harbor is now bypassed by the main flow of the Brazos. A poor water circulation pattern in the area Intracoastal Waterway has been associated with low dissolved oxygen and low organism abundance.[21] Examination of the grease and oil levels given in the appendices shows a range in the area in sediments up to the threshold of polluted conditions (1,500 ppm). Levels are generally considerably greater than for natural hydrocarbon levels (26 to 130 ppm).[32]

A spill into water at the tanker terminal could be rapidly and effectively cleaned up in view of the availability of cleanup services. However damage would occur before containment and removal. Impact of a large spill in the confined area of the harbor would be great, but would affect only this small area. A median spill of 5,300 barrels would spread to cover approximately 3,759 acres of water surface in 24 to 48 hours after the spill under idealized conditions of no wind, currents, or surface obstacles. The lock gates on the Intracoastal Waterway would limit spread to the southwest, keeping oil out of the new channel of the Brazos River.

Offshore spills or spillage from the pipeline to the Seaway Tank Farm would have impacts on more diverse and productive communities than those of the harbor and dome. Marsh and

coastal prairie are the environmental types through which the pipeline would pass. Ocean spills could have an impact on beach areas near the dome as well as on marshland up and down the coast. The marshes and associated bodies of water could be affected from either the coast or inland side.

Communities in the salt dome and dock area include some organisms of the marsh and coastal prairie biotopes upon which the pipeline to the Seaway Tank Farm would intrude. However, many species are missing and some may be prominent which otherwise would not be, simply as a consequence of the highly disturbed conditions. Some species characteristic of disturbed locations may even be present. Additional disturbances of a limited magnitude may actually tend to perpetuate these communities.

Containment and cleanup operations under the U. S. Coast Guard Sixth Regional Oil and Hazardous Substances Contingency Plan would prevent most oil from major spills some distance out to sea from reaching land. However, all oil would not be removed and background levels in the Gulf of Mexico would be increased. Oil levels in Texas coastal waters have been associated with harm to biota. An increase in these levels would exacerbate the detriment. Average effects of chronic pollution on plankton species diversity have been indicated by field studies in the Galveston Bay area although the data were not conclusive.[33] Shallow water ecosystems of the Texas coast which receive oily wastes show reduced species diversity and community metabolism (photosynthesis and respiration). In such ecosystems, there commonly are large diurnal fluctuations in dissolved oxygen concentration and sometimes approach near-anaerobic reducing conditions at the bottom.

Dispersal of oil spilled in the open ocean is difficult to assess. The circulation of the inner Texas continental shelf is indicated to be primarily wind driven but also affected by substantial tidal motions.[52] A computer evaluation by Texas A&M Research Foundation of the trajectories of hypothetical daily major oil spills over a two-year period based on normal wind and current conditions and from 31 miles out to sea from the Freeport vicinity indicated that landfalls would generally occur between Port Arthur and Corpus Christi. Probabilities were very small for the oil contacting land outside this section of coast. The majority of predictions were for landfalls between Galveston and Arkansas Pass.[39]

The Texas shoreline from Galveston to Freeport and in the Corpus Christi area is highly developed and extensively used for recreational purposes but the rest of the coastline is sparsely populated.[39] There are a number of coastal wildlife refugres. The barrier island system along the Texas coast interfers with the introduction of oil from the gulf proper into estuarine systems.[39]

A potential may exist for very long-range dispersal. Disseminules are known to have moved to Gulf of Mexico beaches from other parts of the U. S. Coast, Mexico, the Carribean region, Central America and northeastern South America.[54] Oil has been estimated to have been afloat in the Gulf as chunks or pieces for as long as 4 or 5 months. This may be attributable to eddy systems which retain them.[55]

The persistence of oil in water, sediments and on beaches is not well quantified but may involve periods extending for years. Subsurface water supplies would not be appreciably affected by spills in surface water.

Aquatic Impacts

The impact of releases into water is primarily dependent on: (1) the amount and type of oil released, (2) the time of year, (3) how long the oil "weathers", (4) the number and frequency of spillages, and (5) the type and efficiency of cleanup operations. These concerns also apply to releases on land except that consideration of spill "weathering" is inappropriate. A large potential for introduction of oil into water from land is frequently present. Oil at the land surface is subject to transport by runoff. The oil may infiltrate to the level of ground water. From there it may seep into surface bodies of water. Oil also moves to land from water as deposits on shores or beaches or, in cases of floods, various projecting landscape features.

Oil spilled in water would come into almost immediate contact with aquatic communities. The oil would be affected after release and/or during transport by separating processes of evaporation, dissolution, emulsification, sedimentation, and chemical oxidation, as well as biological degradation. There would be differential effects of surface tension forces on different components. The lighter, more toxic oil components are lost by evaporation. This creates a surface residue which may become heavy enough to sink. Particles in suspension (silt, clay, organic material) may combine with the oil so that sedimentation is increased. Conditions of increased turbidity, such as during periods of high surface water runoff or water turbulance, would increase this effect. Bacterial masses in a slick can increase sedimentation also.[33] Emulsification, perhaps aided by human addition of surface active agents, may result in suspended globules which disperse.[32] Emulsification of water in the oil rather than oil in water can occur and tends to hold the oil mass together.[33] In wetlands, vegetation absorbs oil and is a barrier to its dispersal. A typical holding capacity is about 25 barrels per acre for 75 percent of the oil spilled.

Main groups or organisms which might be affected by oil spillage into water include plankters, nekton, benthos, macrophytes, periphyton, microbes, and aquatic birds and mammals. These groups, except for microbes, are described in Section 2.4.

Plankton, being able to move at relatively slow speeds if at all, would be unable to effectively avoid spill areas. Many zooplankters exhibit daily vertical migrations. Whether they would be deterred in this by oil at some level, most probably at the surface or bottom is not known. Organisms which are planktonic through their entire life cycle generally have a high level of reproduction within lifespans of short duration. They are able to rapidly replace losses. If they were not subjected to a continuing stress, there would be only short term effects. Field data do not conclusively demonstrate an effect. Fish eggs and larvae of many benthic organisms (including oysters, shrimp and crabs) are major components of the temporary zooplankton. These immature stages are often more susceptible to toxic materials. Oil may be ingested by some zooplankton and constituents or it may be transferred to higher levels in food chains. There is little evidence for concentration of the constituents at these higher levels. At dissolved oil levels likely to occur near a heavy spill or an area of chronic pollution, physiological effects have been documented for phytoplankton. Photosynthesis was accelerated at lower concentrations (10 to 30 ppb) and diminished at higher ones (60 to 200 ppb).[33] Organisms associated with the water surface, the neuston, would presumably be subject to toxic or mechanical effects from contact with fresh oil slicks. Under laboratory conditions involving oil suspensions, droplets of oil have been noted to adhere to spines of marine phyto- and zooplankton, especially after contact with the surface film.[34]

Fish, alligators and other larger underwater swimming animals (nekton) should be able to avoid spills. There is evidence suggesting avoidance behavior.[33] Kills have generally only occurred in restricted bodies of water and probably are attributable to direct toxic effects, lowered oxygen by restriction of diffusion from the atmosphere or increased biochemical oxygen demand, or a combination of these. Oil products have been shown to be quite toxic in the laboratory. Fishes may be more resistant than many organisms because the mucus with which their exterior body surfaces are coated is oil repellant.[33] Microscopic studies on gills of fish collected after exposure to oil spilled off the Louisiana coast showed effects of the exposure including loss of cells, "sloughing", and swollen branchial filaments. These responses were attributed to direct toxicity of hydrocarbon fractions within the water column.[35] Toxic effects of aged crude may be greater than for fresh crude.[36]

Fish may be contaminated by intake of petroleum hydrocarbons in food. This may be associated with tainting, which may persist for several months.[33] Lack of sufficient cleanup after a release near the dome would result in a loss of use of fish as food due to the persistance of hydrocarbons in fish flesh. General physiologic effects of oil uptake which influence fish production have not been demonstrated but are thought to exist.

Benthic organisms would be affected mainly by covering over from sedimentation. Reduction in oxygen levels could also be important. Bottom organisms would be susceptible to smothering or to alteration of substrate characteristics. The substrate may be altered so that its former functions as an attachment surface, a food source, or source of cover may no longer be available. Contaminated bottom sediments can act as sources of occasional or continuing recontamination of the water above. Effects would of course depend on the area covered, thickness and composition of sedimented oil, and how long the oil is present. In cases of large-scale marine-spill oil settling, kills have been extremely large, with almost complete elimination of animal life.[33] Effects have been noted to persist for many years under these circumstances. Organisms are not equally successful at recolonizing polluted areas and several years may be required to reattain pre-impact levels of diversity and community structure. Bottom organisms can accumulate petroleum hydrocarbons in their tissues after ingestion.[33] Degradation of settled oil would result in a change in its composition. Longer persistance may be expected of some of the more toxic components, resulting in longer term harmful effects.

Aquatic macrophytes are the dominant organisms in the marsh areas. Oils can penetrate into plants either through stomates or directly through the epidermis. Oil can interfere with transpiration and translocation of materials, by traveling within intercellular spaces, blocking them and stomata.[33] Oil may also travel in the vascular-system.[37] Rates of cellular respiration may be increased or decreased. Photosynthesis can be inhibited. Cell membranes may be substantially damaged by contact with oil hydrocarbons, resulting in leakage of cell sap into intercellular spaces and admitting oil components into the cell.[37]

One time coatings of marsh plants by small to intermediate quantities of oil are not exceedingly harmful, but repeated oil releases are lethal. One-time exposures have resulted in death of heavily coated shoots with regrowth from living roots. Very heavy oil contamination may smother the entire plant. Damage varies with the season. Active growth processes are adversely affected. Annuals tend to be more affected if coated during active growth periods since perennials may regenerate from their roots. Oil may also influence such growth functions as flowering, seed development, and vegetative reproduction by underground roots. Growth stimulation following oil contamination has been reported by several investigators. It has been hypothesized that this might be a consequence of an increased level of nutrients, a "fertilizing effect."[33]

Periphyton communities are very substrate dependent as is true with benthic communities. Since organisms of such communities tend to be small, an oil coating would probably have a very great impact, obliterating most of the community where present. Many of the periphytic organisms are related to plankton. They share with them great potential for increasing numbers in a short period and probably have similar sensitivities to dissolved oil fractions. After the oil is degraded or otherwise removed, they should recolonize suitable surfaces relatively rapidly.

Effects of oil on micro-organisms (bacteria, some fungi and yeasts) are not well described.[38] However, micro-organisms are generally conceded to contribute to oil degradation. The question has been raised whether significant microbial growth on oil might require minimal levels of nitrogen and/or phosphorus availability in the general aquatic medium. In a system with a high detrital component in a warm climate, such as the marsh ecosystem, it appears that conditions would be good for biological degradation.

Birds and mammals are subject to loss of insulating capacity if their feathers or fur come into direct contact with an oil mass. In the case of swimming birds, buoyancy is lost. An affected bird may drown, rapidly lose body heat and starve because of the increased metabolic rate required to sustain heat production, succumb to pneumonia, or be poisoned by ingesting oil during excessive preening. Birds which have come into contact with oil may be diverted from feeding by the excessive preening behavior. Outright poisoning may not result from ingesting the oil, but other physiological disturbances may occur. Oil-exposed birds may not lay eggs, or eggs that they do lay may not hatch. Survival after oil gets on the feathers is very low. Even with birds treated to remove the oil, survival generally has not exceeded 20 percent.[33] Mammals frequenting water such as muskrats, mink, and others are not recorded for the general coastal area around Bryan Mound.[39] Birds, including winter populations of geese and ducks, are very abundant, and a habitat with oil in it is not suitable for them.

Terrestrial Impacts: Oil impacts on land could result from pipeline spills. Levels of impact would depend on the amounts of oil released, biological richness and physical characteristics of the affected area, and times of year when the releases occurred.

Effects on plants and soil animals (springtails, mites, nematodes, earthworms, etc.) can be expected to be severe but very localized in the immediate area of the leakages. If roots of plants are coated or restricted in oxygen availability or water uptake, the plants will soon die. Other organisms in soil -- bacteria, fungi, algae -- probably would not be uniformly affected. Under conditions of good aeration and nitrogen and phosphate availability, there probably would be proliferation of soil microorganisms which could degrade the oil. Indeed, a current method for disposal of oily wastes is spreading them out and plowing them under so that bacterial degradation is facilitated.[40]

With a median spill size of 1,000 barrels and an initial infiltration into the ground to a depth of 1 decimeter about 1,600 meters square or approximately 0.4 acres would be immediately affected. The exact coverage depends on soil types, viscosity of oil, pipeline pressure, soil moisture, and other factors. In a spill of this size oil would probably reach the water table. Slow discharge into nearby bodies of water via water table transport could occur. The spill could be a source of low level contamination for an indefinite period which might exceed several years. Releases into navigable bodies of water can be prevented by a trench dug near the point of entry into such a water body. When oil collects in the trench (generally after rains), it can be pumped off.

Effects of Cleanup Operations: Containment and cleanup operations of oil spills into the harbor from tankers and at dock facilities and spills from oil pipeline ruptures are the overall responsibility of the polluter. The U. S. Coast Guard must be notified whenever a spill occurs and an On-scene Coordinator oversees cleanup operations and takes whatever steps necessary to assure appropriate cleanup procedures are implemented. Biological effects of cleanup operations are minimal. Emulsifiers and other chemical agents have been virtually discontinued and the requirements that use of such agents must be Coast Guard approved on the scene[41] suggests that cleanup operations would not adversely impact the environment. Mechanical removal procedures (booming, skimming and pumping) can be expected to ameliorate the potentially harmful effects of an oil spill and should not be a source of negative biological impact.

Cleanup operations in marshes, prairie, and on beaches could involve removal of damaged vegetation and dead animals. Oil might be removed from beaches by scraping off the oily sand and disposing of it or removing the oil in separators. Burial can have an impact on the specific site used to dispose of such material. It is assumed that chemical cleansing agents would not be used in these situations.

3.7.3 Fires and Explosion on Site

An analysis of the available fire and explosion data associated with petroleum production, storage, and transportation (for example, USGS data) indicates that almost all major fires and explosions are in conjunction with high pressure situations or blowouts.[42] Only during the core hole drilling phase does this danger exist in the program, and even during this phase, it is only a remote possibility. The more probable occurrence is that of minor fires caused during repairs or maintenance, or caused by overheated engines or leaks onto hot surfaces.

The impact on the environment of such fires would generally be a temporary release of smoke to the atmosphere. It is unlikely that any crude or brine spill into the environment would occur because of the protective measures such as levees. Even in conjunction with OCS production, where the risk of environmental release is greater, from 1968 to 1975 only two fires or explosions not associated with blowouts or high pressure operations resulted in oil spills (one of 100 barrels and one less than a barrel). Although it is rare for crude spills to catch fire, if a 100 barrel spill did, the following emissions would occur: CO_2 - 34,000-34,700 pounds; SO_2 - 62-3,400 lbs (SO_2 emissions vary depending on emitted H2S concentrations); and NO_x- 66-1,000 pounds.[43]

Actually, since combustion is incomplete, certain quantities of petroleum would vaporize, and carbon particulates, carbon monoxide, nitrous oxide, and sulfur monoxide would be formed. The weather conditions at the time of the accident would influence the exact amounts. This would degrade the air quality for a short time.

3.7.4 Accidental Injury

In incidents recorded by USGS from 1968 through 1975, a total of 15 people were killed (9 in a single explosion) and 42 injured in some 20 injury or fatality causing OCS accidents that did not entail high pressure or blowout circumstances.[42] Ship specific incidents are not included. Again, offshore operations are more dangerous because the compact work area on a platform causes activities to be performed near one another that from a safety standpoint should not be. Considering these factors and the number of OCS operations during the 8 years of recorded data, the probability of accidental injury or death appears to be minimal with respect to the SPR Program at this salt dome site.

3.7.5 Natural Disasters

Natural disasters that may cause a problem in conjunction with this project include hurricanes, tornadoes, high winds, lightning, and floods. A major hurricane passes through this area about every 4 years.[44] Winds at the site may exceed 125 miles per hour during hurricanes. Heavy rainfall and local or regional flooding are aggravating factors. Tornadoes often accompany hurricanes.[45]

In event of a severe storm, the probability is high that power supply lines might be affected and the various buildings or water supply and discharge lines might be damaged. All pipelines are buried, however, and the oil in underground storage cavities would be safe. Wellheads could be damaged which might cause some loss of crude.

The storage integrity of the facility would not be threatened by a hurricane. Sufficient warning is always available so that oil transfer would be stopped and surge tanks filled for maximum strength. Oil pipelines are buried. The largest potential oil spill would be caused by a wellhead rupture that could release about 100 barrels. This oil would be widely dispersed by the high winds and rain.

Tornadoes which are not associated with hurricanes could be more hazardous because of the surprise factor. It is possible that such a tornado could strike one of the large oil surge tanks near the dock and cause a major oil loss during oil transfer operations. The risk of such an event could be given a conservative upper bound as follows.

Tornado frequency in this area is about 3 tornadoes per 10,000 square miles per year.[46,47] Assume that all of

these events are unexpected so that oil surge tanks are not filled in advance. Thom[46] computed a mean ground track area of 2.8 miles^2 per tornado. Howe[48] has recomputed ground track area by state and region and has estimated 0.94 miles^2 per tornado in Texas. The probability, p, of a point in Texas being struck by a tornado in one year is:

$$p = 3 \text{ tornadoes/yr} \cdot 0.94 \text{ mi}^2\text{/tornado/10,000 mi}^2$$

or

$$p = 2.82 \cdot 10^{-4} \text{ per year.}$$

Over the projected 25 year facility life, the probability of exposure to a tornado is 0.0071.

In the event a tornado should strike the surge tanks, these floating roof tanks are designed to withstand 100 miles per straight winds when empty. A special strong wind design against 125 miles per hour winds is available. Both designs are much stronger when filled. Operators try to fill the tanks to at least 15 feet when a hurricane threatens.[49]

The Explorer Pipelines Glenpool Tank Farm in Oklahoma is believed to have been struck 3 times by tornadoes.[50] Four tanks which were empty buckled. No oil residue escaped. However, it is possible that a large tornado could buckle a full tank, or that tornado winds up to 300 miles per hour could cause missiles such as rocks or trees to penetrate the tank wall. Should a break occur, the oil would be trapped within the diked area except for that portion picked up and dispersed by the wind. The maximum quantity of oil which could be picked up by the tornado is unknown, but should not exceed the magnitude of spills due to pipeline breaks.

3.7.6 Cavity Collapse

The inherent characteristics of solution mined caverns make them one of the safest possible means for crude oil storage. The plastic nature of salt at the temperatures and pressures present permit the caverns to withstand shock forces far in excess of any earthquake known to have occurred in the Gulf Coast region. Although cavity collapses have occurred in this region, these collapses seem to have occurred as a result of factors such as uncontrolled leaching adjacent to the caprock, with subsequent subsidence of the unsupported overburden.[51]

A number of factors affect the stability of cavities in salt domes including: cavity depth, diameter, and temperature; dissolution; and proximity of the salt dome boundary or other cavities. These factors were considered in selecting the cavities proposed for development in the SPR Program. Further information concerning the configuration and stability of the Bryan Mound cavities can be found in Appendices G and H.

For existing cavities, the major factor is changes in proximity to salt dome boundaries or multiple cavities. Since cavities used for oil storage grow approximately 15 percent during each cycle of fill and withdrawal due to dissolution of salt, it may be necessary to control growth of the cavity in some cases. This may be accomplished in the upward direction by maintaining a blanket of oil near the cavity ceiling and may be controlled in all directions by using saturated brine rather than fresh water as the displacement fluid.

The proposed storage caverns use a blanket of crude oil to control growth in the upward directions, (see Figure 3.9). The location of the oil-brine interface may be monitored by any one of several available instruments such as sonic interface detection, nuclear logging, and oil column pressure gauging. One or more of these devices would be utilized to monitor the oil-brine interface. Thus the level of the oil-brine interface can be controlled to preclude upward leaching. However, as may be noted from Figure 3.9, the physical arrangement of the well casings prohibits withdrawal of oil above the location of the annulus through which the oil is withdrawn. Thus an oil blanket would always be present in any leached spaced above the location of the annulus. This provides a fail-safe design not subject to operator error. Casing cement failures at upper levels (for example the 16" @ 2500' in Figure 3.9) would be easily detected and repaired using standard techniques.

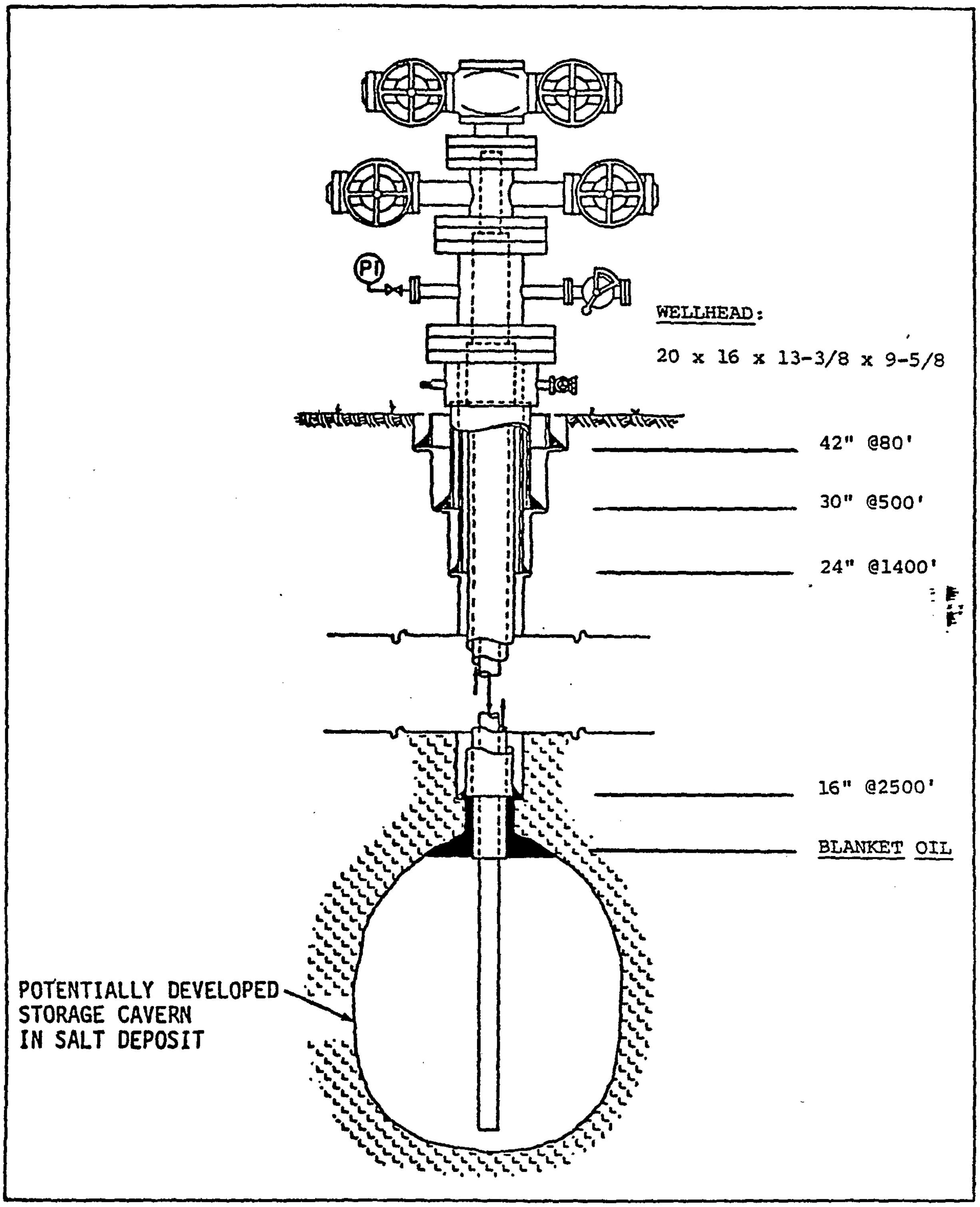


Fig. 3.9 Typical Storage Well

REFERENCES

1 R. K. Gabrysch and C. W. Bonnel, "Land Surface Subsidence in the Houston-Galveston Region, Texas," Texas Water Development Board, Report No. 188, 1975.

2 L. S. Slotta and K. J. Williamson, "Estuarine Impacts Related to Dredge Spoiling," Proceedings of the Sixth Dredging Seminar, Texas A & M University, Center for Dredging Studies Report No. eds-176:20-37, January 25, 1974.

3 H. L. Windom, "Environmental Aspects of Dredging in Estuaries," Journal of the Waterways, Harbors, and Coastal Engineering Division, American Society of Civil Engineers, 98 (WW4), Proceedings Paper, 9342:475-487, 1972.

4 H. L. Windom, "Water Quality Aspects of Dredging Estuarine Environments," Estuarine Research Volume 20, Academic Press, New York, 1975.

5 B. B. May, "Environmental Effects of Hydraulic Dredging in Estuaries," Alabama Marine Resources Bulletin, 9:1-85, 1973.

6 B. B. Saila, et al., Providence Harbor Improvement Spoil Disposal Site Evaluation Study, Phase II, University of Rhode Island, Kingston, Rhode Island, 1971.

7 J. G. Macklin, "Canal Dredging and Silting in Louisiana Bays," University of Texas, Institute of Marine Science, Austin, Texas, 7:262-314, 1962.

8 M. H. Susskind, et al., "Ambient Air Quality Survey, Clute and Freeport, Texas," Texas Air Control Board.

9 Texas Air Control Board Regulations.

10 "Ambient Air Quality Survey - Clute and Freeport, Texas," Technical Support Program, Texas Air Control Board, 1974.

11 Compilation of Air Pollutant Emission Factors, Second Edition USEPA, March 1975.

[12] Compilation of Air Pollutant Emission Factors, Second Edition, Supplement No. 5, U. S. Environmental Protection Agency, December 1975.

[13] "Workbook of Atmospheric Dispersion Estimates," U.S. Environmental Protection Agency, Office of Air Program, Publication No. AP-26, Revised 1970.

[14] Air Pollution Engineering Manual, USEPA Second Edition, May 1973.

[15] E. R. Reigel, Industrial Chemistry, Rheinhold Publishing Company, New York, 1949.

[16] "Evaporation Loss from Floating Roof Tanks," American Petroleum Institute, New York - API Bulletin 2517, February 1962.

[17] "Evaporation Loss from Tank Car, Tank Truck, and Marine Vessels," API, New York, Bulletin 2514, November 1959.

[18] W. G. Brodgen, Productivity for the Mapping Area, In Radian Report for Seadock, Inc., University of Texas Marine Science Institute, 1974.

[19] E. P. Odum, Fundamentals of Ecology (third edition), W. B. Saunders Company, Philadelphia, 1971.

[20] J. W. Day, et al., "Community Structure and Carbon Budget of a Salt Marsh and Shallow Bay Estuarine System in Louisiana," Louisiana State University, Center for Wetland Resources, Publication No. LSU-SG-72-04, 1973.

[21] J. S. Kirpatrick, Lower Brazos River Project Final Report, Texas Qater quality Board, Austin, Texas, 1972.

[22] G. K. Reid, The Ecology of Inland Waters and Estuaries, Reinhold Publishing Corporation, New York, 1961.

[23] U. S. Army Engineers, "Resuspension of Bed Material and Wave Effects on the Illinois and Upper Mississippi River Caused by Boat Traffic." In Draft Supplemental Statement, Volume II, Locks and Dam No. 26 (Replacement) Upper Mississippi River Basin, Mississippi River, Alton, Illinois, Missouri, and Illinois, 1975.

[24] Brazosport Chamber of Commerce, personal communication, June 11, 1976.

[25] Polluting Incidents in and around U. S. Waters, for calendar years 1971 through 1974, Commandant (G-WEP), U.S. Coast Guard, Department of Transportation, Washington, D.C.

[26] Dames and Moore, Environmental Analysis Louisiana Offshore Oil Port, Prepared for Loop, Inc., New Orleans, Louisiana, 1974.

[27] A. D. Webb, U. S. Coast Guard, Captain of the Port, Port Arthur, private communication, May 3, 1976.

[28] J. Premack and G. A. Brown, "Prediction of Oil Slick Motions in Narragansett Bay," Proceedings of Joint Conference on Prevention and Control of Oil Spills, Washington, D. C., March 1973.

[29] Waterborne Commerce in the United States, Part 2, U. S. Army Corps of Engineers, 1974.

[30] D. Boyd and J. Leotta, "Prevention: The Usage of the United States Coast Guard's Pollution Incident Reporting System in Program Management," paper presented at Control of Hazardous Material Spills, New Orleans, Louisiana, April 1976.

[31] U. S. Army Corps of Engineers, Waterborne Commerce in the United States, Parts 1, 2, 3, and 4, 1971 and 1972.

[32] National Academy of Sciences, Petroleum in the Marine Environment. Workshop on Inputs, Fates and Effects of Petroleum in the Marine Environment May 21-15, 1973, Washington, D. C. 1975.

[33] D. F. Boesch, et al., Oil Spills and the Marine Environment, Ballinger, Cambridge, 1974.

[34] Ministry of Defence Working Party, The Fate of Oil Spilt at Sea. A report on the Effects of Natural Factors on the Movement, Dispersal and Destruction of Oil at Sea, 1973.

[35] Environmental Protection Agency, Studies and Investigations of the Fate and Effect of the Shell Oil Spill, Platform B, Block 26, South Timbalier Bay, (December 1, 1970-November 30, 1970). Final Report, U. S. Government Printing Office, Washington, 1972.

[36] Marshland Recovery Studies (210-75) by M. E. Bender. Page 6 in Environmental Research Annual Status Report February, 1976, American Petroleum Institute, Washington, 1976.

[37] Baker, "The Effects of Oils on Plants," Environment Pollution, 1:24-44, 1970.

[38] J. D. Walker and R. R. Colwell, "Microbial Ecology at Petroleum Utilization in Chesapeake Bay," In: Proceedings at Joint Conference on Prevention and Control of Oil Spills, pp. 685-690, Conference sponsored by American Petroleum Institute, EPA, and U. S. Coast Guard.

[39] "Seadock Environmental Report," prepared for the Seadock Inc., Austin, Texas, in part by Dames and Moore, Houston, Texas; Institute for Storm Research, Houston, Texas and Evans Hamilton, Inc., Houston, Texas, 1974.

[40] J. B. Davis, personal communication, Mobile Oil Research Unit, May 1976.

[41] A. D. Webb, Commander, personal communication, U. S. Coast Guard, Marine Safety Office, May 1976.

[42] "Accidents Connected with Federal Oil and Gas Operations of the Outer Continental Shelf," Conservation Division, U. S. Geological Survey, January 1976.

[43] A. I. Levorsen, Geology of Petroleum, W. H. Freeman, California, 1958.

[44] R. H. Simpson and M. B. Lawrence, Atlantic Hurricane Frequencies Along the U. S. Coastline, NOAA Technical Memorandum NWS SR-58, Fort Worth, Texas, Southern Region Headquarters, National Weather Service, June 1971.

[45] D. J. Novlan and W. M. Gray, "Hurricane Spawned Tornadoes," Monthly Weather Review, Volume 102, July 1974.

[46] H. C. S. Thom, "Tornado Probabilities," Monthly Weather Review, Volume 91, October-December 1963.

[47] R. E. Berry and J. W. Reed, "A Discussion of the Tornado Environment and Occurrence Climatology," Sandia Laboratories, SC-M-0688, November 1972.

[48] George M. Howe, "Tornado Path Sizes," Journal of Applied Meteorology, Volume 13, April 1974.

[49] Chicago Bridge and Iron, personal communication, June 7, 1976.

[50] Explorer Pipelines Glenpool Tank Farm, personal communication, Oklahoma, June 7, 1976.

[51] J. D. Martinez, "Environmental Significance of Salt", The American Association of Petroleum Geologists Bulletin, V.55, No. 6 (June 1971).

[52] R. E. Young, Superintendent of Brine Production, Dow Chemical, December 3, 1976, personal communication.

[53] N. P. Smith, "Seasonal Variations in Nearshore Circulation in the Northwestern Gulf of Mexico," Contrib. in Mar. Sc., 19: 49-65, 1975.

[54] C. R. Gunn and J. V. Dennis, "Tropical and Temperate Stranded Seeds and Fruits from the Gulf of Mexico," Contrib. in Mar. Sci., 17: 111-121, 1973.

[55] J. V. Dennis, "A Second Oil Pollution Survey of the Southeast Florida Coast," American Petrol. Inst. Pub. 4231, 1974.

4. PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED

4.1 SUMMARY

Abstracted from the preceding discussions and shown in Table 4.1 are the anticipated environmental impacts of the construction and operation of the proposed Strategic Petroleum Reserve storage program at the Bryan Mound salt dome. Also listed are the causes of the impacts, the mitigative measures available to lessen their effect, and the unavoidable impacts which would still result even if the mitigative measures were employed. Although environmental impacts of extreme severity are not present, several unavoidable disturbances would result. The most significant effects are discussed briefly in this summary.

Construction Impacts

Pipeline construction operations would be the principal contributor to impacts on undeveloped land and the surrounding ecosystems. Approximately 18 acres of marshland involved in pipeline construction would be disturbed and may take several years to recover. This would result in a loss of marshland productivity of about 1.1×10^8 g-dry wt./year, for the first year and something less than this in consecutive years until complete marshland recovery is established. Considering the extent of marshlands in Brazoria County, the impact of these pipelines is minor. Mitigation measures include topsoil restoration and replanting of affected areas.

The construction of new wellheads, surge tanks, pipelines and further development of the storage site itself would involve the temporary disturbance of existing grazing land as well as forcing resident wildlife to emigrate to more tranquil settings until this additional human activity ceases. No intolerable interruption of Dow Chemical Company's operations on the site would be noticed.

The proposed on-site construction of four 400,000 barrel crude oil surge tanks could cause some concern because the possibility exists that the weight of these large tanks would induce local subsidence. Should any significant amount of subsidence occur the strength and integrity of all tanks involved would be decreased and may result in undue risks of oil leaking. Any oil leakage from any of the several tanks on site and at the dock would be retained by the dikes around the tanks, which would be built to hold the full volume of each respective tank.

Operational Air Quality Impacts

The handling of crude oil in general results in temporary, localized increases in hydrocarbon concentrations at the dock facilities. As shown in Table 3.6, these concentrations may be very high during loading and unloading operations. However, these worst-case concentrations would be reduced if vapor recovery systems for tanker loading and unloading were installed. Emission control technology for marine terminals require three systems: (1) a ship-side vapor collection system, (2) a shore-side collection system, and (3) a vapor control unit. The vapor control unit represents the key consideration in emission control technologies, and there are several units which are currently used in the petroleum industry, although they are not generally used for marine terminal and oil transfer operations. Incineration and refrigeration would be the most appropriate methods for the Bryan Mound dock facilities.

The shipboard vapor collection system would convey the hydrocarbon vapors to the shore-side system, with both systems having collection efficiencies between 90 and 95 percent. These vapors would be incinerated via an elevated, smokeless flare. Smokeless flares convert the hydrocarbons to carbon dioxide and water with better than 99 percent efficiency. Flaring these gases can create sulfur dioxide and nitrogen oxides if sufficient sulfur and nitrogen are present in the vapors. These combustion by-products can be removed with at least 90 percent recovery by scrubbing the gas with water. The overall efficiency of a collection-incineration emissions control system is greater than 95 percent.

Refrigeration of the collected hydrocarbon vapors results in the liquification of the vapors which can then be reinjected into the crude oil at the marine terminal. This recovery has been shown to be greater than 90 percent efficient. Should reinjection not be feasible, the recovered vapors can be used for fuel or sold to petrochemical industries. The overall efficiency of such a vapor recovery system is about 86 percent.

Hydrogen sulfide levels are expected to be minimal since most crude expected to be delivered would have weathered sufficiently during transit to substantially reduce these emissions.

Pipeline Accidents

Crude oil spills, with a median volume of 1,000 barrels, along the buried pipeline routes would result in an initial infiltration of ten centimeters into the surrounding soil. This infiltration would result in approximately 0.4 acres of land area being affected. Over a period of years the

oil contamination of this area would decrease due to degradation of the crude and dissolution due to the heavy annual rainfall in the area. Some quantity of any oil spilled from a pipeline failure would reach the water table and consequently migrate with the natural water migration. This can result in a low level contamination of nearby water bodies for a duration of several years. The U.S. Coast Guard recommends digging trenches at the point of entry into the nearby waterbody (Freeport Harbor and Brazos River) to mitigate the effect of this contamination. The oil is then collected from these trenches as it migrates towards the larger water bodies. Oil migration is enhanced by heavy rainfalls and thus the location of the point of entry into either of these water bodies would have to be determined fairly rapidly after spills of a significant size.

The effect of such an underground pipeline spill on soil organisms in the immediate vicinity would be drastic. Organisms such as mites, spring tails, nematodes, earthworms, etc., would be killed locally. It is not anticipated that the soil organisms in the path of the oil migration in the water table would be as drastically affected since the concentrations of crude oil factions would be increasingly diluted with time, rainfall, and distance the oil is from the spill site.

The only above ground pipelines would be at the storage site and at the dock. Should a spill occur above ground it is readily detectible by inspection and the magnitude of such a spill is on the order of barrels (rather than thousands of barrels). These spills are mitigated by containment and rapid cleanup, leaving negligible environmental damage behind.

Tankships Oil Spills

The probability of tankship spills ranging from less than 300 barrels to greater than 10,000 barrels (for 228 trips to transport 58 x 10^6 barrels) is estimated to be from 3.31 x 10^{-4}, to 3.01 x 10^{-4}, respectively. The total expectation quantity of crude spilled is 331 barrels for the fill of the cavity to 58 x 10^6 barrels, with 228 tankship trips. The highest probability is 2.15 x 10^{-3} for a spill volume between 3,000 - 10,000 barrels. Over the life time of the program, assuming five fill and drawdown cycles the total expectation quantity of oil spilled is 3,300 barrels. The total spill volume expected over the lifetime of the project reflects the low probability of such spills, but does not reflect the anticipated median quantity of such a spill, 5,300 barrels/spill, should it occur.

Should a spill of median expected volume occur on open water, an oil slick, uncontained, could cover (in 24-48 hours) 3,850 acres assuming no currents, wind or obstacles.

Depending on the weather conditions and the rapidity of containment and clean-up operations, oil slicks could cover a significant portion of the Freeport Harbor and Entrance Channel. If a spill occurred outside the Freeport jetty, the beach south of Freeport could be contaminated by the oil due to the strong westerly currents. Spills at the dock facility would be contained primarily by marsh grasses and the banks of the river. Mitigation measures include containment and rapid cleanup.

The ecological impacts of a major oil spill (1,000 barrels or more) would probably be most significant to the eggs and larvae populations of many benthic organisms, including oysters, shrimp and crabs. Large, concentrated quantities of submerged crude oil are necessary to produce direct mortality, and this situation is unlikely. What is more likely is the direct ingestion of submerged crude factions into body tissues by the oyster. This greatly decreases the taste and hence the commercial value of the oyster. Direct fouling of suitable substrate for larval settlement is expected to be short term in the event of a spill. Direct contact of the less mobile, benthic organisms with oil is unlikely, however, settling could reduce the food supply. A general increase in the background level of oil contamination in the bottom sediments would result, as well as a disruption of the community structure in the benthic communities effected by an oil spill. Sea urchins, starfish and other subtidal and intertidal benthic invertebrates would recover from the effects of an oil spill by immigration and thus re-establish populations.

Tainting of fish and fish ingestion of crude oil is known to occur after a significant oil spill. Tainting persists for several months and ingestion may cause the fish to taste "oily." Both of these effects reduce the commercial value of fish.

Marsh vegetation appears to withstand light to moderate oil contamination. Short term effects are generally the death of oiled soots, reduced germination of contaminated seeds and consequently the reduction in annual species. Recovery is relatively rapid, taking less than two years. If more than four oil spills (1,000 barrels) occur within a two to three year period, substantial marsh vegetation mortality is sustained and recovery is retarded. The occurrence of spills of this magnitude and frequency is unlikely as witnessed by the low frequency of spills in the Freeport Harbor and its Entrance Channel and the Gulf Intracoastal Waterway to date and the expected fill and refill frequency of the SPR program. Mitigation measures include rapid cleanup and removal of oil coated vegetation and oil saturated soil.

Table 4.1 Summary of Primary Environmental Impacts, Mitigation Procedures and Unavoidable Environmental Effects

PRIMARY IMPACT	CAUSE	MITIGATION	UNAVOIDABLE IMPACT
Land Features & Use			
1. $\sim$37 acres of industrially developed (Dow Chemical) land disturbed	-construction & operation of new entry wells, pump facilities, storage facilities & structures	-none	-same as primary impact
2. $\sim$3 acres of previously developed land disturbed	-construction of ballast treatment facilities at Seaway Dock site	-none	-same as primary impact
3. Possible subsidence on the dome around the 400,000 bbl storage tanks	-previous sulfur mining on the caprock could lead to subsidence in the immediate vicinity of the tanks and the possible compaction of subsurface aquifers could enhance the subsidence	- none	-same as primary impact
4. 18 acres marshland, 26.4 acres coastal prairie, 68.4 acres of developed land will be temporarily disturbed and maintained	-construction and operation of the brine and crude oil pipelines	-none	-same as primary impact
5. Contamination of soil to 10cm depth from buried pipeline spill of $\sim$1000 bbl, covering $\sim$ 0.4 acres	-buried pipeline spill	-none	-same as primary

Table 4.1 (continued)

PRIMARY IMPACT	CAUSE	MITIGATION	UNAVOIDABLE IMPACT
Water			
1. Temporary increase in turbidity as far as one mile down stream from dredge on Brazos River (Turbidity increases to 1000')	-dredging for pipeline crossings - strong currents - weak currents	-use hydraulic dredging techniques	-less than primary impact
2. Minor alterations of surface runoff on the dome	-manmade well pads, levees and roads	-none	-same as primary
3. Elevation of hydrocarbon(oil and grease) levels in surface water bodies	-pipeline or loading/unloading oil spills on land, where oil is carried to water bodies due to runoff	-rapid and effective clean-up	-less water contamination
	-slow release of oil from buried pipeline spill, as it migrates with water table	-dig trenches at point of oil entrance to water body & collect and dispose of oil	-less contamination of water bodies

Table 4.1 (continued)

PRIMARY IMPACT	CAUSE	MITIGATION	UNAVOIDABLE IMPACT
Air Quality & Noise			
1. Releases from a 100 barrel fire: (assuming complete combustion) CO_2: ~34,000-34,700 pounds SO_2: ~62-3,400 pounds (depending on H_2S content) NO: 66-1,000 lbs.	-on site fire	-extinguish fire immediately -contain fire to smallest possible area	reduced releases to atmosphere, primarily incomplete combustion residues as smoke and soot
2. Total hydrocarbon concentrations will be noticeably elevated out to 1 km. within a ~200 m strip. Reactive species will be well below Federal and State Standards	-paint solvent emissions from spray painting storage tanks -meteorological conditions representative of 5% of the time in the area	-use water-based, rubber-based or latex paint	-reduced releases of hydrocarbons to local atmosphere
3. Total hydrocarbon concentrations will be significantly elevated, up to 57,700 $\mu g/m^3$ at .5 km from the dock.	-tankship loading and unloading operations	-vapor recovery system on tankship and at terminal tank connections	-some hydrocarbon concentrations will be elevated in the near vicinity of the dock, however 95% will be contained and little if any will be precursors to smog formation
4. Potential local increase in hydrogen sulfide concentrations near the dock if the crude oil transferred is not weathered, sour crude	-tankship loading and unloading operations	-vapor recovery system designed to scrub for H_2S	less significant H_2S releases
5. Temporary noise levels of >55dBA out to 500 feet from pipeline construction site	-construction of brine pipeline from the dome to Dow's B Plant, passing near developed areas of Freeport along Brazos River	-none	-any activity within 500 feet of pipeline construction will experience a temporary increase in daytime ambient levels

Table 4.1 (continued)

PRIMARY IMPACT	CAUSE	MITIGATION	UNAVOIDABLE IMPACT
Species & Ecosystems			
1. Minor reduction in phytoplankton production and the elimination of some benthic organisms in the Brazos River	-increase in turbidity due to dredging operations	-use hydraulic dredging techniques	less than primary impact
	-increase in turbidity due to increased tankship traffic	-none -replant cleared surface	
	-increase in surface water run-off from clearing and general construction activities at the dome site, dock facilities and pipeline corridors	-replant cleared surface with rapid growing native vegetation -construction and proper maintenance of drainage systems	
2. Some loss of planktonic organisms, some larval fishes and benthic organisms from impingement and/or entrainment on displacement water intake screens	-displacement water intake in Harris and Brazoria Reservoirs	-clean screens frequently to maintain minimal intake velocity	reduced impingement of organisms
3. ∿36,000 lb-C/yr of dense grass flats productivity lost and ∿ 2.02×10^8 Kcal/yr of coastal prairie productivity lost	-construction activities on the Bryan Mound Dome	-none	-same as primary impact

Table 4.1 (continued)

PRIMARY IMPACT	CAUSE	MITIGATION	UNAVOIDABLE IMPACT
Species & Ecosystems			
4. Minor elimination of transient aquatic organisms supported by dredge banks	-disposal of dredging material	-none	-same as primary impact
5. Temporary disturbance of wildlife habitats and migration of mobile animals from area. (Small mammals, birds and reptiles will return within several months of completion)	-pipeline construction	-none	-same as primary impact
	-dock construction	-none	
	-construction on dome	-none	
	-noise	-none	
6. Creation of small ponds potentially supporting a highly productive aquatic habitat	-ponds created from removal of previously deposited dredge material for dike construction	-drain any standing standing water	-no impact
7. Forced migration of mobile organisms supported by marshland bottom sediments and the destruction of immobile benthic fauna from ∿1/2 acre of benthos habitat dredged in the Brazos River. (Recovery will begin within one to two months after completion of pipeline burial.)	-dredging in Brazos River for pipeline burial	-none	-same as primary impact

Table 4.1 (continued)

PRIMARY IMPACT	CAUSE	MITIGATION	UNAVOIDABLE IMPACT
Species & Ecosystems			
8. Possible hazard to all avian & aquatic wildlife, in particular the endangered species Peregrine Falcon, Brown Pelican, Southern Bald Eagle, American Alligator, Texas horned Lizard, Atlantic Ridley Turtle, Leather back Turtle, all thought to be in the general area.	-oil spill in the Freeport Harbor and Entrance Channel of substantial size ($>$ 1000 bbl)	-rapid containment and clean-up of a spill	-less than primary impact
9. $\sim 1.1\text{x}10^{8}$g-dry wt./yr marshland productivity lost and $\sim 2.64\text{x}10^{8}$ Kcal/yr of coastal prairie productivity lost (vegetation is expected to return to corridor within one year)	-construction and burials of brine and oil pipelines	-none	-same as primary impact
10. Planktonic organisms could be temporarily stressed and possibly destroyed by a substantial oil spill. (reproduction is rapid & communities should reestablish in short periods of time)	-oil spill on water (duration and size of spill will determine extent of destruction of planktonic organisms)	-rapid clean-up and containment	-less than primary impact

Table 4.1 (continued)

PRIMARY IMPACT	CAUSE	MITIGATION	UNAVOIDABLE IMPACT
Species & Ecosystems			
11. Destruction of the eggs and larvae of many benthic organisms (including oysters, shrimp and crabs) and zooplankton	-settling of oil from oil spill and subsequent contamination of bottom sediments, and smothering of organisms	-rapid clean-up and containment	-less significant impact on sensitive reproduction grounds for oysters, shrimp & crabs
12. Tainting of fish and fish ingestion of crude oil	-oil spill on water	-rapid clean-up and containment	-tainting persists several months and ingestion may degrade taste of fish and change the commercial value
13. Contamination of soil and vegetation; death of heavily coated living root shoots	-oil spill reaching marshes and oil spills from pipelines	-rapid clean-up removal of coated vegetation and heavily saturated soils	-death to heavily coated vegetation, destruction by removal
14. Birds and mammals may drown, die from pneumonia, starve due to increased metabolism due to loss of body heat or be poisoned from ingestion of oil from preening	-birds and mammals coming in contact with oil mass from spill :loss of feathers or fur insulation capability :loss of bouyancy	-rapid cleanup and containment -attempt to remove oil from involved animals	-birds with feathers that have come into contact with oil have about a 20% survival rate after treatment to remove oil
15. Plants and soil animals in immediate vacinity of pipeline spill would be obliterated (e.g. spring tails, mites, nematodes, earthworms, etc.)	-spill from buried pipeline	-none	-rapid degradation by soil bacteria, fungi algae will minimize duration of impact

Table 4.1 (continued)

PRIMARY IMPACT	CAUSE	MITIGATION	UNAVOIDABLE IMPACT
Socioeconomic			
1. 10 new, permanent jobs created, possibly filled by Dow Chemical employees	-ongoing maintenance of SPR	-none	-same as primary impact
2. Circulation of workers income in Freeport area & Brazoria County ($150,000 to $200,000/ month for first 12 months)	-contractors in the county will be sought for construction operations -most of these people live in Brazoria County	-none	-same as primary impact
3. No new businesses generated	-short duration of construction requirements	-none	-same as primary impact
4. Loss of about $15,000 per year to county treasury from tax on site equipment	-federally owned equipment and materials would be tax-exempt	-tax revenues locally and for the State of Texas will accrue from workers income and purchasing exercise	-net tax gain of $5,000 to $10,000 in first year, followed by annual net tax loss of about $12,000

Table 4.1 (continued)

PRIMARY IMPACT	CAUSE	MITIGATION	UNAVOIDABLE IMPACT
Socioeconomic			
5. Possible delay in the reemployment of skilled laborers at the completion of construction activities and the consequent migration of laborers out of the area	-short duration (12 mos) construction demand of the project	-none	-same as primary impact
6. Possible increase in road maintenance costs to Brazosport area and Brazoria County and to Dow Chemical Company	-increased traffic to and from Bryan Mound	-federal lease payments would compensate for maintenance costs on Dow Chemical Company roadways	-short term increased wear on county and state roads during construction
7. Increased responsibility to assure the security of the facilities and to respond to fire dangers	-operations of the facility during storage and drawndown phases	-SPR employment of security personnel and fire fighting capabilities	-reduced demand on local police & fire departments

Table 4.1 *(continued)*

PRIMARY IMPACT	CAUSES	MITIGATION	UNAVOIDABLE IMPACT
Accidents & Natural Disasters			
1. Damage to the facility structures and equipment	-hurricane	-empty crude and brine from all pipelines, settling tanks, surge and storage tanks & weight tanks down	-reduced structural damage to buildings
		-place all down hole safety devices in safety position	-reduces the risk of an oil leak
		-maintain monitoring operations with standby battery powered electrical systems	
		-have a manually operated remote control to disconnect all electrical power from facilities	
2. ∿10% probability of a crude oil pipeline accident, with expectation volume spilled of 4.3 bbl; mean spill size of ∿1000 bbl.	-rupture of pipeline and concurrent detection delay or failure, and failure of shut-off safety system	-frequent monitoring of pipeline route & pressure -during storage phase, empty all crude from pipeline system	-less than ∿3% probability of pipeline spill if oil is not in the pipeline system during fill and withdrawal operations
3. A median oil spill of 5300 bbl, could result in ∿3850 acres of surface water involved in the spread of the oil slick within 48 hrs. at Freeport Harbor and its Entrance Channel if spill is uncontained	-vessel casualty in Harbor or Entrance Channel	-rapid clean-up & containment of the spill	-reduced slick size if contained within 12-24 hrs. after spill

Table 4.1 (continued)

PRIMARY IMPACT	CAUSE	MITIGATION	UNAVOIDABLE IMPACT
Accidents & Natural Disasters			
4. A median oil spill of 5300 bbl during strong ebbing tide could result in some of the slick being carried outside the jetty at Freeport Harbor	-vessel casualty in Harbor or Entrance Channel	-rapid clean-up and containment	-reduce risk of oil being carried outside the jetty
5. Oil spill outside the Freeport Harbor jetty would result in oil contamination of the beach south of Freeport due to strong westerly currents in the area	-vessel casualty outside the jetty -vessel casualty in the harbor or entrance channel during strong ebbing tid s	-rapid clean-up and containment before spill reaches the beach	-reduced minor beach and water contamination
6. Rupture of surge tanks and consequent release of oil; oil would be contained by dikes, or some oil could be dispersed by tornadoes	-possible rupture from missiles carried by very severe tornadoes	-none	-same as primary impact
7. Buckling of empty surge tanks	-possible severe tornado and/or hurricane	-fill tanks at least to 15 feet for added strength & integrity	-reduced damages

4.2 CONSIDERATIONS OFFSETTING ADVERSE ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTIVITY

The United States possesses abundant natural resources and yet is dependent upon the importation of large quantities of fuels. It has become increasingly dependent upon petroleum imports, which now constitute approximately 35 to 45 percent of the nation's oil consumption and account for 20 percent of the total domestic energy usage. In 1974 the annual cost of these imports was over $25 billion.

In the past twenty-five years, the United States has experienced four sudden denials of oil imports for various reasons by oil-exporting countries. Not, however, until the oil embargo of 1973-74 did the nation find itself without the capacity and resources to offset the interruption of oil imports. This embargo reduced the quantities of petroleum exported to the United States by approximately 2 million barrels per day for 19 weeks and caused world prices for crude oil to escalate.

Although the economic impacts of these events on the United States economy are still under study and debate, most of the macroeconomic study estimates of the repercussions of supply denial and simultaneous price increases tend to indicate a Gross National Product (GNP) loss of approximately $35-45 billion.[1,2] Although not all of this GNP loss can be ascribed to the embargo, the interruption contributed significantly to increases in the consumer and wholesale price indices. In addition, the GNP loss was reflected in higher unemployment and stagnation in several sectors, including automobile sales and housing starts, which exacerbated the economic downturn believed to have started in late 1973. During this period, the embargo prevented real growth that probably would have stabilized unemployment and provided a stronger base for eventual economic recovery.

The United States is now more vulnerable to a petroleum supply interruption than it was in the fall of 1973. In responding to that interruption, many relatively easy steps to conserve energy were taken, and significant improvements in energy efficiency have been achieved. Higher energy prices, natural gas shortfalls, and continued uncertainty about the availability and prices of alternative forms of energy have induced many energy users to restrict their energy consumption and emphasize more effective energy management practices. However, additional improvements will require substantial investment, longer lead times, and even more intensive energy management. Moreover, the program to convert oil- and gas-fired utilities and industrial plants to coal will have converted many plants to coal, which will largely preclude further conversion to coal during a future supply interruption. Some estimates have shown that a future supply interruption of the magnitude of the one in 1973-74 could cause a reduction in GNP that, in terms of employment impact, would be equivalent to the loss of jobs for 2 million workers. Economic effects would not be limited to some geographical areas or industries but would affect the entire nation.

Standby supplies of petroleum have been proposed repeatedly as a way to buffer the impact of future supply interruptions. The National Petroleum Council (NPC)[3], Ford Foundation,[4] and the Energy Laboratory at the Massachusetts Institute of Technology MIT)[5] have all recommended this action. In addition, the International Energy Program (IEP) agreement, which the United States has entered into with 17 other energy importing countries, provides for the establishment of this type of reserve. Although the western European countries and Japan have developed stockpiles, the only appreciable stocks in the United States are working inventories.

The concern voiced by these organizations as well as the public, in addition to the nation's formal commitments to the IEP, provided strong impetus for passage of the Energy Policy and Conservation Act of 1975 (P.L. 94-163), which provides for the creation of the Strategic Petroleum Reserve. The Bryan Mound ESR storage facility provides 58 million barrels of the SPR requirement.

REFERENCES

1. The Economic Impact of an Interruption in United States Petroleum Imports 1975-2000; CRC 245; Center of Naval Analysis, Naval Warfare Analysis Group; by Randall G. Holcombe, Nov. 1974.

2. Emergency Preparedness for Interruption of Petroleum Imports into the United States; National Petroleum Council Committee on Emergency Preparedness, by Carrol M. Bennet, et. al.; Sept. 1974.

3. Petroleum Storage for National Security; National Petroleum Council; Aug. 1975.

4. Time To Choose America's Energy Future; Ford Foundation; 1974.

5. Energy Self-Sufficiency: An Economic Evaluation; Massachusetts Institute of Technology, Energy Laboratory Study Group; 1974.

5. RELATIONSHIP BETWEEN LOCAL SHORT TERM USES OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG TERM PRODUCTIVITY

The Bryan Mound site has been extensively used for brine production and storage of liquids and gases by Dow Chemical for many years. The commitment of the dome for long term storage of crude oil would preclude all further use of that part of the salt dome in proximity of the storage site. However, at the present time, most of the brine operations have been reduced or halted at Bryan Mound in favor of development of the larger Stratton Ridge dome which is also owned by Dow. Additionally, the large number of salt domes in or near the Gulf of Mexico that are available for commercial exploitation, and the quantity of salt at these alternative sources, make it unlikely that the use of the Bryan Mound dome would curtail future salt or brine production.

The present system design calls for no leach water or brine disposal during site preparation and construction. Displacement water and brine disposal associated with facility operation would be supplied by or processed through the Dow Chemical system. Therefore, there would be minimal impacts on area water systems.

As a result of land changes due to levee construction, additional successional habitats may be created which would add to the diversity of species in the vicinity of the site. Retention dikes surrounding the tank farm and storage facility would create an area suitable for some bird species which may otherwise nest and feed in upland regions. At times of high water, these levees could provide limited refuge for wildlife. The construction of the pipeline and ballast water treatment system would remove some marsh land productivity. Most of this would be restored within 2 years of completion of the project. That small portion which would be permanently altered is not expected to cause a significant reduction of the long term productivity of the area.

The most noticeable short term effect would be increased demand on supplies for drilling rigs and for pipe and sheet metal needed for the construction of the storage facilities. This impact should be offset by the long term security of having a supply of crude oil available to maintain required flow rates to refineries in the local area. The migration of workers to the project area during the construction phase would not alter current population trends. Although the number of long term jobs created by the project is small, it would provide a source of steady employment and benefit to the local area.

The availability of crude oil from this project would mitigate the effects of an interruption in supply of foreign oil. Therefore, it would serve to enhance productivity that would otherwise be reduced by loss of fossil (oil) energy sources and petrochemicals.

At the end of the storage facilities' use as part of the Strategic Petroleum Reserve Program, several termination options can be exercised. These options include: (1) the removal of the oil and the refilling of the cavity with brine, the capping of the wells and removal of surface equipment; (2) the conversion of the crude oil storage facility for use in the storing of LPG or petroleum products; or (3) the transfer of the crude storage facility from federal to private use. The range of options is sufficient to allow a choice of alternatives in termination of the facility which would enable the maximum long term productivity at this site to be realized.

6. IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES

Construction of the Bryan Mound storage facility would involve the irretrievable commitment of several resources. Roads constructed for support facilities would be made of shell fragments, safety dikes surrounding storage tanks would be earthen, and pastureland that would be used at the site would be fenced. Each of these general impacts, with minimal effort and expenditure, can be reversed to return the site to its original condition. The resources that are irretrievable are discussed below:

Labor

Labor used in construction and operation would constitute an irreversible expenditure of manpower. Approximately 115 workers would be engaged at the site for about one year. This expenditure is approximately 115 man years of labor during construction plus approximately 530 man years during standby and operation.

Construction Materials

Use of wood, steel, concrete, and other building supplies for site support facilities dedicates those materials to the project. The fact that some of these materials may be recycled or simply relocated for other purposes and projects alleviates the severity of these resource commitments. Pumps, generators, and other electromechanical items deteriorate with use. These resources can only be partially retrieved.

Energy

Energy would be required in the construction of the physical plant and in the conversion of the existing cavities for crude oil storage purposes. Major energy uses would be for drill rigs, road construction, and transportation of workers and materials. The energy used is irretrievable. It represents an investment intended to prevent drastic reductions in energy availability in the future.

Electrical power needed to operate machinery (such as pumps) represents an irreversible and irretrievable commitment of energy and thus, the fuels needed to produce the power. Because electrical power is generated by fossil fuel within the region, petroleum resources would be expended to produce the energy. Drilling, construction, and shipping activity associated with Bryan Mound commits considerable petrochemical resources to the project. These resources would be irreversibly and irretrievably expended.

Materials utilized in the construction of the Bryan Mound facility include estimated maximum amounts of 19,000 tons of steel and 4,100 tons of concrete. Assuming 40 million BTU are required to supply a ton of steel and 6 million BTU are required per ton of concrete, the energy required to supply material is approximately 800,000 million BTU. Equipment operations for site preparation and operation will consume about 50,000 million BTU and the energy required for crude transportation for each fill/withdrawal cycle amounts to about 110,000 million BTU. Therefore, in terms of crude oil equivalence content (5.5 million BTU/barrel), the potential oil resource utilization for a 5 cycle SPR program is about 2.6 x 10 barrels. Since during a 5 cycle program 290 million barrels of crude would be handled by this site, the energy resource utilization amounts to less than 0.1% of the potential energy storage capacity.

Mineral Resources

Utilization of leached caverns for petroleum storage irreversibly commits the portion of the dome used for storage for the project life. Therefore, the strategic petroleum reserve program eliminates the possibility of utilizing these cavities for brine production.

Temporary loss of some crude oil stored in the caverns is inevitable because an oil layer will be retained to protect the roof of the cavern from upward leaching by the displacement water. The amount of oil needed for protection is difficult to estimate because of irregularities in the cavern roofs. Some permanent loss will occur if solution pockets exist in the roof or if natural voids (usually containing gas) are encountered by leaching during oil withdrawal. Compared to the oil blanket the amount of oil permanently lost in solution pockets above the oil withdrawal annulus would be small. However, if the amount of oil lost in these pockets is large enough, new wells could be drilled to recover it.

Water Resources

Assuming that five cycles are involved during the life of the project, approximately 3,024,000,000 gallons (9,280 acre ft) of water would be taken from the Dow reservoir. When the amount of surface water available is considered, the loss of this volume over the life of the project is insignificant.

Investment

The cost of constructing the project at this site is estimated to be approximately 72 million dollars. Operating costs would range from 290,000 dollars/year to two and one-half million dollars/year. These costs do not include the value of the stored oil.

7. ALTERNATIVES TO THE PROPOSED ACTION

Several alternatives to the proposed action have been examined. These include alternative storage sites, alternative facility components and no action.

7.1 ALTERNATIVE STORAGE SITES

During any future oil import interruption, SPR crude oil will have to be distributed to refineries in each of three major markets: East Coast and Caribbean via tanker ship; inland via the Seaway, Texoma and Capline pipelines; and the Gulf Coast refinery complexes (Freeport, Port Neches and St. James). The Bryan Mound salt dome storage site is one of a group of five sites within the eight candidate ESR sites which can service all three markets, including each of the three pipelines (see Figure 7.1). Of the eight sites there are only five candidate sites which can supply both the Gulf Coast, and the Caribbean and East Coast markets. Based on current demand, these two markets combined would, in the event of a supply interruption, require approximately 75 percent of the 150 million barrels in the ESR, or about 110 million barrels. Together the five sites have an existing capacity of approximately 330 million barrels--well above the 110 million barrels needed for the two markets.

Site selection, therefore, will involve a two-step decision-making process. The first decision in the site selection process will be to choose two or three of the five sites for the purpose of satisfying the ESR needs of the Gulf Coast, the East Coast and the Caribbean. These five candidate sites are thus alternatives for accomplishing this purpose. Site specific EISs have been prepared for all five alternative candidate sites. The impacts which would result from development of each of the other four candidate sites are described briefly in Sections 7.1.1 - 7.1.4. The individual statements should be consulted for a detailed assessment of these impacts.

The second step of the site selection process will involve choosing sites to satisfy the ESR requirement for the inland refineries. The remaining three of the eight candidate ESR sites are unique in that oil from them could be distributed only to the inland market area because they are "downstream" on major crude oil transmission pipelines. One would connect with the Seaway pipeline market area, while the other two would service the same part of the inland market area served by the Capline pipeline. Because of their ability to supply this inland market, those of the five candidate sites which are considered in the first step of site selection, but are not selected in that process, would be considered again as alternatives to the three inland market sites during the second step in the site selection process. EISs are now in preparation for the additional three inland sites which will be considered.

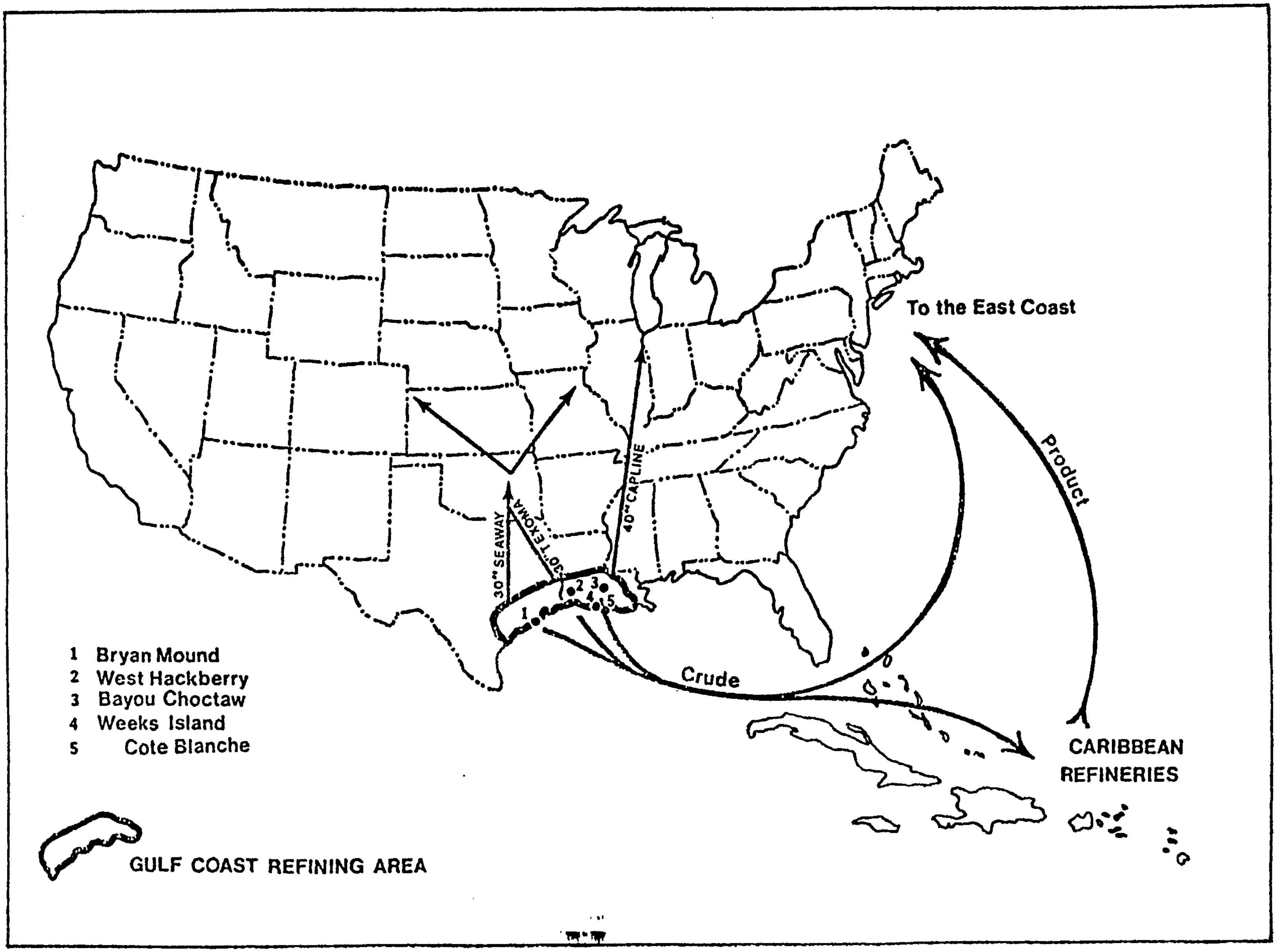


Fig.7.1 SPR Distribution Network

The future site selection for the longer-range portion of the SPR program will be very similar to the process described above for the ESR. Candidate sites will be grouped geographically according to market and distribution requirements. Each group will comprise a set of alternative sites, and EISs will be prepared which compare the impacts of developing each site. Those among the first eight which are not selected for the ESR will be considered as alternative storage sites for the longer-term phase of the SPR if they were rejected as ESR sites for reasons other than unsuitability for oil storage; e.g., if they were found to be unavailable for the ESR within the required time frame.

7.1.1 West Hackberry

Converting existing solution-mined cavities in the West Hackberry salt dome to a 60-million barrel oil storage facility would require drilling three new wells for oil injection and 11 brine disposal wells, and constructing a temporary barge dock on Alkali Ditch as well as a new tanker terminal on the Calcasieu River with connecting oil pipelines to the site. Displacement water for oil withdrawal would be pumped from Black Lake Bayou. The construction and operation of these facilities would cause several unavoidable disturbances, but no long term environmental effects. The most significant of these are displayed in Table 7.1. and discussed below for storage site construction, brine disposal, dock facilities and pipelines, oil displacement, marine operations, and facility operations.

7.1.1.1 Storage Site Construction

The storage site itself would require three new wells, two 10,000 barrel brine surge tanks, pump and office buildings, and access roadways. Since the land is now used for industrial purposes, no major land use changes are anticipated. However, the construction activity would temporarily disrupt soils around the storage site and cause an increase in erosion and runoff which would diminish local water quality. Over the course of construction, the level of suspended solids are expected to increase just over 2 percent.

Construction equipment would temporarily reduce on-site air quality with increased concentrations of carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NO_x), hydrocarbons (HC), and 0.3 tons of particulates per month. Only the HC might exceed primary air quality and standards.

Since the land is classified as already highly disturbed, the water, air, and noise impacts are not expected to affect vegetation, wildlife, or aquatic biota significantly.

Construction of the storage site facilities and brine disposal wells together would generate 700 man-months of labor in the Lake Charles area, which would result in approximately $1.2 million in wages. Although local traffic would increase somewhat during the construction period, no significant adverse impacts on community facilities or local housing are anticipated.

7.1.1.2 Brine Disposal

To dispose of the brine now in the West Hackberry dome cavities would require drilling 11 brine disposal wells and installing two 10,000-barrel surge tanks as well as a 10,000-foot pipeline between the storage site and disposal area. The brine disposal area would include 25 acres of pasture and 10 acres of marsh; filling the marsh would reduce fish and shellfish production by as much as 1,650 pounds annually.

Brine injection would increase salinity in the disposal aquifer by one part per thousant (ppt). Fracture of the overlying rock is not likely at standard brine injection rates, but brine could seep into the Chicot Sands fresh water storage area if old wells around the disposal area were not adequately plugged.

An alternative to injection wells for brine disposal would involve a brine pipeline running 20 miles to the Gulf of Mexico and would protect the geology and water quality near the site but would increase salinity in the Gulf to a maximum of 3.5 ppt 16 feet downstream of the diffuser and 0.1 ppt over a 250-acre area. Construction would temporarily disturb soils and lower water quality along the pipeline route, crossing the Sabine National Wildlife Refuge.

7.1.1.3 Dock Facilities and Pipelines

The proposal for storage at West Hackberry calls for the construction of a temporary barge dock on Alkali Ditch and construction of a new tanker terminal on the Calcasieu River, connected to the storage site by a four-mile pipeline. The temporary facilities at Alkali Ditch would include two 1,000-barrel surge tanks (one for oil and one for brine), while the facilities at the tanker terminal would include a total of six tanks - two 100,000-barrel oil surge tanks, two 100,000-barrel ballast holding tanks, and two 15,000-barrel tanks for emulsion treatment. Construction would require dredging 35,000 yards of material from Alkali Ditch and 1 million yards from the Calcasieu River Channel. This could increase levels of turbidity, toxic sulfides, heavy metals and arsenic, as well as pesticides and other toxic hydrocarbons in bottom material. Disposal of the dredge spoil would destroy 90 acres of marshland. Maintenance dredging would also be required at both sites.

Construction of the proposed dock and pipeline facilities would require about 700 man-months of labor over approximately one year. The payroll for this aspect of the project would be about $1.2 million.

Paint solvent emissions from the preparation of the facilities would exceed standards at 2 kilometers from the site.

As an alternative, the existing Lone Star Terminal could be expanded with a 12-mile pipeline to the storage site as an alternative to construction of a new tanker terminal on the Calcasieu River. Less dredging would be required, 660,000 cubic yards. The dredge spoil could be disposed of in a less sensitive area, an already disturbed abandoned industrial property. However, the longer pipeline would disrupt 180 acres of marsh and farm land, as opposed to 55 acres of farm land, would slightly decrease water quality in the marsh, and would eliminate an additional 312 tons of productive marsh materials.

Two additional alternatives that involve existing pipelines may be possible with minimal new construction. Connection to these pipelines would disrupt 70 acres of brackish marsh and 50 to 80 acres of rice farming, at an income loss of nearly $33,000 in the latter. A third alternative, a new pipeline to the Texoma terminal, would disturb more marsh and dry land than any other alternative. Associated dredging in the Sabine-Neches Waterway would temporarily eliminate bottom organisms and lower water quality in the vicinity.

7.1.1.4 Displacement

Water to displace the stored oil would be taken from Black Lake Bayou at the rate of 10,650 gallons per minute for 150 days, which would increase salinity slightly and temporarily lower the surface of the lake. Intake structures would trap some small organisms, but water quality and ecology in the lake would be restored shortly after displacement was completed.

An alternative environmentally less desirable and more expensive than the use of Black Lake would involve groundwater from drilled wells. Drilling the wells would eliminate the use of coastal plain grasslands for one year, and pumping would depress the local water table and possibly contaminate groundwater temporarily with salt water.

7.1.1.5 Marine Operations

Over the life of the project, the risk of oil spillage from accidents is the same for the proposed facility at West Hackberry as for the alternative of expanding the Lone Star Terminal, estimated at approximately 273 barrels for the tankship option and 3,087 barrels with the temporary barge system. Oil spills would destroy non-mobile species in their path, and leave a residual oily taste in fish caught in the vicinity. Vegetation contaminated by an oil spill would die but the contaminated area would revegetate itself within a couple of years.

Tanker and barge unloading during fill and tanker loading during withdrawal would result in the release of substantial amounts of hydrocarbons. During fill, barges and tankers would release 781 pounds per day and 8,286 pounds per day respectively. During withdrawal, tankers would release 20,953 pounds per day. This would cause the Federal standard of 160 $\mu gm/m^3$ to be exceeded as far as 6 miles downwind for the barge operations, and for the tankers 30 miles during fill and 45 miles during withdrawal. Emissions from crude oil transfers are not regulated in the State of Louisiana.

7.1.1.6 Facility Operations

The major impacts associated with facility operation would occur during fill and withdrawal. During these operations the oil storage tank at the barge dock and those at the tanker terminal would release hydrocarbons at rates of 588 and 500 pounds per day respectively. This would cause the Federal standards of 160 $\mu gm/m^3$ to be exceeded as far as 3 kilometers downwind for the barge dock, and greater than 2 kilometers downwind for the tanker terminal. The storage phase of the program would cause no additional significant impacts.

Only ten people would be needed to operate the facility during the storage phase. During oil recovery operations, 20 to 30 people would be required.

West Hackberry

ENVIRONMENTAL IMPACT SUMMARY

Table 7.1.1

ACTIVITY	IMPACTS DUE TO ACTIVITIES: GEOLOGY AND SOILS	LAND USE	WATER QUALITY AND SUPPLY	AIR QUALITY	NOISE	ECOLOGY	SOCIOECONOMIC
STORAGE SITE CONSTRUCTION							
Drilling of 3 new wells, construction of pump and office buildings and additional roadways	Temporary erosion and sedimentation, change in drainage patterns.	Enclosure of 240 acres now in industrial use disposal of construction waste in existing land fill.	Increase of 2 35% in suspended solids from 5,028 cu yds of sediment; increase in turbidity.	Temporary degradation from construction equipment emissions. increase in fugitive dust of 0 3 tons per month; possible violation of 3-hr HC standards	Noise impact zone (>55 dBA) up to 2,000 feet, nearest residence at 2,000 feet.	No significant impact; vegetation and wildlife at storage site already highly disturbed	$1 2 million of construction labor from Lake Charles area, slightly increased local traffic
BRINE DISPOSAL							
11 brine wells 2 10,000 bbl surge tanks 10,000-ft pipeline to disposal area (P)	10 acres of marsh filled around wellhead.	Conversion of 25 acres from pasture to brine disposal	Salinity increase in disposal aquifer of 1 ppt; increase in salinity of Chicot Sands possible if old wells in area are unplugged.	Slight impact during drilling operations.	Noise impact zone up to 1,800 feet.	Reduction in fish and shellfish production by 1,650 lb/yr due to loss of 10 acres of marsh.	Same as site construction
20-mi pipeline to Gulf (A)	Temporary surface disruption	Some alteration to Sabine-Neches dredging area	Salinity increase of 3.5 ppt 16 feet downcurrent, increase of 0.1 ppt. over 250 acres; increased turbidity atop pipeline routes.	Temporary localized degradation from construction equipment emissions.	Noise impact zone up to 500 feet	Temporary elimination of low mobility organisms near diffuser	Greater impact than proposal
DOCK FACILITY CONSTRUCTION							
Temporary barge dock on Alkali Ditch, new tanker terminal at Calcasieu River, required pumps and tanks (P)	35,000 cu yds of dredging in Alkali Ditch and 1 million cu yds in Calcasieu River Channel, maintenance dredging at both sites, suspended sediment at both sites.	Alteration of 90 acres of marsh by dredging disposal	Localized degradation from increased turbidity, toxic sulfides, heavy metals or arsenic, pesticides, and other toxic hydrocarbons in Alkali Ditch and Calcasieu dredging and spoil disposal	Paint solvent emissions exceeding standards at 2 km	Noise impact zone up to 2,000 feet, nearest residence beyond 4,000 feet	Temporary elimination of bottom species and reduction of plankton productivity from dredging temporary disruption of wildlife and vegetation from dredge disposal	$1.2 million of construction labor from Lake Charles area
Expansion of Lone Star Terminal (A)	Dredging of 660,000 cu yds	Use of 30 acres of abandoned industrial property already disturbed. conversion of 100 acres of marsh to dry land with dredge disposal.	Turbidity downstream to lake; less impact than proposal due to less dredging and preferable disposal area.	Impact same as proposal.	Impact same as proposal	Impact same as proposal	Impact same as proposal
PIPELINES							
4-mi pipeline between site and terminal at Calcasieu (P)	Temporary surface disruption.	1-year disruption of 55 acres of agricultural land	No impact.	Slight hydrocarbon emissions.	Noise impact zone up to 500 feet	Temporary disruption of wildlife	Same as dock facility construction.
12-mi pipeline between site and Lone Star Terminal (A)	Temporary surface disruption	Disruption of 180 acres of marsh and agricultural land.	Slight increase in turbidity in marsh during construction.	Slight hydrocarbon emissions.	Noise impact zone up to 500 feet	Loss of a small amount (312 tons) of marsh productivity during construction	Greater impact than proposal due to longer pipeline
Connect to existing pipelines (A)	Temporary surface disruption.	Disruption of 76 acres of brackish marsh and 50 to 80 acres of rice farming	Slight increase in turbidity in marsh during construction	Slight hydrocarbon emissions	Noise impact zone up to 500 feet.	Temporary wildlife disruption.	Loss of $32,800 in rice farming income.
New pipeline to Texoma Terminal (A)	Temporary soil disruption.	180 acres of brackish marsh, 106 acres of intermediate marsh, 48 acres of fresh marsh, 24 acres of dry land.	Slight increase in turbidity in marshes during construction.	Slight hydrocarbon emissions.	Noise impact zone up to 500 feet	Temporary disruption of wildlife. disruption of benthic community in waterways where dredging required	Greatest impact due to length of pipeline.
Pipeline accidents	Soil fouled in vicinity of pipelines	Land unsuitable for farming until oil dispersed through soil	Local degradation of water quality	Slight hydrocarbon emissions.	Noise from cleanup operations	Temporary destruction of local soil organisms and vegetation (on land) and non-mobile organisms in water	Temporary loss of farm production over small area
OIL DISPLACEMENT WATER SOURCE							
Black Lake Bayou (P)	No impact.	No impact	Slight increase in salinity and temporary drop in surface level associated with withdrawal of 10,650 gpm for 150 days.	Slight hydrocarbon emissions	Noise from pumps	Entrapment of some organisms in intake structures, no effect on productivity temporary loss of wildlife during construction.	Same as site construction
Groundwater wells (A)	Surface disruption from drilling.	1-year loss of sma area of coastal prairie grassland	10,650 gpm for 150 days will result in local cone of depression and some temporary salt water intrusion	Slight hydrocarbon emissions.	Noise impact zone up to 1,800 feet.	Temporary disruption of wildlife during drilling.	Greater impact than proposal
MARINE OPERATIONS	Small amount of erosion on channel bottom.	No impact	Expected oil spill of 273 bbls with tankers, 3,087 bbls with barges.	Barge hydrocarbon emissions of 781 lb/day during unloading, tanker emissions of 8,286 lb/day during unloading and 20,953 during loading; concentrations in excess of 160 μg/m³ would extend downwind for 6 miles and 30-45 miles during the barge and tanker operations respectively.	Very slight impact.	Destruction of non-mobile species and residual oily taste in fish from oil spills.	Reduced marketability of fish fouled by oil.
FACILITY OPERATION	No additional impact.	No additional impact.	Small quantities of sanitary waste; slight impact.	Evaporative hydrocarbon losses of 586 lb/day and 500 lb/day from the storage tanks at the barge dock and the tanker terminal respectively; concentrations would be 160 μg/m³ at 3 km (barge dock) and at >2km (tanker terminal).	Very slight impact; less than 70 dBA at 50 feet; no nearby residences.	No additional impact.	10 people employed during operation; 20-30 employed during oil recovery; payroll during operation of $18,000 per month; payroll during recovery of $43,850 per month.

(P) Proposed system design

(A) Alternative to the proposed system design

7.1.2 Bayou Choctaw

Converting existing solution-mined cavities in the Bayou Choctaw salt dome into a 94-million barrel oil storage facility would require drilling 28 brine disposal wells, constructing related brine handling facilities, expanding an existing dock and storage tank facility on Bull Bay, constructing a new tanker terminal at Addis on the Mississippi River, and constructing an oil pipeline between the dock at Addis and the storage site. Water for displacement of oil during withdrawal operations would come from a small on-site lake. Although the oil storage reserve at the Bayou Choctaw salt dome would not likely cause long term adverse environmental impacts, it would alter the local environment in significant ways. These effects are displayed in Table 7.1.1 and discussed below for storage site construction, brine disposal, dock facilities and pipelines displacement, marine operations, and facility operation.

7.1.2.1 Storage Site Construction

Construction of dikes, roadways, well-heads, and buildings at the storage site would require about 15 months and would disturb farm and swamp land and induce soil erosion, which will, in turn, increase turbidity and suspended solids in nearby waters. Resident wildlife will be forced to emigrate to a more tranquil setting until the construction activities cease.

Construction equipment would temporarily degrade on-site air quality with CO, SO_2, NO_2, HC, and particulates. However, resulting levels of these pollutants, with the possible exception of the hydrocarbon concentrations from drilling rigs within a downwind distance of 0.5 kilometers, would meet federal and state primary standards. Point solvent emissions would be high, but do not exceed Federal three-hour standards and are not regulated in Louisiana.

7.1.2.2 Brine Disposal

The brine disposal system would consist of 28 disposal wells evenly spaced in a rectangular field of 1,150 acres. Brine would be collected in a 500,000-barrel holding pond for temporary storage and settling, and then piped 6,500 feet to the disposal area. Since the brine disposal area is located in a backwater swamp forest, 128 acres of which would be converted to industrial use, construction would result in a loss of wildlife habitat.

The major environmental risk in brine disposal is the danger of acquifer fracture, which could cause contamination of fresh water or interference with oil and gas production. During the filling process at the Bayou Choctaw site, 267 ppt brine would be injected at a maximum rate of 19,450 gallons per minute at depths of -5,000 to -7,000 feet. After 150 days of brine injection under average conditions, the bottom hole pressure would increase but remain well below the fracture pressure. Pressure throughout the well would tend to equalize when injection is stopped and so cause the bottom hole pressure to decrease. After several fill and withdrawal cycles, the bottom hole pressure would steadily increase again but still remain below the fracturing point. However, in thin (50-foot) sand layers, where the average pressure build-up is greater, the bottom hole pressure would probably exceed the fracturing point during the fifth cycle. The likelihood of actual fracture varies with the potential for well clogging, which in turn depends on the chemical and biological compatibility of the injected brine and the saline water in the aquifer.

Some risk of fresh ground water contamination also exists where abandoned oil and gas wells provide passageways between a fresh water aquifer and the saline acquifer used for brine disposal. Two such wells, the conditions of which are unknown, lie within the brine disposal area. In the worst case, 15 million barrels of saline water could leak to the Plaquemine aquifer (a nearby fresh water supply) over 20 years. Relative to the capacity of the Plaquemine aquifer, such leakage is small, and careful inspection and replugging of the 2 abandoned on-site wells can avoid any negative impact.

As an alternative to deep-well injection, a 116-mile pipeline would carry the brine 20 miles into the Gulf of Mexico. Since it would follow an existing right-of-way, this pipeline would avoid many impacts associated with pipelines in general. Nevertheless, the pipeline would eliminate 182 acres of suger cane (one harvest valued at $62,500) and a total of 350 acres of wetlands, an amount considerably more than that affected by the deep well injection of brine. Disposal of brine in the Gulf would increase salinity 0.1 parts per thousand over a 250 acre area and 2.5 ppt over one acre. Although bottom organisms would be destroyed in the diffuser area, they would repopulate shortly after disposal stopped.

7.1.2.3 Dock Facilities and Pipelines

Barges serving the Bayou Choctaw site would use an existing barge dock on Bull Bay for the initial fill of the first storage cavern. The existing dock facility would be expanded by a new barge mooring ship and a new dock. In addition, a new tanker facility with mooring for two tankers would be constructed on the Mississippi River, southeast of Addis and 5 miles east of Bayou Choctaw. Six surge tanks and two ballast tanks would also be constructed at the tanker terminal.

Expansion of the Bull Bay dock would have little impact; however, construction of the new tanker dock would require a 250-acre tract of already disturbed land and 30 acres of property planted in sugar cane. Dredging 86,000 cubic yards of bottom material in the Mississippi would moderately increase turbidity, toxic sulfides, heavy metals, hydrocarbons, ammonia, TKN, and COD at both the dredging and disposal sites. The dredging operations would destroy bottom organisms, and sediment settling would suffocate local mollusks and shellfish.

Oil for storage or distribution would be carried by a 5-mile pipeline between the docks and the storage site. The pipeline would temporarily disturb 30 acres of sugar cane and 25 acres of backwater swamp and thus cause temporary increases turbidity. Ecological impacts would also be temporary since the pipelines would be buried and vegetation expected to return. Although a pipeline accident is very unlikely, an expected spill would releast 16 barrels of oil, which would destroy local soil organisms.

An alternative to constructing a new tanker dock at Addis is to install a pipeline to an existing tank farm at St. James and expand the tanker terminal there. Most effects would be the same, but because it would require less dredging, this alternative would have less impact on water quality and aquatic ecology. In addition, since the river sediment is less polluted at St. James, the effects of dredge disposal would be further reduced. The pipeline itself, along an existing right-of-way, would have little impact on the environment. However, this alternative could prevent 127 acres of sugar cane production, valued at $43,000 (one harvest, requiring three years' growth).

7.1.2.4 Oil Displacement

Water to displace the stored oil would be taken from a 12-acre on-site lake, connected by canal to the Choctaw Bayou and the Intercoastal Waterway, that could accommodate displacement (115 million barrels per cycle) because of connection with these two waterways. No adverse effects to water quality are expected in any of the waters. However, some aquatic species would become trapped during the pumping process, and more mobile species would emigrate from the area. Both types of species would return after displacement is completed.

An alternative to thelake as a water supplv source is the Mississippi River. The ecological impacts of using this water source would be the same, and no adverse effects on river flow would occur.

A third alternative, to use ground water pumped from drilled wells, would have the greatest adverse impact. The water table would be lowered approximately 10 feet wtihin a half mile of this well area, accompanied by loss of swamp productivity.

7.1.2.5 Marine Operations

The major potential impacts from the operations of tankers and barges is the risk of oil spillage from accidents and the hydrocarbon emissions from the various oil transfer operations. Marine operations include both the temporary arrangement of transporting the oil along the Mississippi River by tankship to Port Allen and by barge to Bull Bay, and the permanent use of only tankships docking at Addis.

Vessels loading and unloading would produce estimated total hydrocarbon emissions of about 2,000 tons occuring over about 2.8 years of initial fill operations or about 2,000 tons for each 150 day withdrawal operation. Although hydrocarbon emissions from vessel loading and unloading are not regulated in Louisiana, the downwind associated with these emissions would greatly exceed the three-hour Federal standard of 160 $\mu gm/m^3$ for considerable distance downwind (5-10 Km) during worst case atmospheric conditions.

Statistical analysis of accidents and spillage indicates that expected spills from tankers alone would total 536 barrels, and the temporary combination of tankers and barges, 7,857 barrels in a single fill and withdrawal cycle. The large difference between the two systems arises solely from the need for barges at the temporary Bull Bay dock; the risk from the tankship phase of the operation is the same for both the temporary and permanent phases.

Oil spilled from vessels in transit would temporarily contaminate sediment and might affect the taste of fish in the area. Vegetation contaminated by oil would die, but the area would revegetate within a couple of years.

The potential impact of oil spills would be essentially the same for permanent docks located at Addis or St. James. The shorter travel distance up the Mississippi to St. James is offset by the greater congestion at that terminal.

7.1.2.6 <u>Facility Operations</u>

Operations of the Bayou Choctaw storage site would have no significant impacts other than those associated with oil fill and withdrawal and related employment. Vapor losses from the oil storage tanks at the tanker and barge docks would exceed Federal three-hour standards up to 10 Km downwind from the tanks. The Bayou Choctaw storage facility would employ 20 to 30 skilled workers during oil recovery operations (150 days) and 10 full-time employees for maintenance and site security during the storage phase.

Bayou Choctaw

ENVIRONMENTAL IMPACT SUMMARY

Table 7.1.2

ACTIVITY	IMPACTS DUE TO ACTIVITIES						
	GEOLOGY AND SOILS	LAND USE	WATER QUALITY AND SUPPLY	AIR QUALITY	NOISE	ECOLOGY	SOCIOECONOMIC
STORAGE SITE CONSTRUCTION	Short-term erosion from dikes, roads, and other earthmoving. 701 cubic yards of sediment	104 acres enclosed; industrial use unchanged. 3,000 to 10,000 cubic yards of construction waste in 1 of 9 landfill sites	Small increase in turbidity from grease and oil; 7% increase in suspended solids in local waters.	Temporary degradation from construction equipment and paint solvents not in excess of standards; increase of 19.1 tons/yr of suspended particulates, 7% increase for parish overall.	Noise impact zone (greater than 55 dBA) within 2,000 feet, no residences within 1 mile	Minor disturbance to wildlife, alteration of vegetation	306 man-months of construction employment on site; $675,500 in payroll; slightly increased traffic and resulting maintenance costs for public facilities
BRINE DISPOSAL							
28 Injection Wells 500,000-Barrel Holding Pond 6,500-Foot Pipeline (P)	No rock fracture under average pressure; possible rock fracture in 50-foot sand layers during fifth cycle	1.8 acres of swamp forest changed to industrial use.	Increase in salinity in saline aquifers; possible contamination of fresh aquifers if old wells unplugged.	Slight impact from drilling operations.	95-100 dBA at 50 feet; noise impact zone at 1,800 feet; no residences within 1 mile.	Loss of wildlife habitat and production; <1% probability of brine spill that could destroy some marshland over 120 acres.	Included in storage site construction.
116-Mile Pipeline to Gulf (A)	Temporary surface disruption	102 acres of sugar cane and 350 acres of wetlands lost	0.1-ppt salinity increase in Gulf waters over 450 acres; increase of 2.5 ppt over 1 acre; no increase more than 3.5 ppt.	Slight impact.	Noise impact zone within 500 feet; no residences within one quarter mile	Temporary loss of benthic organisms and fish. <1% probability of brine spill that could destroy marsh	Loss of $62,500 in sugar cane (one harvest; requires 3 yrs growth)
DOCK FACILITY CONSTRUCTION							
Expansion of Bull Bay, Tanker Dock at Addis; Storage and Ballast Tanks (P)	Suspension of sediment	250-acre tract, including 30 agricultural acres, disturbed.	Local increases in turbidity, toxic sulfides, heavy metals, hydrocarbons, ammonia, TKN, COD from dredging, and dredge disposal of 86,000 cubic yards and 1.5 million cubic yards for permanent dock.	Same as site construction.	70 dBA at dock during construction.	No impact at Bull Bay, loss of aquatic species at new dock site.	500 man-months of construction labor at dock sites; $875,500 in payroll.
Expansion of St. James Terminal Pipeline to St. James (A)	Suspension of sediment	30 acres disturbed; 127 acres of sugar cane production possibly precluded	Same as proposal, but larger turbidity plumes that will dissipate more rapidly; river sediment less polluted; less dredging impact	Same impact as proposal	Same impact as proposal.	Less impact than proposal.	Possible loss of $43,000 in sugar cane (one harvest).
PIPELINE							
Oil Line 5 Miles from Addis to Site (P)	Temporary surface disruption.	55 acres disturbed (30 in sugar cane, 25 in backwater swamps)	Temporarily increased turbidity in swamp.	Slight hydrocarbon emissions.	Noise impact zone at 500 feet; few residences within one quarter mile.	Minimal impact during construction only; vegetation will return	450 man-months of construction employment; loss of $7,500 in sugar cane production (one harvest).
Pipeline Accidents	Soil fouled in vicinity of pipeline.	Land unsuitable for farming until oil dispersion through soil complete.	Local degradation of water quality.	Slight hydrocarbon emissions.	Slight impact during cleanup operations.	16 barrels spilled oil would destroy local soil organisms (if underground) and vegetation (if above ground)	Temporary loss of farm and swamp production over small area
OIL DISPLACEMENT WATER SOURCE							
12-Acre On-Site Lake (P)	No impact.	No impact.	No significant impact on lake or replenishing water sources; <1 ppt decrease in lake salinity.	Slight hydrocarbon emissions.	Slight impact; pumps and motors	Temporary migration during displacement; entrapment of plankton, larval fishes, vertically migrating benthics, small aquatic plants.	No impact
Mississippi River (A)	No impact.	No impact.	32,000 gpm, representing 0.035% of river flow; no adverse impact.	Slight hydrocarbon emissions.	Slight impact; pumps and motors.	Impact same as on-site lake.	No impact.
Ground Wells (A)	Surface disruption due to drilling.	5.7 acre-well area.	10-foot reduction in water table level at 0.5 miles from pumping station.	Slight hydrocarbon emissions.	Slight impact; pumps and drilling rigs.	4.2-ton loss of biological swamp production for 1 year plus impacts of on-site lake.	No impact
MARINE OPERATIONS	Small amount of erosion on channel bottom.	No impact.	Expected spill of 536 barrels from tankers or 7,857 from barges per fill/withdrawal cycle. Disposal of 47,500 barrels of ballast water per tanker in brine well; no adverse impact to aquifer.	Worst case hydrocarbon emissions from storage tanks could exceed 160 $\mu gm/m^3$ as far as 10 km downwind; maximum concentrations of 7500 $\mu gm/m^3$ at 0.5 km.	Noise impact zone at 200 feet, no residences within ½ mile	Destruction of non-mobile species and residual oily taste in fish if oil spills occur	Reduced marketability of fish fouled if oil spills occur
FACILITY OPERATION	No impact.	No additional impact.	Small quantities of solid and sanitary waste, no adverse impact.	Vessel loading and unloading could produce 2,000 tons hydrocarbon emissions for each fill or withdrawal; worst case emissions could exceed 160 $\mu gm/m^3$ for considerable distance downwind (5-10 km); maximum concentration at 0.5 km of 6,125 $\mu gm/m^3$.	Noise impact zone at 200 feet, no residences within ½ mile	No additional impact	10 full-time personnel: 6 skilled, 3 laborers, 1 clerical; 20-30 skilled workers for oil recovery.

(P) Proposed system design

(A) Alternative to the proposed system design

7.1.3 Cote Blanche

Converting the Cote Blanche salt mine into a 27-million barrel oil storage facility would require relocation of existing mining operations, construction of a new pump shaft at the existing mine, enlargement of a barge slip, and construction of four barge loading platforms and associated pipelines to the site. Although they are not likely to cause long term adverse impacts, construction and operation of this facility would alter the local environment in several significant ways. These effects are shown in Table 7.1.3 and discussed below for storage site acquisition and construction, dock facilities and pipelines, marine operations, and facility operations.

7.1.3.1 Storage Site Acquisition and Construction

The major construction activity at the storage site itself, sinking a new 12-foot pump shaft and pump station, would require minimum surface grading over 1 acre and therefore create only small, localized increases in dust, and of vehicle exhaust from construction equipment. Ecological effects would be limited to minor accumulations of dust on foliage in the immediate vicinity of the construction. Proposed freezing of the area surrounding the pump shaft would prevent any construction disturbance to the groundwater.

Development of a replacement mine would require considerably more construction activity. Approximately 20 acres of land now in pasture and forest would be needed for new mine development. Grading at the new mine site would increase soil erosion and runoff and lower surface water quality in the local area. The use of drilling mud around the walls of the hole to prevent water inflow would protect groundwater.

Although government acquisition of the mine site would eliminate the annual property tax of $26,000, construction of the storage facilities, including docks and pipelines, would provide 20,000 man-weeks of labor for 83 weeks and total annual earnings of $6.3 million for two years. Economic gain resulting from an interruption in mining to accelerate the storage schedule would be offset by unemployment or underemployment of 120 mine workers and a loss of $1.7 million in earnings. If Domtar decided not to construct a new mine, the 120 jobs permanently lost would eliminate annual earnings of $1.2 million. The multiplier effect of this decision would entail the loss of another 200 service jobs and associated incomes within the region.

7.1.3.2 Dock Facilities and Pipelines

Enlargement of the barge slip and construction of four barge loading platforms would require excavation and disposal of 250,000 cubic yards of soil materials to create 9 acres of open water from marshland and involve another 20 acres of marsh and forest. Construction of four half-mile pipelines between the docks and the storage site would also disturb soils on the island.

Surface water quality would decrease in the access canal near the excavation and disposal sites with increases in biological oxygen demand (BOD) and nutrients and decreases in dissolved oxygen (DO) and ph. Since the existing barge slip is now dredged bi-annually, the additional excavation associated with enlargement of the dock facility would be less significant than in an otherwise undisturbed area.

The dock construction would not affect any rare species but would remove a small quantity of vegetation (e.g., oyster grass), and bottom organisms (e.g., blue crab).

As an alternative to enlarging the dock, the construction of a pipeline from Cote Blanche to St. James, following a route along either Bayou Teche (80 miles) or the Atchafalaya River (60 miles), is more likely if both Cote Blanche and Weeks Island are developed for storage. The Bayou Teche route would affect a larger number of acres (1,201 as opposed to 923), of which a greater percentage is now undisturbed. Both routes would degrade the quality of surface water by lowering pH and DO and increasing nutrient concentrations and BOD from deposits of excavated soils. However, by supplanting the barges, the pipeline would cause less impact from oil spills. The pipeline would be more expensive to construct but less expensive to operate than the barge facilities.

7.1.3.3 Marine Operations

The use of barges for transporting oil to and from the storage facility would increase erosion along the banks of the Intracoastal Waterway (ICW) and would in turn increase turbidity. Over the lifetime of the project, it is expected that about 2,700 barrels of oil would be spilled and that the maximum credible spill (Gulf shore) would be 60,000 barrels from a 45,000 DWT tanker. Although slow water currents and minimal wave action would inhibit the oil from spreading, the oil reaching shore would destroy many sensitive marsh species, which would regenerate after two years.

Transporting the oil to and from the dock at the storage site would result in significant hydrocarbon emissions, both during transit and at the transfer points in the Mississippi River and in the Gulf of Mexico. System leakage ("breathing") losses from tankers and barges would occur at a maximum annual atmospheric loading rate of 244 tons/year during fill and withdrawal. These emissions would be dispersed along the Mississippi River - Intracoastal Waterway route from the Gulf to the storage site. VLCC-tanker transfers in the Gulf and tanker-barge transfers in the Mississippi River would cause emissions at maximum annual rates of 1,220 tons/year and 1,300 tons/year respectively. Under worst case atmospheric conditions, transfers at the Mississippi River transfer point would cause hydrocarbon concentration in excess of the three-hour Federal standard of 160 $\mu gm/m^3$ as far as 6.8 miles downwind. The State of Louisiana currently exempts from regulation emissions from crude oil transfers.

An an alternative to small barges, large, seagoing barges might be used to transport part of the oil directly between the tankers in the Gulf and the site. This system would require larger dock facilities and a pipeline across the island creating a greater impact on the ecology of the island. However, their use could result in a 42 percent reduction in spilled oil and a 37 percent reduction in hydrocarbon emissions.

7.1.3.4 Facility Operations

Transferring the oil from the storage cavern to the barges at the dock would result in significant hydrocarbon emissions as the barge tanks are filled with oil and the vapors contained therein are vented to the atmosphere. These venting losses would occur at a maximum annual atmospheric loading rate of 731 tons/year. Under worst case atmospheric conditions, this operation would cause hydrocarbon concentrations in excess of the three-hour

Federal standard of 160 $\mu gm/m^3$ as far as 4 miles downwind. Because of unavailable system leaks, minor amounts of hydrocarbons and hydrogen sulfide would be emitted during filling of the storage cavern as a result of flaring of the vapors that would be vented during that operation.

Fifteen employees would be needed during the 150-day withdrawal and the 300-day refill periods. Only two to three permanent employees would be needed to maintain security on the site during the storage phase of the program.

Cote Blanche

ENVIRONMENTAL IMPACT SUMMARY

Table 7.1.3

ACTIVITY	IMPACTS DUE TO ACTIVITIES: GEOLOGY AND SOILS	LAND USE	WATER QUALITY AND SUPPLY	AIR QUALITY	NOISE	ECOLOGY	SOCIOECONOMIC
STORAGE SITE CONSTRUCTION							
12 ft Pump Shaft and Associated Aboveground Equipment (P)	Surface grading of 1 acre; no impact on mine structure; excavation of 15,000 cu. yds. of material for landfill disposal; loss of salt resource due to absorption; fracture unlikely due to absence of faulting.	No impact.	Impermeability of salt offsets potential impacts on groundwater system; no impacts.	Small quantities of dust and NO_x, SO_2 from construction vehicle exhaust; no violation of standards.	Less than 6 dB increase in nighttime ambient sound levels in nearby undeveloped areas during construction; no increase in nearby towns.	No impact.	Loss of $26,000 property tax per year; no adverse impact to archaeological sites.
NEW MINE DEVELOPMENT	Expended access to salt deposits; increased gradings and soil erosion.	20 acres of pasture and forest for development of new mine.	Slight decrease from soil erosion and runoff.	Slightly increased dust and construction vehicle exhaust.	37 to 70 dB at 500 feet for ground refrigeration on equipment and service shaft construction, explosives; no impact on nearby towns, however.	No impacts; site of new mine already highly disturbed.	20,000 man-weeks of construction over 83 weeks with earnings of $2,300,000 per year for 2 years; if mining interrupted, unemployment or underemployment of 60 mine workers for 74 weeks and earnings loss of $1.7 million; if mining not interrupted, continuation of 25,000 man-weeks of labor over 103 weeks and earnings of $4,000,000 per year for 2 years.
Permanent Shutdown of Domtar Mine (A)	50% reduction in site excavation and grading.	Surface acreage required for mine site would be unaltered.	Reduction erosion and siltation associated with grading.	Slight reduction in air emissions during construction from those of mine relocation option.	Noise levels reduced over mine relocation option.	No impact.	Elimination of $1.2 million annually in gross wages; local loss of 120 jobs; induced loss of 200 service jobs in region.
DOCK FACILITIES							
Barge Slip and 4 Barge Loading Platforms (P)	250,000 cu. yds. soil dredged; slightly increased runoff (barge slip now dredged biannually).	Alteration of 9 acres from marsh to open water; 20 acres required for aboveground storage, of which 15 acres are marshland and upland forest.	Small decrease at site of excavation and dredge disposal; increase in BOD, decrease in DO, reduction in pH, increase in nutrients, possible increase in heavy metals, suspended solids in access canals.	Increased dust, NO_x, SO_2 from construction vehicle exhaust.	71 dB 10 hours each day at 500 feet from pile drivers for barge dock construction; no impact to nearby towns due to distance.	Removal of 50 x 10^6 grams dry weight of oyster grass; adverse impact to 6 x 10^6 grams of organisms, mostly blue crab.	Included above.
PIPELINES							
Four 0.5-mi Pipelines Between Doc and Site (P)	Disturbance of sand, silt, and clay soils; increased runoff.	About 3 acres affected by representative 500-bbl spill; seepage and movement to barge slip where *it would be contained.*	No significant impact on ground or surface water.	Slight hydrocarbon emissions.	68 dB at 500 feet.	Spills reaching marsh beyond barge slip probably would affect less than 5 acres and would be allowed to weather and degrade naturally.	Included above; protection of potential for archaeological finds *by presence of state archaeologist.*
Pipeline to St. James via Bayou Teche (80 mi) (A)	Temporary disruption of soils along right-of-way, resulting in runoff.	Alteration of 1201 acres, of which 60% are undisturbed swamp.	Possible lowering of pH and DO and increase in nutrient concentrations and BOD from deposit of excavated soils; no impact on ground water; oil spill impacts less than with barge system.	Slight hydrocarbon emissions.	As above.	More adverse impacts on ecology of of unmodified swamp forest than on Atchafalaya route and of dock construction.	Less operation expense than for barge transport; construction employment of 150 persons for one year.
Pipeline to St. James via Atchafalaya (60 mi) (A)	Temporary disruption of soils along right-of-way, resulting in runoff.	Disturbance of 923 acres, of which 42% are undisturbed swamp.	Same as first alternative.	Slight hydrocarbon emissions.	As above.	Less impact than Bayou Teche route.	Less operation expense than for barge transport; construction employment of 120 persons for one year.
MARINE OPERATIONS							
Barges (P)	Increased erosion on banks of ICW and access canal.	No impact.	Slightly increased turbidity in ICW and access canal from barge operations; minimal impact from spilled oil (2724 barrels expected; 60,000 maximum) due to limited potential for lateral spreading.	Hydrocarbon emissions during transit at an annual rate of 244 tons/yr, and during vessel-to-vessel transfers at an annual rate of 1200-1300 tons/yr. Tanker-barge transfers would cause hydrocarbon concentrations in excess of 160μgm/m³ as far as 6.8 mi. downwind.	55 dB at 500 feet for one barge passby; frequency of occurence to increase by less than one additional passby per hour over present rate for 28-month fill, 5-month withdrawal period; noise levels occurring over 12 months if Weeks also developed and barges used for transfer.	Small risk to all fauna and wildlife inhabiting coastal marshes from spilled oil; temporary disruption of vegetation where oil spilled.	Significant increased demand for barges, tug boats, crews with resultant expanded employment and income in region; need for priorities in equipment use during emergency; possible impact to recreational use of water nearby from oil spill; significant cleanup costs.
Seagoing Barges (A)	Greater disruption of soils due to need for larger barge facilities and pipeline across island.	More land required for dock facilities.	Fewer water impacts due to expected spillage of 42% less oil.	Hydrocarbon emissions 37% lower than from smaller barges.	Slightly less impact than smaller barges.	Less impact due to lower expected volume of spilled oil.	Slightly greater than dock operation.
FACILITY OPERATIONS	No impact.	No impact.	No impact.	Hydrocarbon emissions during barge loading at an annual rate of 731 tons/yr, causing concentrations in excess of 160μgm/m³ as far as 4 mi. downwind. Minor hydrocarbon and hydrogen sulfide emissions from system leakage during pumping and minor sulfur dioxide emissions *from flaring of vapors during fill.*	Loading and unloading barges result in 55 dB at 500 feet (at least 12 dB lower than existing background).	No additional impact.	2-3 permanent employees to monitor equipment and provide security; 15 people for 5 months during withdrawal; 15 people for 10 months during refill.

(P) Proposed system design

(A) Alternative to the proposed system design

7.1.4 Weeks Island

Conversion of an existing salt mine to an 89-million barrel oil storage facility at Weeks Island would involve the construction of a new replacement salt mine, enlargement of an existing barge slip, and construction of abutment barge docks and six and one-half-mile pipelines between the barge slip and storage facility. Although the oil storage reserve at Weeks Island is not likely to cause long term adverse impacts, construction and operation of this facility would alter the local environment in several significant ways. These effects are discussed below and in Table 7.1.4 for the construction of the storage site as well as for a new replacement mine, dock facilities, pipelines, marine operations, and facility operations.

7.1.4.1 Storage Site Construction and Acquisition

Conversion of an existing salt mine to an 89 million-barrel oil storage site would entail only temporary, local increases in the levels of hydrocarbons, NO_x and SO_2, as well as dust, which results from the grading needed for the above-ground pump station and small electric substation.

Construction of a new salt mine to replace that converted for oil storage would involve about 20 acres of land used currently as a landfill site. The socioeconomic impact of such construction would depend on whether (1) salt production was interrupted and (2) Cote Blanche followed a construction schedule similar to Weeks Island.

Development of the new mine at Weeks Island with no interruption in salt production would require 18,500 man-weeks of labor over 93 weeks and provide an estimated $6 million in salaries. If mining operations continue uninterrupted at Weeks Island as well as at Cote Blanche, production at both sites would yield a total of $13.9 million.

With a 64-week cessation in salt production at Weeks Island, designed to expedite the completion of the storage facility, 16,800 man-weeks over 73 weeks could be required, and the resulting loss in salt production would decrease state revenue, through severance taxes, by $92,000 and local revenues by $50,000. If construction interrupted salt production at both Weeks Island and Cote Blanche, only $11.7 million in salaries would be released, with $7 million to the local area. The resulting 3.5 million-ton decrease in salt production would proportionately reduce state revenues, through severance tax, by $210,000 and local revenues by $150,000.

A construction schedule for Weeks Island that does not require an interruption in salt mining would cause a shortage of laborers for the time that both mine relocation and storage conversion peak. One possible solution to this problem would entail a different coordination of activities between the two sites. If the Cote Blanche mine were closed during conversion at Weeks Island, the unoccupied work force could assist in mining operations at Weeks Island to expedite construction without drawing heavily from the outside labor market.

7.1.4.2 Dock Facilities and Pipelines

The proposed method of crude oil supply and distribution is designed for barge transport coordinated with a pipeline system. Six abutment docks would be constructed to accommodate 25,000-barrel barges,and the southern portion of an existing barge slip would be enlarged by 80 percent. An estimated 250,000 cubic yards, involving about 9 acres of marsh and spoil banks, would be excavated for the slip and transported to an approved Corps of Engineers site. Ancillary equipment (manifold, pumps, meters) would require ten acres adjacent to the slip. The excavation would temporarily displace local aquatic life, including benthic organisms like blue crabs. Increased runoff from the grading of the adjacent ten acres would cause temporary turbidity, BOD, DO and nutrient problems.

Barge transport would require the construction of six 0.5-mile pipelines between the barge slip and the storage facility. Although excavation and backfilling would, in displacing several thousand cubic yards of soil, temporarily cause sediment to run off into the barge slips and Waterway, overall impact would be small.

Despite the probability that a pipeline rupture would cause oil spill is low, a maximum spill of 500 barrels would most likely affect only three acres.

With both Weeks Island and Cote Blanche as storage facilities, the proximity of the two sites increases the possibility that a large diameter pipeline could replace the barge system as the means of supply and distribution for the sites. Two alternative pipeline routes to St. James are available, one running 80 miles along Beyou Teche and the other 60 miles along Atchafalaya. The first would more adversely affect virgin wetland forest. The pipeline would involve a lower operating expense and probability of oil spill than those of barge transport.

7.1.4.3 Marine Operations

Barge operations would involve a total distance of 225 miles. Oil would be offloaded from very large crude carriers to 45,000 DWT tankers in the Gulf of Mexico, transported up the Mississippi River to Venice, Louisiana, and transferred to 25,000-barrel barges for further transport up the Mississippi through Algiers Lock to the ICW and ultimately Weeks Island barge slip.

Daily barge traffic should increase 11 percent for the 28-month fill period and 36 percent for the shorter 9-month withdrawal period.

The maximum credible oil spill for the Gulf, possibly 60,000 barrels, could render 840 to 1,680 acres of marsh (1.5 percent of total marsh in the area) nonproductive for two years. Of the expected average spill of 1,827 barrels, 312 barrels may occur at the barge slip and 1,515 barrels anywhere in the ICW, Mississippi River, or the Gulf. The maximum credible spill from barges into the ICW, estimated at 20,000 barrels, could affect 10 miles of the channel. Transporting the oil from the dock at the storage site would result in significant hydrocarbon emissions, both during transit and at the transfer points in the Mississippi River and in the Gulf of Mexico. "Breathing" losses from tankers and barges would occur at a maximum annual atmospheric loading rate of 800 tons/year during fill and withdrawal. These emissions would be dispersed along the Mississippi River-Intracoastal Waterway route from the Gulf to the storage site. VLCC-tanker transfers in the Gulf and tanker-barge transfers in the Mississippi River would cause emissions at maximum annual rates of 4015 tons/year and 2140 tons/year respectively. Under worst case atmospheric conditions, transfers at the Mississippi River transfer point would cause hydrocarbon concentrations in excess of the three-hour Federal standard of 160 $\mu gm/m^3$ as far as 7.5 miles downwind. The State of Louisiana currently exempts from regulation emissions from crude oil transfers.

As an alternative to small barges, large, seagoing barges might be used to transport part of the oil directly between the tankers in the Gulf and the site. This system would require larger dock facilities and a pipeline across the island creating a greater impact on the ecology of the island. However, their use could result in a 42 percent reduction in spilled oil and a 46 percent reduction in hydrocarbon emissions.

7.1.4.4 Facility Operations

Transferring the oil from the storage cavern to the barges at the dock would result in significant hydrocarbon emissions as the barge tanks are filled with oil and the vapors contained therein are vented to the atmosphere. These venting losses would occur at a maximum annual atmospheric loading rate of 2,410 tons/year. Under worst case atmospheric conditions, this operation would cause hydrocarbon concentrations in excess of the 3-hour Federal standard of 160 $\mu gm/m^3$ as far as 5.7 miles downwind. Because of unavoidable system leaks, minor amounts of hydrocarbons and hydrogen sulfide would be emitted during pumping. Minor amounts of sulphur dioxide would be emitted during filling of the storage cavern as a result of flaring of the vapors that would be vented during that operation.

Fifteen workers would be required for transfer operations during fill or withdrawal periods. A crew of five or less would be required during the storage phase of the program, primarily for security purposes.

Weeks Island

ENVIRONMENTAL IMPACT SUMMARY

Table 7.1.4

ACTIVITY	IMPACTS DUE TO ACTIVITIES						
	GEOLOGY AND SOILS	LAND USE	WATER QUALITY AND SUPPLY	AIR QUALITY	NOISE	ECOLOGY	SOCIOECONOMIC
STORAGE SITE CONSTRUCTION							
Conversion of existing salt mine to 89 million barrels oil storage facility (P)	Minimal regrading of soil.	Only temporary increase in vehicular traffic likely.	Impermeability of salt offsets potential impacts on groundwater system; no impacts	Temporary local increase in hydrocarbons NO_x, SO_x, particulates, and dust from construction (not measurable beyond several hundred yards from site)	Less than 6 dB increase in nighttime ambient sound levels in nearby undeveloped areas during construction, no increase in nearby towns	Removal of total 45 acres for entire site of low-quality habitat but creation of new "edge" along site perimeter for possible increase in wildlife diversity.	Slight loss of recoverable salt due to minor oil absorption; minor temporary increase in construction-related transportation employment
CONSTRUCTION OF REPLACEMENT MINE (P)	Expanded access to salt deposits; increased gradings and soil erosion.	Approximately 20 acres of land affected on site currently used for landfill. Waste overburden disposed of in 1 acre landfill on site	No impacts to ground or surface water systems, no flooding risk because of high surface elevation of facilities.	Impacts as above	37 to 70 dB at 500 feet for ground refrigeration equipment and service shaft construction, explosives; no impact on nearby towns, however.	No impact, new mine on site of landfill	Increased accessibility to salt deposits due to relocation of operation to new mine; 18,500 man-weeks labor, involving 110 non-local workers, over 97 weeks to generate $6 million ($13.9 million combined with Cote Blanche), with interruption in mining, 16,800 man-weeks labor, involving 80 non-local workers, over 73 weeks to generate $2.9 million ($11.7 million combined with Cote Blanche); loss from interruption of 64 weeks' salt output, $92,000 in severance tax, $210,000 combined sites), $50,000 to local ($150,000 combined sites).
DOCK FACILITIES							
Enlargement of existing slip to 450 x 650 feet and construction of 6 abutment-type barge docks (P)	Estimated 500,000 cubic yards excavated to enlarge southerly portion of existing slip.	Total of 20 acres affected; 9 acres of marsh and spoil deposit to be altered to open water; 10 acres of land adjacent to slip to be used for ancillary equipment (manifold, pumps, meters), excavated material to be disposed of in an approved site	Temporary impact to water quality before bank stabilization complete from increased runoff, small increases in turbidity, nutrient, BOD, DO, decreased pH, possible increase in heavy metals, major impact on Spartina.	Impacts as above	71 dB 10 hours each day at 500 feet from pile drivers for barge dock construction; no impact to nearby towns due to distance	Temporary displacement of local aquatic life by enlargement of slip; approximate loss of 50 x 10^6 grams dry weight marsh grass due to barge slip development and 8 x 10^6 grams of benthic organisms (9 x 10^3 of which would be blue crabs)	Included above.
PIPELINES							
6 0.5-mile pipelines between barge slip and storage facility (P)	Several thousand cubic feet of soil disturbed by excavation and refilling of pipeline trenches.	About 3 acres affected by representative 500-bbl spill; seepage and movement to barge slip where it would be contained.	Sediment runoff to Waterway, barge slip and marsh to west of site.	Slight hydrocarbon emissions	68 dB at 500 feet	Spills reaching marsh beyond barge slip probably would affect less than 5 acres and would be allowed to weather and degrade naturally	Included above.
1 60-mile pipeline to St. James via Bayou Teche (A)	Temporary disruption of soils along right-of-way resulting in runoff and sedimentation.	Alteration of 1,201 acres, of which 60% are undisturbed wetlands.	Possible lowering of pH and DO increase in nutrient concentrations and BOD from deposition of excavated soils; no impact on groundwater; oil spill impacts less than with barge system.	Slight hydrocarbon emissions.	As above.	More adverse impact on ecology of unmodified wetland forest than Atchafalaya route or dock construction.	Less operating expense than for barge transport; construction employment 150 persons for 1 year.
1 60-mile pipeline to St. James via Atchafalaya (A)	Temporary disruption of soils along right-of-way resulting in runoff and sedimentation.	Disturbance of 923 acres, of which 42% are undisturbed wetlands.	Same as first alternative.	Slight hydrocarbon emissions.	As above	Less impact than Bayou Teche route.	Less operating expense than for barge transport; construction employment 120 persons for 1 year.
MARINE OPERATIONS							
Barges (P)	Some erosion of banks generated by tugs and barges moving along waterway.	Very small possibility of large oil spill reaching developed water recreation areas; increases in barge traffic 11% daily during filling period; increases in traffic 36% over shorter 5-month withdrawal period, all in addition to Cote Blanche.	Slight increase in bank erosion during 28-month fill, 5- to 9-month emptying periods from increased barge traffic, minimal impact from spilled oil in ICW (1827 barrels expected, 20,000 barrels maximum) or Gulf (60,000 barrels maximum).	Hydrocarbon emissions during transit at an annual rate of 800 tons/yr, and during vessel-to-vessel transfers at an annual rate of 2140-4015 tons/yr. Tanker-barge transfers would cause hydrocarbon concentrations in excess of 160 $\mu g/m^3$ as far as 7.5 mi downwind.	55 dB at 500 feet for one barge passby, frequency of occurrence to increase by less than one additional passby per hour over present rate for 28-month fill, 5-month withdrawal period; noise levels occurring over 12 months if Cote Blanche also developed and barges used for transfer; if both Weeks and Cote Blanche, probable use of pipelines.	Oil spilled in Gulf could significantly affect habitat and populations; from 840 to 1680 acres of marsh could be lost from productivity for 2 years (1.5% of total marsh in area) if tanker spill occurred inland from Gulf, maximum credible spill in ICW could contaminate up to 320 acres for 2 years if it reached wet marsh	Significant increased demand for barges, tug boats, crews with resultant expanded employment and income in region; need for priorities in equipment use during emergency; possible impact to recreational use of water nearby from oil spill; significant clean-up costs
Seagoing Barges (A)	Greater disruption of soils due to need for larger barge facilities and pipeline across island.	More land required for dock facilities.	Fewer water impacts due to expected spillage of 42% less oil.	Hydrocarbon emissions 46% lower than from smaller barges.	Same as dock facilities	Less impact due to lower expected volume of spilled oil.	Slightly greater than dock operation.
FACILITIES OPERATIONS							
Filling (28 months); storage (unknown period); withdrawal (5 months)	No impact.	No impact.	No impact.	Hydrocarbon emissions during barge loading at an annual rate of 2410 tons/yr, causing concentrations in excess of 160 $\mu g/m^3$ as far as 5.7 mi downwind. Minor hydrocarbon and hydrogen sulfide leakage during pumping and minor sulfur dioxide emissions from flaring of vapors during fill.	Loading and unloading barges result in 55 dB at 500 feet (at least 12 dB lower than existing background)	No additional impact.	Negligible impact; non-local personnel estimated at less than 5 for storage periods; 35 workers (3 skilled, 12 unskilled) during transfer operations

(P) Proposed system design

(A) Alternative to the proposed system design

7.2 ALTERNATIVE FACILITY COMPONENTS

The Bryan Mound SPR facility is designed to use the most feasible options for distribution, brine disposal, and raw water supply system components. These options, however, may be subject to the following shortcomings:

> The proposed common carrier utilization of the Seaway tanker terminal at Freeport Harbor may prove to be too costly, or may not materialize in time to be utilized for ESP fill requirements.

> Dow Chemical may not be able to utilize all of the brine produced, especially if brine of inferior quality is produced.

> Similarly, a raw water source other than/or in addition to Dow Chemical Company reservoirs may be required.

Possible alternatives and the environmental impacts for each of these components are summarized in Table 7.5 and are discussed in detail in the following subsections.

7.2.1 Alternative Distribution Facilities

The proposed method of crude oil supply and distribution for the Bryan Mound SPR facility is to utilize, under a common carrier contract, the Seaway docking and tank farm facilities now under construction. Initially, the facilities would consist of three tanker docks, providing mooring for tanker sizes of from 35,000-85,000 dead weight ton (DWT) and a 3,200,000 barrel tank farm located 7 miles northwest of the harbor. Ultimately the dock facility can be expanded to include 4 docks and the tank farm will be enlarged to a 27,000,000 barrel capacity.

Table 7.5 Summary of Alternative Facilities and Major Environmental Impacts

ALTERNATIVE FACILITIES	CONSTRUCTION IMPACTS	OPERATIONAL IMPACTS
DISTRIBUTION		
1. Seaway Docks and Tank Farm (under construction) Seaway, Inc. (proposed)	No additional dredging. Common carrier facility. Planned 8.2 mile pipeline connection requires 53 acres adjacent to existing levee and industrial land, 54 acres on relatively undisturbed coastal prairie and marsh. Crosses Brazos River.	Increases tanker traffic. (Average 1.1, 254,000 bbl tankers per day; duration 5-10 mos.). Transport accidents: Expected spill quantity 0.59 bbl per tanker trip, median spill 5,300 bbl. Terminal spills: Expected spill quantity 0.86 bbl per tanker trip, median spill 18 bbl. Total calculated loss of 331 barrels per fill or withdrawal cycle.
2. New Barge Docks on ICWW (alternative)	Dredging 106,000 cu. yds. Enclosed 184 acre disposal area filled to an average of 0.35 ft of spoil. Minimum disturbance from 1 mile pipeline connection to storage site.	Anticipated barge traffic (average 14 barges or about 3.4 barge tows per day, duration 5-10 mos). Transport accidents: Expected spill quantity 0.19 bbl per trip, median spill 1,100 bbl. Terminal accidents: Expected spill quantity 0.86 bbl per trip, median spill 18 bbl. Total calculated loss of 2,900 bbl per fill or withdrawal cycle.
BRINE DISPOSAL		
1. Total Utilization Dow Chemical (proposed)	Little or no impact. Existing brine lines to Plant B.	No impact.

Table 7.5 (continued)

2. Disposal in Gulf (alternative)	New pipeline ~2 mi. to Gulf plus 2 mi. to required water depth. Crosses ICWW. Temporary disturbance of 2.0 acres beach, 10.8 acres of coastal prairie and marsh.	Detectable salinity increases (0.1 ppt) in Gulf waters would occur in about 30 acres. Maximum excess isohalines less than 1 ppt on ocean floor under normal current conditions (duration - 10 mos). Benthos in diffuser area would be adversely affected but would repopulate within 2 mos. after cessation of discharges.
3. Subsurface Injection (alternative)	Pipeline construction temporarily affects 10-20 acres of grazing area and coastal prairie or marsh. Full recovery with 1 yr. except ~ 1 acre per each wellhead maintained for life of project. Drilling noise (duration 12 mo.). Drilling mud to be reprocessed; pits reclaimed, little local impact. Slight probability of blowout during drilling.	Small probability (<1.0%) of brine spill due to pipeline or wellhead failure. May destroy local grasses. Over-pressurization could fracture aquiclude resulting in possible fresh aquifer contamination. Well clogging may require flushing possibly resulting in oil fill delays.
<u>RAW WATER SUPPLY</u>		
1. Dow Reservoirs (alternative)	New pipeline from Dow Plant B follows 5 mi existing brine line right-of-way. Temporary disturbance on ~ 15 acres.	Minimum impact on available supply. Vol. of raw water required for displacement during 1 cycle is 10% of total volume of each of two supply reservoirs.

Table 7.5 (continued)

2.	Pipeline from Gulf (alternative)	New pipeline ~ 2 mi., parallel to disposal line to Gulf. Crosses ICWW. Temporary disturbance of 10.8 acres of coastal prairie and marsh. Requires several acres on beach for pump station.	Entrainment of low mobility, unattached organisms near the intake.
3.	Brazos Diversion Channel (alternative)	New pipeline < 1 mile, on industrial land. Temporarily increase turbidity in river.	Entrainment of low mobility, unattached organisms near the intake. Supply may be limited during dry season.

Connections from the Seaway facility to Bryan Mound are planned for a maximum of flexibility in supply and distribution. A 3.7 mile pipeline from the docks to the storage site and a 4.5 mile pipeline from the site to the Seaway tank farm would be constructed (see Table 7.6). The first mentioned pipeline would be routed along the protected side of an existing levee and would present minimum disturbance to the local environment. The second pipeline to the tank farm would cross the Brazos River Channel and some 54 acres of relatively undisturbed coastal prairie and marsh. As described in Section 3.4.2, the construction of this pipeline would have a temporary impact on the coastal environment along the pipeline corridor, primarily consisting of the loss of vegetation which would re-establish within one year. The temporary loss of habitat for primarily fowl, rodents, and reptiles would be insignificant because of the narrow strip of land disturbed, but may also be disrupted periodically during the life of the project by maintenance operations.

As discussed in Section 3.7.1, the probability of an oil spill resulting from a pipeline rupture is very remote (.00425 incidents per year, based on a median spill volume of 1000 barrels) and the effects would be localized if occurring on land. If the rupture occurred at the Brazos River crossing, that section of the pipeline would be isolated quickly by valves located on both sides. The resulting spillage would have potentially more impact on the beaches along the coast (4 miles distant) than on the aquatic environment which is of relatively poor quality at the lower end of the river.

Also described in detail in Section 3.7.2 are the probabilities of oil spill and the associated environmental consequences related to tanker transport accidents in and approaching Freeport Harbor. The maximum increased tanker traffic would occur during an emergency withdrawal of the stored oil. A worst case condition, in which the entire 58 million barrels would be unloaded in 150 days is assumed. This would require 1.5 tankers per day (32,000 DWT) to deliver the oil at the specified 387 thousand barrels per day. With an estimated accident frequency of 3.3×10^{-5} spills per transit (an unlikely event) for tankships, it is expected that 0.008 spills would occur over the 150-day period. The total expectation quantity of oil spilled during the complete withdrawal cycle is 331 barrels, including terminal spills

Table 7.6 Pipeline Alternatives and Affected Areas

		COASTAL PRAIRIE	BEACH	MARSH	WATERWAY	DEVELOPED OR CLEARED AREA	TOTAL
Proposed Distribution Pipeline Seaway Docks	MILES					3.7	3.7
	ACRES					45.0*	45.0*
Proposed Distribution Pipeline Seaway Tank Farm	MILES	2.2		1.5	0.1	0.7	4.5
	ACRES	26.4		18.0	1.2	8.4	54.0
Alternative Distribution Pipeline Barge Docks on ICWW	MILES	0.2		0.3		0.5	1.0
	ACRES	2.4		3.6		6.0	12.0
Alternative Brine Disposal Pipeline: Gulf	MILES	0.7	.12	0.2	0.1	0.88	2.0**
	ACRES	8.4	2.0	2.4	1.2	10.0	24.0
Proposed Raw Water Supply Pipeline: Dow Plant B	MILES					5.0	5.0
	ACRES					15.0***	15.0***
Alternative Raw Water Supply Pipeline: Gulf	MILES	0.7	0.12	0.2	0.1	0.88	2.0
	ACRES	8.4	4.0	2.4	1.2	10.0	26.0

* Parallel existing levee.
** Does not include ~ 2 miles from shore to ocean depth of 20 ft.
*** Parallel to existing Dow right-of-way to Plant B.

and vessel accidents. However, should a credible vessel accident occur, a median spill size of 5,300 barrels is estimated. This amounts to a minute fraction of the total volume of oil to be handled.

An alternative to SPR connections to the Seaway distribution facilities, is to construct an independent barge terminal on the Intracoastal Waterway (ICWW), approximately one mile southeast of the storage site. Construction of this facility would impact marshland, the waterway, a sand dune/dredge material disposal environment, and a cleared/ disturbed land environment. The facility, which may be large enough to accommodate three barges, would be located on the north side of the ICWW. Although the exact location of the alternative dock has not been determined, the general impacts of excavating can be estimated, assuming 3 barge mooring areas (totaling approximately 106,000 cu yds). The soil substrate, consisting of coastal sand, can be easily dredged to the described specification. Such activity would disturb or destroy all benthic organisms within the immediate area (6 to 10 acres) as a result of increased sediment suspension which would suffocate all sessile organisms.

The area of the ICWW where the alternate dock facility has been proposed is historically low in productivity resulting from a poor water circulation pattern. Testing of water quality at the site in 1971 by the Texas Water Quality Board showed extremely low levels of dissolved osygen (bottom readings of 2.6 mg/l and surface reading of 3.5 mg/l).[1] These data, supported by the low numbers of planktonic organisms present, indicate a relatively stagnant water condition. Data taken during the same testing period showed few fish, invertebrates, and benthic organism to be present at the site.[1] These data indicate that dredging for an alternate dock facility would have little or no impact on the organisms of the site. A dock facility, when completed, may have a beneficial impact to the location as it would increase the surface area of the ICWW thus allowing a greater possibility for oxygen exchange of adjacent waters. During oil filling operations when barge and tug traffic is high, area water would be churned up which may further add to the dissolved oxygen levels of the site thereby possibly enhancing the productivity of the area by making it more conducive to habitation by benthic organisms and nekton. This effect would be permanent but relatively insignificant when considering the great expanses of highly productive marshes and other waters in the dome vicinity.

Data obtained in 1974 for an area near the site indicate that the area may be increasing in quality of water. No biological data were taken to confirm that an improvement of habitat has resulted in a greater diversity and numbers of organisms.[2]

The dredge slurry pipe from the site to the disposal area would be 3 miles in length paralleling the ICWW and traversing a dune/dredge disposal environment. Because these pipes would be temporarily placed along the ground surface, little damage to area vegetation and wildlife is expected. Located adjacent to the disposal site are several canals which must be crossed by the slurry pipeline. These canals may be crossed on an existing bridge thereby preventing further impacts to the region.

The disposal area for the dredged material would be in a 184 acre designated disposal area about 3 miles east of Bryan Mound, between Bryan Beach and Quintana, and just southeast of the ICWW. The area, enclosed by spoil retention levees, is a highly disturbed coastal dune and marsh environment which has been used for dredge disposal by the Corps of Engineers. It consists of old channel dredgings and brackish marsh and a small amount of coastal prairie.

Much of the 184 acres of the disposal area which is currently low marshland would be permanently converted to dry land upon eventual dewatering of the dredged material. If the spoil were distributed over the entire disposal site, the elevation would be raised roughly 4 inches by the estimated volume of dredge material. Since the exact acreages of marsh, coastal prairie or old channel dredgings which would be buried cannot be estimated accurately, neither can the productivity lost be estimated. It is most likely that over 60 percent of the area is marsh. Wildlife such as waterfowl, other birds, small mammals, reptiles and amphibians and large, mobile benthic invertebrates would emigrate from the disposal area upon the initiation of disposal activities. Small, immobile invertebrates, plankton and vegetation would be permanently buried. Depending on the dewatering process of the dredged material, as much as 3 to 5 years may pass before revegetation of the area occurs. During that time the material would not serve as a suitable wildlife habitat; however, mosquito breeding areas may increase in potholes in the dredged material.

Due to the increased number of trips required to transport 58 million barrels of crude oil by barge as opposed to tanker transport, as well as a higher accident frequency of 5.4 x 10^{-5} spills per transit, the potential of an accident resulting in an oil spill is increased. Anticipated barge traffic at the alternate facility would be up to 18 barges per day or 4.5 barge tows of 4 barges each per day, for the worst case when drawdown must be completed in 150 days. Delivery rates of 100,00 barrels per day and the expected maximum loading rate of 387,000 barrels per day would be handled at the site. Barges of approximately 21,000 barrels capacity normally would be used. With a transport accident frequency of 5.4 x 10^{-5} spills per transit, the possible number of spills would be 0.15 spills for one complete fill or unloading cycle. In the event of such a spill, the median spill is estimated to be 1,100 barrels. For barges of this size, the spill expectation quantity for vessel accidents is 0.19 barrels per transit, and for terminal losses is 0.86 barrels per operation. Thus, for one fill or withdrawal cycle, the total calculated expected spill volume is 2,900 barrels.

As would be expected, due to the increased number of trips by barges, oil spills from barge operations have greater potential than from tanker operations handling the same volume of oil. Due to the relatively confined area of the Intracoastal Waterway near the alternate barge terminal, however, oil spills could be easily contained for cleanup. The dock areas can be constructed out of the way of normal ICWW traffic so that the area can be isolated by floating booms for containment. Due to the disturbed nature of the ICWW banks and the low productivity of its aquatic environment as discussed earlier, the biological impact of a terminal oil spill would not be severe.

7.2.2 Alternative Brine Disposal

If brine generation at Bryan Mound ever reached a rate too high for Dow Chemical Company to handle as a process feedstock, an alternative disposal location would be the Gulf of Mexico. This alternative would require laying a brine pipeline from Bryan Mound a distance of approximately 2 miles to the Gulf and some 2 miles offshore in order to attain a desired minimum depth of 20 feet for disposal. The route of the required pipeline would necessitate the crossing of salt marsh, the Intracoastal Waterway, and a corporately owned beach, terminating in the Gulf of Mexico. Pipeline construction would require burial along a 100-foot right-of-way and would therefore result in temporary disruption to the region during construction as well as brine discharge impacts in the Gulf during fill operations.

During construction, the temporary disruption of 950 feet of coastal salt marsh (2 acres) is expected. Dominant native species of grasses such as smooth cordgrass, salt grass, and coastal Bermuda, would be destroyed as a result of construction along the 100-foot wide corridor. Revegetation would occur within one year except that rights-of-way may be maintained by occasional mowing.

Vegetation which furnishes habitat to many vertebrates and invertebrates would be removed during pipeline burial. Displaced birds within the region may include the Redwinged blackbird, Seaside sparrow, Great-tailed grackle and many species of shore birds. If construction occurs during the winter months when migratory waterfowl are within the region, the impact created by construction activities would have the greatest effect on wildlife.

Disruption of the marsh environment also would displace organisms by destroying the habitat of shoreline invertebrates such as fiddler crabs, mud crabs, and snails. Loss or displacement of these invertebrates also would have a minor adverse impact on their predators when they are removed form the food chain.

Impact on mammals within the marsh would be adverse but minor along the 100-foot corridor. Marsh mammals within the site are predominantly rabbits and the hispid cotton rat. Construction activity within the region would disrupt and displace these mammals. Impacts on these mammals would, to a limited extent, secondarily affect predator species within the region. Birds such as kites and hawks and predator mammals such as the coyote would be adversely affected by a reduction of prey; however, because the extent of the impacted area is so limited, the effects to predator animals would be extemely minor.

The pipeline corridor would cross the Gulf Intracoastal Waterway near the Brazos River, necessitating dredging for pipeline burial. This would destroy the benthic habitat at the site and result in the destruction of the benthos at and near the immediate proximity to the dredging. According to data from sampling near the site, the region is not productive.[1] Low oxygen levels resulting from little water movement makes the site extremely poor as an aquatic habitat. Turbidity resulting from dredging would affect the few mobile vertebrates and invertebrates of the region. Fish and crabs within the waters would be temporarily displaced to avoid turbid conditions at and near the site. Because the productivity of the construction area is so poor, impacts resulting from construction would be minimal. Recovery of the aquatic community would require several months after pipeline burial.

The pipeline will cross about 136 feet of a sand-dune type of habitat which was formed due to dredge spoil from the ICWW construction. Although not a natural setting, the "dune" environment is stabilizing and the pipeline would disrupt approximately 0.3 acres. Although definitive impacts cannot be determined in regard to the extent of excavation which would be necessary in order to bury the pipeline in the dune environment, they may be locally severe. Destruction of this environment constitutes possibly the greatest impact to a regional ecosystem since the dune area is one of the most fragile of any along the coastal United States. The dunes, which consist predominantly of loose sand, are often held in place only by the roots and runners of the sparse vegetation. Vegetation such as the largeleaf pennywort (Hydrocotyle bonariensis), the beach evening primrose (Oenothera drummondii), saltmeadow cordgrass (Spartina patens), and the soilbind morning-glory (Ipomoea pes-caprae)[3] are primarily responsible for the stabilization of the dunes. Loss of these vegetation types along a corridor may result in blowouts or washouts from tide and storm actions. Historically, replanting disturbed dune areas has been successful and given that these efforts are initiated during favorable weather conditions, substantial re-vegetation can take place within 6 months. In addition, the dune area provides valuable habitat for rodents such as the hispid cotton rat and a variety of skinks and lizards.

Approximately 650 feet of public beach would be traversed for the brine disposal pipeline to the Gulf. The use of this corridor would have an impact on visitors to the site who use the area for recreational purposes. Like much of the Texas Gulf Coast, the beach in proximity to the site is heavily used by bathers during the summer months and by fishermen nearly year around. Construction activities along the beach would create an annoyance to visitors in the form of temporary loss of the visual aesthetic quality of the region and increased noise levels from construction vehicles and machinery. Construction activities would, to a limited extent, displace shore birds and wading birds. Like most of the Texas Gulf Coast, the region provides suitable feeding areas for birds such as terns, gulls, willets and killdeer. Because these birds are generally accustomed to high levels of human activity along the beach environment, the construction of the pipeline would not create a permanent or major temporary impact on the bird populations of the area.

Dredging activities along the littoral regions of the beach would destroy the benthic invertebrates of the area. As a result of these activities, clams and other sessile organisms would be killed. It is expected that 10,000 square feet of this specialized tidal area would be temporarily lost from production. Further, if the littoral substrate is not replaced in a manner which would assure that erosion would not occur, a washout may evolve from tidal action. Such a washout can effectively alter the present environment from its usually productive state.

The extention of the pipeline into the Gulf of Mexico would be 2 miles in length where it terminates at the diffuser. Installation of the pipeline would result in the destruction of the benthic community along the length of the underwater pipeline. Given a 100-foot corridor of Gulf bottom disturbance, a total of 24 acres of benthic habitat will be lost. This loss of habitat represents only a negligible portion of the regional Gulf Coast ecosystem. During pipeline installation impacts in the form of displacement of nektonic organisms would occur. After completion of construction, the fish community would return to normal activities within immediate proximity of the pipe. Benthic organisms within proximity to the site are predominantly polychaetes which comprise approximately 75 percent of offshore assemblages. Nektonic organisms within the immediate water are dominated by phytoplankton, zooplankton (including nauplii and copepods), and many species of fish, primarily of the shad, mullet, menhaden, catfish and drum families.[3]

A simple diffuser design is assumed in plume calculations (Appendix B.8). Seventy 9-inch ports are oriented upward at about 5 feet off the ocean floor and spaced 10 feet apart. The disposal rate of 9,333 gallons per minute is assumed. The actual disposal rate for all of the displaced brine at the currently proposed capacity would average 7000 gallons per minute over a period of 150 days. According to the model presented, the 250 ppt brine* is rapidly diluted in 35 ppt seawater under normal current conditions, assumed to be 0.6 knots or 1.013 feet per second. The overall increase in salinity on the bottom is reduced to 0.3 ppt at a distance of 300 ft downstream. The far field traces of 0.1 ppt excess isohalines extend 1700 ft downstream. At all points on the bottom excess salinity is less than 1 ppt. The total ocean area affected by excess isohalines of 0.1 ppt or greater is shown to be approximately 30 acres under normal current conditions.

Impacts of Brine Disposal into the Gulf

In general, the results of the model presented (Appendix B.8) indicate that except for points immediately adjacent to the diffuser ports, the salinity excesses are relatively insignificant with no portion of the ocean floor in the disposal area experiencing excesses greater than 1 ppt. The mortality to low mobility organisms, such as phoronids, pelecypods, and polychaetes, close to the diffuser would be irreversible. Recolonization, however, should occur relatively quickly once the brine discharges have ceased. There is no reason to believe that mobile organisms susceptible to higher salinities would not avoid the discharge area. Some stimulation of primary and secondary production throughout the marine communities may occur at the edges of the area of appreciable mixing. Nutrient availability for primary producers and consumers may be increased by the mixing.

---

*Assuming the excess brine to be disposed is less than fully saturated (~265 ppt) to prevent crystalization during leaching additional storage space.

Either due to current transport or free mobility, non-benthic organisms would encounter minimal impacts from brine discharges into the marine environment. Mackin, working on oil field brine discharge, reports that marine fishes, mobile organisms, and current-carried forms apparently are not affected by high salinity discharges in large water bodies.[4] Their time in traversing the zone of high salinity is too brief for long lasting impacts.

All available data indicate that mobile organisms which prefer lower salinity levels would avoid the brine discharge area with no apparent difficulty. It is expected that such species as the Southern oyster drill (Thais haemastoma), the stone crab (Menippe mercenaria), the sea robin (Prionotus scitulus), the gray snapper (Latjanus griseus) and the sea bass (Centropristes philadelphica) would avoid areas of high brine discharge.

Mackin reports that if brine concentrations are great enough, an effect on benthic organisms can be measured. In large bodies of water where the capability of dilution is great, dilutions of 1000 parts of seawater to one part of brine can occur in distances of from 8 to 50 feet.[4] However, a continuous discharge over several years, creating localized plumes may serve to increase local salinities by 5 ppt. The effect on mobile organisms would be slight to negligible (similar to that reported for nekton) but the effect on sessile or slightly mobile organisms with narrow salinity tolerances would be moderate to severe.

Given a substantial salinity increase (5-10 ppt) three impact zones would develop. The first zone would be an area of near total destruction. Phoronids, pelecypods, and polychaetes would be destroyed, bacteria may be an exception. In the second, or transition zone, a depression of species and individuals may occur. Stunted development may also be detectable. The extent of the second zone would vary depending on dilution factors. Mackin believed this zone may extend from 100-300 ft in a large body of water.

The third impact zone would be an area of stimulation of the marine communities. Bacteria, yeasts, fungi and phytoplankton numbers would be increased. Minter[5] and Mackin[6] reported heavy phytoplankton and algal productivity near the edge of a transition zone. Increased productivity of organisms near the bottom of the food chain would elicit corresponding increases in primary consumers (zooplankton and filter feeders such as polychaetes and pelecypods) and secondary consumers (crabs).

The impact of offshore brine disposal in an area of limited benthic productivity should not be significant. The localized destruction of the benthic fauna in the immediate vicinity of the diffuser should have negligible effects on total production of the coastal area.

The proposed alternative brine disposal plan would be carried out in accordance with all applicable Federal laws and regulations (see Section 9.2).

Deep Well Injection

A second alternative brine disposal technique would be to use the deep subsurface aquifers beneath the Bryan Mound area to inject the waste brine. In the general vicinity the Evangeline aquifer has been logged to begin near the 1200-foot depth and extend below the 4500-foot depth. In this area the aquifer is largely composed of sand containing water having more than 3000 milligrams per liter of dissolved solids.

A system of 10 injection wells, each handling up to 1000 gallons per minute and spaced on 1000 ft intervals would be located in an area approximately 1 mile off the perimeter of the salt dome. Construction of the pipeline would require that a service roadway be built the length of the system. Because of the marsh environment, elevated fill of several feet would be required for these access roadways. In addition, where sufficient dry land is not available, an area of fill would be required at each well site. An estimated total of up to 20 acres would be primarily affected by the construction of this disposal system. Drilling of the wells from 5000 to 7000 ft deep would be accomplished by typical oil field equipment. Drilling mud pits would be reclaimed after the completion of each well.

During operation, the use of brine ponds as surge pits for the injection pumps should allow the settling of any impurities in the brine and minimize the problem of damage to the pumps or clogging of the wells. Because of the surge capability of the pits, however, a temporary shutdown of the injection system for flushing the wells should not impose any delay on the crude oil filling operations.

7.2.3 Alternative Displacement Water Source

According to present plans, the water required to displace the stored oil would be supplied by Dow Chemical Company from their fresh water supply. A new 24-inch pipeline would be constructed along an existing Dow pipeline right-of-way, some 5 miles to their chemical plant just north of Freeport. The construction of this pipeline should have a minimum impact on the local environment since the route is along the protected side of the Brazos River levee on disturbed industrial land.

The water would be taken from a canal which brings water to the Dow plants from two reservoirs. Brazoria Reservoir is located 12 miles northwest of Freeport while Harris Reservoir is about 22 miles to the northwest. Water to fill these reservoirs is purchased from the Lower Brazos River Authority during high river stages. Each reservoir has a surface area of greater than 5000 acres and a depth of at least 10 feet.[8] Therefore, the volume of each of the supply sources is at least 10 times the projected water requirement for one cycle of crude withdrawal. Section 3.2 discusses the minimal environmental impacts on the use of this raw water source in more detail.

An alternate displacement water source utilizing the Gulf of Mexico is considered feasible for Bryan Mound. Such a system would necessitate installation of a 2-mile pipeline similar to that described for the alternate brine disposal system. As a result, impacts to the environment during construction would be identical, with the exception of a pumping station to be located either on an offshore platform or a small plot of land (1-2 acres) on or near the beach.

Impacts occurring as a result of impingement and entrainment at the intake would occur during operation. Assuming an opening of sufficient dimensions to assure a low velocity of intake water (approximately 0.6 m/sec) and protective screening (1/2 inch mesh) over the opening, impacts to marine organisms would be minimal. In general, entrainment would affect only planktonic organisms. Although it is assumed that an extremely high number of these microscopic organisms would be entrained and killed, it is impossible to determine the most probable number that would be affected. Precise estimates of entrained planktonic organisms depend on the season, the location of the intake pipe, and tidal factors all of which influence planktonic development and abundance in the marine environment. Even if displacement water were taken in at a time of highest plankton abundance, the great volume of Gulf water would suffer an insignificant loss of plankton. Impingement is expected to pose no threat to large mobile nekton since it can be assumed that cleaning of screens to maintain low intake velocity would prevent large fish and other organisms from becoming trapped against the screen.

A second alternative for displacement water would be the Brazos River adjacent to the site and less than a mile from the central pumping facilities. The intake on the Brazos River would most likely be located approximately at mile 2 of the river. Recent data taken at mile 2 by Texas A & M University[2] show the region to be an estuarine environment with surface salinity levels as high as 20 ppt and bottom salinity levels as high as 27 ppt (summer months). Dissolved oxygen at mile 2 ranges from 9.3 mg/l (winter surface) down to 4.8 mg/l (spring bottom). All other water quality measurements made by Texas A & M University for mile 2 of the Brazos River were normal for a typical river/estuarine system. Seasonal changes in volumetric flow rates range from about 400 cfs to nearly 20,000 cfs.

Installation of the intake could necessitate dredging along a small portion of the river. As a result, the benthic community consisting mainly of polychaetes (approximately 75 percent) would be destroyed. Additionally, turbidity resulting from the action and extending downstream would create a slight disturbance to nektonic organisms which feed mainly by sight. Minor impacts to fish may be realized in abrasion to gills and disorientation resulting from turbid conditions. Because these conditions would be of a very short term, they do not present a severe impact to the ecosystem.

Depending on the location of the pipe to bring the river water to the dome, marsh and/or coastal prairie may be impacted. These impacts would be minimal because of two reasons; the pipeline length would probably be less than one mile long, and the pipeline would cross an industrial area which has already been developed.

7.3 NO-ACTION ALTERNATIVE

A description of the no-action alternative and its impacts, as it applies to the entire program, is provided in the Final Programmatic EIS (FES-76-2). Within the SPR, a decision not to develop the Bryan Mound facilities would result in the development of one of the other candidate sites to take its place. In that case, the impacts described in Section 3.0 would not occur and the existing environment of Bryan Mound (as described in Section 2.0) would be maintained. However, a decision not to develop Bryan Mound would result in other impacts: those associated with the alternate facility. Since many of the candidate sites are also located in the Gulf Coast Region, it is likely that many of the impacts resulting from the development of the replacement site would be substantially the same as those for Bryan Mound. However, the detailed impacts of any particular facility are very site-specific and would be discussed in the EIS for that site.

REFERENCES

1. J. S. Kirkpatrick, "Lower Brazos River Project Final Report," Texas Water Quality Board. 1972.

2. R. E. Withers and R. L. Garrett, "Water quality management in the Brazos River Coastal Zone," Report No. 1, Basic Data. 1975.

3. "Seadock Environmental Report." Prepared for Seadock, Inc., Austin, Texas, in part by Dames and Moore, Houston, Texas; Institute for Storm Research Houston; Evans Hamilton, Inc., Houston. 1974.

4. J. G. Mackin, "A review of significant papers on effects of oil spills and oil field brine discharges on marine biotic communities," Texas A & M Research Foundation Project No. 737. 1973.

5. K. W. Minter, "Standing crop and community structure of plankton in oil refinery effluent holding ponds." Ph.D. Thesis, Oklahoma State University. 1965.

6. J. G. Mackin, "Report on a study of the effect of application of crude petroleum on salt grass, Distichlis spicata," Texas A & M Research Foundation, Project 9. 1950.

7. Dames and Moore, "Environmental Analysis of Louisiana Offshore Oil Port," prepared for LOOP, Inc., New Orleans, La. 1975.

8. Ed Williams, Personal Communications, Dow Chemical Company, Freeport, Texas, March 1976.

8. RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE PLANS

The Texas Highway Department has developed a forecast of Brazoria County land use for 1990. This information is based on available data regarding projected land activity. Future land use plans for the various cities and subdivisions have influenced anticipated growth directions. A comparison of existing and forecasted land use in the county, from highway department tabulations, is given in Table 8.1.

The greatest percentage of increases in land use will occur in industrial land use (up more than 547 percent, to 34,200 acres by 1990), and in highway rights-of-way land use (up 709 percent to 3,980 acres). Residential and commercial land use will also increase notably, up 217 percent and 225 percent, respectively. All forecasted increases in land use for industrial, residential, commercial, and other activities will represent the conversion of undeveloped land. Despite the major increase in more urbanized land use categories, almost 785,000 acres, or 81.5 percent of the county's total area, will remain undeveloped, indicating that the county should enter the next century maintaining its predominantly rural environment. By 1990, industrial land use will be comparable to residential land use, with 4.06 percent and 3.55 percent of the county's area, respectively. The forecasted land use as developed by the Texas Highway Department, is based on a 1990 population of 400,000. As discussed in Section 2.6.1, there is one historic site in Brazoria County on the National Register of Historic Places. Two additional sites have been nominated for review of possible addition to the National Register. None of these three sites would be affected by the proposed project. In addition, it has been determined that no non-federally owned sites of historical, architectural or archeological significance would be affected by the project.

Projected significant characteristics of future land use in Brazoria County include:

- o Sparse distribution of urban development throughout the county, but particularly in the area north of State Highway 6, and in the area between Brazoria and Sweeny.
- o Additional public open space associated with enlargement of wildlife refuges and with developmewnt of Bryan Beach as a state park.
- o Extensive industrial development in the vicinity of Chocolate Bayou.

Table 8.1 Land Use in Brazoria County, Texas, 1970 and 1990

	1970		1990		
	Acres	% of Total Area	Acres	% of Total Area	Percent Change 1970-1990
Residential (single and multiple combined)	12,362	1.28	39,140	4.06	217.4
Commercial and Service	2,282	0.24	7,420	0.77	225.0
Industrial	5,284	0.54	34,200	3.56	547.2
Educational	1,033	0.11	2,760	0.29	167.0
Open Space	21,635	2.25	32,154	3.34	48.6
Resource Production	1,036	0.11	1,036	0.11	0
Highway Right-of-Way	491	0.05	3,980	0.41	709.0
Water	57,138	5.94	57,438	5.97	0.5
Undeveloped land	861,011	89.48	784,147	81.49	9.8
Total Area	962,275	100.00%	962,275	100.00%	100.00%

Source: Texas Highway Department, Houston-Galveston Regional Transportation Study

- Predominance of scattered strip development along existing roads and in the vicinity of anticipated county road or state highway intersections.

It should be noted that this land use forecast is based on the projection of existing trends. It is not presented as a proposed land use plan incorporating policy criteria for sound resource use.

Factors Influencing Growth

In the process of reviewing the 1990 land use forecast, the State Highway Department developed two maps as analytical tools. The maps contain data related to the physical aspects on the efficient, safe, and economic use of resources. Considerations for future development depicted on Figure 8.1 include the following incentives for urbanization. Arrows indicate direction of expansion of urban areas and travel to major industrial centers (denoted by *).

- Projected growth rates and directions of existing urban centers.
- State highways and farm to market roads.
- Proposed Freeway 288.
- Coastal beach.
- Proposed offshore and onshore terminal facilities (superport).
- Pressures for growth associated with southward expansion from Houston.
- Rivers and fresh water lakes.
- Wooded areas.

Deterrents and Constraints for Urbanization

The following characteristics are considered as deterrents to expanding Brazoria County urbanization:[1]

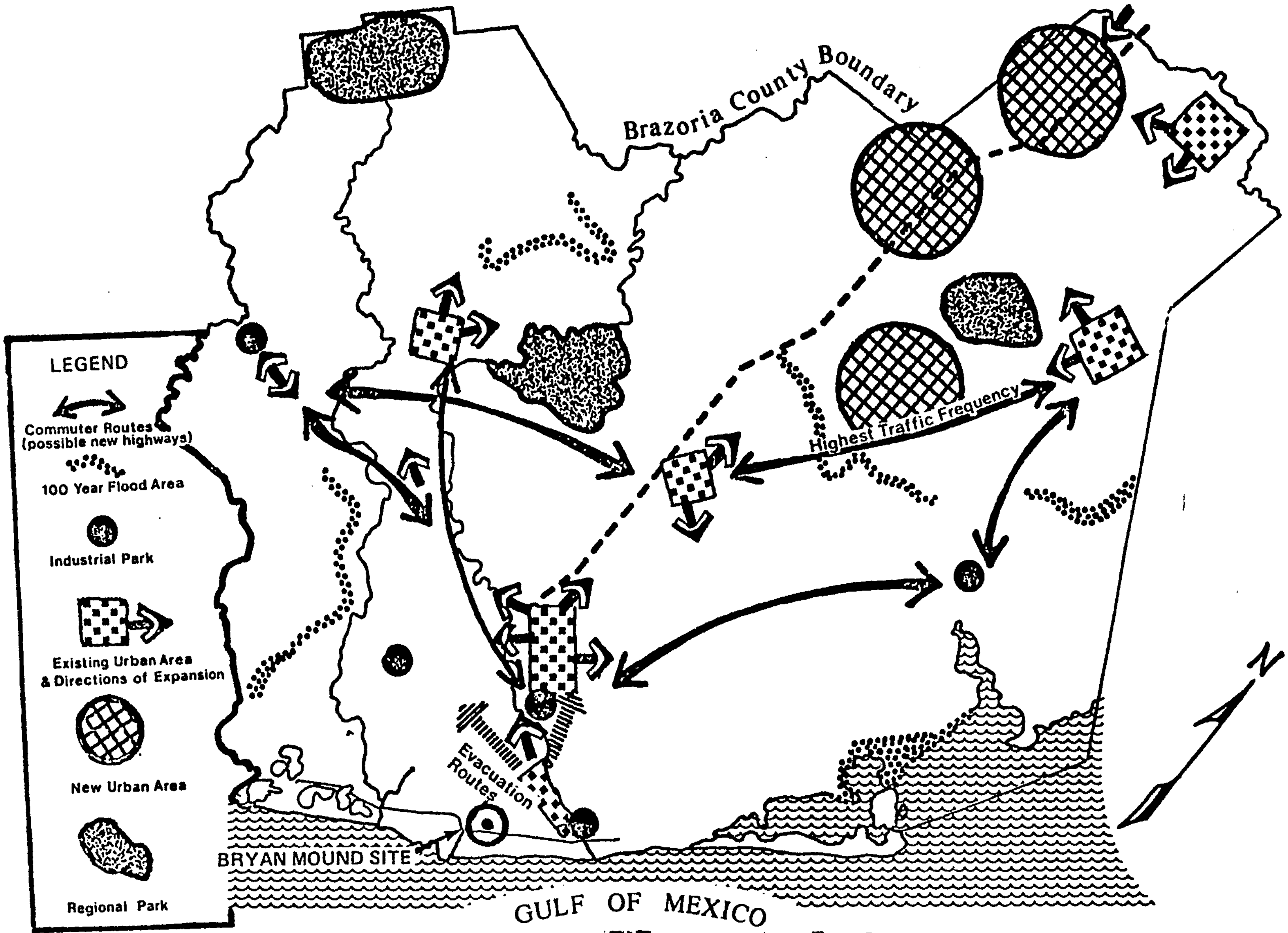


Figure 8.1 Factors Influencing Growth, Brazoria County, Texas

- Flood prone areas
- Marshlands
- Wildlife sanctuaries
- State institutions
- Pipelines
- Proposed state and regional parks
- Oil and gas fields
- Proposed county airport
- Productive agricultural lands.

Recommended land use goals for guiding growth within Brazoria County include establishment of a program for the optimum use of resources (natural and human) ensuring orderly economic growth, enhancing and preserving unique regional advantages or assets, providing for quality in the total environment and compatibility and functional efficiency among the various land use components that comprise the regional community, and ensuring the health and safety of the populace.[1]

Acknowledging the above incentives and deterrents to growth and guided by the goals, the alternate land activity pattern for the county considers the following urbanization development concepts:

- Concentrate community urbanization in areas not prone to floods.

- Emphasize expansion of existing urban centers rather than of scattered development pattern.

- For health, and for aesthetic reasons, physically separate community living areas from heavy industrial centers.

- Encourage creation of definable centers for urbanization rather than of unplanned development.

- Balance urban and private/public open space development.

- Retain large tracts of land for agricultural use.

- Discourage urbanization abutting the new freeway to maximize free traffic flow.

- o Concentrate heavy industrial development in the southern part of the county near the Intracoastal Canal and in the vicinity of Chocolate Bayou.

Potential Development of the Site and Adjacent Areas

The projected land use plan as developed for future urbanization in Brazoria County is shown in Figure 8.2. It indicates anticipated growth relationships rather than providing a definitive land use program for Brazoria County in 1990. The allocation of large areas of land for controlled open space will become increasingly important in the context of both county and regional needs.

Local Planning Agencies

Brazoria County is a member of the Houston/Galveston Area Council which is concerned with the concept of regional planning and cooperation. The Council makes studies and plans to guide unified development of the area, eliminate duplication, and promote economy and efficiency in coordinated area development. The Council makes recommendations to member governments and may, upon request, assist in implementation of those plans. The Brazosport Planning Board is part of the Brazosport Chamber of Commerce. The Board maintains a master plan for Brazosport and coordinates planning for the Brazosport area. Current plans are considered highly flexible and appear to be designed to accommodate the needs of expanding industrialization along the Brazoria County Gulf Coast area. Therefore, it is not anticipated that any land use policies or plans would be in conflict with the proposed Bryan Mound dome Strategic Petroleum Reserve facility.

REFERENCES

1. Bernard Johnson, Inc., "Brazoria County Comprehensive Transportation Plan," Brazoria County Transportation Planning Commission, pp. 142, 1975.

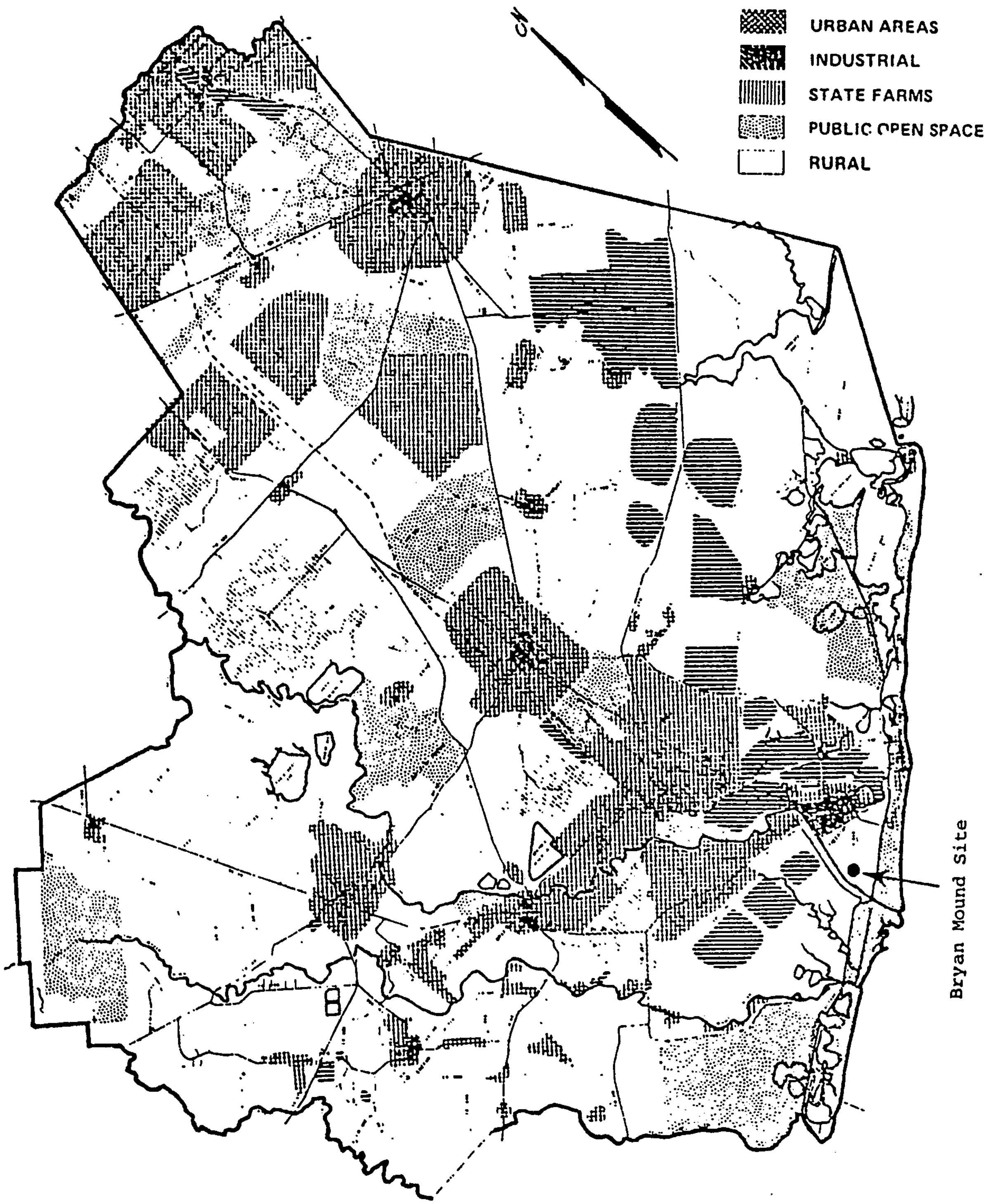


Figure 8.2 Future Urbanization Pattern, Brazoria County, Texas

9. CONSULTATION, RELATED PERMITS, AND DISCUSSION OF COMMENTS

Various local and regional agencies contributed information and assistance for the preparation of this Environmental Impact Statement. A list of these agencies is given in Section 9.1. Further advice and coordination will be sought from agencies having regulatory jurisdiction over those segments of the environment which will or could potentially be affected by the proposed project. Procedures are currently underway to prepare applications for those permits and licenses which would be required to proceed with the implementation of the project. Those Federal and state agencies whose concerns interface with the proposed actions are listed in Section 9.2.

The Draft Environmental Impact Statement was released for public review and comment in September 1976. A list of those agencies and organizations from which comments were requested is given in Section 9.3. The Draft Statement was sent to the Texas State Clearinghouse so that all state agencies of Texas having an interest in the proposed project could review the document and respond to statements and conclusions relating to their concerns. Those comments which were received within the time allotted, are included in Section 9.4. Minor changes to the text of the statement have been made in response to these comments. The comments from various agencies are included in their entirety in Appendix J.

9.1 Agencies and Groups Consulted

In preparation for the Draft Environmental Impact Report, numerous agencies, governmental units and groups were consulted for information and technical expertise pertaining to the proposed project. These groups are listed alphabetically below.

Federal

United States Army Corps of Engineers, Galveston, Texas
United States Coast Guard, Port Arthur, Texas
Environmental Protection Agency, Dallas, Texas, Region VI
Federal Insurance Administration
United States Geological Survey, National Center, Reston, Virginia
Department of the Interior
National Marine Fisheries Commission
National Oceanic and Atmospheric Administration, New Orleans, Louisiana
Occupational Safety and Health Administration, New Orleans, Louisiana

State

General Land Office, Austin, Texas
Texas Park and Wildlife Commission, Austin, Texas
Railroad Commission, Austin, Texas
Tax Assessors Office, Freeport, Texas
Texas Water and Light Commission, Austin, Texas
Texas Water Quality Board, Austin, Texas

Local

Brazos River Authority, Wade, Texas
County Engineer, Brazoria, Texas
Port of Houston Authority, Houston, Texas

Other

Dow Chemical Company, Freeport, Texas
Gulf Oil Corporation, Houston, Texas
Lockheed Aircraft Company, Clean Lake City, Texas
LOOP, Inc., New Orleans, Louisiana
Rice University, Houston, Texas
Seadock, Inc., Houston, Texas
Texas A&M University
Texas Eco, Bryan, Texas
University of Houston, Houston, Texas

9.2 ENVIRONMENTALLY ORIENTED PERMITS AND LICENSES

Regulatory Bodies and Their Jurisdictional Concerns:

A number of Federal regulations which must be complied with during project development are listed in Table 9.1. Also included in the list are state regulations which are relevant to the program. FEA will consult with the state agencies in charge of implementing these regulations pursuant to the Intergovernmental Coordination Act of 1968.

Table 9.1 Regulatory Bodies and Their Jurisdictional Concerns

AGENCY	REGULATORY JURISDICTIONAL CONCERNS	REFERENCE	REMARKS
1. U.S. Army Corps of Engineers, Galveston, District Engineer	"Regulations on Navigable Waters"	33 CRF 209	
	A. "Permits for Activities in Navigable Waters or Ocean Waters"	33 CFR 209.120	
	1. Prohibits the unauthorized obstruction or alteration of any navigable waters.	33 CFR 209.120b(2)	
	2. Discharge of dredged materials into navigable waters.	33 CFR 209.120,(b)(3), (b)(7),(g)(5)(ii)	
	3. Structures or activities affecting the navigability of navigable waters; includes structures under a navigable waterway.	33 CFR 209.120,(b)(3) (e)(i),(g)(5)(ii)	
	4. Discharge of refuse into navigable waters.	33 CFR 209.120(b)(4)	
	5. Temporary occupation with use of any sea-wall, bulkhead, etc.	33 CFR 209.120(b)(5)	
	6. Declares a national policy to encourage a productive and enjoyable harmony between man and his environment.	33 CFR 209.120 (c)(4)	
	7. Preservation of the quality of the aquatic environment as it affects the conservation, improvement and enjoyment of fish and resources.	33 CFR 209.120(c)(5)	
	8. License needed which will reflect upon properties listed in the National Register of Historic Places.	33 CFR 209.120(c)(7)	
	B. "Piers, Dredging, etc. in Waterways."	33 CFR 209.130	
	1. Structures or activities affecting the navigability of navigable waters; includes structures under a navigable waterway.	33 CFR 209.130(b)(14)	
	2. Work connecting canals to navigable waters.	33 CFR 209.130(b)(16)	
	3. Fixed structures on the outer continental shelf.	33 CFR 209.130(q)	

Table 9.1 Regulatory Bodies and Their Jurisdictional Concerns (continued)

AGENCY	REGULATORY JURISDICTIONAL CONCERNS	REFERENCE	REMARKS
	4. Piers or bulkheads at the coastline.	33 CFR 209.130(b)(13), (b)(12)	
	C. "Permits for Discharges or Deposits into Navigable Waters."	33 CFR 209.131	
2. U.S. Coast Guard, District Commander of 8th Coast Guard District (New Orleans)	<u>Coast Guard Regulations on Oil Spills</u>	33 CFR 154	Letters of intent must be submitted and approved 60 days prior to date the operation is intended to begin.
	A. Letter of intent to operate oil transfer facility.	33 CFR 154.110	
3. U.S. Environmental Protection Agency, Region VI	<u>Regulations on Policies and Procedures for the National Pollutant Discharge Elimination System (NPDES)</u>	40 CFR 125	
	1. These Regulations proscribe the policy and procedures to be followed by the Administrator of the U.S.E.P.A. pursuant to Sections 402 and 403 of the Federal Water Pollution Control Act.	33 USC 1251 nt	
	2. Requires permits . . .for any industrial discharges into navigable waters including the "contiguous zone" territorial sea. Such a permit would probably be necessary for discharge of effluents from the offshore and onshore terminal waste treatment facilities. In addition, should the NPDES permit system requirements not apply to a particular operation, certification is still required from the EPA administrator (or from appropriate designated State or Interstate agencies) whenever a Federal license or permit is being sought for activities which may result in discharge into the navigable waters.		

Table 9.1 Regulatory Bodies and Their Jurisdictional Concerns (continued)

AGENCY	REGULATORY JURISDICTIONAL CONCERNS	REFERENCE	REMARKS
	<u>Regulations on Oil Pollution Prevention</u>	40 CFR 112	
	A Spill Prevention, Control, and Countermeasures Plan (SPCC) must be prepared for each oil handling facility, within six months of the commencement of facility operations.	40 CFR 112.3	
	<u>Regulations on Transportation for Dumping, and Dumping of Materials into Ocean Waters</u>	40 CFR 220	
	Permit for ocean dumping required for brine disposal.	40 CFR 220.1(b)(2)	
4. Texas Water Quality Board	(a) Permit for discharge of waste into public waters. (b) Permit required prior to construction of a treatment facility.	Texas Water Quality Act, Chapter 21, Vernon's Texas Water Code, Section 21.079	Board will submit letter of objection or no objection to Corps.
	(c) A waste discharge from any industrial, public or private project or development which constitutes a new source of pollution is required to have the highest and best degree of treatment available under existing technology.	Texas Water Quality Rule 635.6	If treatment facilities are build in a flood area, the design report shall describe precautions taken to prevent waste from entering floodwaters.
	(d) Notification must be given within 24 hours of any spill or accidental discharge.	Texas Water Quality Rule 635.4	
	(e) Activities which are inherently capable of causing spillage or accidental discharge of polluting substances are subject to regulations or preventive measures adopted by the Board.	Texas Water Quality Rule 635.6	

Table 9.1 Regulatory Bodies and Their Jurisdictional Concerns (continued)

AGENCY	REGULATORY JURISDICTIONAL CONCERNS	REFERENCE	REMARKS
	(f) Certification of NPDES permits.	Texas Water Quality Rules, Section 645.	
	(g) Permits required for storm water runoff.		Board will submit letter of objection or no objection to Corps.
STATE			
5. Texas Water Development Board	Certification that well casings are sufficiently sealed and that use of wells will not contaminate fresh water supplies.	Texas Water Conservation Rules and Regulations (Rules 8 and 13)	
6. Texas Water Rights Commission	(a) Appropriate permit required for use of surface waters and leaching and displacement.	Texas Water Code, Chapters 5 and 6	Annual Report of water taken from streams and reservoirs may be requested.
	(b) Appropriation permit required for use of surface waters for water supply system for human use.		
7. Texas Air Control Board	(a) Construction permit required for any facility that may emit air contaminants.	Texas Clean Air Act (Article 4477-5) Section 3.27; Texas Regulation VI, Rule 601	Plans and specifications are to be submitted for determining compliance with air control standards.
	(b) Operating permits are issued for any facility that emits air contaminants.	Texas Clean Air Act (Article 4477-5), Section 3.28.	Application must be made within 60 days after operation commences; monitoring data may be required.

Table 9.1 Regulatory Bodies and Their Jurisdictional Concerns (continued)

AGENCY	REGULATORY JURISDICTIONAL CONCERNS	REFERENCE	REMARKS
8. Texas Railroad Commission	(a) Notification of drilling operations relating to oil activities.	Texas Railroad Commission Rules and Regulations	
	(b) Permit for oil pipelines	Rule 70	
	(c) Submission of monthly storage reports and annual pipeline operation reports.		
	(d) Permit required to dispose of brine.		If all brine is transferred to Dow, no permit is required.
9. Texas General Land Office	Right-of-way for pipelines crossing public lands.		Office will submit letter of objection or no objection to Corps.
10. Texas State Department of Highways	Right-of-way for pipelines crossing highways.		
11. Texas Historical Commission	(a) Notification of findings of survey conducted to determine whether National Register of Historic Places property would be affected by the project.	16 U.S.C. 470(f) "National Historical Preservation Act of 1966.	
	(b) Notification of findings of survey conducted to determine whether properties which would be eligible for nomination to the National Register of Historic Places would be affected by the project.	Executive Order #11593 "Protection and Enhancement of the Cultural Environment," May 1971.	
12. Texas Parks and Wildlife Department	(a) No permit required if all dredged spoil will be used to backfill pipeline trench, and stream banks will be returned to original condition after pipeline construction.		Office will submit letter of objection or no objection to Corps.
	(b) As above, and, if beaches will be returned to original condition after use of Gulf water for leaching and displacement.		

Table 9.1 Regulatory Bodies and Their Jurisdictional Concerns (continued)

AGENCY	REGULATORY JURISDICTIONAL CONCERNS	REFERENCE	REMARKS
13. Texas Department of Health Resources	(a) Approval of plans and specifications required before construction of water supply system, for human use, is commenced.		
	(b) Permit required for collection, handling, storage, and disposal of municipal or industrial solid waste.		
14. Velasco Drainage District	Permits required for laying pipelines through two levees and through wave barrier.		District will submit letter of objection or no objection to Corps.
15. Brazoria County Commissioners Court	Approval required for laying pipelines across county roads.		
16. Brazoria County Health Department.	Permit required for septic tank.		

9.3 PARTIES FROM WHICH COMMENTS WERE REQUESTED

As a part of the review process for the Draft Environmental Impact Statement, comments have been requested from the departments, agencies, and organizations listed below:

Federal Agencies

Advisory Council on Historic Preservation
Appalachian Regional Commission
Department of Agriculture
Department of the Army, U. S. Corps of Engineers
Department of Commerce
Department of Defense
Energy Research and Development Administration
Council on Environmental Quality
Environmental Protection Agency
Federal Energy Administration (10 Regional Offices)
Federal Power Commission
Department of Health, Education, and Welfare
Department of Housing and Urban Development
Department of Interior
Interstate Commerce Commission
Department of Labor
National Science Foundation
Nuclear Regulatory Commission
Department of State
Tennessee Valley Authority
Department of Transportation
Department of Treasury
Water Resources Council

State Agencies

Louisiana Clearinghouses
New York State, Office of Environmental Analysis
Texas Clearinghouse

Regional and Local Agencies

Brazoria County, Texas
Gulf States Marine Fisheries Commission
Velasco Drainage District, Clute, Texas

Other Organizations

Allied Chemical Corporation
American Fisheries Society
American Littoral Society
American Petroleum Institute

Center for Law and Social Policy
Dow Chemical Company, Freeport, Texas
Electric Power Research Institute
Environmental Defense Fund, Inc.
Environmental Policy Center
Friends of the Earth
Funds for Animals, Inc.
Institute of Gas Technology
Interstate Natural Gas Association
Izaak Walton League of America
LOOP, Inc.
National Association of Counties
National Audubon Society
National League of Cities
National Parks and Conservation Association
National Resource Defense Council, Inc.
National Wildlife Federation
Seadock, Inc.
Sierra Club
Sierra Club-Gulf Coastal Regional Conservation Committee
Sierra Club-Southern Plains Regional Conservation Committee
U. S. Conference of Mayors

9.4 Parties From Which Comments Were Received

9.4.1 Federal Agencies

9.4.1.1 Advisory Council on Historic Preservation

Comment a

"Compliance with Section 106 of the National Historic Preservation Act of 1966 (16 U.S.C. 470[f]) The Council must have evidence that the most recent listing of the National Register of Historic Places has been consulted . . . If no National Register property is affected by the project, a Section must appear in the environmental statement."

Response

Section 2.6.1 (page 2-72) of the Draft Environmental Impact Statement describes the two proposed and one existing National Register Historic sites in Brazoria County. None of these sites would be affected by the proposed project. The draft has been supplemented with a description of FEA's compliance with Section 106 of the "National Historic Preservation Act of 1966. (Section 2.6.1,8)

Comment b

Compliance with Executive Order 11593, 'Protection and Enhancement of the Cultural Environment' of May 13, 1971. Under Section 2(a) of the Executive Order, Federal agencies are required to locate, inventory, and nominate elegible historic, architectural, and archaeological properties under their control or jurisdiction to the National Register of Historic Places. The results of this survey should be included in the environmental statement as evidence of compliance with Section 2(a) . . . The environmental statement should contain a determination as to whether or not the proposed undertaking will result in the transfer, sale, demolition, or substantial alteration of eligible National Register properties under Federal jurisdiction."

Response

In compliance with Section 2(a) of Executive Order 11593, the project area has been surveyed for this purpose. The results of this survey show that the proposed undertaking will not result in the transfer, sale, demolition, or substantial alteration of eligible National Register properties. The Draft Statement has been supplemented with this information which appears in Section 2.6.1 and Section 8 of the Final Statement.

The Draft Statement has also been supplemented with the information that as the project progresses, additional surveys will be carried out to determine that no additional eligible properties have been uncovered.

Comment c

"In compliance with Section 1(3) of Executive Order 11593. . . The environmental statement should contain a determination as to whether or not the proposed undertaking will contribute to the preservation and enhancement of non-Federally owned districts, sites, buildings, structures, and objects of historical, architectural, or archaeological significance."

Response

In compliance with Section 1(3), FEA has determined that no non-Federally owned sites would be affected by the proposed project. This determination appears in the Final Environmental Statement, Sections 2.6.1 and Section 8.

9.4.1.2 Department of the Army, Galveston District, Corps of Engineers

Comment a

"Pipelines proposed under this project will cross the Brazos River Diversion Channel, Jones Creek, and various wetland areas. Department of the Army permits will be required for this work."

Comment b

"The pipelines proposed will intersect the Freeport and vicinity hurricane protection project in one or more locations and may require construction within the project right-of-way in other areas. Permits for this work should be obtained from the Velasco Drainage District."

Comment c

"The FEA 30-inch pipeline from the Bryan Mound site to Seaway Tank Farm will cross the Brazos River Diversion Channel right-of-way and the West Brazos River Floodgate access road. Coordination of the pipeline crossing of these facilities with us will be required."

Response for Comment a, b, and c above

Upon project approval, the Federal Energy Administration will apply for all required permits and will coordinate its construction plans with the Department of the Army, Galveston District, Corps of Engineers.

Comment d

"Page 1-12, Figure 1.6. The word 'Highway' should be changed to 'Roadway on Hurricane Flood Protection Levee' and the note 'To Intracoastal Waterway and Gulf of Mexico' should be changed to 'Road to Intracoastal Waterway Floodgates.'"

Response

The changes have been made in the text.

Comment e

"Two factors of considerable concern are critical to continuing use of disposal areas; they are: encroachment of watercourses that provide natural circulation of surface waters and creation of vector problems. Scheduling of work may create difficult and costly disposal problems."

Response

At the Bryan Mound site, the location and design of disposal areas for spoil dredged from the Brazos River have not been established. Such disposal areas will be designed and/or utilized in accordance with all applicable Federal laws and regulations. Such a procedure should preclude any encroachment of water courses in the area that provide natural circulation of surface waters and should also prevent the creation of vector problems. The work schedules will be designed, consistent with other considerations, to minimize the difficulty and cost of the disposal process.

Comment f

The Draft EIS does not consider, " . . . the impacts of surface preparation for painting during construction and operation phases. The adverse impacts on inhabitants, structures, equipment, and terrain can be significant."

Response

It is anticipated that no surface preparation for painting will be required during construction, since the tanks will have been primed prior to shipment. Surface preparation activities during maintenance operations will probably include abrasives blasting prior to the application of paint. Emissions associated with the use of abrasive materials vary as a function of the material used as well as the type of surface. Typical abrasive materials include sand, slag, garnet, and steel grit. The amount of particulate matter entrained into the atmosphere due to the use of the substances would be a maximum for sand blasting. Emission factors developed by the San Diego County APCD* indicate that for operations using sand as the abrasive material, approximately one percent of the applied material would be emitted as fugitive dust. The impact of these emissions at the site boundary during sand blasting operations are expected to be minor assuming worst-case meteorological conditions and a violation of the applicable standards for particulate matter is not anticipated.

*Private Communication with Andy Segal, San Diego County APCD, December 1976.

Comment g

"It is noted that (in connection with the taking of excavated material from a barge slip to a suitable disposal site in accordance with a permit) mention of two important documents have been omitted from each EIS. They are the Federal Water Pollution Control Act (FWPCA), Title 33 U.S.C. 1323 and 1344, and the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA), Title 33 U.S.C. 1413(e). Section 404 of FWPCA provides for control of dredged material disposals in navigable waters and MPRSA provides for control of dredged material disposal and transportation of dredged material for disposal in ocean waters. Federal projects involving disposal in navigable or ocean waters or transportation for disposal in navigable or ocean waters are evaluated for permit and other regulatory actions by the Corps of Engineers and the Environmental Protection Agency under guidelines and criteria promulgated pursuant to the requirements of the FWPCA and MPRSA. The regulatory guidelines and criteria for Corps of Engineers evaluations of proposed projects are contained in Title 33 C.F.R., Part 209 which has also not been mentioned. Other laws enacted before 1972 are also directly related to the procedures for processing permit applications. These include the River and Harbor Act of 1899, the Fish and Wildlife Coordination Act of 1958, the National Environmental Policy Act of 1969, and the Coastal Zone Management Act of 1972, all of which are referenced in Title 33 C.F.R., Part 209. A statement to the effect that, 'the proposed disposals and transportation for disposal of dredged materials will be performed in accordance with all applicable Federal and state acts and regulations,' should be included in each EIS or Statement of Findings for each project."

Response

Permits required pursuant to the Federal Water Pollution Control Act and the Marine Protection, Research and Sanctuaries Act of 1972 are issued by the Department of the Army, Corps of Engineers. The permit procedures and the Acts upon which they are based are outlined in the Army Corps of Engineers Regulations on Navigable Waters, 33 CFR 209. Compliance with 33 CFR 209 was indicated in Table 9.2 on page 9-3, of the Draft Statement. These regulations also appear in Section 9.2 of the Final Environmental Impact Statement. The assurance that the proposed disposals will be carried out in accordance with all applicable Acts and Regulations was added to the Draft Statement, Section 3.2.1.

Comment h

Prevailing high levels of hydrocarbon emissions merit greater consideration of vapor recovery rather than flaring or release. . . Oxidation products of flaring or high levels of hydrocarbon emissions could be objectionable or hazardous to vessels and their crews moored or at work on navigable waters near transfer sites. Including consideration of admittedly excessive emissions and conservation and economic factors, it would seem that application of vapor recovery technology should be given equal consideration for all SPR sites."

Response

A discussion of emission control technology appropriate for the marine terminal and estimated control efficiencies have been included in the text of Section 4.1.

9.4.1.3 United States Environmental Protection Agency, Dallas, Texas

Comment a

"The proposed distribution facilities to be used in conjunction with the dome are the Seaway, Inc. docks, or a new barge terminal on the Intracoastal Waterway. Another alternative which may be available in this regard is the proposed SEADOCK Deepwater Port. Although the first tankers are not anticipated to be received at SEADOCK until after the dome is initially filled, the deepwater port could be used for subsequent refills. This could affect the projected oil spill estimates because very large crude carriers (VLCC's) could be used instead of conventional tankers for crude import. The alternative of utilizing the proposed SEADOCK deepwater port as the major distribution facility for the Bryan Mound storage area should be discussed in the statement."

Response

Although SEADOCK might be an excellent alternative for refills of the Bryan Mound salt dome cavities in the future, the date of availability of SEADOCK is very uncertain at this time. All the approvals required for the construction of SEADOCK have not yet been granted. Assuming all such approvals were granted immediately, the earliest time at which SEADOCK would be available for off-loading VLCC's would be during the year 1980. Based on the latest information, the facility would be ready to receive oil approximately three years after the start of offshore construction.

At such time that the availability of SEADOCK becomes an imminent reality, it then would be appropriate to evaluate its use for refills.

Comment b

"When the oil is removed from the storage cavities, some of the oil will remain on the walls of the cavities and therefore in the brine. When oil is reintroduced to the caverns, the brine will carry the entrained oil with it. The EIS indicates that Dow Chemical intends to use this brine in various of its processes with ultimate disposal in the Gulf of Mexico. The statement should provide assurances that the concentration of entrained oil in this brine will be such that no adverse impacts to the water quality or biota in the area of the discharge will occur. The statement should discuss the possibility of the need for treatment of the brine to remove the oil as well as the ultimate disposal of any recovered oil. A quantitative discussion of evaporative hydrocarbon emissions originating from the brine storage reservoir should also be included in the statement."

Response

All of the caverns under consideration for petroleum storage are currently filled with brine. The walls of such caverns will thus be water-wetted when the brine is displaced by crude oil during the first storage cycle. Although experimental data is currently not available involving water, oil, and salt, past experience involving water, oil, and other material* such as sand or rock suggest that water as opposed to oil will preferentially wet the salt wall. Thus, even when the cavern is filled with oil there is reason to believe that the walls will remain water-wetted. In this case, when the oil is displaced by water, no oil film will be present on the walls. If, however, the walls are oil-wetted a thin film of oil might initially occur along the walls when the oil is being displaced by water. Near the bottom of the cavern, however, the walls would remain water-wetted because this portion of the cavern always contains brine. Thus, as the oil is displaced by fresh or brackish water, the salt walls at the bottom will commence being dissolved by incoming water. Thus any oil film will tend to be "rolled up" as the salt wall to which the film is attached is essentially dissolved out from under it. For these reasons the presence of an oil film on the walls for any long period of time is unlikely when the cavern is filled with water or brine.

*V. L. Streeter, Handbook of Fluid Dynamics, McGraw-Hill Book Company, New York, 1961.

Although the film may not be present, the horizontal interface between the oil (above) and the water (below) will always be present whether the cavern is filled with oil or water. This interface will allow some of the more soluble constituents of the oil to pass into solution in the water which with time will grow increasingly saline. The solubility of crude oil in brine is unknown, but in sea water such solubility ranges from 12.3 to 17.4 ppm for representative crude oils.* With increasing salinity, the solubility of the oil should decrease and thus the maximum level of oil dissolved in the brine should not exceed the range for sea water.

In addition to dissolved oil, some of the oil will form an emulsion in the water. Such an emulsion can be divided into two parts. The first part consists of the larger globules which may initially be present, but which with time will tend to rise to the oil-water interface. At the interface, these globules may coalesce with the main body of oil or they may cluster together, possibly forming a separate layer along the interface. The second part of the emulsion consists of the smaller globules or micelles which are sufficiently small to remain permanently in emulsion. These micelles may be distributed throughout the brine, but logically would be present in greatest concentration near the interface already noted. The amount of oil in either type of emulsion is generally dependent upon the type and degree of agitation occurring at the oil-water interface during both the filling and withdrawal operation, and cannot be predicted. To minimize producing such an emulsion, the filling and withdrawal operations should be accomplished with minimum agitation of the interface in general.

Because of the factors already described during the process of filling the cavern with oil, a certain amount of oil either in solution or emulsion will be transported with the displaced brine. The maximum amount in solution, as previously noted, would appear to be less than 18 ppm. For a 10-million barrel cavern this would be approximately 180 barrels of oil. The amount in emulsion cannot be predicted, but this amount can be minimized by insuring that the oil-water interface remains a safe distance above the withdrawal point.

The maximum rate at which the displaced brine will be pumped from the brine surge ponds to Dow will be 145,000 barrels per day or 9.42 feet^3 per second. The Dow Chemical processes in which the brine may be utilized are not well

*T. Lysyl and E. C. Russell, "Dissolution of Petroleum Derived Products in Water," Water Research, Volume 8, page 863, 1974.

defined at this point. In the worst case, the brine discharged by Dow would contain the same concentration of oil in solution and emulsion as was present when it was pumped from the brine surge pond. It is reasonable to assume that this brine would be mixed with other waste water discharged from the Dow installation via the two canals into the Brazos River as shown in Figure 2-5. As noted in Section 2.2, the average rate of such discharge is currently 2,340 $feet^3$ per second. If complete mixing of the waste water is assumed prior to its discharge into the river, the concentration of oil in solution and emulsion would be reduced by a factor of roughly 248. If the maximum solubility of crude oil is taken as ~18 ppm, the concentration of dissolved oil at the point of entry into the Brazos River would be approximately .07 ppm. This is more than the human taste detection threshold of .01 ppm. With respect to oil in emulsion, the Texas Water Quality Standards require that no visible film of oil be produced on the water surface.* The concentration of oil necessary to produce a visible film is not precisely established, but available experimental data** suggests that such a film becomes visible when oil concentration lies between 5 and 10 ppm. Because of the dilution factor previously noted to produce such a film, the concentration of oil in emulsion in the brine surge ponds would have to be between 1,240 and 2,480 ppm.

Based on the available information, sound engineering practices would dictate monitoring the displaced brine for the level of oil in solution and emulsion prior to pumping the brine to the Dow facility. By use of proper operating procedures, these levels can be minimized and an oil-water separation system does not appear necessary at this time. Such a system will be incorporated into the design, however, if studies which are currently underway indicate that unacceptable levels of oil in emulsion or solution will be encountered. A quanitative assessment of the brine pond would be very conjectural since the primary source of such releases would be from oil globules in the emulsion, and efforts will be made to prevent the emulsion from being pumped out of the cavern.

---

*"Texas Water Quality Standards," Texas Water Quality Board, Austin, Texas, February 1976.

**B. Hornstein, "The Visibility of Oil-Water Discharges," Proceedings of Joint Conference on Prevention and Control of Oil Spills, Washington, D. C., March 13-15, 1973.

Comment c

"The statement should briefly discuss the legal permitting requirements which would be associated with utilization of the alternate brine discharge site located in the Gulf of Mexico."

Response

Regulations concerning brine disposal were outlined in Table 9.2, page 9-3 of the Draft Statement. The assurance that the proposed alternate disposal plan would be carried out in accordance with all applicable Acts and Regulations was added to the Draft Statement, Section 7.2.2.

Comment d

"Because of past removal of sulfur from the caprock of the salt dome and possible compaction of the aquifer, the possibility of subsidence exists when construction of the four 400,000 barrel crude oil storage tanks is completed and the tanks are filled. We would suggest corings be obtained from the areas of sulfur removal to obtain compressive or load testing data in order to provide information for the design of the support pads under the tanks. Also, the EIS should briefly discuss the effects of containment dike failure and pipeline breakage due to subsidence.

Response

A discussion of dike failure and pipeline breakage due to subsidence has been added to the text (Section 3.1).

Comment e

"The statement should point out that Air Quality Control Region (AQCR) 216 is presently under an interim strategy for the attainment of the National Ambient Air Quality Standard (NAAQS) for photochemical oxidants. A discussion needs to be included which will provide assurance that the facility will not adversely affect the attainment and maintenance of the NAAQS."

Response

Section 3.3.2 of the text has been expanded to include a discussion of the proposed revision to the Texas State Implementation Plan. That discussion shows that the proposed system complies with the new requirements. The text also recognizes EPA is presently formulating a tradeoff policy for new source review in non-attainment areas. Because of the high oxidant levels experienced in AQCR 216, FEA is considering the use of marine terminal vapor control and recovery systems. Such systems are not normally utilized for crude oil transfer operations, and are not required by the new interim strategy. However, they are effective mitigative measures, and their availability is discussed in section 4.1. It should be noted that this facility is being designed for emergency use only, and periods of several years may occur between withdrawal and refill activities. The facility would not present a continual air pollution problem. All efforts are being explored to minimize any impact that the project may potentially have.

Comment f

"A possible mitigating measure for hydrocarbon emissions (Table 4.1) is a vapor recovery system on tankships and terminal tank connections. The system envisioned for this purpose should be thoroughly discussed."

Response

This subject is discussed in Section 3.3.2 of the text.

Comment g

On page 3-20 of the Draft, paragraph 1, a "seal factor" of 0.47 was used to obtain the evaporative emission rate of 229 pounds per 400,000 barrel storage tank per day. The commentator points out that the cited references (References 11 and 16) have already included a seal factor (k_s of 1.00 for new tank-modern seals in obtaining the emission rate of 1.22 pounds per 1,000 barrels of crude oil stored per day, and that the inclusion of a seal factor of 0.47 is not only an incorrect seal factor, but it is an additional seal factor. The commentators conclude that, "If another seal factor is multiplied times the emission value, then this value must be a 'fudge factor' because it is not referenced."

Response

The evaporative hydrocarbon losses from the four 400,000 barrel floating roof surge tanks on site have been recalculated. The basis for this calculation is a correlation developed by the American Petroleum Institute (API) in the early 1960's for floating roof tanks storing various stocks with Reid vapor pressures between 2 psia and 14 psia.* The SPR crude oil characteristics The SPR crude oil characteristics assumed for this calculation were based on preliminary design specifications of Reid Vapor Pressure equal to 3 psia and the gravity of 27° API (about 7.4 pounds per gallon). The text and Table 3.6 have been modified accordingly.

9.4.1.4 Federal Power Commission

Comment

". . .there does not appear to be any conflict between the development of the SPR and the continued production, transportation, and sale of natural gas from domestic sources. It therefore does not appear that the proposed project presents any conflict with FPC jurisdictional interests."

No Response

*API Bulletin #2517, "Evaporation Loss from Floating Roof Tanks, 1962.

9.4.1.5 Nuclear Regulatory Commission

Comment

"We have determined that the proposed actions, per se, have neither radiological, health, and safety aspects nor will they adversely affect any activities subject to regulation by the Nuclear Regulatory Commission."

No Response

9.4.1.6 The Department of the Treasury

Comment a

"The Department supports the concept of a strategic petroleum stockpile and considers it to be an essential national need. However, we wish to reiterate that such facilities and the petroleum stored therein should be owned by the Government and that the costs should be borne directly by the beneficiaries--the U. S. energy consumers."

No Response

Comment b

". . .among the benefits or costs of each project is the employment effects, positive in the case of employing construction workers to build storage facilities and negative in the case of 'laying-off' salt mine workers. Conventional cost-benefit analysis deals with a national rather than a regional perspective and assumes a full employment economy. Under such assumptions employment effects are considered neither costs nor benefits since one more job in any region implies one less job elsewhere."

Response

It is recognized that the work force required at each individual site is insignificant compared to national employment levels. However, the sites are located in rural areas where a small scale economy could potentially be disrupted. A local perspective of employment effects was chosen in order to ascertain whether there would be any impact on the surrounding towns and parishes, and if so, to assess the magnitude of such impacts.

9.4.2 State Agencies

9.4.2.1 Texas Department of Agriculture

Comment a

"This DEIS notes that the site is in the midst of a major rice producing area in the country. It does not address the adverse impact the use of this site would have on rice production. This item is too important to be left unevaluated."

Response

Development and operation of the storage site, pipelines, and associated dock facilities would in no way affect or interfere with rice production. There is no agricultural land included in the proposed project area.

Comment b

"This proposed site is in or very close to the coastal wetlands and special programs have been established to protect these wetlands. The relationship between this proposed usage and the protection of the wetlands should be analyzed and reported."

Response

It is felt that the potential affect of the project on wetlands has been thoroughly described in the statement. Sections 2.6.2 and 2.6.3 describe wildlife refuges and biologically sensitive areas. Section 3.4 describes the potential impact of all phases of the project on species and ecosystems. Sections 4, 5, and 6 describe the unavoidable environmental effects which will potentially be associated with the project.

9.4.2.2 Governor's Energy Advisory Council

Comment a

"It is not clear that adequate provision is being proposed for satisfaction of Air Quality Standards particularly with regard to hydrocarbon emissions."

Response

The Final Statement contains a detailed discussion of hydrocarbon emissions, vapor control technology, and the Texas State Implementation Plan for achieving the National Standards (Section 3.3.2 and 4.1).

Comment b

"Alternative proposals are made for brine disposal in case Dow is unable to use the brine produced. Is it to be assumed that construction of facilities for any alternative disposal method would be included in the initial construction? The material provided seems to suggest a preference for disposal in the Gulf over deep-well injection. More specific details would be needed in either case, but particularly with regard to deep-well injection."

Response

It is currently anticipated that the brine will be used by Dow. If this option is unavailable, it is anticipated that disposal will be made to the Gulf of Mexico. Because either disposal to the Gulf of Mexico or by deep well injection would represent a major design change, a decision to employ one of these alternatives would be accompanied by a commitment to amend the Environmental Statement and to provide more specific details on Gulf disposal and disposal by deep-well injection.

Comment c

"While the Brazos River is considered an alternative source for displacement water there is no indication of arrangements for use of surface water if needed from this source. It is not made clear what circumstances might require such use. Therefore, further discussion is recommended."

Response

In the event that water was not available from the Dow Reservoirs, it would have to be obtained from either the Gulf of Mexico of from the Brazos River. At such time as a decision was made to obtain water from the Gulf of Mexico or the Brazos River, the DES would be amended, and arrangements for use of surface water would be sought from the appropriate authorities.

Comment d

"Some question is left concerning the schedule of construction related to the distribution system. Greater detail might be helpful."

Response

The schedule for construction can only be established after the design is finalized in early 1977. It is anticipated that construction could begin on facilities as early as the Spring of 1977, although most work would not begin before mid-year. Since the impacts are not related to the schedule, it is believed that more detailed information is not required in the FES.

Comment e

"There may be some question remaining about the capability of Freeport Harbor and Intracoastal Waterway in handling increased traffic envisioned without increased dangers. Perhaps mitigation procedures should be discussed in greater detail."

Response

The Bryan Mound facility is designed for a maximum 385,000 barrels of oil per day fill or withdrawal rate. Section 3.7.2 contains a detailed evaluation of accident probabilities and associated oil spill probabilities for oil delivery to Freeport Harbor. These probabilities are based on the assumption that the oil will be delivered by tankers with 250,000 barrel capacity. These rates for the delivery of 58 million barrels of crude oil would require 228 tanker trips or a maximum of 1.5 trips per day for a five month period.

It is planned that the crude extraction phase of the project would require up to three ships each day for up to five months. It is not anticipated that the additional 1.5 tanker trips per day over the total length of the project, which would include five additional fill and withdrawal cycles, will appreciably affect Freeport Harbor tanker traffic.

Furthermore, dredging activites are currently being carried out in Freeport Harbor. When dredging is completed in early 1977, the Harbor will be capable of handling 50,000 dwt tankers which have a capacity of approximately 400,000 barrels. The use of tankers of this size would decrease the maximum tanker traffic from 1.5 to 1 trip per day for each fill or recovery cycle.

Under the proposed system, the Intracoastal Waterway will not be used to transport oil for this project, and its traffic will not be affected by the project.

9.4.2.3 Texas Parks and Wildlife Department

Comment a

"It is our understanding that primarily developed areas will be utilized for project facilities and that brine will not be released to the Brazos River or the Gulf. The use of methods that will keep spills of oil to a minimum should be encouraged as oil spills appear to have the greatest potential for environmental damages resulting from the project."

Response

As noted above, disposal of brine to the Brazos River or Gulf is not currently anticipated. The concern over potential damage from oil spills is acknowledged. Methods to reduce potential oil spills are being identified. These methods will be discussed in detail in the Spill Prevention, Control and Countermeasures Plan (required under 40 CFR 112), and will be included in the project's environmental plan.

Comment b

"Mention should be made in the environmental impact statement of the Bryan Beach State Recreation Area, which is located approximately one mile south of Bryan Mound. This area was recently obtained by the Texas Parks and Wildlife Department and recreational facilities are currently being planned for future public use. Bryan Beach State Recreation Area contains 877 acres and has over one mile of Gulf beach. We feel that the environmental impact statement should address the potential noise, odor, and oil spill impacts of the proposed project on this recreation area."

Response

A description of the Bryan Beach State Recreation Area has been included in Section 2.6.2 and in Figure 2.4. Since this recreation area is in the vicinity of the dome and related waterways, it is felt that the Section 3 description of the environmemtal impact of the proposed action can be applied to this area. Section 3.3 addresses the questions of noise and odor associated with development and operation of the storage facility. Section 3.7.2 addresses in detail the subjects of oil spill probability, severity, and mitigation.

Comment c

"Mention of Velasco Beach State Park (Section 2.6.2) should be deleted as this site was returned to control of the Texas General Land Office in 1973."

Response

Mention of Velasco Beach State Park has been deleted from the text.

Comment d

"The project sponsor is encouraged to consult with municipal and county governments in the project area regarding locations of additional parks in the project area."

Response

It is anticipated that no additional parks or recreational areas will be affected by the project.

Comment e

"In Section 2.6.3, pages 2-73 and 2-74, certain biologically sensitive areas and endangered fauna within those areas are mentioned. The second paragraph on page 2-74 erroneously states that the Corpus Christi Bay Area is on the Texas-Louisiana border and that the American alligator is mostly restricted to marsh and prairie areas close to the coast. It is suggested that the subject paragraph be corrected by stating that the range of the American alligator, which includes Brazoria County, extends along the entire Texas Coast and throughout most of the eastern third of the state."

Response

Section 2.6.3 has been revised to reflect this information.

9.4.2.4 Texas Water Development Board

Comment a

"Due to the potential hazard to groundwater quality, we are concerned with deep well injection as a possible brine disposal alternative. We suggest that the FEA give additional consideration to the potential impact of this alternative on groundwater resources in preparing the final environmental impact statement."

Response

The use of deep-well injection for brine disposal represents the least desirable alternative for disposal of brine at the Bryan Mound site, and deep-well disposal is not currently being considered for this site. In the event that deep-well injection is considered in the future, the FES will be amended to provide a detailed evaluation of the potential hazard to groundwater.

9.4.2.5 Texas Water Rights Commission

Comment a

The Texas Water Rights Commission states that the program should be carried forward with close coordination between Federal and state governments and private industry, which would lead to, "uninterrupted, integrated technical, administrative, and operational custody throughout the phased buildup of the [program]." The TWRC also suggests that there be, "mitigation of the increased costs incurred by the states, regions, and private property owners affected by the program."

Response

Current efforts of the program are designed to provide such coordination. Both formal and informal efforts are being undertaken as appropriate.

9.4.3 Local Agencies

9.4.3.1 Velasco Drainage District, Lake Jackson, Texas

Comment a

"Additional detail on hurricane protection and drainage aspects of the site would be valuable and important, and the following data are offered for your use and information. The Freeport and Vicinity, Texas Hurricane Flood Protection Project is a program of strengthening existing levees and constructing new levees and related drainage systems in the Brazosport Area. The Project was authorized by the Federal Flood Control Act of 23 October 1962. House Document No. 495, 87th Congress. Project funding is 70 percent by the Federal Government and 30 percent by local interests, represented by the Drainage District as Local Sponsor.

As part of the project, certain improvements were made relating directly to Bryan Mound and the adjoining area to the North of the Mound and South of the developed area of the City of Freeport (see Figure 1.7).

1. The South Frontal Levee, running from the high ground at Bryan Mound to the South side of the existing Phillips Terminal, has been strengthened and raised to protect the area against the Standard Project Hurricane. The levee parallels the route of the proposed FEA 30 inch pipeline (Figure 1.7).

2. Similarly, the East Bank Brazos River Diversion Channel Levee has been strengthened and raised. It extends from the high ground at Bryan Mound northerly, and parallels the proposed 6 mile 24 inch concrete fresh water pipeline indicated on Figure 1.7.

3. Similarly, protection of the area against flooding from the north is afforded by the levees at the Phillips Terminal, Brazos Harbor and the Old Brazos River.

Consequently, the entire area south of the City of Freeport to the South Frontal Levee is enclosed by a ring levee system and protected against flooding from the Standard Project Hurricane.

Turning to the interior drainage facilities, rainfall runoff is removed from the enclosed area by the following:

1. The West End Pumping Station located at the southwest corner of the developed area of the City of Freeport, Figure 1.8. The station contains three pumps with a total capacity of 450,000 gallons per minute.

2. A gated gravity drainage structure through the South Frontal Levee. The structure consists of two 7 foot by 5 foot concrete boxes.

A second pumping station, the Pine Street Pumping Station transfers runoff from the developed area of the city of Freeport over a lower interior levee southerly into a channel running westerly to the West End Pumping Station. The lower interior levee formerly was the storm protection levee for the city, now afforded by the South Frontal Levee. Accordingly, the Pine Street Pumping Station does not remove runoff from the enclosed basin. The Pine Street station contains four pumps with a total capacity of 200,000 gallons per minute.

When the total protection project was planned, the Galveston District, Corps of Engineers concluded that additional runoff discharge capacity through the South Frontal Levee was not justified, based on the then current stage of development. Based upon a brief review of the project outlined in the Draft Environmental Impact Statement, and assuming that sensitive facilities are sited on the high ground of Bryan Mound, no significant flood damages are foreseen.

Response

The preceding comment provides useful detail concerning the levee system and interior drainage system in the vicinity of the Bryan Mound site. This material has been incorporated into Section 2.1.5 of the EIS.

Comment b

". . .it is the Drainage District's position that development of significant areas of the basin or even small, but low areas of the basin will require additional runoff discharge capacity."

Response

As can be seen in the system description in Section 1.3, almost all of the development for the system is on Bryan Mound or at the Seaway Dock facility. Essentially no low areas will be developed. The total area of modified drainage will be less than 0.5 percent of the basin.

Comment c

The areas of standing water arise from interior rainfall and from discharge of rainfall runoff from the Pine Street Pumping Station. The two gated 7 foot by 5 foot concrete boxes through the South Frontal Levee prevent backflow from the Gulf of Mexico or the Intracoastal Waterway, and the area is not subject to the ebb and flow of saltwater tides. Accordingly, the Drainage District is of the opinion that the area is eminently suitable for development and use.

Response

FEA concurs with this comment. The construction of the facility should have no affect on the existing system or interior drainage systems.

9.4.4 Individuals and Organizations

9.4.4.1 Dow Chemical U.S.A., Midland, Michigan

Comment a

"There are several areas in which the Dow involvement proposed in Dow proposal No. 7761267 is different than described in the Draft EIS. The significant area of difference is that the maximum brine disposal rate proposed to date by Dow is 145,000 barrels per day of saturated brine versus 400,800 barrels per day described in the Draft EIS. There are other differences including pipeline sizes, pipeline uses, and casing sizes that do not have environmental significance."

Response

The maximum brine disposal rate of 145,000 barrels to Dow are correct. The higher number would represent the maximum rate of flow that might occur during pumping operations. Because of the difference between the amount to be handled by Dow, and the amount being released from the cavities, brine surge ponds are being provided as a part of the design.

Comment b

"Dow Proposal No. 7761267, July 23, 1976 has been submitted to the FEA . . . The Proposal, which contains a proprietary rights clause, outlines our desire to modify the caverns to provide 70 million barrels of useable crude oil storage space for lease to the FEA for a 10-year period with a 5-year renewal option. The Proposal also states that Dow does not wish to dispose of or permanently lease the property in a manner that would preclude its use as a source of salt for Dow operations."

Response

FEA is discussing the acquisition and development of storage on Bryan Mound with both Freeport Minerals (owner in fee) and Dow Chemical (leases of the brining rights). No decision will be made concerning whether, or in what manner Bryan Mound would be developed until the NEPA process is complete.

9.4.4.2 LOOP, Inc. (Louisiana Offshore Oil Port) New Orleans, Louisiana

Comment a

"There is no indication that specific, competent geomechanics analyses will be made to assure stability of multicavity configurations after five fill/withdrawal cycles. Such analysis should be required for each of the candidate salt domes (DES 76-4, 5, 6) actually selected.

"The analysis would establish allowable roof distance below the caprock, center to center spacing versus diameter (s/d ratio), vertical separation and plastic zone proximity to the dome flank. These criteria should be related to calculated creep, stress, and subsidence for the actual or safe strength levels of the specific salt and surrounding rock. The arbitrary criteria enumerated in the programmatic draft EIS's are no substitute for geomechanics analyses."

Response

Additional studies of salt dome and storage cavern properties will be conducted as appropriate. A special analysis of cavern stability parameters at Bryan Mound conducted for the FEA SPR office is included as Appendix H. These parameters include roof and wall thickness and cavern dimensions.

9.4.4.3 Seaway Pipeline, Inc., Bartlesville, Oklahoma

Comment a

"The last paragraph on page 2-39 mentions that there is apparently no relationship between the hydrocarbon and ozone concentrations. From this lack of a relationship, it is concluded that the occasional concentrations of hydrocarbons in excess of the Federal Ambient Air Quality Standard is a result of the various pipelines, tank farms, industries, etc. in the area. This conclusion appears to ignore two important points. First, non-methane hydrocarbons can react photochemically to form ozone. Since this is an atmospheric reaction, the resultant ozone concentration will appear at some point downwind of the non-methane hydrocarbon emissions. For this reason, it should not be expected that the ozone and non-methane hydrocarbon concentrations measured at the same point are related except in stagnation masses. More correctly, the ozone concentration possibly can be related to some upwind concentration of non-methane hydrocarbons which are unknown at this time.

"A second point that needs to be considered is that natural sources such as swamps, which are common in the area, can be significant contributors to the ambient hydrocarbon concentration. Although currently available information does not permit a quantification of these natural hydrocarbon emissions in this area, the fact that they do exist needs to be kept in mind when evaluating ambient air quality data. The current wording on page 2-39 leads one to believe the entire hydrocarbon problem in the area is attributable to anthropogenic sources. This is quite likely not the case.

"Based on these facts, it is recommended that the entire last paragraph on page 2-39 be deleted. The current data does not support the conclusions presented."

Response

Hydrocarbons are emitted in the proposed site area in vapor form as fugitive emissions from the storage and handling of fuels, and from stacks and mobile sources as a result of combustion of fuels. Fugitive emissions have low temperatures and exit velocities, and therefore tend to remain at low levels in the atmosphere. As such, fugitive hydrocarbons can produce rather high ground-level concentrations in the vicinity of the storage tanks. As a result of the presence of these materials (chiefly NO_2 and reactive hydrocarbons), the downwind area is subject to high concentrations of photochemical oxidants.

Discussion of the relationship between ozone and hydrocarbon concentrations has been deleted from the text (see Section 2.3.2).

Hydrocarbons are also emitted from natural sources. Much of this is methane and as such does not contribute to the violation of ambient standards. The fraction of reactive hydrocarbon from natural sources is not known.

Comment b

"On page 2-59, paragraph 2.4.4, the wording would indicate ballast treating facilities would be located at the Seaway Dock site. This is contrary to the understanding we have of the current plans inasmuch as the available space at this location would probably not accommodate the facilities required. Similar reference to ballast treating facilities at the dock is also made on page 3-3, paragraph 3.1.2, and page 3-35, paragraph 3.4.3. It is therefore recommended these statements be modified to reflect the current thinking."

Response

The feasibility design upon which this EIS was based locates the ballast treating facility at or near the dock. If, as the working design is refined, it becomes necessary to change the location, the statement will be amended as appropriate.

Comment c

"The last paragraph on page 7-31 refers to Seaway Pipeline, Inc.'s Freeport Terminal as 'a 15,000, 000 barrel tank farm.' This is in error since Freeport Terminal will only have eight 400,000 barrel storage tanks, or a total storage capacity of 3,200,000 barrels. This should be corrected accordingly."

Response

The appropriate change has been made in the text on page 7-25.

APPENDIX A

BRYAN MOUND

Atmospheric Dispersion Model

The pollutants associated with the proposed project which impact ambient air quality may be treated as continuous emissions over periods of hours to a year. A binormal (two dimensional Gaussian) continuous plume dispersion model is used to compute the pollutant concentration downwind from the source. Estimates of dispersion are those of Pasquill as restated by Gifford.[1,2,3]

The basic sample time considered is 10 minutes. This sample time is extended to 1 hour averages with confidence and to 24 hours with degraded accuracy. Annual averages are computed with the aid of an annual wind rose and sector averaging.

"Worst case" results apply to concentration averages over periods up to 24 hours. The variation in annual averages is sufficiently small that worst case results would not be appreciably different. The worst case parameters are determined from annual stability wind rose data for Galveston.[4]

The downwind concentrations for 10 minute averages are given by Equation 1:

$$\chi\ (x,y,z=o,H) = \frac{Q}{\Pi \sigma_y \sigma_z u} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right] \qquad (1)$$

where:

χ = concentration, $\mu gm/m^3$, at x m downwind, y m crosswind at ground level (z=0), for a stack height H.
Q = emissions in $\mu gm/sec$ at source
σ_y = horizontal dispersion coefficient, m
σ_z = vertical dispersion coefficient, m
u = average wind velocity, m/sec
H = effective stack height, m.

The values for σ_y and σ_z are taken from Reference 1. Stability class D (neutral stability) with 5 m/sec wind speed is chosen as a typical case representing about 30 percent of the data. The worst-case parameters are for stability class D with 1 m/sec wind speed. The latter conditions represent about 5 percent of the data. In addition, a stable layer is assumed to exist at 100 meters altitude to hold the pollutant close to the ground. This factor raises concentrations 60 percent at 10 km, but does not affect concentrations at smaller distances.

Corrections for wind meander to correct the 10-minute sample averages for periods up to 24 hours are determined by a power law.[1]

$$X(t) = X(10\text{min}) \cdot \left(\frac{t}{10\text{min}}\right)^{0.17} \tag{2}$$

Equation 2 may be applied only when the average wind direction is constant.

The worst-case downwind concentrations at various ranges for a unit source are given in Table A.1. Similar data for a more typical set of meteorological conditions are given in Table A.2. A measure of the lateral extent of the plume may be obtained from Table A.3, where crosswind distance to concentrations which are 1/10 centerline values are given. The tabular correction data cannot be extended to 1 year to obtain annual average concentration. Instead, the "worst case" wind direction (S) is chosen from the Galveston annual wind rose of Section 2.3. A typical wind speed is chosen to represent each speed group. The neutral stability class, D, is assumed. The annual average concentration is given by:[1]

$$X = \sum_i \frac{2.03\ Q}{\sigma_z\ u_i x} \quad f_i \times 10^6 \tag{3}$$

where

- X = annual average concentration (μgm/m)
- Q = Source (gm/sec)
- σ_z = Vertical dispersion coefficient (m)
- u_i = wind speed for i^{th} group (m/sec)
- x = downwind distance (m)
- f_i = fraction of the time the wind is blowing in the chosen direction in the i^{th} wind speed group.

Table A.1 Worst-Case Downwind Concentrations From a Continuous 1 gm/sec Release

D stability, u = 1 m/sec, H = 20 m

χ (μgm/m^3)

x(km)	SAMPLE TIME 10 min.	30 min.	1 hr.	3 hr.	8 hr.	24 hr.
0.5	260.	216.	192.	159.	135.	114.
1	120.	100.	89.	73.	62.	53.
2	46.	38.	34.	28.	24.	20.
5	14.	12.	10.	8.5	7.3	6.2
10	7.4	6.1	5.5	4.5	3.8	3.3

Table A.2 Typical Downwind Concentrations From a Continuous 1 gm/sec Release

D stability, u = 5 m/sec, H = 20 m

χ (μgm/m^3)

x(km)	SAMPLE TIME 10 min.	30 min.	1 hr.	3 hr.	8 hr.	24 hr.
0.5	52.	43.	38.	32.	27.	23.
1	24.	20.	18.	15.	12.	11.
2	9.2	7.6	6.8	5.6	4.8	4.0
5	2.8	2.3	2.1	1.7	1.5	1.2
10	1.5	1.2	1.1	.92	.78	.66

Table A.3 Crosswind Distance y_{10} to Reduce Concentrations of Tables A.1 and A.2 by a Factor of 10*

x(km)	y_{10}(km)
0.5	.077
1	.148
2	.278
5	.429
10	1.20

* Applies to 10 min sample time. It may be used for other sample times with less accuracy.

The wind speed for a group is taken to be the midvalue. The parameter, σ_zm is taken from graphs.[1] Typical values are:

x(m)	500	1,000	2,000	5,000	10,000
σ_z(m)	18	31	50	89	135

The values of f_i and μ_i from the wind rose are:

μ_i(m/sec)	f_i(%)
1.029	0.7
2.572	2.9
4.373	7.1
6.945	4.4
9.774	0.3
11.318	0.1

The values of these parameters are combined as indicated above for a source strength of 1 gm/sec from a point, ground level source. The annual average concentrations (converted to $\mu gm/m^3$) for the unit source are listed in Table A.4 at several distances.

Table A.4 Annual Sector-Averaged Concentrations for a 1 gm/sec Source (South Winds)

Downwind Distance x(km)	Concentration X (μgm/m^3)
0.5	9.26
1.	2.69
2.	0.833
5.	0.187
10.	0.0617

REFERENCES

1. U. S. Environmental Protection Agency, "Workbook of Atmospheric Dispersion Estimates," Office of Air Programs, Publication No. AP-26, Revised 1970.

2. F. Pasquill, "The Estimation of the Dispersion of Windborne Material," Meteorological Magazine, 90, 1063, 1961.

3. F. A. Gifford, "Uses of Routine Meteorological Observations for Estimating Atmospheric Dispersion," Nuclear Safety, 24, 1961.

4. "Wind Direction by Pasquill Stability Classes, Galveston, STAR 14432," National Weather Records Center, NOAA, 1976.

APPENDIX B

WATER QUALITY DATA AND ANALYSIS

APPENDIX B.1

VOLUMETRIC FLOW DATA FOR THE BRAZOS RIVER

This appendix consists of 2 tables. The first, Table B.1-1, provides the mean monthly flow rates for the Brazos River at Rosharon, Texas during the period October 1971 through September 1974. Table B.1-2 provides the mean daily flow rates for the river, at the same location, during the time period when Texas Water Quality Board water survey was underway in 1971.

Table B.1-1 Mean Monthly Brazos River Flow Rates+
Rosharon, Texas

	CALENDAR YEAR			
	1971	1972	1973	1974
JAN	-	7531	7761	12790
FEB	-	4271	9723	8348
MAR	-	1856	15470	3339
APR	-	641	22210	1897
MAY	-	8167	14620	4775
JUN	-	2057	27870	706
JUL	-	1294	6425	483
AUG	-	1327	2341	1050
SEP	-	1121	4549	19370
OCT	3707	1247	24240	-
NOV	5846	5077	9313	-
DEC	12550	2864	7108	

+Flow Rates are in cfs.

Source: "Water Resources Data for Texas - Water Quality Records," U.S. Department of Interior, USGS, 1974.

Table B.1-2 Mean Daily Flow Rates in Brazos River at Rosharon, Texas during Water Quality Survey

Date	Flow Rate, cfs
February 10, 1971	728
11	529
12	492
April 25, 1971	2480
26	1890
27	1200
28	608
August 1, 1971	2100
2	2200
3	2450
4	3150

Source: "Lower Brazos River Project: Final Report," Texas Water Quality Board, January 1972.

Table B.1-3 Discharge for the Brazos River near Rosharon, Texas: October 1974 to September 1975

BRAZOS RIVER BASIN

08116650 Brazos River near Rosharon, Tex.
(National stream-quality accounting network)

LOCATION.--Lat 29°20'58", long 95°34'56", Fort Bend-Brazoria County line, on right bank at downstream side of bridge on Farm Road 1462, 2.0 miles (3.2 km) downstream from Big Creek, 2.1 miles (3.4 km) upstream from Cow Creek, and 7.3 miles (11.7 km) west of Rosharon and at mile 56.6 (91.1 km).

DRAINAGE AREA.--44,340 mi^2 (114,840 km^2), approximately, of which 9,240 mi^2 (23,930 km^2) is probably noncontributing.

PERIOD OF RECORD.--Discharge: April 1967 to current year.
Water quality: Chemical and biochemical analyses: October 1967 to current year. Pesticide analyses: February 1968 to current year. Water temperatures: October 1967 to current year. Sediment records: October 1974 to September 1975.

GAGE.--Water-stage recorder. Datum of gage is at mean sea level.

AVERAGE DISCHARGE.--8 years, 8,357 ft^3/s (236.7 m^3/s), 6,055,000 acre-ft/yr (7.47 km^3/yr).

EXTREMES.--Discharge: Current year: Maximum discharge, 61,900 ft^3/s (1,750 m^3/s) May 30 (elevation, 44.29 ft or 13.500 m); minimum daily, 1,660 ft^3/s (47.0 m^3/s) Sept. 30.
Period of record: Maximum discharge, 79,900 ft^3/s (2,260 m^3/s) May 14, 1968 (elevation, 50.74 ft or 15.466 m); minimum daily, 40 ft^3/s (1.13 m^3/s) Apr. 7-10, 1967.
Historic: Maximum elevation since at least 1884, 56.4 ft (17.19 m) about Dec. 11, 1913, from information by Texas Highway Department.
Water quality: Current year: Maximum daily specific conductance, 3,000 micromhos Nov. 2; minimum daily, 281 micromhos May 31. Maximum water temperatures, 31.0°C July 31, Aug. 1; minimum, 9.0°C Feb. 7.
Period of record: Maximum daily specific conductance (1968-75), 4,430 micromhos Aug. 8, 1971; minimum daily, 203 micromhos Oct. 26, 1970. Maximum water temperatures, 31.0°C on several days during summer months; minimum, 4.0°C Jan. 12, 13, 1973.

REMARKS.--Discharge records good. Water diverted above station for irrigation, industrial, and municipal supply materially affects low flow. For statement regarding regulation by Soil Conservation Service floodwater-retarding structures, see Brazos River at Washington (station 08110200). Flow is partly regulated by 29 major upstream reservoirs having a combined capacity of 6,892,000 acre-ft (8.50 km^3), 3,643,000 acre-ft (4.49 km^3) for flood control.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	14,700	15,600	21,500	7,580	5,030	13,400	5,160	6,020	44,100	18,400	4,590	2,910
2	14,000	20,100	28,000	8,270	5,360	13,400	4,550	9,060	44,700	21,000	5,020	2,790
3	13,200	30,000	20,500	9,120	7,210	13,400	4,150	10,800	42,400	17,900	5,080	2,770
4	12,200	41,900	20,300	10,900	8,650	13,200	3,910	11,800	35,100	14,300	5,490	2,510
5	11,000	46,000	19,500	13,600	28,800	12,400	3,550	12,100	29,200	12,100	6,550	2,440
6	9,900	38,000	19,800	14,500	46,500	11,600	3,110	11,000	27,000	11,400	7,270	2,660
7	8,910	30,100	19,500	14,800	52,700	11,200	3,020	9,980	27,700	10,900	7,240	2,780
8	7,990	33,100	17,100	14,500	52,300	11,100	3,440	14,200	26,800	10,000	7,220	2,690
9	7,420	40,700	15,500	13,500	45,500	11,300	4,440	20,600	23,400	9,590	6,810	2,560
10	6,960	46,400	14,400	12,600	37,800	11,200	8,920	27,600	23,800	9,330	6,480	2,420
11	6,560	54,000	14,700	12,000	33,400	10,700	9,740	29,500	32,700	9,010	6,310	2,300
12	6,340	56,800	16,900	12,100	30,900	10,500	10,400	28,600	33,400	8,610	5,600	2,290
13	6,210	52,200	19,400	12,300	29,500	10,200	14,000	26,300	26,300	8,210	5,130	2,280
14	5,990	43,200	20,600	12,600	27,600	9,980	14,000	25,700	22,200	7,790	5,330	2,110
15	6,130	35,600	21,600	14,300	25,800	9,610	27,500	24,300	21,900	7,820	4,720	1,890
16	6,060	32,700	22,100	16,900	23,900	8,720	30,000	21,700	21,300	8,690	3,830	1,900
17	5,760	31,000	18,400	17,800	21,400	8,070	21,600	18,700	20,300	8,980	3,430	1,870
18	5,690	27,600	14,900	16,300	18,600	8,400	16,400	15,900	20,100	7,580	3,220	1,810
19	5,800	22,900	13,100	13,900	15,600	9,840	14,600	14,200	19,200	6,670	3,000	1,980
20	5,710	18,500	12,100	12,500	12,900	9,450	14,400	12,000	15,800	6,470	2,790	2,320
21	5,660	15,800	11,500	11,900	11,500	8,500	14,100	10,100	13,500	6,120	2,520	2,410
22	5,360	14,600	11,400	11,200	12,900	8,110	13,300	8,950	12,500	5,530	2,530	2,620
23	5,150	14,000	11,600	10,400	16,900	7,320	11,600	8,170	11,500	5,010	2,460	2,920
24	5,040	14,300	11,400	10,100	18,300	6,360	9,560	8,230	10,300	4,670	2,410	2,670
25	4,630	21,200	10,700	9,670	17,800	5,600	7,700	11,100	9,780	4,280	2,310	2,370
26	3,940	37,500	10,100	8,200	16,700	5,120	6,490	26,300	9,700	4,130	2,410	2,480
27	3,630	48,900	8,790	7,030	15,600	4,770	5,750	44,500	9,680	4,110	3,320	2,640
28	3,340	51,500	7,840	6,310	14,100	4,500	5,380	54,200	10,200	4,180	3,620	2,310
29	3,030	43,600	7,520	5,750	------	4,250	5,160	59,600	13,000	4,240	3,470	1,990
30	3,270	29,600	7,500	5,210	------	4,320	4,780	60,900	15,500	4,280	3,130	1,660
31	9,640	------	7,540	4,980	------	5,140	------	52,800	------	4,200	2,940	------
TOTAL	219,220	1,007.4M	467,790	350,820	653,250	281,640	300,710	694,910	673,060	265,500	136,230	71,350
MEAN	7,072	33,580	15,090	11,320	23,330	9,086	10,020	22,420	22,440	8,565	4,395	2,378
MAX	14,700	56,800	22,100	17,800	52,700	13,400	30,000	60,900	44,700	21,000	7,270	2,920
MIN	3,030	14,000	7,500	4,980	5,030	4,250	3,020	6,020	9,680	4,110	2,310	1,660
AC-FT	434,800	1,998M	927,900	695,900	1,296M	558,700	596,500	1,378M	1,335M	526,600	270,200	141,500

CAL YR 1974 TOTAL 3,282,891 MEAN 8,994 MAX 56,800 MIN 205 AC-FT 6,512,000
WTR YR 1975 TOTAL 5,121,900 MEAN 14,030 MAX 60,900 MIN 1,660 AC-FT 10,160,000

APPENDIX B.2

WATER QUALITY STANDARDS

This appendix consists of 5 tables. Table B.2-1 contains Texas Water Quality Board water quality criteria for the Brazos River tidal and the Old Brazos River Channel (which is the Freeport Harbor). Table B.2-2 presents the proposed EPA numerical criteria for water quality involving public water supply intake. The proposed EPA numerical criteria for water quality, marine water constituents (aquatic life) are presented in Table B.2-3, while the proposed EPA numerical criteria for water quality, (freshwater aquatic life) are provided in Table B.2-4. Table B.2-5 presents the recommended concentration limits for certain sediment parameters.

Table B.2-1 Texas Water Quality Board
Water Quality Criteria

		Segment	
		Brazos River Tidal	Old Brazos River Channel
WATER USES DEEMED DESIRABLE	Contact Recreation	X	-
	Noncontact Recreation	X	X
	Propagation of Fish & Wildlife	X	-
	Domestic Raw Water Supply	-	-
CRITERIA	Chloride (mg/l) avg. not to exceed	-	-
	Sulfate (mg/l) avg. not to exceed	-	-
	Total Dissolved Solids (mg/l) avg. not to exceed	-	-
	Dissolved Oxygen (mg/l) not less than	4.0	4.0
	pH Range	7.0-9.0	6.0-9.0
	Coliform - Fecal (100ml) - log. avg. not more than	200	1,000
	Temperature °F	95	95

Source: "Texas Water Quality Standards," Texas Water Quality Board, February 1976.

*dashes signify "not applicable"

Table B.2-2 Proposed EPA Numerical Criteria for Water Quality, Public Water Supply Intake

Parameter	μg/l
Arsenic	50
Cadmium	10
Chromium	50
Copper	1000
Lead	50
Mercury	2
Zinc	5000
Phenols	1.0
Cyanides	200
Aldrin	1
Chlordane	3
DDT	50
Dieldrin	1
Endrin	0.2
Heptachlor Epoxide	0.1
Heptachlor	0.1
Lindane	4
Toxaphene	5

Source: "Proposed Criteria for Water Quality," Vol. 1, U.S. Environmental Protection Agency, 1973.

Table B.2-3 Proposed EPA Numerical Criteria for Water Quality, Marine Water Constituents (aquatic life)

Parameter	µg/l
Arsenic	50
Cadmium	10
Chromium	100
Copper	50
Lead	50
Mercury	1.0
Nickel	100
Zinc	100
Cyanides	10
Oil and Grease	a. Not detectable as a visible film, sheen, discoloration of the surface, or by odor. b. Does not cause tainting of fish or invertebrates or damage to biota. c. Does not form an oil deposit on the shores or bottom of the receiving body of water.
Aldrin	5.5
DDT	0.6
Dieldrin	5.5
Endrin	0.6
Heptachlor	8
Lindane	5
Toxaphene	0.010
pH	6.5 - 8.5
Ammonia	400
Hydrogen Sulfide	10
Dissolved Oxygen	6.0 mg/l
Phosphorus	0.1

Source: "Proposed Criteria for Water Quality," Vol. 1, U.S. Environmental Protection Agency, 1973.

Table B.2-4 Proposed EPA Numerical Criteria for Water Quality (Freshwater Aquatic Life)

Parameter	µg/l
Cadmium	30 (hardness > 100 mg/l) 4 (" < 100 mg/l)
Chromium	50
Copper	1/10 LC50
Lead	30
Mercury	0.2
Nickel	1/50 LC50
Zinc	5/1000 LC50
pH	6-9
Ammonia	1/20 LC50 (20 µg/l)
Sulfides	2
Suspended & settleable solids	80 mg/l
Turbidity and light penetration	10% change in compensation pt.
Color	10% change in compensation pt.
Oils	1. None visible on surface 2. 1000 mg/kg Hexane extractable substances in sediments 3. 1/20 LC50
Phenols	1/20 LC50 (0.1 mg/l)
Cyanides	1/20 LC50 (.005 mg/l)
PCB	0.002
Aldrin	0.01
DDT	0.002
Dieldrin	0.005
Chlordane	0.04
Endrin	0.002
Heptachlor	0.01
Lindane	0.02
Toxaphene	0.01
Diazinon	0.009
Malathion	0.008
Parathion	0.001
DO	4.0 mg/l (>31°C)

Source: "Proposed Criteria for Water Quality," Vol. 1, U.S. Environmenta Protection Agency, 1973.

Table B.2-5 Recommended Concentration Limits of Selected Sediment Parameters

Parameter	Units (dry weight basis)	Non-Polluted mean	Non-Polluted range	Polluted mean	Polluted range
COD[a]	mg/kg	21,000	2,000-48,000	177,000	39,000-395,000
COD[b]	mg/kg			50,000	
TKN[a]	mg/kg	550	10-1,310	2,640	580-6,800
TKN[b]	mg/kg			1,000	
grease-oil[a]	mg/kg	560	110-1,310	7,150	1,380-32,100
grease-oil[b]	mg/kg			1,500	
sulfide[a]	mg/kg	140	30-150	1,700	100-3,700
mercury[b]	mg/kg			1	
lead[b]	mg/kg			50	
zinc[b]	mg/kg			50	

Source: a - G. O'Neil & J. Scerva, "The Effects of Dredging on Water Quality," World Dredging & Marine Construction, 7 (14) pp. 24-31, 1971.

b - L.S. Slotta & K.J. Williamson, "Estuarine Impacts Related to Dredge Spoiling," proceedings of the 6th Dredging Seminar, Texas A & M University.

APPENDIX B.3

WATER QUALITY DATA
FOR THE BRAZOS RIVER

This appendix contains 2 tables and 11 figures. Table B.3-1 provides water quality data for the Brazos River near Rosharon, Texas for 1974. Table B.3-2 provides all available data concerning water discharge into the Brazos River by Dow Chemical Company at Freeport, Texas. Figures B.3-1 through B.3-10 represent the results of the 1971 water and sediment quality survey at 6 stations on the lower Brazos River by the Texas Water Quality Board. The contents of these 10 figures are as follows:

Figure B.3-1	Average surface and bottom dissolved oxygen values
Figure B.3-2	Average surface and bottom temperature values
Figure B.3-3	Average surface and bottom conductivity values
Figure B.3-4	Water clarity
Figure B.3-5	Average surface and bottom alkalinity, hardness, and pH values
Figure B.3-6	Average surface and bottom biological oxygen demand values
Figure B.3-7	Representative % fixed and volatile solids content of the bottom sediments
Figure B.3-8	Representative mercury and arsenic content of the bottom sediments
Figure B.3-9	Representative % calcium (Ca^{++}) and calcium carbonate ($CaCO_3$) content of the bottom sediments
Figure B.3-10	Total and fecal coliform concentrations

The flow rate of the river during the period when the data for these 10 figures were collected is provided in Tables B.1-1 and B.1-2. The station locations for the survey are indicated in Figure B.3-11.

Table B.3-1 Brazos River Water Quality Data near Rosharon, Texas for 1974

WATER QUALITY DATA, WATER YEAR OCTOBER 1973 TO SEPTEMBER 1974 -

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	DISSOLVED SILICA (SIO2) (MG/L)	DISSOLVED CALCIUM (CA) (MG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED SODIUM PLUS POTASSIUM (MG/L)	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)
OCT.										
12...	1000	15000	8.6	54	5.6	300	--	4.9	112	0
20...	0731	51800	11	51	4.6	9.8	--	5.9	173	0
NOV.										
07...	1040	12800	11	49	6.8	30	--	5.0	140	0
19...	1045	4800	11	59	10	34	--	4.4	190	0
DEC.										
25...	0722	6300	11	78	13	--	72	--	222	0
27...	0925	11600	9.4	56	6.8	41	--	5.5	149	0
JAN.										
07...	0925	5000	9.1	51	7.2	40	--	5.1	134	0
14...	0802	3850	11	81	14	110	--	4.7	204	0
FEB.										
05...	1630	15500	8.3	39	4.6	18	--	4.2	112	0
25...	0648	3450	9.2	71	12	50	--	4.3	215	0
MAR.										
18...	1015	2800	6.6	81	18	100	--	4.9	214	0
APR.										
02...	1545	2720	8.0	80	16	120	--	4.5	193	0
MAY										
09...	0930	4600	10	52	9.1	50	--	5.3	132	0
JUNE										
20...	0930	1350	9.6	64	14	82	--	5.4	200	0
JULY										
12...	1139	610	11	88	21	140	--	4.1	242	0
AUG.										
30...	1030	1800	9.0	64	20	120	--	4.4	185	0
SEP.										
19...	1030	32000	10	25	3.5	15	--	4.9	42	0

DATE	DISSOLVED SULFATE (SO4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)	DISSOLVED FLUORIDE (F) (MG/L)	TOTAL NITRATE (N) (MG/L)	TOTAL NITRITE (N) (MG/L)	AMMONIA NITROGEN (N) (MG/L)	ORGANIC NITROGEN (N) (MG/L)	TOTAL KJELDAHL NITROGEN (N) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)	DISSOLVED SOLIDS (RESIDUE AT 180 C) (MG/L)
OCT.										
12...	67	404	.1	.60	.01	.07	.50	.57	2.0	--
20...	14	11	.3	--	--	--	--	--	--	--
NOV.										
07...	47	50	--	--	--	--	--	--	--	--
19...	41	54	.2	.60	.01	.00	.20	.21	.20	--
DEC.										
25...	72	100	.3	--	--	--	--	--	--	--
27...	40	61	--	.66	.01	.10	.52	--	.66	309
JAN.										
07...	44	59	--	.30	.00	.19	.53	--	.21	292
14...	93	140	.2	--	--	--	--	--	--	--
FEB.										
05...	24	23	--	.30	.00	.07	.53	--	.44	252
25...	62	69	--	--	--	--	--	--	--	--
MAR.										
18...	100	150	--	.04	.01	.02	.20	--	.17	619
APR.										
02...	120	180	--	.01	.00	.50	.31	.81	.20	642
MAY										
09...	64	83	--	1.0	.00	.05	1.0	1.1	.44	375
JUNE										
20...	76	120	--	.01	.00	1.4	.56	2.0	5.0	--
JULY										
12...	120	220	--	.05	.01	.32	.57	.89	.44	727
AUG.										
30...	79	170	--	.00	.00	.13	.79	.92	.15	572
SEP.										
19...	13	11	--	.15	.01	.10	1.5	1.6	.59	132

Table B.3-1 Brazos River Water Quality Data near Rosharon, Texas for 1974 (Continued)

WATER QUALITY DATA, WATER YEAR OCTOBER 1973 TO SEPTEMBER 1974

DATE	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L)	TOTAL NON-FILT-RABLE RESIDUE (MG/L)	VOL. NON-FILT-RABLE RESIDUE (MG/L)	HARD-NESS (CA,MG) (MG/L)	NON-CAR-BONATE HARD-NESS (MG/L)	SODIUM AD-SORP-TION RATIO	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)	TEMPER-ATURE (DEG C)	COLOR (PLATI-NUM-COBALT UNITS)
OCT.										
12...	951	--	--	192	65	10	1780	6.9	21.0	--
23...	137	--	--	15[illegible]	6	.6	317	7.3	20.0	--
NOV.										
07...	292	--	--	154	39	1.3	500	7.[illegible]	20.5	--
19...	315	--	--	164	32	1.1	532	6.8	16.5	--
DEC.										
05...	45[illegible]	--	--	251	66	2.5	821	7.9	13.0	--
27...	295	--	--	176	49	1.4	537	6.8	13.0	--
JAN.										
07...	291	217	38	193	50	1.4	503	7.5	10.0	63
18...	57[illegible]	--	--	26[illegible]	42	2.9	1030	8.0	16.8	--
FEB.										
05...	177	575	82	12[illegible]	29	.7	317	7.1	15.0	130
25...	3[illegible]	--	--	233	59	1.4	640	7.3	11.0	--
MAR.										
14...	599	--	--	280	100	2.6	1020	6.9	22.0	--
APR.										
02...	625	--	--	270	110	3.2	1130	7.8	24.5	23
MAY										
09...	3[illegible]	--	--	173	59	1.9	660	7.2	25.5	43
JUNE										
20...	67[illegible]	--	--	220	53	2.6	820	6.9	29.5	--
JULY										
12...	725	--	--	310	118	3.5	1260	7.7	28.0	--
AUG.										
30...	559	--	--	248	98	3.4	1050	7.4	28.0	--
SEP.										
19...	123	--	--	77	18	.7	206	6.5	25.0	--

DATE	TUR-BID-ITY (JTU)	DIS-SOLVED OXYGEN (MG/L)	PER-CENT SATUR-ATION	BIO-CHEM-ICAL OXYGEN DEMAND 5 DAY (MG/L)	TOTAL PHYTO-PLANK-TON (CELLS PER ML)	IMME-DIATE COLI-FORM (COL. PER 100 ML)	FECAL COLI-FORM (COL. PER 100 ML)	STREP-TOCOCCI (COL-ONIES PER 100 ML)	TOTAL ORGANIC CARBON (C) (MG/L)	METHY-LENE BLUE ACTIVE SUB-STANCE (MG/L)
OCT.										
12...	243	7.9	88	2.6	180	400000	2	7400	20	--
23...	--	--	--	--	--	--	--	--	--	--
NOV.										
07...	--	--	--	--	--	--	--	--	--	--
19...	45	9.6	95	.9	1400	9000	1	41	8.0	--
DEC.										
05...	--	--	--	--	--	--	--	--	--	--
27...	243	7.8	72	1.5	0	160000	10	1300	--	--
JAN.										
07...	18[illegible]	11.4	101	1.2	--	69000	340	1100	7.0	.9
18...	--	--	--	--	--	--	--	--	--	--
FEB.										
05...	209	9.1	91	2.1	--	3100	360	190	15	.0
25...	--	--	--	--	--	--	--	--	--	--
MAR.										
14...	50	9.7	99	1.7	9400	2100	120	48	--	--
APR.										
02...	60	10.2	121	4.0	37000	9300	150	62	14	.8
MAY										
09...	300	7.4	69	2.4	2700	5400	700	260	24	--
JUNE										
20...	43	9.8	86	2.3	24000	4100	58	20	--	--
JULY										
12...	13	9.3	105	1.4	120000	2100	600	70	--	--
AUG.										
30...	45	9.2	116	3.1	100000	7000	310	330	--	--
SEP.										
19...	309	7.0	90	1.2	270	24000	700	600	20	--

Table B.3-1 Brazos River Water Quality Data near Rosharon, Texas for 1974 (Concluded)

WATER QUALITY DATA, WATER YEAR OCTOBER 1973 TO SEPTEMBER 1974

DATE	TIME	TOTAL ALUMINUM (AL) (UG/L)	DISSOLVED ALUMINUM (AL) (UG/L)	TOTAL ARSENIC (AS) (UG/L)	DISSOLVED ARSENIC (AS) (UG/L)	DISSOLVED BORON (B) (UG/L)	TOTAL CADMIUM (CD) (UG/L)	DISSOLVED CADMIUM (CD) (UG/L)	TOTAL CHROMIUM (CR) (UG/L)	DISSOLVED CHROMIUM (CR) (UG/L)	TOTAL COBALT (CO) (UG/L)
OCT. 12...	1000	--	--	2	0	90	0	0	0	0	7
NOV. 19...	1045	--	--	--	--	100	--	--	--	--	--
FEB. 05...	1630	2000	10	1	1	40	0	0	0	0	0
APR. 02...	1545	--	40	--	3	150	<10	0	0	0	<50
JULY 12...	1130	--	0	0	4	190	<10	4	<10	0	<50
SEP. 19...	1030	--	30	10	4	110	<10	0	0	0	<50

DATE	DISSOLVED COBALT (CO) (UG/L)	TOTAL COPPER (CU) (UG/L)	DISSOLVED COPPER (CU) (UG/L)	TOTAL IRON (FE) (UG/L)	DISSOLVED IRON (FE) (UG/L)	TOTAL LEAD (PB) (UG/L)	DISSOLVED LEAD (PB) (UG/L)	TOTAL LITHIUM (LI) (UG/L)	DISSOLVED LITHIUM (LI) (UG/L)	TOTAL MANGANESE (MN) (UG/L)	DISSOLVED MANGANESE (MN) (UG/L)
OCT. 12...	0	16	4	1100	30	15	0	--	--	500	50
NOV. 19...	--	--	--	--	--	--	--	--	--	--	--
FEB. 05...	0	7	5	1100	70	6	0	0	0	240	0
APR. 02...	1	<10	3	2000	30	<100	--	--	30	140	20
JULY 12...	0	<10	3	750	350	<100	2	--	20	210	0
SEP. 19...	0	10	3	10000	60	<100	2	--	0	710	590

DATE	TOTAL MERCURY (HG) (UG/L)	DISSOLVED MERCURY (HG) (UG/L)	TOTAL NICKEL (NI) (UG/L)	DISSOLVED NICKEL (NI) (UG/L)	TOTAL SELENIUM (SE) (UG/L)	DISSOLVED SELENIUM (SE) (UG/L)	TOTAL STRONTIUM (SR) (UG/L)	DISSOLVED STRONTIUM (SR) (UG/L)	TOTAL ZINC (ZN) (UG/L)	DISSOLVED ZINC (ZN) (UG/L)
OCT. 12...	<.2	--	--	--	0	0	--	--	60	--
NOV. 19...	--	--	--	--	--	--	--	--	--	--
FEB. 05...	.2	.2	4	0	0	0	100	120	40	40
APR. 02...	.4	.0	--	2	0	2	--	643	110	100
JULY 12...	.0	.1	--	0	0	0	--	570	40	10
SEP. 19...	1.6	.0	--	3	0	0	--	170	80	0

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	TEMPERATURE (DEG C)	ALDRIN (UG/L)	DDD (UG/L)	DDE (UG/L)	DDT (UG/L)	DIELDRIN (UG/L)	ENDRIN (UG/L)	HEPTACHLOR (UG/L)	HEPTACHLOR EPOXIDE (UG/L)
OCT. 12...	1000	15000	21.0	.00	.00	.01	.00	.01	.00	.00	.00
FEB. 05...	1630	15500	16.0	.00	.00	.01	.00	.00	.00	.00	.00
APR. 02...	1545	2720	24.5	.00	.00	.00	.00	.00	.00	.00	.00
SEP. 19...	1030	32000	25.0	.00	.00	.00	.00	.00	.00	.00	.00

DATE	LINDANE (UG/L)	CHLORDANE (UG/L)	PCB (UG/L)	DIAZINON (UG/L)	MALATHION (UG/L)	METHYL PARATHION (UG/L)	PARATHION (UG/L)	2,4-D (UG/L)	SILVEX (UG/L)	2,4,5-T (UG/L)
OCT. 12...	.00	.0	.0	.01	.00	.00	.00	.00	.00	.00
FEB. 05...	.00	.0	.0	.00	.00	.00	.00	.00	.00	.00
APR. 02...	.00	.0	.0	.00	.00	.00	.00	.02	.00	.00
SEP. 19...	.00	.0	.0	.00	.00	.00	.00	.03	.00	.01

Source: "Water Resources Data for Texas - Water Quality Records," U.S. Dept. of Interior, U.S.G.S., 1974.

Table B.3-2 Water Quality Data for Waste Water Discharged by Dow Chemical Corp. at Freeport

Parameter*	Range of Values (lb/day)
Change in biological oxygen demand	15,000 to 20,000
Change in total suspended solids	-20,000 to -80,000
Change in total chromium	9 to 34

*All water quality data are expressed in terms of the change in the water quality parameter from its original value when removed from the Brazos River to its final value when returned to the river.

Source: M. Moos, Private Communication, Texas Water Quality Board, Austin, Texas, June 3, 1976.

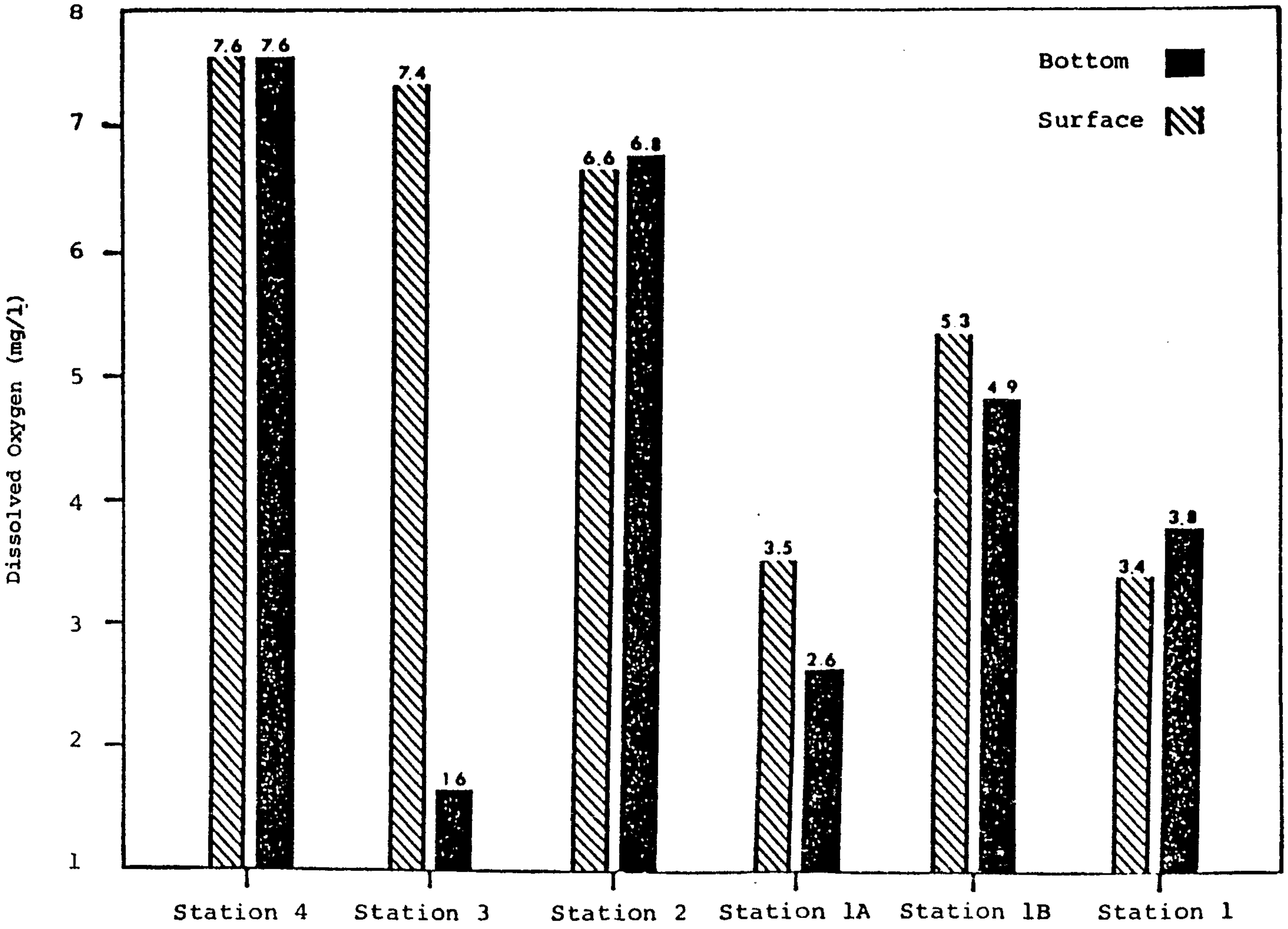


Figure B.3-1 Average Surface and Bottom Dissolved Oxygen Values at Each Station for the Brazos River

Source: "Lower Brazos River Project: Final Report," Texas Water Quality Board, January 1972.

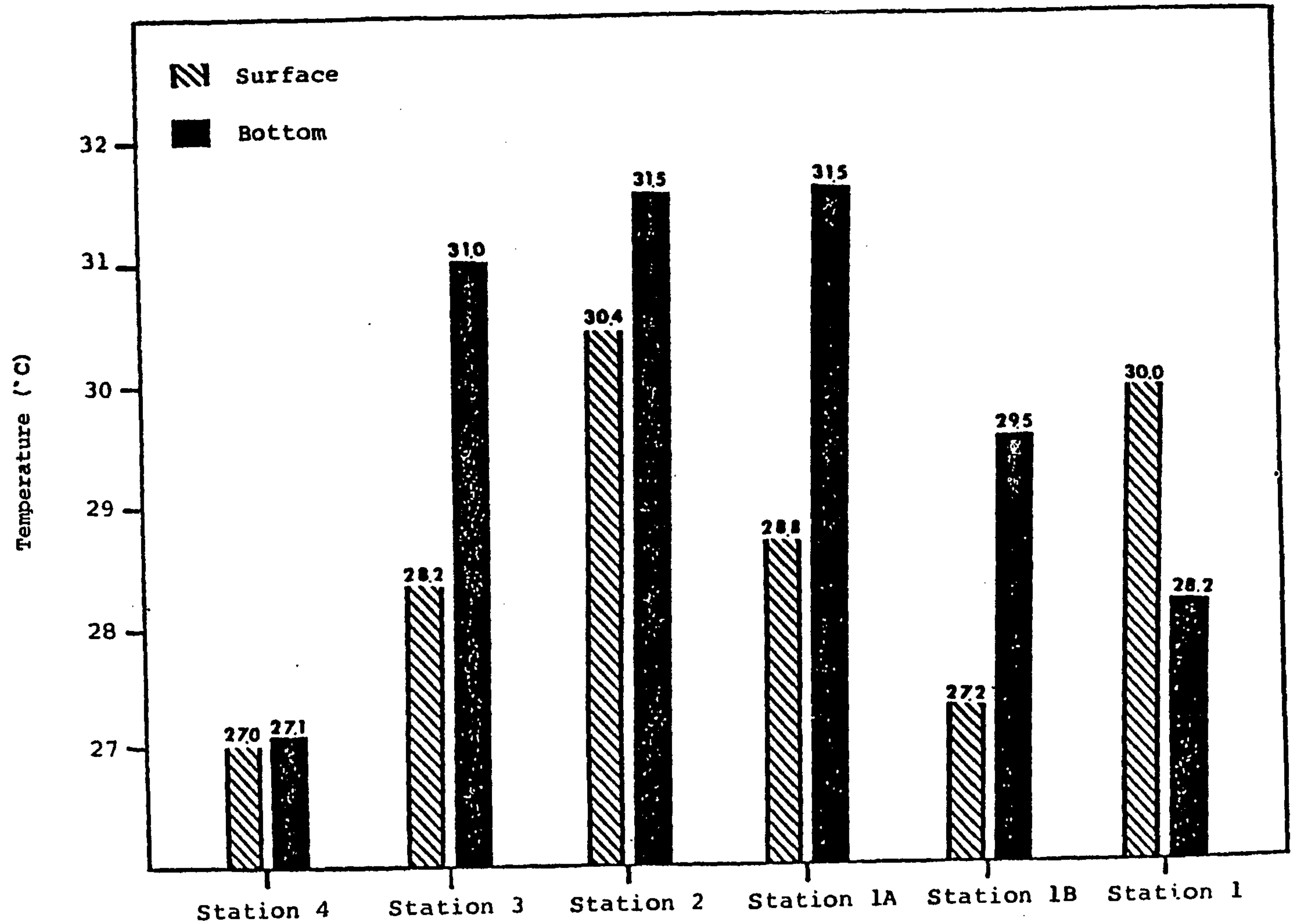


Figure B.3-2 Average Surface and Bottom Temperature Values at Each Station for the Brazos River

Source: "Lower Brazos River Project: Final Report," Texas Water Quality Board, January 1972.

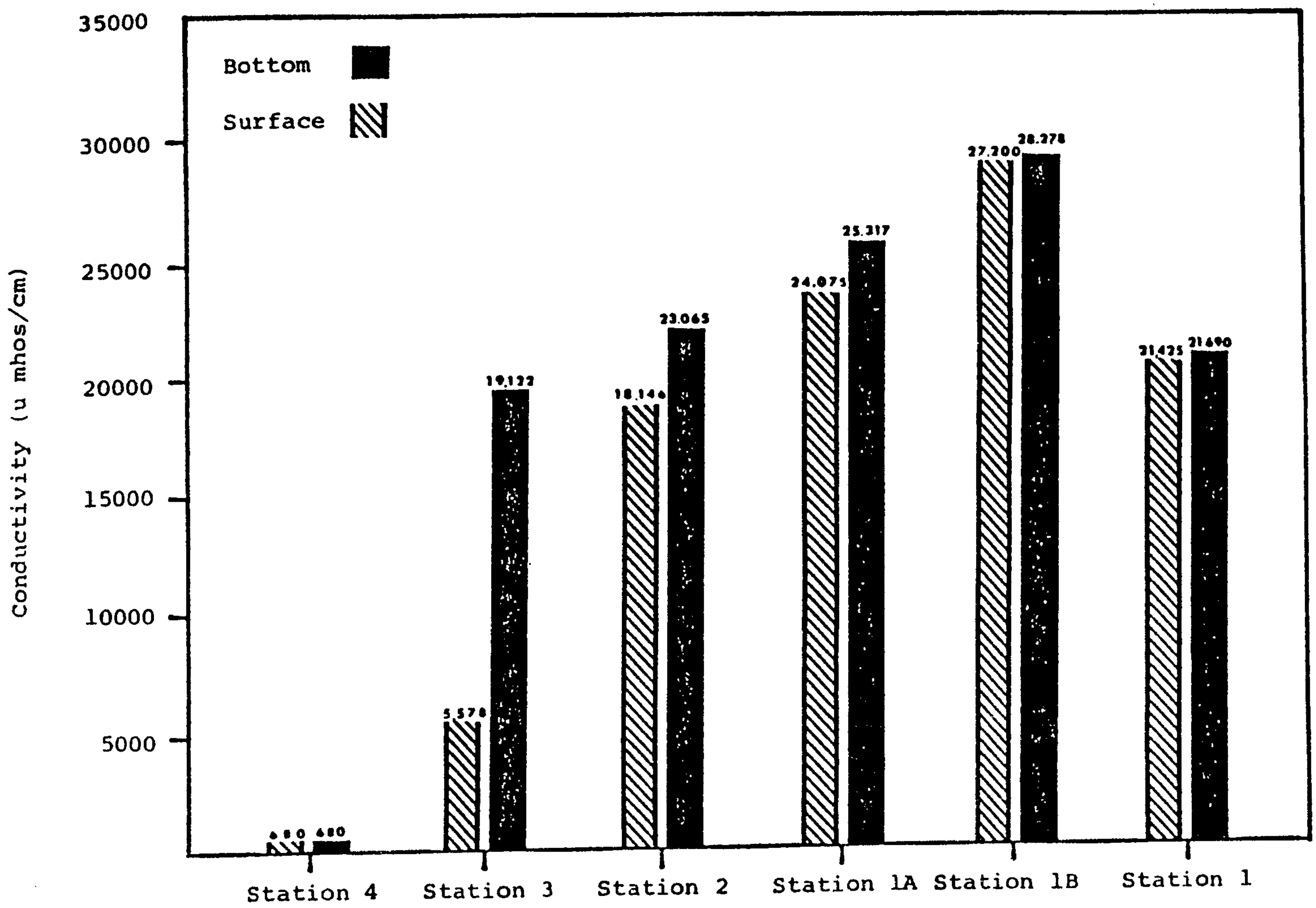


Figure B.3-3 Average Surface and Bottom Conductivity Values at Each Station for the Brazos River

Source: "Lower Brazos River Project: Final Report," Texas Water Quality Board, January 1972.

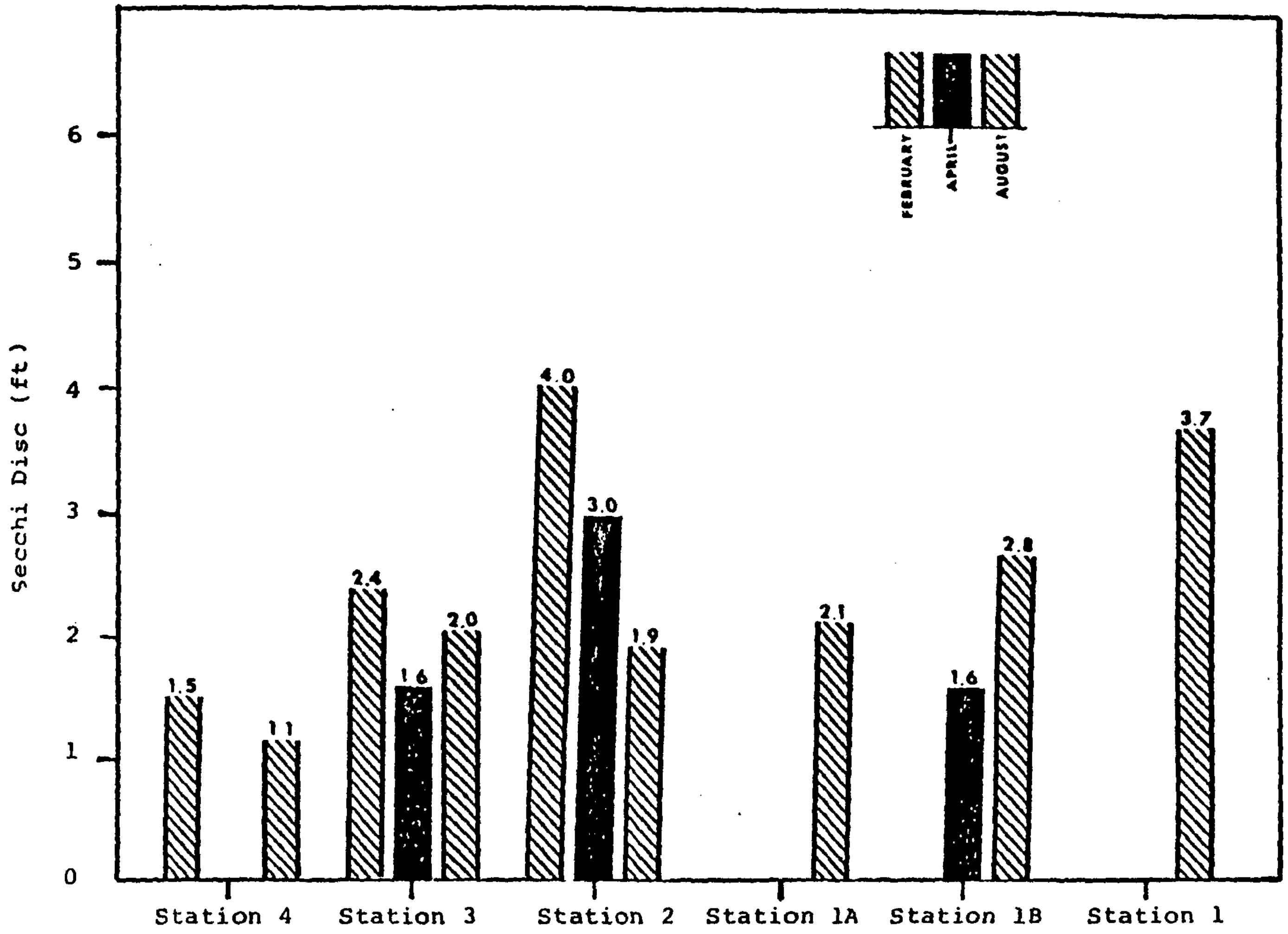


Figure B.3-4 Water Clarity at Each Station on the Brazos River During February, April, and August, 1971

Source: "Lower Brazos River Project: Final Report," Texas Water Quality Board, January 1972.

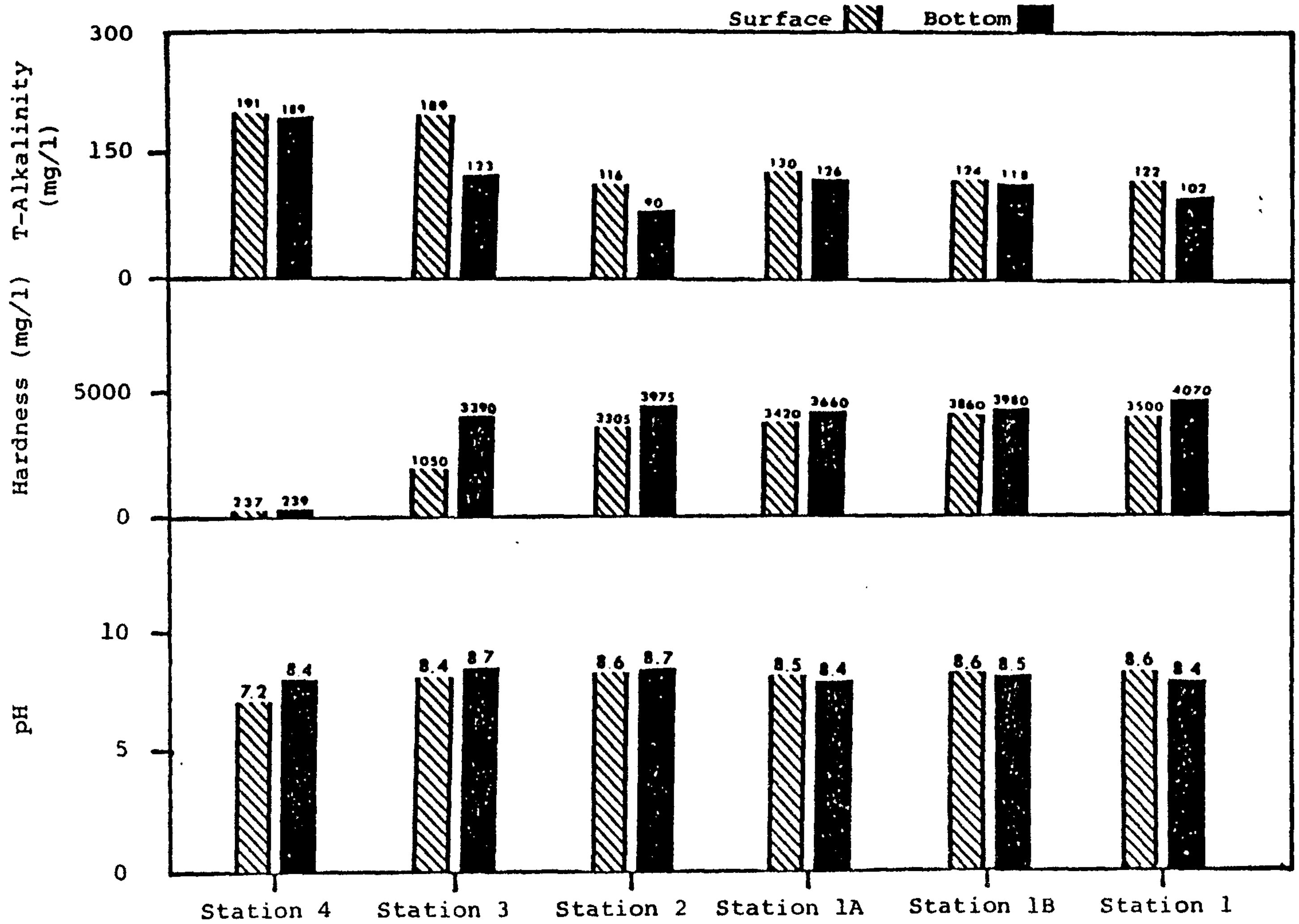


Figure B.3-5 Average Surface and Bottom Alkalinity, Hardness, and pH Values at Each Station for the Brazos River

Source: "Lower Brazos River Project Final Report," Texas Water Quality Board, January 1972.

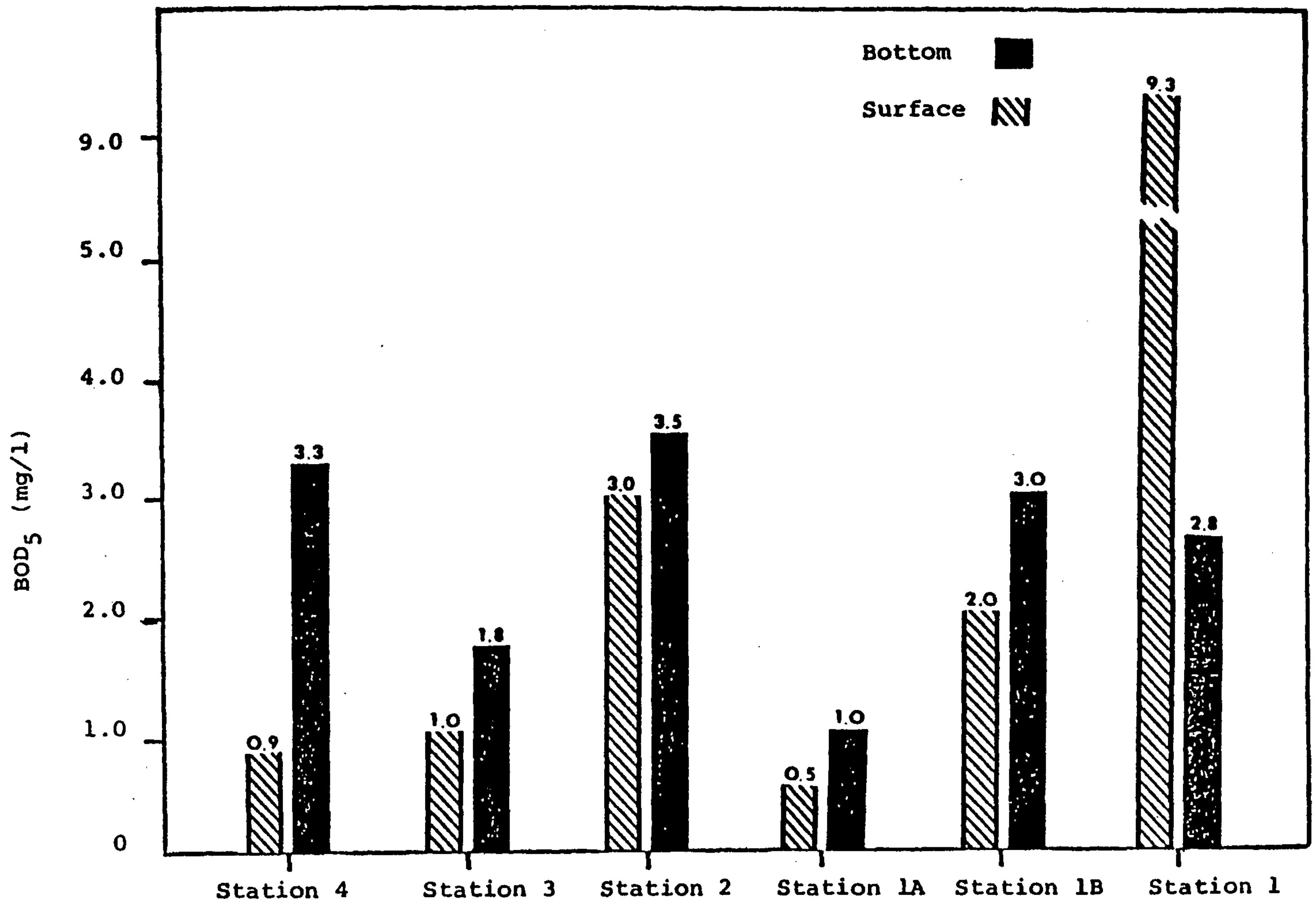


Figure B.3-6 Average Surface and Bottom Biological Oxygen Demand values at Each Station for the Brazos River

Source: "Lower Brazos River Project: Final Report," Texas Water Quality Board, January 1972.

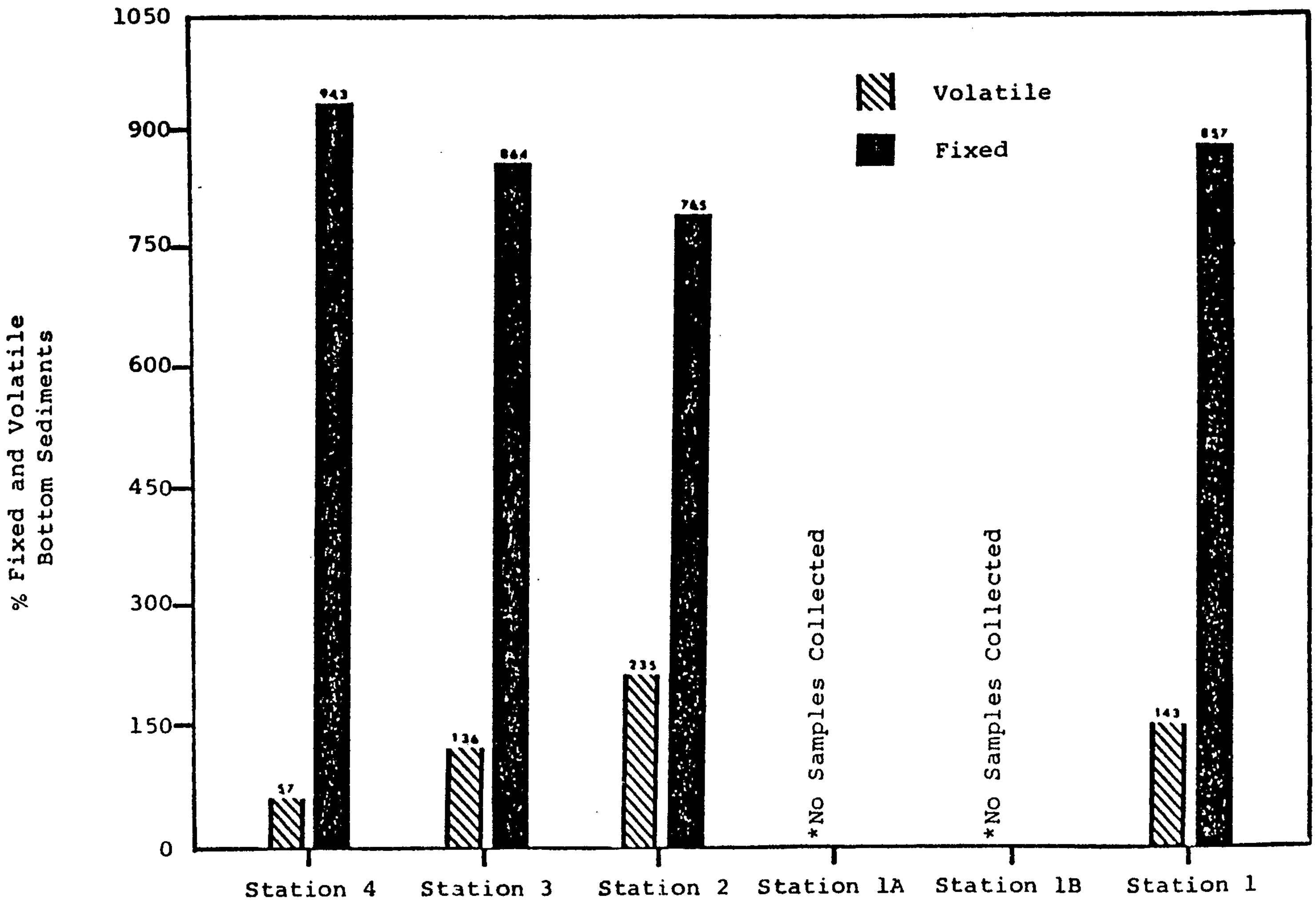


Figure B.3-7 Representative % Fixed and Volatile Solids Content of the Bottom Sediments at Each Station for the Brazos River

Source: "Lower Brazos River Project: Final Report," Texas Water Quality Board, January 1972.

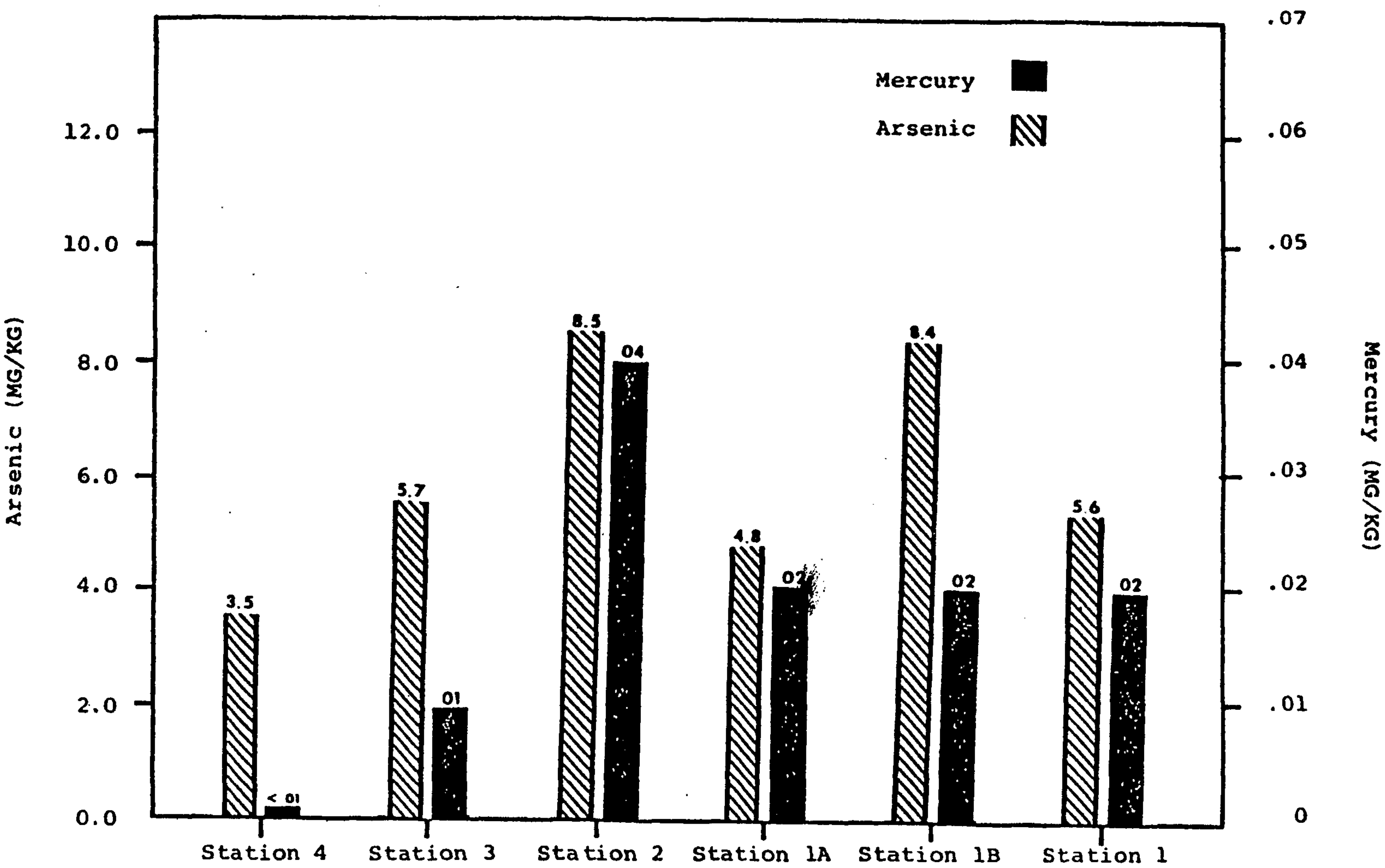


Figure B.3-8 Representative Mercury and Arsenic Content of the Bottom Sediments at Each Station for the Brazos River

Source: "Lower Brazos River Project: Final Report," Texas Water Quality Board, January 1972.

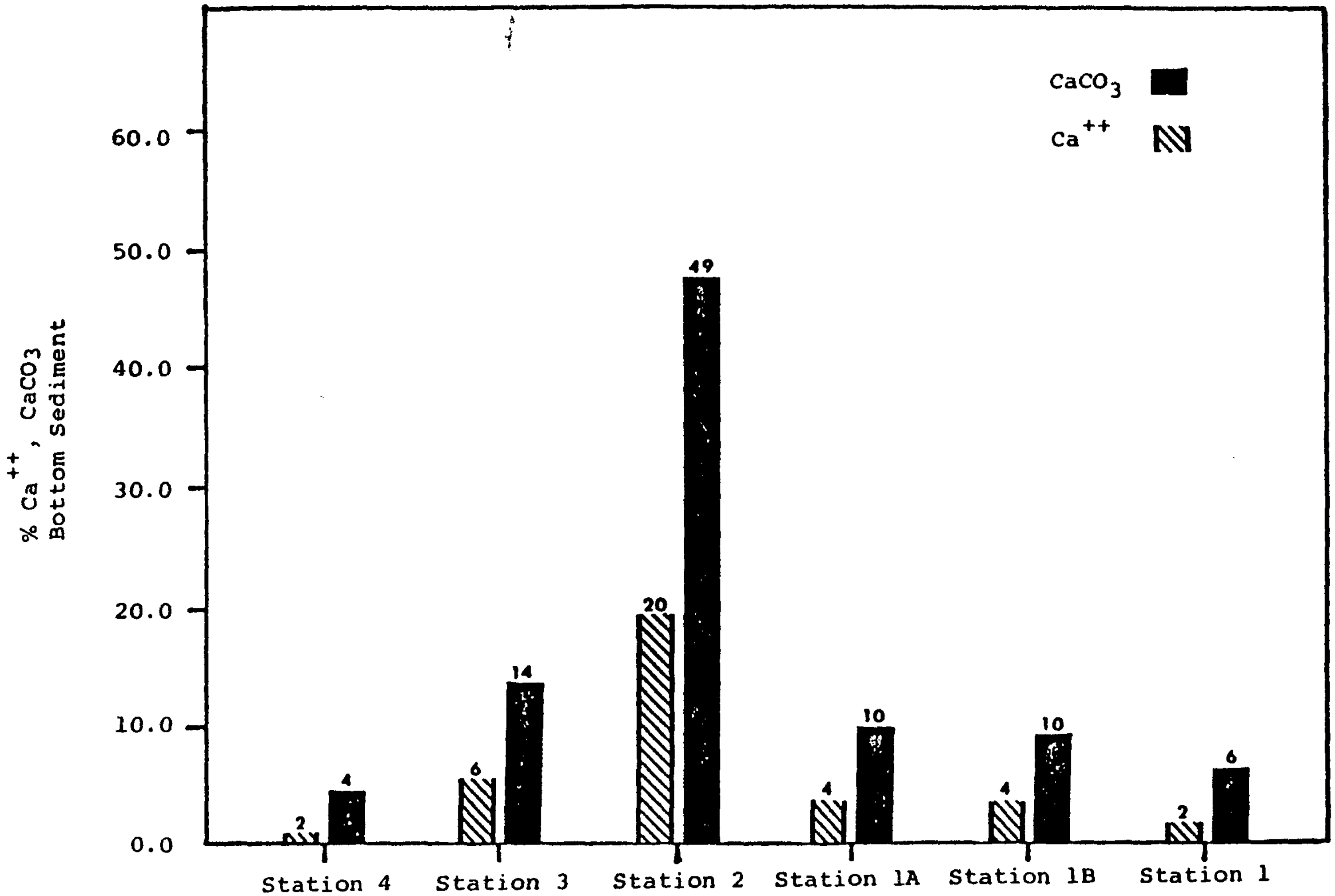


Figure B.3-9 Representative % Calcium (Ca^{++}) and Calcium Carbonate ($CaCO_3$) Content of the Bottom Sediments at Each Station for the Brazos River

Source: "Lower Brazos River Project: Final Report," Texas Water Quality Board, January 1972.

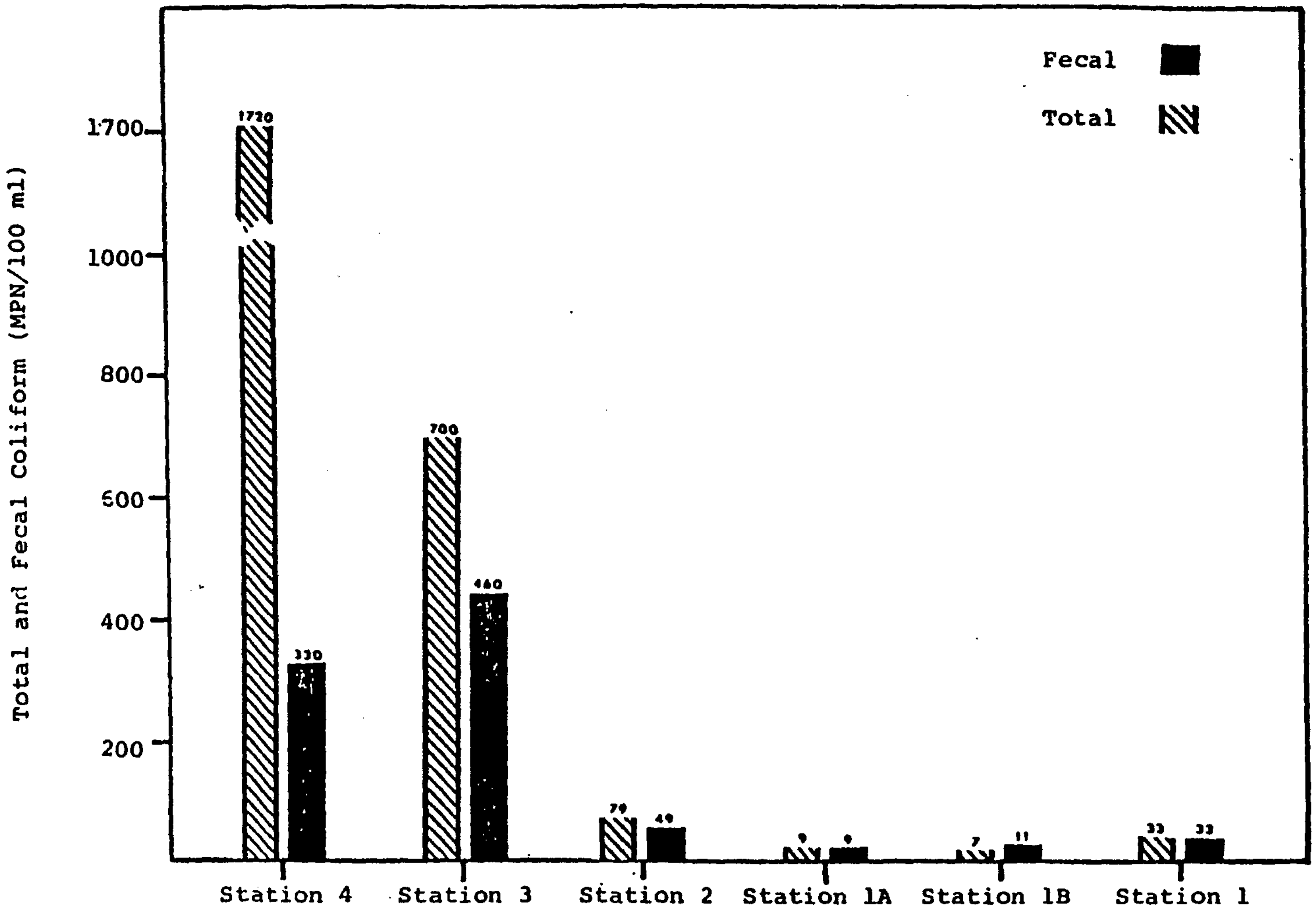


Figure B.3-10 Total and Fecal Coliform Concentrations at Each Station During April, 1971, for the Brazos River

Source: "Lower Brazos River Project: Final Report," Texas Water Quality Board, January 1972.

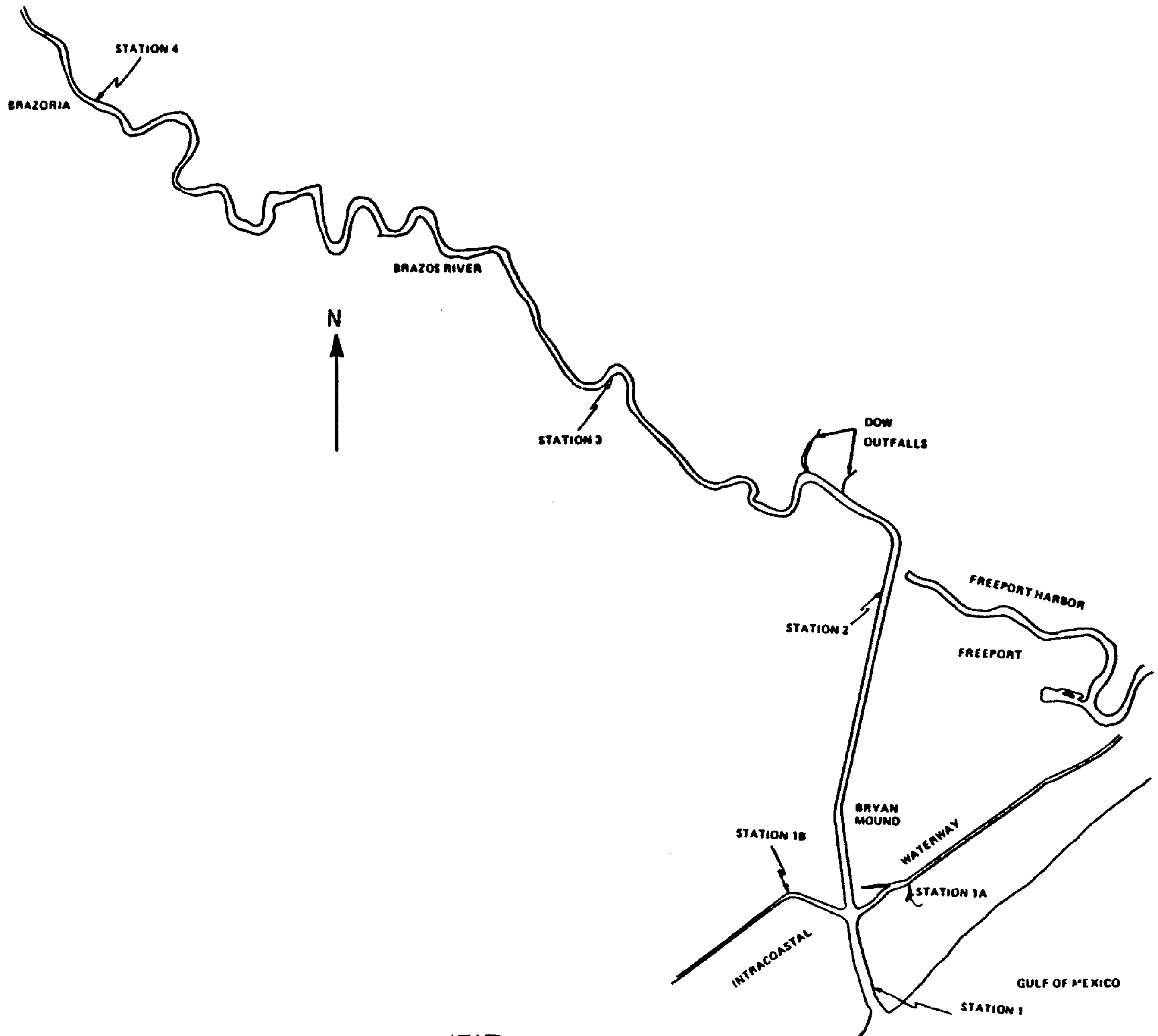


Figure B.3-11 Location of Sampling Stations on the Lower Brazos River

APPENDIX B.4

FREEPORT HARBOR CHARACTERISTICS

Two tables comprise this appendix. Table B.4-1 provides the current dimensions of Freeport Harbor as well as the dimensions of the approved modification. The annual shoaling rates and frequency of dredging estimates for the harbor are provided in Table B.4-2.

Table B.4-1 Freeport Harbor Project Dimensions

Section of Waterway	Depth in Ft. Below low tide	Botton Width in Feet	Length of Channel in Feet
Outer Bar Channel	38 [45]	300	16,000
Jetty Channel	36 [45]	200	4,400
Quintana Turning Basin			
Channel to Brazosport Turning Basin	36 [45]	200-350 [450]	6,351
Brazosport Turning Basin	36 [45]	744-800 [1050]	667
Channel to Upper Basin	36 [45]	350-375 [550]	7,156
Upper Turning Basin	36 [45]	600	600
Channel to Stauffer Chemical Plant	30 (1)	200	6,090
Stauffer Turning Basin	30 (1)	500	500
Brazos Harbor Channel Entrance	30 [36]	200 [450]	
Brazos Harbor Channel	30 [36]	200	2,690
Brazos Harbor Turning Basin	30 [36]	525	675

(1) Improved by local interest to a depth of 25 feet. Available depths are adequate for present commerce and maintenance to the authorized depth of 30 feet has not been required.

Note: Numbers in [] indicate approved modification.

Source: Maintenance Dredging of Freeport Harbor, Texas, Final Environmental Statement, U.S. Army Engineer District, Galveston, Texas, 10 July 1975.

Table B.4-2 Annual Shoaling Rates and Frequency of Dredging

	Outer Bar and Jetty Channels	Brazosport Basin to Upper Turning Basin	Brazos Harbor Channel and Turning Basin
Frequency of Dredging	12 months	24 months	60 months
Existing 36-Foot Project *	1,000,000 Cubic Yards	550,000 Cubic Yards	50,000 Cubic Yards
Modification of 36-Foot Project **	1,000,000 Cubic Yards	640,000 Cubic Yards	50,000 Cubic Yards
Proposed 45-Foot Project **	1,563,000 Cubic Yards	757,000 Cubic Yards	56,000 Cubic Yards

* Average annual shoaling rates experienced.

** Estimated average shoaling rates following construction of proposed modification.

Source: Maintenance Dredging of Freeport Harbor, Texas, Final Environmental Statement, U.S. Army Engineer District, Galveston, Texas, 10 July 1975.

APPENDIX B.5

WATER QUALITY DATA FOR FREEPORT HARBOR AND THE INTRACOASTAL WATERWAY

This appendix consists of 4 tables and 2 figures. Table B.5-1 provides water quality data for Freeport Harbor and the Intracoastal Waterway collected by the U.S. Corps of Engineers in 1971 and 1974. Sediment quality data for Freeport Harbor, collected in 1971 by the Corps are presented in Table B.5-2. Water quality data for Freeport Harbor obtained by the Texas Water Quality Board in 1972 and 1973 are provided in Table B.5-3. Table B.5-4 contains water and sediment quality data collected by the Corps during 1975. This table is especially noteworthy because it provides data before, during and after dredging in the harbor.

Figure B.5-1 provides the locations of the sampling stations for the data provided in Table B.5-1 and B.5-2, while the station locations for the data in Table B.5-4 are indicated in Figure B.5-2.

Table B.5-1 Water Quality Data Collected by the U.S. Corps of Engineers (1971 & 1974) for Freeport Harbor, Texas and Intracoastal Waterway

Station*	Date	Depth (ft)	Water Temp (°C)	Dissolved Oxygen (mg/l)	pH	Salinity (ppt)	Iron (mg/l)	Sulfate (mg/l)	Volatile Solids (mg/l)	Chemical Oxygen Demand (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Oil and Grease (mg/l)	Mercury (μg/l)	Lead (mg/l)	Zinc (mg/l)
1W	7/28/71	1.0	-	5.9	8.0	27.5	-	-							
		27.0		5.0	8.0	28.5			7800	227	1.0	60	< 0.5	< 1.0	< 0.2
	2/11/74	35.0	18.0	7.0	8.0	28.0	-	-							
2W	7/28/71	1.0	-	5.5	8.0	32.0									
		35.0	-	4.4	8.0	32.2			6700	205	1.1	< 1.0	< 0.5	< 1.0	< 0.2
	2/11/74	26.0	18.0	7.0	8.0	29.0									
3W	7/28/71	1.0	-	5.1	8.0	33.5	-	-							
		35.0	-	4.4	8.0	20.5	-	-	7600	216	1.3	< 1.0	< 0.5	< 1.0	< 0.2
	2/11/74	40.0	18.0	6.0	9.0	29.0	-	-							
4W	7/28/71	1.0	-	4.8	8.0	33.5	-	-							
		33.0	-	4.6	8.1	33.5	-	-	7200	193	1.4	< 1.0	< 0.5	< 1.0	< 0.2
	2/11/74	36.0	18.5	7.0	8.4	30.0	-	-							
5W	7/28/71	3.0	-	1.6	8.2	34.5	-	-	7000	203	4.9	< 1.0	< 0.5	< 1.0	< 0.2
	2/11/74	1.0	18.0	7.0	8.0	16.0	0.45	250							
		12.0	18.0	7.0	8.0	22.0	0.40	225							

Table B.5-1 Water Quality Data Collected by the U.S. Corps of Engineers (1971 & 1974) for Freeport Harbor, Texas and Intracoastal Waterway (Concluded)

Station*	Date	Depth (ft)	Water Temp (°C)	Dissolved Oxygen (mg/l)	pH	Salinity (ppt)	Iron (mg/l)	Sulfate (mg/l)	Volatile Solids (mg/l)	Chemical Oxygen Demand (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Oil and Grease (mg/l)	Mercury (μg/l)	Lead (mg/l)	Zinc (mg/l)
6W	7/28/71	2.0	-	1.5	8.2	35.7	-	-	6400	219	4.9	< 1.0	< 0.5	< 1.0	< 2.0
	2/11/74	1.0	18.0	9.0	7.7	13.0	0.18	225							
		12.0	18.0	7.0	7.7	22.0	0.61	225							
7W	7/28/71	1.0	-	0.8	8.3	35.0	-	-	7200	257	5.1	< 1.0	< 0.5	< 1.0	< 0.2
	2/12/74	[illegible].0	18.0	7.0	8.4	8.0	-	-							
		10.0	18.0	8.0	8.0	16.0	2.50	150							
8W	7/28/71	2.5	-	1.0	8.3	35.5	-	-	[illegible]000	219	5.0	< 1.0	< 0.5	< 1.0	< 0.2
	2/12/74	1.0	18.5	9.0	7.8	8.0	-	-							
		11.0	18.5	7.0	8.4	19.0	0.55	125							
9W	7/28/71	1.0	-	4.3	8.1	35.0	-	-							
		36.0	-	5.4	8.1	34.0	-	-	6900	250	1.4	4.0	< 0.5	< 1.0	< 0.2
	2/11/74	1.0	-	8.0	7.6	18.0	0.15	150							
		35.0	-	7.0	7.8	24.5	0.15	200							
10W	2/12/74	1.0	-	7.0	8.0	22.0	0.13	140							
		11.0	-	7.0	7.8	28.0	0.08	150							
11W	2/12/74	1.0	18.0	7.0	7.8	20.0	0.18	150							
		9.0	19.0	9.0	7.8	24.5	0.15	200							
12W	2/12/74	1.0	-	8.0	7.6	18.0	0.15	150							
		12.0	-	7.0	7.8	24.5	0.15	200							

*Sample locations shown on Figure B.5-1

Source: Maintenance Dredging of Freeport Harbor, Texas, Final Environmental Statement, U.S. Army Engineer District, Galveston, Texas, 10 July 1975.

Table B.5-2

Sediment Quality Data Collected by
The U.S. Corps of Engineers (1971) For
Freeport Harbor, Texas

Station* Number	Date Sampled	Vol Sol mg/kg dry wt	COD mg/kg dry wt	Tot Kjel Nitrogen mg/kg dry wt	Oil and Grease mg/kg dry wt	Mercury mg/kg	Lead mg/kg	Zinc mg/kg
1S	7/27/71	44,900	38,400	7,400	910	0.6	26	58
2S	7/27/71	45,900	35,400	5,100	1,240	0.4	23	75
3S	7/27/71	46,700	29,600	6,100	740	0.5	25	49
4S	7/27/71	47,200	35,300	7,000	630	0.6	23	59
9S	7/27/71	49,400	27,200	4,600	720	0.9	23	49

* Sample locations shown on Figure B.5-1

Source: Maintenance Dredging of Freeport Harbor, Texas, Final Environmental Statement, U.S. Army Engineer District, Galveston, Texas, 10 July 1975.

Table B.5-3

Water Quality Data Furnished By
Texas Water Quality Board (1972 & 1973)
For Freeport Harbor, Texas

Location*	No. of Observa-tions	Water Temp °C	Turbid-ity (JTU)	Dissolved Oxygen (mg/l)	pH	Salinity (ppt)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	Coliform MPN/100 ml Total	Coliform MPN/100 ml Fecal
1-Freeport Harbor	1	16.7	10	7.30	8.4	36	1.0	114	3	3
2-Freeport Harbor	1	18.3	15	5.20	8.3	36	1.5	173	9	9
3-Freeport Harbor	1	18.3	12	5.50	8.3	36	1.0	122	23	23
4-Freeport Harbor	1	18.9	12	6.20	8.3	36	1.0	165	43	43
5-Freeport Harbor 2/	2	23.3	-	8.50	-	23	-	-	495	35
6-Freeport Harbor	1	18.9	15	7.75	8.3	34	1.0	179	15	15
7-Jetty Channel	1	16.7	20	8.20	8.4	40	1.0	185	3	3

1/ Sampled 16 November 1972 except as noted.

2/ Averaged data of samples taken 6 and 13 November 1973.

* Station locations are not precisely known.

Source: Maintenance Dredging of Freeport Harbor, Texas, Final Environmental Statement, U.S. Army Engineer District, Galveston, Texas, 10 July 1975.

Table B.5-4 Water Quality Monitoring Data (1975) for Freeport Harbor, Texas

	Sample* No.	Date Sampled	Dist ft From C_L	Water Depth MLT-Ft	Water Temp ^{o}C	Dissolved Oxygen mg/l	pH	Salinity ppt	Conductivity umos/cm	Air Temp ^{o}C	Wind Direction	Moisture Content % Dry Wt	Total Solids mg/l	Total Solids % by Wt.	Total Volatile Solids mg/l	Total Volatile Solids % dry wt	Total Kjeldahl Nitrogen mg/l	Total Kjeldahl Nitrogen mg/kg
				CHANNEL AREA BEFORE DREDGING														
Sediment	F-75A-3S	4/23/75	0	39.0								100		50		6.3		1,400
Water	F-75A-3W	4/23/75	0	39.0	22.0	7	9.0	20.5	32,700	27.0	SE		24,300		5,500		0.22	
Sediment	F-75A-13S	4/23/75	150N	40.0								138		42		9.0		1,900
Water	F-75A-13W	4/23/75	150N	40.0	22.0	8	9.0	20.0	32,000	26.0	SE		22,100		4,500		0.33	
Sediment	F-75A-4S	4/23/75	0	36.0								100		50		8.0		1,500
Water	F-75A-4W	4/23/75	0	36.0	22.0	9	9.0	20.0	32,000	26.0	SE		22,300		4,350		0.25	
Sediment	F-75A-14S	4/23/75	0	38.0								104		49		7.7		1,600
Water	F-75A-14W	4/23/75	0	38.0	22.0	9	9.0	19.5	31,300	25.0	SE		20,300		4,200		0.27	
				DURING DREDGING (See Note 4)														
Water	F-75B-3W	5/23/75	0	35.5	28.0	6	9.0	24.0	37,700	30.0	SE		25,100		4,400		3.5	
Water	F-75B-13W	5/23/75	150N	34.5	28.0	7	9.0	25.0	39,100	30.0	SE		26,800		5,000		1.1	
Water	F-75B-4W	5/23/75	0	34.5	28.0	7	9.0	23.0	36,200	30.0	SE		28,200		5,400		1.3	
				(See Note 5)														
Water	F-75C-4W	6/10/75	0	36.0	25.0	2.6	9.0	31.0	47,500	26.0	S		35,700		6,600		1.3	
Water	F-75B-14W	6/10/75	0	36.0	25.0	4	9.0	30.0	46,200	26.0	S		34,200		5,800		1.2	
				AFTER DREDGING														
Sediment	F-75C-3S	9/18/75	0	38.0								94		52		7.2		1,260
Water	F-75C-3W	9/18/75	0	38.0	29.0	6	9.0	24.0	37,700	31.0	SE		26,700		4,100		0.8	
Sediment	F-75C-13S	9/18/75	150N	37.0								158		39		10.8		1,710
Water	F-75C-13W	9/18/75	150N	37.0	29.0	6	9.0	23.0	36,200	31.0	SE		26,600		4,200		0.9	
Sediment	F-75D-4S	9/18/75	0	36.0								83		55				1,010
Water	F-75D-4W	9/18/75	0	36.0	29.0	6	9.0	23.0	36,200	31.0	SE		27,500		5,100	8.4	1.4	
Sediment	F-75C-14S	9/18/75	0	39.0								77		56				1,620
Water	F-75C-14W	9/18/75	0	39.0	29.0	7	9.0	25.0	39,100	31.0	SE		26,100		4,200	6.6	1.4	

Table B.5-4 Water Quality Monitoring Data (1975) for Freeport Harbor, Texas

(Continued)

	Sample* No.	Oil and Grease mg/l	Oil and Grease mg/kg	Chemical Oxygen Demand mg/l	Chemical Oxygen Demand mg/kg	Chlorides mg/l	Arsenic µg/l	Arsenic mg/kg	Cadmium mg/l	Cadmium mg/kg	Chromium (Total) mg/l	Chromium (Total) mg/kg	Copper mg/l	Copper mg/kg	Lead mg/l	Lead mg/kg	Mercury µg/l	Mercury mg/kg	Nickel mg/l	Nickel mg/kg	Zinc mg/l	Zinc mg/kg
						CHANNEL AREA BEFORE DREDGING																
Sediment	F-75A-3S		670		16,600			5.8		2.4		16		15		20		0.37		22		75
Water	F-75A-3W	6.6		66		11,000	8		0.004		0.04		0.23		0.02		0.33		0.06		0.29	
Sediment	F-75A-13S		630		27,100			6.9		3.5		22		17		26		< 0.1		30		158
Water	F-75A-13W	3.9		107		9,000	2		0.004		0.03		0.13		0.01		0.69		0.03		0.22	
Sediment	F-75A-4S		560		20,900			4.0		2.4		20		17		22		< 0.1		25		90
Water	F-75A-4W	2.8		144		9,800	0		0.004		0.04		0.20		0.01		0.82		0.06		0.32	
Sediment	F-75A-14S		610		24,800			5.7		2.8		20		19		25		0.11		30		103
Water	F-75A-14W	2.3		113		8,500	0		0.003		0.03		0.37		0.01		0.51		0.06		1.0	
						DURING DREDGING (See Note 4)																
Water	F-75B-3W	0		106		12,500	2		< 0.001		0.03		0.08		0.02		< 0.2		0.02		0.08	
Water	F-75B-13W	0		101		13,000	3		< 0.001		0.03		0.10		0.01		< 0.2		0.02		0.15	
Water	F-75B-4W	0		188		13,200	1		< 0.001		0.03		0.11		0.02		< 0.2		0.02		0.12	
						(See Note 5)																
Water	F-75C-4W	0		314		8,200	0		< 0.003		0.04		0.16		0.04		< 0.2		0.06		0.16	
Water	F-75D-14W	0		133		17,000	1		< 0.003		0.04		0.09		0.03		< 0.2		0.05		0.40	
						AFTER DREDGING																
Sediment	F-75C-3S		470		16,600			0.3		0.5		18		10		22		< 0.1		24		61
Water	F-75C-3W	8.6		59		12,200	0.1		< 0.003		0.07		0.13		0.01		< 0.2		0.08		0.13	
Sediment	F-75C-13S		745		27,500			0.5		1.2		28		18		28		< 0.1		36		85
Water	F-75C-13W	8.8		59		13,000	0.2		< 0.002		0.01		0.18		0.01		0.47		0.08		0.13	
Sediment	F-75D-4S		500		19,600			0.4		0.9		21		13		20		< 0.1		35		73
Water	F-75D-4W	5.6		49		13,400	0.1		< 0.002		0.06		0.14		0.00		0.26		0.08		0.14	
Sediment	F-75C-14S		405		21,300			0.4		0.4		21		8		14		< 0.1		30		64
Water	F-75C-14W	7.5		31		12,800	0.5		< 0.003		0.09		0.34		0.00		0.39		0.15		0.22	

Table B.5-4 Water Quality Monitoring Data (1975) for Freeport Harbor, Texas

(Concluded)

	Sample * No.	Oil and Grease mg/l	Oil and Grease mg/kg	Chemical Oxygen Demand mg/l	Chemical Oxygen Demand mg/kg	Chlorides mg/l	Arsenic µg/l	Arsenic mg/kg	Cadmium mg/l	Cadmium mg/kg	Chromium (Total) mg/l	Chromium (Total) mg/kg	Copper mg/l	Copper mg/kg	Lead mg/l	Lead mg/kg	Mercury µg/l	Mercury mg/kg	Nickel mg/l	Nickel mg/kg	Zinc mg/l	Zinc mg/kg
						SPILLWAY AREA BEFORE DREDGING																
Water	F-75A-15W	0.0		90		6,500	1		0.004		0.03		0.12		0.01		0.69		0.04		0.16	
Water	F-75A-16W	2.1		83		5,200	1		0.004		0.04		0.07		0.01		1.2		0.02		0.14	
						DURING DREDGING (See Note 4)																
Water	F-75A-17W	0		162		17,200	6		<0.001		0.03		0.06		0.02		<0.2		0.04		0.08	
Water	F-75B-15W	3		87		7,000	0		<0.003		0.04		0.10		0.02		0.22		0.05		0.14	
Water	F-75B-16W	1		102		6,000	0		<0.001		0.04		0.20		0.04		0.28		0.06		0.25	
						(See Note 5)																
Water	F-75B-17W	2		102		7,000	4		<0.002		0.01		0.08		0.02		0.28		0.02		0.15	
Water	F-75C-15W	0		102		7,500	0		<0.001		0.04		0.16		0.03		<0.2		0.06		0.16	
Water	F-75C-16W	2		80		4,500	5		<0.002		0.04		0.08		0.02		0.21		0.04		0.21	
						AFTER DREDGING																
Water	F-75D-15W	8.2		45		11,100	0.2		<0.001		0.06		0.17		0.02		0.26		0.09		0.13	
Water	F-75D-16W	7.5		45		10,800	0.2		<0.001		0.06		0.15		0.07		0.21		0.07		0.16	

NOTES: 1. EPA Manual states: "When the chloride level exceeds 1,000 mg/l, the minimum accepted value for the COD (of water) will be 250 mg/l. COD levels which fall below this value are highly questionable because of the high chloride correction which must be made." Actual COD results are shown.

2. Tests for Cd, Cu, Pb, Ni and Zn were performed on chelated samples.

4. Dredge located at Freeport Harbor Station 108+00 at time of sampling.

5. Dredge located at Freeport Harbor Station 75+00 at time of sampling.

6. Recent tests have indicated that the container used to collect water samples was contaminating samples with excess copper and zinc. Therefore, resuls for copper and zinc are not considered valid for all water samples tested.

*The last one or two digits in the sample number correspond to the sampling station number. The locations of these stations are indicated in Figure B.5-2.

Source: Water Quality Monitoring Program Results for Hopper Dredging of the Entrance and Jetty Channels of Freeport Harbor, Texas, U.S. Army Engineer District, Galveston, Texas, 2 September 1975.

Table B.5-4 Water Quality Monitoring Data (1975) for Freeport Harbor, Texas (Continued)

	Sample * No.	Date Sampled	Dist From ℄ ft	Water Depth MLT-Ft	Water Temp °C	Dissolved Oxygen mg/l	pH	Salinity ppt	Conductivity umos/cm	Air Temp °C	Wind Direction	Moisture Content % Dry Wt	Total Solids mg/l	Total Solids % by Wt.	Total Volatile Solids mg/l	Total Volatile Solids % Dry wt.	Total Kjeldahl Nitrogen mg/l	Total Kjeldahl Nitrogen mg/kg
				SPILLWAY AREA BEFORE DREDGING														
Water	F-75A-15W	4/23/75	0	12.0	24.0	9	9.0	14.0	23,000	26.0	SE		13,800		2,650		0.28	
Water	F-75A-16W	4/23/75	0	13.0	24,0	9	9.0	12.0	20,000	26.0	SE		10,800		2,250		0.38	
				DURING DREDGING (See Note 4)														
Water	F-75A-17W	5/23/75	—	---	28.0	7	9.0	30.0	46,200	30.0	SE		33,300		5,800		14	
Water	F-75B-15W	5/23/75	0	8.5	28.0	8	9.0	14.0	23,000	30.0	SE		13,700		2,200		1.5	
Water	F-75D-16W	5/23/75	0	6.5	28.0	8	9.0	13.0	21,500	30.0	SE		12,400		2,200		1.9	
				(See Note 5)														
Water	F-75B-17W	6/10/75	—	---	28.0	18	9.5	15.0	24,500	26.0	S		15,100		2,700		5.5	
Water	F-75C-15W	6/10/75	0	9.0	28.0	7	9.0	16.0	26,000	26.0	S		15,500		2,500		1.8	
Water	F-75C-16W	6/10/75	0	10.0	28.0	7	9.0	17.0	27,600	26.0	S		10,000		1,500		1.3	
				AFTER DREDGING														
Water	F-75D-15W	9/18/75	0	11.0	28.5	7	9.0	20.0	32,000	31.0	SE		22,800		4,100		1.5	
Water	F-75D-16W	9/18/75	0	11.0	28.5	6	9.0	20.0	32,000	31.0	SE		22,300		3,900		1.1	

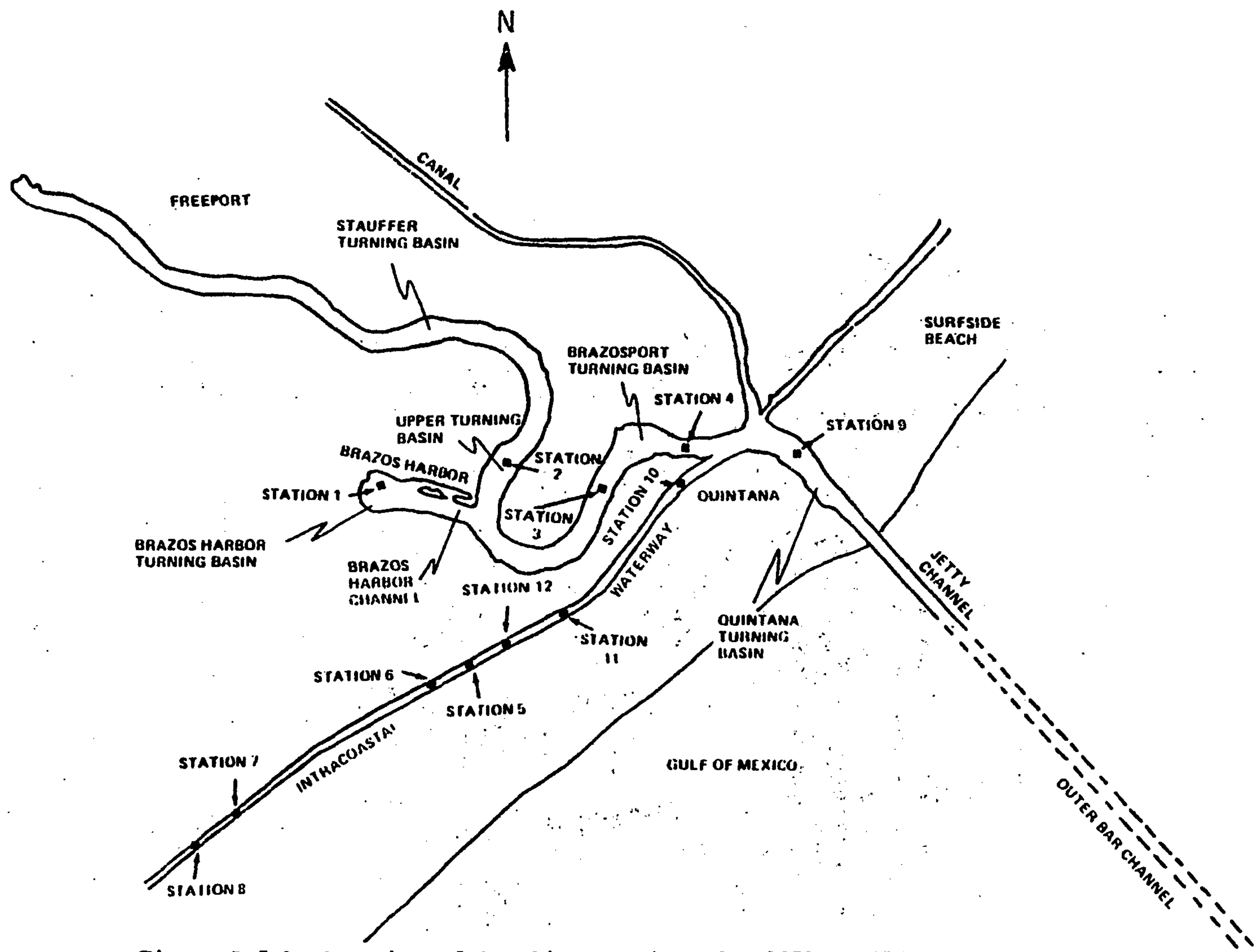


Figure B.5-1 Location of Sampling Stations for 1971 & 1974. Survey by U.S. Corps of Engineers.

Source: Maintenance Dredging of Freeport Harbor, Texas, Final Environmental Statement, U.S. Army Engineer District, Galveston, Texas, 10 July 1975.

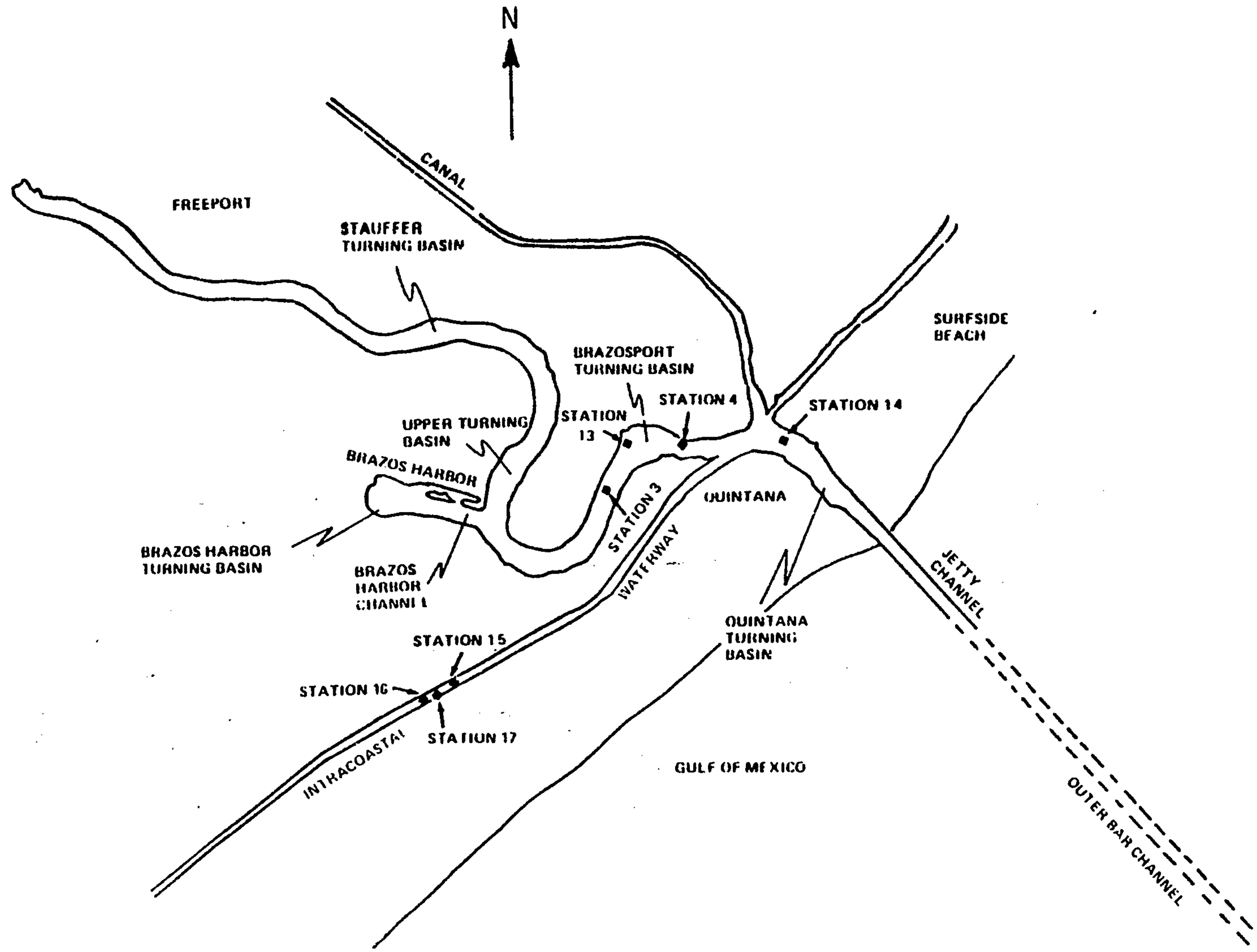


Figure B.5-2 Locations of Sampling Stations for 1975 Survey by U.S. Corps of Engineers.

Source: Data received from Texas Water Quality Board from Corps of Engineers' Freeport Harbor Dredging Project. Monitoring Program, 25 March 1976.

APPENDIX B.6

WATER AND BOTTOM SEDIMENT QUALITY DATA FOR THE GULF OF MEXICO NEAR THE BRYAN MOUND SITE

This appendix consists of 4 tables and 1 figure. Table B.6-1 presents water quality data collected in the Gulf of Mexico in 1974 at a point approximately 3.5 miles to the northeast of the alternate brine disposal site. Both water and sediment quality data collected in 1975 at the same point are presented in Tables B.6-2 and B.6-3. Table B.6-4 provides sediment quality data obtained in the alternate brine disposal in 1974. The locations of the sampling stations for the data presented in the tables are provided in Figure B.6-1.

Table B.6-1 Water Quality Data for the Gulf of Mexico near Freeport Harbor (1974)

Field Sample Number	4-W/O
Date Sampled	15 Apr 74
Source	Filtered Composite of 9 Samples from Disposal Area
Total Solids	32,100
Total Volatile Solids	9,700
Total Kjaldahl Nitrogen	0.3
Total Organic Nitrogen	0.2
Ammonia Nitrogen	0.1
Total Organic Carbon	14
Oil and Grease	0.0
Chemical Oxygen Demand	8.2
Arsenic as µg/l	2
Cadmium Cd	0.05
Chromium (Total) Cr µg/l	13
Copper Cu	0.06
Lead Pb	0.23
Mercury Hg µg/l	14
Nickel Ni	0.04
Zinc Zn	0.07
Chlorides Cl	13,000

NOTES:
1. All results in mg/l except as noted.
2. EPA Manual states: "When the chloride level exceeds 1,000 mg/l, the minimum accepted value which falls below this value is highly questionable because of the high cloride correction shown."
3. Lead and Zinc tests were performed on acid-digested samples.

Source: Water Quality Monitoring Program Results for Hopper Dredging of the Entrance and Jetty Channels of Freeport Harbor, Texas, U.S. Army Engineer District, Galveston, Texas, 2 September 1975.

Table B.6-2 Water and Bottom Sediment Quality Data for the Gulf of Mexico Near the Bryan Mound Site (9/17/75)

Type	Sediment	Water
Sample No.	FH-75A-3S	FH-75A-3W
Date Sampled	9/17/75	9/17/75
Station	DISPOSAL AREA *	DISPOSAL AREA *
Turbidity FTU	-	5
Dissolved Oxygen mg/l	-	6
pH	-	9.5
Salinity ppt	-	28.0
Water Temp °C	-	26.5
Air Temp °C	-	25.0
Wind Direction	-	N
Moisture Content % Dry Weight	37.9	-
Total Solids mg/l	-	31,000
Total Solids % By Wt.	62.1	-
Tot. Vol. Solids mg/l	-	5,580
Tot. Vol. Solids % By Wt.	6.2	-
Tot. Kjeldahl Nitrogen mg/l	-	0.2
Tot. Kjeldahl Nitrogen mg/kg	360	-
Oil & Grease mg/l	-	2
Oil & Grease mg/kg	306	-
Chem. Oxygen Demand mg/l	-	104
Chem. Oxygen Demand mg/kg	18,600	-
Chlorides mg/l	-	15,000

Table B.6-2 Water and Bottom Sediment Quality Data for the Gulf of Mexico Near the Bryan Mound Site (9/17/75 Continued)

Type	Sediment	Water
Sample No.	FH-75A-3S	FH-75A-3W
Date Sampled	9/17/75	9/17/75
Station	DISPOSAL AREA *	DISPOSAL AREA *
Arsenic μg/l	-	<10
Arsenic mg/kg	5.3	-
Cadmium mg/l	-	<0.01
Cadmium mg/kg	<1	-
Chromium (Total) mg/l	-	<0.03
Chromium (Total) mg/kg	18	-
Copper mg/l	-	0.21
Copper mg/kg	15	-
Lead mg/l	-	<0.05
Lead mg/kg	24	-
Mercury μg/l	-	<0.2
Mercury mg/kg	<0.1	-
Nickel mg/l	-	<0.02
Nickel mg/kg	21	-
Zinc mg/l	-	0.09
Zinc mg/kg	88	-

*Corresponds to Station 4/0 in Figure B.6-1

Source: Data received from Texas Water Quality Board from Corps of Engineers' Freeport Harbor Dredging Project. Monitoring Program, 25 March 1976.

Table B.6-3 Water and Bottom Sediment Quality Data for the Gulf of Mexico Near the Bryan Mound Site (12/2/75)

Type	Sediment	Water
Sample No.	FH-75B-3	FH-75B-3
Date Sampled	12/2/75	12/2/75
Station	DISPOSAL AREA*	DISPOSAL AREA*
Turbidity FTU	-	20
Dissolved Oxygen mg/l	-	7
pH	-	9.0
Salinity ppt	-	29.0
Water Temp °C	-	16.0
Air Temp °C	-	17.0
Wind Direction	-	SE
Moisture Content % Dry Weight	39.9	-
Total Solids mg/l	-	32,000
Total Solids % By Wt.	60.1	-
Tot. Vol. Solids mg/l	-	5,740
Tot. Vol. Solids % By Wt.	5.6	-
Tot. Kjeldahl Nitrogen mg/l	-	0.3
Tot. Kjeldahl Nitrogen mg/kg	310	-
Oil & Grease mg/l	-	<1
Oil & Grease mg/kg	248	-
Chem. Oxygen Demand mg/l	-	93
Chemical Oxygen Demand mg/kg	19,300	-
Chlorides mg/l	-	15,000

Table B.6-3 Water and Bottom Sediment Quality Data for the Gulf of Mexico Near the Bryan Mound Site (12/2/75 Continued)

Type	Sediment	Water
Sample No.	FH-75B-3	FH-75B-3
Date Sampled	12/2/75	12/2/75
Station	DISPOSAL AREA*	DISPOSAL AREA*
Arsenic µg/l	-	<10
Arsenic mg/kg	3.5	-
Cadmium mg/l	-	<0.01
Cadmium mg/kg	<1	
Chromium (Total) mg/l	-	<0.03
Chromium (Total) mg/kg	10	-
Copper mg/l	-	<0.02
Copper mg/kg	7	-
Lead mg/l	-	<0.05
Lead mg/kg	10	-
Mercury µg/l	-	<0.2
Mercury mg/kg	<0.1	-
Nickel mg/l	-	<0.02
Nickel mg/kg	14	
Zinc mg/l		<0.02
Zinc mg/kg	45	-

*Corresponds to Station 4/0 in Figure B.6-1

Source: Data received from Texas Water Quality Board from Corps of Engineers' Freeport Harbor Dredging Project, Monitoring Program, 25 March 1976.

Table B.6-4 Sediment Quality Data for the Gulf of Mexico Near the Bryan Mound Site

Field Sample No.*	5-S /O
Date Sampled	4/16/74
Source	Undisturbed Area
Total Solids % by Wt.	56
Total Volatile Solids % by Wt.	8.0
Tot. Kjel Nitrogen mg/kg Dry Basis	890
Ammonia Nitrogen mg/kg Dry Basis	64
Tot. Organic Nitrogen mg/kg Dry Basis	830
Tot. Organic Carbon mg/kg Dry Basis	4600
Oil and Grease mg/kg Dry Basis	480
COD mg/kg Dry Basis	29,000
Arsenic mg/kg Dry Basis	2.9
Cadmium mg/kg Dry Basis	1.6
Chromium mg/kg Dry Basis	3.6
Copper mg/kg Dry Basis	13
Lead mg/kg Dry Basis	23
Mercury mg/kg Dry Basis	0.32
Nickel mg/kg Dry Basis	46
Zinc mg/kg Dry Basis	57

*Sample Station Locations shown on Figure B.6-1.

Source: Water Quality Monitoring Program Results for Hopper Dredging of the Entrance and Jetty Channels of Freeport Harbor, Texas, U.S. Army Engineer District, Galveston, Texas, 2 September 1975.

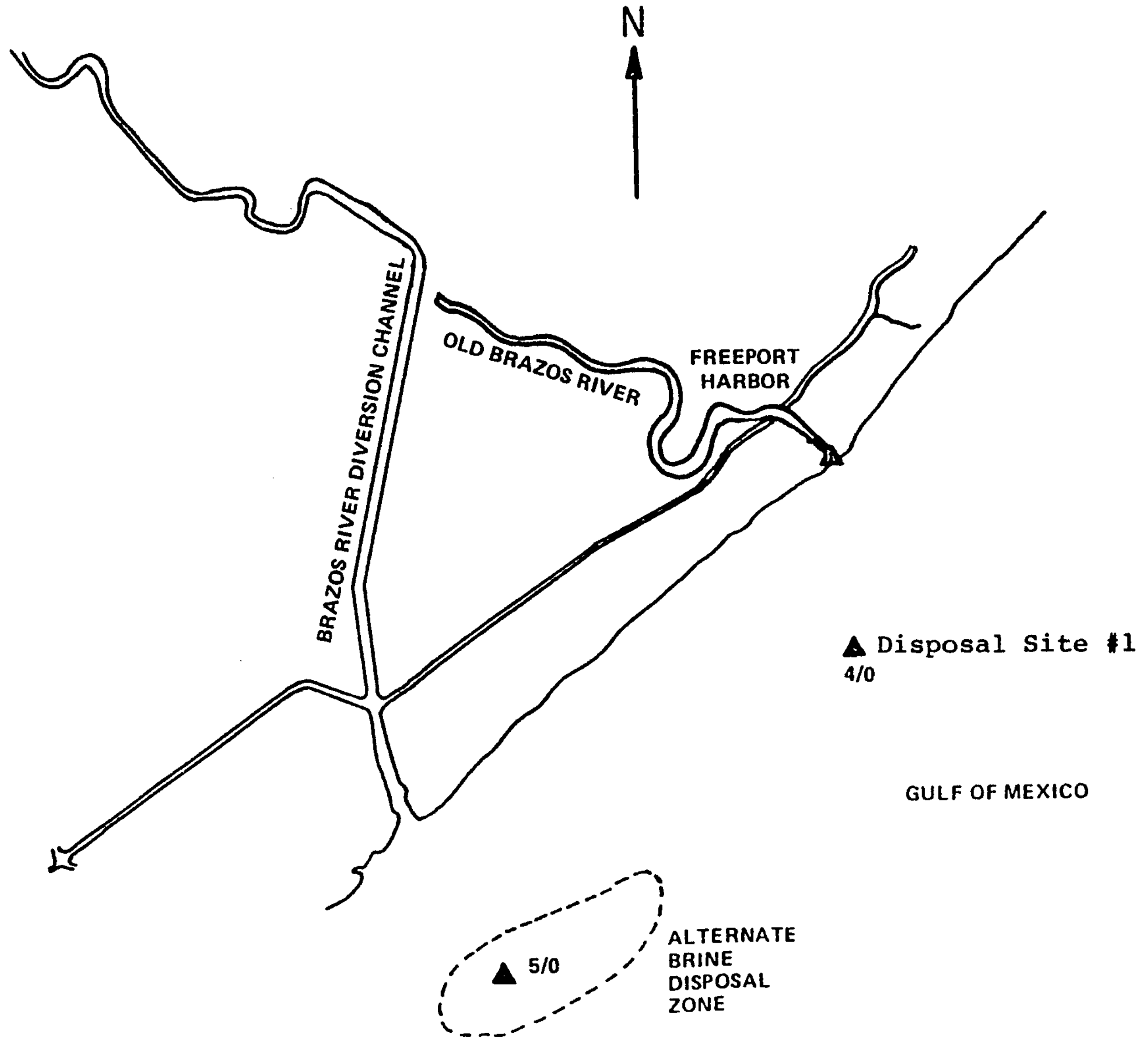


Figure B.6-1 Location of Sampling Stations in the Gulf of Mexico near Bryan Mound

APPENDIX B.7

SUBSURFACE AQUIFER CHARACTERISTICS IN THE VICINITY OF BRYAN MOUND DOME

Five figures comprise this appendix. Figure B.7-1 provides a plot of the altitude of the base of the upper unit of the Chicot aquifer while the thickness of sands in the same upper unit are plotted in Figure B.7-2. The altitude of the base of the Chicot aquifer (which also represents the base of the lower unit of that aquifer) is plotted in Figure B.7-3 while Figure B.7-4 provides a plot of the thickness of sands in the lower unit. Figure B.7-5 presents a hydrologic section in the vicinity of Freeport, Texas, and Bryan Mound.

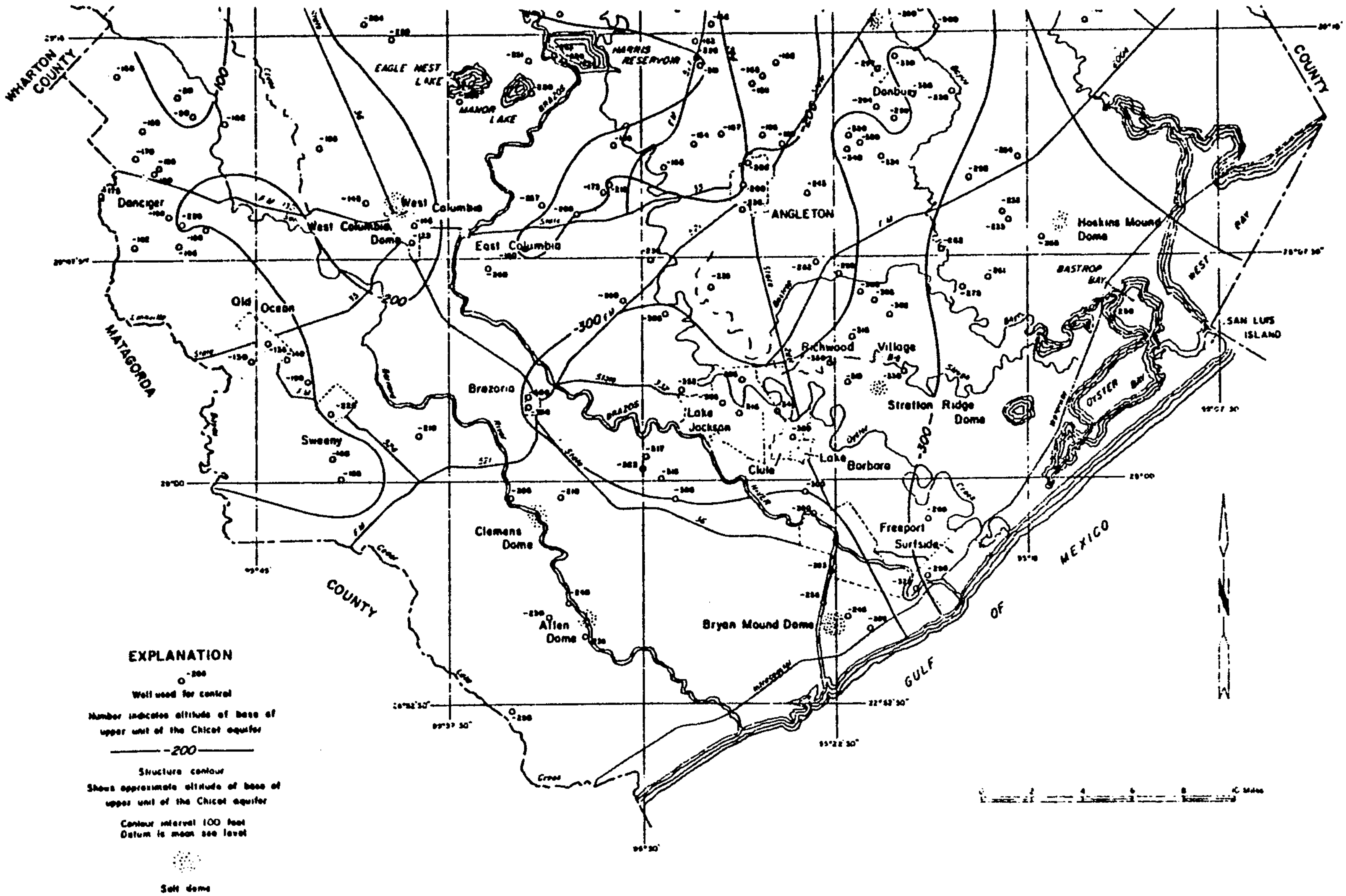


Figure B.7-1

Approximate Altitude of the Base of the Upper Unit of the Chicot Aquifer

Source: W.M. Sandeen and J.B. Wesselman, "Groundwater Resources of Brazoria County, Texas," Texas Water Development Board, Report No. 163, 1973.

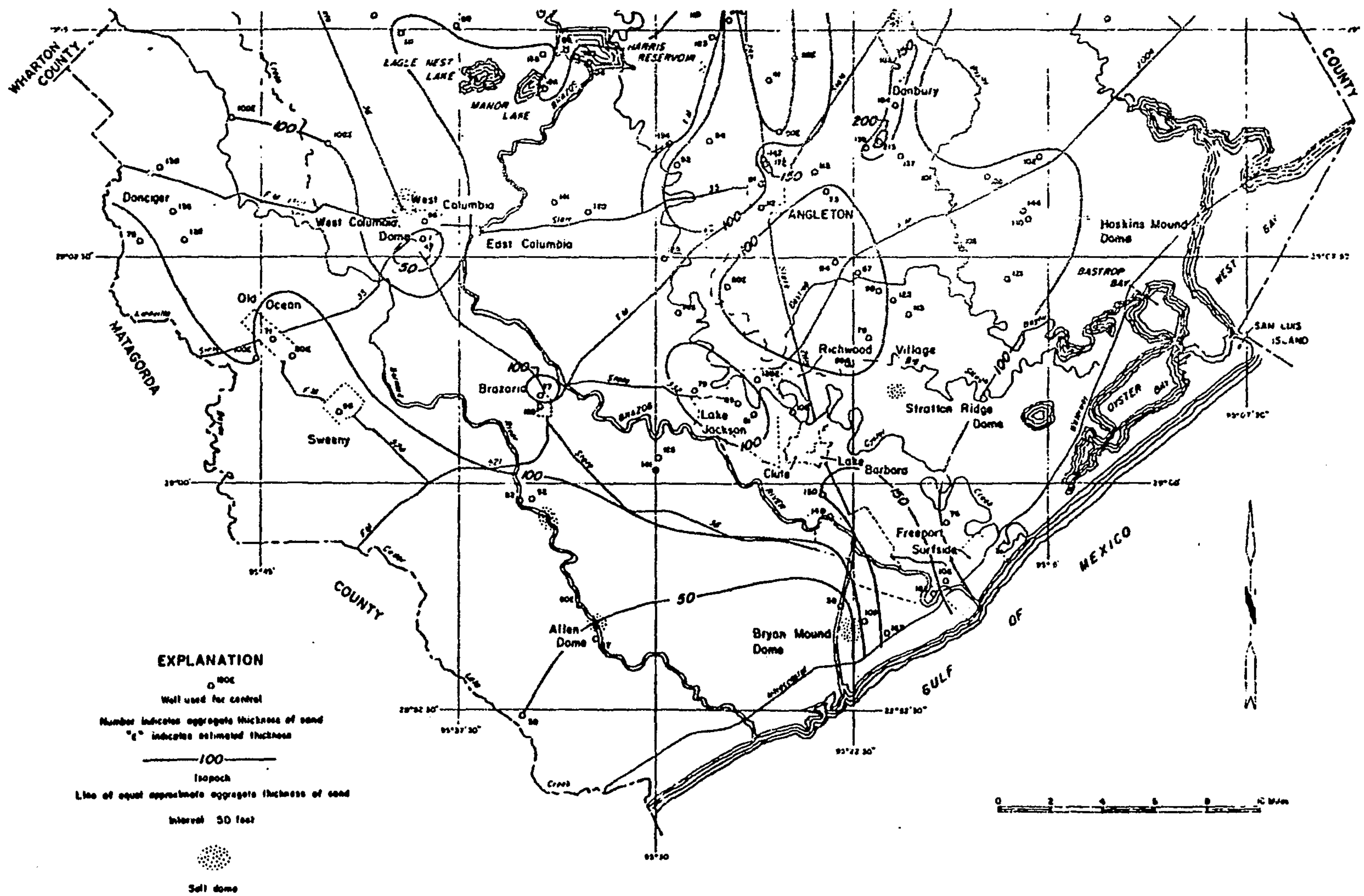


Figure B.7-2

Approximate Thickness of Sand in the Upper Unit of the Chicot Aquifer

Source: W.M. Sandeen and J.B. Wesselman, "Groundwater Resources of Brazoria County, Texas," Texas Water Development Board, Report No. 163, 1973.

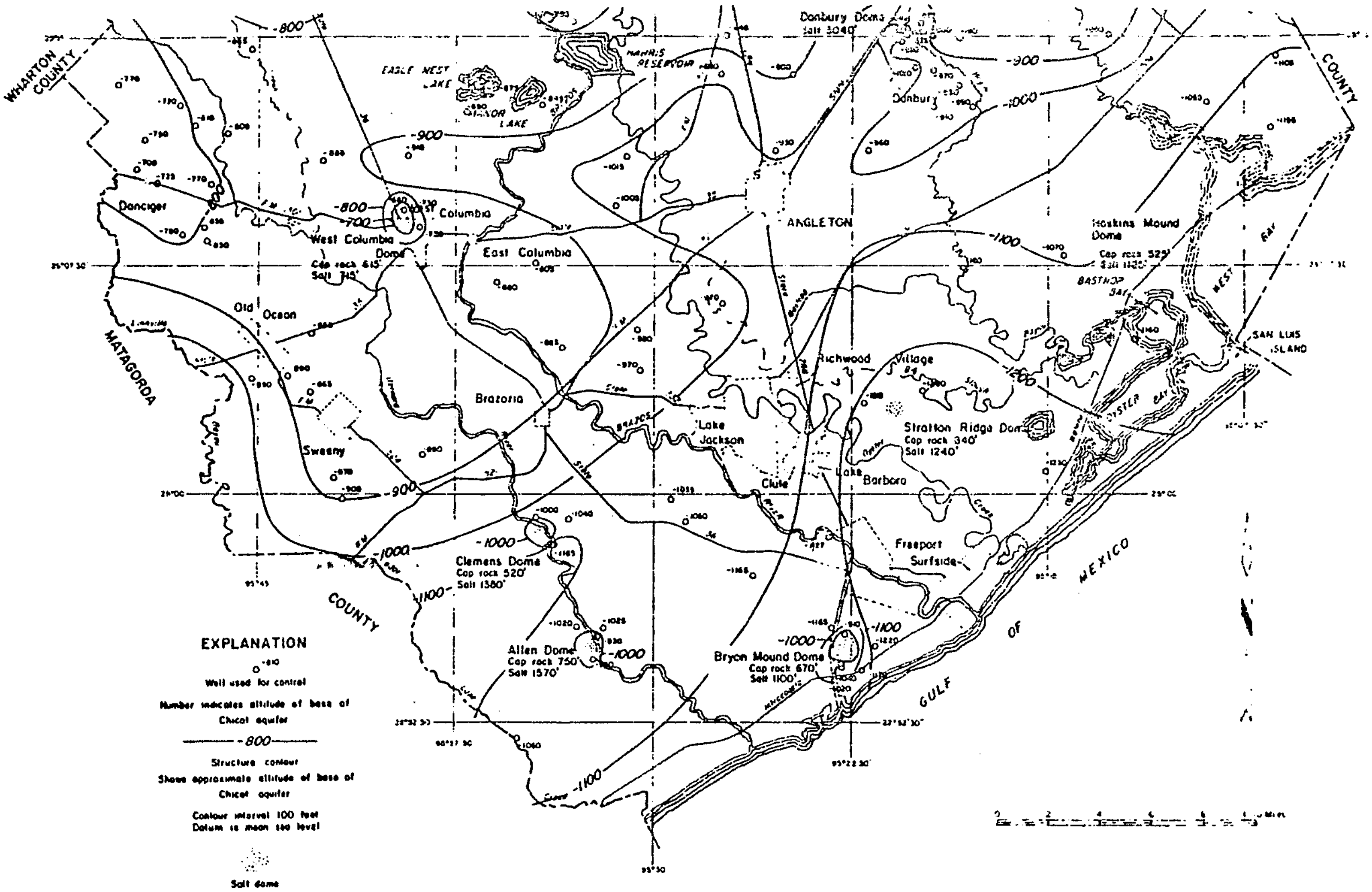


Figure B.7-3

Approximate Altitude of the Base of the Chicot Aquifer

Source: W.M. Sandeen and J.B. Wesselman, "Groundwater Resources of Brazoria County, Texas," Texas Water Development Board, Report No. 163, 1973.

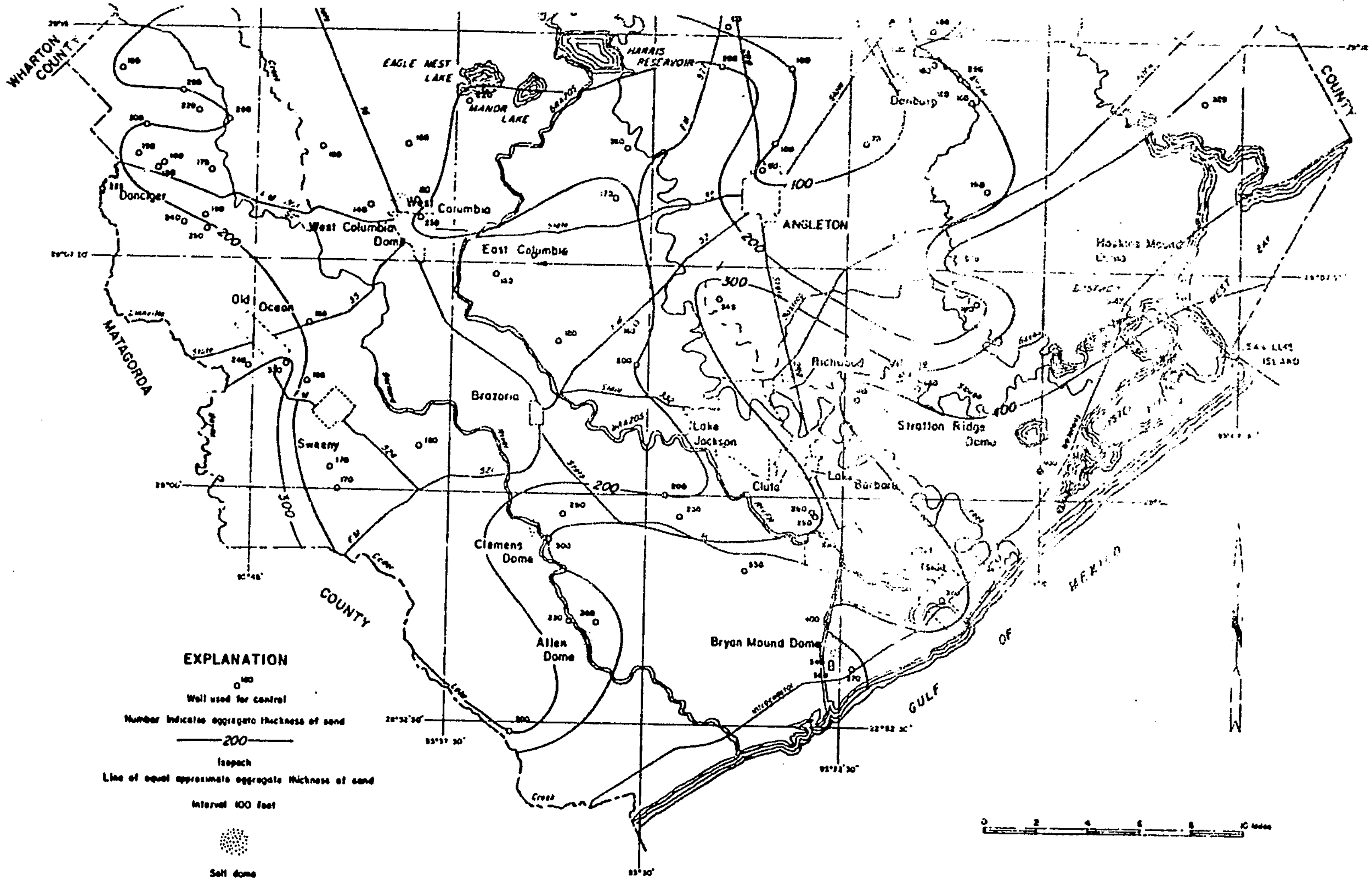


Figure B.7-4

Approximate Thickness of Sand in the Lower Unit of the Chicot Aquifer

Source: W.M. Sandeen and J.B. Wesselman, "Ground Resources of Brazoria County, Texas," Texas Water Development Board, Report No. 163, 1973.

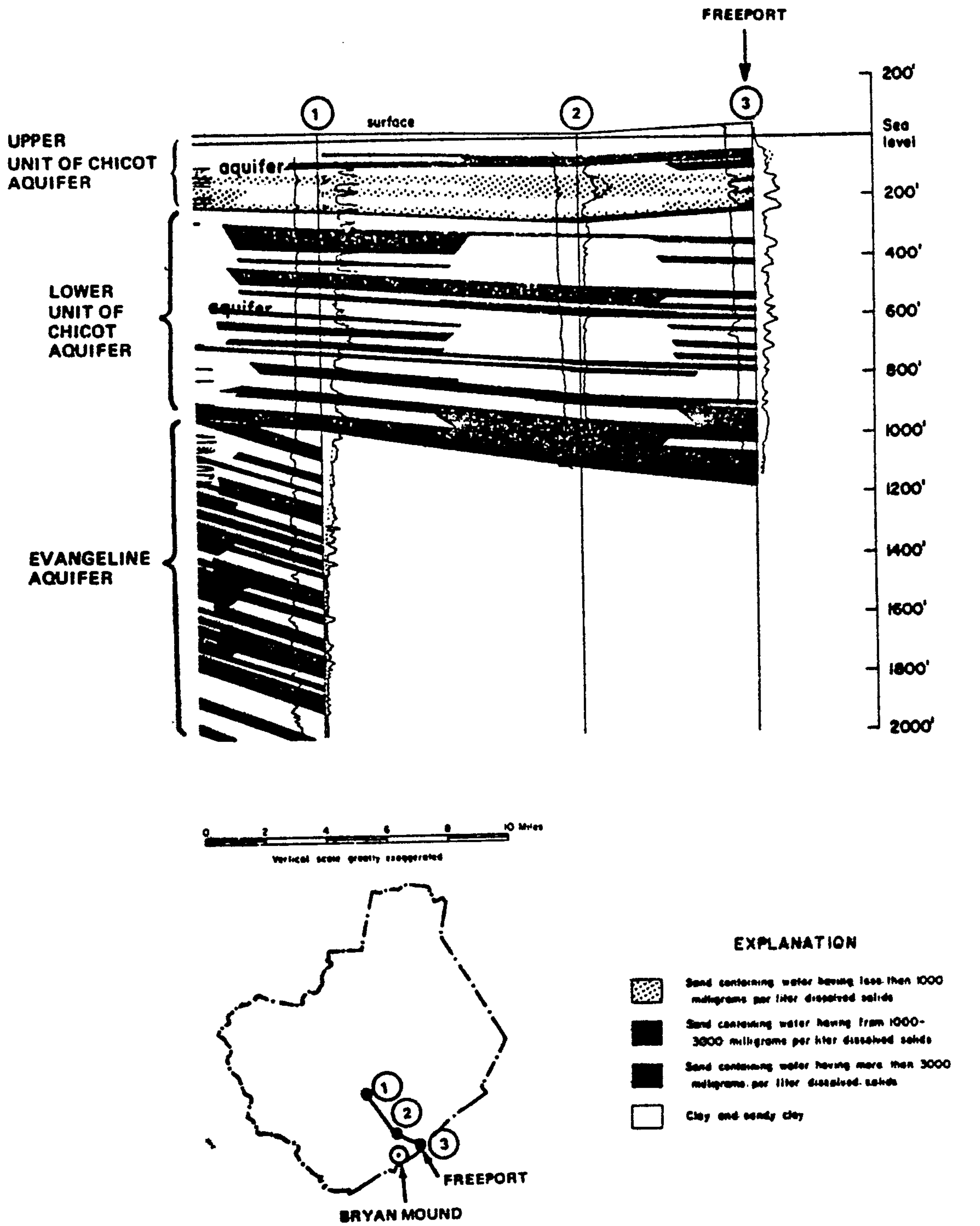


Figure B.7-5 Hydrologic Section in the Vicinity of Bryan Mound

Source: W.M. Sandeen and J.B. Wesselman, "Groundwater Resources of Brazoria County, Texas", Texas Water Development Board, Report No. 163, 1973.

APPENDIX B.8

BRINE DIFFUSION IN THE GULF

In order to gain some indication of the possible results of disposing of brine in the Gulf of Mexico, a test run was conducted with the digital computer program, PLUME. The disposal site was assumed to be located in 20 feet of water approximately 1 mile off the coast as indicated in Figure B.6-1. The prevailing current was assumed to be .6 knots to the NE. The diffuser was oriented perpendicular to the current direction. The diffuser design consisted of a 700-foot pipe, 48 inches in diameter with 70 ports, 9 inches in diameter, spaced at 10-foot intervals. The ports discharged straight upwards, and because the diffuser pipe was mounted 1 foot off the bottom, the discharge ports were 5 feet above the bottom (15 feet below the surface).

Each port produced a jet of brine with a salinity of 265 ppt, which is 15 percent more dense than the surrounding seawater. The seawater salinity was assumed to be 35 ppt with an ambient temperature of 20°C. The brine was assumed to be at the same temperature as the seawater. The exit velocity of each jet was 2.88 ft/sec, but because of its density a jet rose only a short distance before falling back toward the ocean floor. At the same time, each jet was deflected in the direction of the prevailing current. The resulting fluid flow pattern is generally referred to as a negatively buoyant jet in crossflow.

After contact with the ocean floor, each jet tended to drift downstream along the bottom while spreading both vertically and horizontally. After some distance the transverse spreading of the jet caused it to interact with the jets on either side. Ultimately all 70 jets merged to form a saline "tongue" which grew more and more dilute with distance downstream.

Isohalines, computed by the program, PLUME, are presented in Figures B.8-1, B.8-2, and B.8-3 for heights above the bottom of 0, 15 and 10 feet respectively. The bottom isohaline representing salinity of 0.3 ppt as shown in Figure B.8-1 extends downstream approximately 300 feet while the 0.1 ppt isohaline extends to 1,750 feet.

For the isohalines in the horizontal plane corresponding to a height of 15 feet, as shown in Figure B.8-2, the pattern is similar except in the immediate vicinity of the diffuser. The 0.2 ppt and 0.1 ppt excess isohalines extend downstream essentially the same distance as their counterparts on the bottom. The isohalines on the surface, as shown in Figure B.8-3, strongly resemble those at 0 and 15 feet except as expected, except in the vicinity of the diffuser. Based on a comparison of these last 3 figures, it appears that the plume formed by the combined output of the 70 ports is essentially uniformly mixed in the vertical for distances greater than 2,000 feet downstream.

Figure B.8-1 Isohaline for Excess Salinity on the Bottom

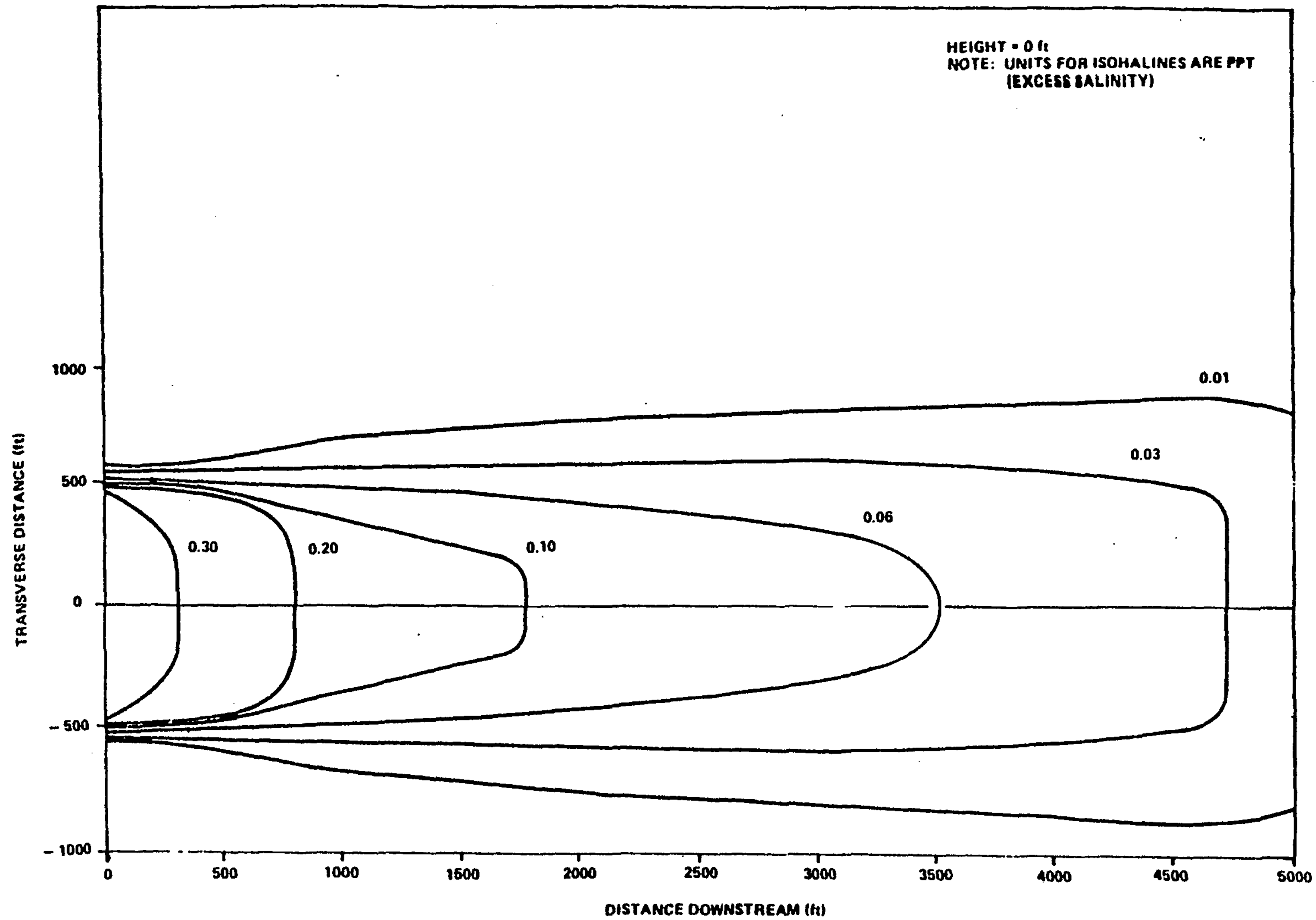


Figure B.8-2 Isohalines for Excess Salinity at a Height of 15 Feet

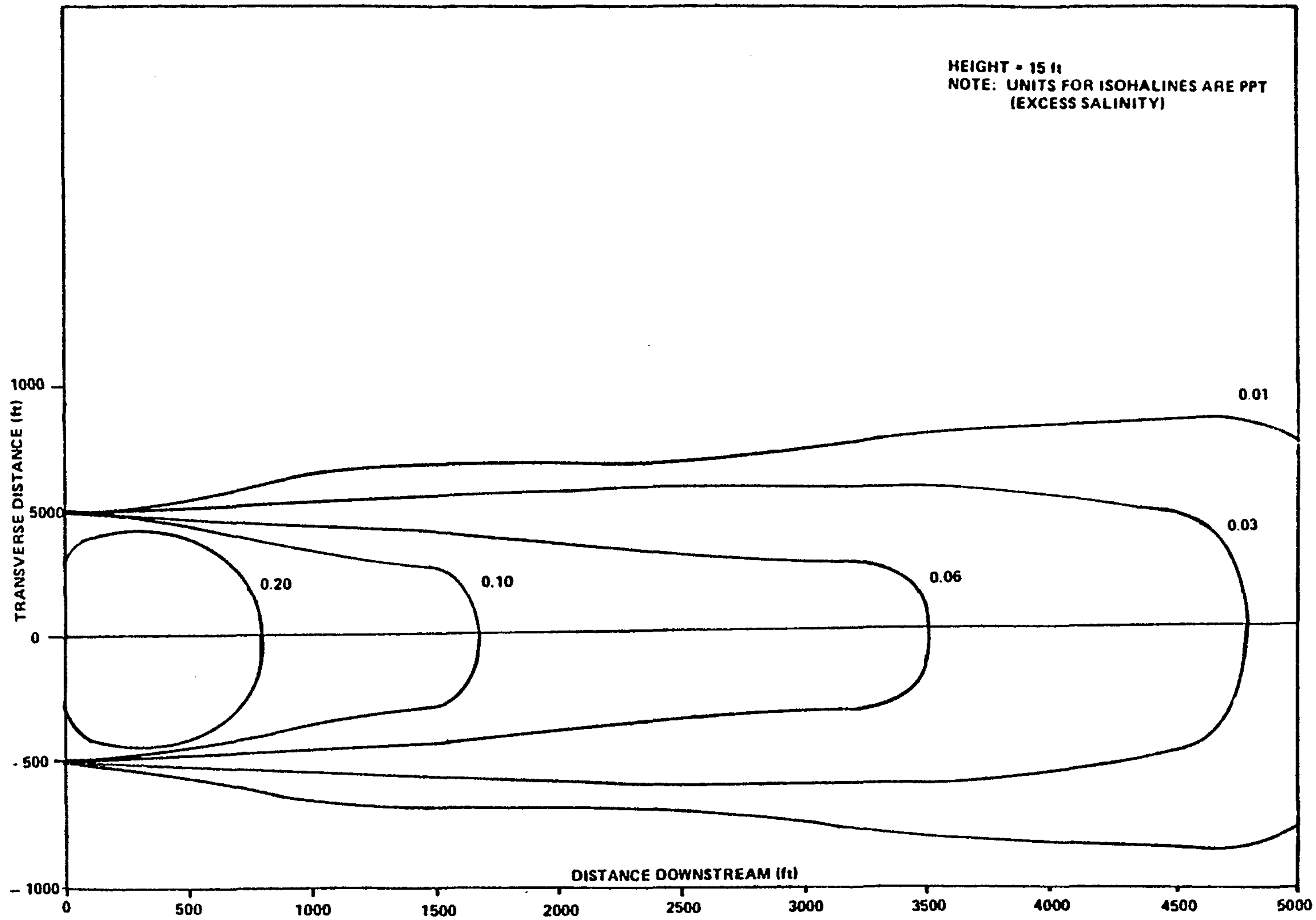
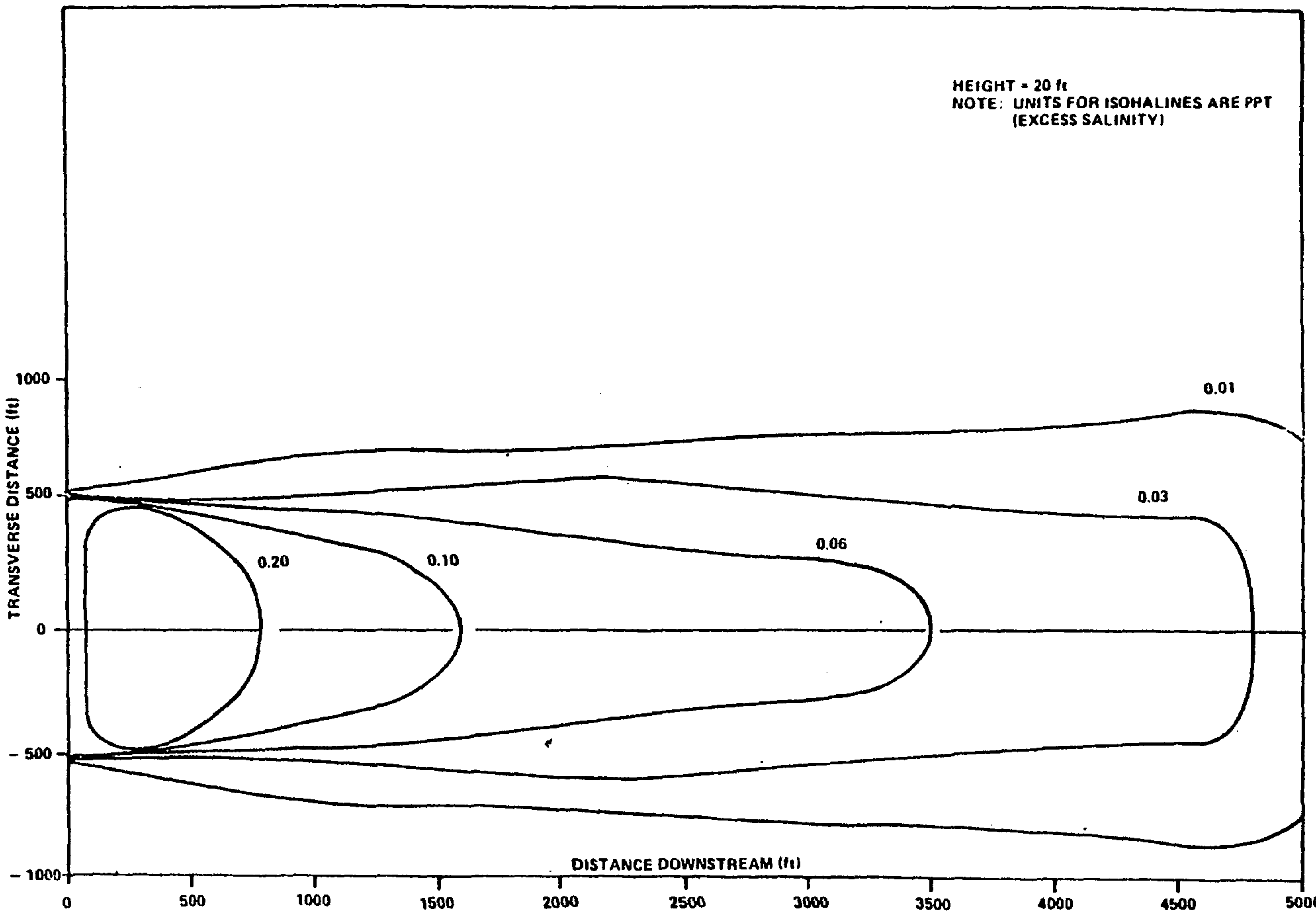


Figure B.8-3 Isohalines for Excess Salinity on the Surface



APPENDIX C

NOISE ANALYSIS

Definitions and Terminology

A-Weight - A frequency weighting network which is used in sound analysis to simulate the response of the human ear. (A-weighted sound levels are expressed in units of dBA).

Environmental Noise - By section 3 (11) of the Noise Control Act of 1972, the term "environmental noise" means the intensity, duration, and character of sounds from all sources.

Equivalent Sound Level - The level of a constant sound which, in a given situation and time period, has the same sound energy as does a time varying sound. Technically, equivalent sound level is the level of the time weighted, mean square, A-weighted sound pressure. The time interval over which the measurement is taken should always be specified.

Sound Level - The quantity in decibels measured by a sound level meter satisfying the requirements of American National Standards Specification for Sound Level Meters S1.4-1971. Sound level is the frequency-weighted sound pressure level obtained with the standardized dynamic characteristic "fast" or "slow" and weighting A, B, or C; unless indicated otherwise, the A-weighting is understood. The unit of any sound level is the decibel, having the unit symbol dB.

Sound Pressure Level - In decibels, 20 times the logarithm to the base ten of the ratio of a sound pressure to the reference sound pressure of 20 micropascals (20 micronewtons per square meter). In the absence of any modifier, the level is understood to be that of a mean-square pressure.

Federal Guidelines

The Federal Environmental Protection Agency has established guidelines for limits of L_{dn} requisite for the protection of public health and welfare.*

Table C-1 Summary of Noise Levels Identified As Requisite to Protect Public Health And Welfare with an Adequate Margin of Safety

Effect	Level	Area
Hearing Loss	$L_{eq}(24) \leq 70dB$	All areas
Outdoor Activity interference and annoyance.	$L_{dn} \leq 55dB$	Outdoors in 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.
	$L_{eq}(24) \leq 55dB$	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor Activity interference and annoyance.	$L_{dn} \leq 45dB$	Indoor residential areas.
	$L_{eq}(24) \leq 45dB$	Other indoor areas with human activities such as school, hospitals, etc.

$L_{eq(24)}$ represents the sound energy averaged over a 24-hour period.

L_{dn} represents the L_{eq} with a 10 dB nighttime weighting.

*Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, "USEPA, 550/9-74-004, March 1974.

Symbols

L_{eq} Equivalent A-weighted sound level over a given time interval.

L_d Daytime equivalent A-weighted sound level between the hours of 0700 and 2200.

L_n Nighttime equivalent A-weighted sound level between the hours of 2200 and 0700.

L_{dn} Day-night average sound level - the 24 hour A-weighted equivalent sound level, with a 10 decibel penalty applied to nighttime levels.

i.e.,
$$L_{dn} = 10 \log \left[\frac{15}{24} \times 10^{\frac{L_d}{10}} + \frac{9}{24} \times 10^{\frac{L_n+10}{10}}\right].$$

Analysis of Construction Operations Noise

The calculation of L_{eq} and L_{dn} requires the estimations of the noise level for each type of machine, the number of machines for each machine type, and the usage factor at each construction site. From these factors a noise impact area about each construction site is calculated. The impact area is then examined for type of land use, i.e., residential, limited outdoor use, schools, playgrounds, etc. Where people are exposed to levels of L_{dn} >55dB or $L_{eq}(24)$>55dB, a noise impact is indicated.

Noise Measures

The descriptors L_{eq} and L_{dn} quantify those aspects of sound which have been found to correlate well cumulative community exposure to noise and community annoyance. Accordingly, the Environmental Protection Agency has selected Equivalent Sound Level (L_{eq}) for the purpose of identifying levels of environmental noise.

Equivalent Sound Level is formulated in terms of the equivalent steady noise level which in a stated period of time would contain the same noise energy as the time-varying noise during the same time period.

The mathematical definition of L_{eq} for an interval defined as occupying the period between two points in time t_1 and t_2 is:

$$L_{eq} = 10 \log \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \frac{p^2(t)}{p_o^2} \, dt \right]$$

where $p(t)$ is the time varying sound pressure and p_o is a reference pressure taken as 20 micropascals.

APPENDIX D

AIR QUALITY DATA

The following tables present summaries of (1) continuous air monitoring performed under the auspices of the Texas Air Control Board at Clute, Texas; (2) a brief sampling period at Jones Creek, Texas, performed by the Southwest Research Institute for Seadock, Inc.,; and (3) a set of sampling done at the Seaway Tank Farm* site by the Southwest Research Institute for Seadock, Inc., which is included to characterize the seasonal air quality.

Data taken at Clute and Jones Creek are characteristic of small town's traffic and the general area where residences predominate. A summary of the conclusions drawn from the Seaway site monitoring precedes these data.

---

* Seadock Onshore Facility

Table D.1

Texas Air Control Board

Continuous Monitoring Data - Sulfur Dioxide (SO_2)

City: Clute, Texas   Location Code: 0950003

Federal Standards: 1^o standard: 24-hr. max = 0.14 ppm
2^o standard: 24-hr. max. = 0.10 ppm
3-hr. max. = 0.5 ppm

Concentrations reported in ppm

	1974 19 July - 30 December	1975 10 January - 24 March	1975 4 April - 27 June	1975 9 July - 19 September
24-hour Averages				
Arithmetic Mean	.0	.0	.0	.0
σ	.0	.0	.0	.0
% hours > 0.10 ppm	.0	.0	.0	.0
% hours > 0.14 ppm	.0	.0	.0	.0
Highest Average	.0	.0	.0	.0
2nd Highest	.0	.0	.0	.0
Total # of Averages	113	48	17	35
3-hour Running Averages				
Arithmetic Mean	.0	.0	.0	.0
σ	.0	.0	.0	.0
Highest Average	.01	.01	.0	.0
Date	19 July	7 Feb.	--	--
2nd Highest	.01	.01	.0	.0
Date	19 July	7 Feb	--	--
Total # of Averages	2724	1208	538	892
1-hour Average				
Highest Average	.05	.02	.0	.0
Date	19 July	27 Jan	--	--
2nd Highest	.02	.01	.0	.0
Date	19 Nov.	27 Jan.	--	--
Total # of Averages	2836	1262	562	932

Table D.2

Texas Air Control Board

Continuous Monitoring Data - Nitrogen Dioxide (NO_2)

City: Clute, Texas   Location Code: 0950003

Federal Standards: 1° & 2°: Annual Arithmetic Mean = 0.05 ppm

Concentrations reported in ppm

	1974 8 August - 31 December	1975 1 January - 24 March	1975 4 April - 30 June	1975 1 July - 30 September
24-hour Running Averages				
Arithmetic Mean	.01	.01	.00	.00
σ (standard dev.)	.01	.01	.00	.00
Highest Average	.05	.03	.02	.02
Date	22 Dec.	14 Jan.	17 April	24 Sept.
2nd Highest Average	.03	.02	.01	.02
Date	21 Dec.	6 March	30 June	5 Aug.
50% hrs. ≤	.01	.01	.00	.00
70% hrs. ≤	.01	.01	.00	.00
90% hrs. ≤	.02	.02	.01	.01
Total # Averages	114	67	58	80
1-hour Averages				
Arithmetic Mean	.01	.01	.01	.01
σ	.01	.01	.01	.01
Highest Average	.1	.08	.08	.08
Date	22 Dec.	26 Feb.	17 April	2 July
2nd Highest Average	.1	.08	.06	.08
Date	21 Nov.	27 Jan.	9 May	24 Sept.
% hrs. ≥ 35 ppm	.01	.01	.00	.00
70% hrs. ≤	.02	.02	.01	.01
90% hrs. ≤	.03	.03	.02	.02
Total # Averages	2848	1615	1480	1964

Table D.3

Texas Air Control Board

Continuous Monitoring Data - Non Methane Hydrocarbons

City: Clute, Texas　　　　Location Code: 0950003

Federal Standards: 1° & 2°: 3-hr. max. = 0.24 ppm

Concentrations reported in ppm

	1974 5 August - 31 December	1975 1 January - 24 March	1975 4 April - 30 June	1975 1 July - 28 September
6 - 9 a.m. measurements				
Arithmetic Mean	1.3	.9	.4	.6
σ	.8	.8	.3	.4
Highest Avg.	3.8	3.1	1.8	1.8
Date	10 Sept.	25 Feb.	6 May	12 Aug.
2nd Highest	3.5	3.1	1.6	1.8
Date	22 Dec.	28 Feb.	17 April	13 Aug.
% hrs. >0.24 ppm	98%	74.5%	61.8%	81.7%
50% time < than	1.0	.6	.3	.4
70% time < than	1.5	1.1	.4	.7
90% time < than	2.0	2.2	.9	1.0
Total # of Averages	51	55	68	60
1-hour Averages				
Arithmetic Mean	1.2	.7	.3	.4
σ	.8	.7	.4	.5
Highest Avg.	5.9	4.4	3.3	5.6
Date	10 Sept.	25 Feb.	18 April	23 July
2nd Highest Avg.	5.4	3.9	3.1	3.2
Date	22 Dec.	28 Feb.	18 April	17 Aug.
50% time < than	.9	.5	.2	.3
70% time < than	1.3	.9	.4	.4
90% time < than	2.2	1.5	.8	.9
Total # of Averages	1218	1267	1580	1395

Table D.4

Texas Air Control Board

Continuous Monitoring Data - Carbon Monoxide (CO)

City: Clute, Texas — Location Code: 0950003

Federal Standards: 1° & 2°: 8-hr. max. = 9 ppm, 1-hr. max. = 35 ppm

Concentrations reported in ppm

	1974 5 August - 31 December	1975 1 January - 24 March	1975 4 April - 30 June	1975 1 July - 26 September
8-hour Running Averages				
Arithmetic Mean	.6	.4	.2	.2
σ (standard dev.)	.7	.3	.2	.2
Highest Average	3.4	3.2	.8	1.1
Date	20 Dec.	6 Jan.	13 May	5 Aug.
2nd Highest Average	3.4	3.0	.8	1.1
Date	20 Dec.	6 Jan.	7 May	5 Aug.
50% hrs. ≤	.3	.4	.1	.2
70% hrs. ≤	.8	.4	.2	.3
90% hrs. ≤	1.3	.6	.4	.5
Total # Averages	1073	1272	1598	1390
1-hour Averages				
Arithmetic Mean	.6	.5	.2	.8
σ	.8	.5	.2	.8
Highest Average	9.3	7.6	2.3	2.7
Date	20 Dec.	6 Jan.	13 May	11 July
2nd Highest Average	8.9	7.4	1.6	2.4
Date	27 Nov.	6 Jan.	30 April	11 July
% hrs. ≥ 35 ppm	0	0	0	0
50% hrs. ≤	.3	.4	.2	.2
70% hrs. ≤	.8	.5	.3	.3
90% hrs. ≤	1.4	.8	.5	.6
Total # of Averages	1080	1267	1581	1393

Table D.5

Texas Air Control Board

Continuous Monitoring Data - Ozone

City: Clute, Texas   Location Code: 0950003

Federal Standards: 1° & 2°: 1-hr. maximum = 0.08 ppm

Concentrations reported in ppm

	1974 28 August - 31 December	1975 1 January - 24 March	1975 4 April - 30 June	1975 1 July - 30 September
1-hour Averages				
Arithmetic Mean	.021	.025	.032	.028
σ	.019	.017	.023	.025
Highest 1-hr. Avg.	.116	.099	.149	.160
Date	21 Nov.	16 March	12 June	1 July
2nd Highest	.110	.096	.143	.155
Date	6 Sept.	14 March	12 June	1 July
% hrs. > 0.08 ppm	1.3%	0.6%	4.4%	4.7%
50% time < than	.017	.022	.026	.021
70% time < than	.028	.032	.039	.032
90% time < than	.048	.048	.065	.063
Total # of Averages	2259	1715	1595	1670

Table D.6

24-Hour Samples, Jones Creek

(Micrograms/Meter^3)

Date February 1972	SO_2	NO_2	Oxidants	Aldehydes	Particulates
10	0	12.8	31.5	10.7	29
11	0	20.9	25.5	10.9	26
12	0	36.2	25.1	15.1	55
13	4.9	13.2	40.2	18.7	30
14	5.4	3.5	43.5	11.8	27
15	7.0	35.8	26.1	7.7	37
16	0	31.1	18.8	7.1	35
17	0	30.3	26.3	9.2	52
18	0	14.1	23.2	7.7	36
19	0	14.1	23.2	7.7	--
Average	1.7	21.2	28.3	10.7	36.3
1° Federal Standard:	365	100 (annual)	98 (4-hr.)	--	260
2° Federal Standard:	260	100 (annual)	98 (4-hr.)	--	150

Source: Seadock, Inc. Environmental Statement. Survey prepared by the Southwest Research Institute, Houston, Texas.

Summary: Seaway Tank Farm*Site, Air Monitoring Results

Spring 16-19 April, 1973

SO_2, NO, NO_2, CO, Particulates: No significant concentrations recorded

Non-Methane Hydrocarbons: Approximately one-third of the samples gave results above the 3-hour maximum of 0.24 ppm specified by Federal Ambient Air Quality Standards. Positive results were obtained with all wind directions.

Oxidants: Non-zero recordings were obtained during partial and complete cloud cover, suggesting some sort of instrumentation problem or interference. The sampling technique was not that specified by Federal Monitoring Regulations, and thus measured concentrations are to be considered representative but not directly comparable to Federal Ambient Standards.

Summer: 20-23 August, 1973
(winds were mostly from the north or variable other than the typical prevailing southerly winds of the summer)

SO_2, NO, NO_2, CO: No significant concentrations recorded

Particulates: Low levels were recorded, principally attributed to sea salt nucleii, blowing dust and vehicle traffic.

Non-Methane Hydrocarbons: Again, approximately one-third of the measurements gave results above 0.24 ppm, with all wind conditions, although very few winds were directly off the Gulf.

Oxidants: Non-zero recordings were obtained, apparently due to natural ozone formations. High levels were found with sunshine and low humidity.

---

* Seadock Onshore Facility

Fall 29 October - 1 November, 1973

SO_2, NO, NO_2, CO, Particulates: No significant concentrations recorded.

Non-Methane Hydrocarbons: Most of the results obtained were considered suspect. During one 8-hour period the winds were consistently from the south and southeast (off the Gulf) with speeds between 2.7 - 3.6 m/sec (6-8 mph), and the values recorded were all around 2 ppm (10 times higher than Federal Ambient Standards).

Oxidants: Non-zero recordings were representative of low level ambient concentrations.

Winter 23 January, 1974; 7, 21-22 February, 1974

SO_2, NO, NO_2, CO: No significant concentrations recorded.

Particulates: Concentrations appear to be high as remnants of a dust storm in southeastern Texas.

Non-Methane Hydrocarbons: Values appeared low when compared to other seasons; a few recordings above 0.24 ppm.

Oxidants: No significant concentrations recorded.

Table D.7

Ambient Air Sampling
(Tabulation of Field Data Based on Sampling Dates
at SEADOCK Onshore Facilities.)

Date		4/16/73						
Time of Sampling		1030	1130	1230	1330	1430	1530	
% Rel. Humidity		100	95	82	82	86	86	
Wind Direction		NNE	E	E	NE	E	ENE	
Wind Velocity, mph		2-3	8-10	6-10	2-4	1-2	4-6	
% Cloud Cover		100	90	90	100	100	100	
Sulfur Dioxide	(ppm)	0	0	0	0	0	0	
Nitrogen Dioxide (NO_2)	(ppm)	.004	.004	.004	.002	0	.004	
Nitric Oxide (NO)	(ppm)	.004	0	0	0	0	0	
Total Hydrocarbons (as CH_4)	(ppm)	1.8	2.0	3.0	3.0	3.6	2.8	
Non-Methane Hydrocarbons (as CH_4)	(ppm)	0	0	0.4	0.7	1.1	0.4	
Carbon Monoxide	(ppm)	0	0	0	0	0.5	0	
Suspended Part. Matter $\mu g/m^3$								56* 58
Total Oxidants $\mu g/m^3$		0	0	33	26	52	26	
	(ppm)			.016	.013	.026	.013	

*24 hour averages

Source: Seadock, Inc. Environmental Statement, SEADOCK Superport.

Table D.8

Ambient Air Sampling
(Tabulation of Field Data Based on Sampling Dates
at SEADOCK Onshore Facilities.)

Date	4/17/73									
Time of Sampling	0440	0540	0635	0730	0830	0930	1030	1130	1330	
% Rel. Humidity	100	100	95	100	100	100	100	100	85	
Wind Direction	E	E	SE	SE	SE	E	ESE	ESE	N	
Wind Velocity,mph	<1	<1	2-6	5-6	8-10	2-3	2-3	4-5	2	
% Cloud Cover	100	100	100	100	100	100	100	100	100	
Sulfur Dioxide (ppm)	0	0	0	0	0	0	0	0	0	
Nitrogen Dioxide (NO_2) (ppm)	0	0	0	0	.004	.004	.004	.004	.008	
Nitric Oxide (NO) (ppm)	0	0	0	0	0	0	0	0	0	
Total Hydrocarbons (as CH_4) (ppm)	2.4	2.4	2.2	2.5	3.0	3.1	3.2	3.2	malfunction	
Non-Methane Hydrocarbons (as CH_4) (ppm)	0.1	0	0.9	0.8	0.2	0	0	0	malfunction	
Carbon Monoxide (ppm)	0	0	0	0	0	0	0	0	0	
Suspended Part.Matter $\mu g/m^3$										31* 31
Total Oxidants $\mu g/m^3$	0	0	0	26	26	39	26	26	26	
(ppm)				.013	.013	.020	.013	.013	.013	

*24 hour averages

Source: Seadock, Inc. Environmental Statement, SEADOCK Superport.

Table D.9

Ambient Air Sampling
(Tabulation of Field Data Based on Sampling Dates at SEADOCK Onshore Facilities.)

Date		4/18/73										
Time of Sampling		1030	1130	1230	1330	1430	1530	1630	1730	1830	1930	
% Rel. Humidity		86	82	82	82	80	90	90	90	95	95	
Wind Direction		ESE	ENE	ESE	E	ESE	ESE	E	E	ESE	ESE	
Wind Velocity, mph		2-4	8-10	4	4	4-6	4-6	6-10	6-8	6-10	6-10	
% Cloud Cover		95	100	90	75	75	100	100	100	100	100	
Sulfur Dioxide	(ppm)	0	0	0	0	0	0	0	0	0	0	
Nitrogen Dioxide (NO_2)	(ppm)	0	0	0	.004	0	0	0	.004	0	0	
Nitric Oxide (NO)	(ppm)	0	0	0	0	0	0	0	0	0	0	
Total Hydrocarbons (as CH_4)	(ppm)	3.2	3.0	3.0	2.4	1.8	2.6	2.6	2.8	2.2	2.0	
Non-Methane Hydrocarbons (as CH_4)	(ppm)	0.2	0.3	0.2	0.2	0	0.3	0.4	0.4	0.2	0.1	
Carbon Monoxide	(ppm)	0	0	0	0	0	0	0	0	0	0	
Suspended Part. Matter $\mu g/m^3$												56*
Total Oxidants	$\mu g/m^3$	98	170	104	52	39	33	19	7	19	7	53
	(ppm)	.049	.084	.052	.026	.019	.016	.010	.003	.010	.003	

*24 hour averages

Source: Seadock, Inc. Environmental Statement, SEADOCK Superport.

Table D.10

Ambient Air Sampling
(Tabulation of Field Data Based on Sampling Dates
at SEADOCK Onshore Facilities.)

Date	4/19/73									
Time of Sampling	0430	0530	0630	0730	0830	0930	1030	1130	1230	
% Rel. Humidity	100	100	100	95	91	90	90	91	91	
Wind Direction	SSE	SSE	SSE	SSE	SSE	S	SSE	S	S	
Wind Velocity, mph	10-12	8-12	8-12	8-12	8-12	10-12	8-11	6-10	6-10	
% Cloud Cover	100	100	100	100	100	100	100	100	100	
Sulfur Dioxide (ppm)	0	0	0	0	0	0	0	0	0	
Nitrogen Dioxide (NO_2) (ppm)	0	0	0	0	0	0	0	0	0	
Nitric Oxide (NO) (ppm)	0	0	0	0	0	0	0	0	0	
Total Hydrocarbons (as CH_4) (ppm)	2.0	1.8	2.1	1.9	2.1	2.0	2.0	2.0	1.8	
Non-Methane Hydrocarbons (as CH_4) (ppm)	0	0	0	0	0	0	0	0	0	
Carbon Monoxide (ppm)	0	0	0	0	0	0	0	0	0	
Suspended Part. Matter $\mu g/m^3$										45* 45
Total Oxidants $\mu g/m^3$	13	7	13	7	26	13	13	13	13	
(ppm)	.006	.003	.006	.003	.003	.006	.006	.006	.006	

*24 hour averages

Source: Seadock, Inc. Environmental Statement, SEADOCK Superport.

Table D.11

Ambient Air Sampling
(Tabulation of Field Data Based on Sampling Dates
at SEADOCK Onshore Facilities.)

Date		8/20/73				
Time of Sampling		1730	1830	1930	2030	
% Rel. Humidity		80	80	84	84	
Wind Direction		SE	SE	SE	SE	
Wind Velocity,mph		1-2	0-1	0-1	0-1	
% Cloud Cover		10	0	0	0	
Sulfur Dioxide	(ppm)	0	0	0	0	
Nitrogen Dioxide (NO_2)	(ppm)	0	0	0	0	
Nitric Oxide(NO)	(ppm)	0.002	0	0	0	
Total Hydrocarbons (as CH_4)	(ppm)	3.3	3.0	3.4	2.8	
Non-Methane Hydrocarbons (as CH_4)	(ppm)	0.5	0	0.6	0.3	
Carbon Monoxide	(ppm)	0	0	trace*	0	
Suspended Part.Matter	$\mu g/m^3$					107** 106
Total Oxidants	$\mu g/m^3$	46	39	72	59	
	(ppm)	0.023	0.019	0.035	0.029	

*Trace values were observed, but were thought to be due to inadvertent sampling of exhaust gases from mobile laboratory.
**24 hour averages
Source: Seadock, Inc. Environmental Statement, SEADOCK Superport.

Table D.12

Ambient Air Sampling
(Tabulation of Field Data Based on Sampling Dates at SEADOCK Onshore Facilities.)

Date	8/21/73											
Time of Sampling	0430	0530	0630	0730	0830	0930	1030	1130	1230	1330	1430	
% Rel. Humidity	98	98	95	95	95	93	91	88	84	80	75	
Wind Direction	var.	var.	var.	var.	var.	NE	NE	NE	ENE	NNE	NE	
Wind Velocity, mph	0	0	0	0	0	0-1	0-1	0-3	2-5	2-4	4-5	
% Cloud Cover	light fog	light fog	light fog	light fog	light fog	light fog	haze	haze	haze	haze	haze	
Sulfur Dioxide (ppm)	0.007	0.007	0	0	0	0.007	0	0	0	0	0	
Nitrogen Dioxide (NO_2) (ppm)	0	0	0	0	0	0	0.008	0	0	0	0	
Nitric Oxide (NO) (ppm)	0	0	0	0	0	0	0	0	0	0	0	
Total Hydrocarbons (as CH_4) (ppm)	2.6	3.0	3.2	2.6	2.6	2.8	2.8	2.8	2.7	2.1	2.3	
Non-Methane Hydrocarbons (as CH_4) (ppm)	0.4	0.2	0	0.2	0.1	0.1	0.2	0.2	0	0	0.1	
Carbon Monoxide (ppm)	0	0	0	0	0	0	0	0	0	0	0	
Suspended Part. Matter $\mu g/m^3$												93 * 92
Total Oxidants $\mu g/m^3$	19	13	13	13	19	39	13	84	13	78	78	
Total Oxidants (ppm)	0.009	0.006	0.006	0.006	0.009	0.019	0.006	0.043	0.006	0.039	0.039	

*24 hour averages

Source: Seadock, Inc. Environmental Statement, SEADOCK Superport.

Table D.13

Ambient Air Sampling
(Tabulation of Field Data Based on Sampling Dates
at SEADOCK Onshore Facilities.)

Date		8/22/73										
Time of Sampling		1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	
% Rel. Humidity		60	57	54	56	57	45	35	45	56	75	
Wind Direction		NE	NNE	NNE	N	NE	NNE	NNE	NNE	NNE	NNE	
Wind Velocity,mph		2	0-2	0-2	0-2	1-3	0-2	0-2	0-1	0-1	0-1	
% Cloud Cover		haze	haze	haze	0	0	0	0	0	0	0	
Sulfur Dioxide	(ppm)	0.004	0	0	0	0	0	0	0	0	0	
Nitrogen Dioxide (NO_2)	(ppm)	0	0	0	0	0	0	0	0	0	0	
Nitric Oxide (NO)	(ppm)	0	0	0	0	0	0	0	0	0	0	
Total Hydrocarbons (as CH_4)	(ppm)	2.3	2.4	2.2	2.6	2.6	2.4	2.2	2.4	2.4	2.4	
Non-Methane Hydrocarbons (as CH_4)	(ppm)	0	0	0.2	0.4	0.2	0.2	0.2	0.3	0.4	0.4	
Carbon Monoxide	(ppm)	0	0	0	0	0	0	0	0	0	0	
Suspended Part.Matter $\mu g/m^3$												86* 82
Total Oxidants	$\mu g/m^3$	48	104	78	104	117	136	124	124	26	13	
	(ppm)	0.025	0.052	0.039	0.052	0.058	0.068	0.062	0.062	0.013	0.006	

*24 hour averages

Source: Seadock, Inc. Environmental Statement, SEADOCK Superport.

Table D.14

Ambient Air Sampling
(Tabulation of Field Data Based on Sampling Dates at SEADOCK Onshore Facilities.)

Date	8/23/73										
Time of Sampling	0430	0530	0630	0730	0830	0930	1030	1130	1230	1330	
% Rel. Humidity	100	100	100	100	88	76	66	54	54	58	
Wind Direction	var.	var.	var.	var.	var.	NNW	var.	S	S	S	
Wind Velocity, mph	0	0	0	0	0	0-1	0-1	1	2-4	1-3	
% Cloud Cover	light fig	light fog	light fog	light fog	light fog	slight haze	0	0	0	0	
Sulfur Dioxide (ppm)	0	0	0	0	0	0	0	0	0	0	
Nitrogen Dioxide (NO_2) (ppm)	0	0	0	0	0	0	0	0	0	0	
Nitric Oxide (NO) (ppm)	0	0	0	0	0	0	0	0	0	0	
Total Hydrocarbons (as CH_4) (ppm)	3.8	3.8	3.8	2.8	2.7	2.5	2.6	2.6	2.5	2.5	
Non-Methane Hydrocarbons (as CH_4) (ppm)	1.0	0.6	0.6	0.6	0.5	0.2	0.1	0	0	0	
Carbon Monoxide (ppm)	0	0	0	0	trace*	trace*	0	0	0	0	
Suspended Part. Matter $\mu g/m^3$											92** 96
Total Oxidants $\mu g/m^3$	7	26	26	20	54	42	71	91	85	98	
(ppm)	0.003	0.013	0.013	0.010	0.027	0.021	0.035	0.045	0.042	0.048	

*Trace values were observed, but were thought to be due to inadvertent sampling of exhaust gases from mobile laboratory.
**24 hour averages

Source: Seadock, Inc. Environmental Statement, SEADOCK Superport,

Table D.15

Ambient Air Sampling
(Tabulation of Field Data Based on Sampling Dates
at SEADOCK Onshore Facilities.)

Date		10/29/73										
Time of Sampling		1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	
% Rel. Humidity		58	56	57	57	57	58	65	70	75	80	
Wind Direction		NE	NE	ENE	E	ESE	SE	SE	-	-	-	
Wind Velocity,mph		6	6	0-1	0-2	2-3	0-2	2-4	0	0	0	
% Cloud Cover		0	0	0	0	0	0	0	0	0	0	
Sulfur Dioxide	(ppm)	0	0.004	0	0	0	0.007	0	0	0	0	
Nitrogen Dioxide (NO_2)	(ppm)	0.004	0.004	0	0	0	0	0	0	0	0	
Nitric Oxide (NO)	(ppm)	0	0	0	0	0	0	0	0	0	0	
Total Hydrocarbons (as CH_4)	(ppm)	1.8	1.8	1.8	1.4	1.4	1.8	1.6	1.4	1.6	1.7	
Non-Methane Hydrocarbons (as CH_4)	(ppm)	0	0	0.2	0.2	0.4	0.2	0.4	0.4	0.6	0.7	
Carbon Monoxide	(ppm)	0	0	0	0	0	0	0	0	0	0	
Suspended Part.Matter $\mu g/m^3$												44* 45
Total Oxidants $\mu g/m^3$		0	13	13	26	26	26	13	13	3	3	
	(ppm)		0.006	0.006	0.013	0.013	0.003	0.006	0.006	0.001	0.001	

*24 hour averages

Source: Seadock, Inc. Environmental Statement, SEADOCK Superport.

Table D.16

Ambient Air Sampling
(Tabulation of Field Data Based on Sampling Dates at SEADOCK Onshore Facilities.)

Date		10/30/73									
Time of Sampling		0430	0530	0630	0730	0830	0930	1030	1130	1230	
% Rel. Humidity		80	80	80	80	80	76	76	74	74	
Wind Direction		S	SE	SE	S	S	S	SSE	S	SSE	
Wind Velocity,mph		2	2	2	4	4	8-10	6-8	6-8	6-8	
% Cloud Cover		100	100	100	100	100	100	100	100	100	
Sulfur Dioxide	(ppm)	0	0	0	0	0	0	0	0	0	
Nitrogen Dioxide (NO_2)	(ppm)	0.004	0.004	0	0	0	0	0	0	0	
Nitric Oxide (NO)	(ppm)	0	0	0	0	0	0	0	0	0	
Total Hydrocarbons (as CH_4)	(ppm)	2.8	2.8	2.9	2.8	3.0	2.8	2.5	3.1	2.9	
Non-Methane Hydrocarbons (as CH_4)	(ppm)	1.8	2.0	2.1	1.8	2.0	2.0	1.6	2.0	1.9	
Carbon Monoxide	(ppm)	0	0	0	0	0	0	0	0	0	
Suspended Part.Matter $\mu g/m^3$											24 * 23
Total Oxidants	$\mu g/m^3$	13	19	19	13	13	13	13	13	13	
	(ppm)	0.006	0.009	0.009	0.006	0.006	0.006	0.006	0.006	0.006	

*24 hour averages

Source: Seadock, Inc. Environmental Statement, SEADOCK Superport.

Table D.17

Ambient Air Sampling
(Tabulation of Field Data Based on Sampling Dates
at SEADOCK Onshore Facilities.)

Date		10/31										
Time of Sampling		1010	1100	1200	1300	1400	1500	1600	1700	1800	1900	
% Rel. Humidity		55	55	52	52	49	47	45	64	73	88	
Wind Direction		NW	WNW	NW	NW	NW	NW	NW	-	-	-	
Wind Velocity,mph		8	4	8	6	8	2	4	0	0	0	
% Cloud Cover		0	0	0	0	0	0	0	0	0	0	
Sulfur Dioxide	(ppm)	0	0	0	0	0	0	0	0	0	0	
Nitrogen Dioxide (NO_2)	(ppm)	0	0	0	0	0	0	0	0	0	0	
Nitric Oxide (NO)	(ppm)	0	0	0	0	0	0	0	0	0	0	
Total Hydrocarbons (as CH_4)	(ppm)	2.0	2.2	2.0	1.9	1.8	1.8	1.4	1.6	1.8	1.9	
Non-Methane Hydrocarbons (as CH_4)	(ppm)	0.8	1.2	1.0	1.0	0.9	0.8	0.7	1.0	0.8	1.1	
Carbon Monoxide	(ppm)	0	0	0	0	0	0	0	0	0	0	
Suspended Part.Matter												24*
	$\mu g/m^3$											24
Total Oxidants	$\mu g/m^3$	13	13	13	13	20	13	20	13	6	20	
	(ppm)	0.006	0.006	0.006	0.006	0.009	0.006	0.009	0.006	0.003	0.009	

*24 hour averages

Source: Seadock, Inc. Environmental Statement, SEADOCK Superport.

Table D.18

Ambient Air Sampling
(Tabulation of Field Data Based on Sampling Dates
at SEADOCK Onshore Facilities.)

Date		11/1/73							
Time of Sampling		0430	0530	0630	0730	0830	0930	1030	
% Rel. Humidity		100	100	100	100	81	69	62	
Wind Direction		var.	var.	var.	var.	SSE	S	S	
Wind Velocity, mph		0-1	0-1	0-1	0-1	1-2	4-6	6	
% Cloud Cover		0	0	0	0	2	30	15	
Sulfur Dioxide	(ppm)	0	0	0	0	0.007	0.007	0.003	
Nitrogen Dioxide (NO_2)	(ppm)	0	0	0	0	0	0	0	
Nitric Oxide (NO)	(ppm)	0	0	0.004	0.004	0	0	0	
Total Hydrocarbons (as CH_4)	(ppm)	4.2	4.2	6.6	5.2	2.6	2.6	2.6	
Non-Methane Hydrocarbons (as CH_4)	(ppm)	1.0	1.2	2.4	3.6	1.6	1.6	1.5	
Carbon Monoxide	(ppm)	trace*	0	0	0	0	0	0	
Suspended Part. Matter $\mu g/m^3$									27** 27
Total Oxidants	$\mu g/m^3$	6	6	6		20	13	20	
	(ppm)	0.003	0.003	0.003		0.009	0.006	0.009	

*Trace CO reading attributed to generator exhaust during zero and variable wind.
**24 hour averages

Source: Seadock, Inc. Environmental Statement, SEADOCK Superport.

Table D.19

Ambient Air Sampling
(Tabulation of Field Data Based on Sampling Dates
at SEADOCK Onshore Facilities.)

Date		1/23/74										
Time of Sampling		1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	
Temperature, °F		52	51	52	52	52	52	51	51	50	49	
% Rel. Humidity		94	94	94	94	94	94	94	94	94	94	
Wind Direction		N	N	N	N	N	N	N	N	N	N	
Wind Velocity,mph		5-8	5-8	5-10	5-10	5-10	5-7	5-7	5-7	5-7	5-7	
% Cloud Cover		100	100	100	100	100	100	100	100	100	100	
Sulfur Dioxide	(ppm)	0	0.002	0.002	0.007	0	0.003	0.003	0.003	0.007	0.003	
Nitrogen Dioxide (NO_2)	(ppm)	0.002	0	0	0	0	0	0	0	0	0	
Nitric Oxide(NO)	(ppm)	0.006	0.008	0.008	0	0	0	0	0.004	0.004	0	
Total Hydrocarbons (as CH_4)	(ppm)	1.4	1.5	1.5	1.3	1.6	1.8	2.0	2.0	2.0	2.1	
Non-Methane Hydrocarbons (as CH_4)	(ppm)	0	0.4	0.2	0.1	0.2	0.3	0.6	0.2	0.4	0.6	
Carbon Monoxide	(ppm)	0	0	0	0	0	0	0	0	0	0	
Suspended Part.Matter $\mu g/m^3$												41* 40
Total Oxidants $\mu g/m^3$		0	45	0	0	0	7	0	7	7	0	
	(ppm)		0.022				0.003		0.003	0.003		

*24 hour averages

Source: Seadock, Inc. Environmental Statement, SEADOCK Superport.

Table D.20

Ambient Air Sampling
(Tabulation of Field Data Based on Sampling Dates at SEADOCK Onshore Facilities.)

Date	2/7/74											
Time of Sampling	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	
Temperature, °F	45	45	46	48	48	47	45	44	47	47	47	
% Rel. Humidity	86	85	85	85	79	79	86	85	86	86	72	
Wind Direction	N	N	N	N	N	NNW	NNW	NNW	NNW	NW	NW	
Wind Velocity, mph	4-6	4-6	4-6	4-6	5-7	5-8	8-10	5-8	5-8	5-7	5-7	
% Cloud Cover	100	100	100	100	100	100	100	100	100	100	100	
Sulfur Dioxide (ppm)	0	0	0.007	0.011	0	0	0	0	0	0	0	
Nitrogen Dioxide (NO_2) (ppm)	0	0	0	0	0.008	0.008	0.008	0.008	0.008	0.008	0.008	
Nitric Oxide (NO) (ppm)	0.002	0.002	0.004	0.004	0.001	0.001	0.002	0.002	0.002	0.002	0.002	
Total Hydrocarbons (as CH_4) (ppm)	1.4	1.3	1.4	1.5	1.6	1.3	1.4	1.3	1.4	1.3	1.3	
Non-Methane Hydrocarbons (as CH_4) (ppm)	0.1	0.2	0.1	0.2	0.2	0.0	0.2	0.1	0.2	0.1	0.1	
Carbon Monoxide (ppm)	0	0	0	0	0	0	0	0	0	0	0	
Suspended Part. Matter $\mu g/m^3$												52* 48
Total Oxidants $\mu g/m^3$	7	7	7	13	13	13	7	13	13	13	13	
(ppm)	0.003	0.003	0.003	0.006	0.006	0.006	0.003	0.006	0.006	0.006	0.006	

*24 hour averages

Source: Seadock, Inc. Environmental Statement, SEADOCK Superport.

Table D.21

Ambient Air Sampling
(Tabulation of Field Data Based on Sampling Dates
at SEADOCK Onshore Facilities.)

Date		2/21/74							
Time of Sampling		1500	1600	1700	1800	1900	2000	2100	
Temperature, °F		67	67	64	61	56	54	53	
% Rel. Humidity		45	45	45	49	49	59	60	
Wind Direction		NW	NW	NW	NW	NW	NW	NW	
Wind Velocity,mph		15-20	15-20	15-20	15-20	15-20	15-20	15-20	
% Cloud Cover		0	0	0	0	0	0	0	
Sulfur Dioxide	(ppm)	0	0	0	0	0	0	0	
Nitrogen Dioxide (NO_2)	(ppm)	0.004	0.004	0.004	0.004	0.004	0.004	0.004	
Nitric Oxide (NO)	(ppm)	0	0	0	0	0	0	0	
Total Hydrocarbons (as CH_4)	(ppm)	1.7	1.4	1.4	1.3	1.3	1.3	1.2	
Non-Methane Hydrocarbons (as CH_4)	(ppm)	0.3	0.1	0.1	0.1	0.0	0.0	0.0	
Carbon Monoxide	(ppm)	0	0	0	0	0	0	0	
Suspended Part. Matter $\mu g/m^3$									98 * 107
Total Oxidants	$\mu g/m^3$	13	20	20	26	39	19	16	
	(ppm)	0.006	0.010	0.010	0.013	0.019	0.009	0.008	

*24 hour averages

Source: Seadock, Inc. Environmental Statement, SEADOCK Superport.

Table D.22

Ambient Air Sampling
(Tabulation of Field Data Based on Sampling Dates
at SEADOCK Onshore Facilities.)

Date		2/22/74								
Time of Sampling		0600	0700	0800	0900	1000	1100	1200	1300	
Temperature, °F		42	42	48	59	59	59	59	59	
% Rel. Humidity		100	100	73	57	57	57	29	29	
Wind Direction		NW	NW	NW	NW	NW	NW	NW	NW	
Wind Velocity, mph		2-4	2-4	5-10	5-10	7-15	8-12	4-17	4-17	
% Cloud Cover		0	0	0	0	0	0	0	0	
Sulfur Dioxide	(ppm)	0.005	0.004	0.004	0	0	0.002	0.004	0	
Nitrogen Dioxide (NO_2)	(ppm)	0.004	0.004	0.004	0.004	0.004	0.004	0	0.004	
Nitric Oxide (NO)	(ppm)	0	0	0	0	0	0	0	0	
Total Hydrocarbons (as CH_4)	(ppm)	1.6	1.6	1.5	1.9	2.1	1.8	1.3	1.3	
Non-Methane Hydrocarbons (as CH_4)	(ppm)	0.0	0.0	0.1	0.3	0.2	0.3	0.1	0.2	
Carbon Monoxide	(ppm)	0	0	0	0	0	0	0	0	
Suspended Part. Matter μg/m³										10* 10
Total Oxidants	μg/m³	16	7	7	19	19	39	46	65	
	(ppm)	0.008	0.003	0.003	0.009	0.009	0.019	0.023	0.032	

*24 hour averages

Source: Seadock, Inc. Environmental Statement, SEADOCK Superport.

APPENDIX E

TERMINAL VULNERABILITY AND OIL SPILL RESPONSE

SPILL VULNERABILITY

Data compiled by the U.S. Environmental Protection Agency[1], based upon a survey of oil gathering and distrubition facilities involving 4,423 oil spills, corroborate the Department of Transportation spill data used in Section 3, with respect to the ratio of pipeline leaks versus terminal equipment that contributed to the spills. However, much of the pipe was very old (over 25 years) and corrosion accounted for over 54 percent of the reported leaks.

The corrosion protection systems to be employed in the Strategic Petroleum Storage prject will reduce significantly the incidence of corrosion related oil spills, but pipeline leaks clearly pose the greatest hazard. The following tables show the distribution of spills by subsystem, (Table E.1) and the relative severity of spills associated with each subsystem, (Table E.2).

Another study sponsored by the U.S. EPA[2] to develop data for a course in oil spill prevention and control, summarized the judgments and experience of oil facility operators with respect to the principal causes of leaks and spills within each subsystem. These judgments, presented on Table E.3, are related in terms of the probability and severity of leaks or spills that are associated with components of those subsystems for which spill data is shown on Tables E.1 and E.2.

The probability symbols, H, M and L represent High, Medium and Low probability of that component failing. The severity of a spill has been evaluated on the basis of cleanup requirements according to the following:

1 - Major cleanup required to restore environment

2 - Intermediate cleanup required to restore environment

3 - Minor cleanup required to restore environment

Table E.1 Gathering/Distribution System Spill Events by Subsystem and Equipment

ELEMENT	NUMBER OF EVENTS	% SYSTEM EVENTS	% SUBSYSTEM EVENTS
Pipeline Subsystem	3226	73.03	100.00
Pipe	3117	70.44	96.44
Scraper Trap Equipment	28	0.63	0.87
Pipe Support Structure	0	–	–
Stream Crossing	7	0.16	0.22
Road Crossing	50	1.13	1.55
Equipment Not Identified	30	0.68	0.93
Storage Subsystem	138	3.12	100.00
Tanks	78	1.76	56.52
Tank Firewall	0	–	–
Tank Associated Equipment	57	1.29	41.30
Power Equipment	0	–	–
Equipment Not Identified	3	0.07	2.17
Pump Station Subsystem	165	3.66	100.00
Pumps	88	1.99	4.32
Centrifugal Pumps	1	0.02	0.62
Reciprocating Pumps	3	0.07	1.85
Manifold Equipment	6	0.14	3.70
Rotary Pumps	0	–	–
Steam Engine	0	–	–
Gas Turbine	0	–	–
Steam Turbine	0	–	–
Internal Combustion Engine	0	–	–
Electrical Motor	0	–	–
Pressure Controls	1	0.02	0.62
Metering Equipment	4	0.09	2.47
Valve	23	0.52	14.20
Valve Operating & Control Equipment	4	0.09	2.47
Electric Power & Control Equipment	2	0.05	1.23
Communications Equipment	0	–	–
Drainage System Equipment	3	0.07	1.85
Power Equipment	0	–	–
Equipment Not Identified	27	0.61	6.67
Safety Subsystem	3	0.05	100.00
Pressure Sensing Equipment	0	–	–
Pressure Switching Equipment	0	–	–
Flow & Gauge Equipment	1	0.02	50.00
Temperature Recorders	0	–	–
Power Equipment	0	–	–
Equipment Not Identified	1	0.02	50.00
Gathering Subsystem	870	19.66	100.00
Gravity	73	1.65	8.39
Suction	41	0.93	4.71
Pressure	8	0.18	0.92
Equipment Not Identified	748	16.90	85.98
Subsystem/Equipment Not Identified	21	0.47	N/A
Total G/D System Failures	4423	100.00	N/A

Table E.2 Spill Events for Onshore Gathering/Distribution Systems by Subsystem and Spill Category

Subsystem	Number of Spill Events				
	Minor	Moderate	Major	Not Identified	Totals
Pipeline	36	2429	634	83	3182
Storage	1	96	38	1	136
Pump Station	1	111	38	10	160
Safety	0	1	1	0	2
Gathering	8	775	83	2	868
Not Identified	2	15	2	0	19
Totals	48	3427	796	96	4367

OIL SPILL CLEAN-UP CAPACITY IN VICINITY OF BRYAN MOUND DOME

Due to the extensive oil production and pipeline transmission activity in the Freeport and Houston area, many oil handling facilities and third party clean-up services are available, with modern equipment, chemicals and absorbent materials. A Crossley survey of Oil Spill control facilities, conducted for the American Petroleum Institute in 1970[3], reports the availability of cooperating oil handling facilities and clean-up contractors by ZIP code, within each state.

This survey shows 72 oil handling facilities, with some clean-up capacity, 15 third party clean-up services, and 2 co-ops in the same ZIP Area as the Bryan Mound salt dome site. In the western contiguous Texas Area there are 27 oil handling facilities and 4 third party clean-up services and in the eastern contiguous ZIP Area (Beaumont/Pt. Arthur area) there are 114 oil handling facilities and another 18 third party clean-up services. The Houston ZIP Area, north of Bryan Mound, reports 10 oil handling facilities and 11 third party clean-up services.

Table E.3 Areas of Potential Spills Probability/Severity

	Tank Farms	Terminals	Onshore Production
EQUIPMENT			
Tanks			
Gauges	H/3	M/3	M/3
Sampling facilities	H/3	H/3	
Shell and bottoms	L/1	L/1	L/1
Underground seepage	L/1	L/1	
Containment dikes	M/2	M/2	L/2
Dike drains	H/2		M/2
Pipe, Valves & Fittings			
Seal failure			L/1
Valve stem packing	M/3	M/3	M/2
Gaskets	M/2	H/3	M/2
Pipe rupture	L/1	L/1	L/1
Pump & Mechanical Equipment			
Seals	M/2	M/3	H/1
Lubricating systems			
Loading Stations			
Fill safeguards		L/1	H/2
Curbs and drains		H/2	M/2
OPERATIONS			
Tanks			
Filling/Overfilling	H/1	H/1	L/2
Sampling	H/2	M/3	L/3
Cleaning	H/1	L/2	L/2
Dike draining	H/2		
Pipe, Valves & Fittings			
Maintenance		H/2	H/2
Collision		H/1	
Pumps			
Maintenace	H/3	H/3	H/2
Loading Racks			
Overfills		H/2	
Loading drips		H/3	

Assuming that the Federal Energy Administration relies principally on third party clean-up contractors for assistance, there are approximately 32 such sources of personnel and equipment within a 100 mile radius of the petroleum storage site.

REFERENCES

1 "Petroleum Systesm Reliability Analysis," (2 Volumes), EPA Report No. EPA-R-2-73-280a, August 1973.

2 "Oil Spill Presentation Control and Countermeasure Plan Review," by Rue University and The School of Public Health, The University of Texas, Sponsored by U.S. EPA, February 1975.

3 "Oil Spill Control Survey for Onshore and Off-shore Facilities," American Petroleum Institute, March 1970.

APPENDIX F

SOCIOECONOMIC CHARACTERISTICS OF BRAZORIA COUNTY

1. Social

1.1 Population

Brazoria County is part of one of the most consistently growing regions of the United States. Since 1850 when the first official census of the state was conducted, Texas has consistently surpassed the United States in percentage growth per decade. In 1950, Texas ranked 25th among the states in total population; by 1900, it climbed to seventh, and in 1960 was the sixth most populous state. Between 1900 and 1960, U.S. population increased 135 percent, while Texas population growth was 214 percent. Between 1950 and 1960, Texas had the largest numerical population gain of any state except California. Population growth in the Houston area has outstripped state growth. Between 1960 and 1970, Houston SMSA population increased 40 percent, compared to 16.8 percent increase in Texas. The Houston area has grown to represent nearly 18 percent of the state's population. Within the Houston area, greatest population growth has occurred outside the City of Houston. As Table F.1 indicates, Brazoria County population increased 42.1 percent from 1960 to 1970,[1] a rate second only to that of Montgomery County (part of Houston SMSA).

Brazoria County has tended to be an exception to the average shift of counties from rural to urban populations. As shown in Table F.2, the county's urban population has grown at a rate comparable to the state's, or an increase of 27 percent compared to 24 percent. However, while the state's rural population declined by nearly 5 percent from 1960 to 1970, Brazoria County's rural population increased 75.1 percent in that same period, reflecting the relative growth and strength of agribusiness in the county. In 1970, about 61 percent of the county's population lived in urban areas of the county. Nearly 42,000 persons resided in rural areas of the county, or nearly 39 percent of the population, compared to 20 percent in the SMSA as a whole.[1]

1.2 Population Density

With 1,422 square miles of land and a 1970 population of 108,312, Brazoria County had a population density of 76.2

Table F.1 Population Growth, Houston SMSA 1960-1970

	1960	1970	Change 1970-1960	% Change 1970-1960
TOTAL SMSA	1,418,323	1,985,031	566,708	40.0
Houston city	938,219	1,231,394	293,175	31.2
Outside central city	480,104	753,637	273,533	57.0
Brazoria County	76,204	108,312	32,108	42.1
Fort Bend County	40,527	52,314	11,787	29.1
Harris County	1,243,158	1,741,912	498,754	40.1
Liberty County	31,595	33,014	1,419	4.5
Montgomery County	26,839	49,479	22,640	84.4

Source: United States Department of Commerce, Bureau of Census

Table F.2 Urban and Rural Population, Texas and Brazoria County, 1960-1970

	Texas			Brazoria County		
	1960	1970	% Change	1960	1970	% Change
Total Population	9,579,677	11,196,730	16.9	76,204	108,312	42.1
Urban Population	7,187,470	8,920,946	24.1	52,270	66,392	27.0
Percent of Total	75.0	79.7	-	68.5	61.3	-
Rural Population	2,392,207	2,275,784	4.8	23,934	41,920	75.1

Source: United States Bureau of Census, Census of Population 1970 persons per square mile, compared to a population density in Harris County of 1,018 persons per square mile. This low population density reflects the current rural nature of the County, and signals an opportunity for rational and judicious development of the County's land use and transportation facilities--an opportunity not available to Counties which have already reached high density levels. Brazoria County has shown a steady increase in population density over the past two decades. In 1950, the density of population per square mile was 32.7; in 1960, 53.6, and in 1970, 76.2.[1]

1.3 Population Centers

Within the County, population growth has concentrated in three principal clusters of gradually urbanizing towns and cities. Table F.3 presents population data for the County's 4 official census subdivisions. The County has been divided as follows (also see Figure F.1):

The Alvin-Pearland area, which had 28.2 percent of the County's population in 1970.

The Angleton-Rosharon area, which had 19.98 percent of the County's population in 1970.

The Brazoria-West Columbia area, which had 16.9 percent of the County's population in 1970.

The Brazosport area, which had 35.8 percent of the County's population in 1970.

Over one-half of the County's population is concentrated in six cities and towns which have populations over 5,000. These six cities and towns, and 53.8 percent of the County's population, are clustered in three general areas.

South, in proximity to Dow Chemical and other petrochemical industries.

North, in proximity to metropolitan Houston.

Midway, enroute between Houston and the Gulf.

South (Lake Jackson/Freeport)

The County's two largest cities are located in the Gulf area, near the County's petrochemical industries.

Table F.3 Population, within Brazoria County, 1960-1970

	1960	1970	% Change 1960-1970	% of County Population, 1970
Alvin-Pearland Division	14,592	30,595	109.7	28.2
Alvin City	5,643	10,671	89.1	9.8
Brookside Village - City	560	1,507	169.1	1.4
Hillcrest Village	-	358	-	0.3
Liverpool City	280	319	13.9	0.3
Manvel City	420	160	74.7	0.1
Pearland City	1,497	6,444	330.5	5.9
(Non-Urban)	6,892	11,190	62.4	10.3
Angleton-Rosharon Division	15,359	20,561	-	18.9
Angleton City	7,312	9,770	33.6	9.0
Angleton South	-	1,017	-	0.9
Bailey's Prairie Village	-	228	-	0.2
Danbury City	250	807	222.8	0.7
(Non-Urban)	N.A.*	8,739	-	8.9
Brazoria-West Columbia Division	17,462	18,339	5.0	16.9
Brazoria City	1,291	1,681	30.2	1.6
Sweeny City	3,087	3,191	3.4	2.9
West Columbia City	2,947	3,335	13.2	3.1
(Non-Urban)	10,136	10,132	-	9.4
Brazosport Division	28,792	38,817	34.8	35.8
Clute City	4,501	6,023	33.8	5.6
Freeport City	11,619	11,997	3.3	11.1
Jones Creek	-	1,268	-	1.2
Lake Barbara Village	477	605	26.8	0.6
Lake Jackson City	9,651	13,376	38.6	12.3
Richwood Village - City	649	1,452	123.7	1.3
(Non-Urban)	N.A.*	4,096	-	3.8
TOTAL, Brazoria County	76,204	108,312	42.1%	100.0%

* N.A. Divisions not used in 1960 Census, data not available.

Source: Bureau of the Census, Texas Census of Population, 1970.

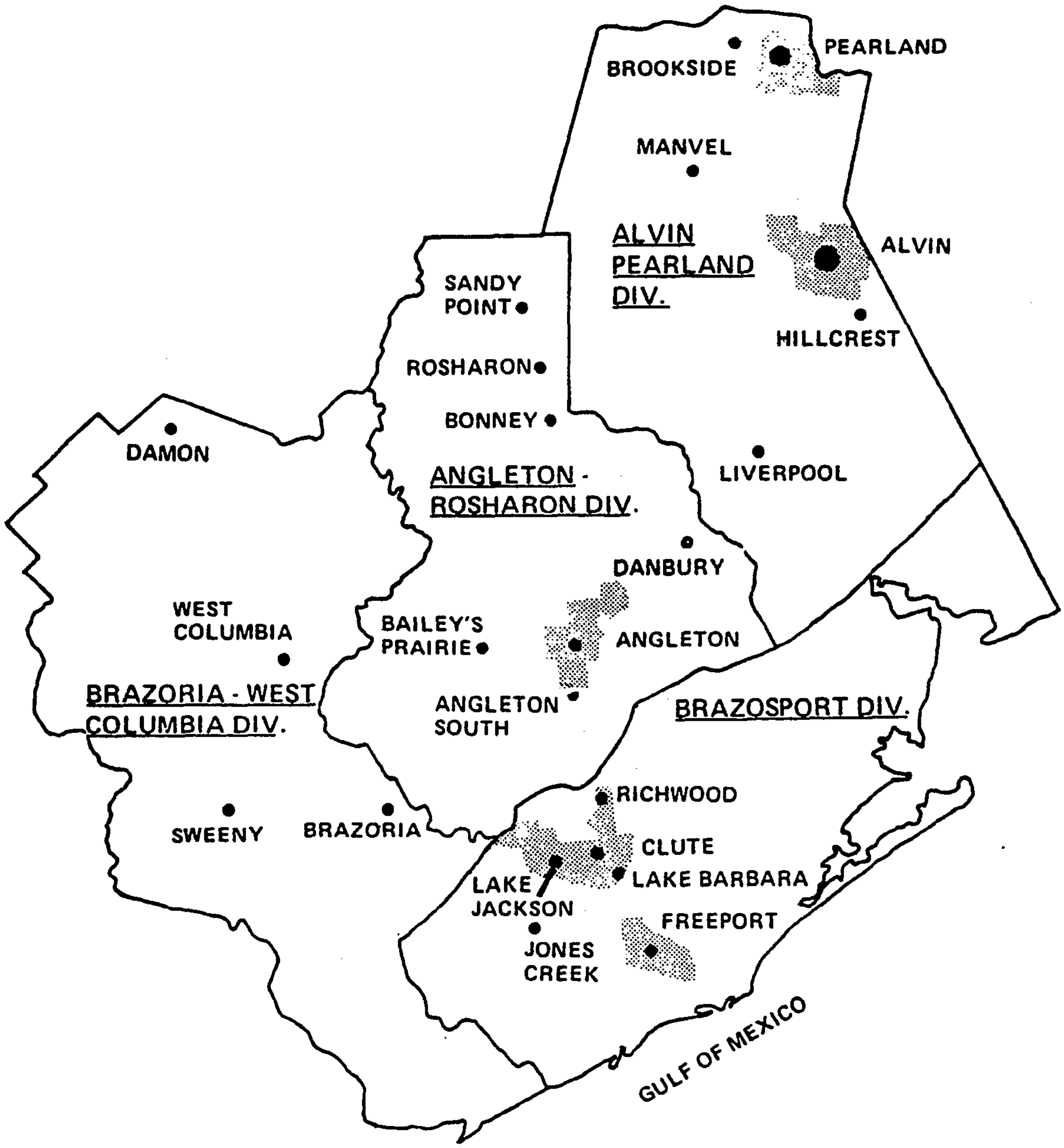


Figure F.1 Brazoria County - Census Divisions - Cities and Towns

Lake Jackson, population 13,376, or 12.3 percent of the County.

Freeport, population 11,997, or 11.1 percent of the County.

Other nearby cities and towns in the Brazosport Division of the County include Clute, population 6,023; Richwood Village, 1,452; Jones Creek, 1,268; and Lake Barbara Village, 605. The Brazosport area is the least rural of the County's four divisions, with only 10.5 percent of the area's population living outside cities and towns.

North (Alvin/Pearland)

The County's second largest cluster of population is at the north, in proximity to metropolitan Houston. Alvin, a city of 10,671, represents almost 10 percent of the County population; Pearland Village, population 6,444, accounts for nearly 6 percent of County population. The overall Alvin-Pearland Division of the County accounts for over 28 percent of the County's population, with 30,595 residents. Of these, over one-third, or 36.8 percent, reside outside cities and towns.

Midway (Angleton)

A third, smaller concentration of population has developed generally midway between Houston and the Gulf, with the town of Angleton, the County Seat, having a population of 9,770, or 9 percent of the County's population. Over 42 percent of the Angleton-Rosharon Division's population reside outside of cities and towns.

The County's fourth division, Brazoria-West Columbia, is predominantly rural, with over 55 percent of its 18,339 residents residing outside of cities and towns, and with no town larger than 3,335 residents.

1.4 Population Forecasts

Several public agencies have developed population projections for Brazoria County. These projections have taken into consideration past growth rates of the County, the Houston SMSA, the Southeast Texas Urban Region, and the state. Original estimates of population growth for the county by the Houston-Galveston Area Council (H-GAC) in 1971, projected about 200,000 persons by 1980 and 400,000 by

1990. This represents an increase of 86 percent between 1970 and 1980, and an increase of about 100 percent between 1980 and 1990.

More recent (1974) projections by H-GAC have revised the above estimates somewhat. This revised population growth forecast predicts approximately 147,000 by 1980 and 176,335 by 1990. These later projections will again be modified if a proposed Superport becomes a reality; the presence of the new port could boost the 1990 figure from 176,335 to 241,000 persons.[2]

The above population projections give a high and medium range projection for the county. A somewhat lower rate of growth is projected for the county by the Governor's office which predicts 145,870 persons in 1980 and 189,130 in 1990. These three sources of population projections together present a high, medium, and low range of growth for the county in the next 15 years.

Conclusion

Population growth in Brazoria County is anticipated to show a sharp increase over the next two decades as a result of increased industrialization. Improved transportation facilities within the county will result in the attraction of greater numbers of commuters who wish to enjoy the more relaxed atmosphere as well as a closer proximity to the Gulf.[2]

2. ECONOMIC

2.1 Employment

Total employment in 1970 for Brazoria County was 24,034, contrasted with 16,666 in 1964, an increase of 44.2 percent. Adjusted unemployment for 1975 was 4.1 percent, contrasted with 2.9 percent in 1970.

The petrochemical industry and growth-related non-manufacturing industries employ the majority of the Brazoria County labor force. As a result, the economy is somewhat less diversified than that of the Houston SMSA as a whole, and links to other counties, and particularly to Houston, remain vital to the economy of Brazoria County. A comparison of nonagricultural employment in Brazoria County and the Houston SMSA is presented in Table F.4.

Table F.4

Comparison of Nonagricultural Employment

Brazoria County and Houston SMSA

	Houston SMSA, March 1969		Brazoria County, 1970		
	No. of Employees	% of Total	No. of Employees	% of County Total	% of SMSA Total
TOTAL NONAGRICULTURAL EMPLOYMENT	792,800	100.00	23,948	100.0	3.0
<u>Total Non-Manufacturing</u>	650,700	82.08	14,032	58.5	2.1
Mining	28,650	3.61	1,225	5.1	4.2
Construction	76,850	9.69	4,013	16.7	5.2
Transportation, Communication & Utilities	58,400	7.37	1,110	4.6	1.9
Retail Trade	126,750	15.99	3,895	16.2	3.0
Wholesale Trade	66,900	8.44	642	2.6	0.9
Finance, Ins, Real Estate	40,250	5.08	693	2.8	1.7
Services (Bus.Pers., Med & Prof., etc.)	145,050	18.30	2,350	9.8	1.6
Government	82,050	10.35	N.A.	N.A.	N.A.
Private Households	25,800	3.38	N.A.	N.A.	N.A.

Table F.4 (Continued)

<u>Total Manufacturing</u>	142,100	17.92	9,812	40.9	6.9
Food & Kindred Products	14,000	1.77	104	0.4	0.7
Textile Mill Products	500	.06	N.A.	N.A.	N.A.
Apparel & other finished products from fabrics & similar materials	1,450	.18	N.A.	N.A.	N.A.
Lumber,Wood Products(Except furniture)	2,750	.35	N.A.	N.A.	N.A.
Furniture & Fixtures	2,450	.31	N.A.	N.A.	N.A.
Paper & Allied Products	3,550	.45	N.A.	N.A.	N.A.
Printing Publ. & Allied Ind.	8,500	1.07	133	0.5	1.5
Chemical & Allied Prod.	22,500	2.84	5,815	24.2	25.8
Petrol.Refin.&Related Ind.	11,050	1.39	1,067	4.4	18.7
Stone,Clay,Glass Prod.	5,700	.72	121	0.5	2.1
Primary Metal Industries	8,350	1.05	N.A.	N.A.	N.A.
Fabricated Metal Prod. (Except ordiance machinery & transportation equip).	19,800	2.50	343	1.4	1.7
Machinery (Except electrical)	25,800	3.25	280	1.1	1.0
Electrical Machinery,Equip. & Supplies	3,600	.45	N.A.	N.A.	N.A.
Transportation Equipment	4,200	.53	N.A.	N.A.	N.A.
Misc. Manufacturing Ind.	7,900	1.00	N.A.	N.A.	N.A.
Unclassified Establishments			104	.4	

Source: Estimates by the Texas Employment Commission.

Notes: "Prof., Scientific & Controlling Instr., etc." are in Misc. Manufacturing Industries. The distributions are shown for Total Nonagricultural Employment.

Manufacturing, particularly petrochemical, plays a stronger role in the County than in the SMSA as a whole. About 41 percent of the County's nonagricultural employees are in manufacturing, compared to about 18 percent in the SMSA. The petrochemical industry is the mainstay of county manufacturing employment, accounting for 70 percent of county employment in manufacturing. Brazoria County petrochemical employment accounts for over one-fourth of the total SMSA's employees in chemical manufacturing, and 19 percent of SMSA employment in petroleum manufacturing, while the county's total nonagricultural labor force represents only 3 percent of the SMSA labor force.

Nonmanufacturing industries employ the majority (59 percent) of the County's nonagricultural workforce, but are less predominant than in the SMSA (82 percent of nonagricultural employment). Construction is the predominant nonmanufacturing industry, employing 16.8 percent, compared to 9.7 percent in the SMSA, reflecting growth in the County.[1]

The manufacturing industries' predominant importance to the County's economy is illustrated by a comparison of taxable payrolls, shown in Table F.5. In 1970, taxable payrolls in Brazoria County totaled $44.8 million. Manufacturing industries, dominated by petrochemical, accounted for nearly 54 percent, or over $24 million. The construction industry accounted for 18 percent or $8.1 million, followed by retail trade, with 8.1 percent or $3.6 million in taxable payrolls.[1]

2.2 Income and Sales

The growth and strength of the County's economy are indicated by increases in the income of its residents and in the growth of both retail and wholesale sales. In the past decade, Brazoria County's economic growth has outstripped that of several other counties in the Houston metropolitan area.

Effective buying income in Brazoria County has increased more than that of the overall Houston metropolitan area. Between 1960 and 1970, the effective buying income of Brazoria County increased 149.3 percent, compared to a 141 percent increase for the Houston metropolitan area and a 140.9 percent increase for Harris County.

Table F.5 Taxable Payroll, Brazoria County, 1970

Industry	Taxable Payrolls	Percentage of Total Taxable Payrolls
Total	$ 44,830,000	100.0%
Manufacturing	24,079,000	53.7%
Construction	8,148,000	18.1%
Retail Trade	3,653,000	8.1%
Services	2,456,000	5.4%
Mining	2,317,000	5.1%
Transportation and Other Public Utilities	1,867,000	4.1%
Wholesale Trade	1,111,000	2.4%
Finance, Insurance & Real Estate	929,000	2.0%
Agricultural Services, Forestry, Fisheries	177,000	0.3%
Unclassified Establishments	93,000	0.2%

Source: U.S. Bureau of Census

The per household effective buying income for Brazoria County in 1970 was $10,453, second only to that of Harris County within the Houston SMSA. The per household effective buying income for Texas in 1970 was $9,776. If the past trend is maintained, Brazoria County residents will be in a most favorable position with regards to the purchasing of all types of goods and services.

The increased value of agricultural crops and further expansion of the higher salaried chemical and petroleum product industries will mean continued relatively higher household incomes for the County.

Increased retail sales reflect the increased incomes in the County. From 1960 to 1971, total retail sales increased 55 percent, reaching nearly $86.8 million. Of the total retail sales for the Houston SMSA in 1971, Brazoria County accounted for 3.4 percent, exceeding that of all other counties but Harris. Houston and Harris County's role as the retail sales center for the entire SMSA is clearly indicated by the fact that over 91 percent of all retail sales in the region centered in Harris County. Brazoria County's transportation links to Houston continue to be vital, notwithstanding anticipated major increases for retail sales in the County.

Wholesale sales for the Houston SMSA increased 78.1 percent between 1958 and 1967 to nearly $6.6 billion. Of this total, Brazoria County accounted for $45.8 million.

2.3 Industrial Base

Unlike many Texas counties adjacent to major cities, Brazoria County has a significant industrial base of its own, and plays a significant role in the overall economy of the Houston metropolitan area. Brazoria County has developed as a significant industrial and agricultural center in the Houston metropolitan region, and boasts one of the largest petrochemical industry complexes in the world. The wealth of natural resources in Brazoria County, and in the Houston area generally, has provided the basis for economic development.[1]

Minerals

The State of Texas has over one-third of all oil reserves in the U.S., produces over 38 percent of natural gas in the nation, and provides over one-fourth of all oil and gas fuel energy in the country. Over 84 percent of Texas' tremendous output is refined on the Gulf coast, with Brazoria County playing a significant role.

Total mineral production in the 8 county southeast Texas region represented 17.4 percent of all Texas production in 1967, and totaled nearly $1 billion. Brazoria County accounted for the greatest proportion of the region's production, contributing 22.7 percent or over $214 million. Minerals found in Brazoria County, in order of value are petroleum, natural gas, natural gas liquids, magnesium, chloride, bromine, salt, lime, magnesium compounds, sulphur, sand, and gravel.

Petroleum Refining

Petroleum refining in the Texas Gulf Coast area has an operating capacity of 2,924,100 barrels of refined products per day, which is 84 percent of the Texas total and 23 percent of the U.S. operating capacity. Phillips Petroleum Refinery, located in Brazoria County, has an 85,000 barrel per day capacity.

Chemical-Petrochemicals

The Gulf Coast area is the world's petroleum refining capital, and center of the nation's greatest concentration of petrochemical and chemical industries. At least 40 percent of every basic petrochemical produced in the U.S. comes from this area and, for some products such as synthetic rubber, this region produces as much as 80 percent. Dow Industries in Freeport, Monsanto Chemicals, and AMOCO on Chocolate Bayou comprise a significant input to the petrochemical industry of the region.

"The Spaghetti Bowl"

A continuously expanding complex of more than 1,200 miles of product pipelines which connect over 100 chemical plants, refineries, salt domes, and gasoline processing plants gives Brazoria County a unique economic advantage through the convenient and low cost transfer of feedstocks, fuel, and chemical products between plants.

Agribusiness

Brazoria County, with its flat topography, moist climate, and rich loam soils constitutes a major segment of the agribusiness in the Houston region. The region, with less than 5 percent of Texas' land area, earns approximately 7 percent of the state's farm cash income. Rice, grain, sorghum, and cattle are principal products. The 13 counties of the region produce nearly 30 percent of the nation's total rice crop. National and international rising demand for rice, grain, and cattle will likely sustain the County's production and growth of these products.

Marine Resources

The bay waters along the Brazoria and Galveston County coastline have long produced more seafood than any other area in the state. More than 250 species of fish are found in these waters. Shrimp is the most valuable for commercial fishermen. Oysters are also an important income source. Freeport is called the "shrimp capital of the world" and significant inland shrimping is now occurring within Brazoria County.

The total value of the shrimp catch in Texas for 1967 amounted to over $45 million. A major share of this catch is attributable to the Southeast Texas Urban Region. A significant share of the total value of the Texas oyster catch, some $1,570,181 in 1967, is also attributable to this region. Provided the waters of the Gulf can be kept free of dangerous pollutants, the economic outlook for marine resources in Brazoria County is highly promising.

Recreation

Because of increasing population, the recreation industry is assuming greater importance as an income source in the area, particularly along the Galveston and Freeport coast, which serve as the closest sea beaches for an estimated three to five million people. Over 70 miles of beaches at Bolivar Peninsula, Freeport, and Galveston are located just one hour's drive from downtown Houston. Brazoria has a public beach at Surfside and extensive fishing, hunting, and boating facilities along its coastal waterways.

Farms, ranches, and woodlands are being converted for picnicking, camping, hiking, fishing, swimming, boating, and hunting. These amenities are important to attract new research and development industries to locate in Brazoria rather than in other less developed areas. Brazoria County will be challenged to provide the type of recreation and cultural amenities which will attract the desired development into the area. Recreation is expected to spawn new industries and Brazoria has great potential for becoming the location of the manufacturing and service segments of this growing segment of the economy.

Research and Development

Of particular importance for the future growth of any urbanizing area are research, development, and communications industries. These industries depend upon a vast array of highly-trained, highly-skilled workers. Only with a strong industrial and educational base, reinforced with cultural and recreational opportunities for its populace, can a region expect to attract and retain those industries which provide the promise of future developments.

With 4,873 Houston-area scientists registered by the National Science Foundation, the 5 county Houston SMSA ranks ninth among major U.S. science centers. The 1970 National Science Foundation Survey also showed the median annual income for Houston SMSA scientists as $16,000. Surveys by the Science Committee of the Houston Chamber of Commerce show a total of 4,020 scientists, and 3,866 technologists involved in $154,619,814 in industrial research for 1969. Contract and grant-supported education and medical research includes 487 scientists working on 799 projects valued at $53,608,758. Totals indicate more than 8,680 scientists and technologists working on research exceeding $208,228,500.

As part of the Houston SMSA, Brazoria County shares in the area's growth of this segment of the economy. With further petrochemical industrial expansion combined with projected increases in higher education facilities in Brazoria and adjacent counties, it is anticipated a more direct share of area research and development activity will be forthcoming for Brazoria.

2.4 Economic Growth Projections

Economic growth in the past decade has reflected the overall growth of the County, and major increases in the labor force, with the rapid development of service-related industries which generally accompany significant population growth. From 1964 to 1970, the number of persons employed in nonagricultural occupations increased nearly 45 percent as Table F.6 shows. Manufacturing employment increased about 24 percent. Nonmanufacturing employment, meanwhile, increased 64.5 percent with growth-reflecting employment showing significant increases.

Table F.6

Growth in Employment, Brazoria County, 1964-1970

Industry	Number Employed 1964	1970	Percentage Change
TOTAL EMPLOYMENT	16,666	24,034	44.2%
Total Agricultural Employment	220	190	(13.6)
Total Non-Agricultural Employment	16,446	23,844	44.9%
Total Non-Manufacturing	8,530	14,032	64.5%
Mining	856	1,225	43.1%
Construction	1,404	4,013	185.8%
Transportation and Utilities	784	1,110	41.5%
Retail Trade	2,993	3,895	30.1%
Wholesale Trade	515	642	24.6%
Finance,Insurance,Real Estate	499	693	38.8%
Services	1,454	2,350	61.6%
Total Manufacturing	7,916	9,812	23.9%

Construction employment, up 186 percent Finance, insurance, real estate employment, up 38.8 percent Transportation and utilities employment, up 41.5 percent Services (professional, medical, business, etc.,) up 61.6 percent

Current projections for growth in employment through the year 2000 are available for the 13 county Houston region and are shown in Table F.7. Overall, a 46.7 percent iscrease in number of jobs in forecast, with non-manufacturing employment experiencing greater increase than manufacturing.

Forecasts for greater rate of growth in the manufacturing sector and higher growth rate for the non-manufacturing sectors of the Houston SMSA economy will be reflected in that of Brazoria County. Table F.8 shows the projected number of jobs for Brazoria County through 2000. A total increase of 23.5 percent is projected, with manufacturing jobs showing a larger increase by 2000 than non-manufacturing jobs.

Table F.7

H-GAC Regional Employment Forecast, 1975-2000

Sector	1975	1980	1985	1990	2000
Agriculture, Forestry, & Fisheries	15,469	13,341	12,190	11,046	8,648
Mining	24,704	22,491	23,864	25,245	23,805
Construction	97,438	109,046	118,471	127,903	152,276
Manufacturing	207,907	234,067	255,518	276,375	331,133
Transportation, Communication, & Utilities	80,462	90,185	96,039	101,902	119,264
Wholesale and Retail Trade	234,339	266,858	298,557	330,299	400,422
Finance, Insurance, and Real Estate	57,164	64,952	70,339	75,734	89,073
Services	304,427	361,679	410,138	458,331	578;848
Public Administration	42,773	52,342	57,911	63,486	83,293
Total	1,064,683	1,215,564	1,343,047	1,470,321	1,786,762

Source: Bureau of Business Research, University of Texas at Austin for Houston-Galveston Area Council, 1974.

Table F.8

Brazoria County Employment Forecasts by Sector, 1975-2000

Sector	1975	1980	1985	1990	2000
Agriculture, Forestry,&Fisheries	1,053	980	947	914	823
Mining	1,105	1,236	1,205	1,175	1,116
Construction	5,531	5,760	5,969	6,179	7,415
Manufacturing	11,962	12,159	13,435	14,712	17,949
Transportation,Communication, & Utilities	3,386	4,551	5,341	6,131	7,112
Wholesale and Retail Trade	8,262	9,817	10,896	11,976	14,851
Finance,Insurance, and Real Estate	1,260	1,433	1,598	1,764	1,764
Services	11,008	13,207	15,056	16,905	21,807
Public Administration	1,772	2,077	2,357	2,638	3,429
Total	45,339	51,220	56,804	62,394	76,266

Source: Bureau of Business Research, University of Texas at Austin for Houston-Galveston Area Council, 1974

REFERENCES

[1] Bernard Johnson, Inc., "Brazoria County Comprehensive Transportation Plan," Brazoria County Transportation Planning Commission, 142 pp., 1975.

[2] U.S. Department of Commerce, County and City Data Book, 1972: A Statistical Abstract Supplement, Social and Economics Statistics Administration, U.S. Bureau of the Census, 1020 pp., 1973.

APPENDIX G

SUMMARY OF INFORMATION ON EXISTING CAVITIES

Five caverns at Bryan Mound are being considered for conversion to crude oil storage for the ESR. The respective volumes determined from sonar surveys and other pertinent cavern data are listed in Table G.1. A plan view of the caverns is shown in Figure G.1. This figure shows that the distance between caverns ranges from a maximum of 500 feet to a minimum of 250 feet. The east-west and north-south cross sections of each cavern are depicted in Figures G.2 through G.9. Cavern # number three is too large to be used for crude oil storage.

TABLE G.1 - Pertinent Cavern Data, Bryan Mound

Well No.	Cavern		Present Cemented String		New Cemented String		Total Volume, Million Bbl	Working Volume, Million Bbl
	Top	Bottom	Size, in.	Depth, ft.	Size, in.	Depth, ft.		
1	2,425'	2,862'	9-5/8	1,476	24	2,400	7.5	6.5
2	1,465'	1,679'	11-3/4	1,497	24	1,415	6.6	5.7
4	2,551'	3,140'	11-3/4	1,496	24	2,500	17.3	15.0
1/ 5 U)	2,140'	2,697'	16	1,401	24	2,100	10.2	8.8
5 L)	--	--	--	--	24	--	25.0	21.6

1/ No. 5 Cavern consists of Upper and Lower Caverns.

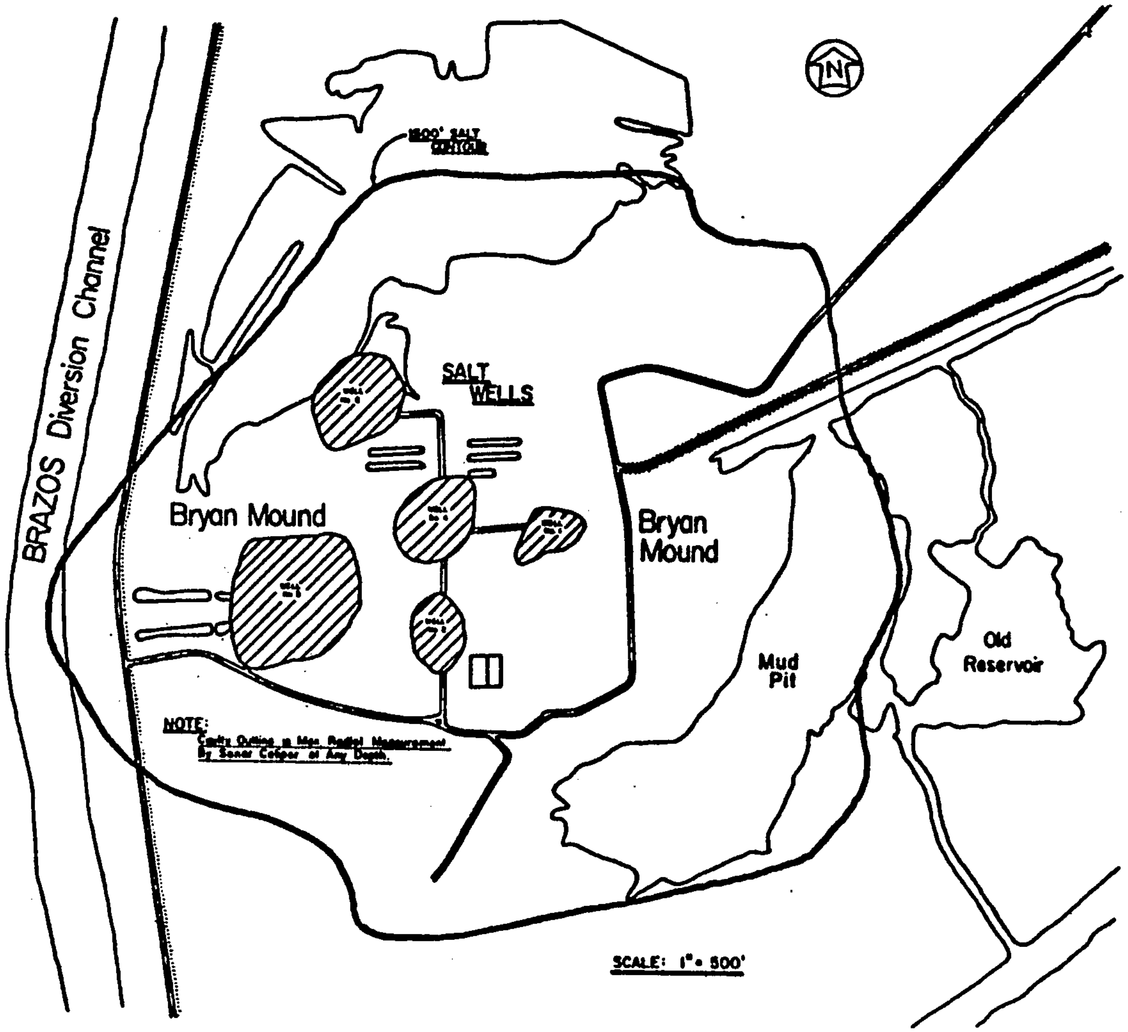


FIGURE G.1 Plan View of Maximum Radial Measurement of Caverns.

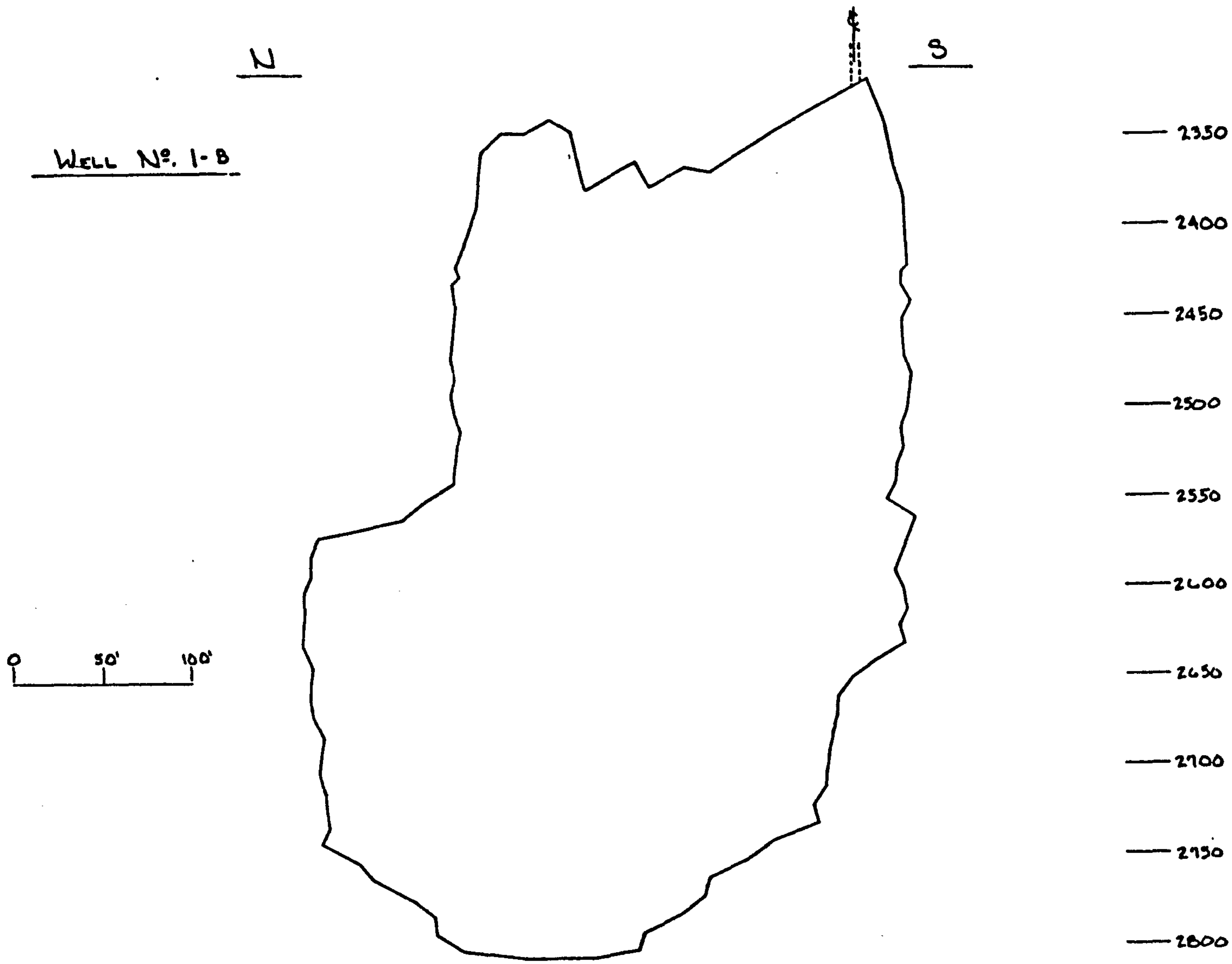


FIGURE G.2 North-South Cross Section of Sonar Survey of Well 1.

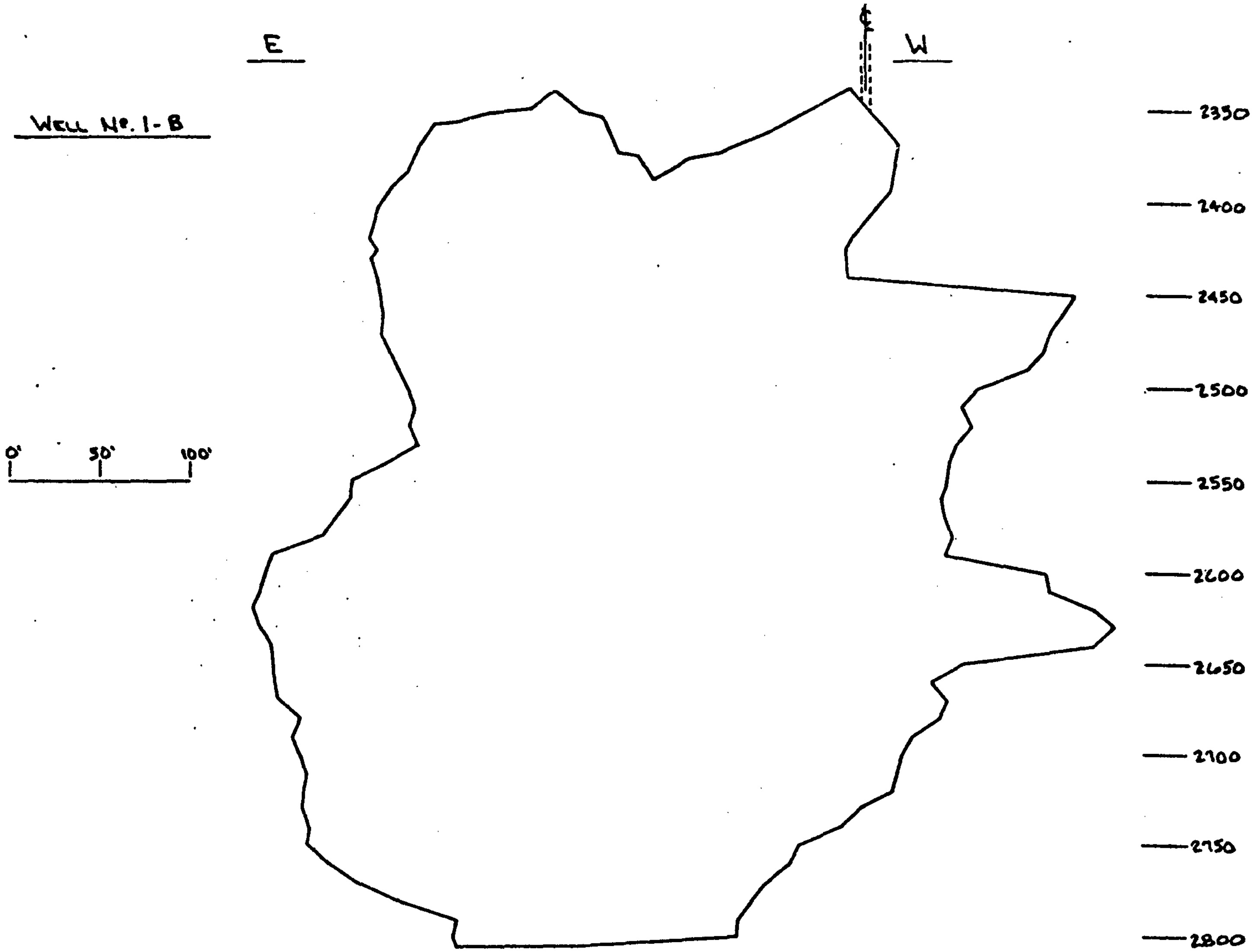


FIGURE G.3 East-West Cross Section of Sonar Survey of Well 1.

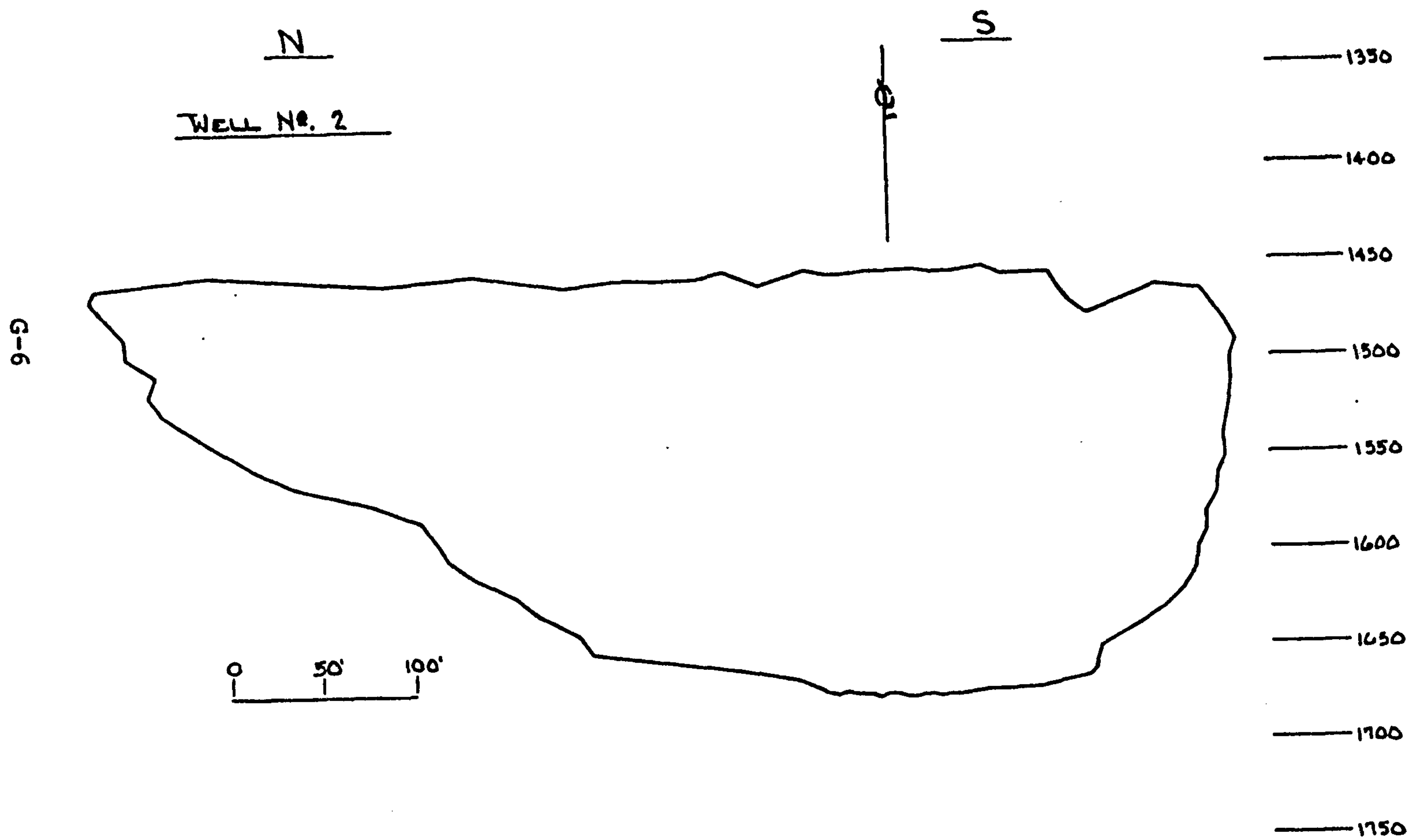


FIGURE G.4 North-South Cross Section of Sonar Survey of Well 2.

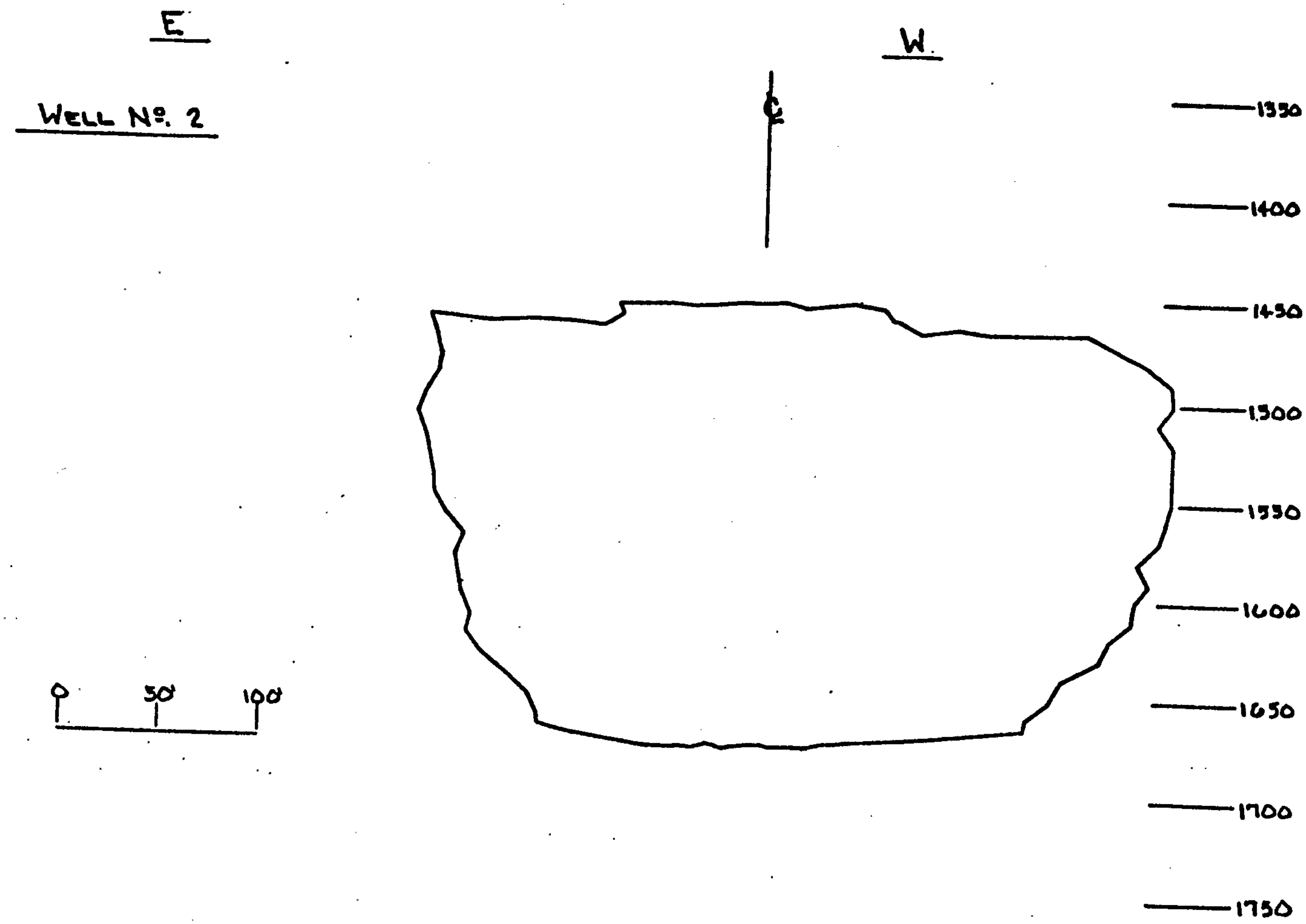


FIGURE G.5 East-West Cross Section of Sonar Survey of Well 2.

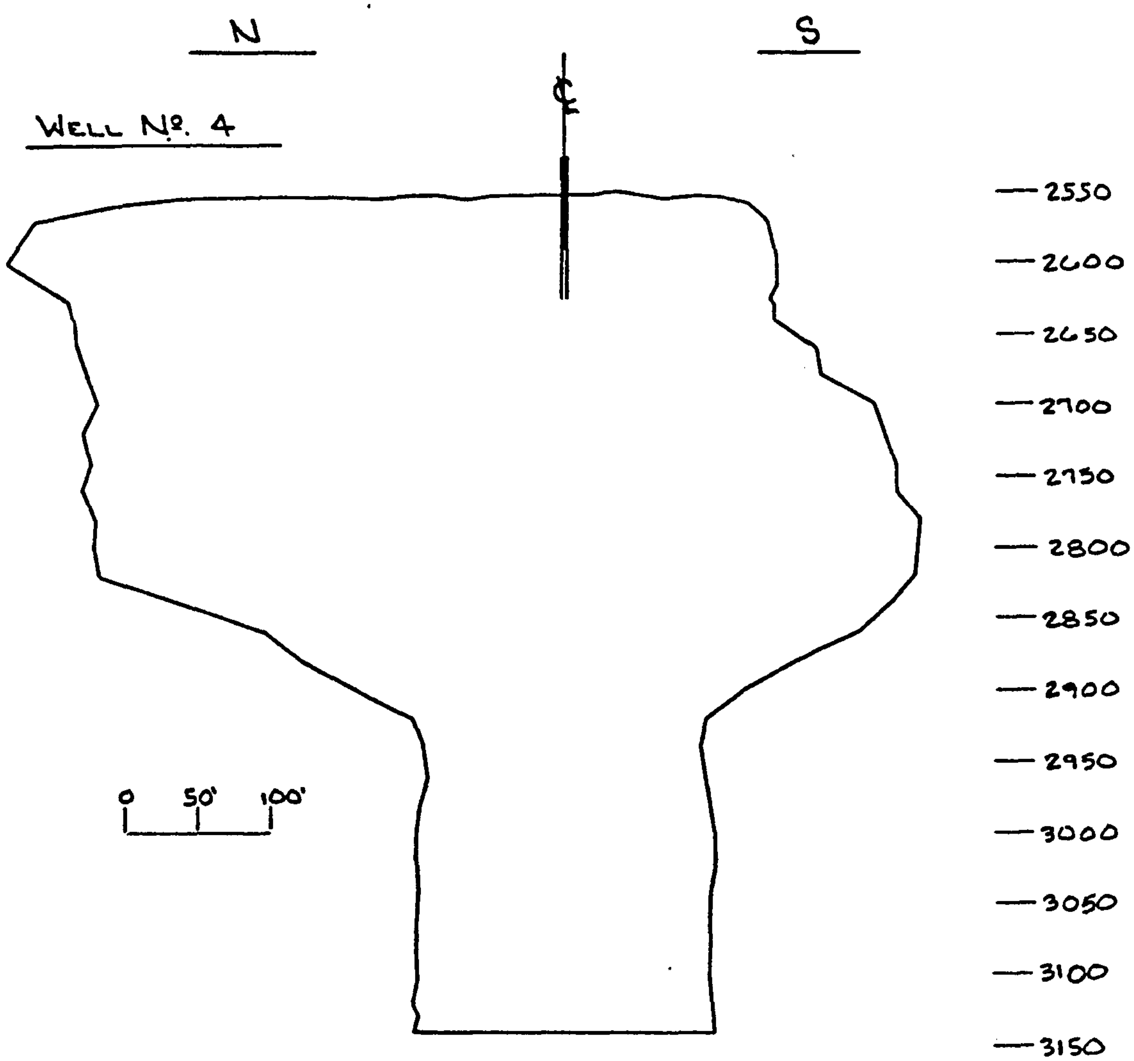


FIGURE G.6 North-South Cross Section of Sonar Survey of Well 4.

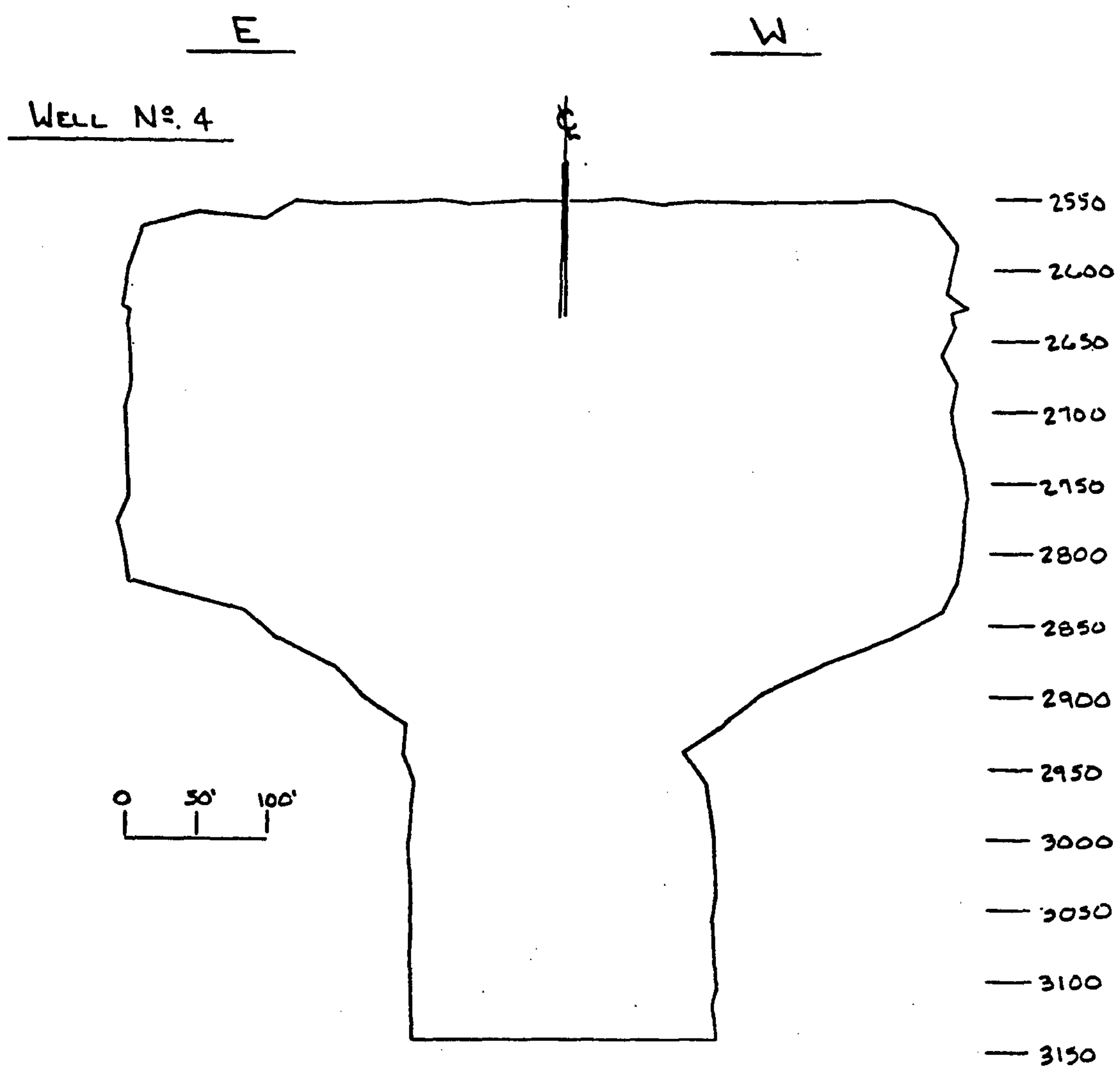


FIGURE G.7 East-West Cross Section of Sonar Survey of Well 4.

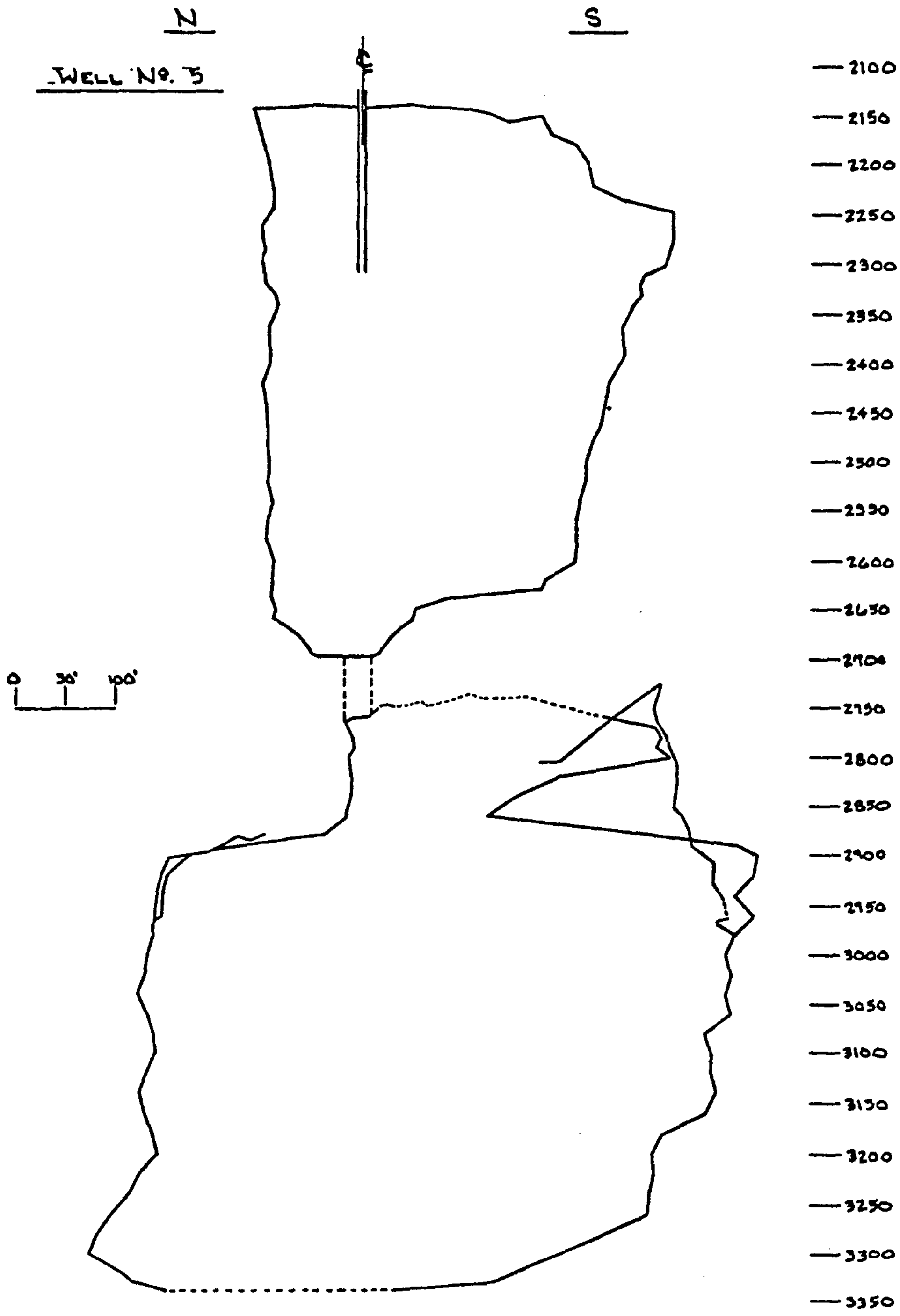


FIGURE G.8 North-South Cross Section of Sonar Survey of Well 5.

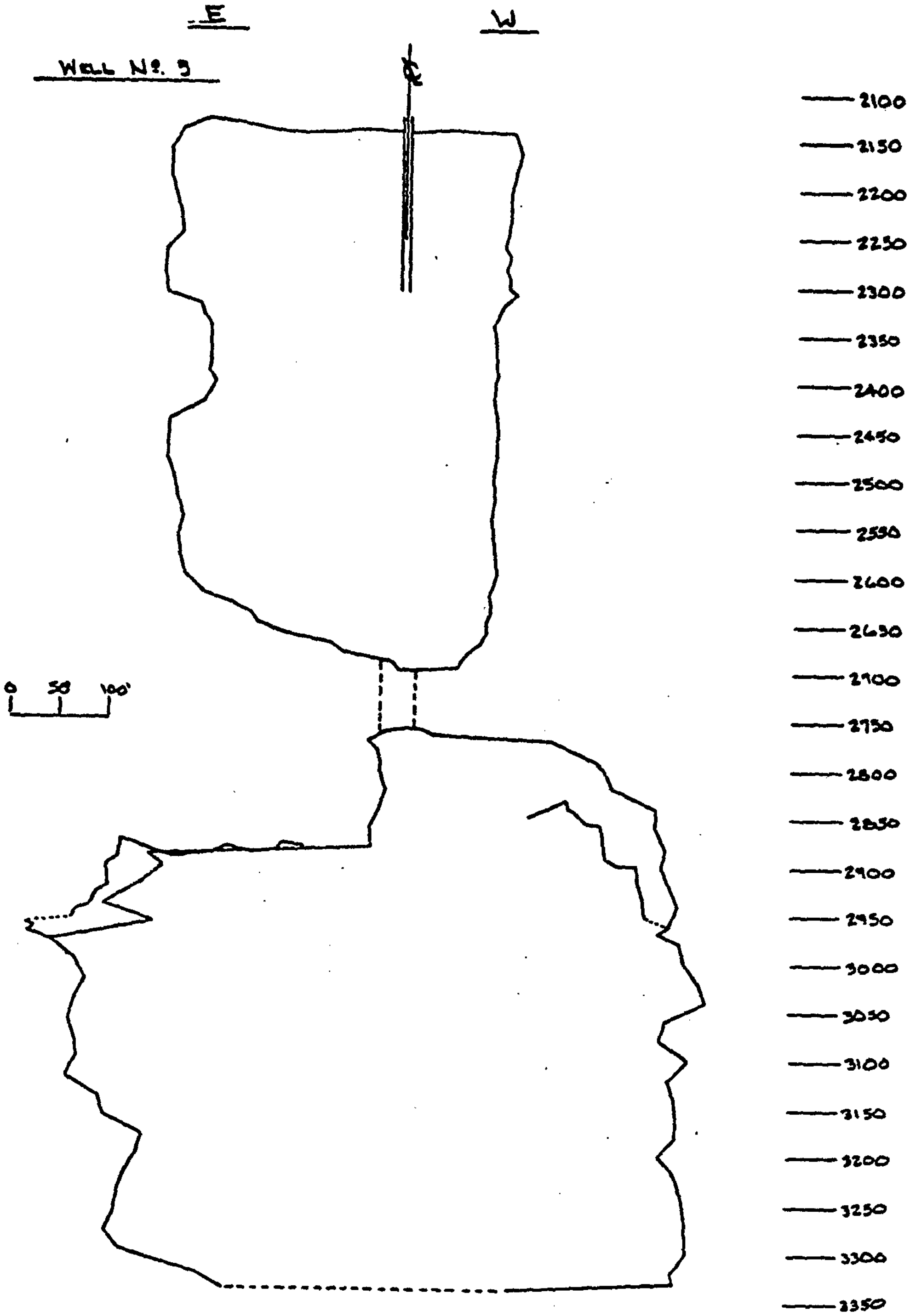


FIGURE G.9 East-West Cross Section of Sonar Survey of Well 5.

APPENDIX H

CAVERN DESIGN ANALYSIS

This appendix evaluates cavern design parameters at Bryan Mound salt dome. The parameters include the cavern dimensions and configuration, proximity to other caverns, the salt dome boundary, the caprock, and the thickness of the plastic and brittle salt which encircles the caverns.[1,2]

Five existing caverns are being considered for oil storage at Bryan Mound. Table H.1 is a compilation of cavern statistics.

Two caverns, 4 and 1, may be close enough together to be in danger of coalescence by either dissolution or subsequent slabbing of the brittle zone. Figure H.1 is a plan view of the caverns and Figure H.2 illustrates caverns 1 and 4 in cross-section. Coalescence of those two caverns would result in the loss of the oil blanket in cavern 4 and uncontrollable upward dissolution of the roof to the level of the oil blanket in cavern 1. Beyond the initial loss of roof support after coalescence, upward dissolution would have little consequence.

Table H.2 presents the maximum and minimum diameters of the cone of influence* and surface areas expected to be expected to be affected if collapse occurs at any of the Bryan Mound storage caverns. Figure H.3 is a site map with the areas of influence superimposed.

The growth of the caverns after various cycles cannot be precisely calculated. It is known that the caverns have the potential of increasing in volume by approximately 14 percent, but there are at least two major complicating factors: (1) - some caverns have complex shapes, (they differ significantly from cylinders, hence, there is more surface area at which dissolution could occur, and consequently the diameter increase estimates based on a 14 percent volume increase of a cylinder would be too large); (2) - the length of time that the volume of fresh

---

*A cone of influence is actually a truncated cone (frustrum), apex down, projected from the caprock to the ground surface. The angle of the frustrum is dependent on the shear angle of the overburden. It is the largest volume of material above a cavern that could be influenced during a collapse.

Table H.1 - Pertinent Cavern Data, Bryan Mound

Cavern Number	Cavern Depth Top*	Cavern Depth Bottom*	Maximum Cavern Diameter*	Cavern Height*	Depth to Top of Caprock*	Total Volume Million**	Working Volume, Million**
1	2,425	2,862	300	437	680	7.5	6.5
2	1,465	1,679	600	214	680	6.6	5.7
4	2,551	3,140	575	589	680	17.3	15.0
1/ 5 U)	2,140	2,697	400	557	680	10.2	8.8
5 L)	2,750	3,350	600	600	680	25.0	21.6

1/ No. 5 Cavern consists of Upper and Lower Caverns.

*Dimensions expressed in feet

**Volumes expressed in barrels

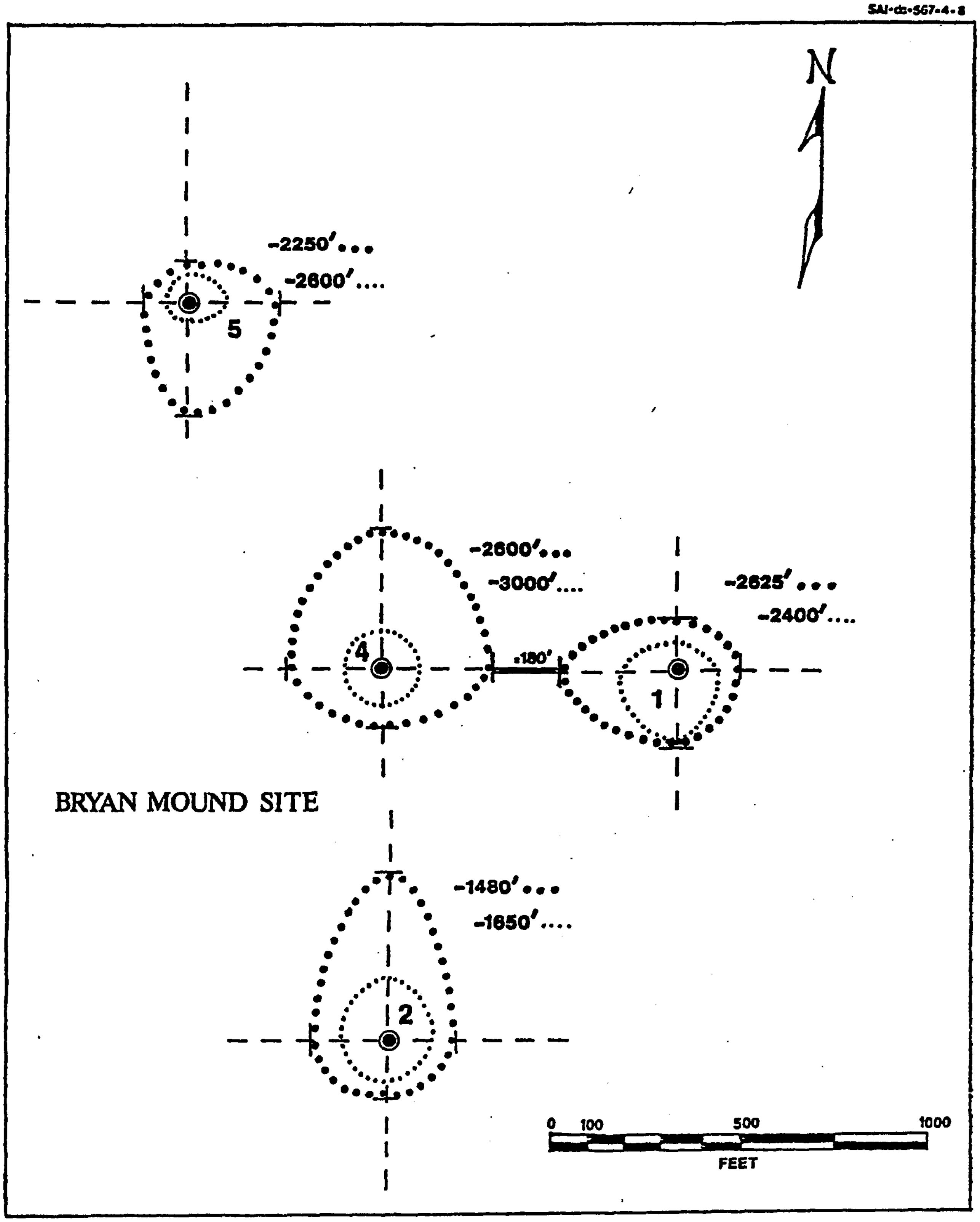


Figure H.1 Plan View of Cavern Cross Sections at Bryan Mound

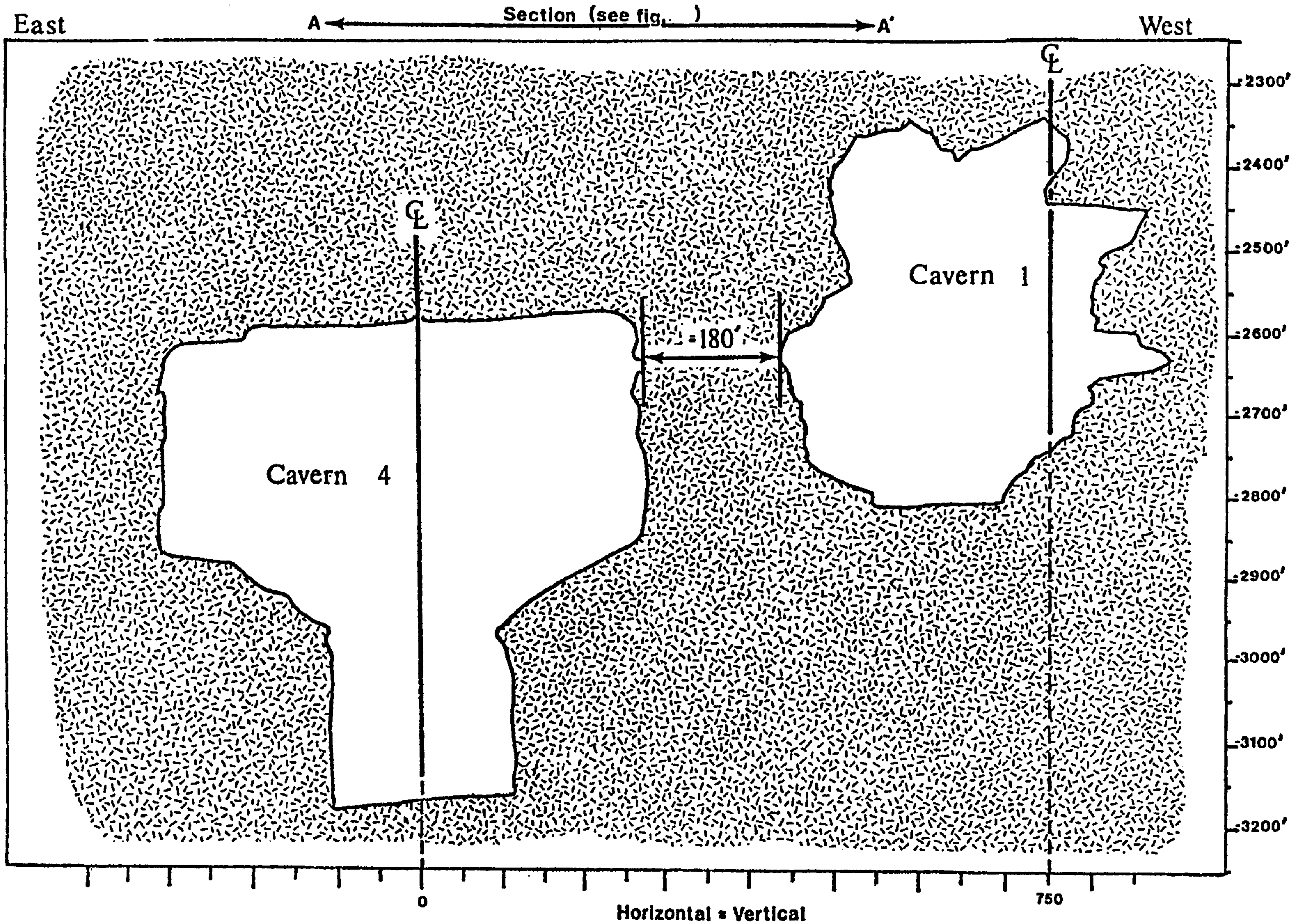


Figure H.2 Cross Sectional Representation of Caverns 1 and 4 at Bryan Mound

Table H.2 **Bryan Mound - Cones of Influence**

Potentially Impacted Land	Cavern Number	Maximum Cavity Diameter*	Depth to Caprock*	Cone of Influence Angle	Maximum-Minimum Cone Diameter *	Acres in the Cone of Influence
4	1	300	680	40°	1,441	37
				15°	664	8
4	2	600	680	40°	1,741	55
				15°	964	17
4	4	575	680	40°	1,716	53
				15°	939	16
4	5iU	400	680	40°	1,541	43
				15°	764	11

1 - Dry Land
2 - Swamp/Marsh
3 - Flowing Water
4 - Contained Reservoirs
 and Brine Ponds

*Dimensions expressed in feet

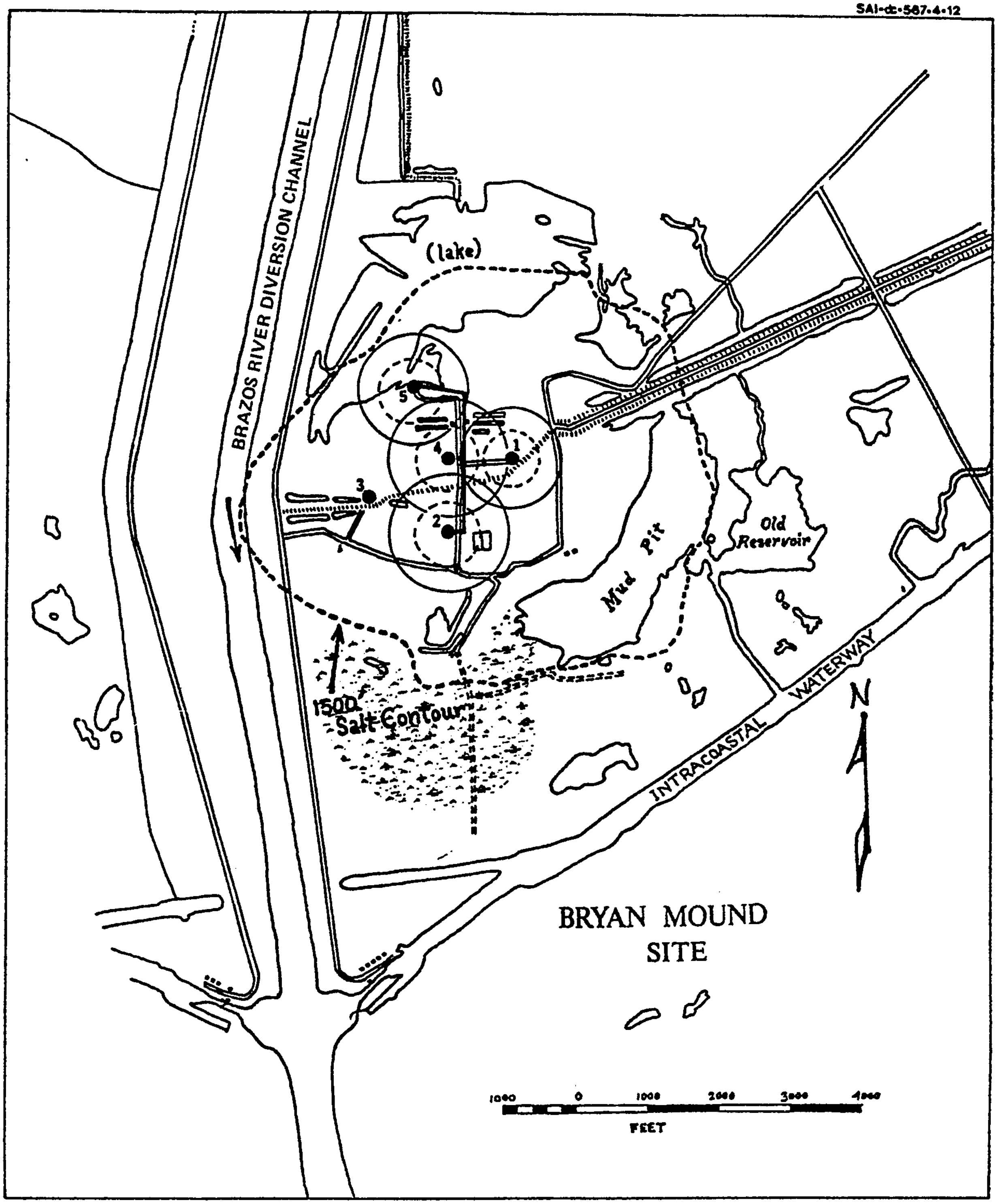


Figure H.3 Site Map of Bryan Mound with the Surface Outline of the Expected Cones of Influence.

displacement water would have to become saturated is not known. Nevertheless, to have some idea of what the maximum possible cavern growth would be, diameters after each cycle were calculated for each cavern (see Table H.3).* The assumptions made were that the caverns were cylinders, and that the displacement water became saturated.

The maximum and minimum thickness of the combined brittle and plastic zone for the roof and wall were calculated using formulas (1) and (2), and the range of values for the octahedral yield point reported in the literature[1] (τ_o = 700 psi to τ_o = 4,000 psi).

$$\delta_w = \frac{a}{2}\left[e^{\left(\frac{\Delta p}{\sqrt{6}\,\tau_o} - \frac{1}{2}\right)} - 1\right] \qquad (1)$$

where δ_w = thickness of plastic zone of the cavern wall

$\frac{a}{2}$ = radius of the cavern

Δp = pressure difference (between lithostatic pressure and minimum oil storage pressure)

τ_o = octahedral yield point**

*It was assumed that the roof and floor were not leached because the roof is protected by an oil blanket and the floor is protected by insoluable residues that settle to the bottom during cavern formation.

**The octahedral yield point, is the magnitude of the shearing stress associated with the octahedral plane when yielding occurs. The octahedral plane is inclined so as to form an equal angle between the principal stress axes at a point in a stress body. The octahedral yield point can only be determined by laboratory analysis of the compressive strength of salt taken from each specific site.

Table H.3 Bryan Mound - Diameter After Each Cycle

Cavern Number	Cavern Diameter (feet)	Cavern Height (feet)	Diameter After Each Cycle* (feet)				
			1	2	3	4	5
1	300	437	320	343	366	391	418
2	600	214	641	685	733	783	837
4	575	589	614	657	702	751	802
5 U	400	557	427	457	488	522	558
5 L	600	600	641	685	733	783	837

U - Upper Cavern
L - Lower Cavern

*In theory the dissolution at any wall is equal to half the difference between diameter of the cavern after each cycle and the original cavern diameter.

$$\delta_r = \frac{a}{2}\left[e^{\left(\frac{\Delta p}{3\sqrt{2}\tau_o} - \frac{1}{3}\right)} - 1 \right] \qquad (2)$$

where δ_r = combined thickness of brittle zone and plastic zone at the roof of the cavern

a = diameter of the cavern

Δp = difference between the lithostatic pressure and the minimum oil storage pressure

τ_o = octahedral yield point

The pressure difference Δp can be calculated according to the relation

$$\Delta p = (\rho_r - \rho_o)(d_s + t)\, g \qquad (3)$$

ρ_r = average density of all solid material above the cavern

ρ_o = density of oil

d_s = depth to salt

t = thickness of salt roof

g = acceleration due to gravity

These formulas are based on plasticity theory and have been used successfully to size the critical dimensions of a system of storage cavities in salt.[1,3] The roof of salt over the cavity was designed so as not to be less than δ_w, and the horizontal distance between cavern centers was not to be less than $2\,\delta_r$.

Figure H.4 illustrates a cylindrical cavern in vertical cross-section with the thickness of the brittle and plastic rock salt. In many cases, the computed thickness is observed to be a negative number. This occurs when the upper range

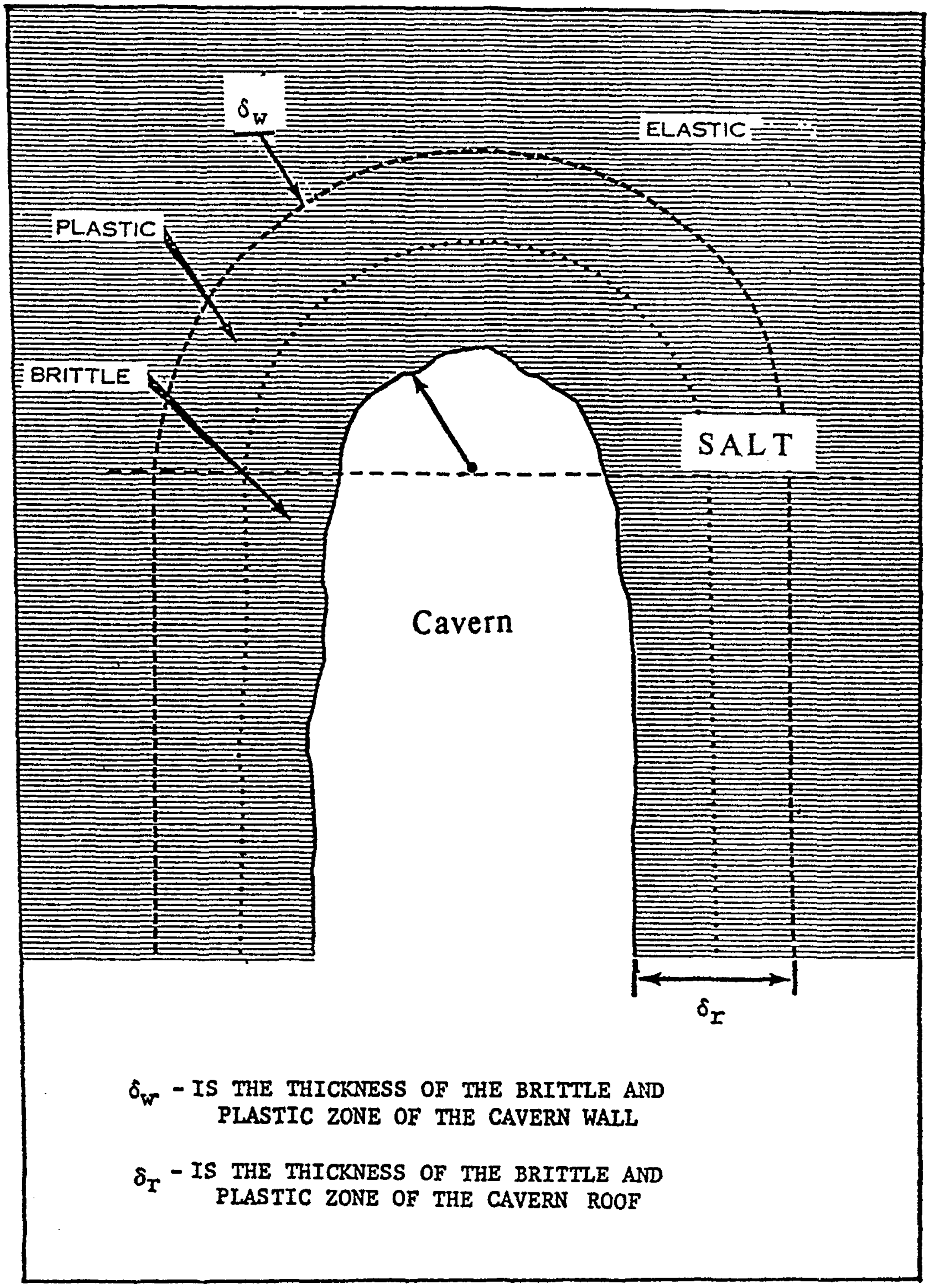


Figure H.4 Vertical Cross-Section of a Cylindrical Cavern With a Hemispherical Roof Illustrating the Thicknesses of the Brittle and Plastic Zones of the Walls and Roof of the yield point is used for a particular cavern. Such a result indicates that for a high compressive strength there is no brittle or plastic zone; all of the salt surrounding the cavern is elastic. This, however, is unlikely and emphasizes the limitation of using ranges of data based on salt tests from other domes. The octahedral yield point of salt varies from dome to dome, and the actual value of this parameter is unknown at the caverns under consideration.

To obtain a closer approximation of the true value of for the roof and walls of each cavern, equations (1) and (2) were solved were solved for τ_o when the thickness of the combined brittle and plastic zone was assumed to be zero. The true value of τ_o then would be slightly greater than the result of this calculation.

Because of the form of equations (1) and (2), it is somewhat difficult to visualize the manner in which the computed thickness of the brittle and plastic zones varies with depth and with octahedral yield point. For the case of the cavern roof, based on equation (2), Figure H.5 provides a series of plots of the dimensionless ration $2\delta_r/a$ (representing the computed thickness divided by the cavern radius) as a function of the roof depth, for values of τ_o varying from 100 psi to 4,000 psi. As indicated in Figure H.5, negative values of the roof thickness radius ratio are predicted for all the values of τ_o. With increasing depth, the ratio increases relatively slowly, but at some point becomes positive. The larger the value of τ_o, the greater the depth at which this crossover point occurs. For example, for a τ_o of 100 psi at the roof, the crossover point occurs at a depth of approximately 310 feet, while for a τ_o of 3,000 psi, the corresponding depth is roughly 8,900 feet. With increasing depth beyond the crossover point, the computed thickness continues to increase in an exponential fashion. Notice should be taken that the shapes of the curves presented in Figure H.5 (including the location of the crossover points) are independent of the cavern radius. The computed thickness itself is, however, directly proportional to the radius.

Similar plots of cavern wall thickness as a function of depth and octahedral yield point are provided in Figure H.6, based on equation (1). The general characteristics of the curves, as expected, closely resemble those given in Figure H.5. The computed thickness of the brittle and plastic zones for a cavern wall is, however, greater than the corresponding thickness for a cavern roof for the same depth and same value of τ_o.

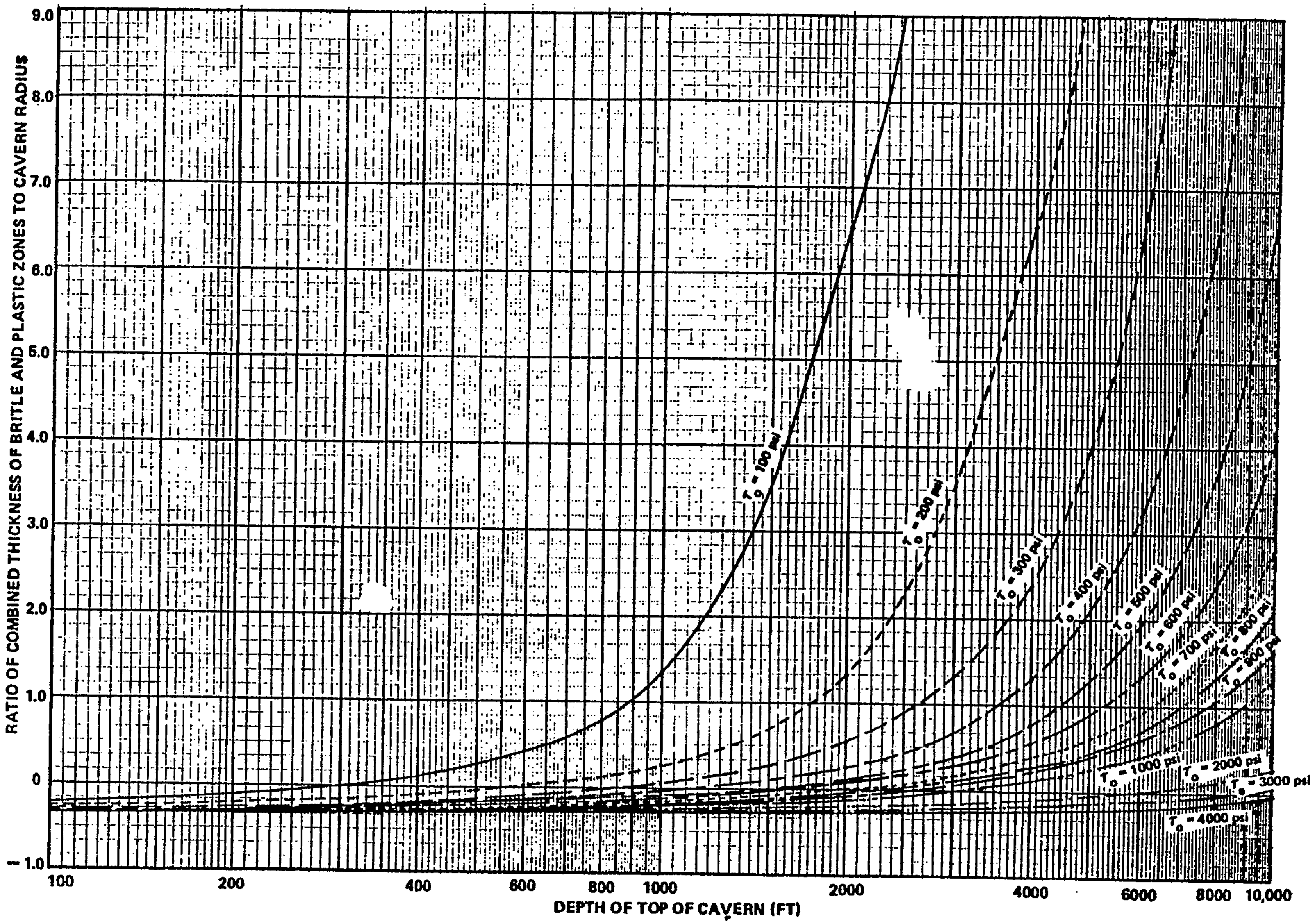


Figure H.5 **VARIATION OF COMPUTED THICKNESS OF BRITTLE AND PLASTIC ZONES FOR CAVERN ROOF**

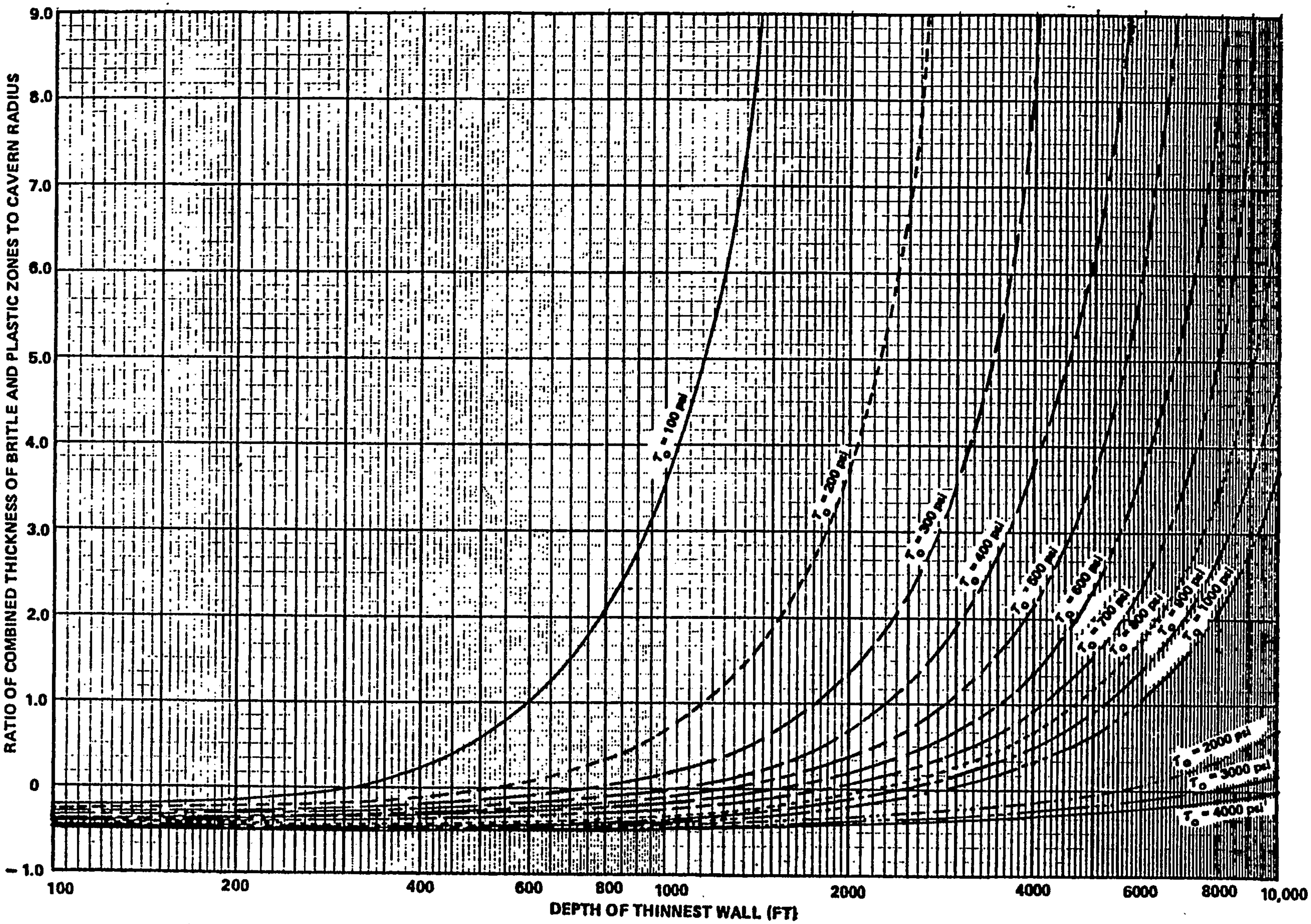


Figure H.6 **VARIATION OF COMPUTED THICKNESS OF BRITTLE AND PLASTIC ZONES FOR CAVERN WALL**

The thickness of the zone of plasticity has been calculated for the roofs of all four caverns at Bryan Mound (Table H.4). These thicknesses were calculated using formula (2). The thickness of the zone of plasticity has also been calculated for the walls of caverns 1 and 4 (Table H.5). The calculations for the cavern walls were made using formula (1).

Two octahedral yield points for salt were used: τ_o = 700 psi and τ_o = 4,000 psi. The roof thicknesses indicate that at τ_o 700 psi, 5 to 29 feet of salt are required to contain the plastic and brittle zones in the roof of these caverns. The -24.9 values indicate that at, τ_o = 700 psi and at a given cavern depth and diameter, this value of the octahedral yield point of the salt exceeded the true value and therefore, a brittle and plastic zone does not exist. These negative numbers are unrealistic because they imply a negative thickness to the plastic and brittle zone.

Using τ_o = 700 psi, the thickness of the zone of plasticity of the wall of cavern 1 is 49.9 feet and for the wall of cavern 4 is 95.9 feet. Combined, the two zones account for 145 feet of the 180 feet of salt between the caverns. This means that there is at least 35 feet of elastic salt in the caverns now. After five cycles, the two caverns will have coalesced by dissolution of salt or sooner if slabbing occurs.

To reiterate, the calculations of diameter increase per cycle are based on the assumption that the displacement water will become saturated before being removed, and that the caverns are cylinders.

Table H.4 Bryan Mound.- Combined Thickness of Plastic and Brittle Zone in the Cavern Roof

(Expressed in feet)

Cavern Number	Maximum Cavern Radius	Depth of Cavern Roof	Depth to Salt	Thickness of Roof Salt	Plastic Zone Thickness for Values of: τ_o = 700 psi	τ_o = 4000 psi	Values of τ_o With Zero Thickness of Plastic Zone
1	150	2,425	1,160	1,265	11.7	-34.6	857 psi
2	300	1,465	1,160	305	-24.9	-75.6	517 psi
4	288	2,551	1,160	1,391	29.1	-65.5	901 psi
5 Upper	200	2,140	1,160	980	5.5	-47.4	756 psi
5 Lower	300	2,750	2,700*	50	41.5	-66.9	---

* Bottom of Upper Cavern

Table H-5 Bryan Mound - Combined Thickness of Plastic and Brittle Zone in the Cavern Wall

(Expressed in feet)

Cavern Number	Maximum Cavern Radius	Depth of Thinnest Wall	Actual Thickness Between Caverns	Plastic Zone Thickness for Values of: τ_0 = 700 psi		τ_0 = 4000 psi		Values of τ_0 With Zero Thickness of Plastic Zone
1	150	2,700	180	49.9	145.8	-45.6	null	1,102 psi
4	288	2,700		95.9		-87.5		1,102 psi

REFERENCES

APPENDIX H

[1]S. Serata and E. F. Gloyna, "Principles of Structural Stability of Underground Salt Cavities," Journal Geophysical Resources, 65, pp. 2979-2987, 1960.

[2]G. E. Korbin, "Simple Procedure for the Analysis of Deep Tunnels in Problematic Ground, 17th U.S. Symposium on Rock Mechanics," Snowbird, Utah, Utah Engineering Station, p. 1, A3-1, 7, 1976.

[3]H. Albrecht and M. Langer, "The Geological Behavior of Rock Salt and Related Stability Problems of Storage Caverns, Advances in Rock Mechanics, Proceedings of the Third Congress of the International Society for Rock Mechanics, Volume II, Part B, National Academy of Science, pp. 967-974, 1974.

APPENDIX I

DISCUSSION OF SUBSIDENCE

The collapse of a storage cavern in salt is not analogous to debris falling into an empty hole and causing a "sinkhole" at the surface. These caverns are always full of a nearly incompressible fluid, brine, or oil which, if a collapse occurs, is displaced volume for volume by falling caprock and overlying sediments.

There appear to be three possible types of surface subsidence associated with caverns in salt or the collapse of such caverns: subsidence due to creep closure of a cavern; subsidence due to surface emergence of oil; and subsidence due to absorption of oil into existing pore space. Only if the stored fluid reaches the surface or moves into voids or pores can there be surface subsidence during collapse.

Creep closure is the tendency of the salt surrounding a cavern to flow in toward the cavern causing a reduction in volume of the cavern. The caprock and sediments overlying a cavern with active closure will also tend to subside, but the rate of subsidence and ground surface manifestation will depend on the cavern depth and the elasticity of the salt and overlying sediments. The subsidence that might occur would probably be very broad (geographically) and shallow (nearly imperceptible without using surveying techniques).

Subsidence with surface emergence of oil can be envisioned by the following analogy. (This analogy is used to illustrate a point and it is not suggested in this report to be a real possibility). If the entire column of sediment, above the cavern has a diameter equal to the diameter of a cylindrical cavern and a height equal to the depth of the cavern roof, and it is lowered into the cavern by a distance equal to height of the cavern in a manner analogous to a piston in a cylinder, and if the fluid in the cavern was completely displaced by percolating through the sediments of the "piston" rather than compressed, there would be a surface depression equal in volume to the original cavern filled but not overflowing with the displaced fluid. This is a simplified case which assumes that, the imperfect packing of falling particles, adsorption, absorption, dissolution, and trapping of the displaced fluid do not occur. In reality, these five mechanisms reduce the amount of oil that will continue to rise through a cone of influence (see Appendix H) and emerge on the surface. With these mechanisms, oil will probably reach the surface as small seeps, and as the sediment settles into the place formerly occupied by the oil, a small surface depression will form. Multiple depressions will appear as a wide area of shallow subsidence filled with oil.

The third type of subsidence occurs without surface emergence of oil. Using the piston and cylinder model again with the assumption that the oil percolates up through water saturated sediments that have zero empty pore space, there is a volume for volume displacement of oil and by the laws of conservation of mass, the combined volume of the oil and saturated sediments remains constant. Now envision an overlying layer of unsaturated sediment with unit volume and empty pore space. If the oil moves up from the saturated layer into the empty pores of the unsaturated layer, there would be a volume decrease in the saturated layer, but the volume of the unsaturated layer would remain constant as long as the oil only fills empty space. The result of "deflating" the saturated layer would be subsidence of the upper layer which now contains oil in the previously empty pore space. Oil would not emerge on the surface unless all of the pore space near a potential seep was filled with oil.

The rate at which collapse and subsidence proceeds has not been quantified, but estimates range from 36 hours to 36 days. Since the viscosity of oil is much greater than brine, the collapse will proceed slower when the cavity contains oil, a surface depression is less likely to form, and a depression caused by collapse of an oil-filled cavern probably will be smaller than a surface dispersion of a brine-filled cavern collapse. There are two reasons for this: (1) a smaller volume of oil will be injected into caprock voids and almost none into aquifers leaving less room for subsidence, and (2) less oil will reach the surface because oil will be trapped more easily than brine.

APPENDIX J

LETTERS FROM RESPONDENTS

The following pages contain copies of the letters that were received from agencies and other interested parties who responded to the request for comments on the Draft Environmental Impact Statement.

Advisory Council on
Historic Preservation
1522 K Street N.W.
Washington, D.C. 20005

October 1, 1976

Mr. Robert L. Davies
Deputy Assistant Administrator
Strategic Petroleum Reserve
Federal Energy Administration
Washington, D. C. 20461

Dear Mr. Davies:

This is in response to your request of September 10, 1976 for comments on the draft environmental statement for the proposed storage of crude oil at the Bryan Mound Salt Dome located in Brazoria County, Texas. Pursuant to its responsibilities under Section 102(2)(C) of the National Environmental Policy Act of 1969, the Advisory Council on Historic Preservation has determined that while you have discussed the historical, architectural, and archeological aspects related to the undertaking, the Advisory Council needs additional information to adequately evaluate the effects on these cultural resources. Please furnish additional data indicating:

I. Compliance with Section 106 of the National Historic Preservation Act of 1966 (16 U.S.C. 470[f]). The Council must have evidence that the most recent listing of the National Register of Historic Places has been consulted (see Federal Register, February 10, 1976 and monthly supplements each first Tuesday thereafter) and that either of the following conditions is satisfied.

A. If no National Register property is affected by the project, a section detailing this determination must appear in the environmental statement.

B. If a National Register property, or property "eligible for inclusion" in the National Register (Section 106 as amended September 28, 1976, PL 94-422) is affected by the project, the environmental statement must contain an account of steps taken in compliance with Section 106 and a comprehensive discussion of the contemplated effects on the National Register property. (36 C.F.R. Part 800 details compliance procedures.)

 Filed [illegible]

II. Compliance with Executive Order 11593, "Protection and Enhancement of the Cultural Environment" of May 13, 1971.

A. Under Section 2(a) of the Executive Order, Federal agencies are required to locate, inventory and nominate eligible historic, architectural and archeological properties under their control or jurisdiction to the National Register of Historic Places. The results of this survey should be included in the environmental statement as evidence of compliance with Section 2(a).

B. Until the inventory required by Section 2(a) is complete, Federal agencies are required by Section 2(b) of the Order to submit proposals for the transfer, sale, demolition, or substantial alteration of federally owned properties eligible for inclusion in the National Register to the Council for review and comment. Federal agencies must continue to comply with Section 2(b) review requirements even after the initial inventory is complete, when they obtain jurisdiction or control over additional properties which are eligible for inclusion in the National Register or when properties under their jurisdiction or control are found to be eligible for inclusion in the National Register subsequent to the initial inventory.

The environmental statement should contain a determination as to whether or not the proposed undertaking will result in the transfer, sale, demolition or substantial alteration of eligible National Register properties under Federal jurisdiction. If such is the case, the nature of the effect should be clearly indicated as well as an account of the steps taken in compliance with Section 2(b). (36 C.F.R. Part 800 details compliance procedures.)

C. Under Section 1(3), Federal agencies are required to establish procedures regarding the preservation and enhancement of non-federally owned historic, architectural and archeological properties in the execution of their plans and programs.

The environmental statement should contain a determination as to whether or not the proposed undertaking will contribute to the preservation and enhancement of non-federally owned districts, sites, buildings, structures and objects of historical, architectural or archeological significance.

III. Contact with the State Historic Preservation Officer.

The procedures for compliance with Section 106 of the National Historic Preservation Act of 1966 and the Executive Order 11593 require the Federal agency to consult with the appropriate State Historic Preservation Officer. The State Historic Preservation Officer for Texas is Truett Latimer, Executive Director, Texas Historical Commission, P. O. Box 12276, Capitol Station, Austin, Texas 78711.

Should you have any questions or require any additional assistance, please contact Michael H. Bureman of the Advisory Council staff at P. O. Box 25085, Denver, Colorado 80225, telephone number (303) 234-4946.

Sincerely yours,

Louis S. Wall
Assistant Director, Office
of Review and Compliance

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT. CORPS OF ENGINEERS
P. O. BOX 60267
NEW ORLEANS, LOUISIANA 70160

IN REPLY REFER TO
LMNPD-RE

10 November 1976

Mr. Steven E. Ferguson
Executive Communications
Room 3309
Federal Energy Administration
Washington, DC 20461

Dear Mr. Ferguson:

Your draft environmental impact statements (EIS) for the first five candidate sites selected for possible use as petroleum storage facilities for the initial phase of the Strategic Petroleum Reserve (SPR) were referred to this office from our Washington Office for comment.

We have reviewed the EIS's for the following candidate sites: West Hackberry salt dome, Bayou Choctaw salt dome, Cote Blanche Island mine, Weeks Island mine, and Bryan Mound salt dome. They have been reviewed in accordance with our areas of responsibility and expertise as outlined in the Council on Environmental Quality guidelines, Title 40 C.F.R., part 1500, published in the Federal Register dated 1 August 1973, and US Army Corps of Engineers administrative procedures for permit activities in navigable waters or ocean waters, Title 33, C.F.R., Part 209, published in the Federal Register dated 25 July 1975.

We offer the following comments regarding the five draft impact statements for your consideration:

a. Comments on West Hackberry site.

(1) General comments.

(a) The West Hackberry site has significant potential for adverse impacts upon the water quality of the adjacent area. The assumption that the naturally occurring sediments in the area of Black Lake are predominantly sand, may be in error. Available soil curves for the material removed during dredging activities in the Calcasieu River at this point indicate a high amount of silt. This could greatly increase the amount of heavy metals, nutrients, and pesticides released to the water column over that as assumed in the EIS. The establishment of soil characteristics (soil curves) and elutriate analyses should be made to quantify the impacts upon the water column. The effluent from any unconfined disposal or open water disposal of dredged material could have a significant impact upon Calcasieu Lake. The minimal release of mercury mentioned (15 ug/l) is significantly above the criteria limit of 0.1 ug/l as established by the 1975 EPA, Proposed Criteria for Water Quality-Marine Water Constituents (Aquatic Life). This site is the least acceptable alternative as far as the impacts upon the water quality in the project area are concerned.

(b) Some areas lack site-specific information which is required to adequately assess the probable impacts. Emphasis is placed too heavily on data taken from areas removed from the project area.

(2) Specific comments.

(a) Page 1-6, paragraph 2. Sabine National Migratory Waterfowl Refuge should be Sabine National Wildlife Refuge.

(b) Page 1-26, paragraph 2. This statement excludes the push-ditch method of pipeline installation which is normally preferred for installation of pipelines in marsh areas of coastal Louisiana. Experience has shown that this method greatly reduces potential environmental damage and it has been proven feasible for lines in excess of 40 inches in diameter.

(c) Page 2-15. Aerial photograph is erroneously labeled. The area labeled "flooded marsh" has not been a marsh for many years; and, "road platform to oil wells" is not a road but is a walkway.

(d) Page 2-26, paragraph 1. Black Lake is part of a contributing productive marsh system and specific water quality and sediment data are required to fully assess and evaluate the impacts.

(e) Page 2-63, table 2.8. We recommend inclusion of Delphinids under "Typical Mammals" and "Inland and Estuarine Waters."

(f) Page 2-72, paragraph 1. Primary productivity, as well as salinity is certainly a controlling factor in the number of species present.

(g) Page 2-72, paragraph 2, line 13. Does this statement imply that the genus is present and/or dominant in the project area?

(h) Page 2-72, paragraph 2, line 17. Some of these genera are not "epiphytic" algae.

(i) Page 2-72, paragraph 4. Site-specific information is necessary. Black Lake cannot be accurately compared to Calcasieu Lake.

(j) Page 2-73, paragraph 1. Further explanation is needed concerning recent salinity increases in the project area, especially the impacts of the Intracoastal Waterway and Calcasieu River upon salinity alterations.

(k) Page 2-76, last paragraph. In 1975 and 1976, the American alligator was harvested for its hide in parts of Cameron, Calcasieu, and Vermilion Parishes.

(l) Page 2-80, paragraph 2. We suggest the word "Atlantic" be placed before "Croaker."

(m) Page 3-3, paragraphs 2 and 3. There will be significant turbidity and bottom erosion due to the turbulence. Reference 4 is not based on sound data from properly conducted studies.

(n) Page 3-10, paragraph 4. Figure 3.4 has been omitted. The location of dredged material disposal areas will be determined by the Corps permit application process. Note General Comment e(2) below, also.

(o) Page 3-19, paragraph 3. A description of the disposal operation is necessary before the impacts can be adequately assessed.

(p) Page 3-29, last paragraph. Water quality data for the Calcasieu River is available from the New Orleans District Office.

(q) Page 3-66, paragraph 4. Construction of roads in wetlands usually constitutes a permanent loss of wetlands and should not be considered a "short-term" impact.

(r) Page 3-68, paragraph 3. Further discussion is needed to explain phytoplankton productivity increases resulting from turbidity. We believe there will be decreases in productivity.

(s) Page 3-112, paragraph 2. Reduction of food supply and habitat description will definitely be of importance.

(t) Page 4-5, paragraph 2. Direct contact of the less mobile benthic organisms with oil is likely, and not unlikely as stated in the EIS.

(u) Page 4-9. Shared uses of disposal areas may not always be permissible. Note General Comment e(2) below, also.

(v) Page 6-1, paragraph 6. In wetlands, natural grasses are usually allowed to revegetate pipeline corridors; hence, installation would not represent a permanent loss of resources. The total of 350 acres of land appears to be excessive for pipeline right-of-way.

(w) Page 6-2, paragraph 2. The withdrawal of surface water may be very significant depending upon the volume of runoff and the time of the year the surface water is withdrawn.

(x) Page 9-3. State of Louisiana regulatory bodies were omitted from this table.

b. Comments on Bayou Choctaw site.

(1) General comment

As stated for the West Hackberry site, the comment on the push-ditch method of pipeline installation applies to this site also.

(2) Specific comments.

(a) Page 2-4, figure 2-2. The area labeled "marsh" should be changed to "swamp" to conform to the description on page 2-3, paragraph 3, which is correct.

(b) Page 2-15, paragraph 1, sentence 2. We disagree with this statement. The first sentence on page 1-23 indicates that about 1,150 acres of wooded swamp would be utilized for the brine disposal system. The wildlife resources of 1,150 acres of wooded swamp are not considered insignificant.

(c) Page 2-73, paragraph 1. The loblolly pine is generally absent from the Mississippi River flood plain and should be deleted from this paragraph.

(d) Page 2-76, paragraph 2. The American alligator is not a commercially valuable wildlife species in the project area and should therefore be deleted from this section.

(e) Page 2-104, paragraph 1. The American alligator also occurs in the swamp of the project area.

(f) Page 3-5, paragraph 7. Change "marshlands" to "swamp."

(g) Page 7-44, paragraphs 2 and 3. Reasons should be given as to why the proposed source of displacement water is a better source than the alternative of Mississippi River withdrawal.

c. Comments on Cote Blanche Island mine and Weeks Island mine sites.

(1) General Comments.

(a) The EIS's for both these sites are almost identical except for site description and page numbering. Comments here are applicable to both sites; however, for reference purposes, the page numbers used are those in the Cote Blanche mine EIS.

(b) Site-specific information on the flora and fauna on these two islands is lacking. Data cited in most cases are from studies which did not include sampling in the project area. Deletion of non-site-specific data and inclusion of data from on-site investigations would substantially improve the statements.

(c) Due to the limited area that would be affected, the Cote Blanche and the Weeks Island sites would be the most environmentally acceptable, as far as the impacts upon the water quality are concerned. The lack of pipeline canals and associated construction activities for these two alternatives appears to impact wetlands the least. The water quality data in EIS's for these two sites are deficient. Additional water quality data is required to more readily quantify the impacts in order to choose the most acceptable alternative site.

(d) Note General Comments d(4) and d(5) below.

(2) Specific comments.

(a) Page 3.1-1, paragraph 3, sentence 3. This sentence should be revised as follows: "The bays are generally shallow and are rimmed by brackish, intermediate, and fresh marshes to the north and by predominantly brackish marsh to the south."

(b) Page 3.1-1, paragraph 3, sentence 5. The only island which provides protection to the Atchafalaya Bay-Vermilion Bay complex is Marsh Island. Several oyster reefs between Marsh Island and Pointe Au Fer to the east could also provide similar protection. Gulf Coast Barrier Islands usually refer to such islands as the Timbalier Chain, Isles Dernieres, and Chandeleurs.

(c) Pages 3.4-15 through 3.4-26. Data presented in tables 3.4-1 through 3.4-12 were obtained from study areas which are located 60 and 90 miles from the project area. The utility of these data with regards to the project area is questionable. Site-specific data should be used.

(d) Page 3.4-31. Comment (c) above applies here also.

(e) Page 3.6-13, paragraph 1, sentence 1. The blue goose is the dark color phase of the lesser snow goose. This sentence should be revised as follows: "Snow geese are also...."

(f) Page 3.6-13, paragraph 1, sentence 5. The reddish egret is uncommon to rare in the project area.

(g) Page 3.6-19, paragraph 5. Change "blue goose" to "lesser snow goose."

(h) Page 3.6-20, paragraph 1, sentence 1. The American alligator was not listed as a game species in portions of Louisiana. The discussion of the American alligator should be removed from the Game Species section and moved to the Threatened and Endangered Species section.

(i) Page 3.6-21, paragraph 2, sentence 3. Change "Vermilion to "Calcasieu."

(j) Page 3.6-22, paragraph 4. Two additional reptilian species that occur in the coastal region of Louisiana, and which are currently considered rare and endangered should be added to this section. These are the hawksbill and the leatherback turtles.

(k) Page 3.6-28, paragraph 1. The choice of studies conducted in Barataria Bay and in the Gulf of Mexico to help characterize the primary producers that could be expected to be found near these two islands is a poor one. Prevailing environmental conditions in the vicinity of the subject study areas are near marine as opposed to near freshwater conditions in Cote Blanche and Weeks Island areas.

(l) Page 3.6-28, paragraph 2, last sentence. None of the representative marsh species cited in this sentence occur in the project area.

(m) Page 3.6-40, paragraph 4. The Atlantic menhaden and the Gulf menhaden are separate species. The Gulf menhaden is the most important fish in terms of harvested weight.

(n) Page 3.6-43, sentences 1 and 2. The dollar/acre values cited are in gross error.

(o) Page 3.6-47, line 4. The American alligator is not a controlled game species.

(p) Page 3.6-58, table 3.6-6. This table should be revised to agree with Federal Register, Volume 41, No. 117, 16 June 1976, "Endangered and Threatened Species, Plants."

(q) Page 3.6-59, table 3.6-7. The hawksbill and the leatherback turtles should be added to this table, as they are known to occur in coastal Louisiana.

(r) Page 3.6-61, table 3.6-9. Data presented in this table are of no value in predicting the primary producers of the project area because the surrounding ecosystem is predominantly freshwater and the primary producers presented here are primarily marine.

(s) Page 3.6-71, table 3.6-14. Comments in (r) above apply for the same reason.

(t) Page 4.2-18, paragraph 2. The statement that the area to be excavated is similar to other Louisiana marsh systems (e.g.; Barataria Bay) is incorrect. The marshes surrounding Barataria Bay are predominantly saline as opposed to the predominantly freshwater marshes of the project area.

(u) Page 4.3-54, paragraph 2. High ambient turbidity restricts growth of submerged aquatic plants in the project area. This paragraph should be deleted.

(v) Page 8.2-28, paragraph 1. The loblolly pine is generally absent from the Mississippi River flood plain and should therefore be deleted from this paragraph.

LMNPD-RE
Mr. Steven E. Ferguson 10 November 1976

(w) Page 8.2-28, paragraph 2. The turkey is not common in the wooded swamp traversed by the pipeline routes.

(x) Page 8.2-30, paragraph 6. Comment a(2)(b) above applies here also.

(y) Page 8.2-31, paragraph 2. Experience has shown that subsidence and oxidation limit the quantity of backfill material resulting in permanent loss of marsh habitat.

d. Comments on Bryan Mound salt dome site.

(1) General comments.

(a) Pipelines proposed under this project will cross the Brazos River Diversion Channel, Jones Creek and various wetland areas. Department of the Army permits will be required for this work.

(b) The pipelines proposed will intersect the Freeport and vicinity hurricane protection project in one or more locations and may require construction within the project right-of-way in other areas. Permits for this work should be obtained from the Velasco Drainage District.

(c) The FEA 30" pipeline from the Bryan Mound site to Seaway Hank Farm will cross the Brazos River Diversion Channel right-of-way and the West Brazos River Floodgate access road. Coordination of the pipeline crossing of these facilities with us will be required.

(2) Specific comment.

Page 1-12, figure 1.6. The word "Highway" should be changed to "Roadway on Hurricane Flood Protection Levee" and the note "To Intracoastal Waterway and Gulf of Mexico" should be changed to "Road to Intracoastal Waterway Floodgates."

e. General comments.

(1) Applications for permits should be made as soon as practicable and well in advance of any need to perform the proposed work.

(2) Two factors of considerable concern are critical to continuing use of disposal areas; they are: encroachment of watercourses that provide natural circulation of surface waters and creation of vector problems. Scheduling of work may create difficult and costly disposal problems.

(3) None of the four EIS's for the proposed sites considers the impacts of surface preparation for painting during construction and operation phases. The adverse impacts on inhabitants, structures, equipment, and terrain can be significant.

(4) It is noted that (in connection with the taking of excavated material from a barge slip to a suitable disposal site in accordance with a permit) mention of two important documents has been omitted from each EIS. They are the Federal Water Pollution Control Act (FWPCA), Title 33 U.S.C. 1323 and 1344 and the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA), Title 33 U.S.C. 1413 (e). Section 404 of FWPCA provides for control of dredged material disposals in navigable waters and MPRSA provides for control of dredged material disposal and transportation of dredged material for disposal in ocean waters. Federal projects involving disposal in navigable or ocean waters or transportation for disposal in navigable or ocean waters are evaluated for permit and other regulatory actions by the Corps of Engineers and the Environmental Protection Agency under guidelines and criteria promulgated pursuant to the requirements of the FWPCA and MPRSA. The regulatory guidelines and criteria for Corps of Engineers evaluations of proposed projects are contained in Title 33 C.F.R., Part 209 which has also not been mentioned. Other laws enacted before 1972 are also directly related to the procedures for processing permit applications. These include the River and Harbor Act of 1899, the Fish and Wildlife Coordination Act of 1958, the National Environmental Policy Act of 1969, and the Coastal Zone Management Act of 1972, all of which are referenced in Title 33 C.F.R., Part 209. A statement to the effect that, "the proposed disposals and transportation for disposal of dredged materials will be performed in accordance with all applicable Federal and state acts and regulations", should be included in each EIS or Statement of Findings for each project.

(5) Notwithstanding the Louisiana State policy exempting crude oil transfer emissions from emission control regulations, prevailing high levels of hydrocarbon emissions merit greater consideration of vapor recovery rather than flaring or release. Flaring is proposed for the Cote Blanche and Weeks Island SPR with considerable attention given to an alternative of using vapor recovery technology. Release is viewed as reasonably acceptable for the Bayou Choctaw and West Hackberry SPR with bare mention made of available vapor recovery technology. Oxidation products of flaring or high levels of hydrocarbon emissions could be objectionable or hazardous to vessels and their crews moored or at work on navigable waters near transfer sites. Including consideration of admittedly excessive emissions and conservation and economic factors it would seem that application of vapor recovery technology should be given equal consideration for all SPR sites.

LMNPD-RE
Mr. Steven E. Ferguson

10 November 1976

Thank you for the opportunity to review and comment on these draft environmental impact statements.

Sincerely yours,

EARLY J. RUSH III
Colonel, CE
District Engineer

Copy furnished
Mr. Timothy Atkeson
Council on Environmental Quality

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
FIRST INTERNATIONAL BUILDING
1201 ELM STREET
DALLAS, TEXAS 75270

November 1, 1976

Mr. Robert L. Davies
Deputy Assistant Administrator
Strategic Petroleum Reserve
Federal Energy Administration - Room 3309
Washington, D. C. 20461

Dear Mr. Davies:

We have reviewed the Draft Environmental Impact Statement for Bryan Mound Salt Dome. The Bryan Mound site has been identified as a candidate site for bulk storage of 58 million barrels of crude oil for use in conjunction with implementation of the Strategic Petroleum Reserve (SPR), Title I, Part B of the Energy Policy and Conservation Act of 1975 (Public Law 94-163). The Bryan Mound site is a salt dome with existing cavities located in Brazoria County, Texas. The proposed action also includes construction of dock facilities and pipelines.

The statement discusses most of the impacts which could be associated with the project; however, we offer the following comments for your consideration in developing the final statement:

1. The proposed distribution facilities to be used in conjunction with the dome are the Seaway, Inc., docks or a new barge terminal on the Intracoastal Waterway. Another alternative which may be available in this regard is the proposed SEADOCK Deepwater Port. Although the first tankers are not anticipated to be received at SEADOCK until after the dome is initially filled, the deepwater port could be used for subsequent refills. This could affect the projected oil spill estimates because very large crude carriers (VLCC's) could be used instead of conventional tankers for crude import. The alternative of utilizing the proposed SEADOCK deepwater port as the major distribution facility for the Bryan Mound storage area should be discussed in the statement.

2. When the oil is removed from the storage cavities, some of the oil will remain on the walls of the cavities and therefore in the brine. When oil is reintroduced to the caverns the brine will carry the entrained oil with it. The EIS indicates that Dow Chemical intends to use this brine in various of its processes with ultimate disposal in the Gulf of Mexico. The statement should provide assurances that the concentration of entrained oil in this brine will be such that no adverse impacts to the water quality or biota in the area of the discharge will occur. The statement should discuss the possiblity of the need for

treatment of the brine to remove the oil as well as the ultimate disposal of any recovered oil. A quantitative discussion of evaporative hydrocarbon emissions originating from the brine storage reservoir should also be included in the statement.

3. The statement should briefly discuss the legal permitting requirements which would be associated with utilization of the alternate brine discharge site located in the Gulf of Mexico.

4. Because of past removal of sulfur from the caprock of the salt dome and possible compaction of the aquifer, the possibility of subsidence exists when construction of the four 400,000 barrel crude oil storage tanks is completed and the tanks are filled. We would suggest corings be obtained from the areas of sulfur removal to obtain compressive or load testing data in order to provide information for the design of the support pads under the tanks. Also, the EIS should briefly discuss the effects of containment dike failure and pipeline breakage due to subsidence.

5. The statement should point out that Air Quality Control Region (AQCR) 216 is presently under an interim strategy for the attainment of the National Ambient Air Quality Standard (NAAQS) for photochemical oxidants. A discussion needs to be included which will provide assurance that the facility will not adversely affect the attainment and maintenance of the NAAQS.

6. A possible mitigating measure for hydrocarbon emissions (Table 4.1) is a vapor recovery system on tankships and terminal tank connections. The system envisioned for this purpose should be thoroughly discussed.

These comments classify your Draft Environmental Impact Statement as LO-2. Generally, we have no objections to the project as proposed in the statement. We are requesting that additional information and discussion be provided concerning potential imapcts to the water and air quality of the area. The classification and the date of our comments will be published in the Federal Register in accordance with our responsibility to inform the public of our views on proposed Federal actions, under Section 309 of the Clean Air Act.

Definitions of the categories are provided on the attachment. Our procedure is to categorize our comments on both the environmental consequences of the proposed action and on the adequacy of the impact statement at the draft stage, whenever possible.

We appreciate the opportunity to review the Draft Environmental Impact Statement, and we would be happy to discuss our comments with you. Please send us two copies of the Final Environmental Impact Statement at the same time it is sent to the Council on Environmental Quality.

Sincerely yours,

John C. White
Regional Administrator

Enclosure

ENVIRONMENTAL IMPACT OF THE ACTION

LO - Lack of Objections

EPA has no objections to the proposed action as described in the draft impact statement; or suggests only minor changes in the proposed action.

ER - Environmental Reservations

EPA has reservations concerning the environmental effects of certain aspects of the proposed action. EPA believes that further study of suggested alternatives or modifications is required and has asked the originating Federal agency to re-assess these aspects.

EU - Environmentally Unsatisfactory

EPA believes that the proposed action is unsatisfactory because of its potentially harmful effect on the environment. Furthermore, the Agency believes that the potential safeguards which might be utilized may not adequately protect the environment from hazards arising from this action. The Agency recommends that alternatives to the action be analyzed further (including the possibility of no action at all).

ADEQUACY OF THE IMPACT STATEMENT

Category 1 - Adequate

The draft impact statement adequately sets forth the environmental impact of the proposed project or action as well as alternatives reasonably available to the project or action.

Category 2 - Insufficient Information

EPA believes the draft impact statement does not contain sufficient information to assess fully the environmental impact of the proposed project or action. However, from the information submitted, the Agency is able to make a preliminary determination of the impact on the environment. EPA has requested that the originator provide the information that was not included in the draft statement.

Category 3 - Inadequate

EPA believes that the draft impact statement does not adequately assess the environmental impact of the proposed project or action, or that the statement inadequately analyzes reasonably available alternatives. The Agency has requested more information and analysis concerning the potential environmental hazards and has asked that substantial revision be made to the impact statement. If a draft statement is assigned a Category 3, no rating will be made of the project or action, since a basis does not generally exist on which to make such a determination.

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

IN REPLY REFER TO:

OCT 14 1976

Executive Communications
Room 3309
Federal Energy Administration
Washington, D.C. 20461

245001

Gentlemen:

We appreciate the opportunity to comment on the five site-specific Draft Environmental Impact Statements for the proposed Strategic Petroleum Reserve (SPR) mandated by Congress under the Energy Policy and Conservation Act of 1975 (P.L. 94-163). We note that this act requires that by 1983 the SPR contain a reserve of approximately 500 million barrels of crude oil to provide protection from potential disruptions to the national supply of petroleum products.

The Federal Power Commission, Bureau of Natural Gas staff has reviewed the SPR impact statements and offers the following comments:

> At the five site locations analyzed, there does not appear to be any conflict between the development of the SPR and the continued production, transportation, and sale of natural gas from domestic sources. It therefore does not appear that the proposed project presents any conflict with FPC jurisdictional interests.
>
> The staff believes that the development of an SPR would protect the supply of energy sources other than oil itself during an emergency. A drastic reduction in oil availability could, for example, be accompanied by increased demand for natural gas for use in electric generation. Such use is regarded as inferior and as having a low priority in view of the needs of industrial, commercial, and residential customers who are feeling the impact of a worsening natural gas shortage. The SPR would lessen the impact of a simultaneous shortage in oil and gas which together provide about three-quarters of the energy consumed in this country.

The Federal Power Commission is actively directing its attention and efforts toward regulatory actions to improve the current imbalance between natural gas supply and demand. After reviewing the SPR site-specific draft environmental impact statements, we believe that the proposed project would be in the national interest.

S. William Yost, Chief
Bureau of Natural Gas

U.S. DEPARTMENT OF LABOR
EMPLOYMENT AND TRAINING ADMINISTRATION
WASHINGTON, D.C. 20213

1976

Strategic Petroleum Reserve Office
Federal Energy Administration
Washington, D.C. 20461

Gentlemen:

This is in response to your recent letter requesting that we review the Draft Environmental Statement (DES) for Bryan Mound Salt Dome. We have reviewed the statement and have no comments.

Sincerely,

WILLIAM B. HEWITT
Administrator
Policy, Evaluation and Research

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

NOV 4 1976

Executive Communications
Room 3309
Federal Energy Administration
Washington, D. C. 20461

00001

Dear Sirs:

This is in response to your letter of September 10, 1976, inviting our comments on the draft environmental statements concerning the following projects:

West Hackberry Salt Dome, DES 76-4
Bayou Choctaw Salt Dome, DES 76-5
Bryan Mound Salt Dome, DES 76-6
Cote Blanche Mine, DES 76-7
Weeks Island Mine, DES 76-8

We have reviewed the statements and have determined that the proposed actions, per se, have neither radiological health and safety aspects nor will they adversely affect any activities subject to regulation by the Nuclear Regulatory Commission. Accordingly, we have no comments to offer.

Thank you for providing us with the opportunity to review these draft environmental impact statements.

Sincerely,

Voss A. Moore, Assistant Director
for Environmental Projects
Division of Site Safety and
Environmental Analysis

TENNESSEE VALLEY AUTHORITY
CHATTANOOGA, TENNESSEE 37401

October 28, 1976

Mr. Robert L. Davies
Deputy Assistant Administrator
Federal Energy Administration
Room 3309, Executive Communications
Washington, D.C. 20461

Dear Mr. Davies:

We have determined that we have no significant substantive comments on any of the five sites or statements involved in the Strategic Petroleum Reserve.

Sincerely,

Peter A. Krenkel, Ph.D., P.E.
Director of Environmental Planning

THE DEPARTMENT OF THE TREASURY
WASHINGTON, D.C. 20220

ASSISTANT SECRETARY

NOV 1 1976

Dear Mr. Davies:

This is in response to your letter of September 16 requesting that this Department review and comment on the draft environmental impact statements for the first five candidate sites selected for possible use as petroleum storage facilities for the Early Storage Reserve. We find the statements to be objectively directed to their stated purpose and it appears that the salt dome and mine storage facilities addressed in the statements are superior to above ground storage from both the economic and environmental viewpoints.

The Department supports the concept of a strategic petroleum stockpile and considers it to be an essential national need. However, we wish to reiterate that such facilities and the petroleum stored therein should be owned by the Government and that the costs should be borne directly by the beneficiaries -- the U.S. energy consumers.

One other comment applicable to the five statements concerns the implication that among the benefits or costs of each project is the employment effects, positive in the case of employing construction workers to build storage facilities and negative in the case of "laying-off" salt mine workers. Conventional cost-benefit analysis deals with a national rather than a regional perspective and assumes a full employment economy. Under such assumptions employment effects are considered neither costs nor benefits since one more job in any region implies one less job elsewhere.

Similarly the "cost" of laying-off salt mine workers is not a cost at all if alternative employment opportunities exist. Some social costs of lay-offs, such as unemployment compensation paid during the time workers are between jobs, might be expected, but these costs relative to the "normal" job turnover costs for the region involved can be expected to be miniscule and probably need not be considered in the analyses.

Thank you for the opportunity to review the statements and I trust that our comments will be of assistance in the preparation of the final environmental impact statements.

Sincerely,

Warren F. Brecht
Assistant Secretary (Administration)

Mr. Robert L. Davies
Deputy Assistant Administrator for
Strategic Petroleum Reserves
Federal Energy Administration
1726 M Street, N.W.
Washington, D.C. 20461

OFFICE OF THE GOVERNOR

DOLPH BRISCOE
GOVERNOR

November 8, 1976

Mr. Robert L. Davies
Deputy Assistant Administrator
Strategic Petroleum Reserve
Federal Energy Administration
Washington, D. C. 20461

Dear Mr. Davies:

The Draft Environmental Impact Statement for the Bryan's Mound Salt Dome (DES 76-6) has been reviewed by this Office and interested State agencies.

The comments of the review participants are enclosed and should be considered in their entirety. The following is a brief summary of these comments:

1. The Texas Water Development Board indicated concern with deep well injection as a possible brine disposal alternative and suggested additional consideration be given to potential impacts on groundwater resources.

2. The Texas Water Rights Commission supported the adoption of monitoring and surveillance measures and the instituting of on-going Federal/State Industry coordination for operations at the site.

3. The Texas Department of Agriculture recommended further evaluation of the adverse impact the use of this site would have on rice production. Also, according to this agency, the relationship between the use of this site for petroleum storage and the protection of adjacent wetlands warrants further analysis.

4. The Texas Industrial Commission noted that similar sites have been used for storing crude oil since the late 1940's with only a few problems.

EXECUTIVE OFFICE BUILDING • 411 WEST 13TH STREET • AUSTIN, TEXAS 78701

5. The Texas Parks and Wildlife Department expressed concern about impacts on adjacent areas which contain endangered fauna and are biologically sensitive. Because State recreational facilities are also located nearby, the Parks and Wildlife Department recommended additional analysis of possible noise, odor, and other impacts on these areas.

The enclosed comments are submitted to assist in your planning efforts. Thank you for the opportunity to review this document.

Sincerely,

Charles D. Travis, Director
Budget and Planning Office

Enclosures

ε Department of Agriculture
ε of the Commissioner

Austin, Texas 7871ˇ
Phone (512) 475-332

MEMO

Draft Environmental Impact Statement: Bryan Mound Salt Dome DES [illegible]
76-6 (Strategic Petroleum Reserve)

Item #1 This DEIS notes that the site is in the midst of a major rice producing area in the country. It does not address the adverse impact the use of this site would have on rice production. This item is too important to be left unevaluated.

Item #6 This proposed site is in or very close to the coastal wetlands and special programs have been established to protect those wetlands. The relationship between this proposed usage and the protection of the wetlands should be analyzed and reported.

Ed Nichols, Assistant Commissioner

A CY REVIEW TRANSMITTAL SHEET

TO: The Honorable John C. White, Texas Department of Agriculture

Date: Sent: 10/06/76

Date: Due: As Soon as Possible

Refer: EIS: 6-010-003

FROM: Charles D. Travis, Director, Budget and Planning Office

SUBJECT: DRAFT ENVIRONMENTAL IMPACT STATEMENT: BRYAN MOUND SALT DOME-DES 76-6 (STRATEGIC PETROLEUM RESERVE)

We have reviewed the cited document and our comments as to the adequacy of treatment of environmental effects of concern are shown below:

	Check (X) for each item: None	Comment enclosed
1. Additional specific effects which should be assessed:		✓
2. Additional alternatives which should be considered:	✓	
3. Better or more appropriate measures and standards which should be used to evaluate environmental effects:	✓	
4. Additional control measures which should be applied to reduce adverse environmental effects or to avoid or minimize the irreversible or irretrievable commitment of resources:	✓	
5. Our assessment of how serious the environmental damage from this project might be, using the best alternative and control measures:	✓	
6. We identify issues which require further discussion or resolution:		✓

[✓] This agency concurs with the implementation of this project.

[ ] This agency does not wish to comment on the subject document because:

J-29

Name & Title of Reviewing Official

AGE. .I REVIEW TRANSMITTAL SHEET

TO: Dr. Charles G. Groat, Bureau of Economic Geoloty, UT   Date: Sent: 10/06/76

Date: Due: As Soon as Possible

Refer: EIS: 6-010-003

FROM: Charles D. Travis, Director, Budget and Planning Office

SUBJECT: DRAFT ENVIRONMENTAL IMPACT STATEMENT: BRYAN MOUND SALT DOME-DES 76-6 (STRATEGIC PETROLEUM RESERVE)

RECEIVED NOV 9 1976 Budget/Planning

We have reviewed the cited document and our comments as to the adequacy of treatment of environmental effects of concern are shown below:

	Check (X) for each item: None	Comment enclosed
1. Additional specific effects which should be assessed:	✓	
2. Additional alternatives which should be considered:	✓	
3. Better or more appropriate measures and standards which should be used to evaluate environmental effects:	✓	
4. Additional control measures which should be applied to reduce adverse environmental effects or to avoid or minimize the irreversible or irretrievable commitment of resources:	✓	
5. Our assessment of how serious the environmental damage from this project might be, using the best alternative and control measures:	✓	
6. We identify issues which require further discussion or resolution:	✓	

☐ This agency concurs with the implementation of this project.

☐ This agency does not wish to comment on the subject document because:

C. G. Groat

Name & Title of Reviewing Official

AGENCY REVIEW TRANSMITTAL SHEET

RECEIVED NOV 10 Budget/Planning

TO: Mr. Alvin Askew, Governor's Energy Advisory Council

Date: Sent: 10/06/76

Date: Due: As Soon as Possible

Refer: EIS: 6-010-003

FROM: Charles D. Travis, Director, Budget and Planning Office

SUBJECT: DRAFT ENVIRONMENTAL IMPACT STATEMENT: BRYAN MOUND SALT DOME-DES 76-6 (STRATEGIC PETROLEUM RESERVE)

We have reviewed the cited document and our comments as to the adequacy of treatment of environmental effects of concern are shown below:

	Check (X) for each item: None	Comment enclosed
1. Additional specific effects which should be assessed:	X	
2. Additional alternatives which should be considered:	X	
3. Better or more appropriate measures and standards which should be used to evaluate environmental effects:	X	
4. Additional control measures which should be applied to reduce adverse environmental effects or to avoid or minimize the irreversible or irretrievable commitment of resources:	X	
5. Our assessment of how serious the environmental damage from this project might be, using the best alternative and control measures:	X	
6. We identify issues which require further discussion or resolution:		X

[X] This agency concurs with the implementation of this project.

[ ] This agency does not wish to comment on the subject document because:

Ray R. Ray Jr.

Name & Title of Reviewing Official

11-08-76

RECEIVED
NOV 10 1976
Budget/Planning

AGENCY REVIEW TRANSMITTAL SHEET

TO : Charles D. Travis, Director, Budget and Planning Office

FROM : Alvin Askew, Governor's Energy Advisory Council

SUBJECT: DRAFT ENVIRONMENTAL IMPACT STATEMENT: BRYAN MOUND SALT DOME-DES 76-6 (STRATEGIC PETROLEUM RESERVE)

(1) It is not clear that adequate provision is being proposed for satisfaction of Air Quality Standards particularly with regard to Hydrocarbon emissions.

(2) Alternative proposals are made for Brine Disposal in case Dow is unable to use the Brine produced. Is it to be assumed that construction of facilities for an alternative disposal method would be included in the initial construction? The material provided seems to suggest a preference for disposal in the Gulf over Deep-Well Injection. More specific details would be needed in either case but particularly with regard to Deep-Well Injection.

(3) While the Brazos River is considered an alternative source for displacement water there is no indication of arrangements for use of surface water if needed from this source. It is not made clear what circumstances might require such use. Therefore further discussion is recommended.

(4) Some question is left concerning the schedule of construction related to the distribution system. Greater detail might be helpful.

(5) There may be some question remaining about the capability of Freeport harbor and Intercoastal Waterway in handling of increased traffic envisioned without increased dangers. Perhaps mitigation procedures should be discussed in greater detail.

A [illegible]CY REVIEW TRANSMITTAL SHEET

TO: Mr. James H. Harwell, Texas Industrial Commission

Date: Sent: 10/06/76

Date: Due: As Soon as Possible

Refer: EIS: 6-010-003

FROM: Charles D. Travis, Director, Budget and Planning Office

SUBJECT: DRAFT ENVIRONMENTAL IMPACT STATEMENT: BRYAN MOUND SALT DOME-DES 76-6 (STRATEGIC PETROLEUM RESERVE)

RECEIVED
OCT 14 1976
Budget/Planning

We have reviewed the cited document and our comments as to the adequacy of treatment of environmental effects of concern are shown below:

	Check (X) for each item: None	Check (X) for each item: Comment enclosed
1. Additional specific effects which should be assessed:	✓	
2. Additional alternatives which should be considered:	✓	
3. Better or more appropriate measures and standards which should be used to evaluate environmental effects:	✓	
4. Additional control measures which should be applied to reduce adverse environmental effects or to avoid or minimize the irreversible or irretrievable commitment of resources:	✓	
5. Our assessment of how serious the environmental damage from this project might be, using the best alternative and control measures:	✓	
6. We identify issues which require further discussion or resolution:	✓	

[✓] This agency concurs with the implementation of this project.

[ ] This agency does not wish to comment on the subject document because:

Experience has proven no more than 3 oil accidents with similar storage. Such storage has been in use in [illegible] since the [illegible] 40's. Durability of the [illegible] is still to be determined.

[illegible signature]
Name & Title of Reviewing Official

TEXAS
PARKS AND WILDLIFE DEPARTMENT

COMMISSIONERS

PEARCE JOHNSON
Chairman, Austin

JOE K. FULTON
Vice–Chairman, Lubbock

JACK R. STONE
Wells

CLAYTON T. GARRISON
EXECUTIVE DIRECTOR

4200 Smith School Road
Austin, Texas 78744

COMMISSIONERS

BOB BURLESON
Temple

JOHN M. GREEN
Beaumont

LOUIS H. STUMBERG
San Antonio

November 4, 1976

RECEIVED
NOV 5
Budget ... nning

Mr. H. Anthony Breard, Coordinator
Natural Resources Section
Governor's Budget and Planning Office
Executive Office Building
411 West 13th Street
Austin, Texas 78701

Dear Mr. Breard:

The Texas Parks and Wildlife Department has reviewed the Draft Environmental Impact Statement: Bryan Mound Salt Dome, DES 76-6 (Strategic Petroleum Reserve). We have the following comments on this document.

It is our understanding that primarily developed areas will be utilized for project facilities and that brine will not be released to the Brazos River or the Gulf. The use of methods that will keep spills of oil to a minimum should be encouraged as oil spills appear to have the greatest potential for environmental damages resulting from the project.

Mention should be made in the environmental impact statement of the Bryan Beach State Recreation Area, which is located approximately one mile south of Bryan Mound (Attachment 1). This area was recently obtained by the Texas Parks and Wildlife Department and recreational facilities are currently being planned for future public use. Bryan Beach State Recreation Area contains 877 acres and has over one mile of Gulf beach. We feel that the environmental impact statement should address the potential noise, odor, and oil spill impacts of the proposed project on this recreation area.

Mention of Velasco Beach State Park (Section 2.6.2) should be deleted as this site was returned to control of the Texas General Land Office in 1973. Also, the project sponsor is encouraged to consult with municipal and county governments in the project area regarding locations of additional parks in the project area.

Mr. H. Anthony Breard
November 4, 1976
Page Two

In Section 2.6.3, Pages 2-73 and 2-74, certain biologically sensitive areas and endangered fauna within those areas are mentioned. The second paragraph on Page 2-74 erroneously states that the Corpus Christi Bay Area is on the Texas-Louisiana border and that the American alligator is mostly restricted to marsh and prairie areas close to the coast. It is suggested that the subject paragraph be corrected by stating that the range of the American alligator, which includes Brazoria County, extends along the entire Texas coast and throughout most of the eastern third of the State (Attachment 2).

The statement is made on Page 2-62 under the section on wildlife that there is no commercially valuable wildlife within the region "except in secondary terms." It is felt that the statement is not accurate and should be deleted. An improvement in the market for upland furbearers has stimulated fur trapping throughout the State. Our records show one fur buyer in Brazoria County for the 1975-76 season with purchases of 464 raccoons, 188 opossums, 49 foxes, and 12 nutrias valued at approximately $4,264. It is probable that additional furs were sold to buyers in other counties.

Thank you for the opportunity to review this document.

Sincerely,

CLAYTON T. GARRISON
Executive Director

CTG:MW:lmw

Attachments

ATTACHMENT 1

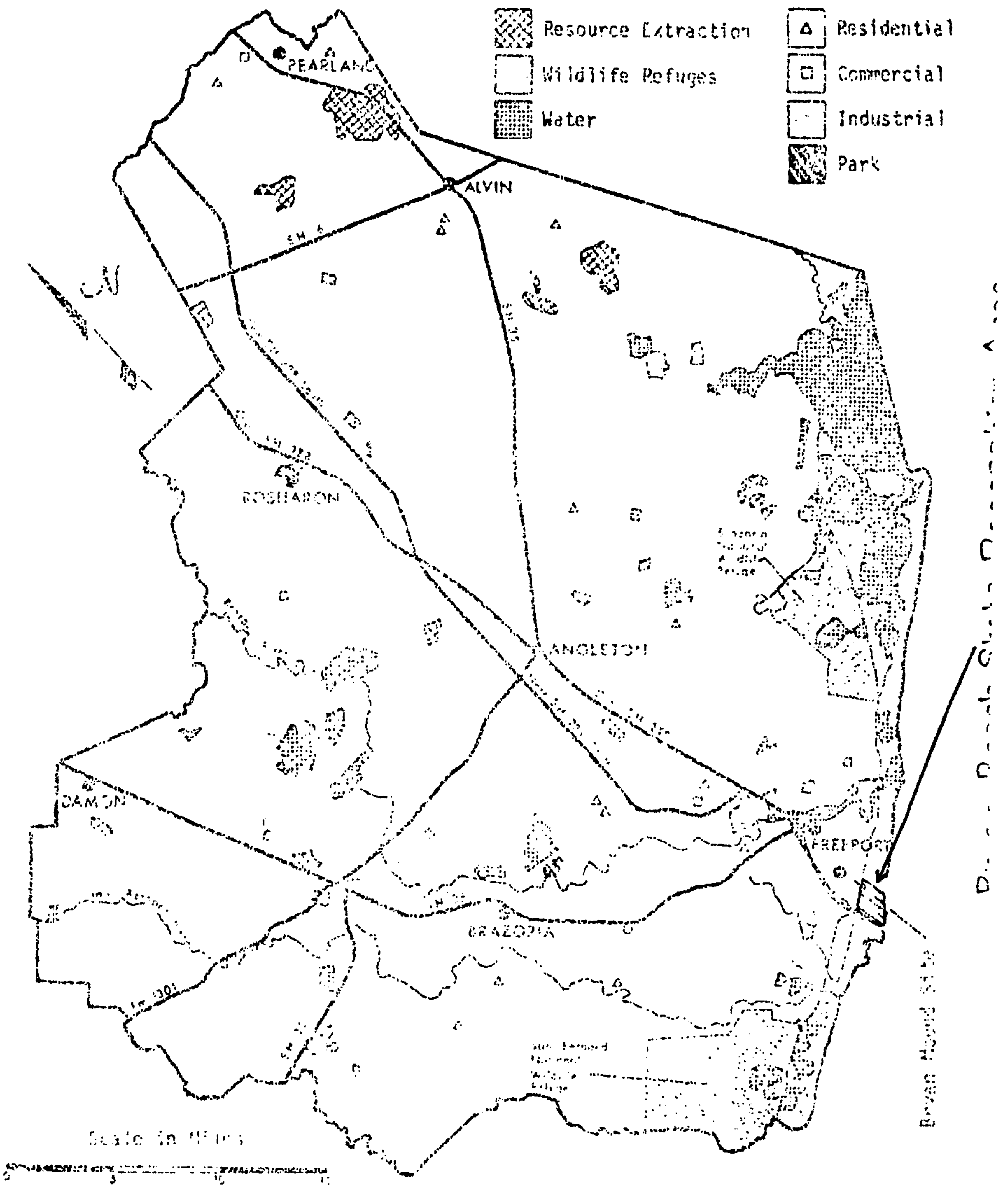
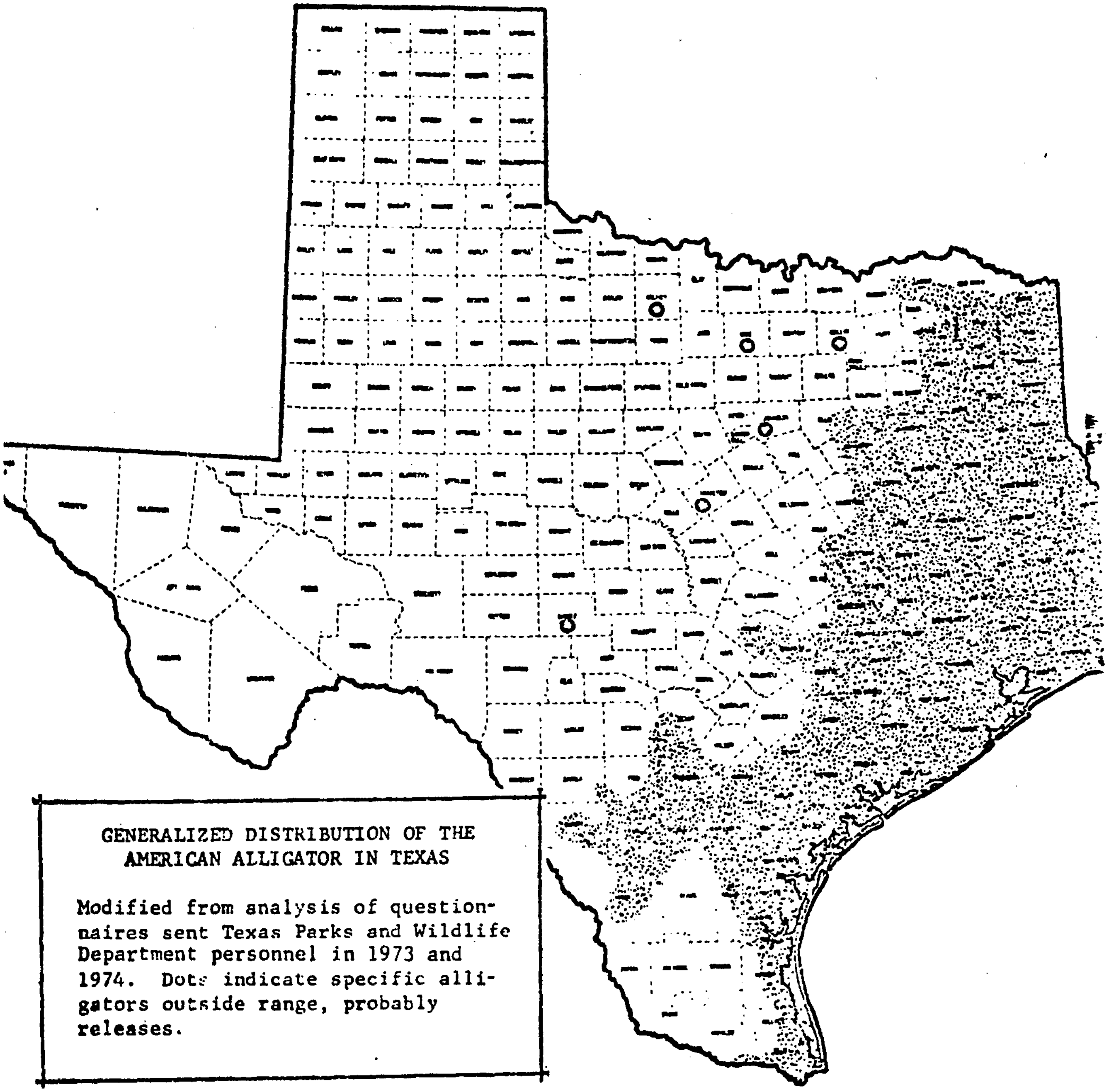


Figure 2.4. Prominent land uses and Distribution in Brazoria County, Texas.



GENERALIZED DISTRIBUTION OF THE AMERICAN ALLIGATOR IN TEXAS

Modified from analysis of questionnaires sent Texas Parks and Wildlife Department personnel in 1973 and 1974. Dots indicate specific alligators outside range, probably releases.

RAILROAD COMMISSION OF TEXAS

OIL AND GAS DIVISION

N RAMSEY, Chairman
CK WALLACE, Commissioner
C. LANGDON, Commissioner

PHILLIP R. RUSSELL
Director, Field Operations

IEST O. THOMPSON BUILDING • CAPITOL STATION - P. O. DRAWER 12967 • AUSTIN, TEXAS 78711

October 29, 1976

RECEIVED
NOV 3 1976
Budget/Planning

MEMORANDUM TO: Charles D. Travis, Director
Budget and Planning Office

FROM: Phillip R. Russell
Director of Field Operations
Railroad Commission of Texas

SUBJECT: Draft Environmental Impact Statement
Bryan Mound Salt Dome-DES 76-6
(Strategic Petroleum Reserve)

Attached is the Railroad Commission's comments on the subject draft.

Phillip R. Russell
Director of Field Operations

PRR:mz
attachment

AG...Y REVIEW TRANSMITTAL SHEET

TO: Mr. Ben Ramsey, Texas Railroad Commission

Date: Sent: 10/06/76

Date: Due: As Soon as Possible

Refer: EIS: 6-010-003

FROM: Charles D. Travis, Director, Budget and Planning Office

SUBJECT: DRAFT ENVIRONMENTAL IMPACT STATEMENT: BRYAN MOUND SALT DOME-DES 76-6 (STRATEGIC PETROLEUM RESERVE)

RECEIVED
NOV 3 1976
Budget/Planning

We have reviewed the cited document and our comments as to the adequacy of treatment of environmental effects of concern are shown below:

	Check (X) for each item: None	Comment enclosed
1. Additional specific effects which should be assessed:	X	
2. Additional alternatives which should be considered:	X	
3. Better or more appropriate measures and standards which should be used to evaluate environmental effects:	X	
4. Additional control measures which should be applied to reduce adverse environmental effects or to avoid or minimize the irreversible or irretrievable commitment of resources:	X	
5. Our assessment of how serious the environmental damage from this project might be, using the best alternative and control measures:	X	
6. We identify issues which require further discussion or resolution:	X	

[X] This agency concurs with the implementation of this project.

[ ] This agency does not wish to comment on the subject document because:

Name & Title of Reviewing Official

TEXAS WATER DEVELOPMENT BOARD

JAMES M. ROSE
EXECUTIVE DIRECTOR

P.O. BOX 13087
CAPITOL STATION
AUSTIN, TEXAS 78711

AREA CODE 512
475-3187
1700 NORTH CONGRESS AVENUE

October 27, 1976

IN REPLY REFER TO:
TWDBP

Mr. Charles D. Travis, Director
Governor's Budget and Planning
  Division
Executive Office Building
Austin, Texas 78701

RECEIVED
NOV 1976
Budget ...

Attention: Mr. H. Anthony Breard

Dear Mr. Travis:

Re: Draft Environmental Impact Statement for Bryan Mound Salt Dome.

The above-cited Draft Environmental Impact Statement has been reviewed at staff level. The Federal Energy Administration (FEA) proposes to implement the Strategic Petroleum Reserve (SPR), Title I, Part B, of the Energy Policy and Conservation Act of 1975 (P.L. 94-163) through the development of a 58 million barrel crude oil storage facility at the Bryan Mound Salt Dome, Brazoria County, Texas. The purpose of the SPR is to mitigate the economic impacts of any future interruptions of the petroleum imports.

The Federal Energy Administration has developed and formulated a comprehensive impact analysis of the site preparation and operation of the Bryan Mound Salt Dome reserve. The Bryan Mound site, a salt dome with existing cavities located in Brazoria County, has been identified as a candidate site because it offers the advantage of a large storage capacity, ready access to dock facilities at Freeport and the Seaway Tank Farm, and a relatively short preparation period. Land requirements for the Bryan Mound Strategic Petroleum Reserve Facility include 30 acres for the main storage site, 3 acres for the dock facilities, and approximately 100 acres for pipeline right-of-ways. Of the different types of storage facilities, existing solution-mined salt dome cavities are among the most attractive for petroleum storage because of the relative low cost of bulk storage and the geological stability of rock salt masses.

TO: Charles D. Travis, [illegible]irector
Budget & Planning Office, Office of the Governor
Executive Office Bldg., 411 W. 13th St.
Austin, Texas 78701
(ATTN: John Gosdin)

Date Sent: 10/8/76

Date Due: As soon possible

Refer: EIS-6-010-00[illegible]

FROM: Robert E. Schneider, Executive Director
Texas Water Rights Commission (TWRC)

Date of Review: 10/[illegible]

SUBJECT: U.S. Federal Energy Admin. (Strategic Petroleum Reserve Office)--Draft Environmental Statement--Strategic Petroleum Reserve, Bryan Mound Salt Dome, Brazoria County, Tx.

		Check (X) for each item: None	Comments
1.	Additional specific effects which should be assessed and mentioned:		See Proviso below
2.	Additional alternatives which should be considered:		"
3.	Better or more appropriate measures and standards which should be used to evaluate environmental effects:		"
4.	Additional control measures which should be applied to reduce adverse environmental effects or to avoid or minimize the irreversible or irretrievable commitment of resources:		"
5.	Our assessment of how serious the environmental damage from this project might be, using the best alternative and control measures:		"
6.	We identify issues which require further discussion or resolution:		"

[XX] This agency concurs with the implementation of this project.

PROVISO: Our previous suggestions on the programmatic DES are reiterated. Substantial technical, socio-economic, and political uncertainties remain warranting the continuing use of stochastic, deterministic, and hybrid models in risk and reliability analyses; and the study of the distribution and analysis of extreme events and their influence in specific site designs and operations. The foregoing requirements can be reasonably assured only if a special plan and strategy are adopted which ensures centralized, overall, uninterrupted integrated technical, administrative, and operational custody throughout the phased build-up of the EPR, ESR, IPR, and RPR. The impacts of these phased reserve build-ups should provide for the prompt mitigation of the increased costs incurred by the States, regions, and private property owners affected by the Program. Mitigation for adverse impacts on water rights and related land resources should be an inherent feature of this entire energy-related Program. TWRC concurrence is contigent upon a reasonable consideration of the foregoing suggestions. These suggestions imply the adoption of proper monitoring and surveillance measures, and very close Federal/State/Industry coordination.

NOTED:
Robert E. Schneider
Executive Director

Alfred J. D'Arezzo
Analyst for Environment
& Interagency Coordination
Name & Title of Reviewing Official

The major impacts on water resources associated with the proposed project include: (1) temporary degradation of water quality during dredging activities by increasing the amount of suspended particulates, and any toxic sulfides, heavy metals, pesticides, or other toxic hydrocarbons as may be present; (2) potential oil spills during marine operations (loading, unloading, and transporting crude oil); (3) possible aquifer compaction and subsidence on the dome resulting from construction of large (400,000 barrel) aboveground storage tanks; and (4) disturbance of 18 acres of marshland and temporary loss of resultant marshland productivity.

Raw water to be used for crude oil displacement during withdrawal operations would be supplied from Harris Reservoir and Brazoria Reservoir, developed and owned by Dow Chemical Company. The water from these reservoirs is purchased from the Brazos River Authority during high flow periods. Water stored in the two reservoirs would be utilized for displacement at a maximum rate of 14,000 gallons per minute. Brine displaced from the cavities during filling operations would subsequently be returned to Dow through existing pipelines and used as production feedstock.

Due to the potential hazard to groundwater quality, we are concerned with deep well injection as a possible brine disposal alternative. We suggest that the FEA give additional consideration to the potential impact of this alternative on groundwater resources in preparing the final environmental impact statement.

Beneficial effects due to the construction and operation of this facility include the economic gains associated with the expansion of petroleum and petrochemical complexes and stimulated employment. The Strategic Petroleum Reserve will ultimately provide the capacity and resources to buffer the impacts of possible future petroleum supply interruptions.

Sincerely,

James M. Rose

SOUTH CENTRAL PLANNING & DEVELOPMENT COMMISSIO!

MEMBER PARISHES ASSUMPTION • LAFOURCHE • ST. CHARLES • ST. JAMES • ST. JOHN THE BAPTIST • TERREBO

November 3, 1976

00003

Executive Communications
Room 3309
Federal Energy Administration
Washington D.C. 20461

Dear Sirs:

We are in receipt of your request for comments on the draft site Specific and Environmental Impact statement for five (5) Salt Dome storage sites in Louisiana and Texas being considerate for use in the Strategic Petroleum Program. None of these sites noted are located within the jurisdiction of this district, and therefore, I have no adverse comments that I feel I can make being as we are not familier with these sites. I feel certain that the districts who have sites involved will make comments to the FEA.

Thank you for the opportunity to comment on this important matter, and I hope in the future, when something applies to my district arises I can be of assistance to you.

Sincerely,

Charles J. Melancon,
Executive Director

CJM/dmm

P.O. BOX 846
THIBODAUX,
LOUISIANA
70301

OFFICE
204 ST. LOUIS STREET

TELEPHONE
(504) 446-0514

J. F. Ross
Vice Chairman
Lake Jackson, Texas

J. A. Travis
Chairman
Freeport, Texas

R. M. Anderson
Secretary
Clute, Texas

Velasco Drainage District

PHONE: 265-4251

Mail Address
Post Office Box 848
LAKE JACKSON, TEXAS 77566

Freight and Express
Drainage Dist. Warehouse
932 Brockman Road
CLUTE, TEXAS

245002

October 20, 1976 [illegible]

Executive Communications
Room 3309
Federal Energy Administration
Washington, D.C. 20461

ATT: Robert L. Davies

Dear Mr. Davies:

The opportunity to review the Draft Environmental Impact Statement for Bryan Mound Salt Dome, DES 76-6, September, 1976 is appreciated. The Bryan Mound site lies within the boundaries of the Velasco Drainage District, and development of an Early Storage Reserve on the site under Public Law 92-163 is of interest to the District. As the westerly boundary of the District is the Brazos River, the proposed facilities situated west of the Brazos would not fall within the District's jurisdiction. Our review has been directed, therefore, to the proposed facilities of Bryan Mound itself.

First, on the basis of the review possible in the limited time available, the District finds the Draft Statement generally to be comprehensive and accurate.

Second, additional detail on the hurricane protection and drainage aspects of the site would be valuable and important, and the following data are offered for your use and information.

The Freeport and Vicinity, Texas Hurricane Flood Protection Project is a program of strengthening existing levees and constructing new levees and related drainage systems in the Brazosport Area. The Project was authorized by the Federal Flood Control Act of 23 October 1962, House Document No. 495, 87th Congress. Project funding is 70% by the Federal Government and 30% by local interests, represented by the Drainage District as Local Sponsor.

As part of the Project, certain improvements were made relating directly to Bryan Mound and the adjoining area to the north of the mound and south of the developed area of the City of Freeport. (See your Figure 1.7).

1. The South Frontal Levee, running from the high ground at Bryan Mound to the south side of the existing Phillips Terminal, has been strengthened and raised to protect the area against the Standard Project Hurricane. The levee parallels the route of the proposed FEA 30" pipeline, Figure 1.7.

2. Similarly, the East Bank Brazos River Diversion Channel Levee has been strengthened and raised. It extends from the high ground at Bryan Mound northerly, and parallels the proposed 6 mile 24" concrete fresh water pipeline indicated on Figure 1.7.

3. Similarly, protection of the area against flooding from the north is afforded by the levees at the Phillips Terminal, Brazos Harbor and the Old Brazos River.

Consequently, the entire area south of the City of Freeport to the South Frontal Levee is enclosed by a ring levee system and protected against flooding from the Standard Project Hurricane.

Turning to the interior drainage facilities, rainfall runoff is removed from the enclosed area by the following:

1. The West End Pumping Station located at the southwest corner of the developed area of the City of Freeport, Figure 1.7. The station contains three pumps with a total capacity of 450,000 gallons per minute.

2. A gated gravity drainage structure through the South Frontal Levee. The structure consists of two 7' by 5' concrete boxes.

A second pumping station, the Pine Street Pumping Station, transfers runoff from the developed area of the City of Freeport over a lower interior levee southerly into a channel running westerly to the West End Pumping Station. The lower interior levee formerly was the storm protection levee for the city, now afforded by the South Frontal Levee. Accordingly, the Pine Street Pumping Station does not remove runoff from the enclosed basin. The Pine Street Station contains four pumps with a total capacity of 200,000 gallons per minute.

When the total protection project was planned, the Galveston District, Corps of Engineers, concluded that additional runoff discharge capacity through the South Frontal Levee was not justified, based on the then current stage of development. Based upon a brief review of the project outlined in the Draft Environmental Impact Statement, and assuming that sensitive facilities are sited on the high ground of Bryan Mound, no significant flood damages are foreseen.

However, it is the Drainage District's position that two conclusions logically arise:

1. Development of significant areas of the basin or even small but low areas of the basin will require additional runoff discharge capacity.

2. The areas of standing water arise from interior rainfall and from discharge of rainfall runoff from the Pine Street Pumping Station. The two gated 7' by 5' concrete boxes through the South Frontal Levee prevent backflow from the Gulf of Mexico or the Intracoastal Waterway, and the area is not subject to the ebb and flow of saltwater tides. Accordingly, the Drainage District is of the opinion that the area is eminently suitable for development and use.

If, during your studies and future implementation of the Strategic Petroleum Reserve Program, the Drainage District may furnish any information or any assistance within its capabilities, the District offers its cooperation.

Sincerely,

VELASCO DRAINAGE DISTRICT

J. A. Travis
Chairman

CBA:gm

DOW CHEMICAL U.S.A.

November 1, 1976

BENNETT BUILDING
2030 DOW CENTER
MIDLAND, MICHIGAN 48640

Mr. Robert L. Davies
Deputy Assistant Administrator
Strategic Petroleum Reserve
Federal Energy Administration
Room 410
1726 M Street, N.W.
Washington, D.C. 20461

Dear Mr. Davies:

We appreciate the opportunity to comment on the draft environmental impact statement for the inclusion of the Bryan Mound Salt Dome into the Strategic Petroleum Reserve. The Dow Chemical Company supports the Federal Energy Administration's efforts to implement the Strategic Petroleum Reserve program. The program will reduce our national vulnerability to future oil supply interuptions and will be a positive benefit for the nation.

We also believe that Bryan Mound is an excellent site for this, or any, hydrocarbon storage project. Dow proposal No. 7761267, July 23, 1976 has been submitted to the FEA for the "Modification and Lease of Bryan Mound Salt Caverns to the Government for Use as Interim Strategic Petroleum Reserve Storage". The proposal, which contains a proprietary rights clause, outlines our desire to modify the caverns to provide 70 million barrels of usable crude oil storage space for lease to the FEA for a 10 year period with 5 year renewal option. The proposal also states that Dow does not wish to dispose of or permanently lease the property in a manner that would preclude its use as a source of salt for Dow operations.

Since discussions on this proposal are still underway, we cannot be certain that the ultimate degree of Dow involvement will be as described in the draft environmental impact statement. There are several areas in which the Dow involvement proposed in Dow proposal No. 7761267 is different than described in the draft EIS. The significant area of difference is that the maximum brine disposal rate proposed to date by Dow is 145,000 barrels per day of saturated brine versus 400,800 barrels per day described in the draft EIS. There are other differences including pipeline sizes, pipeline uses and casing sizes that do not have environmental significance.

We believe that, with the use of Dow's brine disposal capability and related water supply system, no significant adverse environmental damage will result from development of the crude oil storage facility at the Bryan Mound salt dome. Disposal of saturated brine into the Gulf of Mexico or into deep subsurface aquifers is obviously less desirable environmentally and is much more complex. Comments on these less desirable brine disposal alternatives are not appropriate at this time.

As stated earlier, Dow supports the Strategic Petroleum Reserve program and believes that adverse environmental impacts can be avoided.

Yours very truly,

R. William Jewell
Business Services
Supply & Distribution

dla

cc: Roger Gohrband
Director of Purchasing and
Financial Services
Dow Chemical Company
2030 Dow Center
Midland, MI 48640

Thomas E. Noel
Assistant Administrator
Federal Energy Administration
Washington, D.C. 20461

Steven E. Ferguson
Federal Energy Administration
Executive Communications
Room 3309
1726 M Street, N.W.
Washington, D.C. 20461

LOOP INC

350 BANK OF NEW ORLEANS BLDG.
1010 COMMON STREET
NEW ORLEANS, LA 70112
(504) 529-7241

November 3, 1976

File: 5.03

00002

Executive Communications
Room 3309
Federal Energy Administration
Washington, DC 20461

Dear Sir:

The site-specific draft EISs for five candidate ESR sites have been reviewed per your request of September 10, 1976.

We agree that underground storage of crude oil, utilizing existing technology, offers maximum protection against fire, storm and sabotage and is low cost with small environmental impact relative to other storage concepts.

There is no indication that specific, competent geomechanics analyses will be made to assure stability of multicavity configurations after five fill/withdrawal cycles. Such analysis should be required for each of the candidate salt domes (DES 76-4,5,6) actually selected.

The analysis would establish allowable roof distance below the caprock, center to center spacing vs. diameter (s/d ratio), vertical separation and plastic zone proximity to the dome flank. These criteria should be related to calculated creep, stress and subsidence for the actual or safe strength levels of the specific salt and surrounding rock. The arbitrary criteria enumerated in the programmatic draft EIS are no substitute for geomechanics analyses.

LOUISIANA OFFSHORE OIL PORT

For the West Hackberry salt dome (DES 76-4), the impact of the alternate brine disposal by pipeline to the Gulf of Mexico can be quantified while disposal by subsurface injection cannot, in particular, the effect on the freshwater acquifier. Why shouldn't pipeline disposal be preferable here as was the case for the Bryan Mound salt dome (DES 76-6)?

Yours very truly,

W. B. Read

W. B. Read
President

SEAWAY PIPELINE, INC.

BARTLESVILLE, OKLAHOMA 74004
918 661-3700

H V CHRISTENSEN
Vice President
and Project Manager

October 28, 1976

00004

Executive Communications
Room 3309
Federal Energy Administration
Washington, D. C. 20461

Re: Bryan Mound Salt Dome SPR

Dear Sir:

A copy of the Draft Environmental Impact Statement for the development and use of the Bryan Mound Salt Dome as a storage facility for the Strategic Petroleum Reserve has been reviewed. The following comments are being forwarded for your consideration.

The last paragraph on page 2-39 mentions that there is apparently no relationship between the hydrocarbon and ozone concentrations. From this lack of a relationship, it is concluded that the occasional concentrations of hydrocarbons in excess of the Federal Ambient Air Quality Standard are a result of the various pipelines, tank farms, industries, etc. in the area. This conclusion appears to ignore two important points. First, non-methane hydrocarbons can react photochemically to form ozone. Since this is an atmospheric reaction, the resultant ozone concentration will appear at some point downwind of the non-methane hydrocarbon emissions. For this reason, it should not be expected that the ozone and non-methane hydrocarbon concentrations measured at the same point are related except in stagnation masses. More correctly, the ozone concentration possibly can be related to some upwind concentration of non-methane hydrocarbons which is unknown at this time.

A second point that needs to be considered is that natural sources such as swamps, which are common in the area, can be significant contributors to the ambient hydrocarbon concentration. Although currently available information does not permit a quantification of these natural hydrocarbon emissions in this area, the fact that they do exist needs to be kept in mind when evaluating ambient air quality data. The current wording on page 2-39 leads one to believe the entire hydrocarbon problem in the area is attributable to anthropogenic sources. This is quite likely not the case.

Based on these facts, it is recommended that the entire last paragraph on page 2-39 be deleted. The current data does not support the conclusions presented.

On page (2-59) paragraph 2.4.4. the wording would indicate ballast treating facilities would be located at the Seaway Dock site. This is contrary to the understanding we have of the current plans inasmuch as the available space at this location would probably not accommodate the facilities required. Similar reference to ballast treating facilities at the dock is also made on page (3-3) paragraph 3.1.2. and page (3-35) paragraph 3.4.3.. It is therefore recommended these statements be modified to reflect the current thinking.

The last paragraph on page 7-31 refers to Seaway Pipeline, Inc.'s Freeport Terminal as "a 15,000,000 barrel tank farm." This is in error since Freeport Terminal will only have eight 400,000 barrel storage tanks, or a total storage capacity of 3,200,000 barrels. This should be corrected accordingly.

The opportunity to present these comments is appreciated. If any questions arise related to these comments, please contact the undersigned.

Very truly yours,

H. V. Christensen

H. V. Christensen

HVC:jc

APPENDIX K

GLOSSARY OF TERMS

The following glossary of terms is provided for the reviewer when reading this report.

acre-foot	-a measure of water drainage or run-off volume equal to the quantity of water that would cover one acre of land to a depth of one foot (43,560 cu.ft.).
adsorption	-an adhesion of an extremely thin layer of molecules to the surfaces of solid bodies or liquids with which it is in contact.
aldehydes	-various highly reactive compounds typified by acetaldehyde and characterized by the group CHO.
alluvium deposits	-rock fragments that are transported by modern rivers and deposited in river beds, flood plains, lakes and estuaries and natural levees.
amphipod	-small, free-swimming crustaceans (includes beach fleas).
anaerobic	-refers to life or processes occurring in the absense of free oxygen; refers to conditions characterized by the absence of free oxygen.
anhydrite	-an evaporite mineral, $CaSO_4$, associated with gypsum and found in sedimentary rocks.

aquiclude	-a geologic formation so impervious that for all practical purposes it completely obstructs the flow of ground water (although it may be saturated itself), and completely confines other strata with which it alternates in deposition.
aquifer	-a water-bearing strata.
aquitard	-a geologic formation of a rather impervious and semi-confining nature which transmits water at a very slow rate compared to an aquifer.
artesian water	-ground water that is under sufficient pressure to rise above the level at which it is encountered by a well, but which does not necessarily rise to or above the surface of the ground.
artesian well	-a well which reaches artesian water.
bayou	-a stream or small river that is a tributary to another river - term local to southern states.
bbl	-barrel or barrels - one barrel of petroleum equals 42 U.S. gallons.
benthos	-organisms fixed to or growing on the bottom of water bodies.
biocide	-substance destructive to many different organisms.
blanket oil	-used during formation of solution cavity to prevent undesired leaching of cavity ceiling.

bottom scour	-bottom scour is the erosion of sediment by moving water from the bottom of the stream channel.
BPD	-barrels per day - an oil production or distribution rate.
MB/D	-thousand barrels per day.
MMB/D	-million barrels per day.
brackish	-slightly saline water between fresh water (<0.3 ppt) and sea water concentrations (∿35 ppt).
breccia	-a rock consisting of sharp cornered bits cemented together by sand clay or lime. Collapse breccias are derived from material broken up during the collapse of a solution cavity roof, while fissure breccias are accumulations of fragments in a solution fissure.
brine	-concentrated or nearly concentrated salt water achieved by dissolving water with the salt inside a salt dome, thus creating a cavity. Brine produced in this way is commonly used as feedstock (raw material) by chemical industries or for refining into common salt.
brine safety layer	-The brine safety layer is that amount of brine which should be at the bottom of the cavity when it is "full" of crude to assure that crude does not get pushed out of the brine string into the brine surge pits.
^oC	-degrees Celsius (formerly called Centigrade) - conversion of Celsius to Fahrenheit is $9/5\,^oC + 32^o = {}^oF$.
calcareous	-composed of or characteristic of calcium or limestone, having a chalky nature.

calcite	-calcium carbonate, $CaCO_3$, a mineral found in the form of limestone, chalk and marble.
caprock	-a mantle of associated minerals across the top of most shallow, piercement salt domes. No well defined layers are evident due to complexity and irregularity; however, three fairly well-defined zones are distinguishable in developed caprock: (1) anhydrite zone (2) transition zone - contains sulfur, gypsum, and less important minerals (3) calcite zone - top zone in developed caprock.
cast and stack dredging	-type of dredging that deposits dredge spoil on the bank of the canal/river by means of pipeline or conveyor belt.
Centipose	-unit for measuring viscosity, which is the tendency of a fluid to resist change of form.
cfs	-cubic feet per second -a rate of water volume flow.
cheniers	-long sinuous ridges of sand deposited on top of the swamp deposits of a delta. They represent stationary phases of a regressing shoreline. The type area for their development is the Mississippi Delta.
chlordane	-a chlorinated, highly poisonous, volatile oil $C_{10}H_6Cl_8$, used as an insecticide.

cladocera	-small, aquatic crustaceans (includes water fleas).
CO	-carbon monoxide - a colorless, odorless, highly poisonous gas, produced by the incomplete combustion of any carbonaceous material i.e., gasoline.
COD	-chemical oxygen demand.
colloid	-a substance that, when apparently dissolved in water, diffuses not at all or very slowly through a membrane, and usually has little effect on freezing point, boiling point, or osmotic pressure of the solution.
consolidated rock	-incoherent and relatively hard, naturally formed mass of mineral matter.
Cretaceous	-a period of time from 136 million years to 65 million years ago.
crude oil	-unrefined oil as it comes from the ground.
darcy	-a measure of the permeability of rock. One darcy (D) equals a permeability such that one millilitre (ml) of fluid, having a viscosity of one centipoise, flows in one second under a pressure differential of one atmosphere through a porous material having a cross-sectional area of one square centimeter (cm^2) and a length of

darcy (continued) — one centimeter. The working unit is the millidarcy (mD) one thousandth of a darcy. Darcy's Law relates to the flow of fluids, especially gas oil, and water in underground rocks.

DDT — -dichloro-diphenyl-trichloroethane - a powerful insecticide effective on contact.

decibels: dB — -logarithmic unit method of expressing the relative intensity of sound pressure. The human ear is sensitive to changes in atmospheric pressure (sound vibrations) ranging from just barely audible at 0.0002 μbar to the threshold of pain at 2000 μbars. This range in sensitivity is so tremendous that a more workable expression of these ranges is to compress them on a logarithmic scale. In order to do this, the reference sound pressure is usually taken as the sound pressure detectable, that of 0.0002μbars. The intensity of sound is then measured in decibels by the following function:

$$\text{Intensity (in dB)} = 20 \log_{10} \left(\frac{\text{Pressure}}{0.0002\ \mu\text{bar}}\right)$$

Using this method, the range of human sensitivity is from 0 dB (pressure at 0.0002μbar) to approximately 140 dB (pressure at 2000 μbar).

Psychacoustic studies indicate that a 10 dB increase in sound intensity is perceived as a doubling of loudness.

decibels: dBA (continued)	-A-weighted level - a unit is similar to dB Sound Pressure Level (SPL) in that it represents sound intensity level. However, the A-weighted level includes attenuation at each frequency which is similar to the ear's attenuation of frequencies. Since the human ear is much less sensitive to low frequencies, it implies that a sound at 250 Hz of 65 dB (SPL) is perceived relative to a sound at 1000 Hz of 65 dB (SPL) as much less intense. The A-weighted scale has been developed to adjust by frequency the overall sound pressure level of noise to an approximation of how the ear would hear this noise.
detritus	-material produced by the disintegration and weathering of rock that has been moved from its site of origin. Also, fragments of detached or broken down material such as leaves and other plant parts.
diapir	-an intrusion of salt from thc salt bed into overlying sediments, often in the form of a ridge or stalk-like piercement structure.
diazonium	-the grouping (organic chemistry), = N ≡ N, (triple bond of nitrogen).
dieldrin	-chlorinated organic chemical, $C_{12}H_8Cl_6O$, a white crystalline contact insecticide, obtained by oxidation of aldrin; used in mothproofing.
disseminated anhydrite	-particles of anhydrite ($CaSO_4$) dispersed through enclosing rock.
diurnal	-recurring on a daily cycle or in the daytime as opposed to nocturnal.
DO	-dissolved oxygen
dwt or DWT	-deadweight capacity - naval architecture term for total carrying capacity of a ship expressed in long tons (2,240 lbs); displacement of a fully loaded vessel less the weight of the ship itself.

electric logs	-the log of a well or borehole obtained by lowering electrodes in the hole and measuring various electrical properties of the geologic formations traversed.
emulsification	-the process of dispersing one liquid in a second immiscible liquid (liquids that will not mix with one another).
endrin	-a poisonous white crystal, $C_{12}H_8OCl_6$, insoluble in water, used as a pesticide. A stereo-isomer of dieldrin.
entrainment	-capture of an object or organism by a flowing liquid or gas.
euryhaline	-organisms that can tolerate a wide range of salinities.
eurythermal	-organisms that can tolerate a wide range of temperature.
eutrophic	-rich in nutrients and organic materials, therefore, highly productive.
evaporite	-a sediment resulting from the evaporation of saline water. Most evaporites are derived from bodies of sea water. Evaporite minerals are formed in the reverse order of their solubilities, i.e., the least soluble form first.
fault	-a fracture in rock along which there has been an observed amount of displacement. Faults are rarely-singular planar units; normally occurring as parallel sets of planes along which movement has taken place to greater or lesser extent. Such sets are called fault or fracture-zones.
flexure	-bending of sedimentary layers.

floating roof tank — a vertical cylindrical tank with a roof designed to float on top of the stored liquid product (commonly oil) as the level in the tank rises and falls.

fluvial — formed or produced by the action of flowing water.

Frasch mining — much mined sulfur (elemental sulfur) is produced from caprock of salt domes by the Frasch process utilizing superheated steam to melt the sulfur in caprock. Drilling well design consists of a concentric arrangement of pipes of various diameters. Steam is injected into the sulfur bearing zone through one of the inner tubing strings. Compressed air is injected through the innermost tubing string which forces water and molten sulfur to rise in the large outer diameter pipes. The molten sulfur then flows through heated pipes to settling tanks. Frasch process sulfur is very pure, as much as 99.5 percent sulfur.

g dry wt/m^2/yr — grams dry weight per square meter per year - a measure of the rate or organic production per area of yield.

geosyncline — a large, generally linear, geologic trough which subsided deeply throughout a long period of time, in which a thick succession of stratified sediments accumulated (for example, the Gulf of Mexico depression).

geosynclinal axis — a line which is parallel to the longest horizontal dimension of, and roughly bisects, a geosyncline.

GPD	-gallons per day - flow rate for liquids.
GPM	-gallons per minute - flow rate for liquids.
gypsum	-an evaporite mineral, $CaSO_4 2H_2O$. found in clays and limestones, sometimes associated with sulfur.
H_2S	-hydrogen sulfide; an inflammable, poisonous gas with the characteristic smell of rotten eggs.
halite	-an evaporite mineral, NaCl, common salt.
herpetofaunal	-reptiles and amphibians regarded collectively as a faunistic grouping.
Holocene	-the period of time from one million years ago to present.
horizons	-the various layers of soil each of which is a few inches to a foot or more thick.
HP or hp	-horsepower; equal to a rate of 33,000 foot-pounds per minute, the power required to raise 33,000 pounds a distance of one foot in a time of one minute.
humic acid	-a gelatinous material formed as a precipitate when organic matter is treated with a strong base, and the resulting solution is acidified.
hydraulic dredging	-this method includes a suction pipeline with either plain suction or cutting heads for digging hard material. The sediments dredged are conveyed by pipeline either to a barge or to a deposition area on shore.

impingement	-entrapping of object or organism against a screen or filter by the force of a liquid or gas moving through or against the screen.
injection well	-a well that brine will be forced into.
inversion	-a reversal in the normal atmospheric temperature gradient such that temperature increases with altitude (within 300 to 600 ft) and results in an atmospheric inversion. The warmer air on top acts as a ceiling to any material normally diffusing vertically.
isopach	-a line on a map joining points of equal thickness of a rock or sediment type.
isopleth	-(1) a graph plotting the occurrence or frequency of a phenomenon in meteorology, etc., as a function of two variables, time and space. (2) the line connecting points on a graph that have equal or corresponding values with regard to certain variables - synonym - isoline.
isostatic	-subject to equal pressure from every side.
Kcal	-kilocalorie.
$Kcal/m^2/yr$	-kilocalorie per square meter per year - a measure of the rate of organic energy production per area of yield.
kg	-kilogram.
leach	-to remove soluble constituents from a substance by the action of a perculating liquid, in this case, water taking salt from a salt dome into solution.

littoral	-a shallow zone that extends from shore to the lakeward limit or rooted aquatic plants; the shoreward region of a water body; in marine environments the tidal zone.
log normal distribution	-a distribution in which the logarithm of a parameter is normally distributed.
long ton	-2,240 pounds, as opposed to 2,000 pounds in a short ton.
lotic	-pertaining to flowing waters such as streams and rivers.
LPG products	-Liquid Petroleum Gas, commercial petroleum derivatives such as propane, ethane, ethylene, etc.
macrophyte	-any plant that can be seen with the naked, unaided eye; e.g., aquatic mosses, ferns, liverworts, rooted plants.
Mercalli scale	-a 12-point scale for classifying the magnitude of an earthquake.
meteoric water	-water which occurs in or is derived from the atmoshpere.
mg	-milligrams - 1/1000 of a gram.
mg/l	-milligrams per liter.
Miocene	-the time span from 12 to 26 million years ago characterized by the development of large mountain ranges (the fourth epoch of the Tertiary Period).

Moh scale -an empirical hardness scale related to standard minerals:

	MINERAL	COMMON EQUIVALENTS
10.	Diamond	
9.	Corundum	
8.	Topaz	Hard File
7.	Quartz	Penknife
6.	Orthoclase	Window glass
5.	Apatite	Teeth
4.	Fluorite	
3.	Calcite	
2.	Gypsum	Fingernail
1.	Talc	

The steps between various minerals are by no means equal, e.g., diamond is about ten times as hard as corundum, whereas corundum is only about 10% harder than topaz.

monocline -strata that dip for an indefinite or unknown length in one direction and which do not apparently form sides of hills or valleys.

-a step-like bend in otherwise horizontal or gently dipping beds.

MSL -Mean Sea Level.

N/A -not available or unknown.

NaCL -sodium chloride (salt).

Nekton -macroscopic swimming organisms able to navigate at will (fish, amphibians, large aquatic insects, etc.).

NO_x -Nitrogen Oxides - NO, NO_2, etc.

occluded	-prevents the passage of.
OCS	-Outer Continental Shelf.
OD	-Outer Diameter - in reference to pipe or tubing size.
Org/m^3	-organisms per cubic meter.
overburden	-material of any nature consolidated or unconsolidated that overlies a deposit of useful materials, minerals, coal or salt.
pelagic sediments	-sediments derived from open ocean settling from the shells of unicellular organisms known as foraminifera. The shells are composed of either calcium or silicon. In addition, red clays of land mass origin are also deposited.
permeability	-a rock is said to be permeable if water or other liquids in contact with its upper surface tend to pass through the rock more or less freely to the lower surface. Permeability may be achieved by the rock being either porous or pervious. The essential feature of a bed of permeable rock is that the liquid it contains may be extracted by pumping. Permeability is measured in darcies.
permeability of an aquifer	-the capacity of an aquifer to transmit water under pressure.
pervious	-a rock is said to be pervious if it is permeable by virtue of mechanical discontinuities such as joints, bedding planes, fissures, etc. (e.g., some limestones and some igneous rocks).

pH — -a measure of acidity of a liquid determined by the concentration of hydronium (H_3O^+) ions per mole of liquid. The pH value equals the negative logarithm of the hydronium concentration. A hydrogen ion concentration of 10^{-7} equals a pH of 7. The scale has a range from 1 to 14 with values below 7 indicating increasing acidity, and values above 7 indicating increasing alkalinity.

photosynthesis — -the metabolic process by which simple sugars are manufactured from carbon dioxide and water by plant cells using light as an energy source.

piercement dome — -a salt dome in which the salt core has broken through the overlying strata until it reaches or approaches the surface.

piezometric surface — -an imaginary surface that everywhere coincides with the static level of the water in the aquifer.

pimple-mounds — -small rounded circular elevations 15 to 30 feet in diameter and 2 to 6 feet in height.

Pleistocene — -a time span from 1 to 2 million years ago characterized by 4 ice ages in North America (the earlier of the 2 epochs comprised in the Quaternary Period).

Pliocene — -latest epoch of the Tertiary or the corresponding system of rocks.

porosity	-A rock is said to be porous if it possesses cavities between the mineral grains making up the rock which can contain liquid. The term porosity ratio' or simply porosity is given to the percentage of void space that a rock contains. Porosities of sedimentary rocks range from less than 1% to more than 50%; sandstones from 5% to 15%; loose sand and gravel may reach 45%; while clays, which are exceedingly porous rocks, sometimes reach 50% porosity. (Porous rock is not necessarily permeable.)
ppm	-parts per million.
ppt	-parts per thousand.
product	-refined petroleum products.
psi	-pounds per square inch - pressure measurement.
psig	-guage pressure in pounds per square inch and including pressure of atmosphere, as opposed to absolute pressure (psia) pressure measure with respect to zero pressure.
raw water	-As used in this report, raw water is that water used for cavity leaching or oil displacement.
re-entrant	-re-entering or directed inward as a re-entrant angle in a coastline or any indentation in a land form, usually more or less angular in character.
revetment	-a facing made on a soil or rock embankment to prevent scour by weather or water.

rose (wind rose)	-a graphic illustration of wind speed and direction related to percent frequency of occurrence.
rotifer	-a phylum of minute, multicellular aquatic organisms which possess a wheel-like bank of cilia at the anterior (oral) end.
saline	-water containing a significant quantity (>.3 ppt) of dissolved natural salts of sodium, magnesium, etc.
senescent	-the study of the biological changes related to aging.
sonar	-a system that uses underwater sound, at sonic or ultrasonic frequencies, to detect and locate objects in water.
sonar caliper survey	-a technique for measuring internal configurations of a cavity.
standard elutriate	-the supernatant resulting from the vigorous 30 minute shaking of one part of bottom sediment with 4 parts water (on a volumetric basis) collected from the same sample site, followed by a 1-hour settling time and appropriate 0.45 microns (μ) filtration.
stomata (plural of stoma)	-a small opening or pore in a surface.
strike	-The course or bearing of the outcrop of an inclined bed or structure on a level surface; the direction or bearing of a horizontal line in the plane of an inclined stratum, joint, fault cleavage plane or other structural plane. It is perpendicular to the direction of the dip.

substrata	-a layer or stratum of earth or rock lying immediately under another.
surge tank	-a storage tank which serves to keep the pumping rate/pressure through a pipeline constant by storing excess or providing a surplus when the rate of pumping 'surges' up or down, respectively.
suspended particulate matter (particulates)	-Any finely divided solid and/or liquid matter which does not settle from the ambient air.
suspended solids	-a direct measurement quantifying the actual amount of particulate material in the water.
sweet crude	-crude oil with a low sulfur content.
tectonic	-of, pertaining to, or designating the rock structure and external forms resulting from the deformation of the earth's crust. As applied to earthquakes, it is used to describe shocks due to volcanic action or to collapse of caverns or land slide.
Tertiary	-the period of time extending from 65 million to 2 to 3 million years ago.
thalweg	-a line joining the deepest points in a channel.
throw	-the amount of vertical displacement as a result of faulting.
TKN	-total Kjeldahl nitrogen (sum of free ammonia and organic nitrogen compounds).
toxaphene	-organic compound, $C_{10}H_{10}Cl_8$, a toxic, waxy, amber solid, with mild chlorine-camphor smell, soluble in organic solvents, melts at 65-90°C. Used as insecticide (also known as technical chlorinated camphene).

transmissibility, coefficient of	-the rate of flow of water in gallons per day through a vertical strip of the aquifer 1 foot wide extending through the vertical thickness of the aquifer at a hydraulic gradient of 1 foot per foot and at the prevailing temperature of the water. The transmissibility from a pumping test is reported for the part of the aquifer tapped by the well.
turbidity	-a measure of the amount of light that will pass through a liquid. It describes the degree of opaqueness produced by suspended particulate material.
turbidity plume	-a localized area of suspended sediments often associated with dredging operations that reduces the amount of light penetration through the water in that localized area.
Vol.	-volume.
vuggy porosity	-porosity due to vugs in calcareous rock.
vugs	-cavities often with mineral linings different in composition from the surrounding rock.

☆ U. S. GOVERNMENT PRINTING OFFICE : 1976--226-337