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Final Environmental Impact Statement
(Final Supplement to FEA FES 76/77-6)

STRATEGIC PETROLEUM RESERVE

Bryan Mound Salt Dome
Brazoria County, Texas

United States
Department of Energy

DECEMBER 1977

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Department of Energy

Responsible Official:

James L. Liverman
Acting Assistant Secretary for Environment

DECEMBER 1977

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SUMMARY

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

(X) Supplement to a Final Environmental Statement

PREPARED BY: The Strategic Petroleum Reserve Office, U.S. Department of Energy

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

2. Brief Description of the Proposed Action:

On January 7, 1977, the Federal Energy Administration issued a Final Environmental Impact Statement (EIS) for the development of the Bryan Mound salt dome as a storage site for the Strategic Petroleum Reserve (FES 76/77-6). On October 1, 1977, the U.S Department of Energy was created and the programs of the Federal Energy Administration were transferred to the new Department. As such, this final supplement is being issued by the Department of Energy. The salt dome is located in Brazoria County, Texas. The original brine disposal and water supply systems proposed in the EIS depended upon the ability of Dow Chemical Company to dispose of brine during filling operations by utilizing it as a chemical feedstock and to provide water during withdrawal operations from private reservoirs. Since the EIS was published, it has been determined that this arrangement would be inadequate to meet the long term requirements for filling and withdrawing oil at the site, although the disposal of brine to Dow Chemical would be utilized to the maximum extent possible. Therefore, on July 15, 1977, a Draft Supplement to FES 76/77-6 was issued addressing the environmental impacts of construction and operation of two types of brine disposal systems and a new water supply system. The first brine disposal system would include a brine pit, pipeline and deep injection well field to the northeast of the site. The second would include a pipeline to a diffuser located in the Gulf of Mexico. The water supply system would include a water intake structure on the Brazos River Diversion Channel and a pipeline to the site. This final supplement addresses the brine injection well system and the water intake system. A separate final supplement will be issued addressing the construction and use of the brine diffuser system.

3. Summary of Environmental Impacts and Adverse Environmental Effects

This final supplement assesses the environmental impacts caused by the construction and operation of the newly proposed system. The difference between the new and original proposals can be analyzed in terms of three (3) system components: (1) the brine pit; (2) the new brine pipeline and the injection wells; (3) the water intake structure and the pipeline from the intake structure to the site.

Construction of this new system component would cause temporary disruption to land use, water quality, air quality and terrestrial and aquatic ecology. The new facilities would permanently change 17 acres of land from its present use.

Operation of the systems would have relatively small, short-term impacts. Use of the brine surge pit could adversely effect air quality by emitting hydrocarbon vapors (maximum rate of 51.4 tons per year). Operation of the disposal wells would increase the salinity of an already saline aquifer. All operational impacts would be relatively minor and short-term, occurring only during periods of fill or withdrawal of the storage facility.

4. Alternatives Considered:

Alternative Injection Well Locations

Complete Retention of Brine

Alternative Injection Well Pipeline Alignment

5. Comments on the Draft Supplement were received from the following:

Department of the Army

Department of Commerce

Energy Research and Development Administration

Federal Power Commission

Texas Parks and Wildlife Department

Dow Chemical Company

Ralph M. Parsons Laboratory

Brownville - Port Isabel Shrimp Producers Association

Port Isabel Shrimp Association

Texas Environmental Coalition

6. Date made available to CEQ and the Public:

The draft supplement was made available to the Council on Environmental Quality and the Public in July, 1977. This final supplement was made available to the Council on Environmental Quality and the public on December 2, 1977.

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1. DESCRIPTION OF PROJECT

1.1 BACKGROUND

This document is the final supplement to the environmental impact statement (EIS) for an underground crude oil storage facility at the Bryan Mound Salt Dome (FES 76/77-6) located in Brazoria County, Texas. It addresses the construction and use of a water intake system and a network of up to five (5) injection wells for brine disposal. A separate final supplement will be issued addressing the construction and use of a brine diffuser system in the Gulf of Mexico. The storage facility at the Bryan Mound Salt Dome is part of the Strategic Petroleum Reserve (SPR) program currently being implemented by the Department of Energy (DOE). The draft supplement which addressed the water intake, the disposal wells and the offshore diffuser, was published by the Strategic Petroleum Reserve Office of the Federal Energy Administration (FEA), now a part of DOE, in July, 1977.

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 the three years of an Early Storage Reserve (ESR) of 150 million barrels (MMB) as the initial phase of the SPR to provide early protection from near-term disruptions in the supply of petroleum products.

On February 16, 1977, the SPR Plan was transmitted to Congress as Energy Action No. 10. The Plan described the manner in which the Program was to be implemented. As an amendment to the Plan, an acceleration of the development schedule became effective under Energy Action No. 12 on April 18, 1977. Whereas the Act required the attainment of an ESR volume of 150 MMB in storage by the end of 1978 and an SPR of 500 MMB in storage by the end of 1982, the present accelerated schedule has established new targets of attaining 250 MMB by the end of 1978 and 500 MMB by the end of 1980. In addition, a second amendment to the Plan proposing expansion of the SPR to one billion barrels is currently in preparation. These initiatives are an integral part of the President's National Energy Plan Plan and represent a major effort to provide the U.S. with protection against the consequences of a severe petroleum supply interruption as soon as practical.

A final programmatic environmental impact statement (FES 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 December 16, 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 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.

The Bryan Mound final EIS (FES 76/77-6) was made available to the Council on Environmental Quality and the Public on January 7, 1977. That document reflects the design of the facility at the time of publication. That design included disposal of the brine produced during the filling of the cavities through utilization by the Dow Chemical Company as feedstock in nearby petrochemical plants, and use of freshwater from the Dow reservoirs for displacement of the oil during the withdrawal cycle. Since that time, the Dow Chemical Corporation at Freeport has declined to accept brine at the rate originally planned, or to provide the reservoir water required to displace the oil. Therefore, DOE proposed in the July draft supplement to augment Dow's brine disposal capabilities with a dual system comprised of deep brine injection wells and an offshore brine diffuser in the Gulf of Mexico, and to replace the Dow reservoir water source with a water intake system to be constructed on the Brazos River Diversion Channel adjacent to Bryan Mound site. This final supplement addresses only the relocated water intake structure and the brine injection wells. The offshore diffuser will be addressed in a separate final supplement which will be published at a later date.

This final supplement discusses only those immediate areas which would be impacted by the construction and operation of the water intake structure and brine disposal wells. It does not affect the DOE decision to select Bryan Mound for use in the SPR. This decision to select was made subsequent to the end of the 30-day "no action" period for the Final Environmental Impact Statement (FEA 76/77-6).

The supplement is divided into eight sections; Section-1, Introduction; Section-2, Description of the Existing Environment; Section-3, Environmental Impacts; Section-4, Probable Impacts Which Cannot Be Avoided; Section-5, Relationship Between Local and Short-Term Uses of the Environment and Enhancement of Long-Term Productivity; Section-6, Irreversible or Irretrievable Commitments of Resources; Section-7, Alternatives to Proposed Action; Section 8; List of Agencies and Organizations Contacted, Consultation and coordination with others; and four appendices delineated as A, B, C and D.

The bibliography is numbered sequentially on a section-by-section basis and follows Section-B.

1.2 PROPOSED ACTION

As explained in the draft supplement, Dow has agreed to accept brine displaced by SPR oil at the rate of 56,500 barrels per day. The Bryan Mound facility is currently being filled at or near this rate. However, Program fill schedule requirements dictate that all efforts be made to substantially increase the brine disposal capability at Bryan Mound in the immediate future. Therefore, since diposal via injection wells could be implemented within a much shorter time period than disposal via an offshore diffuser, DOE is proceeding in a manner which will allow a decision to be made concerning the construction and use of disposal wells at the earliest possible time. Inasmuch as laboratory analyses are still proceeding which could affect a decision concerning the offshore diffuser, this document addresses only the relocation of the water intake structure and the injection wells (see Figure 1). At the end of the 30-day "no action" period, DOE will decide whether to construct two (2) of the proposed five (5) wells. These wells, in conjunction with the utilization of brine by Dow would provide for a total brine disposal capacity of approximately 120,000 barrels per day. The oil transfer system for the facility should be ready to accept oil at this rate early in 1978. Fill could be maintained at this rate until such time as the final supplement addressing offshore disposal is published, and a decision can be made concerning the diffuser. Whether any or all of the additional three (3) wells would be constructed will depend on the degree to which overlapping capacity would be needed to provide an efficient system with sufficient flexibility to satisfy the maximum disposal requirements under all operating conditions. This will in turn depend on such factors as; the disposal rate required when the maximum fill rate for the facility is reached disposal rates achievable by the wells, any operating conditions or limitations which may be prescribed for the diffuser as a result of the permitting process, and the willingness of Dow to continue the agreement to accept brine. However, this document addresses a maximum of five (5) wells, in the event it is determined that all are needed.

1.2.1 Raw Water Intake System

The proposed water intake system would provide the raw water supply for the displacement of oil during the oil withdrawal phases, for possible inter-cavern transfers, for hydrostatic testing and for brine purging.

The raw water supply intake structure as illustrated in Figure 2 would be constructed on the river side of the Velasco Drainage District East Bank Levee immediately west of Bryan Mound. The total system would contain a riprapped entrance channel, bar trash racks, automatically washed screens, five lift pumps, and a 36 inch diameter pipeline to the main cavern injection pumps. The draft supplement indicated that a centrifugal desander and a desilting pond might be necessary to control sediment in the water. However, a closer examination has shown that none will be needed, since all sediment will settle out while the water (now brine) is in the cavern. The entrance channel would allow

Figure 1 BRYAN MOUND REVISED FRESHWATER INTAKE AND BRINE DISPOSAL SYSTEMS LOCATIONS

sedimentation of the coarser fraction of suspended sediment, because of the low flow rate of less than one-half foot per second under maximum intake volumes at low tidal elevations. The intake structure and entrance channel would not interfere with channel transportation facilities. Debris and flotsam would be controlled by trash bars and intake screens. Effluent from the washing of the intake screens would be returned directly to the Brazos..

Solid waste and effluent streams would be controlled to avoid unfavorable on-site or off-site impacts or nuisances. Detailed plans and construction procedures for pipeline crossings and proposed structures at the flood protection levee system would be coordinated with the Velasco Drainage District to insure the integrity of the levee system is maintained. The pumps and mechanical would be located above the 100 year storm surge estimated to be 12 feet above sea level.[1] Utilization of raw water for the project would not be required in the event of a hurricane or other very severe storm because oil transfer operations would be halted.

The raw water intake facility has been designed to provide water at a maximum rate of 71.3 cubic feet per second (1,100,000 barrels per day-BPD). The intake rate would be only 25 cubic feet per second (385,000 BPD) during displacement of oil from the existing caverns at the Bryan Mound complex. However, the Department of Energy is currently examining the possibility of creating additional storage capacity through solution mining of new caverns at five (5) salt domes, including Bryan Mound, in this general area. Each of the five (5) sites would use the intake system described herein. An EIS (DES 77-10) was issued in September 1977 which considers all five (5) alternatives.

The water intake system would require an area of 120 by 130 feet (for the entrance channel and related facilities) on the river (west) side of the levee. This area will remain in permanent use for the duration of the project. Spoils from the dredging of the inlet channel would be removed by truck and deposited in a nonwetland area onsite.

1.2.2 Brine Pond and Disposal Wells

A fully lined 100,000 barrel pond would be constructed to provide a surge capacity and allow for the settling of any suspended solids. Retention time in the pond would be 16 hours during the initial oil fill. A brine surge tank made from an existing water tank on the site was

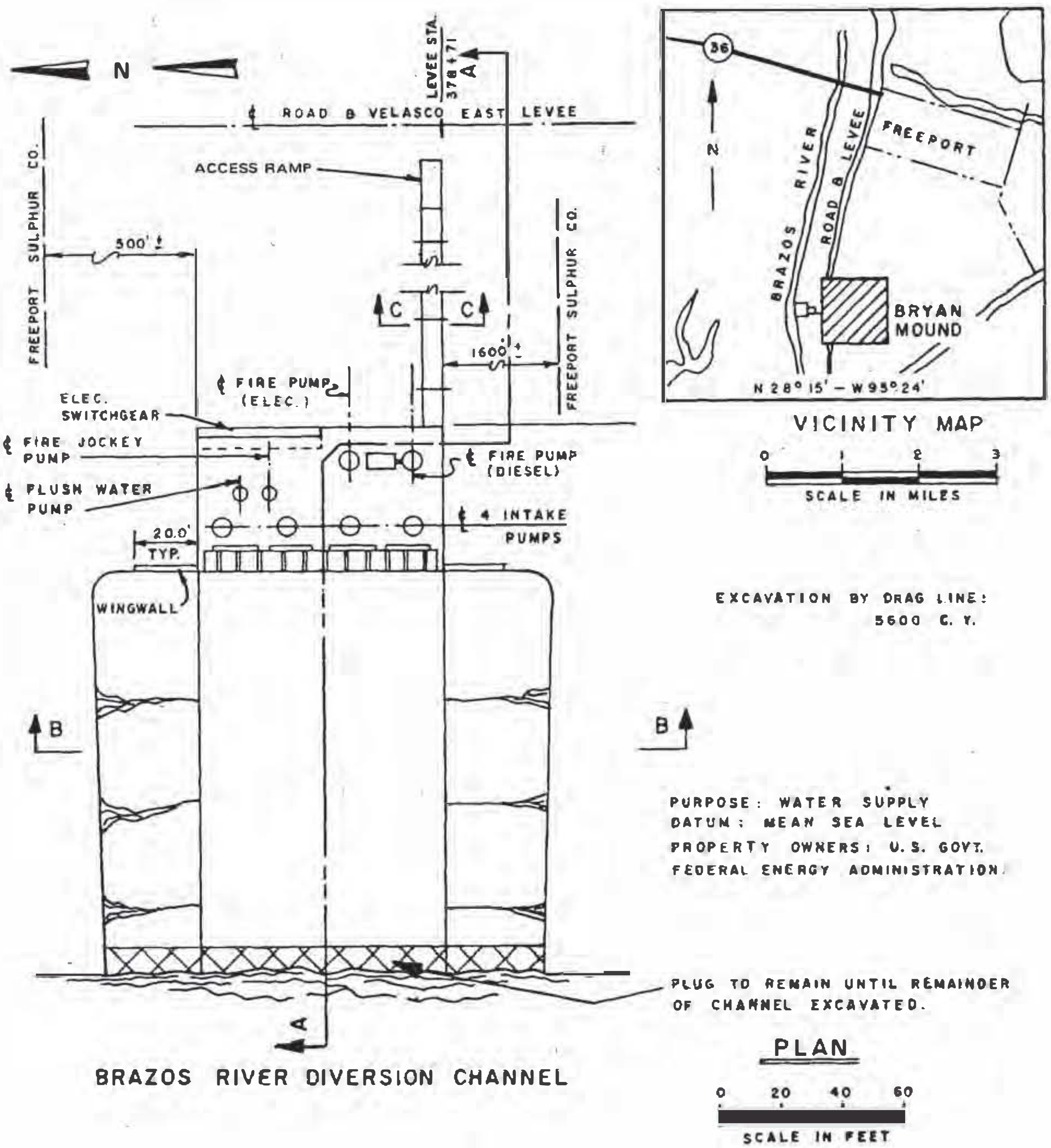
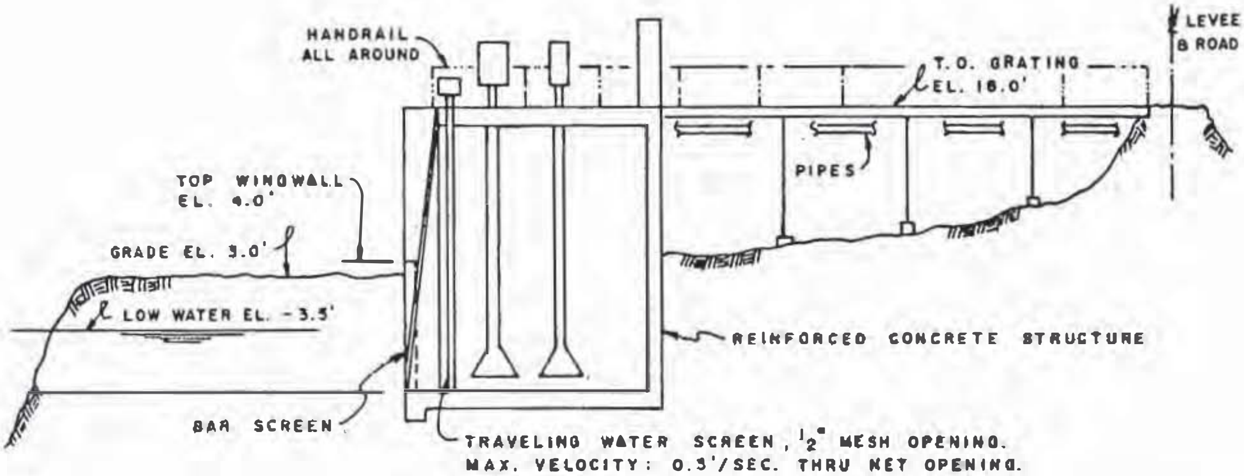
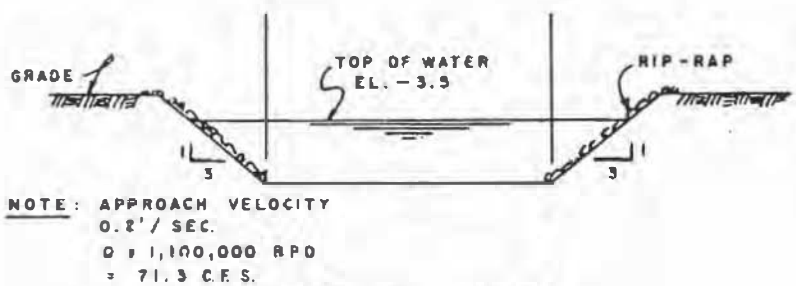


Figure 2 CONCEPTUAL WATER INTAKE STRUCTURE AT BRYAN MOUND



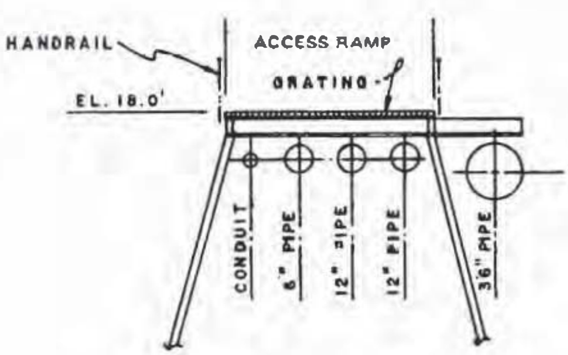
SECTION A-A

N. T. S.



SECTION B-B

N. T. S.



SECTION C-C

N. T. S.

Figure 2 CONCEPTUAL WATER INTAKE STRUCTURE AT BRYAN MOUND (Cont'd.)

thought to be a practical facility to provide for initial fill surges. An engineering analysis of the tank indicated it could not accommodate the expected stresses consequently the surge tank proposal has been eliminated.

The proposed deep well brine injection field would be located approximately one mile east of Bryan Mound. The conceptual system as illustrated in Figure 1, would consist of a 20-inch brine pipeline and up to five (5) injection wells. The brine pipeline would parallel the DOE 30-inch oil pipeline eastward until it crosses Route F.M. 1495 where it would proceed northward to the well pad locations shown on Figure 1. The brine pipeline would make two crossings of Route F.M. 1495 and one of County Road 242 prior to reaching the most distant well, number four. Four of the five well pads would be located approximately 200 to 250 feet east of Route F.M. 1495, while the fifth pad (No. 4) would be located north of Route F.M. 1495, as shown in Figure 1. Pad spacing would allow for approximately 1000 feet between centers.

Two methods of well construction are currently being studied. The first is conventional vertical drill holes, which would necessitate separate pads for each well. Using this method five (5) well pads would be required as shown in Figure 1. Alternatively, directional drilling could be utilized with two or more drill holes located on a pad. Using this method, well pads No. two (2) and five (5) would be eliminated and well pads No. three (3) and four (4) could contain one or two directionally drilled wells in addition to a single vertical hole. For impact analysis the five (5) well or well pad array has been assumed to present the worst case scenario. However, it should be noted that with directional drilling the area of surface impact would be decreased due to the reduction in the number of pads.

The areal extent of each pad is approximately two acres. The specific geometry of each site will vary somewhat depending on property acquired and the number of wells drilled from each pad. A dual lane roadway will connect the well pad to the adjacent public roads. A typical well pad design is illustrated in Figure 3. The geometry of a specific pad may differ from the illustrated design which is diagrammatic.

Each injection well would be designed to accommodate disposal of 30,000 barrels of brine per day. Preliminary Geological studies of the area indicate that a favorable Miocene sand section exists below the minus 4000-foot contour. The specific well designs and completions

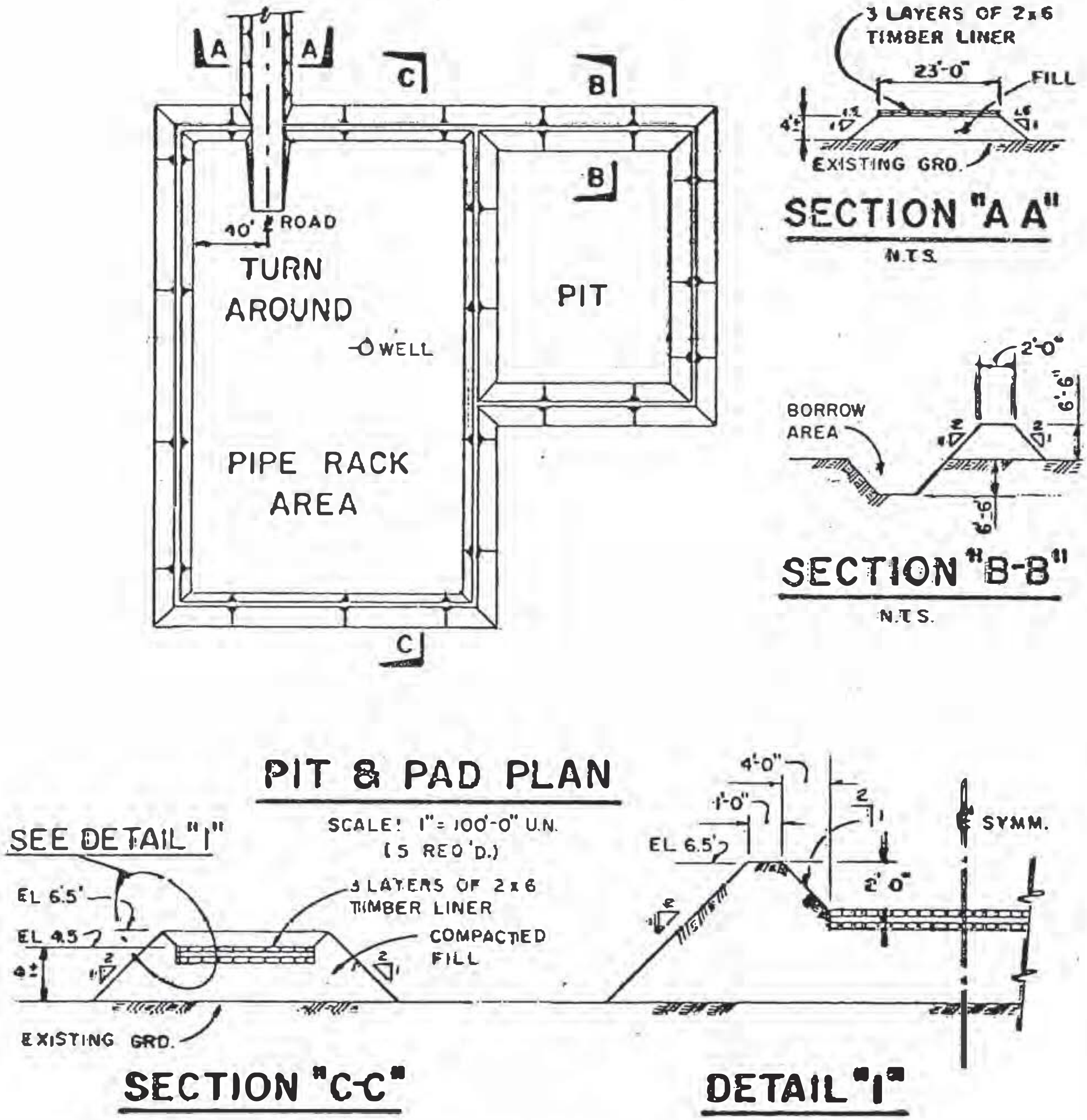


Figure 3 CONCEPTUAL BRINE DISPOSAL WELL GRADING PLAN

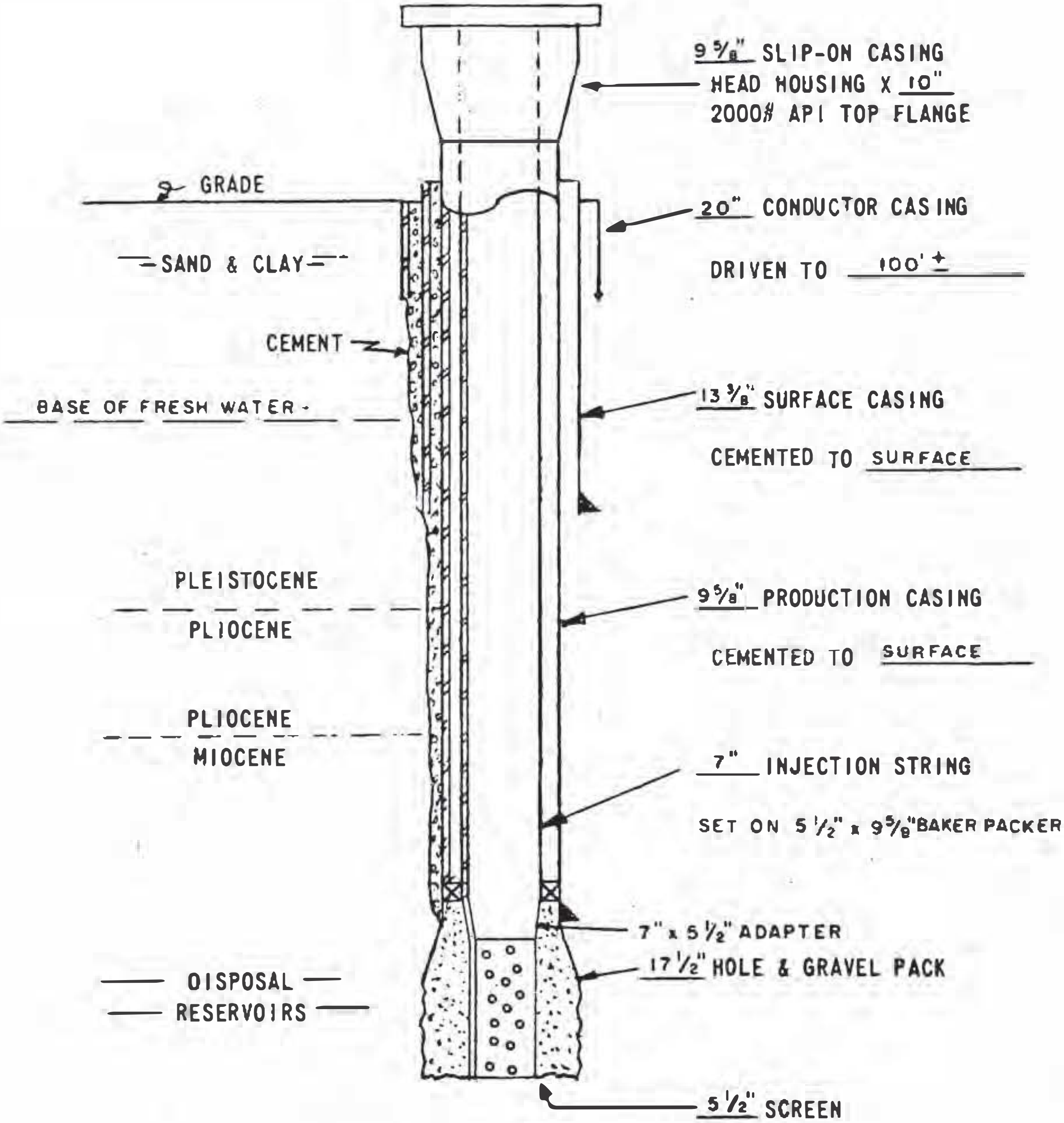


Figure 4 TYPICAL CASING PROGRAM FOR THE BRYAN MOUND BRINE DISPOSAL WELLS

would be formulated following drilling and comprehensive testing of an exploratory well from one of the pads. The test program results would be used to determine: the specific injection zones; drilling, casing, and packing methods to be employed. A typical well casing, cementing and screen design is illustrated in Figure 4. Injection wells employing this design are presently being used satisfactorily at the West Hackberry SPR site for the disposal of brine in Miocene sands.

2. DESCRIPTION OF THE EXISTING ENVIRONMENT

2.1 INTRODUCTION

The Bryan Mound site as shown in Figure 1, is located on the Texas Gulf Coast on the delta of the Brazos River. Bryan Mound was formed by the vertical movement of cylindrical salt stock which created a surface caprock domal expression gently rising to approximately 20 feet above the surrounding marsh. Over a period of geological time the Brazos River has washed around this structure and formed the composite marsh area surrounding the site. In recent times, the combination of resource development and agriculture have altered the natural setting. The salt, sulphur and petroleum resources of the area have been developed and cattle graze around the mound area. The construction of the Intracoastal Waterway, drainage ditches, and reservoirs have drastically altered the terrestrial and estuarine environment in the Bryan Mound area.

A complete description of the existing environment for the general area encomoassing Bryan Mound was presented in the Final Environmental Impact Statement FES 76/77-6 and for the sake of brevity is not repeated in this report. The description of the environment presented in this supplement discusses only those immediate areas which will be impacted by the construction and operation of the following newly proposed systems for the Bryan Mound facility:

- A raw water intake system on the Brazos River Diversion Channel.
- A series of five deep injection wells located approximately 9000 feet east of the mound with a connecting pipeline from the mound.

The information in this section is organized to provide the following information concerning the newly proposed systems of the Bryan Mound Project:

2.2 Physiography
2.3 Geological Resources
2.4 Soils
2.5 Terrestrial
2.6 Air Environment
2.7 Brazos River Diversion Channel
2.8 Land Use
2.9 Aesthetic and Environmentally Sensitive Areas
2.10 Archaeology and Historical Resources

2.2 PHYSIOGRAPHY

The Bryan Mound study area is located within the Gulf Coastal Plain Physiographic Province.[1] It is characterized by flat featureless plains which have poor drainage, and marshes which vary in size because of man-made interruptions and natural barriers. These marshes ultimately drain into the Gulf of Mexico.

Elevations vary from sea level to about 5 feet over the major portion of the area. Sand dunes, spoil deposits, and levees reach elevations of approximately 10 feet, and Bryan Mound, the highest elevation in the area, is approximately 20 feet above sea level.

Spoil deposits occur mainly along the southern edge of the Intracoastal Waterway. Levees protecting the Bryan Mound area parallel the Brazos River Diversion Channel to the west and the Intracoastal Waterway to the east. These levees form a portion of the flood protection control system operated by the Velasco Drainage District. Recently deposited sand dunes parallel the shoreline along the Gulf of Mexico.

2.3 GEOLOGICAL RESOURCES

The lower Miocene Oakville sands have been pierced by the salt at Bryan Mound (Fig. 5). The sands sink toward the Gulf along non-seismic faults which diminish seaward in deep mud. The deep sands are separated from the overlying fresh-water sands at the site by a 580-foot layer of middle Miocene shale. This formation, indicated in the well logs of Greenbrier Bryan #1 well (located 4700 feet southwest of the proposed injection field, Fig. 5), is composed of compacted shales, sand and

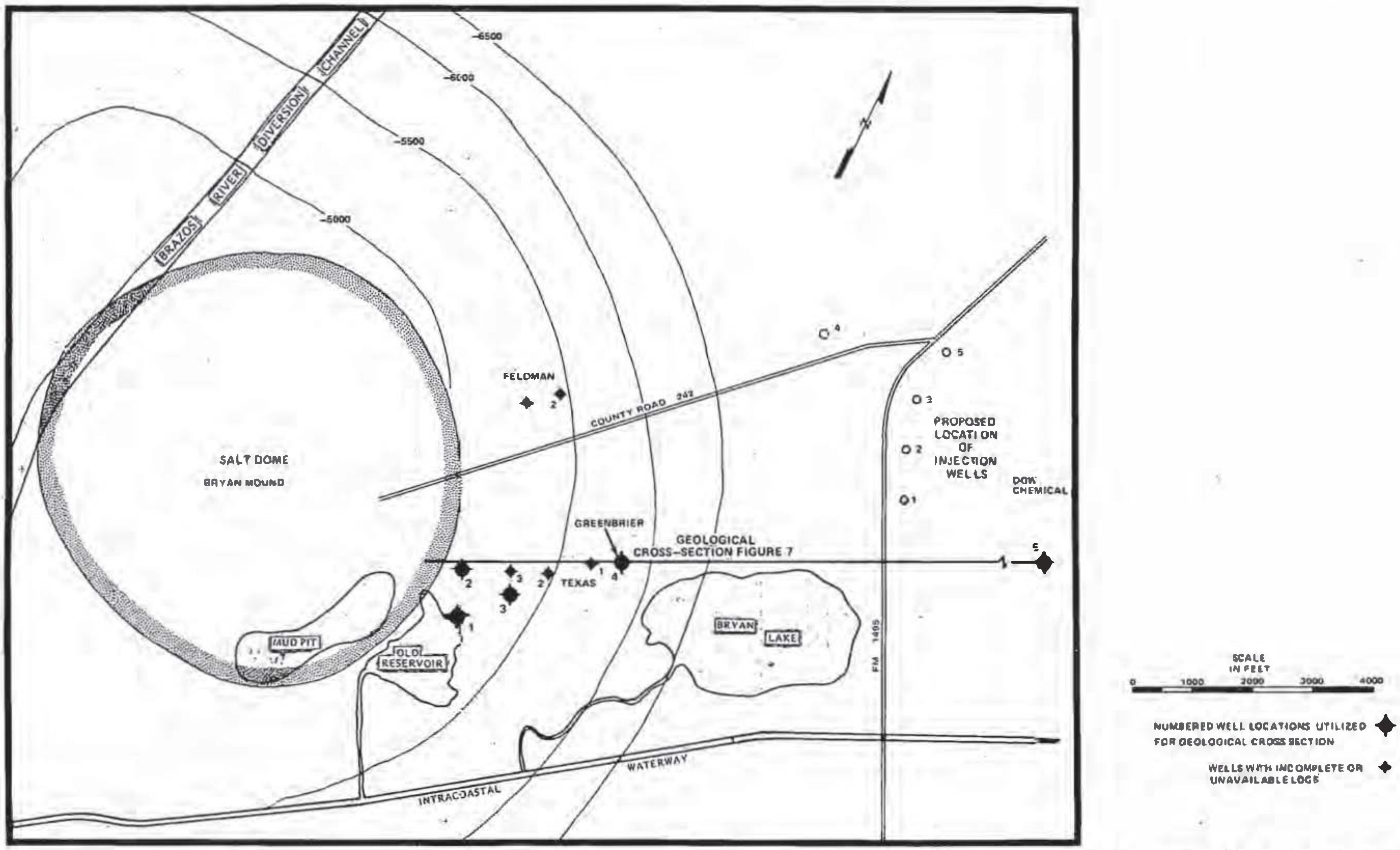


Figure 5 STRUCTURE MAP ON BASE OF MIOCENE

ADAPTED FROM Peppard-Souders & Associates Petroleum Consultants

Table 1
CHEMICAL ANALYSIS OF BRYAN MOUND BRINES

CAVERN NUMBER SAMPLE DATE	C–5 (A) 1/4/77	C–5 (B) 9/30/77	C–1 (B) 9/29/77	C–2 (B) 9/29/77	C–2 (B) 10/6/77	C–2 (B) 10/20/77
SALINITY (g/l)	305	316	318	317	317	318
MAJOR CONSTITUENTS (mg/l)						
Na	117,600	123,802	124,623	124,097	124,037	124,287
K	296					
Ca	720	235	280	305	310	280
Mg	9.2	14	33	31	32	26
Cl	184,100	198,067	191,245	190,174	190,030	190,531
SO_4	1,960	2,000	2,300	2,700	2,600	2,350
MINOR CONSTITUENTS (μg/l)						
Cd	< 2	3	8 *	3	2	N.D.
Cr	< 2	N.D.	N.D.	N.D.	N.D.	N.D.
Cu	2	N.D.	3,920 *	N.D.	N.D.	140
Pb	2	N.D.	N.D.	N.D.	N.D.	N.D.
Hg	< 0.2	N.D.	N.D.	N.D.	N.D.	N.D.
Ni	2	N.D.	N.D.	N.D.	N.D.	N.D.
Zn	80	N.D.	90 *	N.D.	30	30
Ba	< 400	800	800	900	700	N.D.
Fe		1,350	8,200	900	1,200	1,000
Mn	100	60	130	70	30	10
Se	< 2					
Ag	< 10					
As	2					
Sb	< 2					

Footnote: A. Brine analysis conducted by U.S.G.S., National Water Quality Laboratory, Denver
B. Analysis of a referee brine sample conducted by DOE
N.D. Not detected (detection limits not available)
* Contamination suspected from sampler equipped with brass seals.

clay. The shale forms an effective aquiclude between the highly saline water of the Oakville sands and the overlying slightly saline water of the Evangeline Aquifer.

The lower Miocene Oakville sands are saline aquifers throughout Brazoria County.[1] Thus they are considered suitable for deep-well disposal by the Texas Water Quality Board (1977).[2] They have been successfully used since 1942 for disposal of wastes by Dow Chemical in a well located to the northeast of the mound. The Miocene sand section is also indicated in the Dow injection well logs. Operations of the Dow injection well indicate that no environmental impacts have resulted from the operation of the facility.

Well logs for the Bryan Mound area indicate that some of the thinner sands show evidence of originally trapping minor amounts of oil or gas. This indicates that the Miocene section away from the mound does not leak significantly and will provide a suitable aquiclude. The Greenbrier Oil Company Bryan #1 test well logs revealed an excellent sand section and a show of oil in the overlying middle Miocene shale.

All deep-well logs for the immediate vicinity of Bryan Mound indicate that a similar suitable sand injection zone is located at a depth of between 4500 and 5000 feet and overlain with the dense shale which precludes hydraulic contact between the saline aquifers and the overlying Evangeline aquifer which is used for potable water supplies.

The cross section (Figure 6) shows the structural position of the Miocene Oakville sands from the salt dome to the Dow Chemical injection well. At the location proposed for brine disposal (between the Greenbrier and Dow wells on Figure 6) the sands are over 4000 feet deep and separated from all other aquifers by thick shales. The available subsurface data (most of which on the east side is included in the cross-section) gives no indication of faulting or other disturbance away from the piercement salt.

2.3.1 Chemical Composition of the Brine from Bryan Mound

Salt exhibits a unique combination of characteristics which make it an ideal mineral for creation of a cavern for hydrocarbon storage. It is generally impervious to oil and gas, has a compressive strength comparable to concrete, moves plastically to seal fractures or voids, and can be easily mined by dissolving with water.[1]

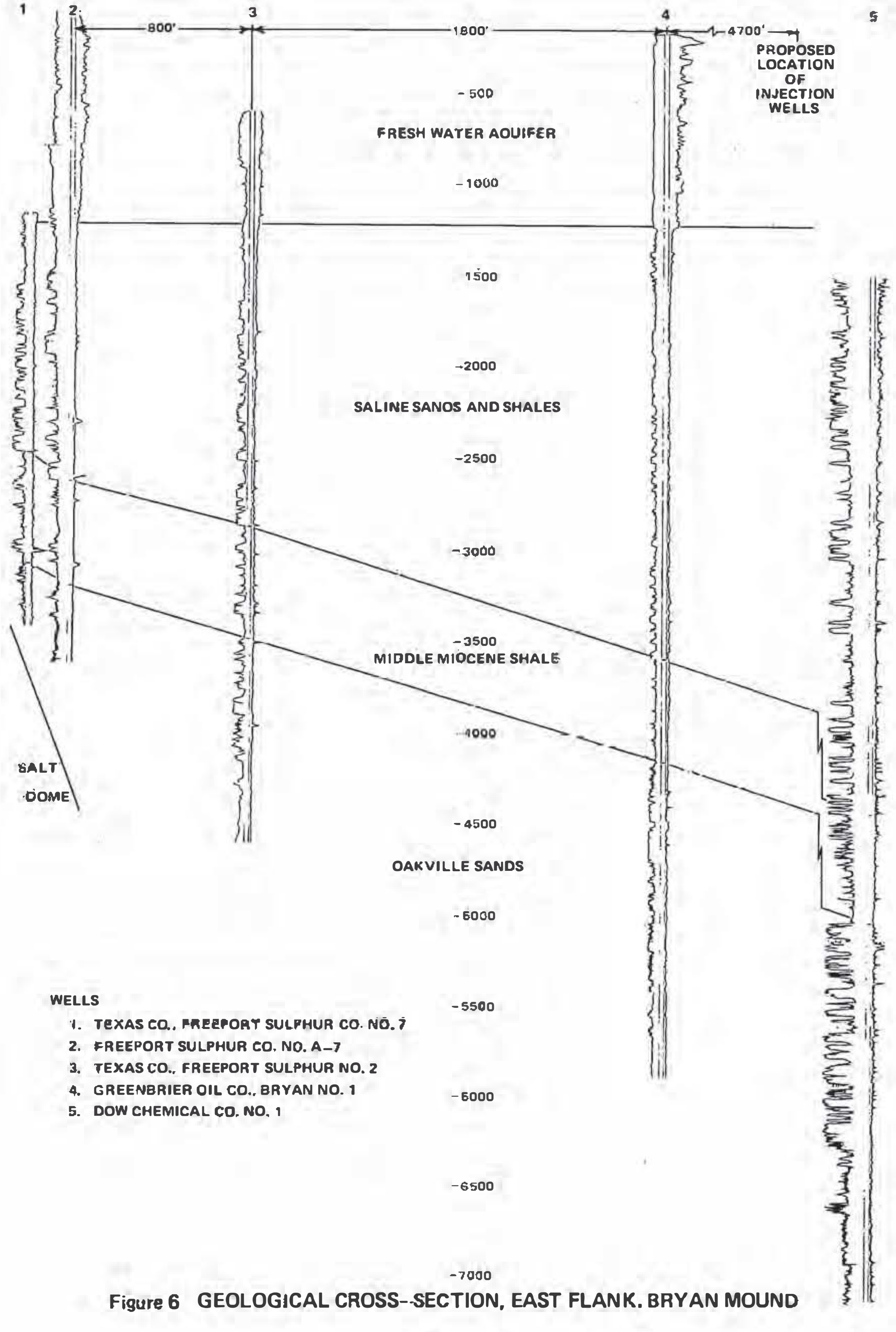


Figure 6 GEOLOGICAL CROSS-SECTION, EAST FLANK, BRYAN MOUND

A brine sample was collected from Bryan Mound Cavern 5 in January, 1977, and analyzed by the U.S. Geological Survey, National Water Quality Laboratory, Denver. After an agreement was consummated between DOE and Dow, a joint program was initiated in September, 1977, in which referee brine samples are periodically collected and analyzed by DOE and Dow. Chloride is determined by classical Mohr titration. The remaining ions are determined by the appropriate standard spectrophotometric methods of of USGS, ASTM, and EPA. Salinities are calculated by summing the major constituents. Results are given in Table 1.

Data obtained to date verify that about 99 percent of the salt is sodium chloride, the remainder being principally calcium sulfate. Magnesium is low and variable. Of the minor elements tested, only zinc, manganese, barium, and iron occur in appreciable amounts, and they are variable. Chromium, mercury, selenium, silver, and antimony have been undetectable in all cases. Arsenic, cadmium, copper, lead, and nickel have been either undetectable or at the threshhold of detection. In all cases, the heavy metal concentrations for saturated brine have been well within standards for public drinking water supply intakes. In all samples there have been no weighable suspended solids. This suggests that the caverns act as natural clarifiers in which insolubles settle to the bottom.

The saturation concentration of salt solutions may be expressed several ways. Chemical solubility tables may state that 1000 grams of water will dissolve 357.9 grams of pure sodium chloride at 60°F (15.6°C). This corresponds to 317.2 grams sodium chloride per liter of solution (brine). The specific gravity of a saturated solution at 60°F is 1.204. Therefore, 317.2 g/l sodium chloride solution corresponds to 263.4 parts per thousand (ppt) by weight. Sodium chloride solubility increases significantly with increasing temperature.

Total dissolved solids (salinity) data in Table 1 show that the brines have been saturated or slightly supersaturated with respect to sodium chloride relative to ambient air temperatures with the exception of the January sample from Cavern 5 which was 96 percent saturated. In the latter case, Cavern 5 was in active brine production at the time. Until initiation of the joint DOE-Dow testing program, Cavern 1 had been shut-in for a number of years and Cavern 2 had been idle for a number of years. These results suggest that displaced brine will be saturated at about 317 g/l (264 ppt) during initial cavern fill and will probably be saturated during succeeding refills.

2.4 SOILS

This section discusses the soils that will be encountered by the construction of the brine pipelines to the deep well injection system.

The proposed brine pipeline (Fig. 7) to the deep well injection system will follow the roadway/levee from Bryan Mound eastward and crossing Highway 1495. It will then turn north and follow the highway to the site of the injection wells near the juncture of Highways 1495 and 288.

The soils in the Bryan Mound area have developed from unconsolidated sediments of late Pleistocene and Holacene age. The Pleistocene alkaline marine clays of the Beaumont Formation are the parent materials for the clayey Lake Charles, Roebuck and Ijam soil series found between Bryan Mound, and the injection well sites.

2.4.1 Soil Orders

The soils that would be encountered by the pipeline are classified into three orders: Vertisols, Mollisols and Entisols. Vertisols have indistinct horizonation and are characterized by having a high clay content; pronounced changes in volume as a function of moisture; deep wide cracks in some seasons; and evidences of soil movement in the form of slickensides and gilgai microrelief. Vertisols are represented by the Lake Charles soil series of the subgroup Typic Pelluderts. Mollisols characteristically have formed under grassland vegetation and have a soft dark colored surface horizon (mollic epipedon). This order is marked by a dominance of calcium in the A and B Horizons and crystalline clay materials of moderate to high cation-exchange capacity. Mollisols are represented by the Roebuck soil series of the subgroup Vertic Hapludolls. Entisols are represented by the Ijam soil series. These soils are comprised of recently developed flood plain alluvial deposits.

The National Cooperation Soil Survey is currently in progress in Brazoria County, Texas. Unpublished data from the U.S. Soil Conservation service shows the location, description and interpretations for each soil series mapped.

2.4.2 Soil Series

The following soils, illustrated in Figure 7, will be encountered during pipeline construction. The soil stations denoted on Figure 7 are approximate locations along the pipeline route.

PIPELINE STATIONS ARE APPROXIMATE LOCATION (IN FEET) FROM BRYAN MOUND

Figure 7 SOIL SERIES ALONG THE PROPOSED BRINE DISPOSAL SYSTEM

Lake Charles series exists along the first 1,030 feet of the injection well pipeline. It is a member of the fine montmorillonitic, thermic family of Typic Pelluderts. This series consists of deep, slightly acid to mildly alkaline, nearly level to gently sloping clayey soils formed in alkaline marine clays mainly of the Beaumont Formation. They are clayey throughout the profile and when dry form deep, wide cracks on the surface. They are somewhat poorly drained and surface runoff is very slow. Internal drainage and permeability is very slow. The available water capacity of the series is high.

Because of the clayey texture throughout the profile, Lake Charles soils have low strength and high shrink-swell properties which impose severe limitations on building and road construction. They are well suited for cropland, and for native and improved pasture and are easy to revegetate when disturbed.

Roebuck series occur from station 9600 to the terminus at station 14,000 of the injection well pipeline. The Roebuck series is a member of the fine, montmorillonitic, thermic family of Vertic Hapludolls. This consists of deep, slightly acid to mildly alkaline, nearly level clayey soils formed in clayey alluvium for Permian red beds. This series is clayey throughout the profile and the permeability rate is very slow. When dry, deep wide cracks develop to allow rapid water entry until the cracks become sealed.

Roebuck soils have severe limitations for use as building sites and road construction due to the clayey texture throughout the profile and wetness from occasional flooding. Agriculturally, the soil is moderately well suited for cropland, native and improved pasture and will be easy to revegetate when disturbed.

Ijam series extends from station 1,030 to 9600 of the injection well pipeline. It is a member of the fine, montmorillonitic, nonacid, thermic family of Vertic Fluvaquents. Ijam soils are on nearly level planes and concave coastal flats bordering waterways, ditches and canals. The series consists of deep, almost level, clayey soils that are alkaline and saline. These soils formed in alkaline, saline, clayey sediments that were dredged or pumped from the Intracoastal Waterway during its construction.

Ijam soils are clayey throughout the weakly developed profile. When they occasionally dry, temporary cracks form on the surface. They are very poorly drained or ponded. Runoff, internal drainage and permeability are very slow and the available water capacity of this series is moderate.

The Ijam soils are wet and clayey and have low strength and high shrink-swell properties which impose severe limitations on building and road construction. Agriculturally this land is unsuited for cropland or pasture. Adapted wetland and shallow water plants grow in this soil and will naturally revegetate most disturbed areas.

2.5 TERRESTRIAL

The area around Bryan Mound project consists of three ecological communites. The purpose of this section is to describe the existing conditions of these ecosystems. Field investigations were conducted and information recorded on the flora and fauna of the following communities in the Bryan Mound area:

(1) Shrub-Savannah

(2) Coastal Prairie

(3) Marshes and Salt Flats

These communities as illustrated in Figure 8 will be described in the following section. However, before describing the specific communities in detail it will be helpful to discuss the region as a whole.

Bryan Mound lies within the Gulf Coast Prairies and Marshes Resource Area of Texas, as defined by Gould.[2] The Coastal Marsh is characterized by low elevations and is often inundated with Gulf water. The marsh ecosystem occurs in narrow belts or patches separated by Coastal Prairie. The Coastal Prairie ecosystem consists of level grass-covered plain, which is integrated with marsh throughout the Bryan Mound Area. Slight differences in elevation and water level balances account for the mosaic distribution of these ecological communities.

The area has been disturbed by the construction of various facilities by the oil, gas and mineral industries. Dredging has been conducted, especially in the Intracoastal Waterway and Brazos River Diversion Channel. The construction of the levee systems has greatly altered the drainage characteristics which in turn has altered the floral complexes.

Figure 8 TERRESTRIAL COMMUNITIES AT BRYAN MOUND

Table 2
COMMON PLANT COMMUNITIES AND FAUNA OF THE BRYAN MOUND AREA

	MARSH AND SALT FALTS	COASTAL PRAIRIE	SHRUB–SAVANNAH
1. Vegetation	Olney Bulrush Saltgrass Glasswort Saltwort Carolina Wolfberry Smooth Cordgrass	Gulf Cordgrass Western Ragweed Sea–Myrtle	Sea–Myrtle Huisache Prairie Mesquite Hercules Club Gulf Cordgrass
2. Herpetofauna	Gulf Salt Marsh Snake	Western Diamondback Rattlesnake	Western Diamondback Rattlesnake
3. Mammals	Eastern Cottontail Rabbit Hispid Cotton Rat Raccoon Striped Skunk Canid Sp. Opposum Nutria	Eastern Cottontail Rabbit Nutria Hispid Cotton Rat Opossum Canid SP.	Eastern Cottontail Rabbit Hispid Cotton Rat Raccoon Opposum Canid Sp.
4. Birds	Pied–Billed Grebe Great Blue Heron Little Blue Heron Common Egret Cattle Egret Tri–Colored Heron Marsh Hawk American Coot Eastern Meadowlark Seaside Sparrow American Bittern Least Bittern Clapper Rail Red–Winged Blackbird Long–Billed Curlew Waterfowl	Waterfowl Great Blue Heron Little Blue Heron Common Egret Cattle Egret American Bittern Least Bittern Clapper Rail Common Gallinule American Coot Least Sandpiper Boat–Tailed Grackle Eastern Meadowlark Mockingbird Seaside Sparrow Red–Winged Blackbird Turkey Vulture Marsh Hawks	Waterfowl Great Blue Heron Little Blue Heron Common Egret Cattle Egret Blackbirds Sparrows Warblers Thrushes Other Passeriformes

SOURCE: (After Seedock, 1975 and Field Investigations) (4)

2.5.1 Shrub-Savannah

The shrub-savannah community consists of woody plants dispersed throughout a prairie-like understory. The overstory ranges in height from 2 to 6 feet and is composed of sea-myrtle (Baccharis halimiflora), prairie mesquite (Prosopopis glandulosa), and hercules club (Aralia spinosa). Gulf cordgrass is the dominant understory. As a result of over-grazing pressures, the seeds of woody plants were able to germinate and become established. The loss of native grasses and valuable wildlife habitat is of concern, since presently 34 percent of the Gulf Coast is now infested with woody brush.(3)

Avifauna of the shrub-savannah consists primarily of passerines. The availability of perches and nesting sites accounts for this, although valuable and diminishing native prairie supports the waterfowl populations of the area.

Animals found in the area include the western diamondback rattlesnake, the eastern cottontail rabbit, racoon, opposum and canid species. Birds that frequent the area are the great and little blue herons, the common and cattle egrets, blackbirds, sparrows, warblers, thrushes and other passerines. These data are summarized in Table 2 for the disturbed shrub-savannah ecosystem.

2.5.2 Gulf Coast Prairie

The Gulf Coast Prairie is the climax vegetation of inland portions of the Bryan Mound area and is influenced more by elevation than any other factor. The dominant plant species is gulf cordgrass (Spartina spartinae), although western ragweed (Ambrosia psilostachya) is abundant in those areas that are heavily grazed. Prickly pear castus (Opuntia sp.) occurs on drier occurs on drier ground.

Like other communities in the Bryan Mound area, birds constitute the most abundant form of wildlife in the Gulf Coast Prairie. Insectivorous species, such as mockingbirds (Mimus poluglottos), eastern meadowlarks (Sturnella magna), and seaside sparrows (Ammospiza maritima) are common residents of this habitat. Turkey vultures (Cathartes aura) and marsh hawks (Circus cyanens) are abundant in the prairie areas as well as throughout the entire study area. Waterfowl, particularly geese, feed heavily on the prairie vegetation. The herons, egrets, American bittern, clapper rail, common gallinule American coot, least sandpiper, red winged blackbird, and boat-tailed Gackle frequent the area when it is in close proximity to marsh habitat.

The diamondback rattlesnake, eastern cottontail rabbit, nutria, hispid cotton rat, and opposum are found in the area.

Cattle are the largest mammalian herbivores found in this community and probably the greatest consumers at this tropic level. On the basis of track size and pace measurements, a canine (Canid sp.) believed to be a coyote-red wolf hybrid was found to occur in this community.[4][5] Dogs also roam the area.

2.5.3 Marsh and Salt Flats

As illustrated in Figure 8, the brine injection system is located principally in the marsh and salt flat terrestrial community. The brine injection pipeline, after crossing county road 242, is located principally in marsh and salt flats.

Coastal marshes are generally considered to be areas of high organic productivity, forming a nutrient link with the Gulf estuarine ecosystem. The marshes in the area of Bryan Mound may be either brackish or saline, and are periodically inundated with seawater, freshwater runoff, or both. Thus vegetation composition is determined more by salinity than any other factor. Typical plant species of brackish marsh are olney bulrush (*Scirpus olneyi*) and saltgrass (*Distichlis spicata*), while saline marsh and salt flat areas are characterized by smooth cordgrass (*Spartina*). Salt flats occur as transition zones between brackish-saline marsh areas and Gulf Coast Prairie. Salt flats occur around the Bryan Mound salt dome in a mosaic distribution within the Gulf Coast Prairie and Shrub-savannah communities. Plant growth in salt flat areas is limited to a few halophylic species such as glasswort (*Salicornia* sp.), saltwort (*Batis maritina*), Carolina wolfberry (*Lycium carolinianum*), and smooth cordgrass.

The marshes and salt flats are excellent habitat for great blue, little blue and tricolor herons, pied-billed grebe, common and cattle egrets, American and least bittern, American coot, marsh hawk, clapper rail and long billed curlew. Many other birds frequent the area.

The Gulf Salt marsh snake, eastern cottontail rabbit, racoon, striped skunk, canid species, opposum, hispid cotton rat and nutria are common to the area.

Birds, especially waterfowl and wading species, constitute the most abundant form of wildlife in the area as a whole. Although coastal marshes are important over-wintering areas for birds, population levels are greatest during migratory periods.

2.5.4 Freshwater Intake

The freshwater intake system will be constructed on the western edge of Bryan Mound. The inlet channel and associated mechanical gear will be 370 feet long. The inlet channel will lie between the Brazos River Diversion Channel and an existing levee and blacktop road (see Figure 8). This area is actively grazed by cattle and has a history of frequent human disturbance, especially during the construction of the levee and the Brazos River Diversion Channel. The vegetation is characteristic of coastal prairie, salt flats, and shrub-savannah communities.

Greatest wildlife usage in the vicinity of the freshwater intake facilities occurs along the bank of the Brazos River Diversion Channel and on the manmade lagoon system located immediately to the north and west of Bryan Mound Storage Site. The wildlife values are marginal because of the heavy utilization for mining and industrial activities. Waterfowl occur on the lagoon system, as they do on any open water area along the coast. Shorebirds and some passerines also occur in the vicinity of the proposed freshwater intake line; however, their usage of this area is limited because of previous disturbances associated with Bryan Mound and the Levee Road.

2.5.5 Brine Disposal Wells

The 5 brine disposal wells will be located approximately 9000 feet east of the Bryan Mound storage facility and approximately 150 feet east of Highway 1495, as illustrated in Figure 8. The pipeline from Bryan Mound to the wells will be constructed partially within an existing FEA right-of-way, adjacent to a 30 inch crude oil pipeline from Bryan Mound to the dock facilities, as discussed in the Environmental Impact Statement FES 76/77-6. The right-of-way lies on the northern side of the drainage canal that is on the Northern side of the levee (see Figure 8). The entire length of this right-of-way, off Bryan Mound across Highway 1495, is marsh habitat. The marsh area that will be affected by the pipeline and disposal well system already shows signs of unnatural disturbance, as evidenced by the presence of typically shrub-savannah vegetation, a good indicator of disturbance in marsh areas.

Wildlife usage in the proposed disposal well area is heavy. Migratory and overwintering waterfowl and marsh birds are abundant and are attracted to the drainage canal lying between the levee and the proposed route. The maintenance of such open water areas is of great importance to the waterfowl and marsh bird populations. The drainage canal drains into Bryan Lake which ultimately drains into the Gulf of Mexico, thus it is an important link in the nutrient flow from the marsh to the ocean.

2.6 AIR ENVIRONMENT

The principal atmospheric pollutant expected to be emitted during operation of the Bryan Mound facilities will be the hydrocarbon compounds during crude oil transfers or from the brine displaced from the storage caverns as crude oil is injected. The Texas Air Control Board has already classified the area which will include the Bryan Mound project as a Non-Attainment area under EPA regulations. FES 76/77-6 presents data concerning the ambient air quality of the area.

The immediate project area is in compliance with the regulations limiting concentrations of carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and particulates. The project is within the Houston-Galveston Intrastate Air Quality Control Region which has been cited for non-compliance with standards for SO_2 and particulates.

2.7 BRAZOS RIVER DIVERSION CHANNEL

The Brazos River Diversion Channel will be used as the raw water supply for the project's requirements. The dredged Brazos Diversion Channel forms the lower 15 miles of the Brazos Estuary with the upper 9 miles being formed by the original channel of the Brazos River. The Brazos estuary is unique for the Gulf coast region in that it discharges directly into the Gulf and not through delta areas or embayments as is typical of other Gulf coast rivers. This fact provides for rapid freshwater flushing of the system's heavy industrial discharges, but at the same time produces a lack of adequate nursery areas for Gulf marine fisheries in comparison to other more productive areas such as the Matagorda and Galveston estuary systems.

This section describes the lower estuary as defined from the Gulf of Mexico upstream to approximately river mile 12. The proposed intake water facility will be constructed at river mile 2. Elements of this section include, hydrology of the freshwater inputs, and water quality and biological communities within the lower estuary. The water quality description utilizes results of a special sampling program conducted during April and July of 1977, as well as previously published data.

2.7.1 Brazos River Hydrological Data

The drainage area of the Brazos River is approximately 44,500 square miles of which approximately 9240 square miles do not contribute to surface runoff.(1) The stream hydrology is greatly affected by the numerous reservoirs and water withdrawals for municipal, agricultural and industrial uses. Within the watershed are 29 major impoundments. The 1970 consumptive water use within the basin amounted to 297,466 acre feet.(2) The most recent mean monthly flows of the Brazos River at Rosharon, Texas, 25 miles upstream from Bryan Mound, are given in Table 3. This data is the most currently available for the site and is more representative than historical data due to the regulated nature of the watershed's runoff pattern. Maximum, mean and minimum flows recorded at Rosharon are 79,900 cubic feet per second (CFS), 8357 and 40 CFS respectively. The maximum calculated flows at Rosharon are in excess of 100,000 CFS. The expected 2 year mean seven day low flow is 969 CFS.(3)

The Bryan Mound site is located on the eastern bank of the Brazos River Diversion Channel which was dredged in the early 1940's for development of Brazosport. The diversion channel is a straight dredged channel ranging from 18 to 24 feet in depth and 400 to 500 feet in width. At river mile 2 the cross sectional area is about 15,000 square feet where approximate calculations of the maximum flooding and ebbing velocities yield 0.16 and 0.61 feet per second (fps) respectively. Flooding occurs in approximately 8 hours and ebbing in 13.6 hours. Normal tidal excursions range about 1.8 feet in height. Under low freshwater input conditions of 1330 CFS the estimated tidal movement is 5757 CFS.(3) The diversion channel downstream of the Intracoastal Waterway (river mile 0 to 1) has experienced serious shoaling, and the 4 to 5 foot depths are hampering channel traffic.

2.7.2 Brazos Sediment Analysis

The Brazos Diversion Channel carries a large sediment load to

Table 3

MEAN MONTHLY BRAZOS RIVER FLOW RATES ROSHARON, TEXAS

cubic feet/second

	CALENDAR YEAR				
	1971	1972	1973	1974	1975
January	—	7,531	7,761	12,790	11,320
February	—	4,271	9,723	8,348	23,330
March	—	1,856	15,470	3,339	9,036
April	—	641	22,210	1,897	10,020
May	—	8,167	14,620	4,775	22,420
June	—	2,057	27,870	706	22,440
July	—	1,294	6,425	483	8,565
August	—	1,327	2,341	1,050	4,395
September	—	1,121	4,549	19,370	2,378
October	3,707	1,247	24,240	7,072	—
November	5,846	5,077	9,313	33,580	—
December	12,550	2,864	7,108	15,090	—

SOURCE: "Water Resources Data for Taxes — Water Quality Records," U.S. Department of Interior, USGS, 1974. (1)

the Gulf of Mexico. The sediment size distribution of the material in suspension and on the bottom were sampled in the study conducted for this project. Results of this study (Appendix C) indicate that the sediments in the vicinity of the proposed intake facility are comprised of fine silt particles with diameters less than 74 microns. Particle size settling determinations on river sediments sampled at the proposed intake facility indicate that after 8 hours of settling 18 percent of the sampled material remained in suspension. The results of the settling studies and the particle size determinations are presented in Table 4.

2.7.3 Water Quality

Water quality characteristics of the lower Brazos Diversion Channel, including that of the proposed intake point, depend upon several factors including fresh water inflow, tidal fluctuations, upstream agricultural practices, and industrial and municipal discharges. The Brazos River carries large amounts of sediment into the coastal estuaries which averaged 26 million tons per year during the last 40 years.(1) The sediment load has been reduced in recent years by the construction of upstream dams and better soil conservation practices, however significant volumes are still carried by the river during high flows.

The tidal segment of the Brazos Diversion Channel, as defined by the Texas Water Quality Board, extends upstream from the Gulf of Mexico 23 river miles(2), and is classified as an effluent limiting stream.(3) The effluent limiting classification applies to any segment where there is adequate demonstration that water quality will meet applicable water quality standards of the State of Texas after required effluent limitations have been implemented.

Water quality monitoring programs are currently being conducted by the Texas Water Quality Board and the U.S. Geological Survey.(4) Much of the data collected by the Geological Survey is gathered through cooperative programs with various other Federal, state and local agencies.

Texas A & M University performed a comprehensive water quality assessment of the main streams of the Brazos River coastal zone in 1974.(4) This information updated the initial water quality management plan for the Brazos Basin prepared by the Brazos River Authority in November, 1974.(5) The study included analysis of physical, chemical,

Table 4

PARTICLE SIZE DISTRIBUTION OF BRAZOS DIVERSION CHANNEL BOTTOM SEDIMENT

Core Sampled at the Proposed Freshwater Intake Site

PERCENTAGE FINER REMAINING	PARTICLE SIZE	SETTLING TIME (Minutes)
100	74 Microns	
55	66	.5
47.6.	47	1
32.5	28	3
27.5	15.5	10
22.5	9	30
20	5	90
18.5	Less than 2.4	480

Particle Size Ranges Determined by Standard Bouyoucos Hydrometer Methods as Defined in Soil Science, Vol. 42, Page 225–229, 1936.

limiting nutrient and heavy metal parameters as well as special analyses of bacteria, cyanide, and pesticides of the Brazos Diversion Channel and the Intracoastal Waterway. In 1973, a water quality study of the lower Brazos, the Intracoastal Waterway, and the immediate Texas Gulf Coast area was conducted by Seadock, Inc. [1] In this study the lower Brazos Diversion Channel was sampled at each river mile from the mouth to 12 river miles upstream in the same manner as the Texas A & M study. Locations of these sampling stations as well as wastewater outfalls from Dow Chemical are shown on Figure 9. In addition, the Texas Water Quality Board operates a sampling station (1201.01) also shown on Figure 9.

To supplement the above existing water quality studies, a water quality sampling program was conducted in April, 1977 on the Brazos River Diversion Channel and at selected points in the Gulf of Mexico. This sampling program was initiated to obtain an estimate of the water quality during high and low tides. The sampling stations in the Brazos Diversion Channel are indicated on Figure 9. The sampling program was conducted at high and low tides at the six channel stations. Bottom, mid and surface samples were taken. This data also provides an estimate of the expected quality of the intake displacement water to be withdrawn from the channel. Additional dissolved water samples were collected for dissolved heavy metal analysis in July, 1977. Water samples from the surface, mid-depth and bottom at three stations designated D E & F on Figure 9 were collected. The three stations correspond to the proposed raw water intake, Dow outfall and an upstream station located between river mile 10 and 11.

Salinity, chemical water quality and the displacement water quality of the Diversion Channel are discussed in the subsections which follow. The discussion is based on analysis of the studies cited above and the April and July 1977 sampling.

2.7.3.1 Salinity

Salinity profiles of the Brazos estuary are controlled by the usual mechanisms of salt water intrusion from the Gulf and the freshwater inflow from the Brazos River.[1] In addition, the discharge of highly saline industrial wastewater to the estuary also contributes to the salinity profiles. The effect of this industrial discharge is illustrated on Figures 10 and 11, which show surface and bottom salinity values respectively, as functions of river mile for high, intermediate and low river

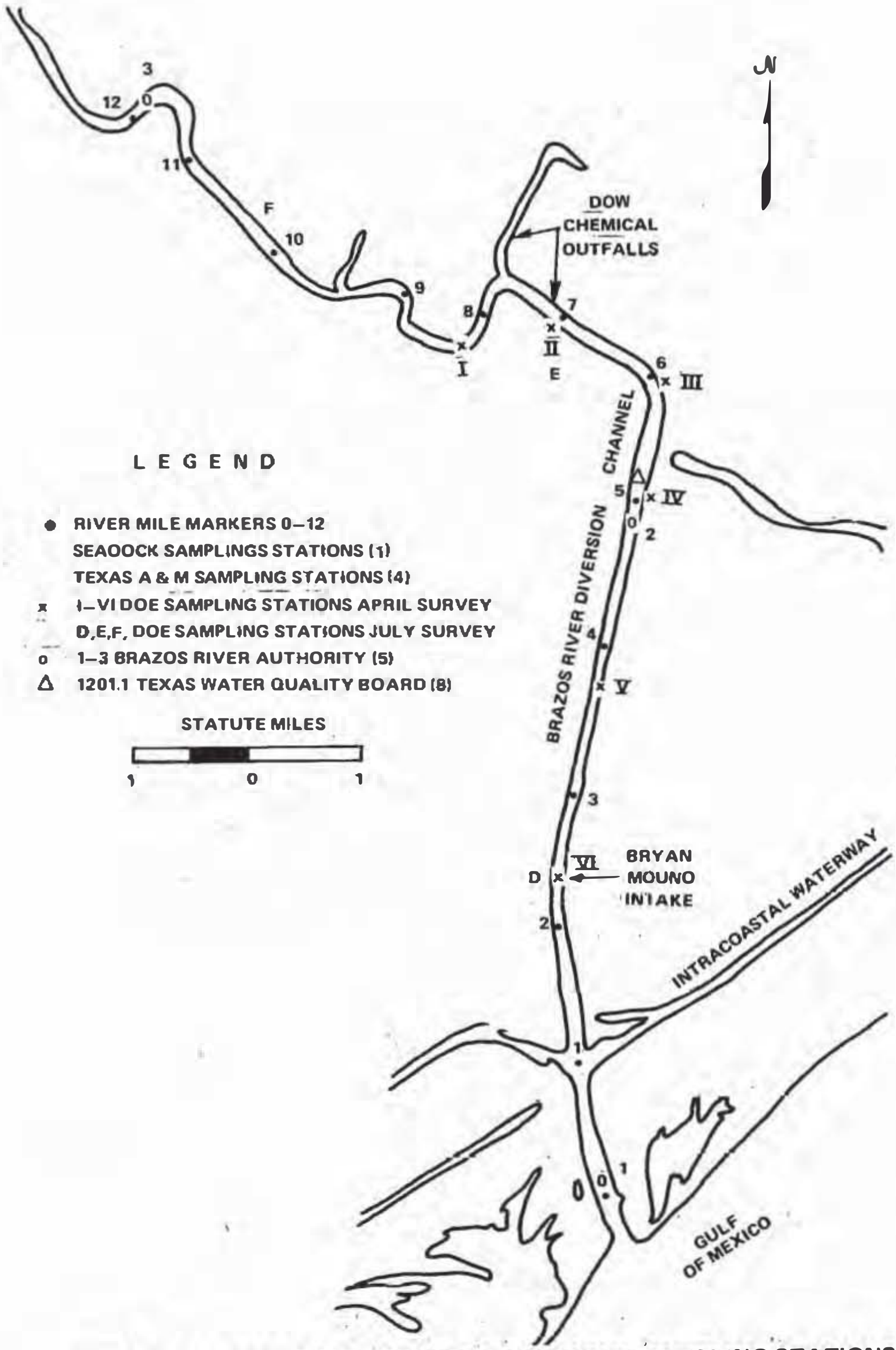


Figure 9 BRAZOS RIVER DIVERSION CHANNEL SAMPLING STATIONS

SOURCE: (2)

RIVER FLOWS (CFS) AT ROSHARON (9)

	PREVIOUS 7-DAY MEAN	14-DAY MEAN	21-DAY MEAN
AUG 1974	629	666	1034
FEB 1974	10470	16330	20280
JULY 1973	3870	4940	4890
FEB 1973	9390	9390	7850

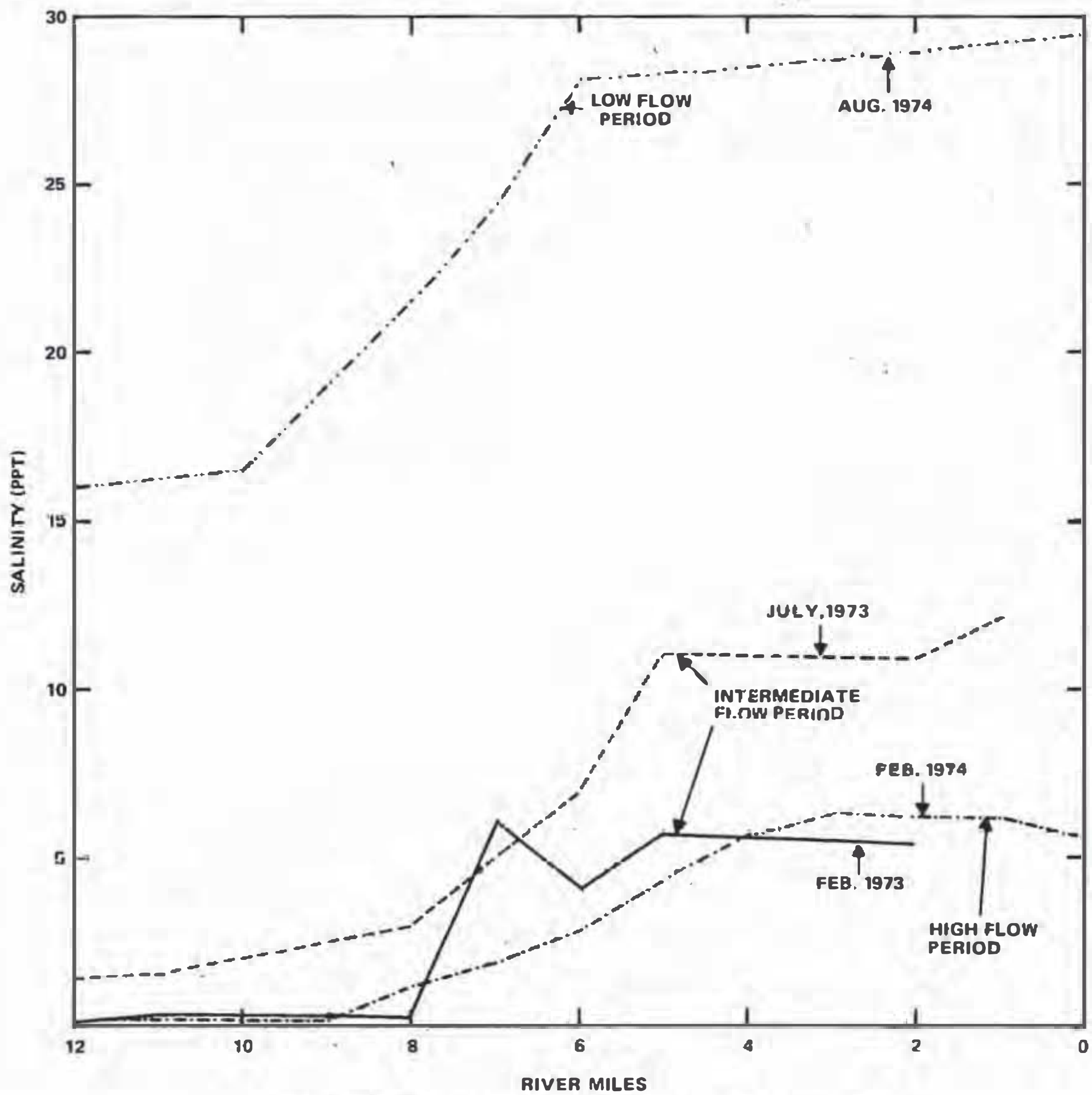


Figure 10 BRAZOS RIVER DIVERSION CHANNEL SURFACE SALINITY (1973 & 1974) (1)(4)

RIVER FLOWS AT ROSHARON (9)
(CFS)

	PREVIOUS 7–DAY MEAN	14– DAY MEAN	21–DAY MEAN
AUG 1974	629	666	1034
FEB 1974	10470	16330	20280
JULY 1973	3870	4940	4890
FEB 1973	9390	9390	7850

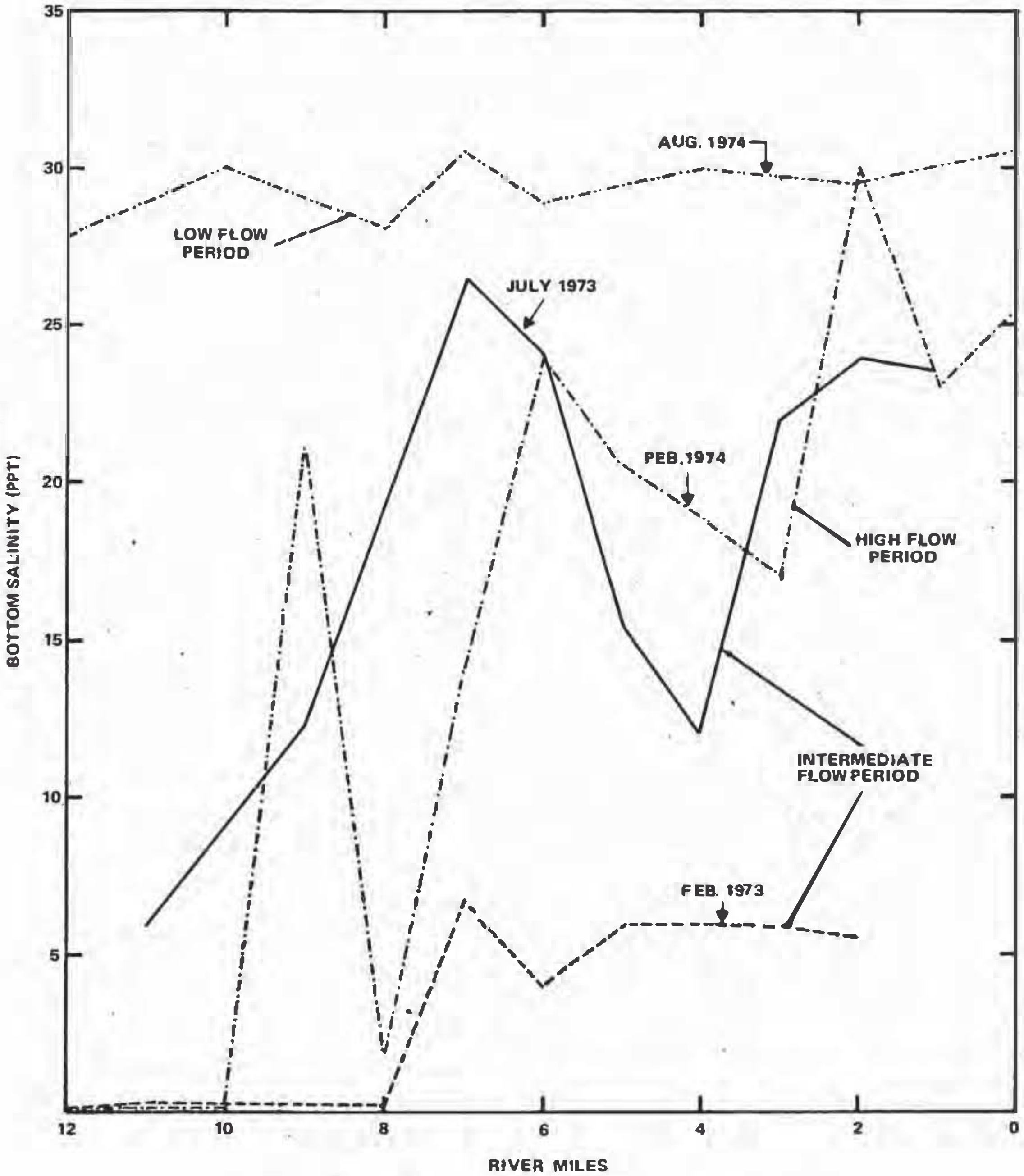


Figure 11 BRAZOS RIVER DIVERSION CHANNEL BOTTOM SALINITY (1973 & 1974) (1) (4)

flows gaged at Rosharon. The top curve on both figures corresponds to the low flow case which shows elevated salinity values (15-30 ppt) along the entire length of the twelve mile portion of the estuary. On Figure 10 (surface salinity profile) the salinity values are shown to be greatly reduced (0-10 ppt) for intermediate and high flow situations. This indicates that the lighter-freshwater from the river is flowing over the saltwater wedge produced by the Gulf water intrusion and the dense saline industrial discharge. Figure 11 which shows the bottom salinity profile illustrates the presence of the saltwater wedge at the bottom depths and also shows the effect of the industrial discharge between river mile 6 and 8 for intermediate and high flows. Salinities in this area range to about 25 ppt.

By analysis of surface water salinity data measured at the Texas Water Quality Board's sampling station (No. 1201.01) at approximately river mile 5, a critical river flow rate can be estimated. Figure 12 shows the surface salinity data at this station compared with the previous 7, 14, and 21 consecutive days river flow for the period of record. The data in this Figure indicate that the most critical change (increase) in salinity occurs as the river flow decreases to 1000 CFS and below. Under these low flow conditions the natural saltwater intrusion from the Gulf combines with the industrial discharge of approximately 4000 CFS to produce high levels of surface salinity. The figure also illustrates that surface salinity rapidly decreases with increased river flow rate. In the previous section on hydrology it was stated that the 2 year seven-day flow was approximately 969 CFS, therefore high surface salinity conditions are likely to occur about every two years similar to the low flow salinity condition illustrated in Figure 10 (Aug. 1974).

2.7.3.2 Chemical Water Quality

The water quality of the lower estuary, river mile 0 through river mile 12 can be divided into three regions. These regions are: upstream of industrial discharge area (river miles 9-12); the area adjacent to the industrial discharge (river miles 5-9); and the areas downstream of the industrial discharges (river miles 0-5). The proposed raw water withdrawal point is slightly above river mile 2. As previously discussed, a one time sampling program was conducted in

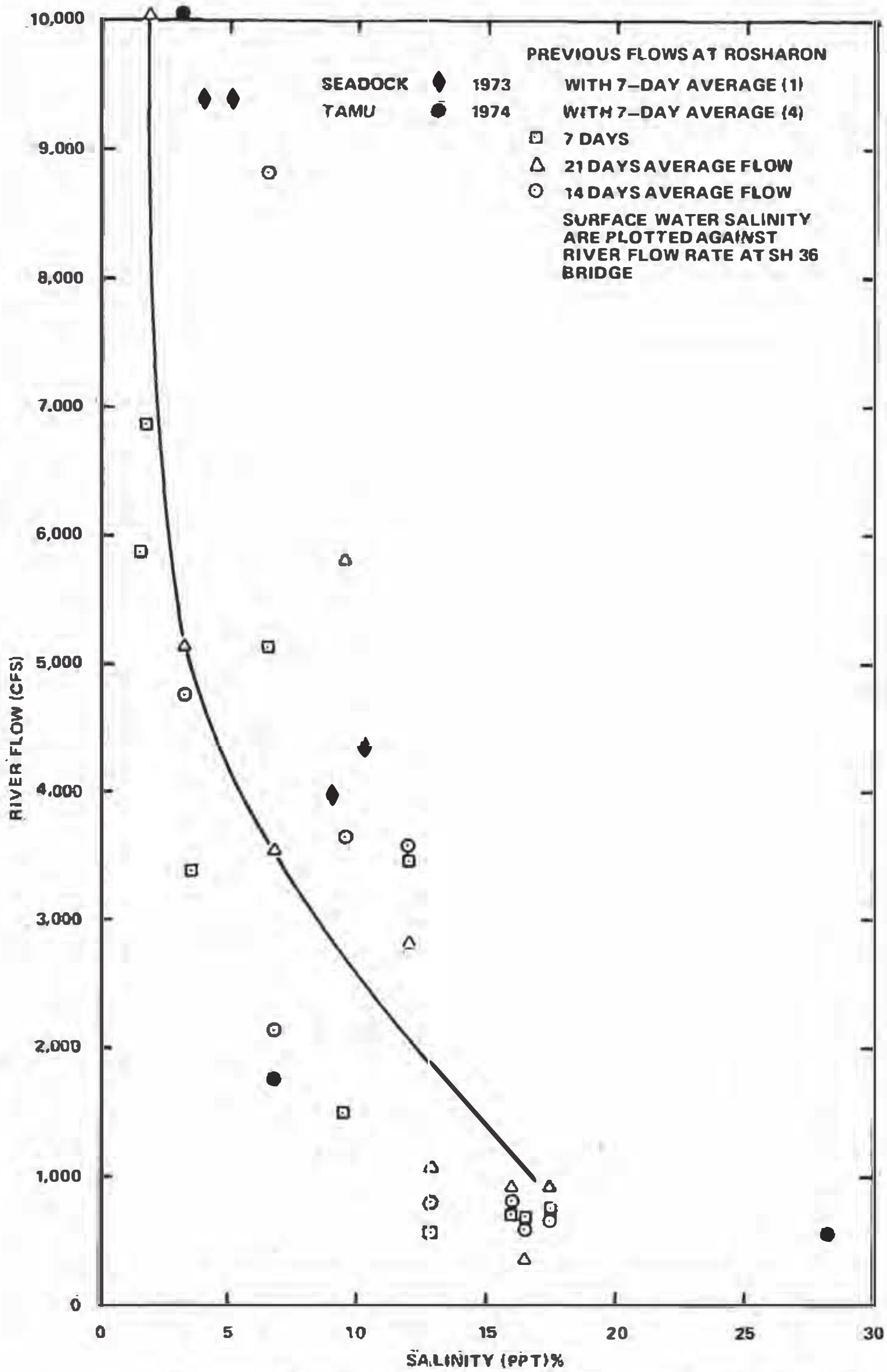


Figure 12 SALINITY INFLUENCES DUE TO FRESH WATER INFLOWS AT THE TEXAS WATER QUALITY BOARD STATION 1201.01 ON THE BRAZOS RIVER DIVERSION CHANNEL

April and July of 1977 to characterize the expected water quality of the intake water.

The initial water quality sampling program was conducted on April 12 and 13 and occurred on the recession of a flood hydrograph which started on April 1, peaked on April 4 at 28,800 CFS, and was declining to 11,000 CFS on April 12 and 9600 CFS on April 13. With the sampling program being conducted on the recession of a hydrograph, the turbidity values and the associated particulate absorbed heavy metal concentrations are believed to present a good illustration of the poorer water quality to be expected at the intake site.

The water quality survey was conducted utilizing unfiltered samples; the heavy metal data therefore represent "total" (dissolved plus acid leachable) concentrations (Table 5A). Because of extremely turbid conditions due to high river stage and winds (Appendix C), the particulate heavy metal fraction resulted in extremely high heavy metal concentrations. To verify if the total heave metal concentrations were dissolved in the water column a dissolved heavy metal analysis was conducted in July 1977 (Table 5B).

Upstream Area Water Quality. The ambient freshwater quality input to the lower estuary was sampled at station 1 and station F (Figure 9). The results of the DOE sampling program are listed in entirety in Appendix C and summarized in Table 5A and 5B as the means three depths. Bottom water suspended solids concentrations indicate that high suspended solids concentrations from the industrial discharge region were carried upstream to station 1 during high tide; heavy metal concentrations were similar upstream and downstream of the industrial discharges. Based on a comparison of the data at the downstream stations it appears that the upstream sampling station number 1, Figure 9, at river mile 8.5 was located too close to the industrial discharge and is not representative of the freshwater inputs. The Diversion Channel was high in oil and grease, total suspended solids and mercury. A composite sample conducted for an organic analysis scan indicated 2.1 ppb methylene chloride, the only organic material detected of the organic chemicals scanned. No PCB's or DDE's were found.

Past water quality studies at river mile 8 have indicated that depressed oxygen levels in the bottom water occur as a result of upstream movement of industrial discharges during the low flow conditions.[1]

Arsenic, barium cadmium, copper, chromium, lead, manganese, mercury, nickel, and zinc are all detectable and within the concentration ranges expected in river waters.

A comparison with historical data indicates that lead and mercury concentrations are higher than previous studies indicate.

The July resampling of dissolved metal, further upstream at river mile 10, station F, indicated normal riverine concentration levels.

Industrial Discharge Area. In the lower estuary between river miles 5 and 8 large and small industrial and municipal discharges occur into the estuary. The principal discharges are from the Dow Chemical Company which averaged approximately 3,500 CFS in 1976.[6] The Dow waste is characterized by a dense brine wastewater which was shown in the salinity section to influence river quality upstream and downstream of the outfalls.

The mean values of three depth samples for two stations in the discharge area are shown in Table 5A for both high and low tides. The data indicate higher concentrations of magnesium, calcium, boron, zinc, chromium, lead, cadmium, mercury and total suspended solids were found in this region. Of the organic compounds investigated, no traces were found, indicating the waste discharges to be inorganic in nature.

With the exception of mercury and manganese, heavy metals were higher at high tide than low tide. At stations 2, 3 and 4, the higher concentrations of metals are found in the bottom samples (Appendix C, Tables C-4 and C-5). The high oil and grease concentrations found at high tide are believed to be attributable to the large amount of shipping activity conducted at river mile 4. Of the total heavy metals measured, lead and mercury were found to exceed the EPA recommended levels at both high and low tides.[7] For the dissolved metals, Table 5B, only mercury was above the EPA recommended levels.[7]

Past water quality sampling studies indicate that the results of the April study are comparable to other comprehensive water quality studies. The Seadock sampling program indicated higher levels of copper and zinc.[1] The present April study only indicated elevated zinc levels. The dense brine layer was observed in this study but was not as concentrated as in previous studies conducted under low flow conditions. The July sampling of dissolved metals showed no significant higher dissolved heavy metals concentrations in the area.

Downstream Area. The area downstream of the major industrial discharges is located between river mile 0 and 5. It is within this area that the proposed projects water intake will be located. As discussed in the salinity section, this area is principally influenced by saltwater from the Gulf and upstream industrial discharges and freshwater inflows.

The present water quality study strongly indicates the effects of industrial discharges on this area especially during ebbing and low tide conditions. A comparison of the data for high and low tide (Table 5A) indicates that at low tides the cyanide, calcium, magnesium, boron, zinc, lead, and mercury concentrations which are elevated in the upstream industrial discharge move downstream and affect the water quality of this area. As found in the industrial discharge area, total lead and mercury and dissolved mercury, Table 5A, concentrations exceed EPA recommended levels.[7] Other heavy metal concentrations are generally the same as those reported in other studies. The only organic compound detected in this area was 0.7 ppb of 2,6-dinitrotoluene.

Other water quality studies have indicated that depleted oxygen concentrations occur during extremely low flows and slightly larger heavy metal concentrations were found in this area.

2.7.3.3. Water Quality of the Displacement Water

The water quality of the displacement water is important since it is used to "displace" the crude oil in the storage cavern and will subsequently be discharged upon refill of the cavern with crude oil.

Although the water quality sampling program was conducted to determine the projected intake water quality, this two time sampling effort cannot be expected to give the ranges of the elemental concentrations. The April sampling program conducted on the recession of a flood hydrograph is considered to give a worse expected water quality than a river under its normal flow regime. The increase in suspended solids and its associated impact on the increase in heavy metal concentrations should therefore give a conservative estimate of the projected intake water

Table 5A

SUMMARY OF DOE WATER QUALITY ANALYSIS IN BRAZOS ESTUARY AND PROPOSED INTAKE WATER SITE

PARAMETERS	EXPECTED DISPLACEMENT WATER QUALITY STATION VI		DOWN STREAM AREA STATION IV & V		INDUSTRIAL DISCHARGE AREA STATION II & III		UPSTREAM AREA STATION I
	MEAN AT HIGH TIDE	MEAN AT LOW TIDE	MEAN AT HIGH TIDE	MEAN AT LOW TIDE	MEAN AT HIGH TIDE	MEAN AT LOW TIDE	MEAN AT HIGH TIDE
Temp. (°C)	22.5	24.67	22.75	24.3	24.4	24.25	23
pH	8.0	8.0	8.0	8.0	8.25	8.0	8.0
DO (mg/l)	7.27	6.97	7	7.0	7.4	6.8	7.83
Salinity (ppt)	3.92	4.3	3.96	5.8	6.5	5.42	—
Phenol (mg/l)	0.023	0.009	0.014	0.008	0.025	0.007	0.006
TSS (mg/l)	215.6	47.33	281.6	131.8	1004.7	203.8	868.3
VSS (mg/l)	45.3	7	54.8	16.5	24.3	23	68
Oil & Grease (mg/l)	8.27	5.1	4.8	8.4	7.8	6.4	5.37
Cyanide (mg/l)	0.031	< 0.02	< 0.02	< 0.02	0.024	< 0.02	< 0.02
Cd (ug/l)	2.67	6	6	14	4.65	2.3	2.3
Cr (ug/l)	60	73.3	55.7	49.3	60.8	53.2	50.7
Cu (ug/l)	7.7	11	8.5	6.15	10	6.65	6.67
Pb (ug/l)	74	100	73.4	79	93.7	87	65.3
Hg (ug/l)	0.48	2.33	1.32	2.6	0.77	2.92	2
Ni (ug/l)	23.3	23.3	35	29.2	30.34	28.3	28.3
Zn (ug/l)	73	73.3	75.35	82.35	87.7	61.8	62.3
Sb (ug/l)	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Ba (ug/l)	126.67	133.3	123.4	102.5	125.8	100	118.3
B (ug/l)	566.7	890	515	1153.4	1091.7	956.65	323.3
Mn (ug/l)	46.7	43.3	44.15	56.2	49.7	60.85	48.3
Se (ug/l)	< 80	< 80	< 80	< 80	< 80	< 80	< 80
Ag (ug/l)	< 2	3	2	3	3.2	2.5	< 2
As (ug/l)	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Ca (mg/l)	94.4	98.8	102.35	125.1	154.7	117.1	82.53
Mg (mg/l)	85	214	185.3	254.1	326.15	254.2	37.6

* Data are composite averages of surface, midpoint and bottom samples for the respective stations.

Table 5B

DISSOLVED HEAVY METALS IN BRAZOS RIVER DIVERSION CHANNEL

HEAVY METAL (ug/l)	EXPECTED INTAKE WATER QUALITY STATION D	INDUSTRIAL DISCHARGE AREA STATION E	UPSTREAM AREA STATION F
Cd	< 1	< 1	< 1
Cr	2.4	1.2	1.2
Cu	4.5	3.1	3.2
Pb	2.7	2.7	3.0
Hg	0.28	0.24	0.30
Ni	1	5	4
Zn	18	14	15
Sb	< 10	< 10	< 10
Mn	56	58	67
Se	< 20	< 20	< 20
Ag	< 0.5	< 0.5	< 0.5
As	< 20	< 20	< 20

Data are averages of surface, middepth, and bottom for the respective stations.
All samples collected 7/7/77.

quality.

High and low tide sampling results as shown in Table 5A indicate that total heavy metals with the exception of manganese were higher at low tide than at high tide. By following the decrease of the element boron downstream, a clear illustration is given of the effects of upstream industrial discharges. A comparison of surface and bottom samples as givein in Appendix C indicates there is a considerable reduction of total heavy metals in the upper water column. For the dissolved fraction however, nickel and manganese were higher in the upper water column; lead and mercury showed no clear trend. High and low tide sampling showed high concentrations of oil and grease on both tides and a decrease in concentrations with depth. With the exception of these high oil and grease concentrations, only total lead and mercury concentrations were found in excess of EPA recommendations for marine land aquatic life. The July sampling indicated only dissolved mercury concentrations were in excess of the low EPA recommended levels.[7]

2.7.4 Estuarine Habitat

The biological habitat of the Brazos River Diversion Channel has been affected by several activities including dredging, leveeing, upstream agricultural practices and municipal and industrial discharges. As an estuarine nursery area, the Diversion Channel is very limited by these factors and consequently its value to overall Gulf biological resources is limited. The specific factors governing the biota of the Diversion Channel are the natural saline intrusion from the Gulf, saline industrial discharges and physical estuarine conditions produced by channelization.

The biota of the estuary is essentially marine at the shallow mouth of the Diversion Channel and gradually becomes a freshwater ecosystem as the salinity decreases upstream. As discussed in the water quality section, heavy industrial discharges occur between river mile 6 and 8. These discharges have created a zone avoided by mobile organisms and devoid of benthic invertebrates as evidenced by low species diversity. Upstream of this zone at river mile 10 a weak estuarine population exists. The presence of a poorly oxygenated zone as a result of a salinity wedge has been described as the causative factor. The biota of the Brazos River Diversion Channel have been sampled in several extensive studies. These studies are used as a basis of this analysis.[1,2,3]

2.7.4.1 Plankton

Winter plankton collections made by Kirkpatrick in February 1971 (Table 6)[1] show that about one-half mile upstream of the mouth of the Brazos Diversion Channel filamentous green algae and diatoms (no genera given) dominate the phytoplankton community. Further upstream, the data showed a lack of plant life until a point 10 miles up river. At this location colonial and filamentous Chlorophyta were the main constituents. Unicellular Cyanophyta (blue-green algae) were found to be abundant in the Brazos Diversion Channel especially in the part below the industrial outfalls.

Comparison data from the Seadock study also presented in Table 6 confirms this pattern.[2] At river mile 1, the diatoms are the dominant members of the phytoplankton community. In spring, various species of Chaetoceros were most numerous, whereas in summer the genera Nitzschia,

Table 6
PHYTOPLANKTON SPECIES OF THE BRAZOS RIVER IN TEXAS

	RIVER MILE 0.5[1]		RIVER MILE 0.5[2]		RIVER MILE 5.6[1]	RIVER MILE 12[1]	RIVER MILE 12[2]	
	WINTER	SPRING	SPRING	SUMMER	SPRING	SPRING	SUMMER	FALL
Anabaena sp.								x
Ceratium macroceros							x	
Ceratium massiliense							x	
Ceratium trichoceros				x			x	
Chaetoceros affinis			*					
Chaetoceros dicipiens			*					
Chaetoceros diversus			*					
Colonial chlorophyta					x			
Coscinodiscus centralis			x					
Diatoms	*							
Filamentous chlorophyta	*							
Gleocystis ampha							*	
Navicula sp.			x	x				
Nitzschia sp.				*				
Nodularia sp.							*	
Ophiocytium sp.							x	
Oscillatoria sp.							x	
Pleurosigma sp.			x					
Scenedesmus quadricauda							*	
Skeletonema costatum			x					
Thalassionema nitzschioides			x					
Thalassiosira sp.				*				
Thalassiothrix frauenfeldii			x					
Unicellular cyanophyta		*			*			
Volvox sp.							x	
(* MOST ABUNDANT) X-PRESENT								

SOURCE: 1. KIRKPATRICK (1972)(1)
2. SEADOCK, INC. (1975)(2)

and *Thalassiosira* were most abundant. Twelve miles upstream, various members *Gleocystis*, *Nodularia* and *Scenedesmus* of the Chlorophyta and Cyanophyta become dominant.

Productivity measurements in the Brazos River during April 1971 were low. Measurements of 0.325 mg/l/hr O_2 productivity values were obtained at river mile 12 and 0.092 mg/l/hr O_2 at river mile 7.6.[1] These low former measurements at river mile 12 were attributed to turbid water conditions, while the measurements at river mile 12 were thought to be the result of poor water quality from industrial and municipal discharges. Chlorophyll a measurements were 34 mg/m^3 in the river environments.[2]

2.7.4.2 Zooplankton

The information on Brazos estuary zooplankton communities is limited. Sampling studies conducted by Kirkpatrick .indicate a general increase in the number of organisms noted from the Gulf to a point 10 miles upstream except at the industrial outfall region where a sparsity of life existed.[1] Copepods were the predominant member of the zooplankton up to the outfall in February 1971. Further upstream nauplii larvae comprised a greater fraction.[1]

In spring sampling, few zooplankters were collected below the outfall. Further up the river nauplii larvae were very abundant along with copepods to a lesser degree.

2.7.4.3 Benthic Invertebrates

The benthic fauna was the most consistently sampled biological data collected in the Brazos Diversion Channel. Generally the trend exhibited by the data is one of greater species diversity at the river mouth and slightly upstream,leading to a lower diversity upstream in the less saline environment.

A list of benthic organisms in the Brazos River is presented in Table 7. The data from the Seadock report (1975) indicate a rather impoverished benthic community in the river, with no dominant member. Polychaetes were the most often encountered class, although oligochaetes were the abundant group 12 miles upstream in winter.

The benthic community, as presented by Kirkpatrick is much richer according to the number of individuals near the river mouth.[1]

Table 7
BENTHIC INVERTEBRATES OF THE BRAZOS RIVER IN TEXAS

	.1 MILE OFFSHORE[2]			RIVERMILE 0[2]	RIVERMILE 0.5[1]			RIVER MILE 1[2]		RIVER MILE 5.6[1]		RIVER MILE 12[1]		RIVER MILE 12[2]		
	SPRING	SUMMER	FALL	SPRING	WINTER	SPRING	SUMMER	SUMMER	FALL	SPRING	SUMMER	WINTER	SPRING	WINTER	SPRING	FALL
Abra Aequalis (B)		x														
Acetes Americanus (D)	x		x													
Amphipoda										x						
Ancistrosyllis Jonesi (P)			x	x												
Anenomes	x				*											
Bivalvia					*	*										
Callinectes Sp. Post Larva				x												
Cerebratulus Lacteus (N)	x		x													
Chironomidae												x	x			
Chironomidae Larva														x		
Cirrepedia					*											
Cobioides Brussoneti (B)							x									
Corbula Cariboea (B)			x													
Crustacea										x	x					
Decapoda					x											
Dosinia Discus (B)		x														
Gastropoda						x										
Glycera (P)	x															
Glycinde Solitoria (P)		x														
Gyptis Vittata (P)		x														
Hemichordata			x													
Hemipholis Elongata (O)	x	x														
Hydracarina Sp. A (Ar)														x		
Hydracarina Ap. B (Ar)														x		
Lumbrineris Sp. (P)			x													
Lunarca Ovalis (B)		x														
Magelona Pettiboneae (P)	x		*	x											x	x
Mediomastus Californiensis (P)	x	x		x												
Membranipora Tenuis (Br)		x														
Mulina Lateralis (B)		*														
Nassarius Acutus (G)		x	x													
Natica Pusilla (O)		x														
Nemertea															x	
Nemertea Brown Ringed	x	x														
Nemertea Red Ringed	x	x														
Nereidae					x											
Nereis Sp. (P)	x	x														
Ninoe Nigripes (P)			x													
Oligochaeta						x	*							x		

X-PRESENT
*-MOST ABUNDANT

Table 7

BENTHIC INVERTEBRATES OF THE BRAZOS RIVER IN TEXAS (Cont'd)

	1 MILE OFFSHORE [2]			RIVER MILE 0 [2]	RIVERMILE 0.5 [1]			RIVER MILE 1 [2]		RIVER MILE 5.5 [1]		RIVER MILE 12 [1]		RIVER MILE 12 [2]		
	SPRING	SUMMER	FALL	SPRING	WINTER	SPRING	SUMMER	SUMMER	FALL	SPRING	SUMMER	WINTER	SPRING	WINTER	SPRING	FALL
Onuphis Ermita Oculata (P)		x														
Ophiuroidea					x											
Ophiuroidea Fragments				x												
Pholalidae, Young (B)		x														
Pinnixa Cristata (D)			x													
Pinnixa Sayana			x													
Pinnixa Sp.			x													
Pinnixa Sp. Young		x														
Polychaeta							x									
Polychaeta Sp. A					*	*										
Polychaeta B					x	x										
Polychaeta C						x										
Polychaeta Fragments									x							x
Prionospio Pinnata (P)	*	*	*	x					x							
Pseudeurythoe Ambigua (P)	x		x													
Raeta Plicatella (B)		x														
Sabellides Sp. (P)		x														
Serpulidae	x															
Sigambra Tentaculata (P)	x	x	x													
Streblospio Benedicti (P)				x												

* Most Abundant X-PRESENT

Ar	Arthropoda	N	Nemertea
B	Bivalvia	O	Ophiuroidea
D	Decapoda	P	Polychaeta
G	Gastropoda		

SOURCES: 1. KIRKPATRICK (1972)-(1)
2. SEADOCK INC. (1975)-(2)

Table 8
NEKTONIC INVERTEBRATES OF THE BRAZOS RIVER IN TEXAS

	1 MILES OFFSHORE[2]			RIVER MILE 0.5[1]			1 MILE UPSTREAM[2]		RIVERMILE 12[1]		12 MILES UPSTREAM[2]
	SPRING	SUMMER	FALL	WINTER	SPRING	SUMMER	SUMMER	FALL	WINTER	SPRING	SUMMER
Callinectes danae	—	— * —	— x								
Callinectes sapidus	— * —	—	—	— * —	— * —	— x —	— x —	— x —	— x —	– x	
Gulf crab	—	—	—	— x							
Lolliguncula brevis	— x —	—	— x								
Penaeus aztecus	—	—	—	—	—	—	— * —	—	—	—	— x
Penaeus setiferus	—	—	— * —	—	—	—	—	— x			
Squilla empusa	—	—	— x								
Xiphopenaeus kroyeri	—	— x —	— x —	—	—	—	— x				

1 – Kirkpatrick (1972)(1)
2 – Seadock, Inc. (1975)(2)

* Most abundant   X-PRESENT

Apparently, as the salinity influence of Gulf waters decreases upstream, a corresponding decrease in the benthic composition occurs. In spring, polychaetes, cirripedes, and bivalves were the dominant organisms at the sampling stations located between the Gulf and the Intracoastal Waterway. In April, the bivalves at river mile 1 were more prominent, while in August the oligochaetes were the most numerous.

In an unstressed system, species diversity usually decreases from the offshore environment to the upper estuary, generally the portion where extremely variable conditions make it possible only for the hardiest forms to survive. From this point upstream, a diversity increase is generally noted. The biological data show that the decline is not located in the upper portion of the estuary, but rather near river mile 5.6.[1,2,3]

Table 8 contains the data of nektonic invertebrates collected by the Seadock study and Kirkpatrick. All the species listed are essentially marine in nature or have a strong link to this environment, and most of them are concentrated in the lower mile of the Brazos Diversion channel. Blue crab and shrimp were generally the dominant species in this section of the channel. Both the brown shrimp and the blue crab were observed 10-12 miles upstream, although not in any significant quantity.

Ballineares spidu, Penaeus aztecus, and P. setiferus all occurred 30.6 miles upstream or beyond, during periods of low river runoff when the saline gulf waters intruded far up the Brazos estuary into the old river channel.

2.7.4.4 Ichthyofauna

The same general pattern of decreasing species diversity occurs with fish as well as the other groups previously mentioned. In the lower part of the river, the ichthyofauna is predominantly marine and becomes progressively more freshwater in composition as the salinity drops. Greatest diversity was exhibited at river mile 1 during the summer,[2] and during winter at river mile 10.[1] Species listed by these studies are presented in Table 9 .

Most abundant species include the Atlantic croaker (Micropogon undulatus) in winter and Alligator Gar (Lepisosteus spatula)in spring at river mile 0.5, sand seatrout (Cynoscion arenarius) and banded drum (Larimus fasciatus) in summer at river mile 1, channel catfish, freshwater drum, dollar sandfish, threadfin shad, and warmouth in winter at river mile 10, and sand seatrout in summer at river mile 12.

A small population of tarpon has reestablished in the lower part of the Brazos River recently.[4]

Several fishes with strong links to the marine environment were recorded at river mile 12 and include Brevoortia gunteri (finescale menhaden), Cynoscion arenarius (sand seatrout) and Micropogon undulatus (Atlantic croaker).

Under low flow conditions during 1973 and 1974, Brevoortia patronus (Gulf menhaden), Anchoa mitchelli (bay anchovy) and Micropogon undulatus were all reported at river mile 30.6 or further upstream.[3]

Table 9

ICHTHYOFAUNA OF THE BRAZOS RIVER IN TEXAS

	1 MILE OFFSHORE[2]		RIVER MILE 0.5[1]			RIVER MILE 1[2]		RIVER MILE 5.6[1]		RIVER MILE 12[1]		RIVER MILE 12[2]
	SUMMER	FALL	WINTER	SPRING	SUMMER	SUMMER	FALL	SPRING	SUMMER	WINTER	SPRING	SUMMER
Anchoa Mitchelli	—	—	X									
Arius Felis	—	X	—	X	—	—	X					
Bagre Marinus	—	—	—	—	—	X						
Brevoortia Gunteri	—	—	—	—	—	X	—	—	—	—	—	X
Chilomycterus Schoepfi	X											
Choroseombrus Chrysurus	—	—	—	—	—	X						
Corosoma Petenense	—	—	—	—	—	X						
Cynoscion Arenarius	—	—	—	—	—	*	—	—	X	—	—	*
Cynoscion Nebulosus	—	—	—	—	—	X						
Cynoscion Notus	—	X										
Dorosotta Cepedianum	—	—	—	—	—	X						
Larimus Fasciatus	—	*	—	—	—	*						
Micropogon Undulatus	*	X	*	X	—	X	X	—	—	—	—	X
Mugil Cephalus	—	—	—	X	—	X						
Paralichthys Lethostigma	—	—	—	X	—	X						
Peprilus Burti	—	X										
Pogonias Cromis	—	—	—	X								
Polydactylus Octunemus	—	X	—	—	—	X						
Prionotus Tribulus	—	—	X									
Symphurus Plagiusa	—	X										
Trenectes Maculatus	—	—	—	—	—	X						
Alligator Gar	—	—	—	—	—	—	—	—	—	X		
Black Crappie	—	—	—	—	—	—	—	—	—	X		
Black Striped Topminnow	—	—	—	—	—	—	—	—	—	X		
Blue Catfish	—	—	—	—	—	—	—	—	—	X		
Bluegill Sunfish	—	—	—	—	—	—	—	—	—	X		
Bullhead Minnow	—	—	—	—	—	—	—	—	—	X		
Channel Catfish	—	—	—	—	—	—	—	—	—	X		

X-PRESENT

*-MOST ABUNDANT

Table 9

ICHTHYOFAUNA OF THE BRAZOS RIVER IN TEXAS (Cont'd)

	1 MILE OFFSHORE[2]		RIVER MILE 0.5[1]			RIVER MILE 1[2]		RIVER MILE 5.6[1]		RIVER MILE 12[1]		RIVER MILE 12[2]
	SUMMER	FALL	WINTER	SPRING	SUMMER	SUMMER	FALL	SPRING	SUMMER	WINTER	SPRING	SUMMER
Dollar Sunfish	—	—	—	—	—	—	—	—	—	— x		
Flathead Minnow	—	—	—	—	—	—	—	—	—	— x		
Freshwater Drum	—	—	—	—	—	—	—	—	—	— x		
Gar	—	—	—	—	—	—	—	— x				
Gizzard Shad	—	—	—	— x —	—	—	—	— * —	—	— x —	— x	
Largemouth Bass	—	—	—	—	—	—	—	—	—	— x		
Longear Sunfish	—	—	—	—	—	—	—	—	—	— x		
Longnose Gar	—	—	—	—	—	—	—	—	—	—	— x	
Naked Goby	—	—	—	—	—	—	—	—	—	— x		
Redear Sunfish	—	—	—	—	—	—	—	—	—	— x		
Sailfin Molly	—	—	—	—	—	—	—	—	— x			
Sheepshead	—	—	—	— x								
Sheepshead Minnow	—	—	—	—	— x —	—	—	—	—	— x		
Smallmouth Buffalo	—	—	—	—	—	—	—	—	—	— x		
Spadefish	—	—	—	— x								
Spotted Gar	—	—	—	—	—	—	—	—	—	— x		
Tadpole Madtom	—	—	—	—	—	—	—	—	—	— x		
Texas Shiner	—	—	—	—	—	—	—	—	—	— x		
Threadfin Shad	—	—	—	—	—	—	—	—	—	— x		
Warmouth	—	—	—	—	—	—	—	—	—	— x		
White Crappie	—	—	—	—	—	—	—	—	—	— x		
White Mullet	—	—	—	—	—	—	—	—	—	— x		
Yellow Chub	—	—	—	— x								

* Most Abundant x – Present

SOURCES: 1. Kirkpatrick (1972) (1)
2. Seadock Inc. (1975) (2)

2.8 LAND USE

Bryan Mound is located in southeastern Texas about 70 miles south of Houston near the Gulf of Mexico. The site is three miles southwest of Freeport in Brazoria County. The site is bounded by the Intracoastal Waterway on the south, the Brazos River Diversion Channel on the west and marsh and salt flats on the north and east. The Gulf of Mexico is approximately 2 miles from Bryan Mound.

This section contains a description of existing land use for Bryan Mound and the area in the immediate vicinity. Future land use, based on current plans, is also discussed.

2.8.1 Bryan Mound

Bryan Mound site contains approximately 100 acres.[1] The site was controlled by Dow Chemical before it was purchased by the government. The land around the site is owned primarily by Freeport Sulphur Company. The site has been used by industry since 1912 for production of sulfur, oil and brine. Between 1949 and 1965, 19,000 barrels of oil were produced.[1] Currently Dow Chemical is mining brine at the site. The area around the mound shows the evidence of alterations caused by past and present industrial developments. This includes buildings and equipment on the site that are no longer in use. Some of the land is now used for cattle grazing.

The poorly drained mound surface is surrounded by marshland and numerous bodies of water. Two natural ponds, one north and one northeast, are on the edge of the site; Mud Pit (Lake) is on the southeast corner. Bryan Lake is located one mile due east.

Approximately one-half mile east of the site are facilities of Phillips Petroleum and Houston Natural Gas, including small storage tanks and degasifying equipment to handle offshore operations.

Bryan Mound, along with a levee system, provides flood protection to the area north and east of the site.

The flood protection and drainage aspects of the area are administered by the Velasco Drainage District. Access to the immediate vicinity of the site is provided by a paved road that leads from Freeport. This road travels along the top of a levee beside the new Brazos River Channel and past the entrance to the site. County-maintained roads provide access to the site from the east and west. The pipeline leading to the injection sites would be constructed parallel to the DOE oil pipeline, cross route 1495 and turn northward along route 1495 to the well sites. The land use in the area of injection wells and pipeline consists of flood protection levees, roadways, marsh land, and some industrial development. The land uses within a half mile radius of the injection wells is vacant land, warehousing and outside storage for the Brazos Harbor complex. The closest residences to the injection wells are located approximately 2,000 feet to the northeast along the Bryan Beach Road (Route 1495). Midway between the dome and the proposed injection well sites are located the onshore gas oil water separator components of the offshore Buccaneer platform system. The pipeline connecting the Seaway Tank Farm to their Freeport Harbor dock facility is routed between the proposed injection wells. One mile south of the well sites is an industrial development area along the Intracoastal Waterway. The levee and its associated dredge burrow ditch and Bryan Lake constitute important fishing areas for the local population. Due to its easy acess fishing pressures in the area in the summer are quite high.

2.8.2 Intracoastal Waterway and Brazoria County Beach

The Intracoastal Waterway is a vital transportation artery, linking the Texas Gulf Coast with the eastern United States by providing shallow draft barge transportation. Traffic on the waterway has doubled between 1960 and 1974, increasing from about 35 million tons per year to 70 million tons per year.[2]

Within the vicinity of the proposed project (Freeport Harbor to the Brazos River Channel Diversion) the waterway is fairly straight, with depths ranging from 12 feet in the channel to 15 feet at the mouth of the Brazos River. Dredge spoil taken from the channel has been deposited along the Gulf side of the waterway and forms a five foot high levee with occasional isolated piles reaching fifteen feet in elevation. The Intracoastal Waterway between the Diversion Channel and the Freeport Harbor is dredged every other year by the Corps of Engineers. Although primarily used for barge traffic, the Intracoastal Waterway is open to fishing and pleasure crafts, and work boats for the offshore facilities.

There are approximately 33 miles of Brazoria County beach frontage adjacent to the Gulf of Mexico, of which 22 miles is accessible and open to the public. This beach extends from the Brazoria-Galveston County line to a point west of where the Brazos River Diversion Channel empties into the Gulf of Mexico.[3] Two recreation areas are located within this area, Quintana-Bryan Beach (a county park) and Bryan Mound State Recreation area. The Quintana-Bryan Beach area is located two miles southeast of the Bryan Mound site; it has a playground and is used primarily for swimming and surfing.[3] The Bryan Mound Beach State Recreation Area is composed of 877 acres of undeveloped land, located approximately one mile south of Bryan Mound.

2.8.3 Future Land Use

The Bryan Beach recreational area will be developed to meet some of the regional needs for more leisure time activities. Facilities for picnicking, swimming and various concessions are planned for the area.

The increasing U.S. demand for raw materials and other goods will result in increased ship traffic in the Gulf.[2] Continued use of the Gulf as a means of disposing of wastes is expected, however, environmental regulations may reduce the amount of harmful pollutants discharged into its waters.

Increased U.S. demand for energy and mineral resources is also expected to occur. The potential for discovery of additional offshore oil and gas wells in the area is great, and if the wells are as productive as expected, drilling and production in the Gulf will increase.[1]. With the increased offshore development the increase in shoreline support facilities will have to be developed for transportation processing and gathering systems.

Future offshore development is currently being planned for the Brazos Coastal Region. Seadock, a consortium of 8 oil companies plus Dow Chemical, has planned to build an offshore crude oil off-loading facility in 100 feet of water, 26 miles southwest of Freeport. The offshore unloading facility, will consist of a Single Point Mooring facility and a pumping platform complex. A proposed 50-mile long shipping fairway will join the existing fairway south of Seadock and provide an approach to the facility. This is expected to consist of two 1-mile-wide lanes, for inbound and outbound traffic. An anchorage area, approximately 3 x 3 miles, will lie southeast of the docking area.[1]

The Corp of Engineers has been authorized a 45 foot Federal Enlargement of the Freeport Harbor. The proposed dredge spoil areas to be utilized by the Corps of Engineers includes the proposed DOE injection well area. The utilization of the area has been coordinated with the Galveston office of the Corps of Engineers.

With the current expansion of the shipping industrial and commercial activity within the Brazos Harbor the flood secure land located between route 1495 and the dockside industrial areas would be expected to further expand for industrial uses. Due to the flood protection rendered this area by the recently installed and renovated South Storm Levee, the marsh located adjacent of route 1495 will receive increased demands for industrial and utility right-of-way purposes.

2.9 Environmentally Sensitive Areas and Aesthetics

There are several areas of special ecological interest within the Bryan Mound area which would be sensitive to the construction perturbations associated with the proposed action. Although the entire Texas coast is of considerable wildlife value, especially to migratory birds, the open water and marsh areas in the vicinity of Bryan Mound are particularly valuable and sensitive. The value of these areas is increasing as the amount of such habitats decreases due to man's encroachment. Because of their value to avifauna, the open water and marshes surrounding Bryan Mound are frequented by local bird watching enthusiasts and waterfowl hunters.

Even though Bryan Mound is on the fringe of a highly industrialized and disturbed area, the numerous canals and lakes around the site are heavily utilized by local sport fishermen. Bryan Beach is an important camping and recreation area for local beachgoers.

The Bryan Mound area has high aesthetic value to local residents due to its proximity to the Gulf of Mexico and the abundant wildlife resources associated with its waterways and marshes. Camping, bird watching, fishing, hunting, and beach-going are common outdoor recreational uses by local residents. Easy access to marshes and beaches exists as a result of levee roads and construction roads surrounding Bryan Mound. Although heavily utilized by local residents, its aesthetic attraction to tourists is marginal because of the intrusion of the large industrial areas in the immediate vicinity.

2.10 Archaeology and Historical Resources

The Texas coastal zone contains archaeological sites providing evidence that humans have inhabited the region for as long as 15,000 years.[1] 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 these found in the coastal zone in that they contain middens of Ostrea and Rangia shells, and most are located on or near the strand.[1]

In compliance with Section 2(a) of Executive Order 11593, "Protection and Enhancement of the Cultural Environment" (May 13, 1971), a survey was carried out to locate, inventory and nominate eligible historic, architectural and archaeological properties to the National Register of Historic Places. Although no sites were discovered, as the project progresses, additional surveys will be carried out to determine that no additional eligible properties have been uncovered.

Section 1(3) of Executive Order 11593 requires that a determination be made 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 archaeological significance. A determination will be made of the effects of the proposed facilities on such resources prior to beginning construction.

3. ENVIRONMENTAL IMPACTS

While the short-term impacts of constructing the proposed raw water intake and brine disposal system would be greater than those of the originally proposed systems, the long-term environmental protection afforded by the new systems warrants these short-term impacts in order to provide a system reliability commensurate with environmental protection during year-to-year operations.

This section discusses the environmental impacts to be expected from both the construction and the intermittent operations of the intake and the brine disposal system. The general format follows that of Section 2 for easy identification and reference.

Evaluation of potential environmental impacts requires simultaneous consideration of the major elements of the actions proposed in Section 1 and the specific environmental characteristics of the areas in which these actions would occur, as described in Section 2. The major elements of this proposal and their scales and locations can be summarized from Section 1 as shown in Table 10.

3.1 CONSTRUCTION

3.1.1 Geological Resources and the Deep Well Disposal System

The only proposed construction activities which might affect the geological resources of the area are the drilling and operation of the five (5) brine injection wells.

Each well would be drilled using conventional, vertical or directional rotary technology as necessary to assure a separation of 1000 feet between any two bottom hole locations. The bore holes would be cased with

Table 10
MAJOR ELEMENTS OF THE PROPOSAL

PROJECT ELEMENT	SIZE	LOCATION
RAWWATER SUPPLY		
Intake System	120 ft. X 370 ft.	Brazos River
Pipeline	30" diameter 0.5 mile, 100 ft. R.O.W.	East from Brazos River to Mound
BRINE INJECTION WELL SYSTEM		
Wells	5 wells, 2 acres/well	1 mile NE of Mound
Brine Retention Lagoon	1 acre	Bryan Mound
Pipeline	20" diameter 14,600 ft., 75 ft. R.O.W.	Mound to wells

steel pipe as illustrated in Figure 3 to prevent sloughing of earth or rock into the hole, and to provide for control so that the brine would be injected into the desired sands deeper than 4000 feet. The "mud" used during the drilling operations (a water slurry of clay and chemicals) returns to the surface continually and would be stored in mobile commercial steel tanks for recycling. Cuttings from the shaker screen would be either buried on site or removed to an approved land fill. There would be small, transient impacts from the exhaust and the noise of the engines driving the drilling rigs. These unfavorable impacts would be of short duration, i.e. several weeks per well. For the construction of five (5) well pads approximately 36,000 cubic yards of fill material would be required.

3.1.2 Soils

The only significant impacts on the soils from construction of the proposed facilities would be those from digging and filling the pipeline trenches. The Lake Charles and Roebuck and Ijam soils are the predominant series along the water intake and disposal well pipelines, and these soils possess the necessary qualities of depth, texture, and fertility to provide easy revegetation.

Pipeline construction disturbances would mix the soil profile over the pipeline trench. However, since the Lake Charles and Roebuck soils are fairly uniform throughout the profile, this mixing would have minimal effect on soil behavior. The revegetation of these soils with native or adapted domestic grasses can easily be established using the standard planting and culture practices prescribed by the Soil Conservation Service and the Cooperative Extension Service. Thus, there would be very little long-term construction impact on these soils since revegetation occurs rapidly.

The soils along the pipeline route either have erosion resistant textural characteristics or support a soil binding vegetative community of rhizomatous plants. Careful pipeline construction and revegetation techniques would preclude offsite sedimentation.

3.1.3 Terrestrial Environment

The major adverse impact from construction activities would result from the long-term alteration or permanent loss of terrestrial habitat. However, in view of the already disturbed condition of the Bryan Mound neither the brine injection pipeline and wells, nor the freshwater intake system would result in a significant impact to the four ecosystems described in Section 2.5.

General Impacts Resulting From Construction. The marsh ecosystem is sensitive to construction perturbations resulting from disruption of drainage and removal of vegetation. Alteration in the drainage pattern resulting from changes of elevation or obstruction presents the greatest threat to the integrity of existing marsh areas. Within the Bryan Mound area, drainage patterns have already been drastically disrupted causing replacement of marsh areas with coastal prairie vegetation that is characteristic of drier sites. This has resulted from past pipeline construction and ICWW maintenance, and construction of roads and flood control levees. In view of these past practices, the maintenance of the remaining marsh areas in the Bryan Mound area is of critical concern.

Short-term impacts, in the form of temporary loss of wildlife habitat during construction, are unavoidable. This impact is expected to be minor, since wildlife populations would adjust to small changes in habitat conditions and availability. Restoration of the pipeline rights-of-way to their original condition would retrieve marsh habitat for wildlife within 1-2 growing seasons. During the interim period, wildlife would be able to make use of the open mud flats and puddles of water along the right-of-way. The construction schedule can be manipulated to avoid peak migratory periods and nesting seasons, thereby mitigating potentially significant impacts on the avifauna which are the predominant form of wildlife. The actual loss of wildlife as a result of construction activities would be minor.

Noise and construction activities would result in temporary displacement of the mobile forms of wildlife from the construction areas. Rabbits, rats, blackbirds, hawks, egrets, herons, meadowlarks, and snakes are examples of the wildlife forms that would emigrate from the construction sites. This type of wildlife displacement would result in an increased stress on neighboring populations, but because of the short duration, should not significantly decrease the wildlife populations in the Bryan Mound area.

Injection Well Pipeline and Well Sites. The brine injection pipeline and injection wells would be located entirely in marsh and salt flats habitat. The importance of this community to wildlife is appreciable. Because the pipeline to the disposal wells would be adjacent to a maintained levee and road, there presently exists a zone of disturbance along the entire length of the proposed route. This is evidenced by the presence of some typically shrub-savannah vegetation, an indicator of disturbance in marsh areas. The pipeline and levee would be separated by a drainage ditch approximately 50 feet wide, thus reducing the effects of activity on the levee to the marsh habitat. A zone of disturbance also exists adjacent to Highway 1495 in the vicinity of the disposal well sites (see Figure 8). Drainage restoration would return the pipeline portion of the injection well system to its original condition in 2-3 growing seasons, resulting in a minor, short-term construction impact. Wildlife would be temporarily displaced and no permanent habitat modification should result. The pipeline would affect approximately 11,860 feet of marsh ecosystem.

Long-term loss as much as 10 acres of marsh habitat could result from the construction and maintenance of the disposal well sites depending on the actual number of well pads required. This loss would be unavoidable and would involve the area encroached by the well heads and their access roads. The lost marsh habitat would be replaced by shrub-savannah habitat if allowed to revegetate naturally. Although this loss appears negligible, similar habitat modification is already resulting in the incremental loss of valuable marsh habitat in the Bryan Mound area.

Brazos River Freshwater Intake System. The terrestrial impacts resulting from the construction of the freshwater intake system would be long-term because of the permanent loss of existing habitat. Because the area surrounding the intake receives constant grazing pressure and is already influenced by the activity associated with the levee road and Bryan Mound, the habitat that would be lost because of the fres-water intake is of marginal value. Approximately 1.0 acre of disturbed coastal prairie-shrub-savannah habitat would be lost between the Brazos Diversion Channel and the Levee Road. This would actually constitute a minor loss of wildlife habitat in view of the amount of more favorable habitat existing in the surrounding area. The several acres utilized for spoil on the SPR site would be rehabilitated and incorporated into the overall surface habitat of Bryan Mound. With proper rehabilitation the wildlife value of this area would be improved.

The intake channel would create a barrier in the strip of land between the Brazos River and the levee. Domestic cattle now freely roaming the area would be forced to bypass the intake channel by moving onto the levee road.

3.1.4 Biological Impacts of Constructing the Freshwater Intake System

Construction and operation of the Bryan Mound freshwater intake system on the east bank of the Brazos River Diversion Channel is expected to have a negligible impact on the estuarine biological community. The construction of the inlet structures would require the construction of a small cofferdam to facilitate trench dewatering and cement work for the inlet flume. The placement of the cofferdam along the east bank of the Diversion Channel would remove an estimated area of 1,000 square feet from production for several months duration. The benthic community would experience the most debilitating impacts. The segment of the Diversion Channel which would be impacted is affected by upstream industrial discharges and is rendered of very low biological value. Due to the factors of small area impact of the cofferdam and the degraded biological habitat of the river the construction impacts are considered negligible. Upon removal of the cofferdam benthic organism recruitment from the immediate area is expected.

3.1.5 Socio-Economics

It is estimated that the total manpower requirements for the two major components of the proposed system would be approximately 100 men working over a 7-month period. Construction of the several components would be carried out by two separate crews: a 50-man crew for the construction of brine pipeline and a 50-man crew for the construction of the injection wells, pump station and water intake facilities. It is anticipated that the construction of these components would be carried out simultaneously, so that 100 workers may be in the area during the same time period.

It is expected that a large number of skilled workers would be available in the area for the construction of the project, and that most of the manpower would be drawn from Houston and nearby locations in Brazoria County.

Only 50 more men would be required to construct these facilities than would be required to construct the facilities as proposed in the Final EIS. The economic impacts would be minor since the conditions presented in the Final EIS would not be greatly altered as to labor supply, housing, or community services in the area.

3.1.6 Land Use

Fresh Water Intake. The location of the water intake facility downstream of all existing water users on the Brazos River precludes any impacts on existing uses. The large tidal flows passing the site have sufficient volumes to negate potential impacts on the water resources of the estuary, even during periods of maximum withdrawal. The Bryan Mound storage facility is expected to utilize a maximum withdrawal rate of approximately 25 cubic feet per second intermittently during oil withdrawal and this would represent less than 1% of the tidal flow at the site.

Approximately one to two acres of roadside grazing land would be removed by the construction of the intake facility. This is a minor impact. Existing vegetation on about 4 acres on site would be lost for approximately one growing season due to the disposal of spoil created during construction of the intake facility. The spoil disposal site located on the SPR site would be restored along with the overall site restoration program.

The construction of the lift pump and intake facility would have a small aesthetic impact as viewed from the blacktop levee road. Along this portion of the Brazos Diversion Channel, little building development has occurred, thus, the construction of the facility adjacent to the roadside would hamper the visually uninterrupted roadside view of the Brazos Diversion Channel.

The protrusion of the intake facilities 300' inland would block free movement of grazing cattle along the Brazos, but because of the remaining open range, adequate movement is ensured. Only a grazing nuisance would be created; no blockage of free range movement would occur.

Short-term impacts on the road along the Brazos to the Intracoastal Waterway would be generated during the construction of the intake facility. Scheduling of construction of the intake and cutting of the road to lay the water pipelines to the mound would create traffic delays. However, since this route is not a major artery, the impacts would be minor and short-term. There are alternative routes to the Intracoastal Waterway, thus vehicle access would be insured.

Brine Injection Well System. The present and future land use projections call for continued and increased utilization of the area for industrial development, flood protection structures, roadways and recreation. Construction of the injection wells system would have some short-term impacts on these different land uses but in the long-term, the proposed system would not preclude any anticipated future land use plans for the area.

The construction of the proposed injection wells would result in a minor long-term impact on land use. A maximum of 10 acres of vacant land with limited recreational use would be developed. The associated pipeline would result in a minor short-term impact. The construction activity and associated noise would displace some of the wildlife, however impact would be minor and last only during the construction period. Construction activity and the movement of crews and equipment along the local roads in the vicinity of the construction would add some temporary traffic congestion to Route 1495.

Disruption of vegetation at the injection well site would result in a minor long-term impact, resulting in the loss of some wildlife habitat and displacement of some wildlife. Construction of the associated and connecting pipeline would result in a disruption of the land along the right-of-way. This would be limited to the period of construction. The right-of-way would be revegetated and restored following construction and would revert to existing wildlife usage. Although these structures are not consistent with the natural environment of the area, they are consistent with the pattern of industrial development which has taken place in the surrounding area. Therefore, these structures would have only a minor adverse impact on the area's aesthetic environment. The construction of the injection well pads could reduce the size of the designated Corps of Engineers dredge spoil area located east of Route 1495 by as much as ten acres, depending on the actual number of well pads required.

3.1.7 Aesthetic and Sensitive Areas

The construction of the proposed facilities is not expected to impact any rare or endangered species within the Bryan Mound area. The proposed facilities have been carefully located with respect to existing areas of disturbances such as utilizing existing pipeline rights-of-way.

While the raw water intake system is not located on a sensitive area, the construction of the facility would produce a minor aesthetic impact along the Brazos levee road. Until now, the river view along this area has been relatively undisturbed. The construction of the intake lift pumps and screens would produce a minor visual disturbance.

The location of the injection well pipeline would utilize as much existing pipeline right-of-way as possible. The alignment of the majority of the brine pipeline along the oil pipeline right-of-way reduces the required right-of-way. The injection well sites would be located 250 feet from Route 1495, consequently little visual impact would accrue.

3.2 OPERATION

3.2.1 Geological Resources

The impact upon the geological resources at Bryan Mound resulting from the injection of brine into the deep wells would be minor and long-term. The proposed aquifer which is likely to be used is presently filled with saline water.

The major concern of deep well injection operations is the potential of contaminating shallow potable water supplies. This could occur as a result of 1) casing failure, 2) vertical escape around the outside of the well casing, 3) vertical escape through the confining aquiclude, or 4) vertical escape through nearby wells that are improperly plugged, cemented, or have corroded casing. The injection wells will have two strings of casing cemented through the freshwater aquifers. The injection pressures would be controlled at a level low enough to prevent fracture of the overburden. These design considerations together with proven construction techniques and practices make the invasion of brine into potable water aquifers very unlikely. Consequently, the risk of this type of failure is very low.

If brine was accidently released, the most probable leakage would be through nearby abandoned wells. This potential impact would be minimized by locating the injection wells a sufficient distance from known existing wells. Typical industrial practice is to locate the injection well at a distance of at least one-half mile from existing wells. The closest wells of record to the proposed injection wells, see Figure 5, are the Feldman #2 at 5700 feet, and the Greenbrier #1 at a distance of 4,700 feet.

An analysis of these sands indicates that the pressure buildup resulting from brine injection will be insufficient to cause fracturing which might allow brine to escape and possibly invade the freshwater zone.

Correlation of well logs from deep holes away from the dome indicates that the thick sands in the Miocene Oakville section are continuous over an area of many square miles. In particular, the sand found near 5,000 feet varies in thickness only 150 to 200 feet in several wells over a 10 mile-wide area around the site. The porosity and permeability of this sand will be determined on completion of each well. A preliminary log analysis, however, indicates at least 30% porosity as calculated from the Archie formula. The permeability, although more difficult to estimate, is probably well over 1 darcy as indicated by the high self potential shown on the electric logs.

Such a sand should have little pressure buildup away from the borehole. Since the volume available within the sand for brine disposal is much greater than the amount of brine to be injected, a point-source calculation of over-pressure shows approximately 1 PSIG/day (total 400 PSIG) at the borehole.

In addition, there are several other good sands in the Miocene (Oakville) section, so that possibly as much as 400 feet of sand are highly permeable. In this case, the over-pressure would be limited to 200 PSIG. A residual of 20 to 50 PSIG may accumulate with each injection cycle. The fracture gradient usually observed is equivalent to the geopressure, approximately 1 PSIG/foot of depth. These sands are presently close to hydrostatic pressure, with a gradient of 0.44 PSIG/foot as indicated by drill stem tests.

At 5,000 feet, the present pressure is estimated at 2,200 PSIG and the additional over-pressure required to cause fracture leakage would be 2,800 PSIG.

The few hundred PSIG at the disposal wells will thus be dissipated into the sands without upward leakage.

No indication of faulting away from the salt dome was found, and only a few minor shows of oil were found in the logs. These minor shows tend to support the conclusion that the middle Miocene shale is tight and will provide an aquiclude suitable for the project requirements, i.e. prevention of vertical migration of the injected brine.

The likelihood of earthquake stimulation at the injection site is considered to be negligible. Based on the operations of the Dow Chemical Company and the large number of injection wells in the Texas-Louisiana Gulf Coast which have operated successfully for many years, operation of the proposed injection system in a similar stable geological formation is not expected to produce any seismic activity. Analysis of the logs has failed to indicate any faulting of the area surrounding the proposed injection well location.

Only 19,000 barrels of oil has been produced around Bryan Mound. This oil was taken from a small area on the south side of the dome which is naturally sealed against salt and produced through side-tracked holes drilled into the salt itself. The oil has migrated updip from offshore where the Miocene sands are deeper and thicker. The increase in reservoir pressure as a result of the deep well injection is not expected to reach the production area or affect any potential oil and gas development. The possibility of impacts from operation of the brine injection system on the production of oil and gas in the area surrounding Bryan Mound is considered remote. The proposed injection wells will be approximately 9,000 feet from the production area located immediately south of Bryan Mound, and over this distance the increase in reservoir pressure is not expected to affect any present or future production. Log analysis of tests between the production area and the injection wells did not indicate any commercial oil or gas which could be affected by higher reservoir pressures.

3.2.2 Operational Impacts on the Terrestrial Environment

The impacts to this terrestrial environment that may result from the operation of the proposed facilities are minimal but long-term

The loss of terrestrial habitat where above ground facilities are constructed will continue throughout the life of the project. The land above the pipeline will be revegetated and restored. Routine operation and maintenance procedures will further mitigate any terrestrial impacts resulting from construction. An exception to these reduced levels would be the need to repair a section of pipeline. The isolated disruption would result in impacts similar to that of the initial construction but very localized.

At water crossings, once the pipe is buried and the trench material is replaced no further impact will occur.

3.2.3 Air Quality

During the intermittent discharges of saturated brine from the oil storage caverns to the surface brine control facility hydrocarbon air emissions would occur due to the release of pressure and normal vaporization rates of hydrocarbons contained within the brine. Dissolved hydrocarbons in the brine from cavern filling, storage and displacement will be released to the vapor phase upon discharge into the surface brine control pond. Calculations of reactions and rates of reaction in comparison to the particular hydrocarbons contained in the brine are given in Appendix B. Results of the air quality study indicate that of the hydrocarbons would be discharged to the surface brine control facility approximately 87.5 percent vaporize, 9.8 percent would remain in solution and 2.7 percent would be retained in the surface layer.

Calculations of hydrocarbons air emission rates for the particular operational sequences at Bryan Mound indicate the following:

	Emission Rate
Theoretical Maximum Worst Case(Any Caverns)	7.80 grams/second
Initial Oil Fill(Any Caverns)	3.97 grams/second
Second and Subsequent Oil Fills	
Cavern 1	1.71 grams/second
2	3.07 grams/second
4	1.88 grams/second
5	0.93 grams/second

In estimating the incidence of non-compliance with the national guideline for ground level non-methane hydrocarbons of 160 ug/m^3, dispersion downwind and stability conditions D, E and A were assumed. The mixing heights and wind conditions are listed in Appendix B, Table 8-4. Results of the air emission analysis indicate that non-compliance with the national guideline for ground level non-methane hydrocarbons concentration of (160 ug/m^3) would occur under the following cases:

Case I: For emissions at a 10-meter effective height from a brine pond (area source) with D stability and a 5 meter/second wind. Non-compliance would occur in the near-distance range (to 0.1 km) for all fills (except second and subsequent fills of cavern No. 5) and at distances to 0.5 (plus) km for the theoretical maximum worst case condition and all initial fill conditions.

Case II: For emissions at a 10-meter effective height from a brine pond (area source) with E stability, a wind of 2 meters/second and a dispersion "cap" at 500 meters. Non-compliance would be experienced in the ranges 0-2 (plus) km for the theoretical maximum worst case emission rate; 0-1 (plus) km for all initial fill cases; and 0-0.500-0-1.0 km in other cases, depending upon the particular cavern brine being discharged.

Case III: For emissions at a 10-meter effective height from a brine pond (area source) with A stability, a 3 meter/second wind and no dispersion "cap". Non-compliance would be experienced in the 0-0.2 (plus) km range at the maximum worst case emission rate and in the range 0-0.1 (plus) km for all initial cavern fills and for all subsequent refills of cavern No. 2.

A second air impact parameter is the air "burden" due to emissions integrated over a period of time; usually one year. The projected air pollution burden from operating the Bryan Mound surface brine control facility will be 28.3 tons emitted over a 75 day period during initial oil fill and 59.2 tons emitted over 420 days during all subsequent oil refills. The projected air burdens are intermittent and infrequent and within the zone requiring interpretation of the issuing air permit agencies. These emissions would be in addition to the onsite oil surge tank which were originally estimated at 120 pounds per day (21.9 tons per year) of hydrocarbons. DOE has more recently refined this estimate to be 85.4 tons per year.

3.2.4 Brazos River Diversion Channel

The operation of the raw water intake system would be on an intermittent basis. Thus the operation impacts associated with the Brazos River Diversion Channel must be considered relative to the intermittent operation of the storage facility.

The impact upon the Brazos River Diversion Channel as a result of the operation of the Bryan Mound Storage facilities would be minor and intermittent for the duration of the program.

The proposed location of the water intake is at a section of the channel considered to be of low biological value due to the upstream industrial waste effluents which render the area of poor quality for habitat or nursery use.[1,2] Some recovery of the biota does begin in this vicinity of the channel since much of the waste effluent has settled out and dilution has occurred.

Whereas the construction phase of the water intake system would cause impacts principally upon the benthic biota, the operational phase would affect the organisms of the water column. Linked to the intake of water are the problems of impingement, entrainment and entrapment. Impingement is the collision of organisms against the screens covering the water intake structures where they are subject to predations, abrasion, mechanical damage, exposure, asphyxiation, or reimpingement. The magnitude of impingement is a function of several factors including the number of organisms, location of the intake structure, system design, operating characteristics (i.e. intake velocity), season and tidal stage.

Entrainment is defined as the process whereby organisms, primarily phytoplankton and zooplankton pass through the 3/8 inch mesh intake water screens and into the storage system to be eventually discharged with the effluent. Mortality of entrained organisms would be 100%.

The alteration of the existing habitat may result in passive or active attraction (entrapment) of organisms to the immediate vicinity of the intake structures with subsequent impingement and/or entrainment.

The amount of displacement water that would normally be withdrawn from the Brazos River is 25 cfs for the currently proposed storage facility. This volume constitutes less than one percent of the ebb tidal flow during periods of low freshwater flow in the channel.

The magnitude of impingement and entrainment would be minimal. Not all of the organisms drawn into the intake channel would be impinged or entrained since many with locomotory abilities would escape any harm. Low intake velocities (less than 0.5 feet/second) would further reduce the number of organisms impacted. Even if a worst case were assumed and all organisms within the intake waters were lost, only a negligible fraction of the biota would be lost.

Elutriate from the screen washing operations would not affect net water quality or marine biota of the lower estuary. These small return flows of less than 1 cfs would not contain any constituents which would be deleterious to the biota.

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4. PROBABLE IMPACTS WHICH CANNOT BE AVOIDED

The information presented and analyzed in Section 3 makes it apparent that the impacts which can be expected to result from the proposed actions fall into two general categories: those which can be avoided, eliminated or mitigated by attentive design and construction practices; and those which cannot be avoided and must therefore be recognized as an inherent part of the proposed actions. The following section discusses these unavoidable impacts, first in terms of several basic actions such as land requirements, and air pollution; and second in terms of the two geographical areas of operation. The discussion follows this outline:

4.1 Acreage Dedicated to the Proposed Project
4.2 Air Pollution
4.3 Water Intake Facilities
4.4 Brine Injection Wells

4.1 ACREAGE DEDICATED TO THE PROJECT

The maximum amount of land required for the water intake and brine injection system will be about 43 acres. This would be distributed among the various components of the project as follows:

	Acreage
Water intake facilities	2
Water pipeline to Bryan Mound	6
Surface storage of brine and spoil disposal (on Bryan Mound)	5
Brine pipeline to brine injection wells	20
Brine injection wells (5 sites maximum)	10
Total	43

Since the surface storage and treatment facilities for brine and the small spoil disposal area would be located on the Bryan Mound site, already discussed in the Final Environmental Impact Statement, only about 38 additional acres would be required for the facilities which are the subject of this Environmental Statement. Twenty-six acres would be dedicated to pipeline rights-of-way, meaning that they would be revegetated after construction of the pipeline and then returned to their original use. Therefore, the maximum amount of land to be removed permanently from existing uses would be approximately 17 acres.

4.2 AIR POLLUTION

Adverse impacts on air quality may occur from both instantaneous concentrations of a pollutant, and atmospheric "burdens" integrated over a period of time. The hydrocarbon emissions from the surface brine storage pond at Bryan Mound would impact the air quality in both ways.

Expected instantaneous concentrations of non-methane hydrocarbons are tabulated in Appendix B. Calculated estimates of the emitted concentrations indicate that non-compliance with the national guideline for nnn-methane hydrocarbons (160 ug/m^3) will occur under the atmospheric conditions discussed in Section 3.2.3.

Potential atmospheric burdens due to hydrocarbons released from the surface brine control facility have been calculated and presented in Appendix B. Calculations indicate that hydrocarbon emissions would occur intermittently during 75 days of the 420 day initial brine discharge. The atmospheric burden from these emissions would be 28.3 tons of hydrocarbons. During the second and any subsequent brine discharges, hydrocarbon emissions would occur during the entire brine discharge period of 420 days. The calculated atmospheric burden under these conditions would be 59.2 tons (51.4 annual tons) of non-methane hydrocarbons. When added to the projected emissions from the oil surge tanks the annual burden during the initial fill would be 113.7 tons and 144.6 tons for each subsequent fill.

To control the atmospheric hydrocarbon burden from the facility, DOE is actively pursuing the possible use of double sealed floating roof tanks. Recent preliminary research performed by Chicago Bridge and Iron (1976) indicates that such tanks reduce the standing storage hydrocarbon emissions for crude oil by a factor of 4 or greater (up to 10).[1] Incorporation of these tanks would conservatively reduce the net hydrocarbon burden emitted from the facility from 113.7 tons to 61.4 during the initial fill and from 144.6 to 92.3 tons during subsequent fills.

4.3 WATER INTAKE FACILITIES

The intermittent water intake for each 150-day oil withdrawal would be at a rate of 25 cubic feet per second. The inlet velocities across the screens would be less than 0.25 feet per second under normal operations. At these low velocities, all but the least mobile forms of marine life should avoid entrainment. All non-mobile life forms entrained into the lift pumps would be lost. Due to the large tidal wedge of water passing this location and the impoverished estuarine biological community, this impact would be negligible and have an immeasurable effect on the estuarine population.

The intake channel is expected to fill with sediment and may provide a favorable habitat for estuarine species. This could lead to the establishment of a community similar to that of the existing channel. The water velocities in the intake channel would be similar to the current in the Brazos Diversion Channel and are expected to provide favorable environment for mobile forms even under operating conditions.

4.4 BRINE INJECTION WELLS

The underground injection of brine would cause the unavoidable increase in salinity of an already saline aquifer. This would result in increased pressure and the risk of aquifer fracture, which could lead to communication with fresh water zones. However, this risk is low, due to the massive nature of the injection sands and the degree of vertical separation between them and potable water strata.

The injection wells would have two strings of casing cemented through the fresh water zones to prevent leakage of brine into potable water aquifers. Injection pressures would be controlled and low enough to prevent fracture of the overburden. These design considerations together with proven construction techniques and practices make the invasion of brine into potable water aquifers very unlikely. Consequently, the risk of this type of failure is very low.

The proposed location of the brine injection well pads has been changed following consultation with several Federal and State agencies in an effort to minimize the impact of the project on valuable wetlands. The DOE is currently evaluating the possible use of directional drilling from well pads built at the new location in order to further reduce the impact on wetlands. If directional drilling proves feasible and is successful, the total wetland area requiring fill for well pads could be reduced to 4 acres.

5. RELATIONSHIP BETWEEN LOCAL AND SHORT-TERM USES OF THE ENVIRONMENT AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The comments in this section must be considered together with those in Section 5 of the Final Environmental Impact Statement which address the overall Bryan Mound Project. The long-term benefits which will accrue as a result of this project have been adequately presented there-in.

The utilization of the deep well brine disposal system would result in less significant impact once the wells are drilled. The sand structure within the wells already contains brine. Well drilling and operating procedures are proven techniques and as a result system failure is very unlikely.

The proposed location of the freshwater intake system on the Brazos River would not disturb existing water users, since it would be downstream of all users. Furthermore, the quantity of water to be drawn from the Brazos would be an insignificant fraction of the local river flow.

Retention of the originally proposed option for disposing the brine to Dow Chemical in Freeport provides the Bryan Mound Project with an additional degree of flexibility.

The single long-term environmental impact would be the removal of 17 acres of land from present use.

6. IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES

The actions proposed in this Supplement require only a small additional commitment of resources compared with the project as originally proposed. Constructing a raw water intake and brine disposal system would result in the utilization of additional labor, materials and land, as already discussed in detail in the preceding sections. The construction and operation of these systems would continue the existing industrial development of this coastal area and would draw on the labor and supply capabilities of the area to provide the needs of the project.

The additional amount of material required for the project as a result of the newly proposed systems constitutes only a minor fraction of the materials necessary for the entire oil storage program at Bryan Mound. The energy to be utilized by the project in relation to potential energy in storage was estimated at less than .1 percent in the initial proposal. This net energy consumption figure should not change appreciably as a result of the amended actions. The materials utilized for the project are approximately equivalent to the materials utilized in the systems replaced.

7. ALTERNATIVES TO PROPOSED ACTIONS

Three raw water supply alternatives and several brine disposal systems were originally investigated for the Bryan Mound Site. All of these were discussed in the Bryan Mound FEIS, though not necessarily in equal detail since specific actions seemed advantageous at that time.

7.1 RAW WATER SUPPLY ALTERNATIVES

Three alternative water supply systems were investigated for the Bryan Mound project. These were the Gulf of Mexico Intake, the Dow Chemical Company Reservoir and the Upstream Brazos Diversion Channel alternative.

Gulf of Mexico Intake. This alternative would require the construction of an offshore intake and a two mile pipeline from the Gulf across the Intracoastal Waterway to Bryan Mound. This alternative was found to be the least favorable from an environmental and economic standpoint. The intake operations would have to be located in a very rich marine biological area. In comparison to the biological impacts generated by the Brazos River intake proposed herein, the Gulf intake would generate more serious marine impacts due both to the larger amount of entrainment during water withdrawal and to larger construction impacts. Terrestrial impacts from this alternative would be much greater than the proposed water pipeline which is to be constructed along a previously disturbed area.

Dow Reservoir. Procurement of water from the Dow Reservoir System would involve a conflict of water uses between the private industrial consumer and the demands of the project. The construction of the connecting 5-mile pipeline from Dow Plant B would require the disturbance of approximately 15 acres of non-critical land. However, because of competing consumptive use of the existing water supplies, the Dow source is considered to be an unreliable alternative to the system proposed herein. The Dow water quality would be superior to that from the proposed withdrawal from the Brazos Diversion Channel.

7.2 BRINE DISPOSAL ALTERNATIVES

Alternate brine disposal systems reviewed were: alternate deep well injection sites around Bryan Mound, and the construction of a surface reservoir which would allow complete retention of the brine.

7.2.1 Injection Well Alternatives

Several alternative deep well injection systems were reviewed for the oil storage program. These alternatives were an alternate pipeline route to the proposed well field and several alternative well site locations around Bryan Mound.

The alternative pipeline alignment (Figure 1) would have been approximately the same length and traverse similar terrestrial habitat and soils series as the proposed pipeline. This alignment would require an entirely new right-of-way and require multiple crossings of the Seaway Oil Pipeline. Since the right-of-way would revegetate within two growing seasons in either case, the long-term effects of both alignments would be relatively minor.

Two alternative deep well injection sites were reviewed between the proposed site and Bryan Mound. The first site was located midway between the present location and Bryan Mound. The geological conditions at this site are very similar to those at the proposed site and a similar five (5) well arrangement was proposed. A land use review of the area indicated that the site was located on a proposed Corps of Engineers dredge spoil area and there were numerous questionable shallow wells within one-half mile of the site. Due to these constaints this site was eliminated. The second well site arrangement as proposed in the Draft Supplement was located immediately west of State Route 1495. This site was eliminated after discussions between DOE and U.S. Fish and Wildlife Service, National Marine Fishery, Corps of Engineers and Texas Parks and Wildlife personnel indicated that a premium had been placed on the preservation of the marshland on the west side of State Route 1495. This review indicated the marshland to the east of route 1495 was marginally inferior due to the interrupted drainage patterns and had a greater potential for wetland encroachment by spoil disposal and commercial expansion. As a result of these discussions wells numbered 1,2,3 and 5 were moved from the west side of the road to their present locations on the east side. The location of well number 4 remained unchanged. With the possibility of utilizing multiple directionally drilled injection wells from well pads numbered 3 and 4 the possibility of eliminating well pads number 2 and 5 exists. The feasibility of this alternative will not be known until a full drilling and engineering program is completed.

7.2.2 Brine Retention

The complete retention of brine was suggested as a possible brine disposal alternative at the Texas Railroad Commission Hearings, held on September 15, 1977. This suggestion was reviewed by the DOE and eliminated from further consideration when the environmental and overal design difficulties of this proposal were reviewed. The use of a surface retention pond would require a design capable of preventing any seepage into the underlying aquifers. This requirement would necessitate a fully lined brine pond similar to the site's smaller lined brine surge pond. The area of this pond to simply contain one complete cycling of the Bryan Mound SPR, would require the storage of 63 million barrels of brine (8120 acre feet). Assuming a nominal 10 foot depth this would require a minimal surface area of 812 acres.

The open storage of brine in the Bryan Mound area must take into consideration the ratio of net annual evaporation (53 inches) to annual precipitation (45 inches)[1] and the evaporation depression due to higher salt concentrations. With a salt concentration of 314 grams per liter (g/l) the calculated annual evaporation from a waterbody decreases to 55 percent of ambient conditions, (29 inches), 16 inches less than precipitation. Due to the depressed evaporation the reservoir would crease until the net annual precipitation input balance the evaporation losses. Based on the calculated reduced evaporation rates, the salt concentration of the reservoir would have to be decreased to approximately 105 g/l in order for this to occur. Calculations of the reservoir dynamics indicate that the reservoir size would be increasing for approximately 200 years until the brine is finally diluted threefold to approximately 105 g/l. This would require a threefold increase in the reservoir volume to 24,360 acre feet (8120 X 3) requiring a 2,436 acre holding pond assuming a ten foot depth. A further expansion of this acreage would be required if a portion of the diluted brine was withdrawn and reused for oil displacement and later returned to the reservoir near saturated conditions of 317 g/l. The current design calls for a potential five cycle oil fill withdrawn scenario.

It can be readily seen the permanent construction of a 2436 acre brine retention pond is prohibitive and unacceptable from land use environmental standpoints.

8. CONSULTATION, RELATED PERMITS, AND DISCUSSION OF COMMENTS

Various local, state, and Federal agencies contributed information and assistance in the preparation of this Final Supplement to the Bryan Mound Final Environmental Impact Statement. A list of these agencies is given in Section 8.1. Further advice and coordination will be sought from agencies having regulatory jurisdiction over the activities necessary to develop the systems proposed in this EIS Supplement. Procedures are currently underway to procure permits and licenses which would be required to proceed with the implementation of the proposals discussed herein. Those Federal and state agencies with regulatory interest in the development of Bryan Mound as a Strategic Petroleum Reserve site were listed in the Final Environmental Impact Statement (FES 76/77-6). Federal permits required for the current proposal are discussed in Section 8.2.

The Draft Supplement-Final Environmental Impact Statement Bryan Mound Salt Dome was released for public review and comment in July, 1977. A list of those agencies and organizations from which comments were requested is given in Section 8.3. Those comments which were received within the time alloted, are included in Section 8.4. Changes have been made in the text of the statement in response to these comments. The comment letters of various agencies and groups are included in their entirety in Appendix D.

8.1 AGENCIES AND GROUPS CONSULTED

In preparation of the Draft Supplement to the Bryan Mound Final Environmental Impact Statement, numerous agencies, governmental units and groups were consulted for information and technical expertise pertaining to the new proposed systems. These groups are listed below:

Brazoria County Engineer	Angleton, Texas
Brazos River Authority	Waco, Texas
General Land Use Office	Austin, Texas
Houston Galveston Area Council of Government	Houston, Texas
National Marine Fishery Service	Galveston, Texas
Louisiana State University	Baton Rouge, Louisiana
Office of Water Research and Technology	Galveston, Texas
U.S. Department of Interior	Washington, D.C.
Ralston Purina, Inc.	St. Louis, Missouri
Seadock, Inc.	Houston, Texas
Soil Conservation Service	Angleton, Texas
Texas A & M University Marine Laboratory	Galveston, Texas
Texas Highway Department	Houston, Texas
Texas Parks and Wildlife	Austin & Angleton, Texas
Texas Water Development Board	Austin, Texas
Texas Water Quality Board	Austin, Texas
University of Texas	Port Aransas, Texas
U.S. Army Corps of Engineers	Galveston, Texas
U.S. Fish and Wildlife Service Red Wolf Recovery Farm	Beaumont, Texas
U.S. Geological Survey	Houston, Texas
University of California at Berkeley Sanitary Engineering Laboratory	Berkeley, California
Waterways Experiment Station of U.S. Army Corps of Engineers	Vicksburg, Mississippi

8.2 ENVIRONMENTALLY ORIENTED PERMITS

The actions necessary to develop the water supply and brine disposal systems described herein will include dredging operations in the Brazos River Diversion Channel as well as filling in a small amount of land designated as wetlands by the U.S. Army Corps of Engineers. As such, Department of the Army permits under Section 10 of the Rivers and Harbors

Act of 1899 and Section 404 of the Federal Water Pollution Control Act Amendments of 1972 will be required prior to construction.

The Department of Energy will consult with the appropriate Federal and state agencies having regulatory interest in the proposed project pursuant to the Intergovernmental Coordination Act of 1968.

8.3 PARTIES FROM WHICH COMMENTS WERE REQUESTED

As a part of the review process for the Draft Supplement, comments have been requested from the departments, agencies, and organizations listed below:

Federal

- Federal Energy Administration Regional Offices (I-X)
- Advisory Council on Historic Preservation
- Council on Environmental Quality
- Department of Agriculture
- Department of Commerce
- Department of Defense
- Department of Health, Education, and Welfare
- Department of Housing and Urban Development
- Department of Interior
- Department of Labor
- Department of State
- Department of Transportation
- Department of Treasury
- Energy Research and Development Administration
- Environmental Protection Agency
- Federal Power Commission
- Interstate Commerce Commission
- National Science Foundation
- Nuclear Regulatory Commission
- U.S. Army Corps of Engineers
- Water Resources Council

States

- Louisiana
- Texas
  - Texas Railroad Commission
  - Texas Water Quality Board
  - Texas Air Control Board
  - Texas Energy Advisory Commission
  - Texas Parks and Wildlife Department
  - Office of the Governor

Others:

- American Petroleum Institute
- Brazoria County
- Center for Law and Social Policy
- East Texas Council of Governments
- Environmental Defense Fund
- Environmental Policy Center
- Friends of the Earth
- Franklin County
- Funds for Animals, Inc.
- Hopkins County
- Izzak Walton League of America
- Morton Salt Company

National Audubon Society
National Parks and Conservation Association
Natural Resources Defense Council
National Wildlife Federation
Nature Conservancy
Orange County
Rice University
Sabine River Authority
Seadock, Inc.
Sierra Club
Smith County
Southern Methodist University
Southwestern Electric Power Company
Texas A&M University
University of Texas
Gulf States Marine Fisheries Commission
American Fisheries Society
American Littoral Society
Dow Chemical Company
City of Freeport
Velasco Drainage District
Houston-Galveston Area Council of Governments

8.4 PARTIES FROM WHICH COMMENTS WERE RECEIVED

COMMENTS, AND RESPONSE, TO THE PARTIES WHOSE COMMENTS WERE RECEIVED WITHIN THE ALLOTTED RESPONSE PERIOD

DEPARTMENT OF THE ARMY
GALVESTON DISTRICT, CORPS OF ENGINEERS

Comment A

The authorized 45-foot Federal Navigation Channel Enlargement for Freeport Harbor would have a proposed dredged material disposal area near the injection well pipelines.

Response

The proposed disposal area has been noted in Section 2.8.3. The proposed injection well location has been coordinated with the Galveston District Office of the U.S. Army Corps of Engineers, the Department of Interior Fish and Wildlife Service and the Department of Commerce National Marine Fishery Service in an effort to minimize the adverse impact of the injection system on wetlands. The pads have been relocated to a less productive wetland, which has also been designated as potential spoil area. The Galveston District has reviewed this change and has indicated that it would not interfere with the spoil disposal plans.

Comment B

Request that the second sentence of the third paragraph of Section 1.2.1 be changed to read "Detailed plans and construction procedures for pipeline crossings and proposed structures at the flood protection levee system will be coordinated with the Velasco Drainage District to insure the integrity of the levee system is maintained," in lieu of "All construction work wuld be coordinated with the Velasco Drainage District to avoid creating a flood hazard to the property behind the levee."

Response

The requested change has been made.

Comment C

The proposed water intake in the Brazos River Diversion Channel, will require Department of the Army permits under Section 10 of the River and Harbor Act of 1899 prior to construction. Facilities constructed in wetlands will require Department of the Army permits under Section 404 of the Federal Water Pollution Control Act Amendments of 1972.

Response

Federal permits necessary for construction of the proposed facilities are discussed in Section 8.2.

Comment D

Page 1-3, Paragraph 1.2.1 - Consideration should be given to the alternative of locating the pump station on the interior side of the hurricane protection levee.

Response

Location of the pump station on the interior side of the levee would necessitate substantial excavation in the levee itself. The proposed design has been developed in recognition of the DOE responsibility of preserving the integrity of the Freeport Flood Protection System. The massive excavation required to locate the pumping station on the land side of the levee would violate this responsibility.

Comment E

Page 107, Section A-A - There may be erosion at the base of the walkway supports and at the sides of the pump station during high discharges, and riprap protection should be considered.

Response

The final design of these facilities will be in accordance with the standard engineering practices. Every effort will be made to minimize the potential for erosion.

Comment F

Page 2-24, Paragraph 2.7.1 - Identify the source of the statement "combined storage capacity of approximately 6,900 acre-foot."

Response

A recheck of the major reservoir capacities within the Brazos River drainage area indicates this value is incorrect and the reference has been removed in the final EIS.

Comment G

The maximum Brazos River discharges at Rosharon are calculated to exceed 100,000 cfs, since the one percent discharge at River Mile 52 is approximately 103,000 cfs.

Response

The data given in the Draft EIS in Paragraph 2.7.1 was the measured and not the calculated maximum flows at Rosharon. Both measured and calculated flow data have been incorporated in the final EIS.

Comment H

Pumps and mechanical gear susceptible to flood damage should be raised to an elevation at or above the one percent flood elevation in consonance with Executive Order 11988. "Normal flooding elevations" is an ambiguous term which does not specifically indicate compliance with the flood damage prevention requirements contained in the Executive Order. Figure 2 implies that susceptible gear is located above 18 feet elevation, but such items are not specifically labelled on the elevation view.

Response

The calculated 100-year storm surge in the vicinity of Freeport Texas is 12 feet (1). All flood susceptible gear will be located above the one percent flood elevation in accordance with Executive Order 11988.

(1) Natural Hazards of the Texas Coastal Zone, Texas Bureau of Economic Geology, 1974.

Comment I

It is suggested that construction of the injection well pipeline be coordinated with the Brazos River Harbor Navigation District so as to avoid reductions in capacity of the disposal area. Also, construction of the pipeline crossing the small drainage ditch between the injection wells and the proposed disposal area should be coordinated with the U.S. Fish and Wildlife Service.

Response:

The location of the brine disposal system has been coordinated with the Galveston District Corps of Engineers, the U.S. Fish and Wildlife Service, the National Marine Fishery Service and Texas Park and Wildlife Department in an effort to minimize the effects of DOE facilities on wetlands and to minimize reduction of the spoil disposal sites.

UNITED STATES DEPARTMENT OF COMMERCE

Excerpted are the comments related to the brine injection wells and Bryan Mound raw water supply.

3. Environmental Impacts

3.1 Construction

3.1.3 Terrestrial Environment

Injection Well Pipeline and Well Sites

Page 3-7, paragraph 2. This section states that "Long-term loss of about 3 acres of marsh habitat...would be unavoidable...". The alternative of directionally drilling the disposal wells from nearby upland terrain should be thoroughly discussed since that would make the marsh habitat loss avoidable.

Response

After consultation with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, Texas Parks and Wildlife Department, and the U.S. Corps of Engineers the proposed well locations as denoted in the draft statement, figure 1, page 1-4, have been moved from west of route 1495 to the east side as illustrated in figure 1. This eastward relocation will place the well pads in an area which has a lower marsh habitat value and has been designated as a Corps of Engineers spoil disposal area for the Freeport Harbor project.

The comments to reconsider directional drilling as an alternative to reduce the number of required pads is being reviewed by the DOE. If the feasibility of this proposal appears favorable, directional drilling may be incorporated to eliminate the requirement for several well pads. The acceptability of this design will be dependent on the incorporation of all the injection design criteria and objectives to complete the injection wells and not merely on the feasibility of drilling the directionally oriented holes.

3. Environmental Impacts

3.2 Operation

3.2.4 Brazos River Diversion Channel

Page 3-21, paragraph 4. The statement "Even if a worst case were assumed and all organisms within the intake waters were lost, only a negligible fraction of the biota would be lost," should be documented.

Response

At a withdrawal rate of 25 CFS the volume of the water withdrawn represents only 0.3% of the mean freshwater discharge and approximately 0.1% of the tidal discharge passing the withdrawal point. Therefore, assuming a net distribution of organisms equally throughout the water column the maximum amount of organisms lost would be approximately 0.1% of the population.

In relation to the overall estuarine biota this value should be reduced when the reduced quality and quantity of the biological population, at the intake site, are considered.

FEDERAL POWER COMMISSION

Comment A

The solution mining of additional salt dome caverns or enlargement will impact areas much larger than stated.

Response

The Draft EIS did not address the enlargement of the storage capacity at Bryan Mound. This topic is discussed in the Draft Environmental Impact Statement for the Seaway Group Salt Domes (DES77-10) and is not a part of the project analyzed in this EIS supplement.

Comment B

Super saline conditions will probably persist for a longer period, depending upon the frequency of storage operation.

Response

Assuming that this comment was addressing the salinity of the brine coming from the cavern it was assumed for the impact analysis that any brine removed from the caverns would be saturated to the measured 317g/l regardless of the storage time within the cavern.

Comment C

Initial filling of storage should be at a lesser rate to reduce emulsification.

Response

Due to the buoyancy of the oil, the annular jet geometry, and the large volume of the salt caverns the jetting energy necessary to produce significant amounts of emulsified fluid is not expected to occur. However, the DOE is reviewing their operating criteria based on available operating information and data to reduce any deleterious oil/brine interactions.

Comment D

Consideration should be given to filtration of the brine discharge.

Response

Prior to discharge all brine will be processed through the lined brine control pond which has a 16 hour retention time for the initial oil fill period. During this retention period heavy suspended solids will settle out of the brine. The amount of solids which will be produced by the operations, other than the crystallizing salt, is believed to be minimal. This is due to the cavern's natural settling action which will occur during the long retention period and the relative purity of the salt mass.

DOW CHEMICAL U.S.A

Comment A

On pages 1-9 and 1-10, it is stated that there is an agreement with the FEA whereby Dow would dispose of 56,500 BPD of brine from the site. Dow and the FEA have been discussing this possibility for sometime, but there was no firm agreement at the time of the statement and there is still no agreement now. So the impact statement is in error and misleading on this point.

Response

At the time of the draft publication no definite agreement had been reached and the comment is correct. However, an agreement has been currently reached to process up to 56,500 BPD of chemical quality brine into the Dow facility.

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APPENDIX A

OIL-IN-BRINE MODEL STUDY

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APPENDIX A

1. INTRODUCTION

The storage of crude oil in the Strategic Petroleum Reserve Program will entail the contact of oil with brine solutions. This contact would result in the dissolving and entrainment of small concentrations of hydrocarbons in the brine through a number of physical phenomena. In order to assess the magnitude of oil concentrations discharged into the brine surface control facilities, a study was performed to determine the mechanisms of interactions between the oil and brine within a typical underground oil storage cavern. This appendix discusses the results of that study.

The primary cavern interactions which would distribute the oil into the brine are dissolution and dispersive reactions. Dispersive reactions require a physical energy input to the system to agitate the micro oil particles into the underlying brine. Dissolution occurs on the molecular level where the hydrocarbon solute dissolves into the brine solvent system. Although both of these reactions occur simultaneously during certain operational phases, the study indicates that principally dissolved components would be discharged to the surface brine control facilities.

Results of the study indicate that under a worst-case situation, the brine discharge would contain an estimated maximum 32 parts per million (ppm) of oil. However, this condition is not expected to occur. A more reasonable estimate of the dissolved oil-in-brine concentration discharged from a typical cavern during initial fill is approximately 16 ppm, and during approximately the later 10% of an individual cavern discharge and 6 ppm during the entire individual cavern discharge period for subsequent refills.

The sections which follow describe the oil/brine interactions within a storage cavern (Section 2), dissolving reactions (Section 3), dispersive reactions (Section 4), expected concentration of oil-in-brine discharged to the surface brine control facilities (Section 5), and conclusions (Section 6).

2. OIL/BRINE INTERACTIONS IN A SALT SOLUTION-MINED STORAGE CAVERN

The following sections briefly describe the major interactions that occur between the oil, brine, and raw water within a salt dome storage cavern. The interactions which occur during the operational phases of the storage program are illustrated schematically in Figure A-1 and are described herein as:

The initial oil fill and discharge of brine;
The long-term storage of oil in a quiescent state;
Raw water injection to displace oil;
Storage Cavern Conditions after oil is displaced; and
The second and subsequent refills.

2.1 INITIAL OIL FILL

The salt dome cavern, prior to the initial oil fill, is filled with brine. As crude oil injection begins, jetting (approximately 8 feet per second) causes turbulence at the oil-brine interface which produces an emulsion of oil and brine and affects solution of various hydrocarbons into the brine. Turbulence would be confined to approximately the upper 50 feet of the cavern. As cavern filling continues, interface turbulence would decrease as the interface descends. At a depth of approximately 50 jet diameters, the oil jet momentum would be one-tenth of its initial value and interface turbulence would have ceased.[1]

The lighter, more soluble hydrocarbons diffuse across the oil-brine interface, while the heavier, less soluble components slowly begin to form a relatively dense and viscous refractory layer between the oil and brine. Thus, the major oil contamination of the brine occurs during the

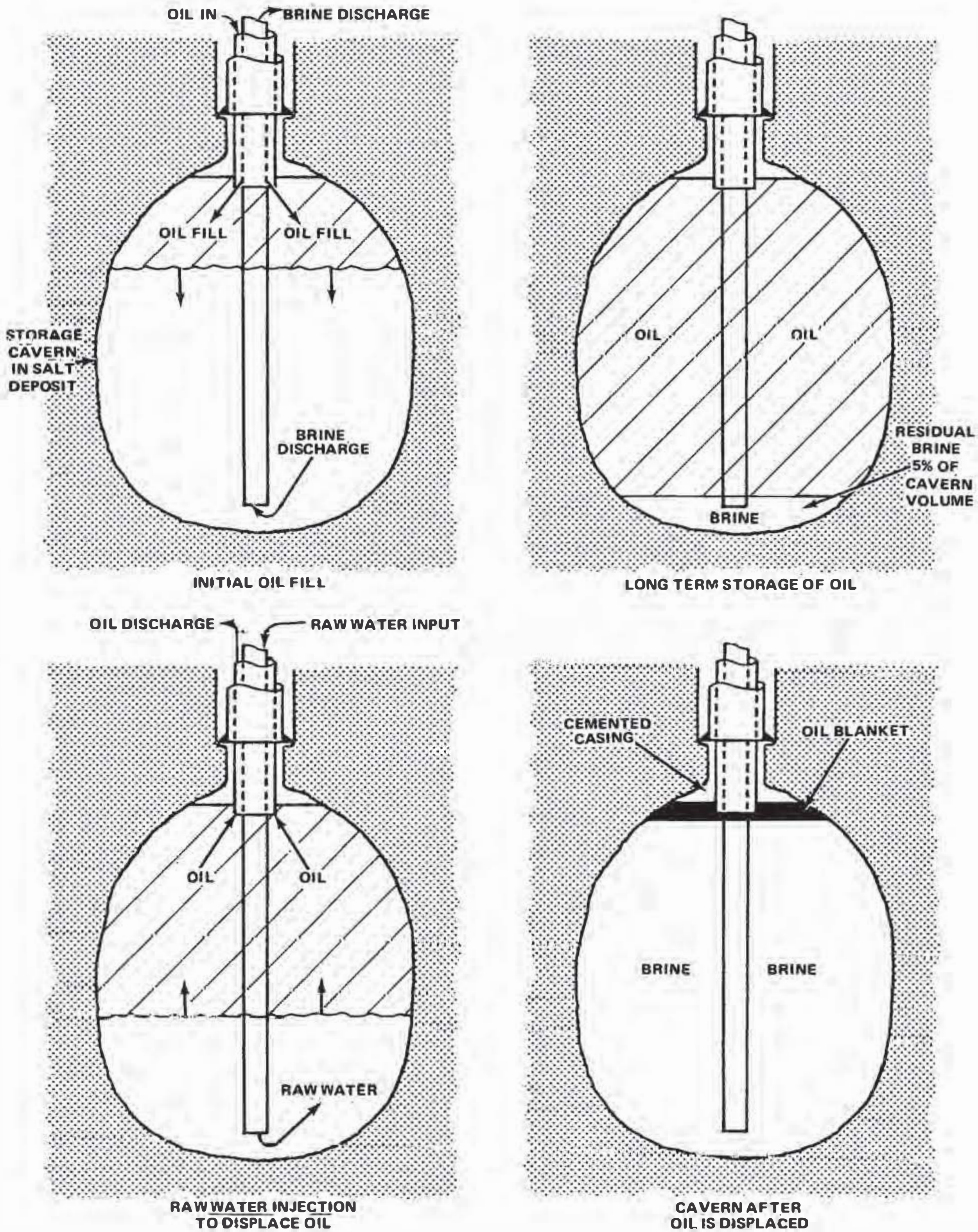

Figure A–1 OPERATIONAL PHASES OF OIL STORAGE PROGRAM

initial period of the filling phase while turbulence is high.

Dissolved and dispersed oil is expected to remain within the uppermost 100 feet of the brine column during initial fill due to a low rate of vertical diffusion. Consequently, during the early stages of fill the oil concentration of the discharged brine would be near zero. As the oil/brine interface approaches the bottom of the brine displacement tubing, oil concentration of the discharged brine would increase and average 16 ppm during the final stages of fill (Section 5).

2.2 LONG-TERM OIL STORAGE

During long-term oil storage, a brine layer is maintained at the bottom of the solution cavern and would amount to approximately 5 percent of the total cavern volume. The oil concentration within this brine is assumed to reach equilibrium during long-term storage. A refractory layer would form at the oil brine interface because of the loss of soluble hydrocarbons into the underlying brine and a consequent enrichment of heavier, relatively insoluble hydrocarbons. Any remaining small fraction of dispersed oil in brine would be expected to rise to the oil-brine interface contributing to the refractory layer or be absorbed by suspended particles and in turn settle to the bottom. The long-term storage is the only phase of the program where time allows the hydrocarbons to dissolve and establish equilibrium conditions with respect to the brine.

2.3 INJECTION OF RAW WATER AND DISPLACEMENT OF OIL

The oil is displaced from the cavern by injection of raw water into the lower level, causing the upward displacement of oil. The raw water would dilute the residual brine solution in the bottom of the cavern and may resuspend settled particles. The resultant dilution of both the brine and dissolved oil concentration would allow further dissolution of oil into brine. Initially, there would be turbulence at the oil-brine interface which may disperse some of the oil. The refractory layer at the oil-brine interface would effectively limit diffusion and dispersion. When the crude oil is displaced from the storage cavern, an oil film would remain on the cavern walls. This oil film would, in time, partly dissolve into the brine and partly rise to the oil-brine interface as solution of the underlying salt progresses. For calculation purposes, in this report, this oil film was assumed to be totally dissolved, adding approximately 1.6 ppm to the oil-in-brine concentration.

The raw water being injected into the cavern would rise toward the surface due to its lower density and induce a circulation within the brine. This may result in an increase in the diffusion of oil into the now non-equilibrium system. As the interface rises within the cavern, the circulation would decrease in the upper brine column due to the rapid dilution of the raw water. The brine temperature within the cavern will eventually rise to approximately 150°F and an increase in salinity will occur as the dissolution of the cavern walls proceeds. The net effect is a decrease in oil solubility because the salinity factor has a greater influence than that of temperature (Section 3). The dissolved oil concentration in the brine at the end of this operation is therefore the result of:

(1) the twentyfold dilution of the residual brine which had reached equilibrium oil concentrations at the bottom of the cavern,
(2) some dissolution of the oil layer on the cavern walls, and
(3) some small additional dissolution at the oil-brine interface during displacement.

2.4 STORAGE CAVERN CONDITIONS AFTER OIL IS DISPLACED

After the cavern is filled with water and the crude oil removed, a small amount of the crude oil would be retained as a blanket on top of the brine column. The oil blanket acts as a barrier between the solution cavern ceiling and the brine, thereby minimizing salt dissolution around the cemented casing. The oil at the oil-brine interface will be composed of a relatively dense, viscous layer and would only allow slow diffusion of the soluble hydrocarbon components. The additional oil concentration dissolved into the brine during this operation is judged to be minimal.

2.5 SECOND AND SUBSEQUENT OIL REFILL PHASE

The oil-brine interface whould now have had sufficient time for a dense refractory layer to form. This layer would reduce the diffusion and dissolution during subsequent refills. Throughout subsequent oil refills approximately 6 ppm of oil in brine (as calculated in Section 5) will be discharged to the surface brine control facilities, providing the dense refractory layer continues to act as a barrier. In the event that the refractory layer is penetrated by the input jet of oil, reactions similar to those of the initial fill cycle would occur.

3. DISSOLUTION REACTIONS DURING CAVERN OPERATIONS

The solubilities of various hydrocarbons in water and in brine have been studied by a number of workers. The data illustrated in Figure A-2 indicate that for each homologous series of hydrocarbons, the logarithm of solubility in water is a linear function of hydrocarbon molar volume. The solubility of hydrocarbons as illustrated in Figure A-2 and listed in Table A-1 increase with a decrease in molar volume and molecular weight and an increase in branching and degree of unsaturation. The most soluble hydrocarbons are the low molecular weight aromatics.[2,3]

Review of studies which were conducted to determine the saturation concentrations for oil in seawater and in freshwater, indicate that as the hydrocarbons dissolve, solubility rates decrease before equilibrium conditions are established.[2]

Equilibrium concentrations at standard temperature and pressure for four different crudes are listed in Table A-2. Equilibrium concentrations found by other researchers for crude oil in both freshwater and saltwater, range from 7 to 40 ppm with the preponderance of data ranging from 20-30 ppm.[4,5,6,7]

Selected data for the La Rosa and Murban crudes, presented in Table A-3, reveals the variations in equilibrium concentrations which can be expected. This data indicates that the hydrocarbon composition of a particular stored crude would effect the concentration of dissolved oil being discharged with the brine. For the purpose of calculating estimated oil concentrations in a brine discharge, the Middle East Murban crude was considered as a possible crude to be stored in the Strategic Oil Reserve Program.

The equilibrium concentration of Murban crude in seawater with a

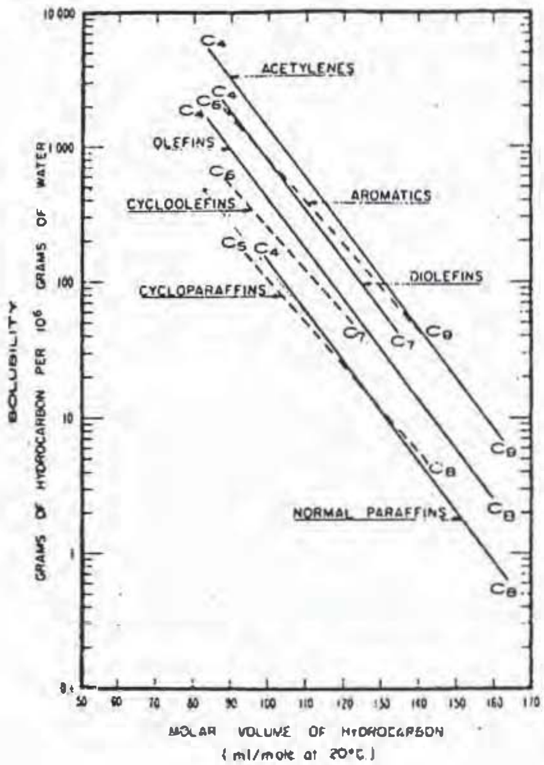

Figure A–2 COMPARISON OF THE SOLUBILITIES IN WATER AT 25°C OF VARIOUS TYPES OF HYDROCARBONS, AS FUNCTIONS OF THEIR MOLAR VOLUMES.

SOURCE: McAULIFFE, 1969 (3)

Table A–1
AQUEOUS SOLUBILITY VALUES
OF INDIVIDUAL COMPOUNDS AT 25° C IN PPM

COMPOUND	PRICE	MCAULIFFE
PENTANE	39.5	38.5
HEXANE	9.47	9.5
HEPTANE	2.24	2.93
OCTANE	0.431	0.66
NONANE	0.122	0.22
ISO PARAFFINS		
2,3 – DIMETHYLBUTANE	19.1	
2,2 – DIMETHYLBUTANE	21.2	
2 – METHYLPENTANE	13.0	
3 – METHYLPENTANE	13.1	
2,4 DIMETHYLPENTANE	4.41	
2,2 – DIMETHYLPENTANE	4.40	
2,3 – DIMETHYLPENTANE	5.25	
3,3 – DIMETHYLPENTANE	5.94	
2,2,4 – TRIMETHYLPENTANE	1.14	
2,3,4 – TRIMETHYLPENTANE	1.36	
ISOPENTANE	48.0	
2 – METHYLHEXANE	2.54	
3 – METHYLHEXANE	2.65	
3 – METHYLHEPTANE	0.792	
4 – METHYLOCTANE	0.115	
BICYCLOPARAFFIN		
(4.4.0) BICYCLODECANE	.889	
NAPTHO–AROMATIC	88.9	
CYCLOPARAFFINS		
CYCLOPENTANE	160	156
METHYLCYCLOPENTANE	41.8	42
PROPYLCYCLOPENTANE	2.04	
PENTYLCYCLOPENTANE	0.115	
1,1,3 – TRIMETHYLCYCLOPENTANE	3.73	
CYCLOHEXANE	66.5	55.2
METHYLCYCLOHEXANE	16.0	14.0
1,4 – TRANSDIMETHYLCYCLOHEXANE	3.84	
1,1,3 – TRIMETHYLCYCLOHEXANE	1.77	
AROMATICS		
BENZENE	1740.	1780
TOLUENE	554	515
M – XYLENE	134	
O – XYLENE	167	175
P – XYLENE	167	
1,2,4 – TRIMETHYLBENZENE	51.9	57
1,2,4,5 – TETRAMETHYLBENZENE	3.48	
ETHYLBENZENE	131.1	152
ISOPROPYLBENZENE	48.3	50
ISOBUTYLBENZENE	10.1	

SOURCE: PRICE, 1973. (2)
McAULIFFE, 1969 (3)

Table A–2
HYDROCARBONS DISSOLVED IN SEA WATER*
EQUILIBRATED WITH OIL SAMPLES

COMPOUND	SOUTH LOUISIANA CRUDE (1) ppm	KUWAIT CRUDE (1) ppm	VENEZUELA LA ROSA CRUDE (2) ppm	MIDDLE EAST MURBAN CRUDE (2) ppm
ALKANES				
ETHANE	.54	.23	2.011	.23
PROPANE	3.01	3.30	3.63	2.150
n BUTANE	2.36	3.66	1.88	2.880
ISOBUTANE	1.69	.90	.76	.800
n PENTANE	.49	1.31	.60	1.340
ISOPENTANE	.70	.98		1.030
CYCLOPENTANE + 2 METHYLPENTANE	.38	.59		
METHYLCYCLOPENTANE	.23	.190	.275	.355
HEXANE	.09	.290	.65	1.35
CYCLOHEXANE			.190	.410
METHYLCYCLOHEXANE	.22	.080	.160	.235
n HEPTANE	.06	.090	.100	.330
C_{16} n PARAFFIN	.012	.0006		
C_{17} n PARAFFIN	.009	.0008		
TOTAL $C_{12} - C_{24}$ n PARAFFINS	.089	.004		
AROMATICS				
BENZENE	6.75	3.36	3.30	6.080
TOLUENE	4.13	3.62	2.80	6.160
ETHYLBENZENE	1.56	1.58	.275	.825
M – P – XYLENE			.840	1.940
O – XYLENE	.40	.67	.350	1.010
TRIMETHYLBENZENE	.76	.73	.300	.750
NAPHTHALENE	.12	.02		
1 METHYLNAPHTHALENE	.06	.02		
2 METHYLNAPHTHALENE	.05	.008		
DIMETHYLNAPHTHALENE	.06	.02		
OTHER AROMATICS	.021	.013		
TOTAL SATURATES	9.86	11.62	11.200	11.100
TOTAL AROMATICS	13.90	10.03	7.860	16.800
TOTAL DISSOLVED HYDROCARBONS	23.76	21.63	19.000	27.900

*Seawater (36 PPT) at Standard Temperature and Pressure

SOURCE: 1 ANDERSON, et. al., (1974) (7)
2 MCAULIFFE (1976) (4)

Table A–3
RELATIVE AROMATIC COMPONENTS OF CRUDE
AND THEIR EFFECT ON EQUILIBRIUM CONCENTRATIONS*

	MURBAN CRUDE (ABU DHABI)		LA ROSA CRUDE (VENEZUELA)	
	EQUILIBRIUM CONCENTRATIONS ppb	PERCENT COMPOSITION IN CRUDE	EQUILIBRIUM CONCENTRATIONS ppb	PERCENT COMPOSITION IN CRUDE
BENZENE	6,080	.13	3,300	.07
TOLUENE	6,160	.49	2,800	.22
TRIMETHYLBENZENE	750	.74	300	.30
TOTAL	12,990	1.36%	6,400	.69%

*In Seawater at Standard Temperature and Pressure

REF. MCAULIFFE, 1976 (4)

salinity of 36 ppt is 27.9 ppm at standard temperature and pressure as shown in Table A-2.

As temperature and pressure change within the storage cavern, the resultant equilibrium concentrations can be expected to change. General hydrocarbon solubility studies indicate that as temperature and pressure increase, solubility and equilibrium concentrations increase. Increasing the salinity of the solvent yields a decrease in the hydrocarbon solubility and a reduction of the equilibrium concentrations. The following sections summarize the anticipated changes in cavern equilibrium concentrations of the oil in brine as a result of a temperature increase to 150°F, an increase in pressure to approximately 1500 psi and an increase in salinity to 310 parts per thousand.

3.1 INCREASED TEMPERATURE EFFECTS ON EQUILIBRIUM CONCENTRATIONS

As illustrated in Figures A-3 and A-4 the temperature/solubility relationship is non-linear and until temperatures in excess of 257°F are reached significant increases in solubilities do not occur. The operating temperature for the caverns will be approximately 150°F. Published data indicate that for an increase of from 70°F to 150°F an equilibrium concentration increase of 1.5 is the maximum that can be reasonably expected.(2,8) For model calculation purposes, a temperature multiplier of 1.5 has been utilized.

3.2 INCREASED SALINITY EFFECTS ON EQUILIBRIUM CONCENTRATIONS

The aqueous solubility of hydrocarbons is an inverse function of salinity.(2,6) Within the salt dome caverns brine concentrations will be in excess of 310 parts per thousand (ppt).(4) The results of solubility experiments on discrete hydrocarbons listed in Table A-4 indicate that large reductions in hydrocarbon solubility can be expected with increases in salinity. Recent studies on a number of domestic crude oils (Table A-5) exhibit similar decreases in hydrocarbon solubility when compared over the smaller range of salinity. Based on these studies a salinity multiplier of 0.15 is reasonable and perhaps even conservative.

3.3 INCREASED PRESSURE EFFECTS ON EQUILIBRIUM CONCENTRATIONS

The effect of increasing pressure on the solubility of hydrocarbons

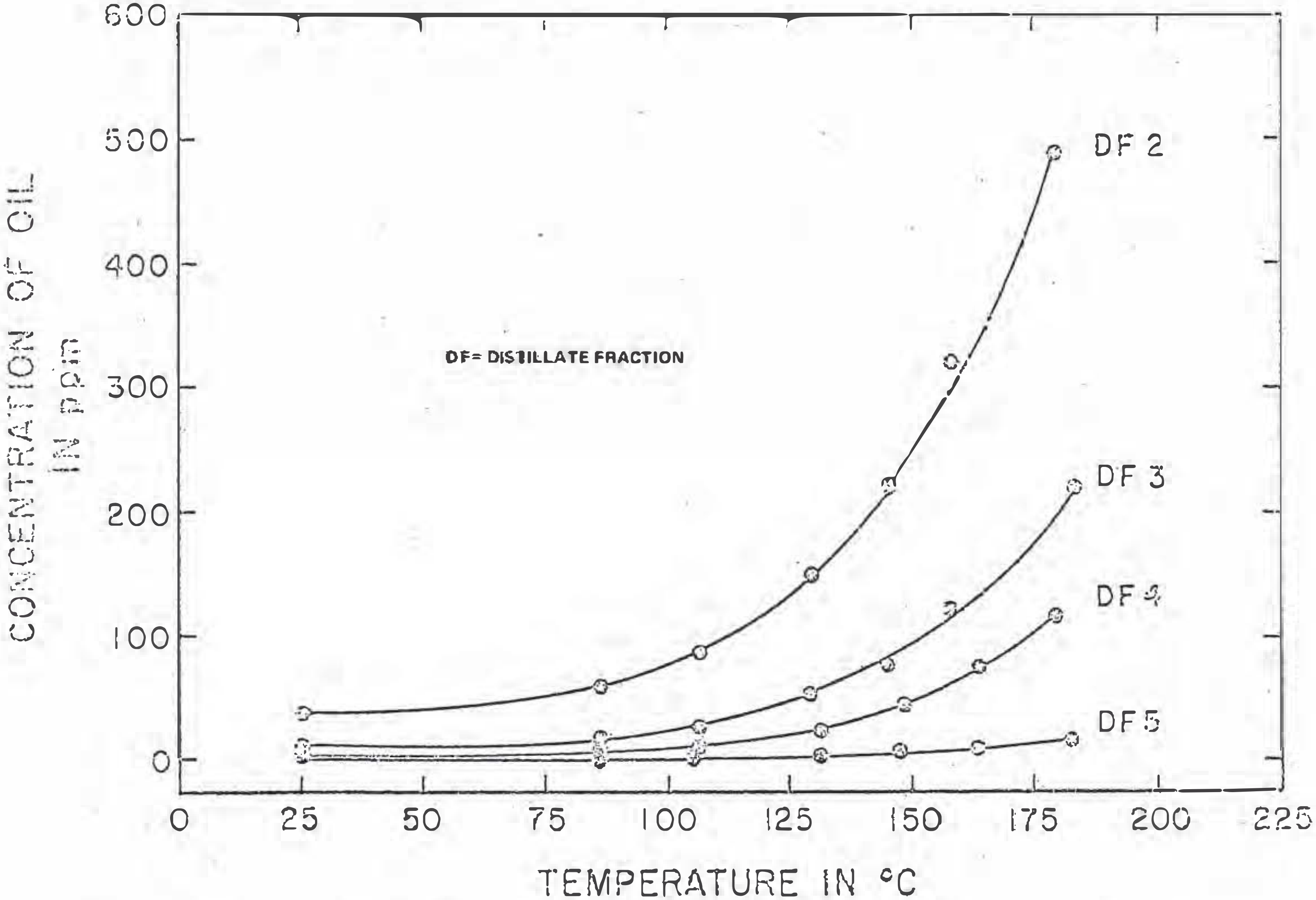

Figure A–3 THE SOLUBILITIES OF THE SECOND (DF 2, 132–193°C), THIRD (DF 3, 193–232°C), FOURTH (DF 4, 232–316°C) AND FIFTH (DF 5, 316–371°C) DISTILLATION FRACTIONS OF THE GHAWAR ARABIAN CRUDE OIL IN WATER AS A FUNCTION OF TEMPERATURE AT SYSTEMS' PRESSURE.

SOURCE: PRICE, 1973 (2)

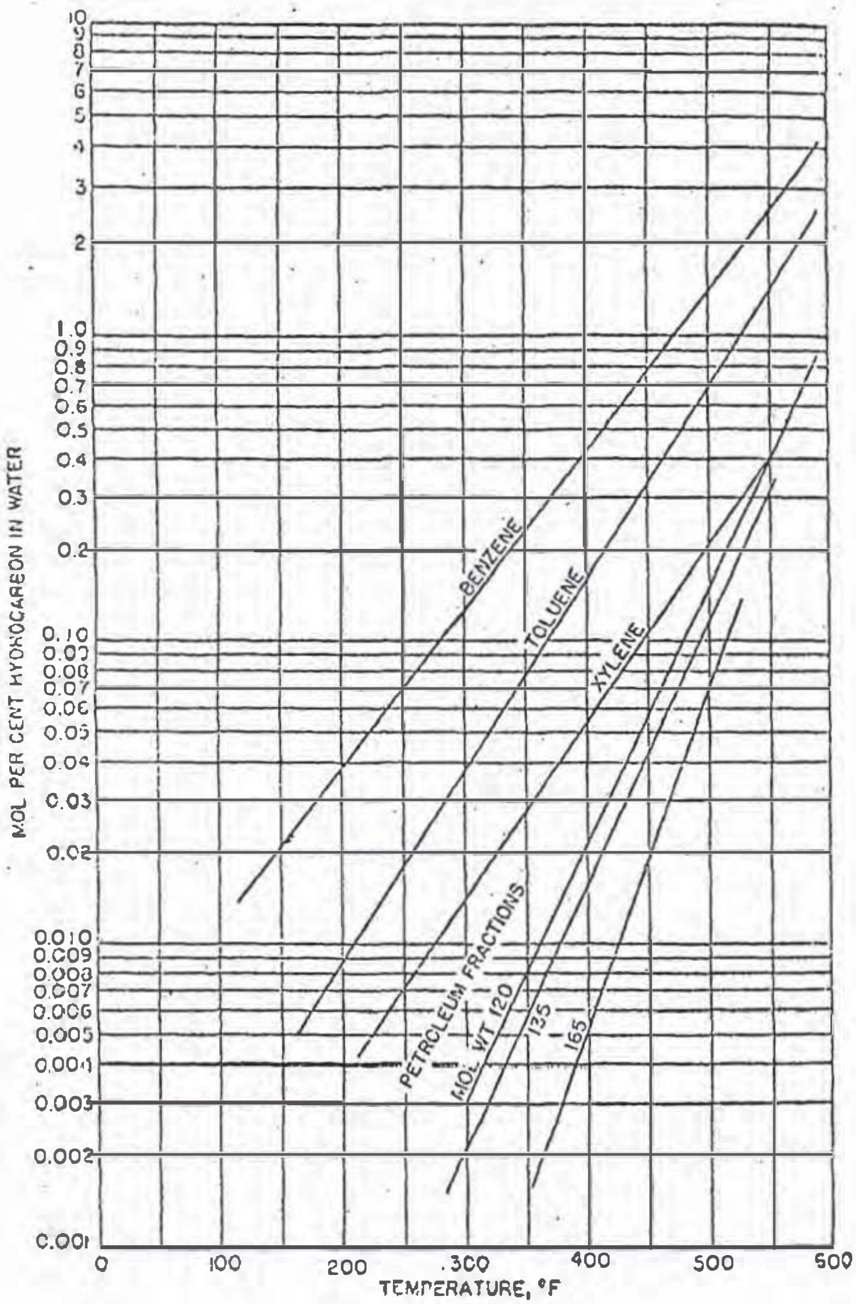

Figure A—4 SOLUBILITIES OF HYDROCARBONS AND PETROLEUM FRACTIONS IN WATER AT TOTAL SYSTEM PRESSURE

SOURCE: GRISWOLD, 1942 (8)

Table A–4
SOLUBILITY OF INDIVIDUAL HYDROCARBONS IN AQUEOUS SOLUTIONS AT 25° C AS A FUNCTION OF NaCl CONCENTRATION

NaCl CONCENTRATION IN PPM	SOLUBILITY OF HYDROCARBON IN PPM			
	PENTANE	BENZENE	TOLUENE	METHYLCYCLOPENTANE
0	39.5	1740	544	41.8
1,002	36.8	1718	526	38.0
10,000	34.5	1628	490	36.3
SEAWATER * 34,472	27.6	1391	402	29.2
50,030	22.6	1194	359	27.0
126,100	10.9	593	182	12.7
199,900	5.91	388	106	5.72
279,800	2.64	214	53.8	3.36
358,700 **	2.01	134	37.2	1.89

* ARTIFICIAL SOLUTION

** SATURATED NaCl SOLUTION

SOURCE: Price, 1973 (2)

Table A–5
DISSOLVED OIL CONTENT OF BRINES EQUILIBRATED WITH VARIOUS OILS

	BRINE ppt	GRAVIMETRIC mg/l
GULF COAST TEXAS CONDENSATE	1	9.64
	30	5.83
	100	2.45
GULF COAST TEXAS HIGH GRAVITY CRUDE	1	6.87
	30	4.03
	100	2.15
LOUISIANA MEDIUM GRAVITY CRUDE	1	6.16
	30	5.63
	100	3.68
EAST TEXAS MEDIUM GRAVITY CRUDE	1	11.49
	30	6.96
	100	3.11
EAST TEXAS LOW GRAVITY CRUDE	1	5.02
	30	3.96
	100	2.41
CALIFORNIA LOW GRAVITY CRUDE	1	0.40
	30	0.31
	100	0.60
CALIFORNIA MEDIUM GRAVITY CRUDE	1	9.64
	30	4.58
	100	3.87
ALASKA CRUDE	1	9.56
	30	7.83
	100	5.04
FLORIDA CRUDE	1	10.51
	30	7.51
	100	4.15

SOURCE: Caudle, 1977 (6)

is to increase their solubility. As illustrated in Figure A-5, this effect is most significant for the lighter or lower molecular weight hydrocarbons such as methane and butane. Similar effects for larger hydrocarbon molecules could not be identified. The data as listed in Table A-6 and shown in Figure A-5, taken at a temperature of 160°F to approximate cavern conditions, indicates a corresponding increase in solubility with pressure in addition to the importance of the hydrocarbons molecular size and boiling point. This data suggests that pressure has a diminishing effect on the solubility of the hydrocarbons as their molecular weights and boiling points increase.[2,11] For convenience, the boiling points of the hydrocarbons are also listed on Figure A-5. Since no data was located for pressure/solubility relationships for the higher boiling point hydrocarbons, a pressure multiplier of 5 was used for calculation purposes. The pressure multiplier of 5 is plotted on Figure A-5 in relation to the boiling point of benzene. The pressure multiplier factor of 5 appears to be a reasonable worst case assumption and only operating data or precise experimentation would provide closer approximations.

3.4 CALCULATIONS OF DISSOLVED OIL CONCENTRATIONS

Based on the preceding discussion, expected cavern equilibrium concentration for Murban crude can be computed as follows:

Seawater Equilibrium		Temperature Multiplier		Salinity Multiplier		Pressure Multiplier		
(27.9 ppm)	X	(1.5)	X	(0.15)	X	(5)	=	(31.4 ppm)

Allowing the cavern brine to reach equilibrium conditions, the concentrations of hydrocarbons will be roughly equivalent to that of seawater concentrations as determined by McAuliffe. Personal communications with McAuliffe on this subject reveals that 25-30 ppm would be a reasonable equilibrium concentration.

The equilibrium concentration would occur only during the long oil storage period. However, this concentration would ultimately be diluted by a factor of 20 by raw water during displacement of the oil (see Section 2 and 3). This dilution would lead to non-equilibrium conditions and a resumption of dissolution. During the relatively short periods between cessation of oil withdrawal and completion of cavern refill the entire volume of brine should not attain an equilibrium concentration of dissolved oil. Solution would be retarded by the refractory layer at the

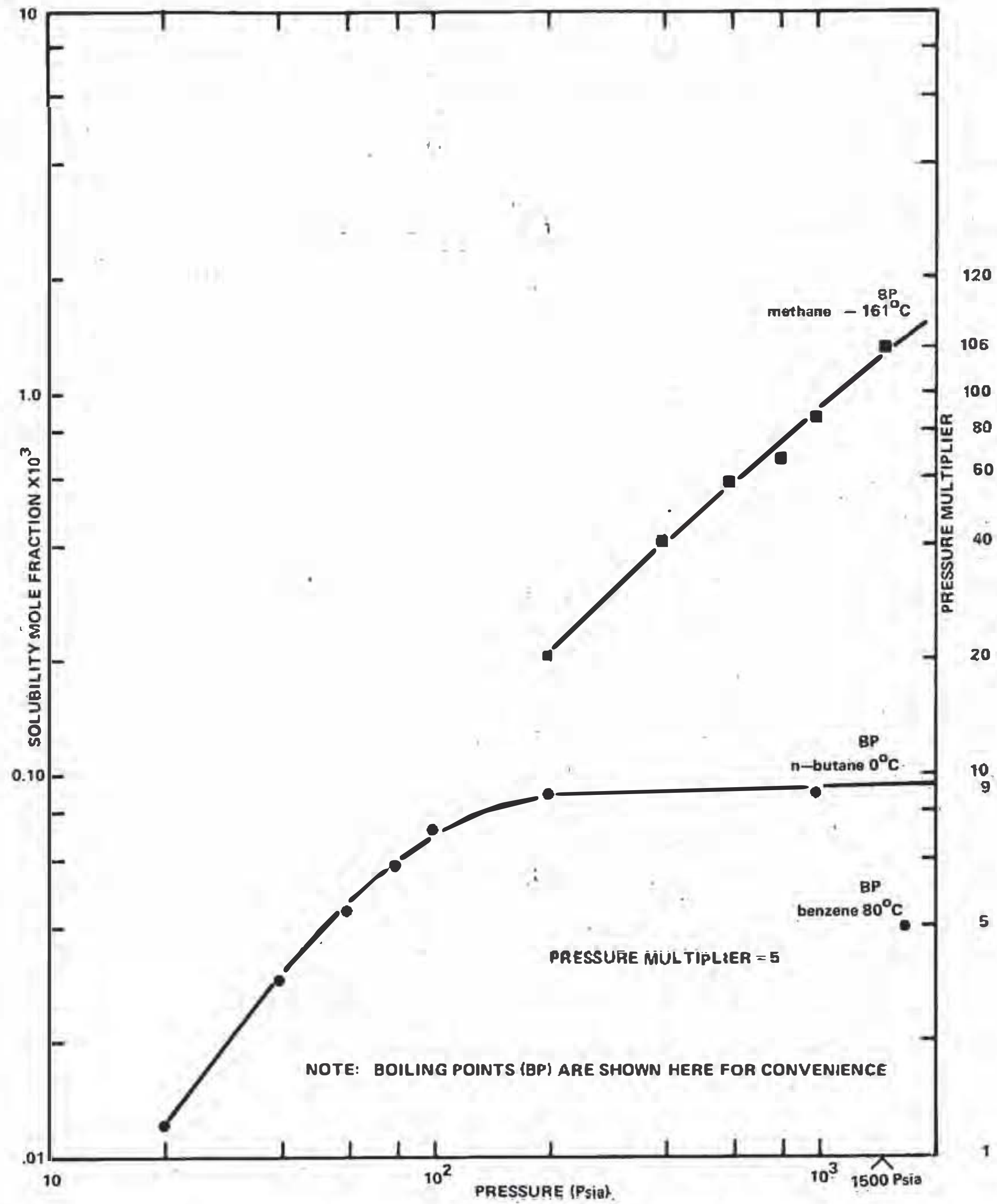

Figure A–5 PRESSURE EFFECT ON SOLUBILITY

SOURCE: Reference Petroleum Production Handbook (11)

Table A–6

PRESSURE EFFECT ON SOLUBILITY

SMOOTHED VALUES FOR THE SOLUBILITY OF METHANE IN WATER IN THE VAPOR–LIQUID REGION

PRESSURE, psia	MOLE FRACTION $CH_4 \times 10^3$ 160° F*
200	0.203
400	0.407
600	0.599
800	0.780
1,000	0.945
1,250	1.133
1,500	1.308
2,000	1.608
2,500	1.861
3,000	2.094
3,500	2.309
4,000	2.516
5,000	2.888
6,000	3.221
7,000	3.519
8,000	3.782
9,000	4.007
10,000	4.211

*Temperature of the System

SOURCE: McKetta and Wehe (1962) (11)

Table A–6

PRESSURE EFFECT ON SOLUBILITY
(cont'd.)

SOLUBILITY OF n–BUTANE IN WATER	
PRESSURE psia	MOLE FRACTION OF n–BUTANE X 10^3 160° F *
20	0.012
40	0.029
60	0.044
80	0.058
100	0.071
200	0.088
300	0.088
400	0.088
500	0.089
600	0.089
800	0.089
1,000	0.090
5,000	0.098
10,000	0.103

*Temperature of the System

SOURCE: McKetta and Wehe (1962) (11)

brine/oil interface and downward diffusion of dissolved oil will proceed very slowly,

The dissolved oil concentrations contributed from the cavern wall (based on the dimentions of cavern number 4 at Bryan Mound) will be 1.6 ppm. This calculation was based on an estimated 50 micron oil film remaining on the wall during oil displacement and subsequent dissolution into the brine as the underlying salt is dissolved away. The oil film adhering to the cavern wall would be thick for heavy, viscous crudes but relatively thinner for the lighter more fluid crudes. An effective film thickness was calculated by considering the largest (in molecular volume) hydrocarbon which has a measurable solubility. Under cavern operating conditions, the largest normal paraffin which would dissolve in appreciable amounts is C_{10} (decane) which has a typical layer thickness of 50 microns. A molecular layer was estimated to remain on the cavern wall.

An analysis of the wall oil layer component to the brine (based on cavern number 4) indicates that for a millimeter wall layer, the oil in brine concentration would increase to 28.6 ppm. The latter concentration is roughly equivalent to the equilibrium concentration for the entire volume.

The amount of hydrocarbons which would dissolve from the oil-brine interface during oil fill and withdrawal and during non-oil storage periods is difficult to estimate due to the lack of experimental data. The rates of solubility as determined by Price[2] were based on studies of hydrocarbons and brine solutions in test tubes. Under these conditions, Price observed that it required 2-4 days to achieve equilibrium conditions. Under these relatively slow rates and given the infinitely larger volumes of the cavern, it is reasonable to assume that only the brine close to the oil-brine interface would be affected by dissolved oil during oil filling and withdrawal phases. The dissolution of hydrocarbons during the oil withdrawal and refill phases should be reduced with the existence of the refractory layer at the oil-brine interface. This layer will develop as a result of lighter, more soluble hydrocarbons dissolving into the underlying brine leaving the heavier, relatively insoluble hydrocarbons at the interface. The resistance of this layer to dissolution would increase with time until practically all diffusion across the interface ceases.

The hydrocarbon concentration due to dissolution occurring during the period of non-equilibrium conditiond between oil withdrawal and cavern refill will be 3 ppm. This value is based on the assumption that the time between cessation of drawdown and completion of refill will be of such short duration so that only the volume of the uppermost 50 feet of brine will approach equilibrium. Assuming a 500 foot cavern height, a ten-fold dilution of the equilibrium concentration would occur; resulting in 3 ppm of oil dispersed within the brine column. This average value would change as a function of the cavern geometry and phase within the brine discharge cycle. The addition of this component to the total hydrocarbon concentration being discharged would be minor during first quarter of a cavern's discharge cycle and increase as the oil brine interface descends toward the bottom of the brine pipe. The near equilibrium concentration close to the oil brine interface would not be discharged due to cavern enlargement and diffusion during oil withdrawal and refill phases.

The total dissolved hydrocarbon concentration expected to be discharged is derived as follows:

(1)	Long-Term Storage Equilibrium Component	= 1.6 ppm	Assumes the residual 5% volume of brine attains equilibrium of 31.4 ppm and is diluted 20 times during oil withdrawal.
(2)	Wall Oil Component	= 1.6 ppm	The solution of the 50 micron oil film from the cavern wall's surface. (cavern geometry dependent)
(3)	Oil Withdrawal, Non-Storage Period and Refill, Non-Equilibrium Component	= 3.1 ppm	Assumes the upper most fifty feet of the cavern volume attains equilibrium concentrations and is diluted by the remaining brine volume. (cavern geometry dependent)
	Total dissolved hydrocarbon concentrations	= 6.1 ppm or 6 ppm	

4. DISPERSION REACTIONS

Whereas dissolution occurs on a molecular level, dispersive reactions occur on a particle level. This reaction requires a breakup of the oil into particles and dispersing them into the underlying brine. The energy for this reaction is produced during the initial oil injection where oil is jetted at a velocity of approximately 8 feet per second into the brine and micro particles dispersed into the upper area of brine. This agitation would diminish and eventually cease as the downward oil-jet momentum is balanced by the buffering force of the oil thereby limiting the depth of the turbulent zone.

Studies of the dispersion of oil in seawater under oil slick conditions indicate that the greatest amount of oil is dispersed in a particle size of 40 microns or less in diameter.(12) For illustrative purposes data for Bunker C, listed in Table A-7, show the distribution of particle sizes ranges from 10 to 80 microns.

The suspension time for oil particles in the brine would be very short because of the large density differential of the oil (sp.gr.approx. .85) versus the brine (sp.gr. 1.19). Studies of crude dispersions, Table A-8, in seawater illustrates the rate of floatation. With the greater density differential, as in saturated brine, the dispersed oil within the caverns would be expected to show even faster floatation rates.

Within the cavern, even under the most rapid fill rates, the dispersed particles would have several weeks in which to rise and coalesce at the oil/brine interface. This is believed to be sufficient time for the dispersed oil concentrations to decrease to values of less than 1 ppm. For calculation of oil in brine, a value of 1 ppm of dispersed oil is assumed to be discharged to the brine surface control facilities.

Table A–7
DISTRIBUTION OF PARTICLE SIZE BENEATH AN OIL SPILL *

	NO. AND VOL. OF PARTICLES IN 10–MICRON RANGE CENTERED AT							
	10u	20u	30u	40u	50u	60u	70u	80u
NUMBER	323	147	57	19	4	3	3	1
VOLUME	0.45	0.96	1.42	1.35	0.40	0.66	1.12	0.60

* BUNKER C OIL

SOURCE: The Fate of Oil Spilt at Sea (12)

Table A–8
SETTLING TIME AND DISPERSED OIL PARTICLES *

TIME OF SETTLING DAYS	OIL CONTENT PPM
0.01	31
0.02	10
0.04	4.5
0.33	2.5
1.0	4.6 **
1.1	1.5
2.2	2.7 **
147	0.5

SOURCE: THE FATE OF OIL SPILT AT SEA, (12)

* TYPE OF CRUDE OIL NOT STATED
** REASONS FOR OIL CONTENT INCREASE NOT GIVEN

5. DISCHARGE OF THE OILY BRINE TO THE SURFACE CONTROL FACILITY

The discharge of brine containing hydrocarbons, as schematically illustrated in Figure A-6, will involve different scenarios dependent upon whether it is during initial fill or subsequent refills.

For initial fill, an assumption was made that the top 50 feet of brine became saturated with hydrocarbons (31.4 ppm) and this was diluted into the uppermost 100 feet yielding approximately 16 ppm (see Section 2.1). This initially high hydrocarbon concentration would result from the fresh unweathered crude not having sufficient time to form a refractory layer before fill is completed. In subsequent fills the refractory layer will be present. The 16 ppm would exhibit a concentration gradient (0 to 31 ppm) when discharged; however, its average over the discharge period is expected to be about 16 ppm.

It is expected that low levels of oil averaging approximately 6 ppm would be discharged continuously during subsequent refills. Contingent upon differing cavern geometries, the oil concentration would vary from 4 to 15 ppm.

The only available data from similar operations are from the German oil storage facility at Etzel, Germany and the French oil storage facility at Manosque, France.

The Etzel data[13] indicate that the oil concentration of brine discharged from the brine control surface facility is less than 1 ppm.

The Manosque data[14] indicate an oil concentration of 17 ppm in the brine discharged from the cavern to the surface facilities. Neither the duration of storage or type of crude were identified.

These data from the two operating oil storage facilities clearly

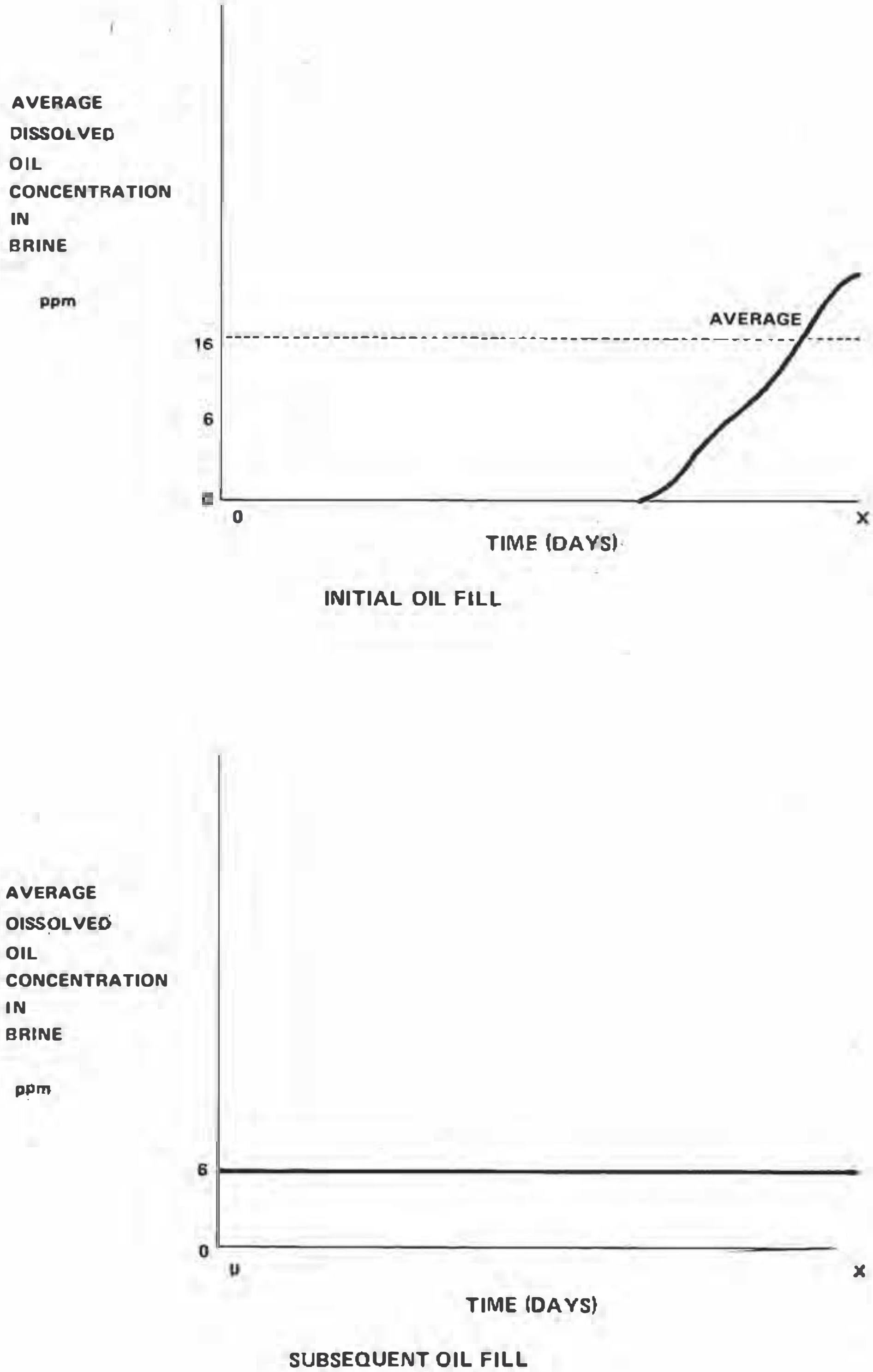

Figure A–6 SCHEMATIC REPRESENTATION OF OIL IN BRINE CONCENTRATIONS DISCHARGED FROM A TYPICAL CAVERN indicate that with an expected eighty percent reduction of the oil concentration due to vaporization of light hydrocarbons such as butane, pentane and benzene[3] and an additional reduction by oil skimming, the estimated oil concentration in the discharged brine of approximately 6 ppm appears reasonable for the proposed U.S. facilities.

6. CONCLUSIONS OF THE OIL BRINE STUDY

The major conclusion of this study is that there is insufficient time, turbulence and circulation within the cavern during oil fill and withdrawal phases, to allow the dissolved oil to reach equilibrium. Equilibrium concentrations for the thirteen crudes studied will not exceed approximately 31 ppm under the cavern operating conditions. Thus, during the time when the cavern is principally filled with non-equilibrium oil-brine concentrations of less than 31 ppm, dissolution and diffusion reactions will occur in the upper brine column.

The results of the study undicate that the dissolved oil in the brine discharged to the brine surface control facility is expected to average 16 ppm for the later stages of the initial oil fill of each cavern and average approximately 6 ppm for subsequent oil refills from a cavern of specific geometry. Differing cavern geometry effects the duration of the initial oil discharge and the concentration of the dissolved oil in subsequent discharges. The oil concentration in the brine will be principally composed of dissolved hydrocarbons rather than dispersed oil as is commonly found beneath oil slicks at sea. The dispersed oil component which is created during initial turbulent oil injection is quickly and naturally removed from the brine column due to its high buoyancy and less than 1 ppm would be expected in the brine discharge.

Studies of the effects on hydrocarbon solubility as a function of increasing the temperature to 150°F, pressure to 1500 psi and salinity to 310 ppt indicate that solubility changes of: 1.5 times would occur due to temperature increase, 5.0 times for pressure and 0.15 times for salinity. The net effect of these would be an increase in solubility of only 1.125 times in comparison to seawater equilibrium concentrations. Thus, cavern oil equilibrium concentrations will be very similar to values measured for the various crudes in seawater at standard conditions of temperature and pressure.

The oil film remaining on the cavern wall is not expected to appreciably affect the net oil concentrations of the brine due to the large dilution effect within the cavern and the estimated 50 micron thickness of the wall film.

At the start of filling operations the oil jet velocities should be controlled to limit the amount of turbulence during initial fill and the possible disruption of the refractory layer during the subsequent refills.

A refractory layer is expected to form at the oil brine interface which will reduce dissolution and to a degree dispersion reactions.

APPENDIX A

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APPENDIX B

HYDROCARBON EFFLUENTS FROM THE SURFACE BRINE-CONTROL FACILITY

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APPENDIX B

HYDROCARBON EFFLUENTS FROM THE SURFACE BRINE-CONTROL FACILITY

B-1 INTRODUCTION

A model was developed and discussed in Appendix A for describing the interaction between crude oil and brine in a salt cavern environment. Elements of this model show that the extent of that interaction will vary with the fill-withdrawal-refill history of the storage cavern and that, in consequence, the amounts of hydrocarbons which will be incorporated in the brine will differ between first and subsequent fillings of the cavern, and between individual cavern geometries.

The purpose of Appendix B is to estimate the amounts of hydrocarbons that may be released to the atmosphere when brine is displaced from crude-oil-storage caverns and processed through the surface brine-control facility. As in Appendix A, the Murban Crude is used as a typical crude which could be stored in the storage facility.

The model presented in Appendix A is a general model. For the purposes of this Appendix, hydrocarbon concentrations specific to each cavern and each filling are required. Table B-1 lists the dimensions of the existing four caverns at Bryan Mound, the expected concentrations of oil-in-brine and the durations of the brine-discharge periods for first and subsequent fillings. Data from this table are utilized as input for calculations which determine potential levels of hydrocarbon pollutants from the surface brine-control facility.

The stages through which specific hydrocarbon components of the crude oil must pass in going from cavern storage to potential atmospheric/water pollutants are outlined below and displayed as a flow diagram in Figure B-1.

Table B–1
CALCULATED OIL CONCENTRATIONS AND DURATIONS OF BRINE DISCHARGE TO THE SURFACE BRINE–CONTROL FACILITY AT BRYAN MOUND

CAVERN NUMBER ⟶	No. 1	No. 2	No. 4	No. 5
VOLUME (FT^3)	3.986×10^7	3.50×10^7	9.185×10^7	1.87×10^8
VOLUME OF UPPERMOST 50 FT (FT^3)	3.89×10^6	1×10^7	1.28×10^7	4.31×10^6
VOLUME OF UPPERMOST 100 FT (FT^3)	1.03×10^7	1.89×10^7	2.55×10^7	8.61×10^6
SURFACE AREA OF WALL (FT^2)	4.13×10^5	2.62×10^5	7.32×10^5	1.37×10^6
VOLUME OF 50 MICRON OIL FILM ON WALL (GALLONS)	510	322	900	1,680
CONCENTRATION OF DISSOLVED OIL FROM LONG–TERM STORAGE COMPONENT (PPM)	1.57	1.57	1.57	1.57
WALL COMPONENT	2.26	1.82	1.6	1.46
CONTRIBUTION FROM DISTRIBUTED OIL	3.06	8.97	4.38	0.72
TOTAL LONG–TERM CONCENTRATION OF DISSOLVED OIL (PPM)	6.88	12.36	7.55	3.76
DURATION OF 2ND AND SUBSEQUENT DISCHARGES (DAYS)	47	42	109	222
FRACTIONAL DURATION OF DISCHARGE AT 16 PPM DURING INITIAL FILL $\left[\frac{\text{VOL. OF UPPERMOST 100 FT.}}{\text{VOL. OF CAVERN}}\right]$	0.258	0.54	0.278	0.046
DURATION OF INITIAL DISCHARGE (DAYS)	12	23	30	10
CAVERN VOLUME (MILLIONS OF BARRELS)	7.09	6.24	13.36	33.39

(Total Cavern Storage 63 million barrels)

- Within the oil-storage caverns, hydrocarbon constituents of crude oil will be in equilibrium with brine at elevated pressure and temperature.
- Upon discharge of brine to the surface brine-control facility, the pressure would immediately drop to atmospheric; temperature and salinity would remain high.
- Upon release of pressure, the low-boing hydrocarbons (C_2 - C_5 aliphatics) would flash-vaporize and the remainder of the aliphatics (C_6 - C_7) and the aromatics (C_6 - C_9) will partition between a dissolved phase and a film on the surface of the brine.
- With additional time some of the hydrocarbons which form the surface film phase would volatilize.

To estimate the quantity of released hydrocarbons, and for projecting air/water quality impacts, a "base" calculation was completed, assuming the maximum amount of crude oil which can be incorporated into brine. The results of this worst-case condition were then ratioed to yield a set of numerical values for each of the caverns and brine-discharge sequences under consideration. The relative distribution of hydrocarbons will be essentially the same in all cases; only the absolute amounts will change.

In Section B-2, which follows, the fate of hydrocarbons in brine discharged to the surface is outlined; each constituent hydrocarbon and each phase is identified. Table B-2 presents detailed information on the concentration of hydrocarbons in various phases. This data is converted to pollutant generation rates and summarized in Table B-3 for the "base" case, for the "first fill" of each cavern and for subsequent fills.

In Section B-3, data are presented which describe several typical atmospheric-pollutant-dispersion situations. Tables B-5 through B-7 summarize the results of these calculations. Emissions from an open-surfaced brine pond (area source) are considered in the discussion. Atmospheric "burdens" (total emissions integrated over a period of time) from the brine-control facility are listed in Table B-8.

B-2 SURFACE BRINE CONTROL: PARTITIONING OF HYDROCARBONS

Table B-2 is structured to correspond with the flow in Figure B-1. The following explanation is keyed according to the order of columns in this Table.

- Columns (1), (2) and (3) identify the principal hydrocarbons which will dissolve in brine. Carbon numbers, formulae and chemical names are listed. The aliphatic hydrocarbons are divided into two groups: the first group has boiling points lower than the temperature of the discharged brine. The second group has boiling points above the temperature of the discharged brine.
- Column (4) lists the maximum possible concentrations of individual hydrocarbons of Murban crude in equilibrium with brine at the conditions prevailing in a cavern. The derivation of these data follows the analysis presented in Appendix A for the hydrocarbons found in seawater equilibrated with Murban crude as analyzed by McAuliffe.[2]
- Column (5) tabulates the maximum-possible concentrations of each hydrocarbon which will remain in solution after the initial flash vaporization. The numerical values in column (5) are one-fifth of the counterpart values in column (4) because the pressure coefficient of (hydrocarbon) solubility (Appendix A) has been reduced by a factor of five.
- The hydrocarbons which initially flash into the vapor phase are only the low boiling point aliphatics as summarized in column (6).
- The hydrocarbons remaining in solution will tend to separate into a transient surface film or remain in the solution phase.* With time in the brine pond (column 8), this surface film would further separate into a vapor phase (column 9) and a residual floating liquid (column 10).
- Residual dissolved hydrocarbons are shown in column (7).

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* It is assumed that a brine-delivery pipe will be situated low in the receiving pond. Thus, when flash-vaporization of the low-boiling aliphatics occurs the resulting vapor bubbles will rise quickly through the brine, collecting and carrying with them oil that has come out of solution.

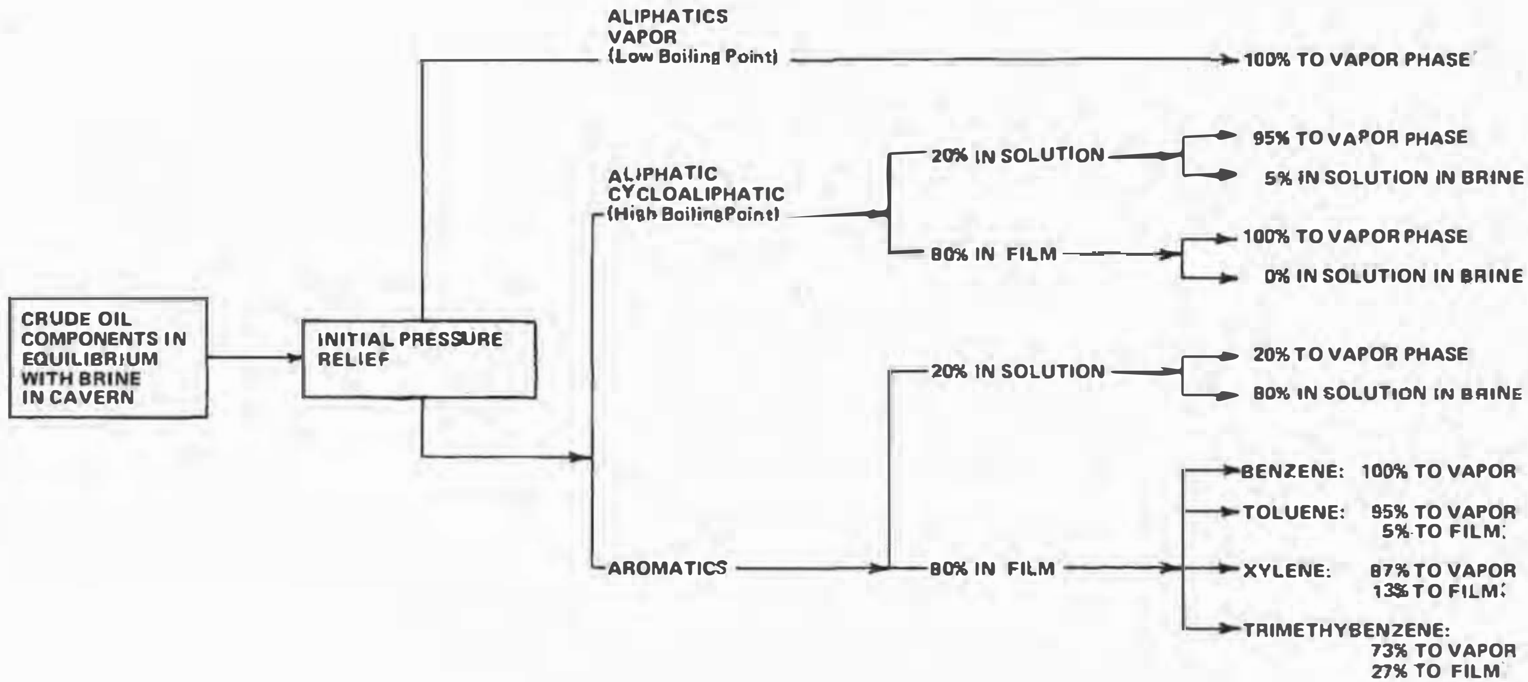

Figure B–1 FLOW DIAGRAM SHOWING PARTITIONING OF HYDROCARBONS AMONG VAPOR, BRINE AND "FILM" PHASES

Partitioning of the residual aliphatics and aromatics (columns 6 and 7) is based on data in Table II of McAuliffe (1969)[1] and in McAuliffe (1976)[2]. The 95% vapor - 5% liquid separation applied to the C_6 and C_7 aliphatics is an average of the reported data. Similarly, the 20% - 80% separation of the aromatics is an extension of data for benzene and toluene given in McAuliffe (1969).[1]

Distribution of the aromatics shown in columns (9) and (10) is based on data in McAuliffe (1976)[2] and Harrison, et al (1975).[3] The values are derived from observations of the half-lives of various hydrocarbons in ocean-surface oil slicks. The half-lives of C_6 - C_9 aliphatics in a surface film are short enough, McAuliffe (1976)[2], that essentially all would partition into the vapor phase. The partitioning of different aromatics varies with carbon number, as shown by the data in the Table.

Summarizing the calculations of Table 8-2, the total emissions, expressed as ug/liter of brine discharge, would be:

.In the vapor phase	-	27,495 ug/liter brine	87.6 percent
.Remaining in solution	-	3,047 ug/liter brine	9.7 percent
.Remaining in surface film	-	840 ug/liter brine	2.7 percent

Taking the rate of brine discharge from the cavern as 10 cubic feet per second (284 liters per second), the production rates of hydrocarbons in vapor, solution and surface film phases for the "base" case will be:

Vapor	-	7.80 grams/second	87.6 percent
Solution	-	0.865 grams/second	9.7 percent
Surface Film	-	0.24 grams/second	2.7 percent

Table B-3 summarizes hydrocarbon production rates for this "base" case, as well as for the initial fills of any cavern and for the second, and subsequent, fills of each cavern.

The vapor-phase emission of hydrocarbons (potential air pollutants) is dealt with in Section 8-3, following. Hydrocarbons remaining in solution will flow out of the storage facility and are a potential source of water pollution. It is assumed that oil in the surface film would be removed by skimming and would therefore not create a pollution hazard.

Table B–2

PARTITIONING OF HYDROCARBONS–IN–BRINE AMONG VAPOR, SOLUTION AND FILM PHASES AT BRINE–CONTROL FACILITY

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
					DISSOLVED FRACTION			PARTITION OF COMPONENTS IN FILM	
CARBON NUMBER	COMPONENT NAME	COM–PONENT FORMULA	CONCENTRATION in EQUILIBRIUM in CAVERN, ug/l	ug/l in SOLUTION at 1 ATMOSPHERE	ug/l to VAPOR	ug/l to BRINE	ug/l to "FILM"	ug/l to VAPOR	ug/l RESIDENT in FILM
	ALIPHATICS			20% of (4)	100% of (4)	0% of (4)			
2	ETHANE	C_2H_6	258	52	258				
3	PROPANE	C_3H_8	2,420	484	2,420				
4	N–BUTANE	C_4H_{10}	3,240	648	3,240				
4	ISO–BUTANE	C_4H_{10}	900	180	900				
5	N–PENTANE	C_5H_{12}	1,510	302	1,510				
5	ISO–PENTANE	C_5H_{12}	1,160	232	1,160				
					9,488 *				
				20% of (4)	95% of (5)	5% of (5)	80% of (4)	100% of (8)**	0% of (7)
6	METHYL–CYCLOPENTANE	C_6H_{12}	400	80	76.0	4.0	320	320	
6	N–HEXANE	C_6H_{14}	1,520	304	288.8	15.2	1,216	1,216	
6	CYCLO–HEXANE	C_6H_{12}	460	92	87.4	4.6	368	368	
7	METHYLCYCLO–HEXANE	C_7H_{14}	264	53	50.4	2.6	211	211	
7	N–HEPTANE	C_7H_{16}	370	74	70.3	3.7	296	296	
			12,500	2,500	573 *	30 *	2,411	2,411*	0

** ALL COMPONENTS IN THIS FRACTION HAVE SHORT HALF–LIVES.

Table B–2 (Cont'd)

PARTITIONING OF HYDROCARBONS–IN–BRINE AMONG VAPOR, SOLUTION AND FILM PHASES AT BRINE–CONTROL FACILITY

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
CARBON NUMBER	COMPONENT NAME	COM–PONENT FORMULA	CONCENTRATION in EQUILIBRIUM in CAVERN, ug/l	ug/l in SOLUTION at 1 ATMOSPHERE	DISSOLVED FRACTION ug/l to VAPOR	ug/l to BRINE	ug/l to "FILM"	PARTITION OF COMPONENTS IN FILM ug/l to VAPOR	ug/l RESIDENT in FILM
				20% of (4)	20% of (5)	80% of (5)	80% of (4)	% of (8) varies as shown	% of (8) varies as shown
	AROMATICS								
6	BENZENE	C_2H_6	6,840	1,368	274	1,044	5,472	100% = 5,472	0% = 0
7	TOLUENE	C_7H_8	6,940	1,388	277	1,111	5,552	95% = 5,274	5% = 278
8	ETHYLBENZENE	C_6H_{10}	930	186	35	151	744	95% = 707	5% = 37
8	M–P–XYLENE	C_8H_{10}	2,180	436	87	349	1,744	87% = 1,517	13% = 227
8	O-XYLENE	C_8H_{10}	1,140	228	56	172	912	87% = 794	13% = 118
9	TRI–METHYL– BENZENE	C_9H_{12}	845	169	34	135	676	73% = 496	27% = 180
			18,900	3,780	763 *	3,017 *	15,100	14,260*	840*
	GRAND TOTALS		31,400	6,280	10,824	3,047	17,511	16,671	840

*THE SUM OF ALL STARRED NUMBERS = 31,382, WHICH ≅ 31,400.

Table B–3

GENERATION RATES OF POTENTIAL AIR AND WATER POLLUTANTS OVER LIFETIME OF CAVERN USAGE

CAVERN NO.	EQUILIBRIUM CONCENTRATIONS OF OIL–IN–BRINE MG/l	RATE OF GENERATION OF POTENTIAL AIR/WATER POLLUTANTS,* GRAMS/SECOND			
		VAPOR PHASE TO ATMOSPHERE	SOLUTION PHASE TO WATER	PPM TO WATER	FILM PHASE
"BASE" CASE (THEORETICAL WORST–CASE CONDITION)	31.4	7.80	0.865	3.05	0.24
ANY CAVERN	16.0	3.97	0.440	1.55	0.12
1B	6.88	1.71	0.190	0.67	0.053
2	12.36	3.07	0.341	1.20	0.095
4	7.55	1.88	0.208	0.73	0.058
5	3.75	0.93	0.103	0.36	0.029

* Assuming a brine discharge rate of 10 cfs (= 284 l/sec).

B-3 ATMOSPHERIC DISPERSION OF HYDROCARBON POLLUTANTS

Hydrocarbon vapors released from brine at atmospheric pressure will go into the atmosphere in the absence of some vapor-recovery system.

Results presented in this section come from atmospheric-dispersion calculations covering five cases involving typical atmospheric situations prevailing in the Brazos area, and from calculations of atmospheric burdens. Examples which describe worst-case situations are presented, and distances (from source) of potential non-compliance with ambient air quality regulations are discussed. These calculations follow the approach used in Appendix A of the Final Environmental Impact Statement, FES 76/77-6. However, additional cases for 3-hour concentrations at ground level are calculated using the expression:

$$X(t_2) = X(t_1) \left[\frac{t_1}{t_2}\right]^{0.2}$$

Where t_1 = 10 minutes, t_2 = 180 minutes. The 3-hour values are used to characterize hydrocarbon concentrations during the period 6-9 a.m. These should be compared with the "standard" value of 160 micrograms per cubic meter.

The procedures followed here are those described in EPA's "Workbook of Atmospheric Dispersion Estimates" Report No. AP-26 (1969 version), hereafter referred to as "Workbook."

The air-emission source is the proposed uncovered brine surge pond, located just southwest of Dow Cavern No. 5. Pond design provides a surface area of about 4300 square meters. An effective source height of 10 meters is assumed, following the same reasoning for plume buoyancy used above. The various parameters investigated in this study are listed in Table B-4.

The brine pond is an area source. In this case, the values of pollutant concentrations downwind of the pond have been determined by developing a fictional point source, of equivalent total source strength, located up-wind of the pond. The up-wind offset of the virtual source is a function of atmospheric stability. Following procedures outlined in the Workbook, the offsets are calculated to be:

Stability Class	Up-wind Offset (Meters)
A	50
8	80
C	130
0	200
E	270
F	430

Tables 8-5 through B-7 provide data developed through graphical analysis using Figures 3.50, 3.5E and 3.5A of the Workbook. Values for 3-hour concentrations were first calculated for unit emission rate (1 gram/second). These values were then converted to concentrations (ug/m^3) for all six of the emission rates given in Table B-3. A comparison of the data with the national standard (160 ug/m^3) shows the distances from source at which non-compliance is demonstrated. Total air pollution burdens derived from these data are listed in Table 8-8.

Table B—4

CONDITIONS CONTROLLING ATMOSPHERIC DISPERSION OF HYDROCARBON VAPORS RELEASED FROM BRINE *

PARAMETER	CASE I	CASE II	CASE III
SOURCE	POND	POND	POND
SOURCE HEIGHT (Meters) (Effective)	10	10	10
ATMOSPHERIC STABILITY	D	E	A
WINDSPEED, U (m/sec)	5	2	3
O/U	0.2	0.5	0.33
MIXING OR INVERSION HEIGHT (m)	5000	500	5000
FIG. NO. IN WORKBOOK	3.5D	3.5E	3.5A

* ASSUMES EMISSION RATE = 1 gram/second

Table B–5

GROUND–LEVEL HYDROCARBON CONCENTRATIONS AT 0.1 – 10 KM. FROM BRINE STORAGE.

DISTANCE FROM SOURCE (km.)	DISTANCE FROM EFFECTIVE SOURCE (km.)	XU/Q FROM GRAPH* (m^{-2})	GROUND–LEVEL CONCENTRATION FOR Q= 1g/sec.		3–HOUR AVERAGE GROUND–LEVEL CONCENTRATION FOR EMISSION RATES IN TABLE B–2 (ug/m^3)					
			$X_{10\ min.}$ ug/m^3	$X_{3\ hour}$ ug/m^3	$X_3 \cdot 7.8$ (max.)	$X_3 \cdot 3.97$ 1st fill	$X_3 \cdot 1.71$ cav. 1B	$X_3 \cdot 3.07$ cav. 2	$X_3 \cdot 1.88$ cav. 4	$X_3 \cdot 0.93$ cav. 5
0.1	0.3	8.30×10^{-4}	166.0	93.1	726.2	369.6	158.6	285.5	176.3	87.2
0.2	0.4	5.70×10^{-4}	104.0	58.3	454.7	231.5	99.6	178.8	110.5	54.5
0.5	0.7	2.40×10^{-4}	48.0	26.9	209.8	106.8	45.7	82.5	51.0	25.2
1.0	1.2	1.05×10^{-4}	21.0	11.8	92.0	46.8	20.1	36.2	22.4	11.0
2.0	2.2	4.40×10^{-5}	8.8	4.9	38.2	19.5	8.4	15.1	9.3	4.6
5.0	5.2	1.20×10^{-5}	2.4	1.4	10.9	5.6	2.4	4.3	2.7	1.3
10.0	10.2	4.30×10^{-6}	0.86	0.5	3.9	2.0	––	1.5	0.9	––
0.0	0.16	1.29×10^{-3}	258.0	144.7	1128.6	574.5	247.2	443.7	274.1	135.4

CASE I SOURCE = Pond; H = 10m; Stability = D,
U = 5 m/sec; Q = 1 g/sec; Mixing Height = 5000m
Q/U = 0.2 gm^{-1}.

* Use Figure 3.5 D in Workbook

Offset of Effective Source = 0.2 km.

Table B–6
GROUND–LEVEL HYDROCARBON CONCENTRATIONS AT 0.1 – 10 KM. FROM BRINE STORAGE

DISTANCE FROM SOURCE (km.)	DISTANCE FROM EFFECTIVE SOURCE (km.)	$XU/_Q$ FROM GRAPH* (m^{-2})	GROUND–LEVEL CONCENTRATION FOR Q= 1g/sec.		3–HOUR AVERAGE GROUND–LEVEL CONCENTRATION FOR EMISSION RATES IN TABLE B–2 (ug/m^3)					
			$X_{10\ min.}$ ug/m^3	$X_{3\ hour}$ ug/m^3	$X_3 \cdot 7.8$ (max.)	$X_3 \cdot 3.97$ 1st fill	$X_3 \cdot 1.71$ cav. 1B	$X_3 \cdot 3.07$ cav. 2	$X_3 \cdot 1.88$ cav. 4	$X_3 \cdot 0.93$ cav. 5
0.1	0.37	9.40×10^{-4}	475	266.5	2078.7	1058.0	446.4	817.2	504.8	249.4
0.2	0.47	7.20×10^{-4}	360	201.9	1574.8	801.5	344.9	619.1	382.5	189.0
0.5	0.77	3.70×10^{-4}	185	103.8	809.6	412.1	177.4	318.3	196.6	97.0
1.0	1.27	1.83×10^{-4}	92	51.6	402.5	204.8	88.1	158.2	97.7	48.2
2.0	2.27	8.20×10^{-6}	41	23.0	179.4	91.3	39.2	70.5	142.1	21.5
5.0	5.27	2.40×10^{-6}	12	6.7	52.3	28.6	11.4	20.5	12.7	6.1
10.0	10.27	9.00×10^{-6}	4.5	2.5	19.5	9.9	4.2	7.7	4.8	2.3
0.0	0.22	1.22×10^{-3}	610	342.2	2669.2	1358.5	583.8	1049.4	117.1	320.0

CASE II SOURCE = Pond; H = 10m; Stability = E, U = 2 m/sec;
Q = 1 g/sec; Mixing Height = 500m; Q/U = 0.5 gm^{-1}.

*Use Figure 3.5 E in Workbook

Offset of Effective Source = 0.27 km.

Table B–7
GROUND–LEVEL HYDROCARBON CONCENTRATIONS AT 0.1 – 10 KM. FROM BRINE STORAGE

DISTANCE FROM SOURCE (km.)	DISTANCE FROM EFFECTIVE SOURCE (km.)	$XU/_Q$ FROM GRAPH* (m^{-2})	GROUND–LEVEL CONCENTRATION FOR Q= 1g/sec.		3–HOUR AVERAGE GROUND–LEVEL CONCENTRATION FOR EMISSION RATES IN TABLE B–3 (ug/m^3)					
			$X_{10\ min.}$ ug/m^3	$X_{3\ hour}$ ug/m^3	X_3 · 7.8 (max.)	X_3 · 3.97 1st fill	X_3 · 1.71 cav. 1B	X_3 3.07 cav. 2	X_3 1.88 cav. 4	X_3 0.93 cav. 5
0.0	0.01	1×10^{-3}	3333	2100	16,380	8337	3578	6440	3978	1968
0.1	0.15	3.50×10^{-4}	116.3	65.2	508.6	258.8	111.1	200.0	123.5	60.9
0.2	0.25	1.40×10^{-4}	46.50	26.1	203.6	103.0	44.6	80.0	80.0	24.4
0.5	0.55	2.00×10^{-5}	6.66	3.74	29.2	14.8	5.4	11.5	11.5	3.5
1.0	1.05	2.80×10^{-6}	0.931	0.52	4.1	2.1	–	1.6	1.6	–
2.0	2.05	4.00×10^{-7}	0.13	0.07	–	–	–	–	–	–
5.0	5.05	7.50×10^{-8}	0.02	0.02	–	–	–	–	–	–
10.0	10.05	4.10×10^{-8}	0.01	0.01	–	–	–	–	–	–

CASE III SOURCE = Pond; H = 10m; Stability = A,
U = 3 m/sec; Q = 1g/sec; Mixing Height = 5000m
Q/U = 0.33gm^{-1}.

* Use Figure 3.5 A in Workbook

Offset of Effective Source = 0.05 km.

Table B–8

ATMOSPHERIC–POLLUTANT BURDEN DUE TO HYDROCARBONS DISPERSED FROM THE SURFACE BRINE CONTROL FACILITY AT BRYAN MOUND

BRYAN MOUND CAVERN NO.	1B	2	4	5	TOTAL
MAX. HYDROCARBON CONCENTRATION (MURBAN CRUDE) (mg/l)	31.4	31.4	31.4	31.4	
EQUILIBRIUM CONCENTRATION OF OIL IN BRINE: INITIAL FILL (mg/l)	16.0	16.0	16.0	16.0	
EQUILIBRIUM CONCENTRATION OF OIL IN BRINE: SUBSEQUENT FILLS (mg/l)	6.88	12.36	7.55	3.75	
DURATION OF DISCHARGE: SUBSEQUENT FILLS, (days)	47	42	109	222	420days
DURATION OF DISCHARGE DURING INITIAL FILL (days)	12	23	30	10	75days
HYDROCARBON LOSS RATE: INITIAL FILL ONLY (grams/sec)	3.97	3.97	3.97	3.97	
ATMOSPHERIC BURDEN FROM INITIAL FILL (tons)	4.5	8.7	11.3	3.8	28.3 tons
HYDROCARBON LOSS RATE: SUBSEQUENT FILLS (grams/sec)	1.71	3.07	1.88	0.93	
ATMOSPHERIC BURDEN FROM SUBSEQUENT FILLS (tons)	7.7	12.3	19.5	19.7	59.2tons

APPENDIX B

REFERENCES

1. McAuliffe, Clayton, "Determination of Dissolved Hydrocarbons in Subsurface Brines." Chemical Geology 4, 1969, pp 225-233.

2. McAuliffe, Clayton D., "Evaporation and Solution of C2 and C10 Hydrocarbons from Crude Oils on the Sea Surface." Proceedings of Symposium on Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms, November 10-12, 1976, Seattle Washington.

3. Harrison, Wyman, et al., "Disappearance of Aromatic and Aliphatic Components from Small Sea-Surface Slicks." Environmental Science and Technology 9, Number 3, March 1975, pp 231-234.

APPENDIX C

WATER QUALITY OF THE LOWER BRAZOS ESTUARY

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APPENDIX C

WATER QUALITY SAMPLING DATA AND LABORATORY ANALYSIS FOR BRAZOS RIVER LOWER ESTUARY AND PROPOSED BRINE DIFFUSER LOCATIONS

C-1 INTRODUCTION

The purpose of this water quality sampling program was to determine the ambient water quality in the lower Brazos Estuary from river mile 2 through river mile 8. Water sampling was conducted in April 1977. The sampling, analytical procedures and resulting data are presented in this Appendix.

The Brazos River Diversion Channel, Fig. C-1, is the proposed source of raw water for the project's requirements. The man-made Brazos Diversion Channel forms the lower 15 miles of the Brazos Estuary with the upper 9 miles being formed by the original channel of the Brazos River. The Brazos estuary is unique for the Gulf Coast region in that it discharges directly into the Gulf and not through deltas or embayments typical of Gulf Coast rivers.

The proposed water intake system will be constructed at river mile 2 and will provide the raw water supply for the displacement of oil during the oil withdrawal phases, for possible inter-cavern transfers, and for hydrostatic testing.

The principal use for the intake water is for the displacement operation of the oil storage caverns. The water drawn from the Brazos for this operation will ultimately be discharged either into a deep well injection system or it will be used as a chemical feedstock.

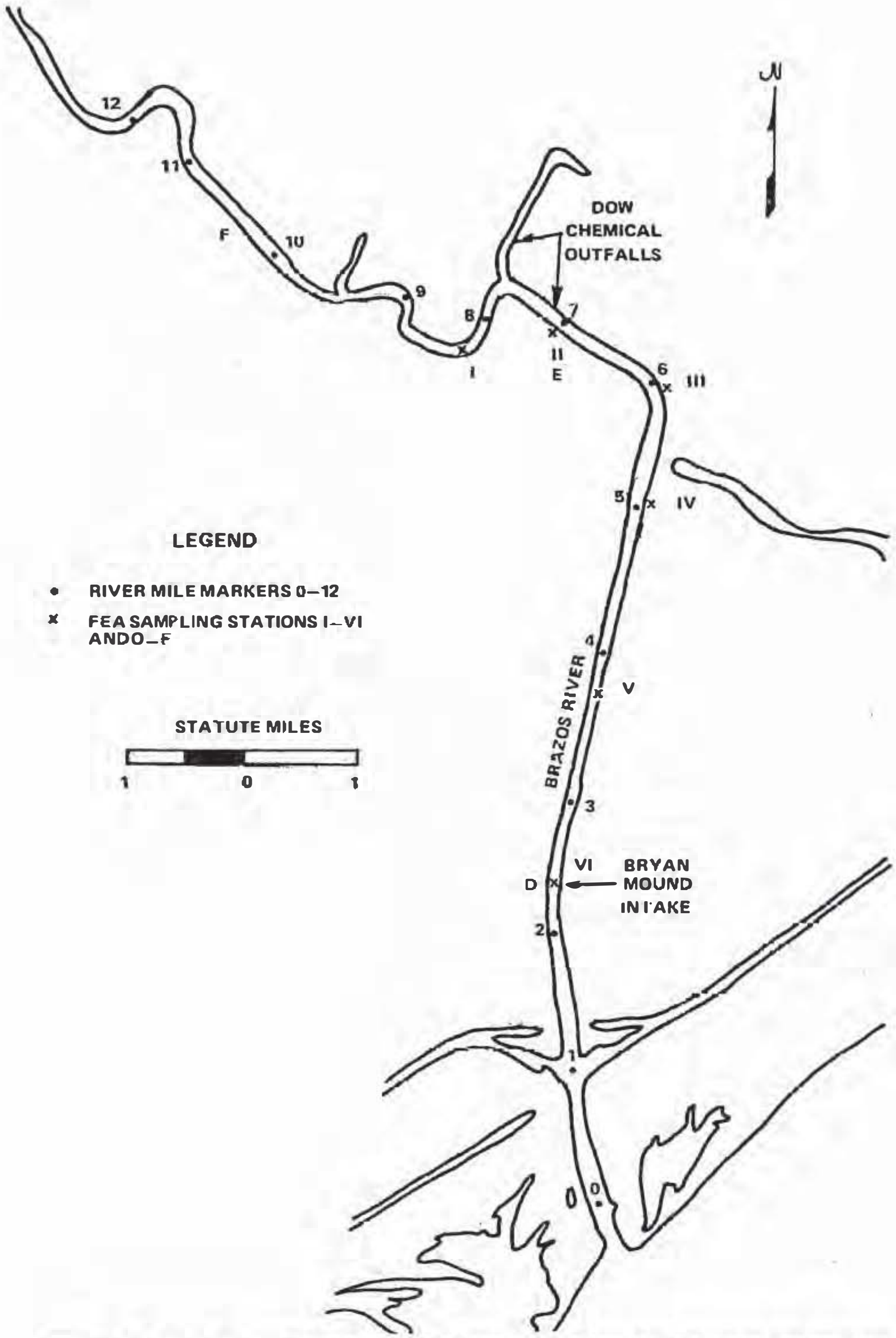

Figure C–1 BRAZOS RIVER DIVERSION CHANNEL SAMPLING STATIONS

C-2 FIELD MEASUREMENTS AND SAMPLING

Water samples were taken at the surface, mid-depth and bottom at each of six estuarine stations (Figure C-1). Stations II through VI were sampled at high and low tide; Station I was sampled only at high tide. All water samples were obtained with 2-liter PVC Van Dorn samplers.

For the analysis of organic constituents other than phenol and oil and grease, separate samples for volatile fractions and non-volatile fractions were collected at Stations I, IV and VI at high tide. For each fraction at each station, samples from the three discrete depths were composited into a prewashed container. The samples were iced and delivered to the laboratory the same day for processing within 24 hours.

Additional water samples were collected for the analysis of trace inorganics, suspended solids, phenol, and oil and grease. Six separate aliquots were withdrawn into appropriately prewashed containers and preserved according to the following schedule.

Parameters	Bottle Material	Bottle Size	Preservative
Oil & Grease	Glass	1 Liter	H_2SO_4, 4^oC
Phenol	Plastic	1 Liter	H_3PO_4 to pH 2,$CuSO_4$, 4^oC
Cyanide	Amber Plastic	500 ml	NaOH, 4°C
Metals (unfiltered)	Plastic	500 ml	conc. HNO_3, 4^oC
Boron & Selenium	Plastic	1 Liter	4^oC
Solids	Plastic	500 ml	4^oC

Following preservation, all trace inorganics, suspended solids, phenol, and oil and grease samples were immediately packed in ice and were delivered to the lab for processing within 24 hours of collection.

Finally, field measurements of temperature, pH, dissolved oxygen, and conductivity were made aboard ship on discrete samples according to the methodology shown in Table C-1. Results of the field measurements are given in Tables C-2 and C 3.

As illustrated by the Brazos River discharge (Table C-12) the field sampling was conducted during the recession of a high water stage.

Dissolved metal samples collected in July were transferred immediately to polyethylene bottles, stored in the dark and chilled on ice until received at the laboratory where they were filtered (0.45 μ) and acidified as soon as possible.

C-3 LABORATORY ANALYSIS

Neutral, basic and acidic nonvolatile organic fractions were extracted utilizing standard laboratory techniques from 250 ml aliquots of the three one gallon samples from Stations I, IV and VI. The extracts were analyzed on a gas chromotograph equipped with a 6' x 1/4" glass column packed with a standard packing (OV-17). The three 50-ml composite volatile organic samples (VOA) were stripped of volatiles by nitrogen purging and concentration onto Tenax absorbent. The volatile components were analyzed on a gas chromatograph equipped with a 0.01" capillary column packed with standard packing, CD-200. Detection limits for the nonvolatile extracts were 0.2×10^{-9} g/liter (0.2 ppb) and for the VOA's, 0.1×10^{-9} g/liter (0.1 ppb) related to the original samples. Sampling and analysis were performed in accordance with "Sampling and Analysis Procedure for Survey of Industrial Effluents for Priority Pollutants" EPA, March 1977.

Phenol, oil and grease, suspended solids, and trace inorganics with the exception of mercury were analyzed by the procedures given in "Standard Methods for the Examination of Water and Wastewater," 14th Edition, 1975. Mercury was analyzed according to "Manual of Methods for Chemical Analysis of Water and Wastes," EPA, Cincinnati, Ohio, July 1976. "Total" (dissolved plus acid-leachable) metal analyses were performed on acidified, unfiltered samples. Due to the high heavy metal concentrations encountered, corroborative analyses were performed at a separate, independent laboratory on the high tide samples from all depths at the proposed intake site (Station VI). Dissolved metal analyses were performed on chilled samples which were unacidified prior to filtration. After filtration samples were acidified to pH less than 2 with about 5 ml spectroscopic grade HNO_3 per liter of filtrate. Filtrates were analyzed spectrophotometrically by the methods referenced above.

Method summaries, instrumentation and reference citations are given for each chemical constituent in the annotated Table C-1.

C-4 RESULTS

Results of the volatile and nonvolatile organic analyses are given in Table C-6. A total of 89 compounds listed by EPA as priority organic contaminants were scanned by gas chromotograph and are alphabetically listed in Tables C-7 through C-11 according to operational property. Of the 89 contaminants scanned, only two were detected, 2.1 ppb methylene chloride at Station I and 0.7 ppb of 2,6 dinitrotoluene at Station VI.

Results of the remaining variables are shown for the estuary at high tide, and at low tide in Tables C-4 and C-5, respectively, and for dissolved metals in Table C-13. Arsenic, antimony, and selenium were undetected in all cases. Silver was generally low to undetectable in the estuary. The total concentrations of the remaining metals are generally high in the extreme which is probably attributable to the fraction acid-leached from extremely high total suspended solids (TSS). In contrast, the dissolved fraction of the remaining metals is lower by up to an order of magnitude with the exception of manganese. The dissolved metal concentrations are comparable to literature values for that area. High TSS levels were the result of heavy runoff and winds during survey operations. Suspended solids were further analyzed for their naturally occurring organic content. The organic content is expressed in the tables on a mass basis as volatile suspended solids (VSS) and as a percentage of the total. Oil and grease (O&G) was high and variable in the estuary, ranging from 2.1 to 15 ppm with no significant difference between tidal stages. Cyanide was detectable in the estuary in four of the eighteen high tide samples and was undetectable in the low tide samples.

Table C–1

STANDARD METHODS OF WATER QUALITY ANALYSIS

CHARACTERISTIC	METHODOLOGY	REFERENCE	SENSITIVITY	EQUIPMENT	INTERFERENCE
TOTAL ARSENIC	UNFILTERED AND ACIDIFIED, DIGESTED, INDUCTIVELY COUPLED ARGON PLASMA ATOMIC EMISSION SPECTROPHOTO–METRIC	PART 301AII * Manufacturer's Instructions	0.05 mg/l	JARRELL ASH 96–975 ICAP ATOM COMP	NOTE 1 NOTE 3
TOTAL SELENIUM	UNFILTERED AND ACIDIFIED, DIGESTED, INDUCTIVELY COUPLED ARGON PLASMA ATOMIC EMISSION SPECTROPHOTO–METRIC	PART 301AII * Manufacturer's Instructions	0.08 mg/l	JARRELL ASH 96–975 ICAP ATOM COMP	NOTE 1 NOTE 3
TOTAL MERCURY	UNFILTERED AND ACIDIFIED, DIGESTED, FLAME LESS COLD VAPOR ATOMIC ABSORPTION SPECTROPHOTOMETRIC	EPA, p. 118 **	0.2 ug/l	INSTRUMENTATION LABORATORIES 253–02	NOTE 1
TEMPERATURE	ALIQUOT WITHDRAWN FROM VAN DORN AND IMMEDIATELY SAMPLED		1/2 °C	FISHER LABORATORY THERMOMETER	
pH	CALIBRATED PRIOR TO EACH STATION SAMPLE ALIQUOT WITHDRAWN FROM VAN DORN AND IMMEDIATELY SAMPLED	Manufacturer's Instructions		MICRO SENSOR MICRO50	
DISSOLVED OXYGEN	ALIQUOT WITHDRAWN FROM VAN DORN AND IMMEDIATELY SAMPLED	Manufacturer's Instructions	1% of full scale 0–20 ppm	YELLOWSPRINGS MODEL 54	
CONDUCTIVITY	ALIQUOT WITHDRAWN FROM VAN DORN AND IMMEDIATELY SAMPLED	Manufacturer's Instructions	1% of full scale 0–5000	UNI LDC 770	
DEPTH	SOUNDING LINE				

Table C–1

STANDARD METHODS OF WATER QUALITY ANALYSIS

CHARACTERISTIC	METHODOLOGY	REFERENCE	SENSITIVITY	EQUIPMENT	INTERFERENCE
PHENOL	4–AMINOANTIPYRINE SPECTROPHOTO–METRIC, CHLOROFORM EXTRACTION AFTER DISTILLATION	PART 510A PART 510B •	1 ug/l	BAUSCH AND LOMB SPECTRONIC 20	NONE
OIL AND GREASE	PARTITION–GRAVIMETRIC WITH TRICHLORO–TRIFLUOROETHANE	PART 502A •	1–10 mg/l	METTLER H10T ANALYTICAL BALANCE	NONE
TOTAL SUSPENDED SOLIDS	GRAVIMETRIC NONFILTERABLE RESIDUE DRIED AT 103–105°C	PART 208D •	1 mg/l	METTLER H10T ANALYTICAL BALANCE	NONE
TOTAL VOLATILE SOLIDS	GRAVIMETRIC RESIDUE VOLATIZED AT 550°C	PART 208E •	1 mg/l	METTLER H10T ANALYTICAL BALANCE	NONE
TOTAL CYANIDE	PYRIDINE–BARBITURIC ACID SPECTROPHOTOMETRIC AFTER DISTILLATION	PART 413A •	20ug/l	BAUSCH AND LOMB SPECTRONIC 20	NONE
TOTAL BORON	CURCUMIN SPECTROPHOTOMETRIC	• PART 405A	0.2 mg/l	BAUSCH AND LOMB SPECTRONIC 20	NONE
TOTAL CALCIUM	UNFILTERED AND ACIDIFIED, DIGESTED, ATOMIC ABSORPTION SPECTROPHOTO–METRIC	PART 301AII PART 306A •	80 ug/l	INSTRUMENTATION LABORATORIES 253–02	NOTE 1
TOTAL CHROMIUM	UNFILTERED AND ACIDIFIED, DIGESTED, ATOMIC ABSORPTION SPECTROPHOTO–METRIC	PART 301AII PART 307A •	20ug/l 253–02	INSTRUMENTATION LABORATORIES	NOTE 1
TOTAL COPPER	UNFILTERED AND ACIDIFIED, DIGESTED, ATOMIC ABSORPTION SPECTROPHOTO–METRIC WITH CARBON INDUCTION FURNACE	PART 301AII • PART 308A manufacturer's Instructions	2 ug/l	INSTRUMENTATION LABORATORIES VARION TECHTRON CRA–U3	NOTE 1
TOTAL LEAD	UNFILTERED AND ACIDIFIED, DIGESTED, ATOMIC ABSORPTION SPECTROPHOTO–METRIC WITH CARBON INDUCTION FURNACE	PART 301AII • PART 308A Manufacturer's Instructions	7 ug/l	INSTRUMENTATION LABORATORIES 253–02 VARIAN TECHTRON CRA–63	NOTE 1

Table C–1 (Cont'd.)

STANDARD METHODS OF WATER QUALITY ANALYSIS

CHARACTERISTIC	METHODOLOGY	REFERENCE	SENSITIVITY	EQUIPMENT	INTERFERENCE
TOTAL MAGNESIUM	UNFILTERED AND ACIDIFIED, DIGESTED, ATOMIC ABSORPTION SPECTROPHOTOMETRIC	PART 301AI1 • PART 313B	20ug/l	INSTRUMENTATION LABORATORIES 253–02	NOTE 1
TOTAL MANGANESE	UNFILTERED AND ACIDIFIED, DIGESTED, ATOMIC ABSORPTION SPECTROPHOTOMETRIC WITH CARBON INDUCTION FURNACE	PART 301AI1 • PART 314A Manufacturer's Instructions	1 ug/l	INSTRUMENTATION LABORATORIES 253–02 VARION TECHTRON CRA–63	NOTE 1
TOTAL NICKEL	UNFILTERED AND ACIDIFIED, DIGESTED ATOMIC ABSORPTION SPECTROPHOTOMETRIC	PART 301AI1 • PART 316A	1 ug/l	INSTRUMENTATION LABORATORIES 253–02	NOTE 1
TOTAL SILVER	UNFILTERED ACIDIFIED, DIGESTED, ATOMIC ABSORPTION SPECTROPHOTOMETRIC WITH CARBON INDUCTION FURNACE	PART 301AI1 • PART 319A Manufacturer's Instructions	2 ug/l	INSTRUMENTATION LABORATORIES 253–02 VARION TECHTRON CRA–63	NOTE 1
TOTAL ZINC	UNFILTERED AND ACIDIFIED, DIGESTED, ATOMIC ABSORPTION SPECTROPHOTOMETRIC	PART 301AI1 • PART 323A	20 ug/l	INSTRUMENTATION LABORATORIES 253–02	NOTE 1
TOTAL BARIUM	UNFILTERED AND ACIDIFIED, DIGESTED, ATOMIC EMISSION SPECTROPHOTOMETRIC	PART 301AI1 • Manufacturer's Instructions	20 ug/l	INSTRUMENTATION LABORATORIES 253–02	NOTE 1
TOTAL CADMIUM	UNFILTERED AND ACIDIFIED, DIGESTED, ATOMIC ABSORPTION SPECTROPHOTOMETRIC WITH CARBON INDUCTION FURNACE	PART 201AI1 • PART 305A	1 ug/l	INSTRUMENTATION LABORATORIES 253–02 VARIAN TECHTRON CRA–63	NOTE 1
TOTAL ANTIMONY	UNFILTERED AND ACIDIFIED, DIGESTED, ATOMIC ABSORPTION SPECTROPHOTOMETRIC WITH CARBON INDUCTION FURNACE	PART 301AI1 • Manufacturer's Instructions	0.01 mg/l	JARREL ASH 810 JARRELL ASH FLA–100	NOTE 1 NOTE 2

Table C–1 (Cont'd.)

* STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER, 14TH EDITION (1975)

** MANUAL OF METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTES, ENVIRONMENTAL PROTECTION AGENCY, CINCINNATI, OHIO, JUL. 76

NOTE 1 PROBLEMS OF SIGNAL INHIBITION OR ENHANCEMENT FROM BACKGROUND MATRIX INTERFERENCE ARE OVERCOME BY INTERNAL STANDARDIZATION DOSE–RESPONSE CURVES

NOTE 2 PHOTOMULTIPLIER "FLOODING" AT SHORT WAVELENGTHS IS CORRECTED BY INSTRUMENTATION POSSESSING DUAL MONOCHROMETERS CAPABLE OF NEAR NON–ABSORBING WAVELENGTH SIGNAL NULLIFICATION.

NOTE 3 POOR SENSITIVITY AND CHEMICAL INTERFERENCE AT SHORT WAVELENGTHS IS CORRECTED BY INSTRUMENTATION POSSESSING HIGH ENERGY EXCITATION SOURCE.

Table C–2

ESTUARY SAMPLING – HIGH TIDE

STATION	DATE	TIME	DEPTH	TEMP. °C	pH	D.O. mg/l	CONDUCTANCE MICRO SIEMENS
VI SURFACE	4/12/77	0800	0 FT.	22.5	8.2	6.8	8000
VI MID	4/12/77	0800	11 FT.	22.5	8.0	7.5	9500
VI BOTTOM*	4/12/77	0800	23 FT.	22.5	7.8	7.5	10500
V SURFACE	4/12/77	0920	0 FT.	22.5	8.0	7.0	6500
V MID	4/12/77	0920	10 FT.	22.5	8.0	7.2	8000
V BOTTOM*	4/12/77	0920	20 FT.	22.5	7.9	7.4	12500
IV SURFACE	4/12/77	1000	0 FT.	23.0	8.0	7.5	6000
IV MID	4/12/77	1000	11 FT.	23.0	8.0	6.9	6000
IV BOTTOM*	4/12/77	1000	23 FT.	23.0	8.0	6.0	17500
III SURFACE	4/12/77	1030	0 FT.	23.0	8.3	8.2	3500
III MID	4/12/77	1030	14 FT.	24.5	8.2	7.5	6500
III BOTTOM*	4/12/77	1030	28 FT.	24.5	8.5	7.5	27500
II SURFACE	4/12/77	1110	0 FT.	24.5	8.0	7.8	2500
II MID	4/12/77	1110	9 FT.	25.0	8.2	6.8	15000
II BOTTOM*	4/12/77	1110	18 FT.	25.0	8.3	6.5	22500
I SURFACE	4/12/77	1150	0 FT.	23.0	8.0	8.0	950
I MID	4/12/77	1150	10 FT.	23.0	8.0	7.6	1000
I BOTTOM*	4/12/77	1150	19 FT.	23.0	7.9	7.0	1250

* SAMPLES TAKEN APPROXIMATELY 2 FEET OFF THE BOTTOM

Table C–3

ESTUARY SAMPLING – LOW TIDE

STATION	DATE	TIME	DEPTH	TEMP. °C	pH	D.O. mg/l	CONDUCTANCE MICROSIEMENS
II SURFACE	4/13/77	1240	0 FT.	22.0	8.0	7.5	3000
II MID	4/13/77	1240	9 FT.	22.6	8.0	7.0	7000
II BOTTOM	4/13/77	1240	18 FT.	24.5	7.8	6.5	13500
III SURFACE	4/13/77	1325	0 FT.	25.5	8.1	7.5	4250
III MID	4/13/77	1326	14 FT.	25.5	8.0	6.6	13500
III BOTTOM	4/13/77	1326	28 FT.	25.5	8.0	5.8	29000
IV SURFACE	4/13/77	1402	0 FT.	24.0	8.0	7.5	4000
IV MID	4/13/77	1402	11 FT.	24.0	8.0	6.9	11000
IV BOTTOM	4/13/77	1402	23 FT.	25.0	8.0	6.2	22000
V SURFACE	4/13/77	1431	0 FT.	24.0	8.0	7.5	5500
V MID	4/13/77	1431	10 FT.	24.0	8.0	7.0	7000
V BOTTOM	4/13/77	1431	20 FT.	25.0	8.0	6.8	17500
VI SURFACE	4/13/77	1458	0 FT.	24.6	8.0	7.2	5500
VI MID	4/13/77	1458	11 FT.	24.5	8.0	7.2	12000
VI BOTTOM	4/13/77	1458	23 FT.	25.0	8.0	6.5	13500

Table C—4

ESTUARY WATER QUALITY HIGH TIDE

	STATION I			STATION II			STATION III			STATION IV			STATION V			STATION VI		
	SURFACE	MID	BOTTOM	SURFACE	MID	BOTTOM	SURFACE	MID	BOTTOM	SURFACE	MID	BOTTOM	SURFACE	MID	BOTTOM	SURFACE	MID	BOTTOM
Phenol, mg/l	.010	.005	.003	.008	.060	.043	.007	.008	.021	.008	.013	.018	.014	.014	.014	.036	.034	.011
TSS, mg/l	409	488	1708	344	227	417	292	328	4420	173	159	518	66	170.5	603	97	282	268
VSS, mg/l	23	37	144	30	21	26	20	28	204	17	18	43	8.5	14.5	45	10	64	62
% Organics	5.62	7.58	8.43	8.72	9.25	6.24	6.85	8.54	4.62	9.83	11.32	8.3	12.88	8.5	7.46	10.3	22.7	23.13
O & G, mg/l ***	6.5	4.8	4.8	8.5	11.4	11.4	3.6	6.2	5.5	3.4	6.9	5.0	2.1	3.6	7.8	12.8	6.4	5.6
Cyanide, mg/l	< .02	< .02	< .02	.036	.025	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< 0.02	.027	.046
Cd, ug/l	2	2	3	3	2	4	7	3	9	2	2	6	3	3	20	2	3	3
Cr, ug/l	47	47	58	47	62	73	49	56	75	48	54	61	51	57	63	50	60	70
Cu, ug/l	5	7	8	6	9	14	5	11	15	6	10	12	6	8	9	5	7	11
Pb, ug/l	66	65	65	48	65	122	66	98	163	55	57	131	48	66	74	66	74	82
Hg, ug/l	2.16	1.9	1.9	0.58	0.72	1.05	0.44	0.83	1.00	0.55	0.56	1.28	1.5	1.94	2.10	0.5	0.5	0.44
Ni, ug/l	20	30	35	20	25	32	30	35	40	30	40	40	30	30	40	18	22	30
Zn, ug/l	50	62	75	75	83	85	88	95	100	60	70	80	100	70	72	72	72	75
Ba, ug/l	105	110	140	105	160	160	90	100	140	110	120	180	70	110	150	100	140	140
B, ug/l	260	290	420	490	930	2200	160	370	2400	290	280	920	360	390	850	620	500	500
Mn, ug/l	40	50	55	45	55	60	43	46	50	42	51	52	35	40	45	40	40	60
Ag, ug/l	< 2	< 2	< 2	< 2	< 2	6	< 2	< 2	5	< 2	< 2	< 2	< 2	< 2	4	< 2	< 2	5
Ca, mg/l	68	69.6	110	70.0	116	212	72.0	86	372	76.8	79.2	176	82.4	85.6	114	88.8	96.0	98.4
Mg, mg/l	24.8	24.8	63.3	44.4	272	612	65.5	133	830	96.8	106	306	117	134	352	157	185	213
As, ug/l	All samples less than 50 →																	
Sb, ug/l	All samples less than 10 →																	
Se, ug/l	All samples less than 80 →																	

***O & G = Oil & Grease

Table C–5

ESTUARY WATER QUALITY – LOW TIDE

	STATION II			STATION III			STATION IV			STATION V			STATION VI		
	SURFACE	MID	BOTTOM	SURFACE	MID	BOTTOM	SURFACE	MID	BOTTOM	SURFACE	MID	BOTTOM	SURFACE	MID	BOTTOM
Phenol, mg/l	.009	.008	.009	.006	.007	.003	.006	.005	.008	.009	.010	.011	.008	.010	.009
TSS, mg/l	126	223	119	105	119	531	90	116	403	45	55	82	55	39	48
VSS, mg/l	19	30	19	15	10	45	9	17	41	6	10	16	10	4	7
% Organics	15.08	13.45	15.97	14.29	8.40	8.47	10	14.66	10.17	63.33	18.18	19.51	18.18	10.26	14.58
O & G, mg/l**	4.3	8.8	8.6	3.7	7.4	5.6		15.	7.0	4.9	4.3	10.8	4.9	5.3	*
Cyanide, mg/l	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02
Cd, ug/l	< 1	1	2	2	3	5	5	19	54	1	2	3	2	7	9
Cr, ug/l	41	46	55	42	55	80	43	56	64	33	42	53	70	70	80
Cu, ug/l	6	6	6	7	7	8	6	6	12	3	4	6	8	12	17
Pb, ug/l	66	82	120	66	82	106	66	82	139	48	57	82	80	90	130
Hg, ug/l	3.9	2.6	3.3	2.6	2.3	2.8	2.3	2.2	2.5	2.6	3.0	3.0	2.2	2.2	2.6
Ni, ug/l	30	30	40	20	20	30	20	35	40	20	30	30	20	20	30
Zn, ug/l	67	67	83	45	47	62	82	78	90	57	78	129	60	70	80
Ba, ug/l	60	95	140	55	110	140	90	120	140	50	75	140	140	130	130
B, ug/l	190	830	960	330	730	2700	330	1150	1900	420	420	1100	700	870	1100
Mn, ug/l	60	50	50	55	74	76	61	55	55	35	35	61	40	40	50
Ag, ug/l	<2	3	4	< 2	< 2	<2	< 2	4	6	< 2	<2	<2	< 2	< 2	6
Ca, mg/l	67.2	73.2	116.0	72.0	126.0	248.0	74.0	120.0	224.0	75.2	81.2	176.0	78.4	102.0	116.0
Mg, mg/l	51.7	86.2	277.0	76.5	300.0	735.0	77.9	288.0	619.0	98.8	131.0	309.0	113.0	249.0	280.0
As, ug/l	All samples less than 50 →														
Sb, ug/l	All samples less than 13 →														
Se, ug/l	All samples less than 80 →														

* Broken

**O & G = Oil & Grease

Table C–6

ORGANIC COMPOUNDS DETECTED

STATION I	
VOLATILES	2.1 ppb METHYLENE CHLORIDE
NEUTRAL FRACTION	NONE DETECTED
BASIC FRACTION	NONE DETECTED
ACID FRACTION	NONE DETECTED
PCB's	NONE DETECTED
STATION IV	
VOLATILES	NONE DETECTED
NEUTRAL FRACTION	NONE DETECTED
BASIC FRACTION	NONE DETECTED
ACID FRACTION	NONE DETECTED
PCB's	NONE DETECTED
STATION VI	
VOLATILES	NONE DETECTED
NEUTRAL FRACTION	0.7 ppb 2,6 DINITROTOLUENE
BASIC FRACTION	NONE DETECTED
ACID FRACTION	NONE DETECTED
PCB's	NONE DETECTED

Table C-7

VOLATILE ORGANICS SCANNED

Detection Limits .1ppb

Acetone

Benzene

Bromoform

Bromomethane

Butyl Alcohol

Carbon Tetrachloride

Chlorobenzene

Chloroethane

2-Chloroethly Ether

2-Chloroethylvinyl Ether

Chloroform

Chloromethane

Chloromethyl Ether

Chlorophenol

1,4-Dichlorobenzene

Dichlorobromomethane

Dichlorodifluoromethane

1,1-Dichloroethane

1,2-Dichloroethane

1,1-Dichloroethylene

1,2-Dichloroethylene

1,3-Dichloropropene

Dimethoxane

3,5-Dinitro-o-Cresol

2,4-Dinitrophenol

Ethyl Benzene

Formaldehyde

Hexachloroethane

Methyl Alcohol

Methylene Chloride

Methylethyl Ketone

O & M-Dichlorobenzene

Table C-7

VOLATILE ORGANICS SCANNED (Cont'd)

Pentachloroethane
Phenol
Styrene
1,1,1,2-Tetrachloroethane
1,1,2,2,-Tetrachloroethane
Tetrachloroethylene
Toluene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethylene
Trichlorofluoromethane
Vinyl Chloride

Table C–8

NEUTRAL FRACTION SCANNED

Detection Limits .2 ppb

Benzyl Alcohol
Biphenly
4-Bromophenyl Ether
Chlorobenzene
2-Chlorophenol
4-Chlorophenylether
1,2-Dichlorobenzene
2,4-Dichlorophenol
4,4'-Dichlorophenyl Ether
2,4-Dimethylphenol
2,4-Dinitrotoluene
2,6-Dinitrotoluene
3,5-Dinitro-o-Cresol
2,4-Dinitrophenol
Diphenylether
Hexachlorobenzene
Hexachloroethane
m & p-Dichlorobenzene
Nitrobenzene
2-Nitrophenol
4-Nitrophenol
Pentachlorophenol
Phenol
1,2,4-Trichlorobenzene
2,4,6-Trichlorophenol
Triethylene Glycol

Table C–9

BASIC FRACTION SCANNED

Detection Limits .2ppb

Benzidine
Cyclohexylamine
3-3'Dichlorobenzidine
Hexamethyldiamine
Pyridine
N-Nitrosodimethylamine
N-Nitrosodi-N-Propylamine
N-Nitrosodiphenylamine

Table C-10

ACID FRACTION SCANNED

Detection Limits .2ppb

Dimethyl Azelate
(Azelaic Acid)

Methyl Acetate
(Acetic Acid)

Methyl Formate
(Formic Acid)

Methyl Stearate
(Sodium Stearate)

Table C-11

PCB's SCANNED

Detection Limits .2ppb

PCB Compound	Mass Number
Chlorobiphenyl	188 190 152
Dichlorobiphenyl	222 224 152
Hexachlorabiphenyl	109 110 145
Hexachlorobiphenyl	360 362 358
Pentachlorobiphenyl	127 109 128
Tetrachlorobiphenyl	220 73 222
Trichlorobiphenyl	256 258 186

Table C–12

BRAZOS RIVER DISCHARGE NEAR ROSHARON, TEXAS
STATION 0 116650

DATE MARCH 1977	CUBIC FEET PER SECOND
20	8,080
21	7,120
22	6,280
23	5,740
24	5,690
25	5,400
26	4,870
27	4,350
28	4,090
29	4,010
30	4,090
31	4,380
APRIL	
1	11,900
2	20,100
3	25,700
4	27,600
5	27,800
6	25,600
7	22,200
8	17,800
9	15,200
10	14,600
11	12,800
12	11,000*
13	9,030*

* FEA SAMPLE DATE
** UNPUBLISHED RECORDS SUBJECT TO REVISION

SOURCE: United States Department of the Interior Geological Survey

Table C–13
ESTUARY DISSOLVED HEAVY METAL BURDEN OF 7/7/77

HEAVY METAL (ug/l)	EXPECTED INTAKE WATER QUALITY STATION D			INDUSTRIAL DISCHARGE AREA STATION E			UPSTREAM AREA STATION F		
	SURFACE	MIDDEPTH	BOTTOM	SURFACE	MIDDEPTH	BOTTOM	SURFACE	MIDDEPTH	BOTTOM
Cd	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cr	1.6	2.5	3.0	1.0	1.0	1.5	0.5	1.5	1.6
Cu	4.0	4.4	5.2	2.8	2.8	3.6	2.8	3.2	3.6
Pb	3	2	3	4	2	2	4	2	3
Hg	0.30	0.23	0.30	0.27	0.27	0.23	0.33	0.30	0.27
Ni	2	<1	1	8	6	2	6	4	2
Zn	17	17	21	11	12	18	14	16	16
Sb	<10	<10	<10	<10	<10	<10	<10	<10	<10
Mn	60	55	53	77	78	20	91	70	41
Se	< 20	< 20	<20	< 20	< 20	<20	< 20	< 20	< 20
Ag	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	<0.5	<0.5	< 0.5	<0.5
As	<20	<20	<20	<20	<20	<20	< 20	<20	<20

APPENDIX D

LETTERS FROM RESPONDENTS

The following pages contain copies of the letters which were received from agencies and other interested parties who responded within the given 45 day comment period ending September 7, 1977. A response to the comments dealing with the raw water supply and brine disposal to the Dow Corporation and deep well injection are discussed in section 8 of this document. Other comments which were received after the due date are discussed within the report text. The comments regarding the Gulf Brine Diffuser System will be deferred until the appropriate final supplement on this disposal system is made.

Comments on the draft received during the forty-five day comment period were received from the following:

1. U.S. Department of Army
2. U.S. Department of Commerce
3. U.S. Energy Research and Development Administration
4. U.S. Federal Power Commission
5. Texas Parks and Wildlife Department
6. Dow Chemical Company
7. Ralph M. Parsons Laboratory
8. Brownsville-Port Isabel Shrimp Producers Association
9. Port Isabel Shrimp Association
10. Texas Environmental Coalition

OA

DEPARTMENT OF THE ARMY
GALVESTON DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1229
GALVESTON, TEXAS 77553

376301

REPLY TO ATTENTION OF:
SWGED-E

2 SEP 1977

Executive Communications
Room 3309
Federal Energy Administration
Washington, D.C. 20461

Dear Sir:

This is in response to your letter dated 15 July 1977, which provided a copy of the "Draft Supplement Final Environmental Statement, Strategic Petroleum Reserve, Bryan Mound Salt Dome," for our review and comments.

Our comments are as follows:

a. The authorized 45-foot Federal Navigation Channel Enlargement for Freeport Harbor would have a proposed dredged material disposal area near the injection well pipelines. A copy of Figure 1, page 4, showing the proposed dredged material disposal site is inclosed.

b. Request that the second sentence of the third paragraph of Section 1.2.1 be changed to read "Detailed plans and construction procedures for pipeline crossings and proposed structures at the flood protection levee system will be coordinated with the Velasco Drainage District to insure the integrity of the levee system is maintained," in lieu of "All construction work would be coordinated with the Velasco Drainage District to avoid creating a flood hazard to the property behind the levee."

c. The proposed water intake in the Brazos River Diversion Channel, the Seven Mile Pipeline, and the offshore brine diffuser structure will require Department of the Army permits under Section 10 of the River and Harbor Act of 1899 prior to construction. Facilities constructed in wetlands will require Department of the Army permits under Section 404 of the Federal Water Pollution Control Act Amendments of 1972.

d. Page 1-3, Paragraph 1.2.1. - Consideration should be given to the alternative of locating the pump station on the interior side of the hurricane protection levee.

e. Page 1-7, Section A-A. - There may be erosion at the base of the walkway supports and at the sides of the pump station during high discharges, and riprap protection should be considered.

f. Page 2-24, Paragraph 2.7.1. -

Identify the source of the statement "combined storage capacity of approximately 6,900 acre-foot."

The maximum Brazos River discharges at Rosharon are calculated to exceed 100,000 cfs, since the one precent discharge at River Mile 52 is approximately 103,000 cfs.

g. Pumps and mechanical gear susceptible to flood damage should be raised to an elevation at or above the one percent flood elevation in consonance with Executive Order 11988. "Normal flooding elevations" is an ambiguous term which does not specifically indicate compliance with the flood damage prevention requirements contained in the Executive Order. Figure 2 implies that susceptible gear is located above 18 feet elevation, but such items are not specifically labelled on the elevation view.

h. It is suggested that construction of the injection well pipeline be coordinated with the Brazos River Harbor Navigation District so as to avoid reductions in capacity of the disposal area. Also, construction of the pipeline crossing the small drainage ditch between the injection wells and the proposed disposal area should be coordinated with the U.S. Fish and Wildlife Service.

Sincerely yours,

JON C. VANDEN BOSCH
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

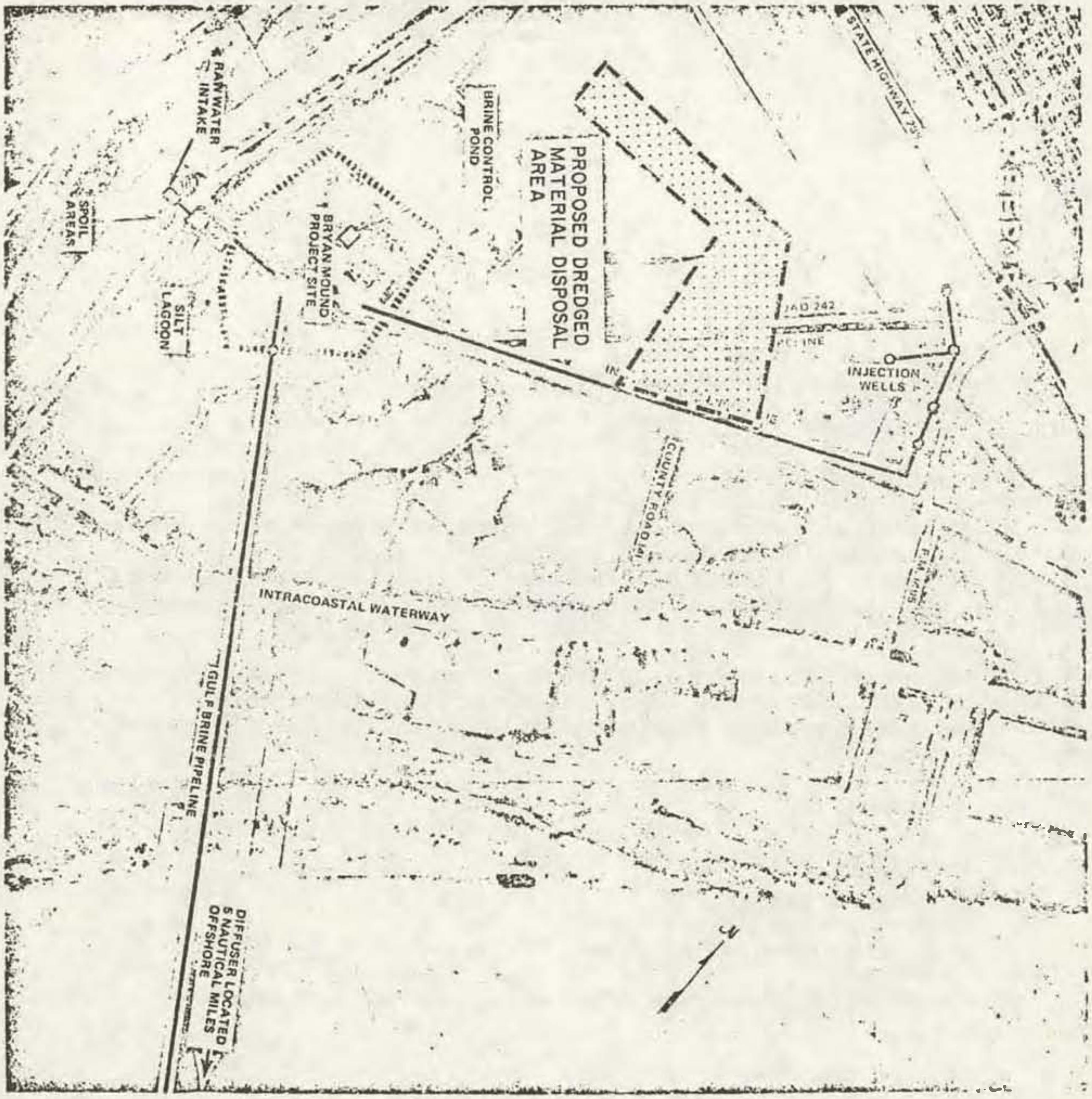

Figure 1 BRYAN MOUND REVISED FRESHWATER INTAKE AND BRINE DISPOSAL SYSTEMS LOCATIONS

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Science and Technology
Washington, D.C. 20230
(202) 377-3111

September 2, 1977

Executive Communications
Federal Energy Administration
Room 3309
Washington, D. C. 20461

Gentlemen:

This is in reference to your draft supplement final environmental impact statement entitled "Strategic Petroleum Reserve, Bryan Mound Salt Dome." The enclosed comments from the National Oceanic and Atmospheric Administration (NOAA) are forwarded for your consideration.

Thank you for giving us an opportunity to provide these comments, which we hope will be of assistance to you. We would appreciate receiving fifteen (15) copies of the final statement.

Sincerely,

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

Enclosure: Memo from NOAA, National Marine Fisheries Service

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Duval Building
9450 Gandy Boulevard
St. Petersburg, FL 33702

AUG 22 1977

August 12, 1977 FSE61/DM

TO: Director, Office of Ecology & Environmental Conservation, EE

AUG 22 1977

THRU: for Assistant Director for Scientific and Technical Services, F5

FROM: William H. Stevenson, Regional Director

SUBJECT: Comments on Draft Supplement Final Environmental Impact Statement - Bryan Mound Salt Dome (FEA 76/77-6)

The draft supplement final environmental impact statement for Bryan Mound Salt Dome, has been received by the National Marine Fisheries Service for review and comment.

The statement has been reviewed and the following comments are offered for your consideration.

Specific Comments:

1. DESCRIPTION OF PROJECT
1.2 PROPOSED ACTION
1.2.2 Brine Disposal
1.2.2.3 Marine Disposal in the Gulf of Mexico

Page 1-10, paragraph 5. The rationale for the necessity of this brine disposal method, which would adversely impact some marine life, should be discussed since it is stated on the same page, second paragraph, that the projected fill rate would be 150,000 BPD and in the 4th paragraph, that the proposed five injection wells would be designed to accommodate disposal of 150,000 BPD.

2. DESCRIPTION OF THE EXISTING ENVIRONMENT
2.9 GULF OF MEXICO MARINE ENVIRONMENT
2.9.3 Marine Ecology

Page 2-68. The various descriptions of salinity tolerances found in subsections under Marine Ecology should, where appropriate, include a discussion of the work done by Copeland and Bechtel (1974) and Gunter, Ballard and Venkataramiah (1974).

2.9.3.5 Shrimp

Page 2-86, Figure 22. This figure was apparently developed primarily from information contained in Figure 2.7, Migration of Gulf of Mexico Penaeid Shrimp in the Atlas of the Living Resources of the Seas published by FAO, Department of Fisheries, Rome, in 1972. However, the boundaries of the major white and brown shrimp fishing grounds shown in Figure 22 are considerably different than those in Figure 2.7 of the FAO publication. Also, the migration routes were illustrated as examples only by FAO.

Realizing some errors even in their publication, FAO is in the process of revising it. We, therefore, recommend that the figures on pages 7 and 11 of the Bureau of Commercial Fisheries Circular 312 (Osborn, Magham and Drummond, 1969) be used to portray the brown and white shrimp fisheries.

In addition, we believe that Figure 23 (page 2-87) sufficiently portrays the migration of larval and juvenile penaeid shrimps, so that the incomplete and inaccurate portrayal can be deleted from Figure 22.

Page 2-88, paragraph 1. Since the peak migration of brown shrimp to the Gulf occurs during May and June (Trent, 1966), it appears that brown shrimp migration from the estuaries is unrelated to temperature reduction.

Page 2-88, paragraph 2. The statement that white shrimp post-larvae, which come into the estuary later in the year, "overwinter in the estuaries," should be modified to state that they may overwinter in the estuaries.

It is also stated in this paragraph that "some recent information indicates that a white shrimp spawning stock occurs 5-7 miles off Bryan Beach." It should also be noted that the Associate Marine Fisheries Specialist of the Texas Agricultural Extension Service at Angleton recently informed the NMFS by letter of August 9, 1977, of documented spawning populations of white shrimp inside of the proposed diffuser site, in waters about 4 miles offshore, as well as beyond. He denoted three sites ranging about 0.8 to 3 nautical miles from the proposed diffuser site where he collected white shrimp with spermatophores, ready to spawn. He noted that during three collecting trips in 1977 they have investigated an area extending east of the Freeport jetties to west of the San Bernard River and out to 10 fathoms in search of mated shrimp. He stated that "the three sites are the only locations in which we have documented female white shrimp with spermatophores, thus far. The presence of these spermatophores indicates a definite spawning site." (A copy of the letter discussed above is being forwarded to the FEA contact designated for this EIS.) Since an alternative of placing the diffuser 12.5 N miles offshore is presented, the comparison of the shrimp resources and fishery at that location, in to 10 N miles, should be compared to these in the vicinity of the proposed site, in view of this additional information. The Associate Marine Fisheries Specialist is preparing a letter reviewing the fisheries in both the proposed location and alternate sites out to 12.5 N miles offshore. That will also be forwarded to the FEA contact when available. The final supplement EIS should also discuss all the additional information on the fisheries at each possible diffuser site. Copies of both letters should be included in the FEIS.

3. ENVIRONMENTAL IMPACTS
3.1 CONSTRUCTION
3.1.3 Terrestrial Environment
Injection Well Pipeline and Well Sites

Page 3-7, paragraph 2. This section states that "Long term loss of about 3 acres of marsh habitat...would be unavoidable...". The alternative of directionally drilling the disposal wells from nearby upland terrain should be thoroughly discussed since that would make the marsh habitat loss avoidable.

3.2 OPERATION
3.2.4 Brazos River Diversion Channel

Page 3-21, paragraph 4. The statement "Even if a worst case were assumed and all organisms within the intake waters were lost, only a negligible fraction of the biota would be lost," should be documented.

3.2.5 Gulf of Mexico Brine Diffuser
3.2.5.3 Biological Impacts of the Gulf Diffuser Operation

Page 3-37. The supplemental final environmental impact statement should include and discuss the results of bioassays recommended in the Summary and Conclusions section of the Proceedings of the Strategic Petroleum Reserve Workshop - Environmental Considerations of Brine Disposal Near Freeport, Texas, held in Houston, Texas, on February 17 and 18, 1977. It was concluded that at least three candidate organisms be selected for tolerance studies under laboratory conditions. These include: white shrimp (all life stages), red drum (adult and juvenile), and polychaete worms. It was further recommended that brine from the Bryan Mound Dome be used for these tolerance studies and that the water used to form the brine for the bioassays be from the same source as the water that will be used during the drawdown phase and when enlarging the dome by leaching. This is extremely important since, as the EIS notes, the Brazos River Diversion Channel (from which the water will be drawn) is often extremely polluted. The results of the bioassays should also be included and discussed in the final supplement.

7. ALTERNATIVES TO PROPOSED ACTIONS

7.2 BRINE DISPOSAL ALTERNATIVES

7.2.2 Gulf Diffuser System Alternatives

7.2.2.2 Alternate Diffuser Site

Page 7-7. Since locating the diffuser 10 N miles offshore would apparently locate it beyond the white shrimp spawning grounds and the sportfishing bank, this location should also be discussed as an alternative because it should involve less construction costs and less disruption of Gulf bottom than the 12.5 N mile alternative. Any additional information available concerning the fisheries in the vicinity of these sites should be discussed.

Literature Cited

Copeland, B.J. and T.J. Bechtel, 1974. Some environmental limits of six Gulf coast estuarine organisms. Contributions in Maine Science (Univ. TX) Vol. 18, p. 169-204.

Gunter, G., D.S. Ballard, and A. Venkataramiah, 1974. A review of salinity problems of organisms in United States coastal areas subject to the effects of engineering works. Gulf Research Reports (Gulf Coast Research Lab., Ocean Springs, MS) Vol. 4, No. 3, p. 380-475.

Osborn, K.W., B.W. Maghan, and S.B. Drummond, 1969. Gulf of Mexico shrimp atlas, U.S. Dept. of Int., Bur. of Comm. Fish., Circular, 312, 20p.

Trent, L., 1966. Size of brown shrimp and time of emigration from the Galveston Bay system, Texas. Proc. Gulf Carib. Fish. Inst., 19th Annual Session, p. 7-16.

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

078003

SEP 1 1977

Executive Communications
Federal Energy Administration
Room 3309
Washington, D.C. 20461

Dear Sir:

This is in response to Mr. Michael E. Carosella's transmittal dated July 15, 1977, in which he invited the Energy Research and Development Administration (ERDA) to review and comment on the Federal Energy Administration's draft supplement to the final environmental impact statement for the Bryan Mound salt dome (FES 76/77-6).

We have reviewed the supplement and have determined that we have no objection to the change in the design of the Bryan Mound brine disposal and water supply systems. We have no comments to offer on the supplement itself.

Thank you for the opportunity to review and comment on the draft supplement.

Sincerely,

W. H. Pennington, Director
Office of NEPA Coordination

cc: Council on Environmental Quality (5)
Mr. Michael E. Carosella, FEA

0A
9/7

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

IN REPLY REFER TO:

August 2, 1977

3?6006

Executive Communications
Room 3309
Federal Energy Administration
Washington, D.C. 20461

Dear Sir:

I am replying to your request of 15 July 1977 to the Federal Power Commission for comments on the Draft Environmental Impact Statement for the Bryan Mound, Strategic Petroleum Reserve. This Draft EIS has been reviewed by appropriate FPC staff components upon whose evaluation this response is based.

The staff concentrates its review of other agencies' environmental impact statements basically on those areas of the electric power and natural gas industries for which the Federal Power Commission has jurisdiction by law, or where staff has special expertise in evaluating environmental impacts involved with the proposed action. It does not appear that there would be any significiant impacts in these areas of concern nor serious conflicts with this agency's responsibilities should this action be undertaken.

Our review, however, noted the following items for your evaluation:

1) The solution mining of additional salt dome caverns or enlargement will impact areas much larger than stated.

2) Super saline conditions will probably persist for a longer period, depending upon the frequency of storage operation.

3) Initial filling of storage should be at a lesser rate to reduce emulsification.

4) Consideration should be given to filtration of the brine discharge.

Thank you for the opportunity to review this statement.

Sincerely,

Jack M. Heinemann
Advisor on Environmental Quality

OA 9/7

TEXAS
PARKS AND WILDLIFE DEPARTMENT

CLAYTON T. GARRISON
EXECUTIVE DIRECTOR

4200 Smith School Road
Austin, Texas 78744

37001

August 8, 1977

Federal Energy Administration
Executive Communications, Room 3309
Washington, D. C. 20461

Re: Draft Supplement - Final Environmental Impact Statement,
Bryan Mound Salt Dome

Dear Sirs:

Reference is made to the document which was submitted to this agency for review and comment on July 15, 1977. We have reviewed the draft and offer the following comments for your consideration.

The plans for operation of the Bryan Mound Salt Dome Strategic Petroleum Reserve include three methods of disposing of brine from the facility - use as feedstock by Dow Chemical Company, use of injection wells, and disposal by diffuser in the Gulf of Mexico. It is recommended that disposal in the Gulf of Mexico be kept as low as possible in order to avoid adverse impacts to the offshore fisheries, particularly with respect to the white shrimp fishery.

Section 3.1.8 of the draft should be expanded to discuss possible interference with navigation and trawling operations which may result from the installation of a Gulf brine diffuser system. Section 4.6 should also be expanded to discuss this subject.

The opportunity to review and comment upon this document is appreciated.

Sincerely,

CLAYTON T. GARRISON
Executive Director

CTG:BDK:gs3/1

cc: Mr. Ward C. Goessling, Jr., Coordinator
Natural Resources Section
Governor's Budget and Planning Office
Executive Office Building
411 West 13th Street
Austin, Texas 78701

OA

078002

DOW CHEMICAL U.S.A.

BARSTOW BUILDING
2020 DOW CENTER
MIDLAND, MICHIGAN 48640

September 1, 1977

Executive Communications
Room 3309
Federal Energy Administration
Washington, D.C. 20461

Gentlemen:

Thank you for the opportunity to comment on the Draft Supplement to the Final Environmental Impact Statement, Bryan Mound Salt Dome. We have no comment on the technical portion of the statement. However, on pages 1-9 and 1-10, it is stated that there is an agreement with the FEA whereby Dow would dispose of 56,500 BPD of brine from the site. Dow and the FEA have been discussing this possibility for sometime, but there was no firm agreement at the time of the statement and there is still no agreement now. So the impact statement is in error and misleading on this point.

Sincerely yours,

Roger Gohrband
Director of Planning

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RALPH M. PARSONS LABORATORY
FOR WATER RESOURCES AND HYDRODYNAMICS
DEPARTMENT OF CIVIL ENGINEERING. BLDG. 48—321
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075005

PHONE: (617) 253- 6761

August 22, 1977

Executive Communications
Room 3309, Federal Energy Administration
Washington, D.C. 20461

Dear Sirs,

The purpose of this letter is to address two small issues concerning the design and operation of the offshore brine diffuser and to make several small corrections to those parts of the document for which we at MIT were responsible.

The first point concerns the orientation of the diffuser ports. The angle of 90° was selected for preliminary analysis based on prior experimental data obtained with that orientation. We are presently conducting some experiments in which the question of nozzle orientation will be explored in detail. We expect to have some results available by mid-fall, and hope that these could be factored into the final design.

The second point concerns the operation of the diffuser at flow rates less than the maximum discharge. The table on page 1-15 suggests that the recommended range in Froude number of 16-20 will be maintained. This could be accomplished by incorporating raw water from the Brazos as mentioned on page 1-12 or by capping a number of nozzles. If the risers were threaded so that caps could be easily fitted or removed, then it would also be possible to fit nozzles which might discharge at angles of other than 90°.

The following errata are noted:

1. The discussion of the MIT model appears to be extracted directly from section 7.3 of NOAA's Bryan Mound report. Thus the two figures on pages D-4 and D-5 actually refer to the previous section of the NOAA report and their inclusion is somewhat out of context.

2. On page D-58 the dimension of 16d on part a) of the figure (upper part) should read 8d.

3. On page D-77, the first sentence of the 2nd paragraph should read, "The properties of a round buoyant submerged jet (or a negatively buoyant surface jet) can be determined using an integral jet analysis."

4. On page D-78, several of the table entries are in error. A revised table is enclosed.

Sincerely,

E. Eric Adams

E. Eric Adams
Research Engineer

enclosure

cc. Dr. Dail Brown

Table 18 Comparison of Parameters for Typical Ocean Discharges of Thermal, Sewage and Saturated Brine Effluents

	Thermal	Sewage	Saturated Brine
Nature of Discharge	Condenser cooling water for 2000 MWe Nuclear Power Station	200 MGD Sewage Treatment Plant	Proposed Bryan Mound Brine Discharge
Flow Rate, Q_o (m^3/s)	100	10	1.2
Initial Density Difference, $\rho_o - \rho_a / \rho_a$	.003 (12°C temperature rise)	.025 (fresh-salt water)	-.25 (saturated brine)
Buoyancy Flux, $(\rho_o - \rho_a) g Q_o / \rho_a$ (m^4/s^3)	2.9	2.5	-2.9
Typical Dilution Required	10	100	50-100

BROWNSVILLE-PORT ISABEL
SHRIMP PRODUCERS ASSOCIATION

378007

P. O. BOX 953
BROWNSVILLE, TEXAS

August 24, 1977

Executive Communications
Room 3309
Federal Energy Administration
Washington, D.C. 20461

Dear Sirs:

Concerning brine disposal from the Bryan Mound salt dome, the Brownsville -Port Isabel Shrimp Producers Assoc. would like to go on record as opposing the proposed location of brine diffuser pipes just 5 nautical miles offshore from Freeport, Texas.

Fleets from our area depend on the entire Texas Coast for shrimp production and over the years the fishing grounds just offshore from Freeport have become recognized as prime white shrimp areas.

The proposed location of the brine diffuser system would directly conflict with major white shrimping efforts and would definitely hamper production. There is a distinct possibility that high salinity waters found in the area could affect reproduction of gravid white shrimp, which congregate near shore for mating and spawning.

We are also concerned about the effect of brines on the migration patterns of larval and juvenile shrimp, respectively, immigrating and emigrating to and from bays.

An alternative diffuser site at 12.5 N. miles offshore, would not significantly conflict with the interest of most shrimpers, in which case, our Association strongly supports a diffuser site further from land than the proposed 5 nautical mile site. We further recommend that whichever site chosen be properly marked for night and day observation.

Sincerely,

Julius Collins
PRESIDENT

376008

PORT ISABEL SHRIMP ASSOCIATION
P. O. BOX 1046
PORT ISABEL, TEXAS 78578

August 24, 1977

Executive Communications
Room 3309
Federal Energy Administration
Washington D.C. 20461

Dear Sirs:

In reference to the environmental impact statement (EIS), for the Bryan Mound salt dome, the Pt. Isabel Shrimpers Assoc. would like to submit the following comments.

Our local Shrimpers Assoc. fully recognizes our Nation's need for energy at a reasonable cost, but at the same time we, as representatives of the Texas Shrimp Industry, also realize that a healthy marine enviroment must not be sacrificed toward those goals.

The Port Isabel Shrimpers Assoc. has a great deal of interest in fishing zones other than those just off our coast. By nature of our far ranging shrimp fleets, which harvest shrimp over the entire northern Gulf, we cannot ignore events which might be of detriment to common shrimp grounds, whether they are 50 or even 600 or more miles from port.

Shrimp and many other commercially important marine species use near shore areas as well as bays and estuaries, during all or a part of their life cycle. We feel that these areas must be protected to allow our renewable fishery resources to retain a high level of productivity. we therefore express our concern that the proposed location of a Bryan Mound diffuser system - only 5N. miles from shore, would definitely conflict with production, and possibly reproduction of white shrimp in that area. White shrimp production decreases would certainly result from the direct trawl hindrance of diffuser pipes in the area. It is not inconceivable that high saline (314 parts per thousand) brines, could affect mating behavior of white shrimp, which occurs in the diffuser site area.

Survival of newly fertilized eggs and developing larvae exposed to abnormally high salinities, must also be considered. High saline brines might also disrupt normal emigration patterns of juvenile white and brown shrimp, as they leave bays and estuaries, and possible interfere with longshore migrations of adult shrimp.

A diffusion site located 11.5 to 12.5 miles offshore, would be less harmful to both shrimp biology and commercial shrimping activity, and as such, our Association highly recommends that such a site be selected instead of the 5 N mile diffusion area.

Sincerely

Sammy Snodgrass
President

c.c. Freeport Shrimp Assoc.
P. O. Box 1123
Freeport, Texas 77541

c.c. Col. Jon C. Vanden Bosch
District Engineer
Galveston District
P. O. Box 1229
Galvaston, Texas 77553

COASTAL BEND CONSERVATION ASSOCIATION INC. ~~Box 500 Corpus Christi Tex 78~~

P.O. Box 1116, Port Aransas,
Texas 78373

August 27, 1977

Executive Communications
Room 3309
Federal Energy Administration
Washington, D.C. 20461

RE: Draft Supplement, Final Environmental Impact Statement, Bryan Mound Salt Dome. FEA 76/77-6, July 1977.

Dear Sirs:

My comments here are being submitted as those of the Texas Environmental Coalition.

Following our meeting with Mr. Thomas E. Noel, Assistant Administrator, Strategic Petroleum Reserve, on July 11, 1977, at Freeport, Texas, we have had an opportunity to examine the supplemental document of which he spoke and to which we have reference in this communication. At the time of our meeting, Mr. Noel indicated that the draft supplement would answer a number of the questions raised at our meeting. On examination, we find that, though a number of the questions raised were addressed in the document, definitive answers are lacking.

Our concerns here are mainly with the impacts of placing a brine diffuser in the Gulf of Mexico, at the proposed location beginning 30,380 feet from shore and extending seaward an additional 2,000 feet. We also have some concerns regarding the construction of the brine transmission line from Bryanmound to the diffuser site.

We are in agreement with the following paragraph from Sec. 3.2.5. (page 3-21) of the draft supplement that states:

> The magnitude of the impacts of the brine discharge are an interaction of the quality of the displacement water, oil-brine reactions within the cavern, oil-brine reactions in the brine surface control facility, respective water quality parameters at the diffuser site, existing current conditions, diffuser response and salinity tolerences of the indigenous marine species, timing sequence and discharge rates.

And, we further agree that a monitering system, as described to be in the planning (in the next paragraph, page 3-22) is an absolute necessity, should the project be undertaken. The predisposal laboratory and field studies (mentioned in the same paragraph) are also a necessity, and should have been completed before this draft suppleme was prepared for distribution and comment. The subjects of the pre-disposal studies are primarily those which raised the greatest concern in our meeting with Mr. Noel, and which are most inadequately discussed in the draft supplement.

The brine tolerence of various indigenous species, and their life-cycle forms is not now known, relative to the brines under consideration, and this is made quite clear in the draft supplement, though a great deal of information of questionable applicability is presented, in an effort to demonstrate that these species may not be harmed. The assumption is made in the draft that those species that are mobile enough will move away from the highly impacted brine diffusion area, thus the conclusion (Page 5-1) "The single long-term environmental impact [of the entire project] would be the removal of 15 acres of land from present use." This conclusion discounts the real possibility of damage, especially to a known white shrimp spawning area. If the brine disposal results in mortality associated with the spawning, then a long-term impact has been created. The draft tends to play down the significance of this spawning area, as well as the shrimp fishery in this area. It further suggests that the white shrimp is not of great importance to the Texas shrimp fishery. The draft is in error on all three stands. The area under discussion is one of the few where egg-bearing white shrimp have been collected for research purposes, consistently. As recently as early August, 1977, one Gulf shrimp boat, in a six-day period landed 2,600 pounds of marketable shrimp from the immediate vicinity of the proposed diffuser site (Brazosport Facts, August 10, 1977). Also, the white shrimp is important to the fishery in terms of poundage landed as well as its seasonal catch aspect, that allows for more productive working days for the Texas fleet, that otherwise would be responding only to the seasonal catch of brown shrimp. It is also recognized (page 4-6) that the project may have an adverse impact on redfish spawning, yet this potential consequence is also glossed over by the suggestion that these fish will probably spawn elsewhere, thus, having no real effect. What data indicates that this would be the case, to the extent that there would be no adverse effect on spawning success? Data are not presented in the draft regarding the recreational fishery of the area, and the potential loss, should the project be constructed.

Water quality data, both in the diffuser area, and in relation to displacement water is scanty in the draft supplement. In fact, most conclusions of the draft are based on one set of samples, taken in April, 1977. Considerably more background data on water quality is necessary before any validity can be expected from the monitering program, and, certainly before any valid predictions can be made about how the brine may effect ambient water quality.

Biologic populations in the immediate area of impact are not described. Of special importance are the benthos, which will surely sustain some level of loss. It may be that the benthos, in combination with the yet to be examined bottom sediments of the area are in some way responsible for this being a successful spawning area for shrimp and redfish.

The coastal dynamics of the immediate vicinity of the proposed diffuser site are also not reported in the draft supplement. Data used in preparing the diffusion models were not taken from the immediate area, and do not reflect the magnitude of day-to-day and hour-to-hour changes that could take place in the local current regime. In addition, local experience indicates that the 16-day stagnation period, chosen as an extreme in the model projections, may, in fact, fall short of the extreme condition.

As we told Mr. Noel at our July meeting, the needed data for making a valid assessment of the environmental impacts of the brine diffuser in the proposed application are not in hand. Minimal sampling, by any scientific standard, has taken place in advance of preparation of the draft supplement, and crucial laboratory data is only now being collected. Any final environmental statement on this project should contain sufficient biological, chemical and physical data to approach the real questions, discussed here, concerning the impacts of the proposed brine and displacement water disposal in the Gulf of Mexico.

Regarding construction of the brine transmission line, we urge that all possible restoration techinque be employed after trench backfill on land and in the wetlands. The draft supplement indicates a recognition of this necessity, and a practical understanding of the factors and lengths of time involved. Monitering and necessary additional work should be undertaken during the restoration period to assure total restoration in the delicate areas of wetlands and dunes. Removal of excess dredge material after backfill of the pipeline trench in the Gulf is apparently not contemplated, therefore the work should be undertaken at a time when the increased turbidity and bottom sedimentation will have the least adverse environmental impact, in regard to migratory and spawning species in the vicinity. (Note: see attached letter to Col. Jon C. Vanden Bosch, District Engineer, Galveston District, Corps of Engineers, regarding permitting for this pipeline construction.)

We appreciate this opportunity to comment on the draft supplement in hand, and look forward to further consideration of this matter. If you have any questions, please do not hesitate to contact us at any time.

Very truly yours,

Steve Frishman

Steve Frishman
for the Texas Environmental Coalition

ASTAL BEND CONSERVATION ASSOCIATION INC.

Box 1116, Port Aransas, Texas
78373

August 27, 1977

Col. Jon C. Vanden Bosch
District Engineer
Galveston District
U.S. Army Corps of Engineers
P.O. Box 1229
Galveston, Texas 77553

Dear Col. Vanden Bosch:

RE: SWGCO-RP, Permit Application -12062; and the Reglatory Program of the Corps of Engineers, published in the Federal Register, July 19, 1977.

In the past we have discussed the Bryanmound Strategic Oil Reserve project in relation to the need, or lack of need, for a Sec. 404 permit in regard to construction of a 30 inch brine outlet pipeline and brine outlet diffuser in the Gulf of Mexico.

As I understand your note of 22 July 1977, it appears that you are interpreting this line and diffuser as a utility. While I may not agree that a diffuser is a utility, and may further, at some point, argue the entire concept of all pipelines being utilities, I see that you are reading the definition of"utility" in §323.4-3 (a)(1) of the 1977 regs. Therefore, we have no resolvable disagreement regarding this point.

The point I wish to press is that, in this case, according to the same citation, "excess material must be removed to an upland disposal area." I find from FEA's draft supplement to the Final Environmental Impact Statement for the project that (Sec. 3.1.6) the assumption is that the excess material will be washed away by the prevailing current, and I really can't imagine that any excess material would even be considered for removal to shore.

In addition, under §323.4-3 (b)(2) of Corps regs, "The discharge will not occur in areas of concentrated shellfish production." The FEA draft supplement (Sec. 3.1.6) states,"Dredging operations are expected to be conducted over a period of four months and would commence in November to avoid interference with the white shrimp spawning season which begins in April."

As I see it, the conditions under which a 404 permit application is not necessary have not been met on at least two fronts.

Further, under the new regs, it would seem that the associated oil pipeline (Public Notice SWGCO-RP, Permit Application -12112) would not require a 404 permit, though your office's notice says it does.

As you know, my concern is for process in this case, and I am seeking to retain every level possible at which public input remains at a premium. Sec. 404 gives the public a better handle than Sec. 10, and I am interested that this handle be retained to its fullest extent within existing law.

I look forward to your consideration of the points I have raised regarding this issue, and am ready to discuss the matter at your convenience.

Thank your for your interest in this matter.

Very truly yours,

Steve Frishman

Steve Frishman

p.s. I am still most easily reached by phone at 512/743-6377, or by writing the letterhead address.

cc Executive Communications
Room 3309
Federal Energy Administration
Washington, D.C. 20461