DE/EIS-0029

Final Environmental Impact Statement

(Final Statement to FEA-DES-77-8)

STRATEGIC PETROLEUM RESERVE

Texoma Group Salt Domes

(West Hackberry Expansion, Black Bayou, Vinton, Big Hill)

Cameron and Calcasieu Parishes, Louisiana and Jefferson County, Texas

U.S. DEPARTMENT OF ENERGY

November 1978

Volume 3 of 5

Appendix C

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Responsible Official

Ruth C. Clusen
Assistant Secretary for Environment

U.S. DEPARTMENT OF ENERGY
Washington, D.C. 20545

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Appendix C

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C. ENVIRONMENTAL IMPACTS OF THE PROPOSED AND ALTERNATIVE ACTIONS

C.1 INTRODUCTION

This chapter contains a detailed evaluation of the environmental impacts which would be associated with the construction and operation of the four candidate SPR salt dome sites. A discussion of impacts associated with alternative facility components is provided.

C.2 ENVIRONMENTAL RISKS RELATED TO TRANSPORT AND STORAGE OF OIL

Summary

The potential for accidents and natural disasters is discussed in this section with particular emphasis on the possible occurrence of spills of crude oil. This discussion pertains to West Hackberry, both ESR and expansion, and the three salt dome sites which are currently alternatives to West Hackberry expansion.

The probabilities of occurrence were generated from historical accident and natural disaster data. Care was taken to use probabilities generated for circumstances and environments similar to those existing for the SPR project.

A comparison of the estimated oil spill risk for the several operations of transporting and storage at the West Hackbery expansion and alternative sites, during their initial fill is presented in Table C.2.1. Risk is presented as the probability of a spill exceeding a given size. There is no additional risk of oil spills from the twin 36-inch pipeline between the Sun Terminal and West Hackberry for the expansion storage caverns at West Hackberry. For Black Bayou and Vinton, only the incremental risk associated with short lengths of pipelines connecting to the twin 36-inch line is given. The reason for assessing the risk in this way is that the twin 36-inch pipeline also serves the West Hackberry ESR storage caverns, and is therefore full of oil and can experience accidental spills whether or not the West Hackberry expansion, Black Bayou or Vinton Dome sites are used. The risk of spills from this line is presented in Section C.2.1.3.

In general, the risk of spills is small, amounting to no more than a few percent. For spills greater than 1,000 barrels, the risk of spills is generally less than one percent, except during tankship transport in the Sabine-Neches Channels, and at the dock at Sun Terminal.

Details of the development of the risk of spills of oil and brine are presented in the following subsections. Since the pipelines would contain oil at all times, and not just during filling or distribution, the risk of oil spills from these lines during the planned 25-year lifetime of the SPR project are discussed below.

Table C.2-1. Summary Comparison of Risk of Oil Spills During Transport and Storage at the West Hackberry Expansion Site and Alternative Sites During the Initial Fill Period (38 months)

	West Hackberry Expansion 150 x 10^6 bbls.		Black Bayou 150 x 10^6 bbls.	
Operation	Spill Probability	Area Affected	Spill Probability	Area Affected
Marine Transport				
Number of Tankship Trips	375		375	
Spills During Lightering and trans-shipment.				
>100 bbls.	0.014	Gulf Coast Beaches between Matagorda Bay and Calcasieu Pass	0.040	Same as for West Hackberry
>1,000 bbls.	0.0062		0.0062	
>10,000 bbls.	0.0007		0.0007	
Spills in Harbors and Docks				
>100 bbls.	0.058	Banks and Shore of Sabine Pass, Sabine-Neches Canal, Northern part of Sabine Lake and the Neches River	0.058	Same as for West Hackberry
>1,000 bbls.	0.019		0.019	
>10,000 bbls.	0.0045		0.0045	
Pipeline Transport				
Spills at the Site				
>100 bbls.	0.00069	Dry Land at West Hackberry	0.0053	Marsh
>1,000 bbls.	0.00032		0.00026	
>10,000 bbls.	0.00003		0.00003	
Spills Between Marine Terminal and Site				
>100 bbls.	a.	a.	0.00061	Marsh in the Sabine National Wildlife Refuge
>1,000 bbls.			0.00034	
>10,000 bbls.			0.00012	
Storage				
Number of Caverns	15		17	
Spills <100 bbls. from caverns	0.00005	Dryland at West Hackberry	0.00005	Marsh

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a. There is no increased risk from pipeline oil spills for West Hackberry expansion. This pipeline is a part of the West Hackberry ESR system.

Table C.2-1 (Continued)

Vinton		Big Hill	
50 x 10^6 bbls.		100 x 10^6 bbls.	
Spill Probability	Area Affected	Spill Probability	Area Affected
125		250	
0.013 0.0021 0.0002	Same as for West Hackberry	0.027 0.0042 0.0005	Same as for West Hackberry
0.019 0.0062 0.0015	Same as for West Hackberry	0.039 0.012 0.0030	Same as for West Hackberry
0.00040 0.00017 0.00002	Dry Land, Ged Lake	0.00075 0.00032 0.00003	Pasture
0.0017 0.00092 0.0016	Marsh and prairie north of the Intracoastal Waterway	0.0060 0.0030 0.00051	Mostly prairie and pasture, but some marsh and woodland
5		12	
0.00002	Dryland, Ged Lake	0.00004	Pasture

C.2.1 Oil Spill Risks

C.2.1.1 Oil Spills from Salt Dome Caverns

This section contains a discussion of accidents which could result in the loss of oil from a storage cavern during the storage cycle.

A failure mode and effects analysis was performed which is summarized in Table C.2-2. The most significant loss mechanisms involve various failures of the wellhead and associated piping. The most frequent of these is the development of a leaky gasket on the isolation valves or the wellhead connections. Such leaks, as based on industrial experience, would occur rather frequently, 0.05 per year per wellhead, but would be small, much less than 100 bbls, and easily contained by a proposed dike system. These leaks if too small to be detected by abnormal behavior of pressure at the wellhead, would be detected during routine daily checks of the wellhead.

Much larger spills, but with a very much smaller probability, could occur from more substantial damage to the wellhead such as "shearing off" or fracture of the wellhead as the result of some accident. This, together with such failures as corrosion or rupture because of a defective weld or pipe seam, were estimated to occur at a frequency of 1×10^{-6} per wellhead per year. This estimate is believed to be conservative since it is based on the reported failure frequency for ordinary line pipe for transporting liquid petroleum products (See Section C.2.1.3.) Wellhead components are made of much thicker steel. "Break of brine line at wellhead" refers to a rupture or fracture type of failure of only the brine portion of the wellhead. "Break of oil line at wellhead" refers similarly to the oil side of the wellhead.

Such failures can result in substantial losses of oil because of a subsequent relief of pressure and elastic expansion of: the stored oil, brine in the sump, and the salt. These expansions combine to squeeze oil out of the cavern. Assuming that the brine-oil interface would be at a depth of 3,000 feet below the surface of the ground in a typical cavern, the planned storage mode is to maintain the oil under a pressure of 450 psig, which is equivalent to the differential pressure between 3,000-foot heads of oil and brine plus 50 psi. If the wellhead is sheared off or the oil-side piping fractured, the entire 450 psi pressure on the oil is relieved since the heavier columm of brine sinks to a level such that the oil head and brine head are equal at the oil-brine interface in the cavern. Because the cavern is so large (1×10^7 bbls), the resulting elastic expansions are also large (but less than 1 percent of the cavern volume): 22,500 bbls,

Table C.2-2. Failure Modes and Effects: Oil Spills from Caverns During Storage

Failure	Probability	Result	Environmental Consequences
Leak in oil line via gasket failure	0.05 per yr per wellhead	Outflow of oil from cavern through leak because of wellhead pressure. Leak easily detected by visual inspection.	A minor spill of less the 100 bbls, assuming once per day inspections. Spill easily retained by a small dike.
Shearing-off of wellhead (simultaneous break of both brine and oil lines)	10^{-6} per yr per wellhead	Outflow of oil from cavern because of relaxation of compressed oil and salt upon relief of 450 psi wellhead pressure (oil side).	A spill of 40,000 bbls of oil around wellhead if not retained by dike.
Break of brine line at wellhead	10^{-6} per yr per wellhead	Outflow of brine (initially water) from cavern because of relaxation of compressed oil and salt upon relief of 450 psi down to 399 psi (at oil side).	A spill of 4,500 bbls of brine around wellhead if not retained by dike.
Break of oil line at wellhead	10^{-6} per yr per wellhead	Outflow of oil from cavern because of relaxation of compressed oil, brine and salt upon relief of 450 psig wellhead pressure (oil side.)	A spill of 40,000 bbls of oil around wellhead if not retained by dike.

Table C.2-2 (continued)

Failure	Probability	Result	Environmental Consequences
Leak in wellhead brine tubing because of corrosion or defective weld	5×10^{-4} per yr per wellhead	Contamination of brine/water with oil; increase in water side wellhead pressure.	No spill of oil outside of system.
Leak in wellhead oil casing because of corrosion or defective weld	$<5\times10^{-5}$ per yr per wellhead	Single casing through caprock region only. Leaking oil would be impeded by cement grouting. Leak would be difficult to detect.	Possible contamination of caprock and nearby aquifers with oil.
Collapse of cavern caused by sudden loss of well pressure (e.g., shearing off of wellhead)	$<<1\times10^{-6}$ per yr per wellhead	Sudden loss of pressure could cause severe slabbing which in turn could lead to general collapse. Little oil is expected to reach ground surface, most being trapped under impervious layers and wet soils.	In general, any oil reaching surface would be retained within the surface subsidence depression.

based on a compressibility of $\frac{\Delta V}{V} = .5 \times 10^{-6}$ per psi, for the oil; 15,200 bbls, based on a compressibility of $\frac{\Delta V}{V} = 3.4 \times 10^{-6}$ for the salt and 2,250 bbls for the brine in the sump (assumed to 10 percent of the oil).

If the fracture occurs only on the brine side, then brine cannot displace the oil and only the extra 50 psi pressure is relieved. Hence, only brine is displaced out of the cavern by the elastic forces following relief of the pressure. Because of the lower pressure relief the brine displaced is only ten percent $(\frac{50 \text{ psi}}{450 \text{ psi}})$ of the oil in the above situation.

The next two failures in Table C.2-2 are the corrosion and leakage through the brine tubing and the well casing (contains oil). The former would result in the contamination of effluent brine with oil during a refill and would present no major problem if the leak were small (the oil could be removed from the surface of the brine surge pond or surge tank). In the latter situation, oil could leak into the caprock and contiguous aquifers, provided the oil also could find a leak path through the grouting cement.

For the last failure mode in Table C.2-2, a sudden loss in pressure caused by the fracture or shearing off the wellhead, could lead to rapid expansion followed by severe slabbing (falling away of large masses of salt) from the roof of the cavern and the triggering of a general collapse. Because the top of the caverns would be located 500 to 1000 feet below the top of the salt, this occurrence is believed to be unlikely. This, combined with the already low probability of fracturing or shearing of the wellhead, makes cavern collapse by this mechanism extremely remote.

General collapse of the storage cavern also could be caused by other mechanisms. However, evidence indicates these to be even still more remote. For one, the cavern could be fractured by an earthquake, but even moderate earthquakes are rare in the area which is classified by the National Oceanic Atmospheric Administration as being in Zone 0, "no reasonable expectancy of seismic damage." Moreover, domial salt is plastic, and fissures and cracks which might be developed by minor earthquakes would close rapidly.

Another mechanism is the loss of the protective oil blanket, during refill or initial leaching, with the consequent dissolving of the salt at the roof of the cavern. Although this has happened on two occasions in the past during early development of solution mining techniques of salt domes, over 250 caverns have been solution mined since then without incident.

Approximately 100 of these caverns are used for the storage of liquefied petroleum gases. Present practice is to use redundant techniques to insure maintenance of the oil blanket and to detect incipient loss of control of the leaching process, especially in the upward direction. These include monitoring the location of the oil-brine interface; detection of oil outflow with the brine; monitoring the inflows and outflow volumes of water, oil and brine; determination of cavern dimensions by sonic soundings, and the re-entrant placement of the oil casing within the cavern near its roof. Because of this redundancy, loss of control over the leaching process is very unlikely.

C.2.1.2 Risk of Oil Spills During Marine Transportation

C.2.1.2.1 Introduction and Summary

This section presents estimates of both the probability and the size of oil spills arising from accidents during marine operations and transport. Marine operations considered include: (1) for the ESR initial fill only, the voyage of the barge tow along the Calcasieu Ship Channel and associated waterways from the Gulf to the terminal (Amoco Dock) at West Hackberry, and loading and offloading operations at that terminal, (2) for the permanent dock at Sun Terminal, the voyage of a 45,000 DWT tankship through the Sabine Pass, the Sabine-Neches Canal and the Neches River to the terminal, and loadings and offloadings at that terminal, and (3) lightering from LVCCs onto the 45,000 DWT tankship and its voyage to the entrance to the Sabine Pass.

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

The estimates are based on statistical analyses. The number of vessel casualties, which would result in the spill of oil, were derived primarily from the Coast Guard's listing of Commercial Vessel Casualties for fiscal years 1969 through 1974. The count of the ship transits in the Calcasieu and Sabine Channels was obtained from Waterborne Commerce of the United States and Engineer's Annual, both publications of the U. S. Army Corps of Engineers. Combined, these data yielded the expected frequency of spills per transit of a tankship or tankbarge from the Gulf to the terminal. This procedure was followed for all vessel casualties except tankship collisions in the Sabine channels for which the frequency was estimated via a model. This model allows the use of a much broader data base and accounts for the length of the channel, traffic density, and the speed and dimensions of the ships. The frequency of spills for loading and offloading oil at the terminal was obtained from incidents reported by the Coast Guard's Pollution Incident Reporting System and Corps of Engineer traffic data, both for the U. S. Gulf Coast region. Because of the high degree of similarity between lightering and offloading at terminals, the spill frequency for the former was assumed to be the same as for the latter. The distribution of the quantity of oil spilled, with the number of spills, was developed from Coast Guard Commerical Vessel Casualty data for losses from tank barges in Western Rivers* and the inland Gulf region. The quantities spills are distributed

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*Primarily the Mississippi River System

log normally versus number fraction of spills. This relationship was modified for application to tankship casualties. The distribution of quantity of oil spilled during loading and offloading at marine terminals was developed from the Pollution Incident Reporting system data.

The above methodology is based on the assumptions that the planned crude oil transport operation is essentially the same as that for which the accident experience has accrued. This assumption seems justifiable since the facilities, tankships and barges to be used would be nearly the same as those now used in the area.

The estimates of 'risk of accidential oil spills is summarized in Tables C.2-3 and C.2-4 for the West Hackberry ESR program and the alternative expansion programs, respectively. The estimates assume the transport of crude oil ti fill the salt dome caverns in a nominal 45,000 DWT tankship containing 400,000 bbls to or from the Sun Terminal. Only 60 percent of the stored oil would be distributed by tankship, the remainder would be distributed by pipeline. Larger tankships, up to 100,000 DWT, might be used, but would be light loaded so that their draft would not exceed 40 feet. In this case it is assumed that they would contain approximately 400,000 bbls, also. The tank barges used in the Calcasieu Channel during the initial fill of the ESR program are assumed to be nominal 3,000 DWT containing 21,000 bbls.

The expectation quantity of crude oil spilled per trip from vessel accidents, such as collisions, groundings, rammings (striking fixed objects, submerged or on or above the water surface), structural failure, fires and explosions, etc., is 0.15 barrels per trip for the barges, and 0.60 barrels per trip for the tankships in the Sabine channel and 0.058 barrels per trip in the Gulf between the lightering point and Sabine Pass. (Expectation quantity is an effect the average amount spilled per trip - the total amount spilled for a very large number of trips divided by the number of trips. However, the amount spilled in any one accident will be very much larger than the expectation value as indicated by the size of the median spill.) The median spill from barge casulaties is 1,100 bbls, and the median spill from tankship casualties is 3,100 bbls. Accidents at the marine terminal, such as overfilling a tank, opening the wrong valve, etc., have an expectation quantity of 0.086 barrels spilled per trip for either barges or tankships. The median spill during transfer at the dock is 0.5 bbl. The total expected quantity of oil spilled during the transport of the oil to fill or to be distributed from the various salt dome caverns are listed in Tables C.2-3 and C.2-4. These tables also list the probability of a spill exceeding certain amounts during the movement of the states amount of oil.

Table C.2-3 Risk of Oil Spills During Marine Transport for the EST West Hackberry Program.

	West Hackberry Initial Fill (by Barge)	West Hackberry Permanent ESR Facility	
	$(6 \times 10^6$ bbls.)	Fill 60×10^6 bbls.	Distribute 36×10^6 bbls.
Number of Vessel Trips	288	150	90
Spills in Inland Waters:			
Expectation quantity of oil spilled, bbls.	68	103	62
Probability of a spill exceeding			
100 bbls.	0.045	0.023	0.014
1,000 bbls.	0.012	0.0076	0.0046
10,000 bbls.	0.0014	0.0019	0.0011
Spills in The Gulf of Mexico:			
Expectation quantity of oil spilled, bbls.	N/A	22	N/E
Probability of a spill exceeding			
100 bbls.	N/A	0.016	N/E
1,000 bbls.	N/A	0.0025	N/E
10,000 bbls.	N/A	0.0003	N/E

N/A - Not Applicable.
N/E - Not Evaluated.

Table C.2-4 Risk of Oil Spills During Marine Transport for West Hackberry Expansion and Alternative Sites.

	West Hackberry Expansion		Black Bayou		Vinton Dome		Big Hill	
	Fill 150×10^6 bbls	Distribute 90×10^6 bbls	Fill 150×10^6 bbls	Distribute 90×10^6 bbls	Fill 50×10^6 bbls	Distribute 30×10^6 bbls	Fill 100×10^6 bbls	Distribute 60×10^6 bbls
Number of Tankship Trips	375	225	375	225	125	75	250	150
Spills in Inland Waters:								
Expectation quantity of oil spilled, bbls.	257	154	257	154	86	51	172	103
Probability of a spill exceeding								
100 bbls.	0.058	0.035	0.058	0.035	0.019	0.012	0.039	0.023
1,000 bbls.	0.019	0.011	0.019	0.011	0.0062	0.0037	0.012	0.0075
10,000 bbls.	0.0045	0.0027	0.0045	0.027	0.0015	0.00091	0.0030	0.0018
Spills in The Gulf of Mexico:								
Expectation quantity of oil spilled, bbls.	54	N/E	54	N/E	18	N/E	36	N/E
Probability of a spill exceeding								
100 bbls.	0.0400	N/E	0.040	N/E	0.013	N/E	0.027	N/E
1,000 bbls.	0.0062	N/E	0.0062	N/E	0.0021	N/E	0.0042	N/E
10,000 bbls.	0.0007	N/E	0.0007	N/E	0.0002	N/E	0.0005	N/E

N/E - Not Evaluated.

Oil spilled onto water produces a very extensive slick. The following relationship between spill quantity, and ultimate slick area or radius, assumes unhindered (no wind, currents, or surface obstacles) spreading and a circulat-shaped slick:

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

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

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

	Quantity Spilled (Barrels)		
	0.5	1,100	3,100
Slick Area (m^2)	0.015×10^6	4.8×10^6	10.5×10^6
Slick Radius (m)	123	1,237	1,826

The ultimate slick areas calculated above correspond to an average coverge of oil ranging from 0.1 bbl/acre for the 0.5-barrel spill to approximately 1 bbl/acre for the largest spill. These coverages are somewhat lower than those estimated to cause environmental damage, as discussed in Sections C.3.2, C.4.2, C.5.2 and C.6.2. Hence, the ultimate slick diameter in open water may be 5 to 50 times the area in which actual environmental damage may occur.

With respect to the temporary barge-fill system, spills at the Amoco Terminal are expected to remain at the site, and in the absence of booms or other containment measures, they would spread into the surrounding marsh areas rather evenly. There are no known major water currents in th area and the vegetation above the water surface in the marshes would greatly limit the effect of wind on the movement of the slicks. Spills in the Alkali ditch and the Intracoastal Waterway would be expected to behave similarly during periods of light winds (occurring 19 percent of the time). However, during periods of higher winds, the slick would be blown along these waterways at about 2 to 3 percent of the wind velocity (Premack and Brown, 1973). An oil slick in the Intracoastal Waterway would move in a westerly direction about 25 percent of the time. However, the edges of the slick which have penetrated into the bordering marshes would tend to remain in place, unaffected by the wind.

Spills from a tankship in the Sabine Pass or jetty channel would tend to be confined by the jetties, land or spoil banks. However, the tidal currents (1 to 2 knots typical in Sabine Pass) would carry a slick out to sea or into Sabine Lake if not confined in time by booms. Containment of marsh and shore along Sabine Pass would be expected from any spills.

Similarly, spills from accidents in the Port Arthur Canal and the Sabine-Neches Canal also would be confined by adjacent land and spoil banks, which would become contaminated. In these cansls there is a negligible current and the spread of the slick in either direction could be readily prevented by booms. However, spills in the upper part of the Sabine-Neches Canal near the mouth of the Sabine River might spread into Sabine Lake and contaminate adjacent shore and marsh lands. Because of the predominance of easterly and southerly winds in the area, oil slicks entering the lake would probably contaminate only the lake's western shore and not the marsh of the Sabine National Wildlife Refuge bordering the eastern shore.

Spills from accidents in the Neches River and at the Sun Terminal probably would contaminate the marshy banks of the river. The current in the river is weak except during periods of high water after heavy rains, hence, oil slicks are expected to be carried downstream into Sabine Lake only during these periods.

Spills during lightering and transshipment across the Gulf to the entrance to Sabine Pass could affect any of the shore both east and west of Sabine Pass. Figure C.2-1 shows the approximate location of the lightering area relative to Sabine Pass and the Port Arthur areas. Figures C.2-2 and C.2-3 show the probability distribution of directions and speeds of curents during winter and summer months in the lightering area. Similarly, Figures C.2-4 and C.2-5 show the probability distribution (wind rose) of wind speeds and direction. Since oil slicks drift with the water current and approximately 3 percent of the wind velocity, these data may be used to estimate the landfalls of uncontained, spilled oil.

During both summer and winter the ocean currents average about 1 knot and are towards the north, west and northwest

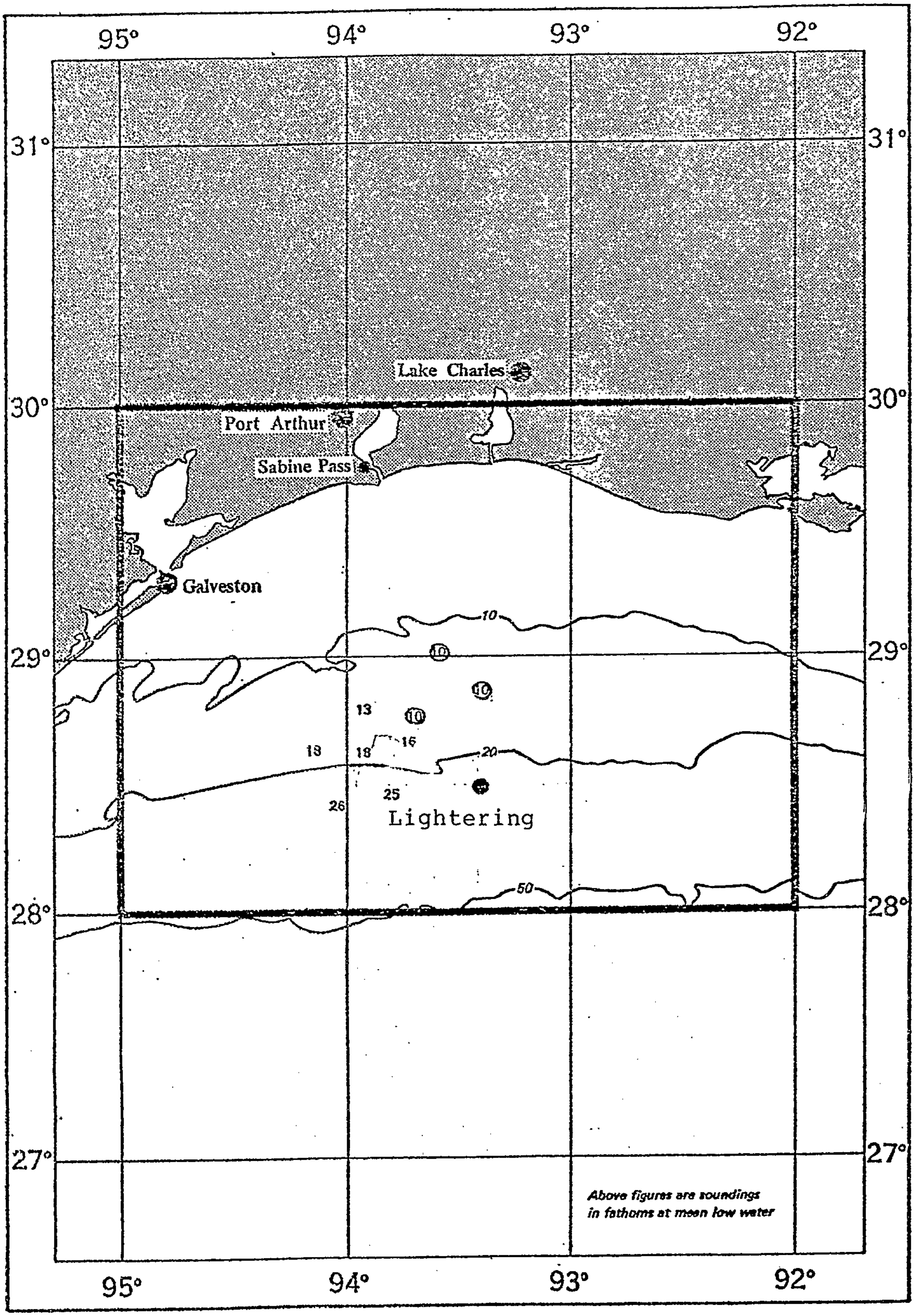

Figure C.2-1 Approximate Location of Lightering Operations.

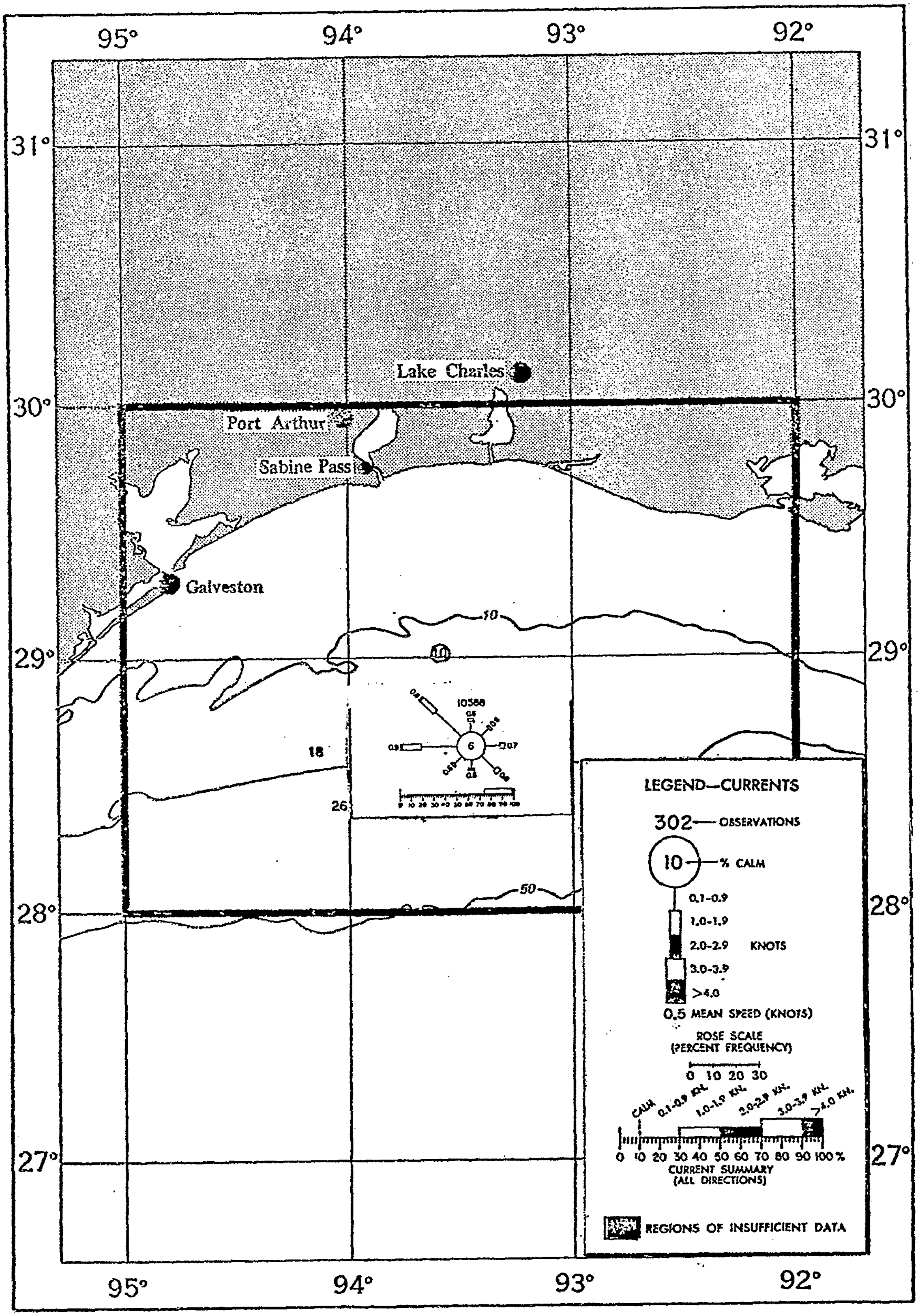

Figure C.2-2 Probability Distribution of Ocean Currents During Winter in the Vicinity of the Lightering Site.

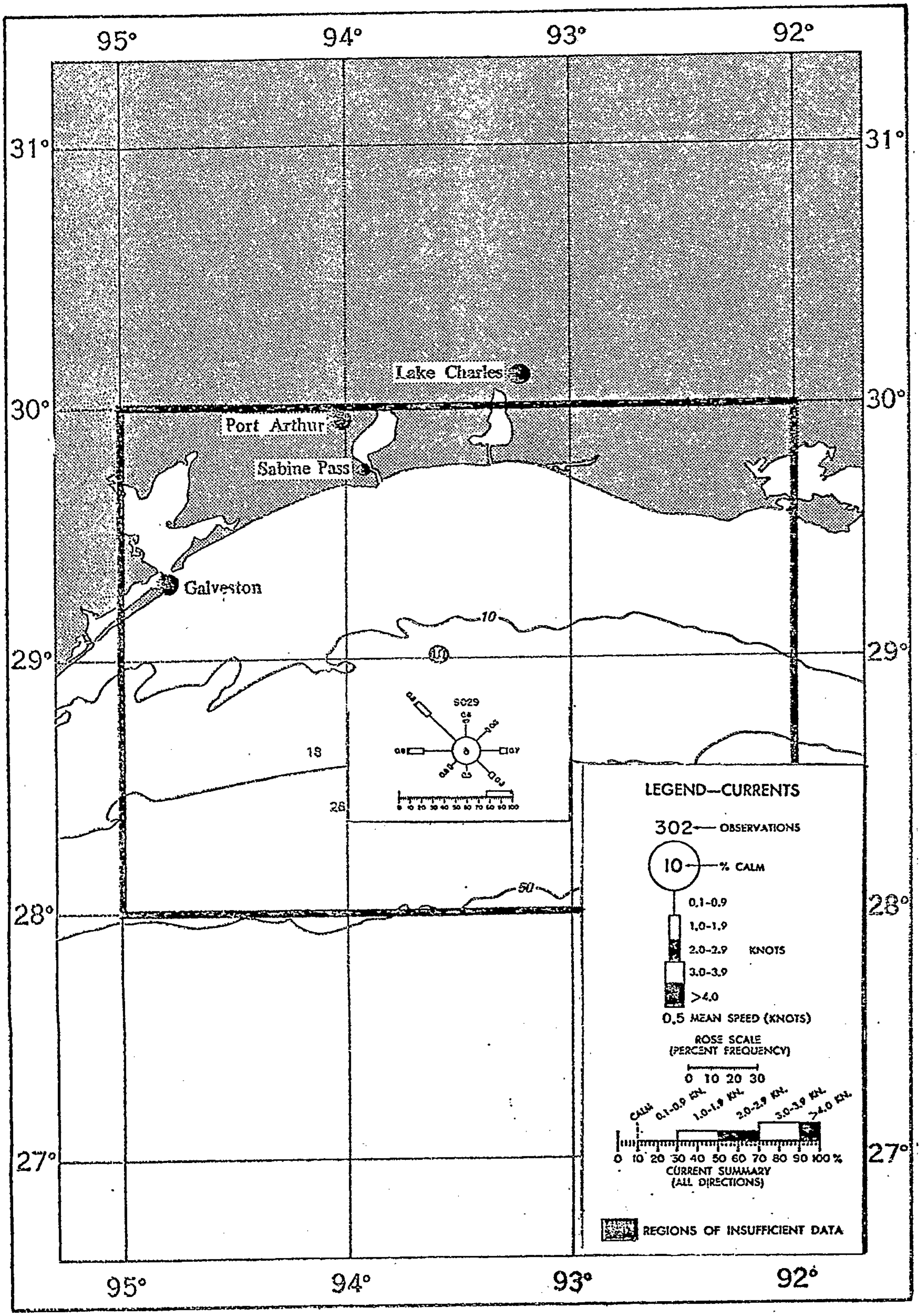

Figure C.2-3 Probability Distribution of Ocean Currents During Summer in the Vicinity of the Lightering Site.

WINTER WIND ROSE
(Jan-Mar & Oct-Dec)

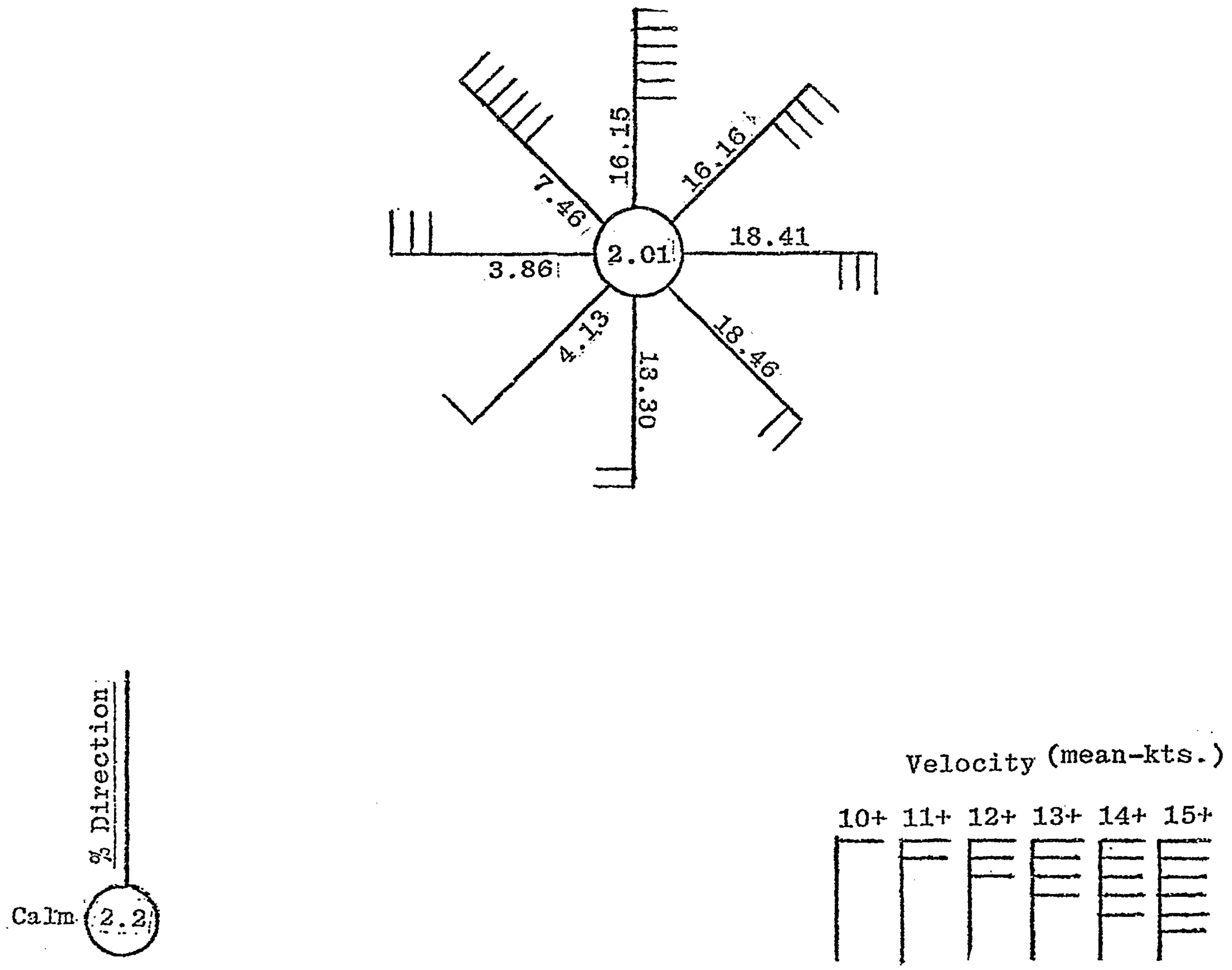

Figure C.2-4 Wind Rose For the Lightering Site During Winter.

SUMMER WIND ROSE
(Apr-Jun & Jul-Sep)

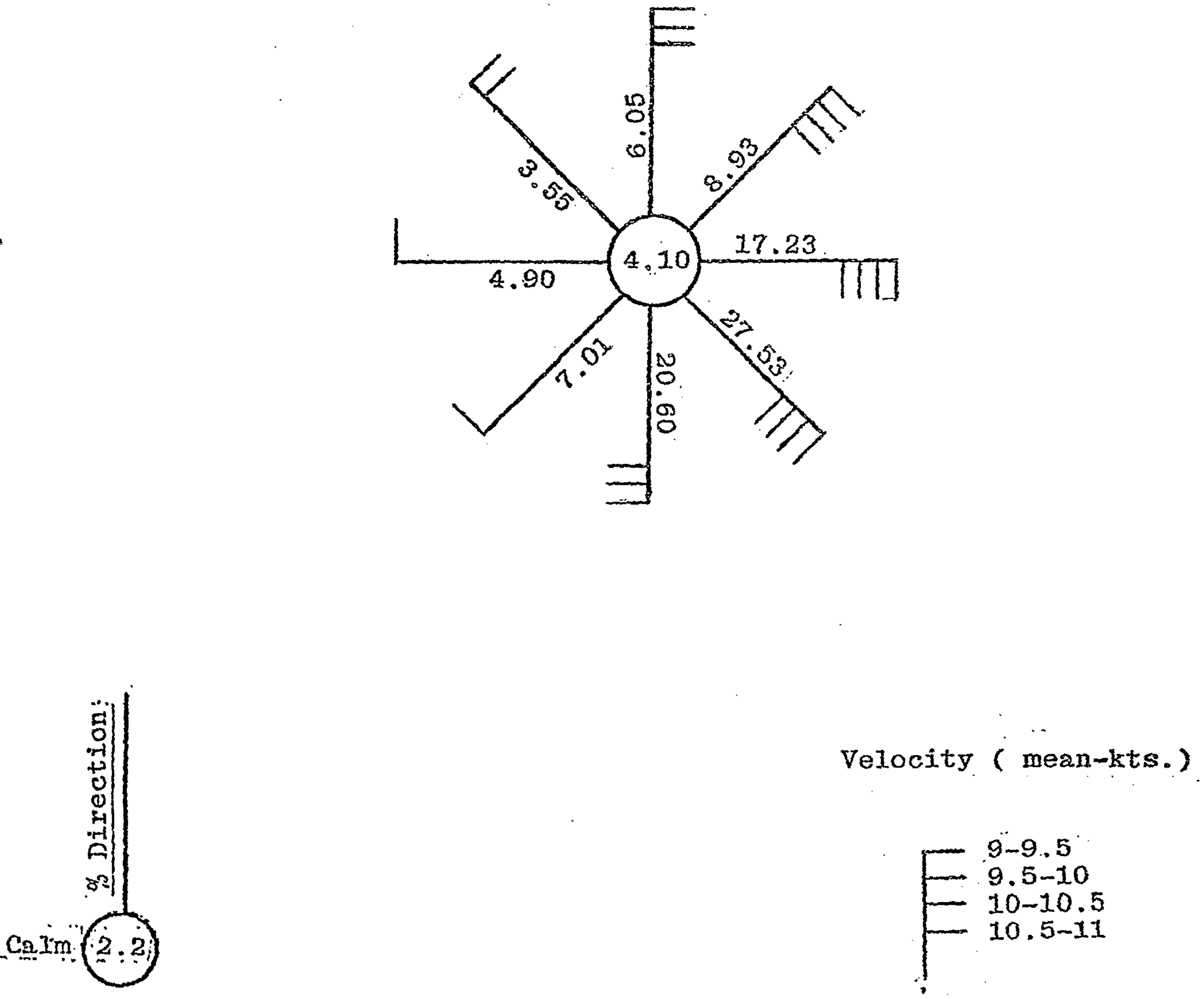

Figure C.2-5 Wind Rose For the Lightering Site During Summer.

approximately 60 percent of the time. In summer the ocean currents are supported by winds of 10-11 knots in the same direction 65 percent of the time. In winter, the frequency of winds in these directions decrease to 50 percent of the time, and strong winds of 14-15 knots blow away from shore approximately 40 percent of the time. These latter winds would tend to cause an oil slick to drift away from shore at approximately 0.4 to 0.5 knots. The data suggest that oil spilled during lightering could drift ashore somewhere between the Calcasieu Pass and the Matagorda Bay areas approximately 60 percent of the time in summer and 40 percent of the time in winter. In either season, a slick when reaching these areas would be well weathered, having been at sea for at least 3 days (a minimum distance of 75 miles from shore divided by 1 knot, the average current speed).

C.2.1.2.2 Oil Spills from Lightering and Transshipment

As presently planned, crude oil would be shipped into the Gulf of Mexico aboard VLCC's and lightered off onto smaller vessels, approximately 45,000 dwt, for transshipment to the Sun Terminal. The lightering operation would be perfomed 50 to 100 miles out to sea from Saine Pass. The analysis of the risk of oil spills considered both the lightering operation and transshipment from the point of lightering to the entrance of the Sabine Pass Challen.

Lightering of VLCCs in the U. S. Coastal waters has become a routine operation. It has been estimated that approximately 20 percent of the oil imported comes via lightering. The exact amount lightered is not reported, however, during 1975, there are indirect data suggesting that approximately 13 x 10^6 short tons (equivalent to 84 x 10^6 barrels of API 27^o crude oil) of oil were imported into Gulf Coast ports by this method.* Considering the size of tankships available for lightering service in the Gulf, an average size of 28,000 dwt, this is equivalent to approximately 467 lightering tankship trips per year into Gulf Coast ports.

Even though this rather extensive operation exists, there are no data on the spillate of oil during lightering, apparently because there is no requirement to report such spillages. Moreover, there are no reported spills from casualties associated with

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* Based on data reported by the U. S. Army Corps of Engineers for the total mount of imported oil, 67 x 10^6 short tones, in Waterborne Commerce, and oil imported 54 x 109^6 short tons, in foreigh trade ships, in Engineers' Annual.

lightering operations. Casualties would become known to the Coast Guard (greater than $1500 damages) and would appear on Lloyds Weekly Casualty List. However, this lack of reported polluting incidents does not mean that they do not occur. For this analysis, it has been tentatively assumed that the spill frequency and sizes are the same as for loading and offloading at a dock. These data are developed and discussed in Section C.2.1.2.4. Accordingly, the spillage frequency is 9.2×10^{-3} per lightering operation and the median spill size is 0.5 barrels.

The justification for this assumption is the high degree of similarity between ship-tp-ship transfers and offloading at a dock. During lightering, the two ships are tied to each other with numerous mooring lines and with large cylindrical rubber fenders in between. The resilience of the latter takes up any slack in the moorning lines and thereby minimizes fatigue stress in the lines. The oil transfer is performed as at dockside with 10 or 12 inch hoses hoisted by the ship's lifting gear. The hoses are supported in such a manner to prevent sharp bends and kinking. All connections are carefully checked before transfer begins and as a further check, the pumps are brought up to speed slowly while the connections are checked again for leaks. These precautions are observed also during dockside transfers.

Oil spill risk from transport of the oil in the lightering ships between the point of lightering and the entrance to Sabine Pass was estimated using casualty statistics for tankships operating in the Gulf of Mexico and the Caribbean Sea. During the period 1969 through 1975, there were 7 tankship casualties in which some or all of an oil cargo or oily ballast was lost. These are listed in Table C.2-5, including the cause of the casualty and an estimate of the loss of oil, if known.

The estimate of casualty frequency was derived by dividing the number of casualties by the "exposure" of tankships to accidents: the number of tankship operating hours in the Gulf and Caribbean. Tankship traffic consists primarily of coastwise trade (in U. S. Flag ships), and imports of foreign oil and petroleum products. Most of the coastwise trade is between Gulf Coast ports and East Coast ports. Hency, most of the tanker traffic crosses the Gulf of Mexico, going through the Florida Straights or the Caribbean and Gulf, passing through the Yucatan Channel.

Based on an analysis of traffic into Gulf Coast ports for the year 1975, presented in Appendix G.2, the following ship

Table C.2-5 Oil Spills from Tankship Casualties in the Gulf of Mexico and Caribbean Sea

Tankship	Size (1,000 dwt)	Year	Type of Casualty	Location[a]	Oil Outflow (barrels)
Texaco Nevada Full Cargo	19.9	1969	Structural Failure	Open Sea	Unknown Amount
Vassiliki	69.1	1971	Structural Failure	Open Sea	Unknown Amount
Stolt Sveve	16.3	1971	Breakdown	Open Sea	Unknown Amount
Mar Star	17.5	1971	Breakdown	Open Sea	Unknown Amount
V. A. Fogg	20.8	1972	Explosion	Coastal	11,200
Zoe Colotron	25.7	1973	Grounding	Coastal	35,000
(Liberian Flag)	Unknown	1975	Collision	Open Sea	714

[a] Coastal means within 50 nautical miles of shore whereas open sea means beyond 50 nautical miles of shore.

count was derived (loaded tankships traversing the Gulf and/or the Caribbean into U. S. Ports):

Shipping	Number of Trips
Foreign Flag Tankers	4,316
U. S. Flag-Foreigh Trade Tankers	182
Lighter Tankers	467
Non-petroleum Tankers	407
U. S. Flag - Domestic Trade Tankers	5,533
Total	10,905

Similarly, counts of tankship traffic were estimated for the other years of the 1969 through 1975 period. The total number of trips made during this period was 66,390. Assuming that the average trip across the Gulf and Caribbean is 1,000 nautical miles, and that the average speed is 12 knots, per hour, the average duration of a trip is 3.5 days. Therefore, the total number of tankship years of exposure during this period was

$$\frac{3.5}{365} \times 66{,}390 = 637 \text{ tankship years.}$$

Since the tankship casualty data includes ships in ballast (see Appendix H), the traffic count should be doubled. It is assumed that for each trip made by a loaded tankship there is a return trip made across the Gulf and Caribbean in a ballasted condition. On this basis, the exposure to accidents during 1969 through 1975 is 1,274 tankship years.

Combining this value with the number of incidents yields

$$\frac{7}{1274} = 0.0055 \qquad \frac{\text{casualty caused oil spills}}{\text{tankship-year}} .$$

It is of interest to note that this oil spill rate in the Gulf of Mexico and the Caribbean Sea is approximately one third that of world-wide experience. Card, Ponce and Snider, 1975, reported that there were 452 oil polluting incidents from tankship casualties during 1969 through 1973. In 1969, the world population of operating tankships was 5,869, and in 1975, it was 6,607 tankships. During the 5-year period of 1969 through 1973, the exposure to accidents was 31,964 tankship years. Therefore, the worldwide accident and spill rate was

$$\frac{452}{31{,}964} = .014 \quad \frac{\text{casualty-caused oil spills}}{\text{tankship-year}} .$$

Assuming an average speed of 10 knots, the time required for a lightering ship to traverse the 75 miles between the lightering location and the entrance to Sabine Pass is approximately 8 hours. Therefore, the exposure time is $\frac{8}{24x365}$ years, and the probability of a casualty and spill during that trip is

$$0.0055 \text{ x } \frac{8}{24x365} = 5.0x10^{-6} \text{ spills per trip.}$$

The size distribution of spills from tankship casualties is derived in Section C.2.1.2.3 and is presented in Figure C.2-9. The size distribution of spills during ship-to-shore transfer operations is derived in Secton C.2.1.2.4 and is presented in Figure C.2-12. That distriburion is assumed to apply to ship-to-ship transfer operations, as well as ship-to-shore offloading because of the similarity of the operations as discussed above. All of these data were combined to give the per trip frequency of oil spills of selected size ranges, listed in Table C.2-6 and the per trip frequency of oil spills exceeding a given size, shown in Figure C.2-6. These data, in turn were utilized to develop the probabilities for spillage during the transport of stated amounts of oil, listed in Table C.2-4.

Table C.2-6. Estimated Spill Size Frequency from Lightering Operations and Transshipment

Spill Size (barrels)	Frequency of Spill During Lightering (per trip)	Frequency of Spill from Vessel Casualty (per trip)
>1	6.01×10^{-3}	
1-3	1.55×10^{-3}	
3-10	1.03×10^{-3}	
10-30	2.9×10^{-4}	
30-100	1.85×10^{-4}	
100-300	7.2×10^{-5}	
300-1,000	2.02×10^{-5}	8.3×10^{-7}
1,000-3,000	9.12×10^{-6}	1.21×10^{-6}
3,000-10,000		1.36×10^{-6}
10,000-30,000		7.55×10^{-7}
30,000-100,000		3.45×10^{-7}
>100,000		9.0×10^{-8}

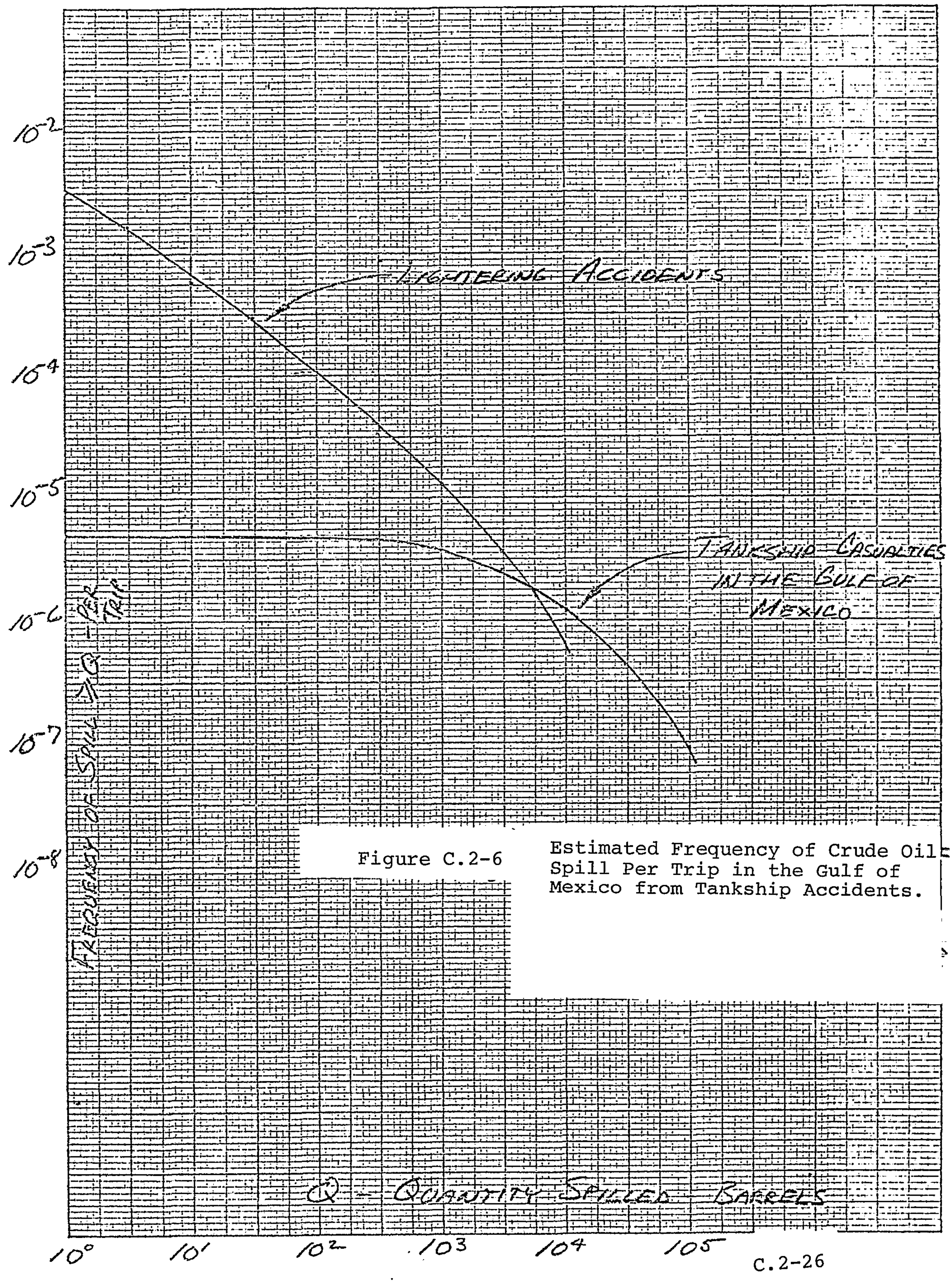

Figure C.2-6 Estimated Frequency of Crude Oil Spill Per Trip in the Gulf of Mexico from Tankship Accidents.

C.2.1.2.3 Risks of Spills from Vessel Casualties in Harbors and Channels

The estimation of the frequency of shipping accidents and spills of oil was based on the number of reported accidents to tankships and tankbarges compared with the number of trips these vessels made into U. S. ports along the Gulf Coast (Brownsville, Texas to Key West, Florida). The accident data were obtained from the U. S. Coast Guard Commercial Vessel Casualty Reporting System in which pertinent items of information have been recorded on magnetic tape. The data for the Gulf Coast area are summarized in Tables C.2-7 and C.2-8 for tank ships and tank barges, respectively.

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

In order to maximize the use of these data, the frequency of collision-caused casualties were estimated using a previously developed model (SAI, 1975). This model interpolates collision experience between different U. S. ports. It takes into account local ship traffic density, the dimensions and speeds of individual ships and the resistance of the hull to collision damage. The model is calibrated to actual collision experience as obtained from the Coast Guard Commercial Vessel Casualty data together with traffic data from the U.S. Army Corps of Engineers "Waterborne Commerce of the United States." With this model, the computed estimate of a collison and spill from the SPR tank ship is 0.613×10^{-5} per trip along the 31.5 miles from the entrance of the Sabine Pass to the Sun Terminal. This frequency is slightly smaller than might be estimated from the accident experience for the entire U. S. Gulf Coast area, (see Table C.2-7). The model also permits calculation of collisions with other tank vessels in which the SPR vessel is the striking ship. The estimated frequency of a spill from the other tank vessel is 1.14×10^{-5} per trip of the SPR tank ship. The details of the model and the calculations performed to make these estimates are described in Appendix I.

Table C.2-7 Tankship Accidents in Inland Gulf Waters During Fiscal Years 1969-1974

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

Table C.2-8 Tank Barge Accidents in Inland Gulf Waters During Fiscal Years 1969-1974

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

The model was not used for collision-caused spills from SPR tank barges because the traffic is restricted to one way in the Calcasieu Channel (Dames & Moore, 1974). Also, the model has not been extended to estimation of spills from groundings, rammings, etc. For the estimation of these frequencies, the number of spill accidents in Tables C.2-7 and C.2-8 were divided by the appropriate total inbound tank vessel traffic for the Gulf Coast region. During calendar year 1974, there were 9,830 inbound tank ship trips and 76,856 inbound tank barge trips. For a 6-year period corresponding to FY 1969 through FY 1974, it was estimated that there were 50,000 tank ship trips into Gulf Coast ports druing which liquid cargo was carried.

These estimates are believed to be correct to within at least a factor of 2. The reason for this is that the count of outbound ships and barges very nearly equals the inbound count and it is likely that many, if not most, carry a liquid cargo.

This count of tankship traffic was combined with the count of Non-collision casualties having a cargo loss, Table C.2-7, to obtain an estimate of spill frequency from rammings and groundings:

$$\frac{2 \text{ (losses in 6 years)}}{59{,}000 \text{ (transits in 6 years)}} = 3.39 \times 10^{-5} \text{ spills/transit}$$

In using this estimate, it must be kept in mind that it represents an average of the entire Gulf Coast area. Since vessel traffic conditions and channel configuration of the Sabine Pass, Canal and Neches River differ from the other Gulf Coast port areas, the actual loss frequency to be expected could be somewhat different.

Similarly for spills from ESR tank barge casualties, it was estimated that there were a total of 460,000 tank barge trips in Gulf Coast ports, during GY 1969 and GY 1974, in which a liquid cargo was carried. This value was combined with the count of ramming and grounding casualties with cargo loss from Table C.2-8 Yield,

$$\frac{25 \text{ (losses in 6 years)}}{460{,}000 \text{ (trips in 6 years)}} = 5.4 \times 10^{-5} \text{ spills/transit}$$

for tank barges in the Calçasieu Channel and Alkali Ditch.

The Coast Guard Vessel Casualty data reports the dollar value of the cargo loss. These data for tank barge casualties in both the Gulf Coast region and on Western Rivers (mainly the Mississippi Ohio River system) have been plotted in Figure C.2-7. The cost of the material spilled in each incident is distributed log normally with the number of spills. The cumulative distribution curve in Figure C.2-7 should be interpreted as a given percent of all spills having cargo value equal to or less than the indicated value. Most of the spilled cargos consisted of crude oil and petroleum fuels, and at the time most of the spills occurred, it is assumed that the average value of these materials was $3.00 per barrel. Using this value, the data in Figure C.2-7 were converted to a frequency distribution of quantity spilled as shown in Figure C.2-8. The curve in Figure C.2-8 begins to bend over at spill quantities of 8,000 to 10,000 barrels and this reflects the fact that the capacity of many barges is between 10,000 to 20,000 barrels.

The median quantity spilled is approximately 1,100 barrels. From Table C.2-9, the most common tank barge sizes are 1,500, 2,750 and 3,000 tons. The two larges sizes are those planned for use in the temporary phase to fill the West Hackberry salt dome cavities. These barges will hold 15,000 to 21,000 barrels of oil in 6 tanks of 2,500 to 3,500 barrel capacity each. Hence the median spill represents approximately 1/3 the capacity of a typical barge cargo tank. This reflects the facts that the damage in a casualty is such that all the cargo cannot leak out, and that the outflows often are sufficiently slow to permit taking measures, such as transfer of the cargo to another vessel or tank, to limit the amount lost.

The barge spill distribution curve was modified to estimate the spill size distribution for tank ship casualties. For this, it was assumed that the loss of 1/3 the volume of a single tank would be equivalent the median spill from a tank ship casualty.

Table C.2-10 shows the characteristics of a tank ship with a cargo capacity slightly more than 400,000 barrels. Although large tank ships may be used (up to 125,000 DWT), these would be light loaded. Regardless of the size of the tank ship used, it is assumed that they would carry approximately 400,000 barrels of oil with approximately 9,200 barrels in each wing tank. Accordingly, loss of one third the contents of one of these tanks is 3,100 barrels which is assumed to be the median spill. Also, assuming the same variance as for the tank barge spill distribution, the estimated spill size distribution for tank ships is shown in Figure C.2-9.

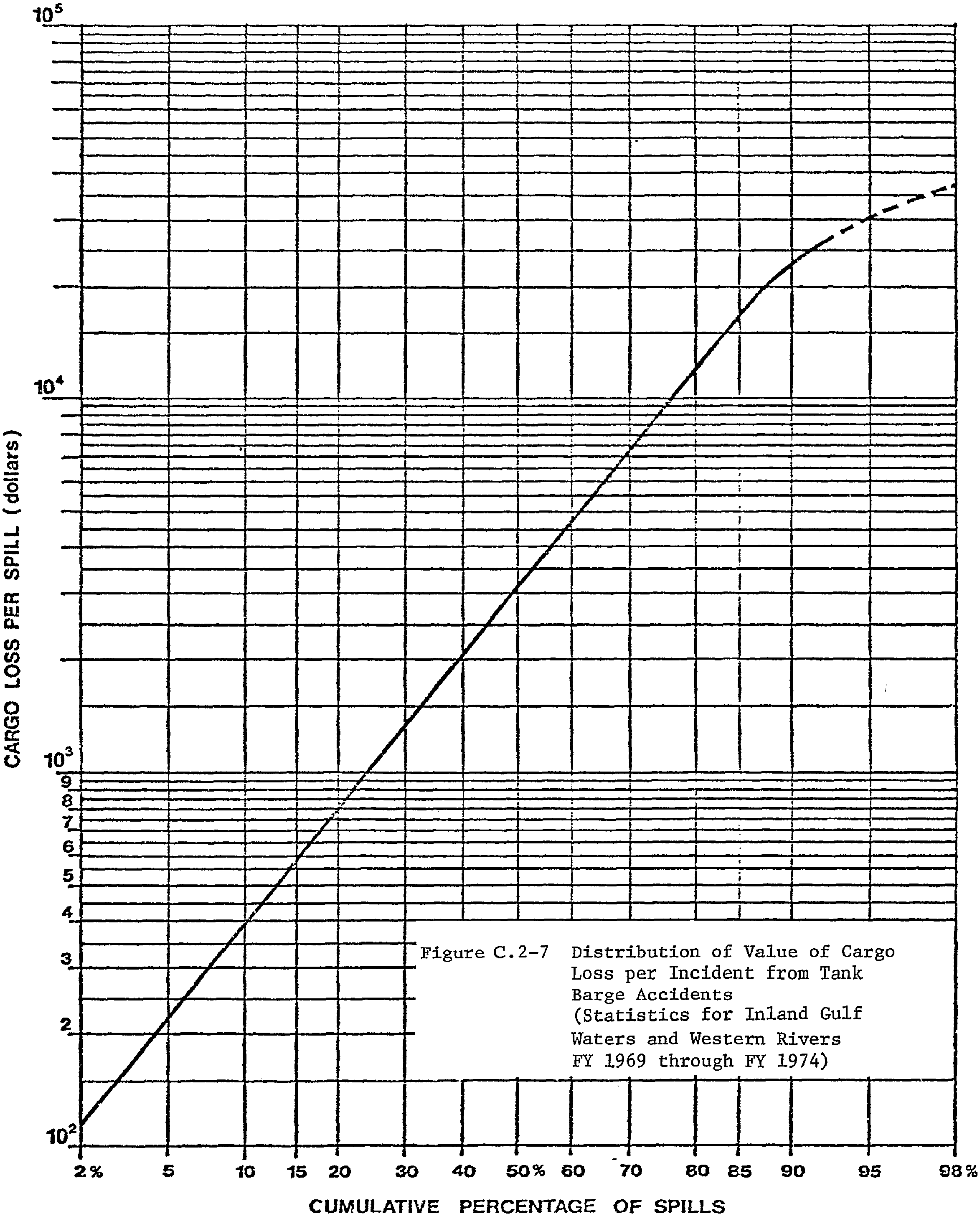

Figure C.2-7 Distribution of Value of Cargo Loss per Incident from Tank Barge Accidents (Statistics for Inland Gulf Waters and Western Rivers FY 1969 through FY 1974)

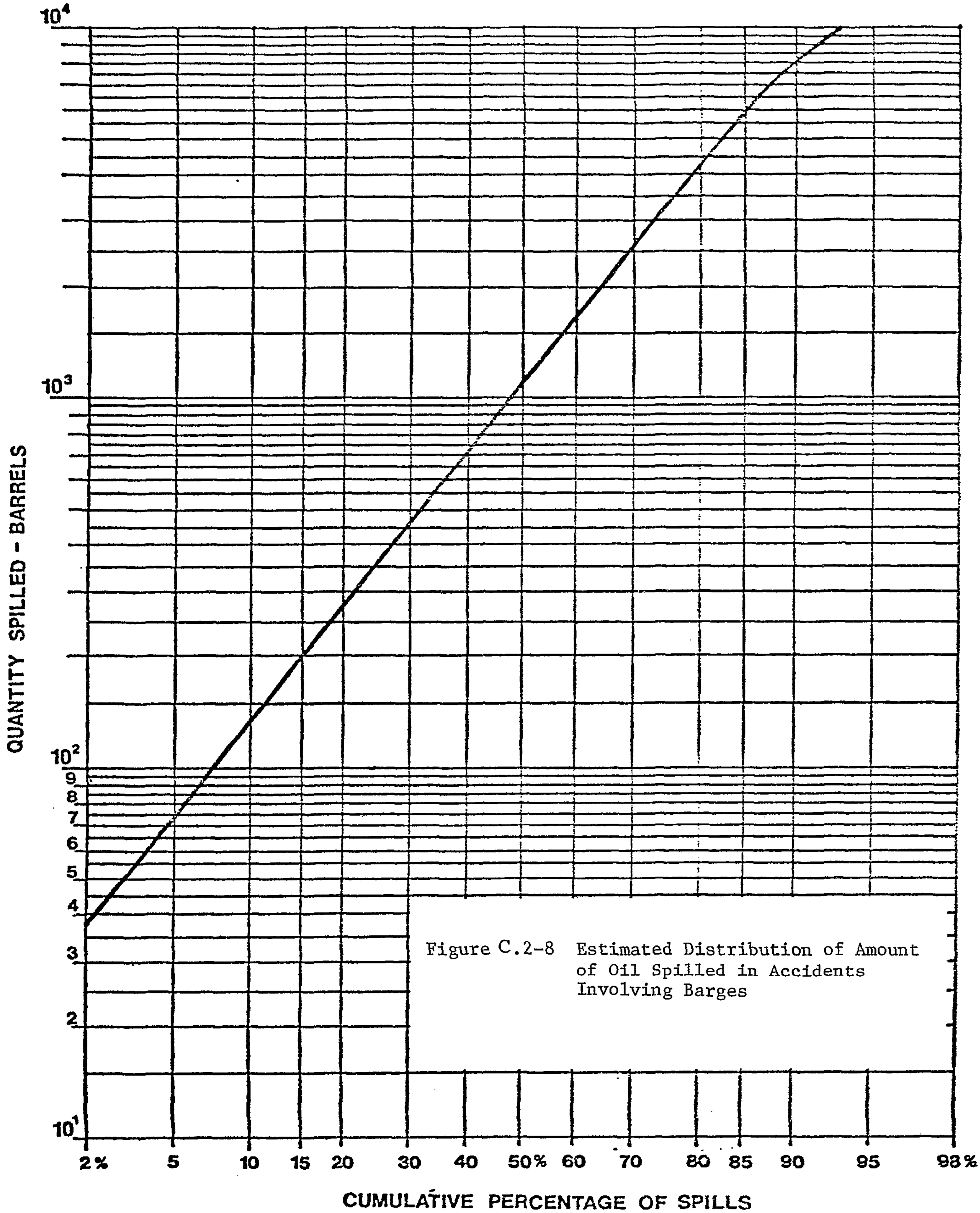

Figure C.2-8 Estimated Distribution of Amount of Oil Spilled in Accidents Involving Barges

Table C.2-9 Barge Size Distribution, Tank

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

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

Table C.2-10 Characteristics of a 45,000 DWT Tankship

Length Overall	743 feet
Beam	102 feet
Draft	39.5 feet
Gross Tonage	30,000
Net Tonage	19,800
Number of Wing Tanks	24
Approximate Capacity of the Wing Tanks	9,200 bbls
Number of Center Tanks	11
Approximate Capacity of the Center Tanks	18,000 bbls
Approximate Total Cargo Volume	409,500 bbls

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

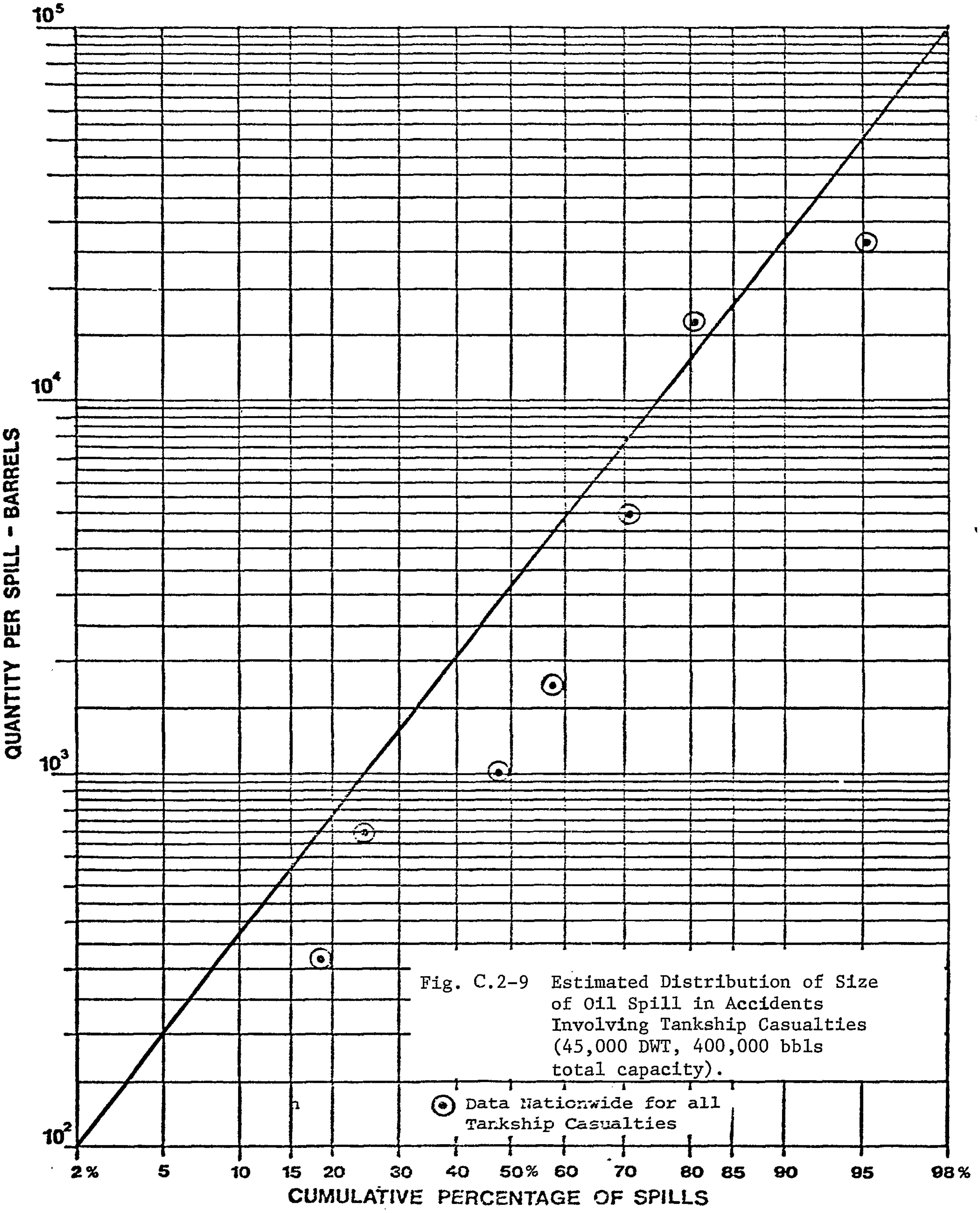

Fig. C.2-9 Estimated Distribution of Size of Oil Spill in Accidents Involving Tankship Casualties (45,000 DWT, 400,000 bbls total capacity).

Figure C.2-9 also indicates the reasonableness of this estimated distribution. The distribution of spill sizes from all tank ship casualties in the U.S. inland coastal waters during fiscal years 1969 through 1974 is shown by the points plotted. These lie below the estimated curve for a 45,000 DWT tank ship as expected since the casualties include a large number of smaller tank ships.

Estimates of the expected spill size frequency from tank ship and barge casualties are presented in Table C.2-11 and Figures C.2-10 and C.2-11, respectively. The per trip frequencies are simply the product of the spill frequency and the fraction of spills in the given size range from Figures C.2-8 and C.2-9. From the discussion above the frequency of spills per barge trip is 5.4×10^{-5} caused by rammings and groundings. The frequency for tank ships is 5.1×10^{-5} spills per trip which includes collisions as well as rammings and groundings. The expectation quantity of crude oil spilled is the sum of the products of frequency and quantity spilled (the average of the size ranges are in Table C.2-11) for all spill sizes. For tankbarge casualties the expectation quantity is 0.15 bbl/trip; for tankship casualties, it is 0.60 bbl.

C.2.1.2.4 Spills at the Marine Terminal

The frequency and size of spills during operations at the barge and tank ship terminals have been estimated in a manner similar to that used for vessel casualties. An analysis was made of the total number of spills as well as the quantity spilled at marine terminals in the Gulf Coast region during the period January 1974 through September 1975. Next, an estimate was made of the total number of barges and tank ships loaded or unloaded at these terminals. Spill frequency was obtained simply by normalizing these data to the same time period and dividing the number of incidents by the number of loading and offloading operations. A spill size distribution was derived from analysis of the spill data.

These accident and spill data reflect the safety of oil transfer operations at marine terminals during the early 1970's. Because the SPR operations at Sun Terminal and at the Amoco Dock would be similar to those conducted in the Gulf Coast region during that time, these same data provide a reasonable estimate of oil spills at these locations. However, it is anticipated that improved procedures and protective devices would be implemented by the SPR program. These would tend to make the oil spill estimates, developed below, conservative in the sense that the actual risk of spills would be less than that indicated by the data.

The data base for both the number and size of spill incidents was the U.S. Coast Guard's Pollution Incident Reporting System, PIRS (U.S. Coast Guard). Information concerning all pollution incidents reported to the Coast Guard and/or investigated by them are encoded and recorded on magnetic tape; the information includes locations, material spilled, quantity, cause, source and operation. Although this system has been in operation from the beginning of 1971, some Coast Guard

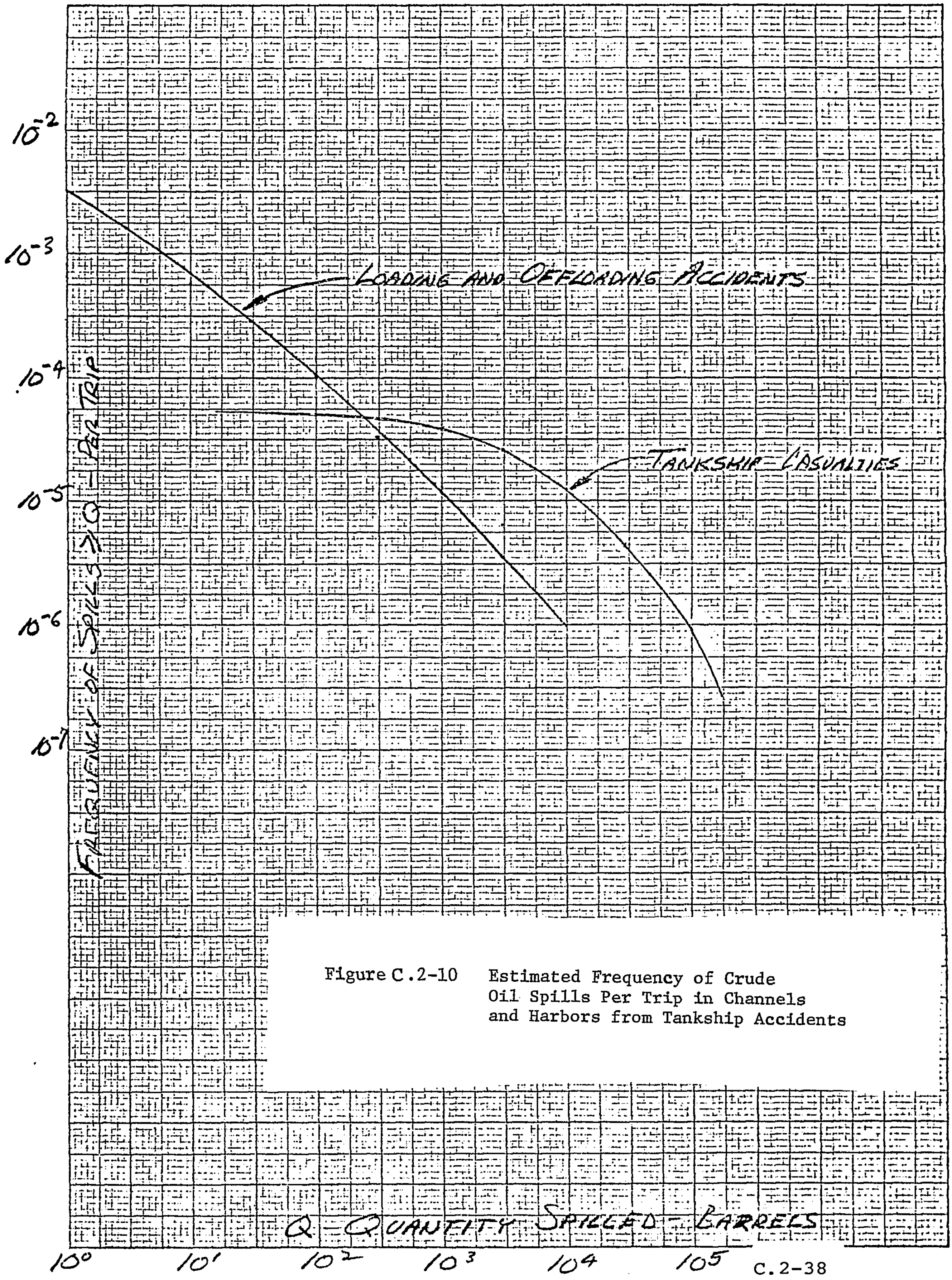

Figure C.2-10 Estimated Frequency of Crude Oil Spills Per Trip in Channels and Harbors from Tankship Accidents

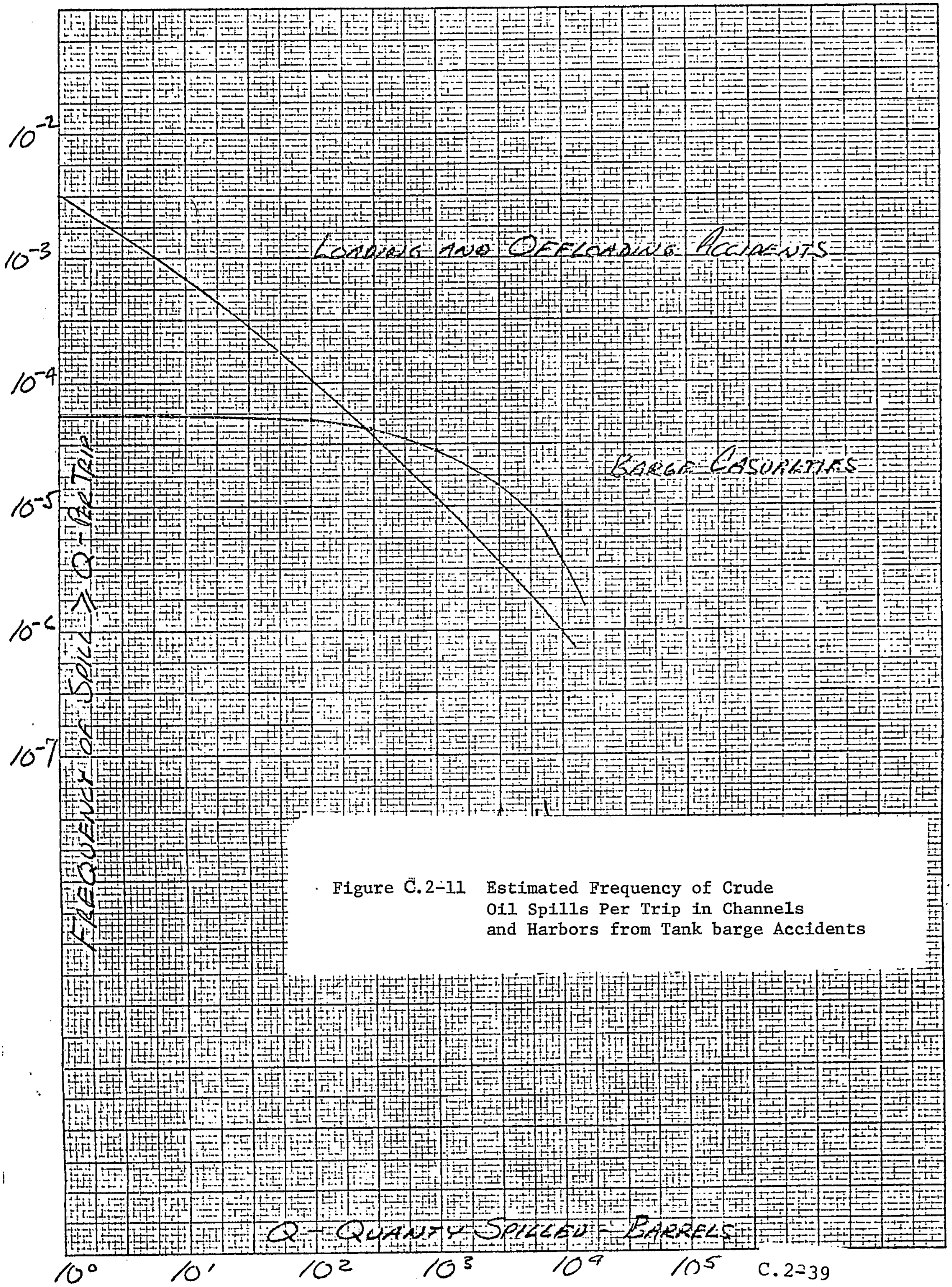

Figure C.2-11 Estimated Frequency of Crude Oil Spills Per Trip in Channels and Harbors from Tank barge Accidents

Table C.2-11 Estimated Spill Size Frequency From Tankship and Tank Barge Casualties

Spill Size (barrels)	Frequency[a] (per barge trip)	Frequency[b] (per tankship trip)
<100	3.83×10^{-6}	1.00×10^{-6}
100-300	7.61×10^{-6}	3.20×10^{-6}
100-1,000	1.41×10^{-5}	8.40×10^{-6}
1,000-3,000	1.34×10^{-5}	1.24×10^{-5}
3,000-10,000	1.16×10^{-5}	1.39×10^{-5}
10,000-30,000	3.62×10^{-6}	7.66×10^{-6}
30,000-100,000		3.52×10^{-6}
>100,000		9.18×10^{-7}

---

[a] The maximum quantity that can be spilled is 21,000 barrels.

[b] The maximum quantity that can be spilled is 400,000 barrels

officials feel that a high level of relaiability of the data base was not achieved until the beginning of 1974. On this basis, only data for the years 1974 and 1975 were used (data for 1976 have not yet been made available). All cases that did not pertain to loading and offloading at marine facilities (docks, terminals, etc.) in the Gulf Coast region were rejected from consideration, and the relevant cases were then sorted by source and size of spill. The final results of this sorting, for the time period January 1974 through Sèptember 1975, are shown in Table C.2-12. The average number of spills during a twelve month period was 794; the average and median spill sizes were 11.5 and 0.5 barrels, respectively.

The manner in which the number of loading and offloading preparations were counted tends to overestimate the frequency of spills. During 1974 (12 months), there were approximately 9,800 tank ship trips into all Gulf Coast ports (U. S. Army Corps of Engineers, 1971 and 1972). A major fraction of tank barge traffic into U. S. ports occurs in Gulf Coast ports, approximately 76,000 trips inbound annually (U. S. Army Corps of Engineers, 1974). It is assumed that for each inbound trip into a port, a tank ship or tank barge makes at least one stop to load or offload a bulk liquid cargo. This adds to a total of 86,000 loading and offloading operations. Not included in this count is an appreciable tank barge traffic along the Intracoastal Waterway. The reason this was left out was to avoid double counting; many of the barges arriving and departing at Gulf Coast Ports also travel the waterway as part of the same trip.

Combining this value with the number of spill incidents listed in Table C.2-12 the following spill frequency is obtained:

$$\frac{1,390}{86,600} \quad x \quad \frac{12}{21} \quad = \; 9.17 \text{ x } 10^{-3} \text{ spills/trip}$$

for loadings and offloadings at marine terminals.

Spill sizes reported in the Coast Guard's PIRS data were used to develop a spill size distribution, which is shown on Figure C.2-12. The PIRS data used for this are specific to the type of operation and geographic region, current, and statistically meaningful. Combining this distribution and spill frequency, the frequency of spills in particular size ranges were calculated, as shown in Table C.2-13. These data also were presented in Figures C.2-10 and C.2-11. The data presented in Table C.2-13 also were used to calculate the median spill size and expected spill quantities per offloading (0.5 bbls and 0.086 bbl) above.

Table C.2-12

SPILLS OCCURRING AT GULF COAST MARINE FACILITIES
January 1974 - September 1975

Number of Incidents are Characterized by Size and Source

Barrels Discharged	Source						
	Marine Facility: Bulk Cargo Transfer	Marine Facility: Non-Bulk Cargo, Fueling, Other	Tankship	Tank Barge	Other Vessel	Total No. of Incidents by Size	Percentage of Total Incidents
0-.5	89	124	114	307	70	704	50.65
.5-1.0	20	28	43	96	20	207	14.89
1-2	13	23	36	84	7	163	11.73
2-3	7	8	14	38	5	72	5.18
3-5	11	8	29	41	5	94	6.76
5-10	3	12	19	26	2	62	4.46
10-30	6	8	5	21	4	44	3.17
30-100	2	6	10	9	1	28	2.01
100-300	1	3	1	5	1	11	0.79
300-1000	0	1	1	1	0	3	0.22
1000-3000	0	0	1	0	0	1	0.07
3000-10,000	0	0	0	1	0	1	0.07
Total No. of Spills	152	221	273	629	115	1390	100.00

No. of incidents per year = 794 Average Spill Size = 11.5 barrels Median Spill Size = 0.5 barrels

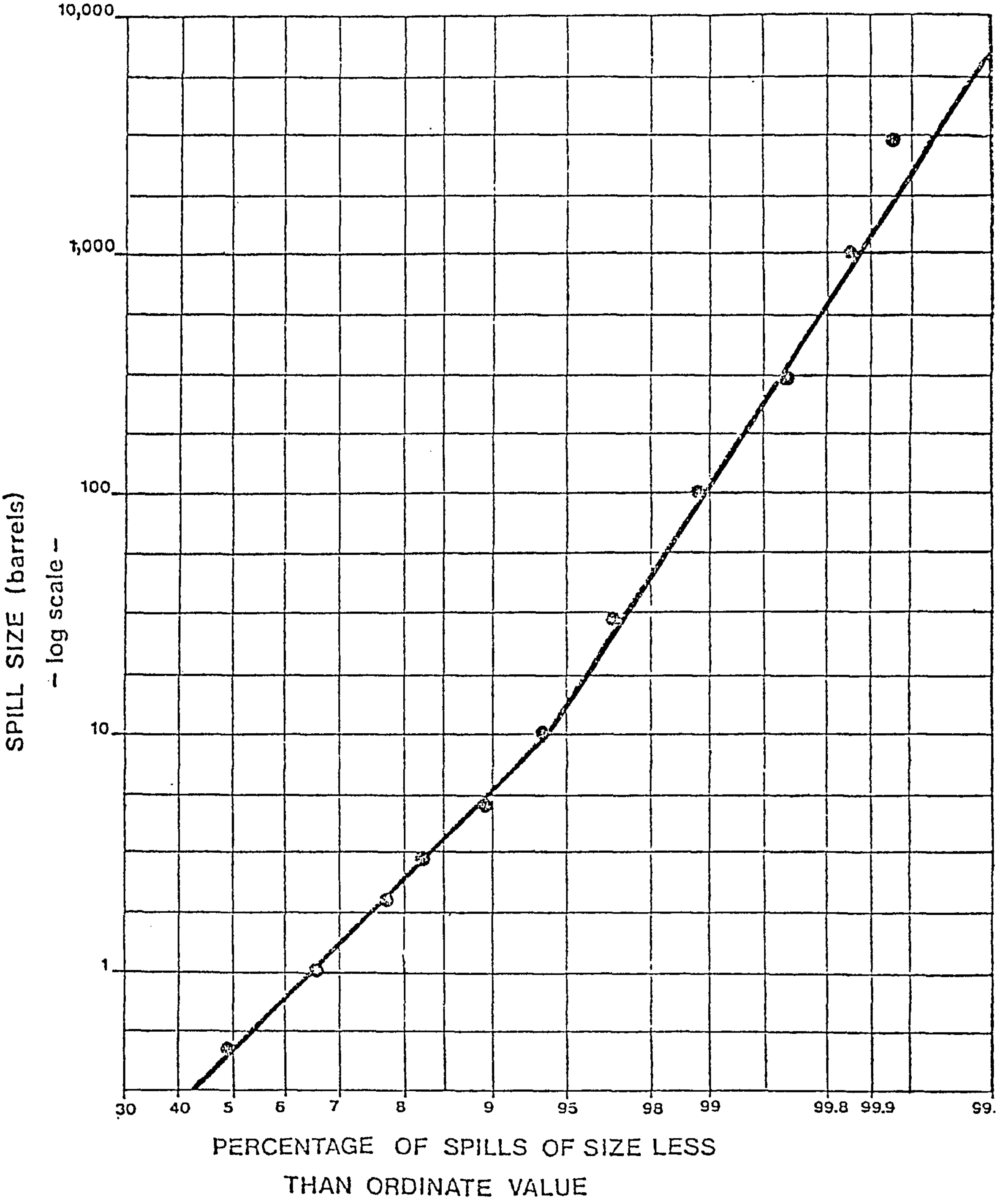

Figure C.2-12 Distribution of Quantity of Oil Spilled in Accidents During Loading and Off-loading Tankships and Tankbarges.

Table C.2-13 Estimated Spill Size Frequency from Accidents at a Marine Terminal

SPILL SIZE (barrels)	FREQUENCY
< - 1	6.01×10^{-3}
1 - 3	1.55×10^{-3}
3 - 10	1.03×10^{-3}
10 - 30	0.291×10^{-3}
30 - 100	0.184×10^{-3}
100 - 300	0.072×10^{-3}
300 - 1000	0.020×10^{-3}
1000 - 3000	0.009×10^{-3}
> - 3000	0.004×10^{-3}

C.2.1.3 Oil Spills from Pipelines

Estimates of the frequency and the amount of oil spilled because of possible pipeline accidents are based in part on statistics collected by the Office of Pipeline Safety (OPS), Department of Transportation (Ulrich, 1977). By law, U.S. pipeline operators must report spills to the OPS if they exceed 50 barrels, or if there is an injury or death associated with the accident. The population of pipelines to which the spill statistics apply were obtained from the Bureau of Mines, Department of Interior. Every three years they issue a report giving the total mileage of crude oil and oil product trunklines and gathering pipelines in the U. S. As of January 1, 1974, there were 222,355 miles of pipeline in the U. S., which are distributed fairly evenly between the three groups (U. S. Department of Interior, 1974). Of this total, 190,331 miles were 12 inches in diameter or less. Only 32,024 miles of pipeline were larger than 12 inches, and only 2,272 miles were 36 inches in diameter or larger.

Information on spills from pipelines is reported to OPS on DOT Form 7000-1, and includes the owner of the pipeline, the spill location, the cause of the spill, the installation date of the pipeline, the diameter, the product carried, and the amount of oil spilled (usually a best estimate). Table C.2-14 lists pipeline spills during the five-year period, 1971 through 1975, by cause. The major cause of spills from older pipelines, those installed before 1950, is external corrosion. Since the 1940's, much improved techniques have come into usage to prevent corrosion. Thus, the major cause of spills in newer pipelines is accidental breakage by excavation or construction equipment. Most larger pipe, that greater than 12 inches in diameter has been installed since 1950, and for it, too, the major cause of spills is damage by excavation equipment.

The spillage data were broken down into two categories according to size. There are insufficient data, statistically, for a breakdown for each individual size of pipeline. In general, pipe 12 inches or less in diameter is used for individual lines to a salt dome cavity. Larger pipe is used for trunklines and manifolds.

The spill frequency from pipelines less than 12 inches in diameter was estimated by dividing the total number of spills by the mileage existing at the beginning of 1974 and normalizing to one year:

$$\frac{738 + 519}{190{,}331} \times \frac{1}{5} = 1.32 \times 10^{-3} \text{ spills/mile-year}$$

Because the data necessary to distinguish between the populations of older and newer pipe are unavailable, it was

Table C.2-14 Causes of Pipeline Leaks and Spills in the U.S. During 1971 - 1975.

	Pipelines 12 inches and Less in Diameter (190,331 miles in U.S. in 1974)		Pipelines Greater than 11 inches in Diameter (32,024 miles in U.S. in 1974)
Cause	Installed Before 1950 (Number of Incidents)	Installed After 1950 (Number of Incidents)	(Number of Incidents)
External Corrosion	297	50	9
Internal Corrosion	40	46	8
Line Ruptured by Excavation Equipment	142	128	28
Prior Damage By Excavation Equipment	6	18	3
Defective Pipe Seam	83	71	19
Defective Weld	22	11	7
Rupture of Gasket, Seal, Etc.	23	56	2
Fire or Explosion	6	14	0
Flow Control Malfunction	3	11	0
Flow Control-Operator Error	23	12	0
Incorrect Operation by Carrier Personnel	2	11	0
Natural Disasters (Landslide, Flood, Windstorm, Freezing, Etc.)	36	24	0
Unknown	55	67	8
TOTAL INCIDENTS	738	519	85

necessary to sum the spills for both groups of pipe. For this reason, it is believed that the above estimated spill rate is higher than it would actually be for the newly installed SPR pipelines. For pipelines greater than 12 inches in diameter, a similar treatment gives:

$$\frac{85}{32,024} \times \frac{1}{5} = 5.31 \times 10^{-4} \text{ spills/mile-year}$$

The data from OPS also were used to estimate the spill size frequency distribution. These data have been plotted on log normal probability coordinates in Figure C.2-13. For the larger diameter pipelines, these data show the median spill size to be approximately 850 barrels. For pipelines less than 12 inches in diameter, the median spill size is 360 barrels. The data in Figure C.2-13 and the estimates of spill frequency were combined to give the frequency of spills exceeding a given quantity, as shown in Figure C.2-13.

These data were applied to predict the risk of oil spills from the pipelines proposed for the West Hackberry and alternative storage sites. Tables C.2-15 through C.2-19 list the lengths of the crude oil pipelines and the expected frequency of accidental spills per year from these pipelines. The annual spill frequencies were estimated as the product of pipeline length and the frequencies (per mile-year) developed above. The tables also list the number of years the pipelines are expected to be in use for the SPR project. It has been assumed that this period is 25 years for all sites. Table C.2-20 lists the probability of spills exceeding a given size for each site, and the trunklines. These values were estimated using the annual spill frequencies listed in Tables C.2-15 through C.2-19, and the spill size distribution shown in Figure C.2-13. Also, the spill probability for a period of years was assumed to be described by the bionomial distribution.

Figure C.2-13 Size Distribution of Spills from U.S. Terrestrial Pipelines Transporting Liquids

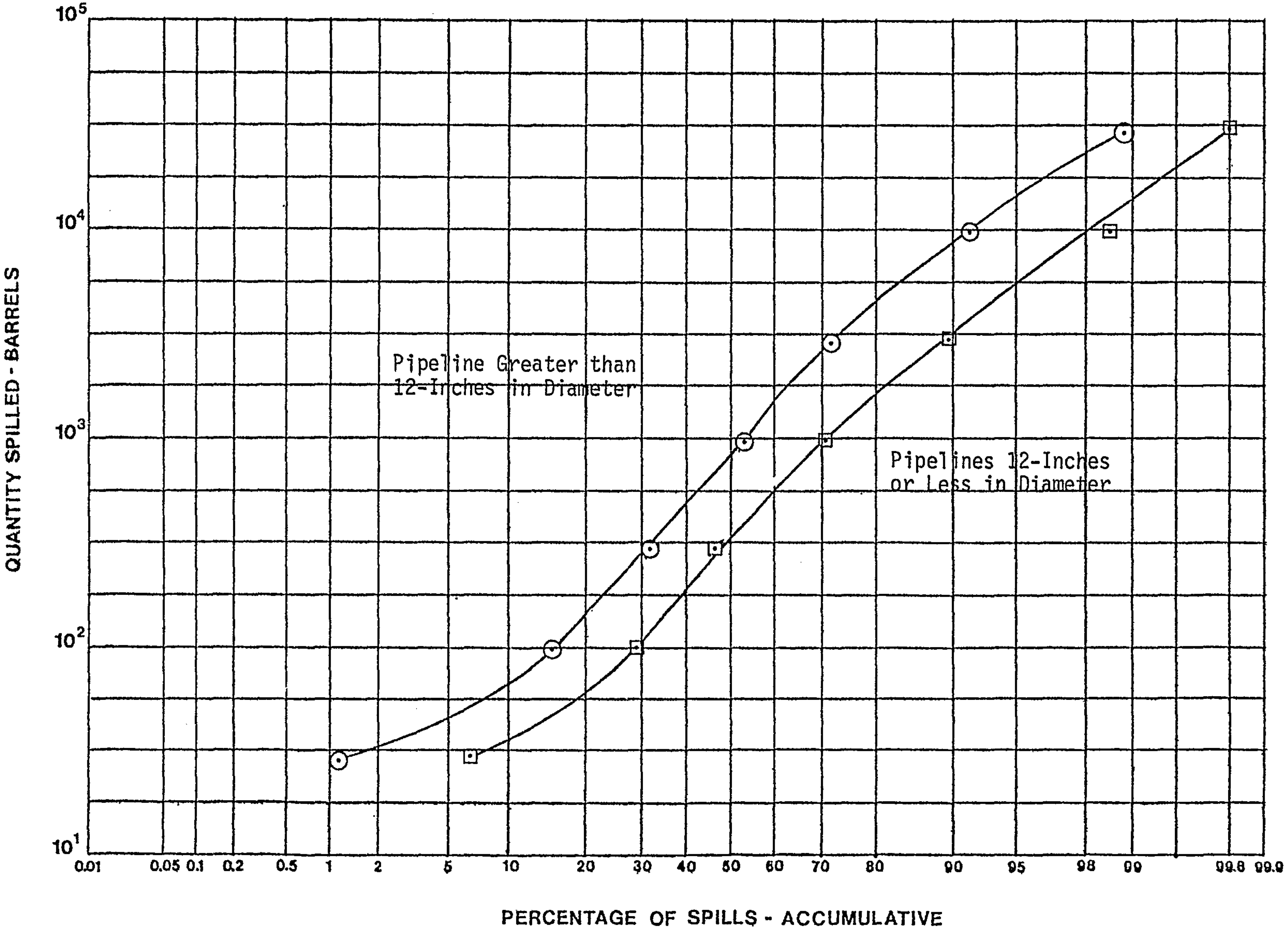

Table C.2-15 Crude Oil Pipelines and Accident Frequency: Early Storage Reserve.

Type of Pipeline	Approximate Length (miles)	Accidental Spill Frequency (per year)	Number of Operational Years
Trunk Line: 36 in.	2 x 41.5 = 83	0.0441	25
Site:			
< 12 inches	2.0	2.64×10^{-3}	25
> 12 inches	3.0	1.59×10^{-3}	25
Temporary Barge Dock Line, 10 3/4 in.	1.5	1.98×10^{-3}	1.0

Table C.2-16 Crude Oil Pipelines and Accident Frequency: West Hackberry Expansions.

Type of Pipeline	Approximate Length (miles)	Accidental Spill Frequency (per year)	Number of Operational Years
Trunk Line:	Existing [a]		
Site:			
< 12 inches	1.0	1.32×10^{-3}	25
> 12 inches	1.0	5.3×10^{-3}	25

---

[a] Built for the Early Storage Reserve program.

Table C.2-17 Crude Oil Pipelines and Accident Frequency: Black Bayou Alternative.

Type of Pipeline	Approximate Length (miles)	Accidental Spill Frequency (per year)	Number of Operational Years
Trunk Line: 42 in.	2.7[a]	1.43×10^{-3}	25
Site:			
< 12 inches	0.6	7.9×10^{-4}	25
> 12 inches	1.1	5.8×10^{-4}	25

---

[a] Connecting the Site and the ESR West Hackberry - Sun Terminal Trunkline.

Table C.2-18 Crude Oil Pipelines and Accident Frequency: Vinton Dome Alternative.

Type of Pipeline	Approximate Length (miles)	Accidental Spill Frequency (per year)	Number of Operational Years
Trunk Line: 42 in.	7.5[a]	3.98×10^{-3}	25
Site:			
< 12 inches	0.7	9.2×10^{-4}	25
> 12 inches	0.3	1.6×10^{-4}	25

---

[a] Connecting the Site and the ESR West Hackberry - Sun Terminal Trunkline.

Table C.2-19 Crude Oil Pipelines and Accident Frequency: Big Hill Alternative.

Type of Pipeline	Approximate Length (miles)	Accidental Spill Frequency (per year)	Number of Operational Years
Trunk Line: 42 in.	27.0	0.0143	25
Site:			
< 12 inches	1.2	1.58×10^{-3}	25
> 12 inches	0.8	4.2×10^{-4}	25

Table C.2-20 Risk of Crude Oil Spills From Pipeline Accidents

Quality Spilled	West Hackberry ESR	West Hackberry Expansion	Black Bayou Alternative	Vinton Dome Alternative	Big Hill Alternative
	Probability of Spill Over 25 Year Lifetime				
Oil-Trunkline					
Probability of Spill					
> 100 bbls	0.57	a	0.031[b]	0.081[b]	0.26
> 1,000 bbls	0.32	a	0.017[b]	0.046[b]	0.15
> 10,000 bbls	0.061	a	0.0032[b]	0.0090[b]	0.027
Expectation Quantity of Oil Spilled, bbls.	575	a	126[b]	349[b]	1258
Oil Pipelines on Site					
Probability of Spill					
> 100 bbls	0.078	0.034	0.026	0.019	0.036
> 1,000 bbls	0.038	0.016	0.013	0.0088	0.017
> 10,000 bbls	0.0049	0.0019	0.0017	0.00082	0.0018
Expectation Quantity of Oil Spilled, bbls.	225	90	77	44	88

---

[a] There is no added risk for the off-site pipeline since it would be used also for the ESR portion of the storage program.

[b] The oil spill risk for the off-site pipeline for these sites is limited to the connector line between the site and the Sun Terminal - West Hackberry trunk line, since the latter would be used also for the ESR program.

The results presented in Table C.2-20 show that only for the crude oil trunklines from the Sun Terminal to West Hackberry, and to the alternative site, Big Hill, is the risk of a large spill (>1,000 bbls.) significant, 32 percent for the ESR Sun Terminal - West Hackberry trunkline and 14 percent for the Sun Terminal - Big Hill trunkline. For pipelines on the several sites, the risk of a spill greater than 100 barrels is less than 10 percent. This result is reflected in an alternative presentation of spill risk, the expectation quantity of oil spilled (the sum of the products of spill frequency and spill size), also listed in Table C.2-20.

It also should be pointed out that the risk of oil spills for the trunkline for the West Hackberry expansion is assessed to be zero. The reason for this is that the line would exist and would be used for the ESR program also. Hence, the expansion program would not increase the risk of oil spills from the trunkline. The same assessment principle also was applied to the offsite pipelines for Black Bayou and Vinton. For the oil trunkline of these sites, the added risk arises only from the relatively short segments connecting the Sun Terminal-West Hackberry trunkline with the site.

In considering these results, it should be kept in mind that the probabilities are based on conservative assumptions which tend to make them high. In particular, a 25 year utilization period was assumed. Although the lines would be full of oil during this period, they would be in active use only during approximately one-third of this time, assuming five fill-distribution cycles. During the periods of inactivity, the pressure in the line would be reduced, and block valves would be closed. The amount of oil released in an accident during this time would be substantially less than when the pipeline were active.

The areas affected by the spilled oil vary from open water to dry land. For the West Hackberry ESR and Expansion sites, the crude oil lines would be located in (buried), or on dry land. The modest amount of oil expected to be spilled accidentally would be confined to a localized area near the spill. Also, because of the high water table in the area, leaks of oil from the buried portions of the pipelines would not be expected to move very far in a downward direction. During rainy periods, oil migrating to the surface would behave as runoff material. As indicated in Table C.4-3, the crude oil trunkline between the site and the Sun Terminal crosses a variety of terrain. Most of the route is through marsh (27 percent), and along a spoil bank (39 percent). In marshes, the oil would tend to rise to the water surface and spread out. However, the spreadking is much more limited compared to that on open water because of absorption and retnetion by grass and organic debris. Water, soil, and vegetation would be contaminated. Cleanup and removal would be difficult and even undesirable, since such an effort in itself may cause substantial environmental damage in such areas. Oil from pipeline leaks in the spoil bank would migrate either into the parallel Intracoastal Waterway or into the marsh on the other side. Oil escaping onto the ICW would be confined by the banks and would be relatively easy to clean up. Most of the remainder of the pipeline route is through woodlands (13 percent), or prairie (17 percent). In these areas, the oil would tend to be absorbed in the surface layers of soil. However, if these are saturated with water, the oil would behave as runoff material.

For the Black Bayou alternative, spills at the site would be into marsh where, as noted above, the oil is difficult or undesirable to clean up, but the oil does not spread as far as on open water. From Table C.5-3, the oil distribution line which connects with Sun Terminal - West Hackberry line is 30 percent under marsh and 70 percent under water. Most of the latter is the Black Bayou Cutoff Channel and leaks would rise, spread out on the water surface, and accumulate in the marshy borders of the Bayou.

The crude oil pipelines at the Vinton dome site would be buried on dry land, but near Ged Lake. Because of the high water table, oil escaping from leaking or damaged pipe would tend to saturate the top most soil layers, if dry, or rise to the ground surface and runoff onto Ged Lake. Leaks from the trunkline, connecting to the West Hackberry - Sun Terminal pipeline, could effect either prairie or marsh 26 percent of the pipeline route would be through marsh and 74 percent would cross prairie.

At the Big Hill alternative site, all wells and crude oil pipelines are on solid ground, primarily pasture for grazing cattle. The pipelines would be buried and any leaks would tend to saturate the surface soils above the pipelines. In areas where there might be a significant grade, the leaking oil might migrate along the pipeline trench and surface at some distance from the leak. Oil reaching the surface would behave as runoff material.

The trunkline connecting Big Hill and Sun Terminal would cross prairie land (82 percent of the route), marsh (11 percent of the route), woodland (5.6 percent of the route), and would parallel an existing roadway for 1.4 percent of the route. The behavior of leaks of oil in these types of terrain has been discussed above.

C.2.2 Risk of Brine Spills

The primary source of accidental brine spills are accidents to the various pipelines that collect the brine at the sites and the trunklines that transport the brine to the disposal area (injection wells or the sea). Accidents to brine pipelines are treated in the same manner as was done for crude oil pipelines. Additionally, it is assumed that the accident data (frequency and spill size) derived from oil pipeline experience also is valid for brine pipelines. This last assumption seems reasonable since the lines would be made of the same materials and laid in the same manner as for the crude oil pipelines.

Tables C.2-21 through C.2-25 list the brine pipeline mileage, expected annual spill frequency and the number of operational years for each site. In the latter set of values it is assumed that the pipelines would contain brine only during leaching and oil refilling operations. At all other times the brine would be emptied from the pipelines and the lines flushed with water. For all sites the initial leaching period is estimated to be 38 months except the West Hackberry SPR site, for which the initial leaching period is planned to be 26 months. The refill period for all sites is 30 months, except for the combined ESR and Expansion wells as West Hackberry, for which the refill period would be 40 months. A total of four refills have been assumed to occur.

These data were applied to develop the estimates of brine spill risk presented in Table C.2-26. Both the probability of spills exceeding a stated quantity and the expectation quantity of brine spilled during the operational lifetime of the brine lines are listed. The results, of course, are similar to those for the crude oil pipelines; the longer the pipeline and/or the greater the number of operational years, the probability of a spill greater than 100 barrels exceed 20 percent.

The highest spill probabilities are associated with brine lines that terminate offshore in the Gulf (West Hackberry, Black Bayou and Big Hill). These lines extend approximately 4 to 7 miles offshore and hence approximately 25 percent of the predicted spills for these lines would occur in the Gulf. Most of the remainder of the spills from these lines would occur in marshland or prairie. Spills from the brine lines on sites would affect prairie land except for the Black Bayou site which is in a marsh. Brine is readily miscible with water, and accordingly, any spills are expected to disperse readily into the soils and waters of the area. At present no effective means are available to clear up spills of brine, but some soils may be treated with gypsum or other soil chemical additions to ameliorate the effects of the brine.

Table C.2-21 Brine Pipelines and Accident Frequency: Early Storage Reserve.

Type of Pipeline	Approximate Length (miles)	Accidental Spill Frequency (per year)	Number of Operational Years
Trunkline: 30 in.[a]	2.5	1.33×10^{-3}	15.5
Site:			
< 12 inches	1.0	1.32×10^{-3}	15.5
> 12 inches	1.5	8.0×10^{-4}	15.5
Temporary, < 12 inches	2.5	3.30×10^{-3}	1.0

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[a] Line to injection wells.

Table C.2-22 Brine Pipelines and Accident Frequency: West Hackberry Expansion.

Type of Pipeline	Approximate Length (miles)	Accidental Spill Frequency (per year)	Number of Operational Years
Trunkline: 36 in.			
Alternate Highway 27 Route [a]	28.4	0.0154	16.5
Proposed Calcasieu Route [a]	24.8	0.0143	16.5
Site:			
< 12 inches	1.0	1.32×10^{-3}	16.5
> 12 inches	1.0	5.3×10^{-4}	16.5

---

[a] Alternative pipeline routes for brine disposal in the Gulf of Mexico.

Table C.2-23 Brine Pipelines and Accident Frequency: Black Bayou Alternative.

Type of Pipeline	Approximate Length (miles)	Accidental Spill Frequency (per year)	Number of Operational Years
Trunkline: 36 in.	27	0.0143	13.2
Site:			
< 12 inches	0.6	7.9×10^{-4}	13.2
> 12 inches	1.1	5.8×10^{-4}	13.2

Table C.2-24 Brine Pipelines and Accident Frequency: Vinton Dome Alternative.

Type of Pipeline	Approximate Length (miles)	Accidental Spill Frequency (per year)	Number of Operational Years
Trunkline: 24 in.	2.75	1.46×10^{-3}	13.2
Site:[a]			
< 12 inches	1.1	1.45×10^{-3}	13.2
> 12 inches	1.6	8.50×10^{-4}	13.2

---

[a] Includes pipeline connecting the trunkline with the disposal wells.

Table C.2-25 Brine Pipelines and Accident Frequency: Big Hill Alternative.

Type of Pipeline	Approximate Length (miles)	Accidental Spill Frequency (per year)	Number of Operational Years
Trunkline: 36 in.	13.2[a]	7.0×10^{-3}	13.2
Site:	16.5[b]	8.75×10^{-3}	13.2
< 12 inches	1.2	1.58×10^{-3}	13.2
> 12 inches	0.8	4.2×10^{-4}	13.2

---

a Proposed Route

b Alternate Route

Table 4.2-26 Risk of Brine Oil Spills From Pipelines During Operational Lifetime

Quantity Spilled	West Hackberry ESR	West Hackberry Expansion	Black Bayou Alternative	Vinton Dome Alternative	Big Hill Alternative
Brine Trunkline Probability of Spill					
> 100 bbls	0.018	0.19[a] 0.18[b]	0.15	0.016	0.075[c] 0.093[d]
> 1,000 bbls	0.0095	0.11[a] 0.010[b]	0.083	0.0089	0.043[c] 0.053[d]
> 10,000 bbls	0.0019	0.020[a] 0.020[b]	0.017	0.0017	0.0084[c] 0.010[d]
Expectation Quantity of Brine Spilled, bbls.	72	192[a] 180[b]	664	68	325[c] 406[d]
Brine, Site Pipelines Probability of Spill					
> 100 bbls	0.027	0.023	0.014	0.023	0.019
> 1,000 bbls	0.013	0.011	0.0067	0.011	0.0089
> 10,000 bbls	0.0016	0.0012	0.00091	0.0014	0.00093
Expectation Quantity of Brine Spilled, bbls.	74	59	40	64	47

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[a] The Highway 27 Route.

[b] The Calcasieu Route.

[c] Proposed Route

[d] Alternate Route

C.2.3 Related Risks

C.2.3.1 Fires and Explosions

The expected specific gravity and Reid Vapor Pressure of the crude oil to be imported are 27° API and 3.0 psi, respectively. These characteristics indicate the the flash point is below 20°F. About one percent by weight of the oil consists of volatile pentane and lower weight hydrocarbons. Thus, the vapor from spills of unweathered crude oil may be easily ignited provided an ignition source is nearby.

Of prime importance in evaluating offsite fire risks is the maximum downwind travel of a flammable vapor air mixture. From the properties mentioned above, it is estimated that a maximum of one percent of the crude oil can vaporize spontaneously. This vapor can mix in the surrounding air and be ignited at some distance downwind from the spill. Table C.2-27 lists estimated maximum distances for the existence of a flammable vapor mixture from spills typical of pipeline breaks and marine accidents. The estimates were calculated assuming normal diffusion over flat terrain, "instantaneous" vaporization and a lower flammable limit of 4,500 g/m^3, which is typical of aliphatic hydrocarbons. The table indicates that spills of 1000 bbls or less (e.g. from pipeline leaks and accidents at the Sun Terminal) probably would not be ignited since the flammable plume would rarely extend offsite. Onsite ignition sources would be rare, in keeping with the usual fire safety practices characteristic of oil storage and transfer facilities. Spills from vessel casualties, especially tankship casualties (3,100 barrel median spill), if not ignited during or shortly after the collision (see below), could produce a flammable vapor-air mixture which would reach shore and could be ignited. However, this generally would present little danger to persons living onshore since less than 10 percent of the vapor would be mixed with air in a flammable composition.

Accident experience indicates that only localized fires are to be expected from spills of crude oil. Data from the U. S. Coast Guard's reports on commercial vessel casualties indicate that spills of crude oil from ship collisions are ignited immediately in at least 90 percent of the instances. The cause of ignition is not known precisely, but apparently short circuited electrical wires and hot metal fragments play a major role. For the storage and terminal facilities, accident experience at bulk petroleum marine terminals during 1971 through 1974 indicated a total of 29 fires originated from accidents on the terminal property, and of these only one spread to property offsite.

Table C.2-27 Maximum Downwind Drift of Flammable Crude Oil Vapor-Air Mixtures

Pasquill Atmospheric Stability	Relative Frequency of Occurrence	Downwind Distance (meters)		
		0.5 bbl Spill	1100 bbls Spill	8300 bbls Spill
A,B,C,D	.64	<100	250	550
E	0.13	<100	350	750
F	0.23	150	600	1250

The same data indicated that there were an average of 700 such terminals in operation during the four year period. Hence, from these data the frequency of offsite fires is approximately

$$\frac{1}{4 \times 700} = 4 \times 10^{-4} \text{ per year.}$$

Acutally this probably is a high estimate since many of the liquids (such as gasoline) handled at the 700 terminals are much more flammable than crude oil.

The environmental impact of a crude oil fire generally would be a localized destruction of vegetation and the release of smoke and combustion products to the atmosphere. Not all the spilled crude oil would burn in a "pool" fire. Only the more volatile components would be consumed; heat feed back from the flame is insufficient to vaporize the high molecular weight components. For a 27° API gravity oil, it is estimated that a maximum of 50 percent of the spilled oil would burn in a "pool" fire. The emissions would consist of soot, hydrocarbons, CO, and SO_2. Negligible nitrogen oxides are expected because of the low flame temperatures characteristic of this type of fire. These emissions would cause only a temporary and very localized degradation of air quality.

C.2.3.2 Accidental Injury

Because accidental fires would be localized to the spill area, it may be expected that injuries also would be localized. Hence, it is mainly employees and the crews of the ships that would suffer the consequences of any accidents. This is supported by data on accidents and fires compiled by the Coast Guard and the National Fire Protection Association. Table C.2-28 summarizes the fatalities resulting from fires and explosions that have occurred in bulk liquid storage terminals (both marine and otherwise) nationwide during the 25-year period 1950 through 1975. Only four employee deaths and two non-employee deaths have resulted from fires involving the storage of crude oil. The two non-employee deaths were two boys who are playing on top of storage tanks. A cap pistol ignited the vapor in one of the nearly empty tanks. Applying the accident experience in Table C.2-28 for refined petroleum fuels, gasoline, fuel oil, aviation fuel and napthalene, which are <u>much more</u> flammable than crude oil, an upper limit on the frequency of fatalities and injuries may be estimated for the storage of crude oil. In 1967 there were 26,000 bulk storage establishments for petroleum fuels in the United Stages. Assuming an average of 20,000 over the 26 year period covered by the data, the frequency of non-employee deaths per establishment is

Table C 2-28 Civilian and Employee Fatalities from Fires and Explosions Involving Flammable Liquid Bulk Storage During the Years 1950-1975

Product	Employee Deaths	Non-Employee	Unknown
Gasoline	27	11	4
Fuel Oil	5	4-10	0
Aviation Fuel	1	0	0
Napthalene	3	0	0
Flammable Ink	2	0	0
Crude Oil	4	2	0
TOTALS	43	17-23	4

Source: National Fire Protection Association, Fire Case Histories, via personal communications from M. L. Sullivan, Environics Inc., April 1976.

$\frac{31}{26} \times \frac{1}{26{,}000} = 6 \times 10^{-5}$ per year, where the unknown category in Table C.2-28 has been included with non-employee death. The corresponding estimate for the frequency of employee deaths is

$$\frac{43}{26} \times \frac{1}{20{,}000} = 8 \times 10^{-5} \text{ per year.}$$

Since as a reule of thumb, the injury rate in accidents is approximately 5 to 10 times the mortality rate, it is estimated that there would be 6×10^{-4} non-employees injured per year and 8×10^{-4} employees injured per year.

Because these frequencies were derived from data for much more flammable materials, it is concluded that the risk of death and injury to employees and persons offsite is very small.

C.2.3.3 Natural Disasters

According to the National Oceanic and Atmospheric Administration (NOAA), the region of Sabine Lake and the Sun Terminal are described as a Zone 0 seismic risk area, meaning an area of negligible risk of damage from an earthquake.

During the period 1899-1971 some 32 tropical cyclones have passed through the area with winds in excess of 34 knots. Of these, 15 had developed hurricane force winds (65 knots and above) and have had an average recurrence interval of about 5 years (NOAA, 1972). Heavy rainfall, local and regional floodings, and tornadoes often accompany hurricanes. The storage integrity of the facility would not be threatened by a hurricane. Sufficient hurricane warning is available so that oil transfer would be stopped. Storage and surge tanks would be left full in order to increase their resistance to winds and flooding. Except at the marine terminal, all oil and brine pipelines are buried and therefore, would not be affected.

Tornadoes not associated with hurricanes could be more hazardous because of the lack of warning. It is possible that a tornado could strike and damage an oil tank. Tornado frequency in this area is about 3 tornadoes per 10,000 square miles per year.

Howe (1974) has computed ground track area by state and region, arriving at an estimate of 0.61 square miles per tornado in Louisiana. The frequency, f, of the marine terminal being struck by a tornado in one year is:

$$f = \frac{3}{10{,}000} \times 0.61 = 1.83 \times 10^{-4} \text{ per year.}$$

The oil surge tanks are designed to withstand very strong winds and should remain intact for small tornadoes and large tornadoes which are "near misses." However, should the tank be damaged, the tornado might "suck up" some of the oil. This oil would be dispersed over such a wide area that adverse environmental effects would be minimal. Any oil leaking from the damaged tank would be retained inside the dike.

Lightning may interrupt operations and cause fires if certain system components are hit. There is a very low probability that fires would occur, but in the event that they occur, they would cause only slight environmental degradation in the form of air pollution.

C.2.4 Accident Risk Reduction

As discussed in the above sections, the risk of oil spills and attendant fire hazards are an ever-present factor in petroleum handling operations. There are practices which can be employed during the development and operation of the Strategic Petroleum Reserve sites which would reduce the risk of spills and fires. Generally, such risk reduction equipment and techniques are employed as standard practice throughout the petroleum industry. During construction at the storage caverns the risk of blowouts can be greatly reduced in some operations through the use of blowout preventers on drilling rigs. During well-workover operations, depressuring the system with strict control of potential ignition sources could substantially reduce the risk of accidents. Radiographic inspection of all pipeline welds, cathodic protection of buried pipelines and proper identification of pipeline location can greatly reduce the chances of pipeline spills.

Redundant high and low pressure detection mechanisms as well as pump vibration and high temperature detection devices integrated into the oil delivery system can greatly reduce the probability of spills resulting from equipment failure. Downhole safety valves can also be employed for certain well designs in order to reduce the volume of oil spilled in the event of major damage to the wellhead during the static storage phase of the program.

The use of specific equipment, instrumentation and operational procedures is a function of the detailed system design. As this detailed design is developed, appropriate oil spill risk reduction measures will be incorprated into the system consistent with the goals and operational philosophy of the SPR. Human error is by far the most common cause of oil spills. Proper training and close supervision of both terminal and site operations personnel is the most effective means of reducing the risk of spills caused by human error.

C.3 PROPOSED SITE - WEST HACKBERRY

C.3.1 Impact on Site Preparation and Construction

C.3.1.1 Land Features

The proposed expansion of the ESR facilities at the West Hackberry dome would provide 150 million barrels of additional storage capacity. The ESR oil distribution pipeline to the Sun Terminal at Nederland, Texas, would be available for use by the SPR expansion facility, whether located at West Hackberry, Black Bayou, or Vinton. Other ESR facilities which would be used for expansion at West Hackberry are the central plant and the raw water supply system. Brine disposal for the expansion facility would be by a new 24.8-mile pipeline into the Gulf of Mexico. The additional storage wells would be located on dry land on a 160-acre tract adjacent to the ESR development.

C.3.1.1.1 Geomorphology

Since the 15 new wells to be drilled for the expansion of the SPR facility at West Hackberry would be located on dry land there are no requirements for filling. Also the roads that would be built would require a minimum of grading and filling. These activities therefore would have little or no impact on the land forms at the site. There would be no major impact on drainage patterns on site since there would be no interference with streams or bayous.

Since the ESR oil distribution pipeline from West Hackberry to Sun Terminal is being constructed as part of the ESR development, no new impacts to land forms or drainage patterns would result from the manifolding of the expansion facility into the pipeline. Construction of a new tanker dock would require dredging and removal of 2 million cubic yards of spoil. This would be an impact on the bathymetry* at the dredge site and the landforms at the spoil disposal area.

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* bathymetry - The measurement of depths of water in oceans, seas, and lakes; and, the information derived from such measurements.

C.3.1.1.2 Soils

Only minor impacts to soils would be experienced during the construction of well heads and service roads, these impacts would be confined to the construction areas. Soils in these areas would be exposed to erosion (see Appendix D), and construction traffic could result in compaction and destruction of internal soil structure near the surface. The addition of gravel or shell as a road surfacing would also slightly alter the composition of the soil along roadways.

The soils along the oil pipeline route from West Hackberry to the Louisiana/Texas borders include: the Morey-Beaumont Association, and a soil grading from Harris salt water marsh to Harris fresh-water marsh associations. Both of these soils occur as mounds of spoil dredged from the ICW. Above standing water these soils are very poorly drained. Since they have been once disturbed by dredging there is no internal structure characteristic of undisturbed soil; therefore,pipeline construction would not destroy or improve soil drainage characteristics. No alteration of soil composition would occur other than vertical mixing.

In Texas the northwest/southeast leg and the east/west leg of the pipeline cross areas of Morey, Crowley soils. Since these soils are already poorly drained, disturbance during pipeline construction would not impact the drainage of the soil. The northeast/southwest leg of the oil pipeline to Nederland crosses Harris type soils which are generally under water. The only perceptible impact of construction would be a vertical mixing of the soil in the trench.

No alteration of soil characteristics would occur away from the immediate area of pipeline construction along either of the two proposed brine disposal pipeline routes. Where actual digging would occur,the soil profile and its drainage characteristics could be altered but, but no alteration of compositio would occur except for vertical mixing of material.

The proposed brine disposal pipeline route is covered predominantly by Harris salt-water marsh association which is usually flooded; therefore,disruption of internal soil structure with regard to drainage would not be a serious impact.

The Crowley-Morey-Mowata association at the storage site and the Morey-Beaumont association east of the site are also traversed by the proposed brine line, but these soils are already poorly drained; therefore,disruption of the internal structure of these soils would not seriously affect soil drainage.

The brine disposal pipeline alternative would traverse areas that are covered by the three soil types discussed above; therefore, the impacts of construction are expected to be the same. This route does, however, encounter another soil type, the Harris Cheniere variant-Palm Beach association. The poorly drained Harris, Cheniere phase soils at low elevations make up 60 percent of the association (General Soil Map, Cameron Parish, 1971). The Palm Beach soils at higher elevations are well drained and make up 20 percent of the association. Construction could, in localized areas, decrease the internal drainage characteristics of this member by altering soil characteristics.

Soil at the Sun terminal consists of material excavated from canals, ditches and waterways (Crout, et. al. 1965). Construction at the terminal site would not result in significant alteration of the existing soil conditions.

C.3.1.1.3 Stratigraphy, Geologic Structure, and Mineral Resources

There would be no impacts to stratigraphy or geologic structure during construction at the West Hackberry storage site, along any of the pipeline routes or at the terminal and dock facilities. It is understood that part of one structural/stratigraphic element (the salt dome) would be removed during cavern construction, but this does not alter the description of stratigraphic or structural conditions. Construction activities at the storage site would not have an impact on the availability of oil produced along the flanks of the West Hackberry dome. No mineral extraction is occurring within the area of proposed expansion; therefore, there would be no construction impacts on salt or sulfur mining.

C.3.1.2 Water*

Site preparation and construction at West Hackberry would produce certain impacts on the water environment. Subsequent discussion dealing with these impacts is organized in two parts as follows:

- Surface Water
- Subsurface Water

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*The description of impacts under the heading Water is generally limited to changes in the physical and chemical characteristics of the water. Biological impacts resulting from such physical/chemical changes are presented in the Species and Ecosystems, Section B.3.1.5. This same procedure is used for the three alternative sites.

C.3.1.2.1 Surface Water

Withdrawal of Leaching Water from the Intracoastal Waterway

No significant impacts on the supply or availability of surface water would result from withdrawal of water for the leaching operation associated with the creation of new caverns. The withdrawal would also have little effect on either the supply or quality of surface water. The proposed point of withdrawal would be on the south side of the ICW, 3.5 miles east of Goose Lake, with a withdrawal rate of 1.03 million bpd (barrels per day) or 30,000 gpm (gallons per minute), and would extend over 1140 days (38 months).

The impact from the withdrawal of leaching water should be slightly less than that due to the withdrawal of water for displacement. During the leach water cycle, 1.03 million bpd would be withdrawn to create new caverns at West Hackberry. Later as oil is displaced for the West Hackberry and Sulphur Mines sites, the maximum intake rate of 1.47 million bpd would be utilized. Based on predictions of the MIT Water Quality Network Model (Harleman et al, 1976), as described in Appendix D.14, this flow rate would alter flow velocities throughout the ICW by 0.03 ft/sec or less.

Based on the same model during the 150-day withdrawal process the increases in salinity would be small in the ICW and would be similar for both sets of salinity regimes given in Appendix D.27. The dual salinity regimes were used to approximate the seasonal salinity variations of the ICW near the withdrawal point. The maximum salinity increase observed in the vicinity of the withdrawal point was less than .05 ppt. The maximum salinity increase at any location in the ICW was less than 1 ppt. A detailed description of salinity increases along the entire waterway under the two sets of boundary conditions is presented in Appendix D.27.

Withdrawal of Leaching Water from Black Lake

If water were withdrawn from the alternate intake location on Black Lake, this would affect both the supply (or availability) and quality of surface water in the lake. The point of withdrawal, as indicated in Figure C.3-1, would be on the south side of Black Lake about 2000 feet west of Black Lake Bayou.

If Black Lake served as the sole source of leaching water, and if the lake were completely isolated from other water bodies the withdrawal rate previously noted would lower the water level of the lake 6.05×10^{-2} ft/day (as explained in Appendix D.12). Because the lake is connected with both Calcasieu Ship Channel via Black Lake Bayou and with the ICW

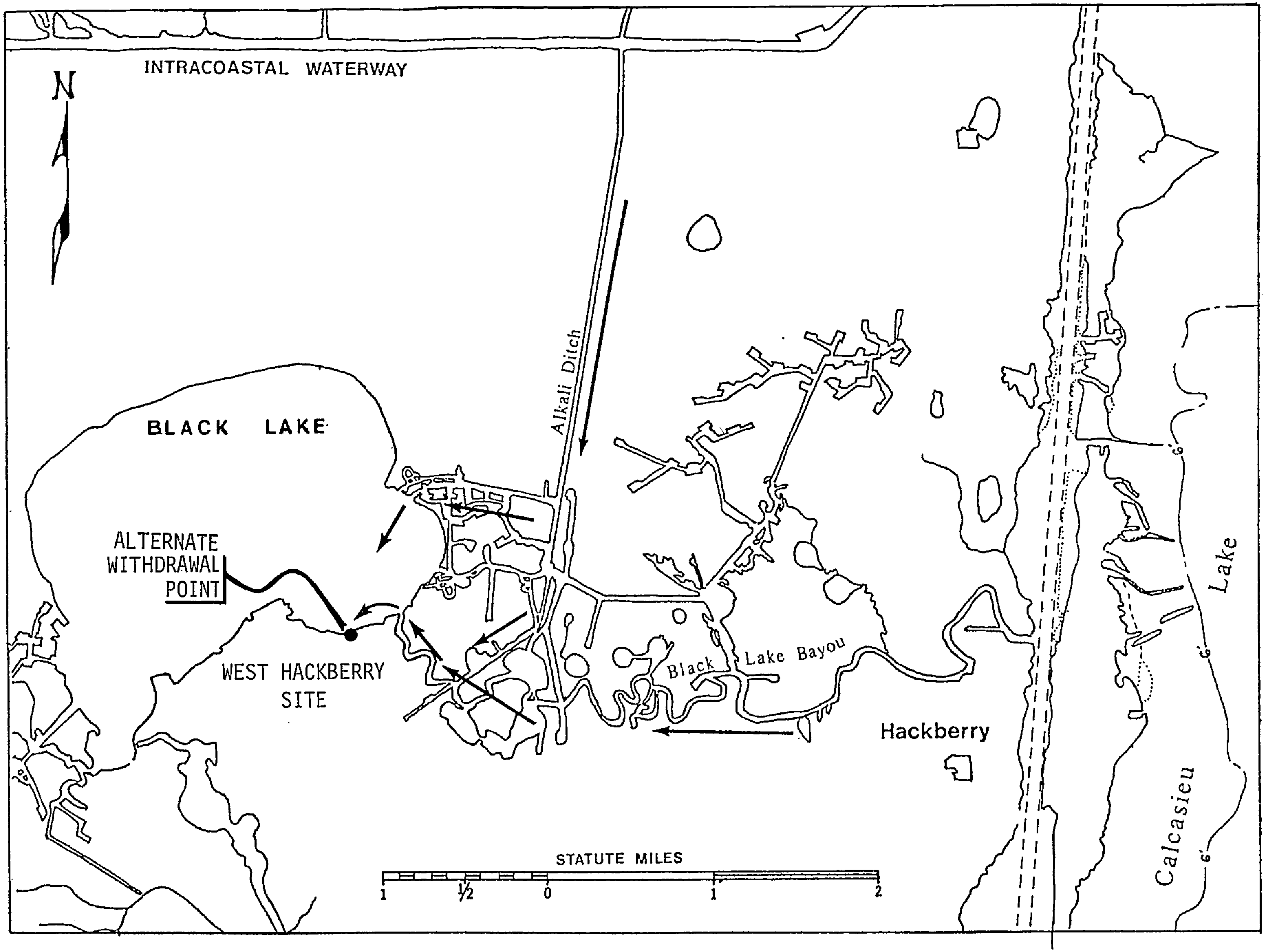

Figure C.3-1 Induced Currents in Surface Water Systems resulting from the use of the Black Lake (alternate) Water Withdrawal System.

(Intracoastal Waterway) via Alkali Ditch, the actual rate of all of water would be much less than the value noted. As indicated in Figure C.3-1, induced currents in both the bayou and the ditch would serve to replenish the water withdrawn from the lake. Thus, essentially all the replenishment water would actually come indirectly from the Calcasieu Ship Channel or the ICW.

In order to predict the impact of the withdrawal process for leaching water on the surface water system, a numerical solution of the equations governing the flow of water in an estuarine system must be obtained. The MIT Water Quality Network Model has been used for this purpose. To reduce the amount of computation, however, the model has been set up only for the case of withdrawal of water for displacement purposes, as discussed in Section C.3.2.2.1. Because the withdrawal rate during leaching is less than that during displacement, the effects during leaching should be less than those during displacement.*

Based on the model results presented in Section C.3.2.2.1, and in Appendix D.12 the withdrawal of leaching water would depress the level of Black Lake less than .17 feet. Induced flow effects in Black Lake Bayou would produce current changes of less than .13 ft/sec while in Alkali Ditch such changes would amount to less than .11 ft/sec. Because more of the replenishment water entering Black Lake would be supplied via Alkali Ditch (which connects with the Calcasieu Ship Channel), the salinity in Black Lake would decrease during the withdrawal process. A decrease in salinity in Alkali Ditch and in that portion of Black Lake Bayou between Black Lake and Alkali Ditch would also be expected. In that portion of Black Lake Bayou between Alkali Ditch and Calcasieu Ship Channel, the salinity would increase due to more salty water being drawn from Calcasieu Ship Channel. The maximum increase in salinity in this reach of the bayou would be less than 3.2 ppt.

None of the predicted impacts on water level or salinity resulting from the withdrawal of leaching water under normal environmental conditions appear significant. Under special conditions involving wind-driven tides, as described in Section C.3.2.2.1, the combined effect of withdrawal and a depressed water level could prove significant for a period of a few days, in portions of the lake less than one foot deep.

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*The leaching process occurs over a longer period of time but the changes in salinity, water depth and flow velocity would be less than those produced by the withdrawal of displacement water.

In addition to changes in water level or salinity, certain other potential impacts exist. Water quality for the Calcasieu Ship Channel has been discussed in Section B.3.1.2.1. As indicated in Table B.3-3 near the mouth of Black Lake Bayou* the water in the channel exceeded the EPA numerical criteria** for phenols, mercury, and phosphorus. In addition, the level of oil and grease at the Corps of Engineers sampling stations (see Appendix D) was excessive. The numerical EPA criteria for oil and grease are given in terms of LC_{50} values which at this time have not been defined. To the extent that Calcasieu Ship Channel serves as a secondary replenishment source for Black Lake, a portion of such contaminants in the channel would be transported via Black Bayou into Black Lake.

The ICW represents the primary replenishment source via Alkali Ditch. The limited water quality data for the ICW indicates that the levels of phosphorus, arsenic, mercury, toxaphene, lindane, heptachlor, aldrin, chlordane, dieldren, endrin and O, P'-DDT exceed the EPA numerical criteria**. In addition, the level of oil and grease, heptachlor, epoxide, methoxychlor, P, P'-DDT, O, P'ODDE, P,P'-DDE, O,P'-DDD and p,p'-DDD pose possible problems. Because the ICW would be the primary replenishment source for Black Lake, the contaminants previously noted would be introduced into the lake via Alkali Ditch.

Withdrawal of Leaching Water from Calcasieu Ship Channel

The Calcasieu Ship Channel has also been proposed as an alternate source of leaching water for the West Hackberry site. The approximate location of the withdrawal point is shown in Figure C.3-2. The impact of such withdrawal should be less than that occurring during the displacement process (which is described in Section C.3.2.2.1 and Appendix D.13) because the rate of withdrawal during leaching is less than that during displacement.*** Based on the results presented in Section C.3.2.2.1 the surface height of the Calcasieu Ship Channel in the vicinity of the withdrawal point would be reduced less than .01 feet. Induced flow effects in Calcasieu Ship Channel due to withdrawal would be insignificant. Likewise in Calcasieu Lake induced flow velocities would be small, with maximum change amounting to less than .02 ft/sec. In West Cove, velocities changes would be less than .03 ft/sec.

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*The mouth of Black Lake Bayou is located between Sample Station 7 and Mile 16.5 as shown in Figure D.4-1.

**For marine aquatic life - given in Appendix D.3.

***The leaching process occurs over a larger period of time, but the changes in salinity, water depth and flow velocity should be less than those produced by the withdrawal of displacement water.

In essentially all portions of Calcasieu Ship Channel, Calcasieu Lake, and West Cove the change in salinity would be small. Actually, as described in Section C.3.2.2.1 during the 150-day withdrawal process the salinity decreased or remained essentially constant throughout most of the water system. The salinity decreases are generally not considered to be the result of the withdrawal operation, but are primarily due to the presence of nonequilibrium conditions existing in portions of the water bodies at the time the withdrawal process commenced.

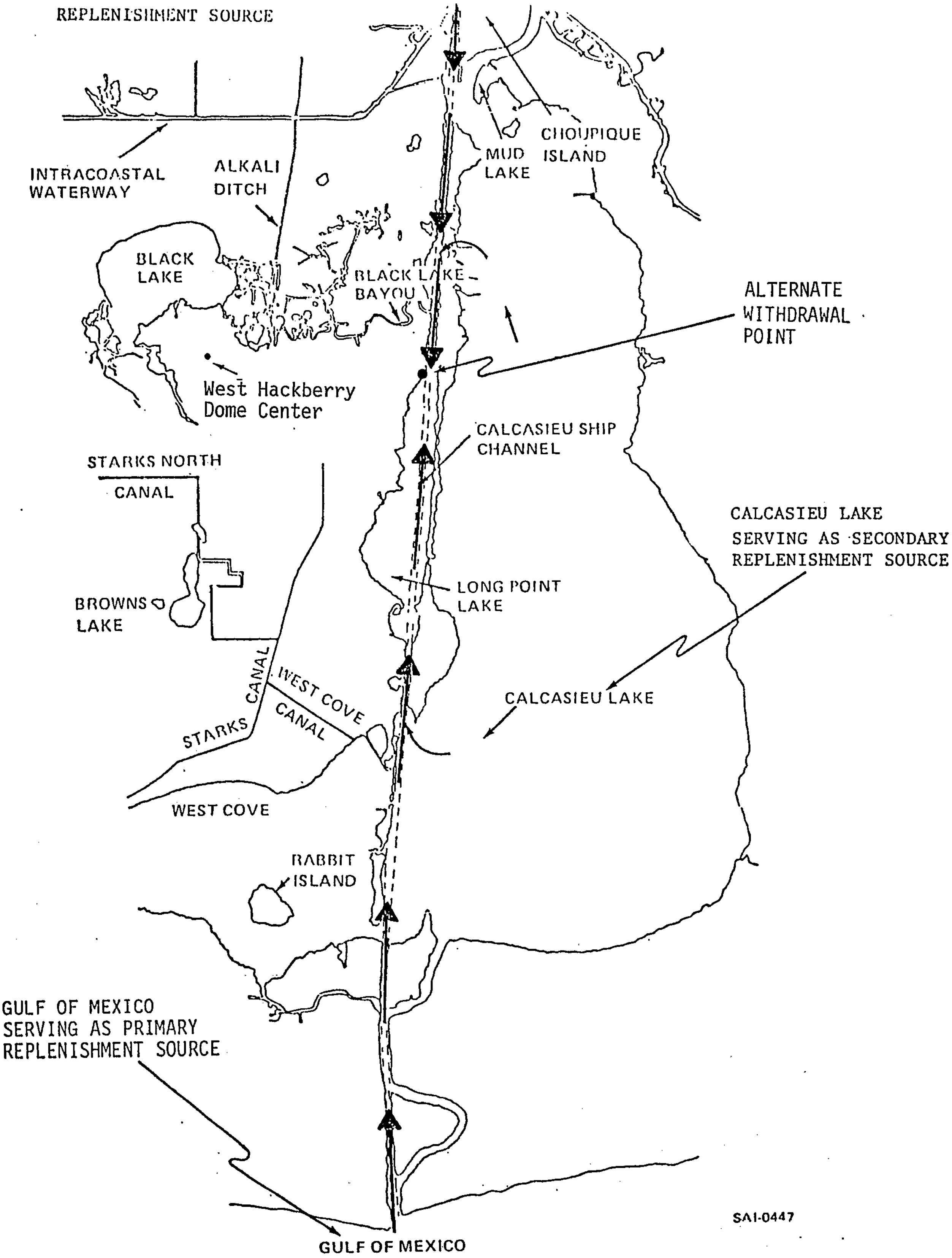

Figure C.3-2 Induced Flow Produced by Withdrawal of Water from Calcasieu Ship Channel

Brine Disposal

During the leaching process at West Hackberry, 230 ppt brine would be discharged at a maximum rate of 1.03 million bpd or 30,000 gpm for a period of 1140 days. Current design calls for the disposal of the brine by means of discharge into the Gulf of Mexiso. The general disposal area in the Gulf, along with the brine pipeline route leading from the West Hackberry site to the Gulf, is indicated in Figure C.3-3.

Brine Diffuser Design

Based on environmental conditions in the disposal area, plus operational requirements and engineering limitations, the following specific criteria for the brine diffusers have been proposed (NOAA; 1977):

- diffuser location - approximately 7 miles South of Holly Beach, Louisiana
- depth of water - approximately 30 feet
- diffuser length - 3070 feet
- diffuser orientation - perpendicular to coast
- number of diffuser ports - 52
- distance between ports - 59 feet
- diameter of ports - 3 inches
- orientation of port riser - 90° to ocean bottom
- port exit velocity - 25 ft/sec

Brine Plume Predictions

With the preceding basic diffuser design and under various ocean current conditions, a series of test cases were conducted as described in Appendix D.25. The following discussion details the results of (1) the initial model runs based on literature and regional data, and (2) later results based on actual site specific oceanographic and meteorological data.

As discussed in the appendix, the base case involved a non-tidal current cycle with a period of 96 hours, a maximum upcoast (eastward) current of 0.5 ft/sec and a maximum downcoast (westward) current of 1.0 ft/sec. The resultant predicted farfield excess salinity contours, corresponding to the end of the 21st hour of the fourth current cycle, are presented in Figures C.3-4, C.3-5, and C.3-6, for the bottom, mid-depth and surface planes respectively. As might be expected, due to the negative buoyancy of the brine plume, the excess salinities are greatest in the bottom plane and become progressively smaller with height above the bottom. The resultant predicted farfield excess salinity contours, corresponding to the end of the 93rd hour of the 4th cycle are presented in Figure C.3-7. The contours at this point appear to be circular in shape, reflecting the near-completion of one cycle.

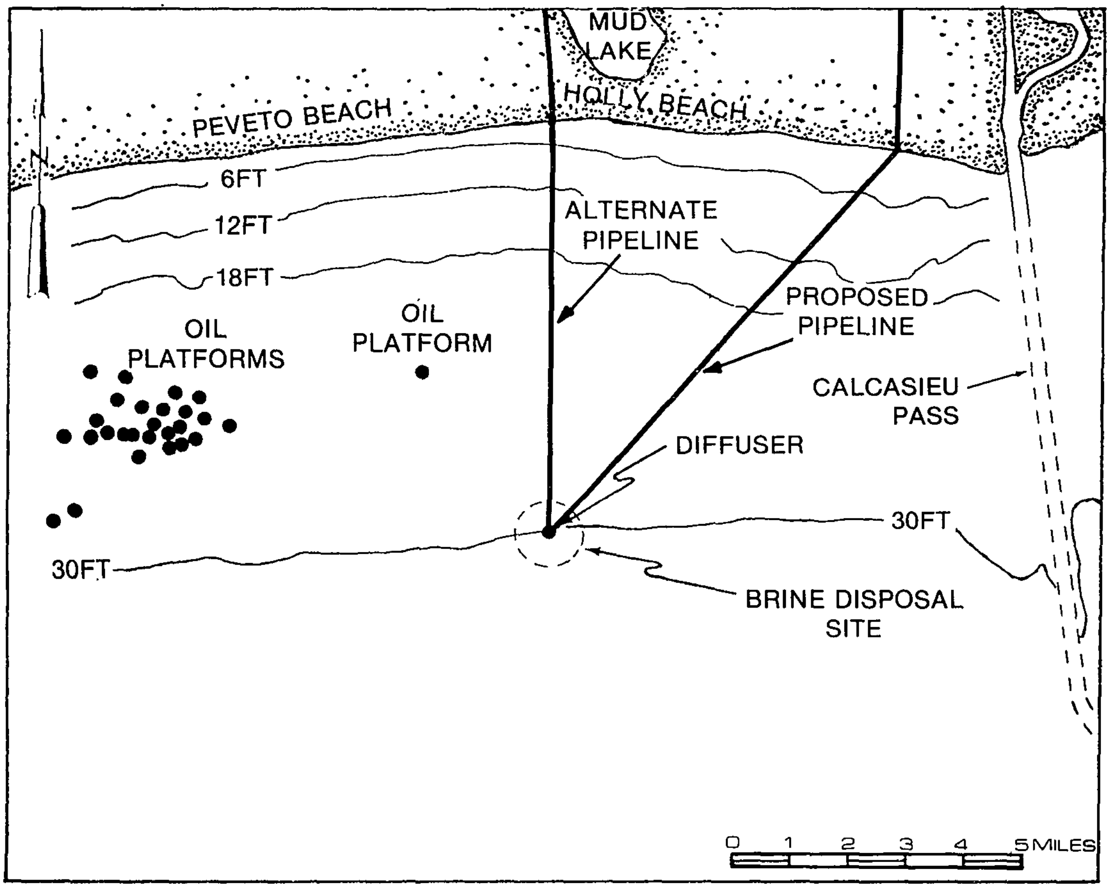

Figure C.3-3 BRINE DISPOSAL SITE FOR WEST HACKBERRY

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Fig. C.3-4 Predicted Far Field Excess Salinity (ppt) Calculation at Bottom H=30 ft Base Case

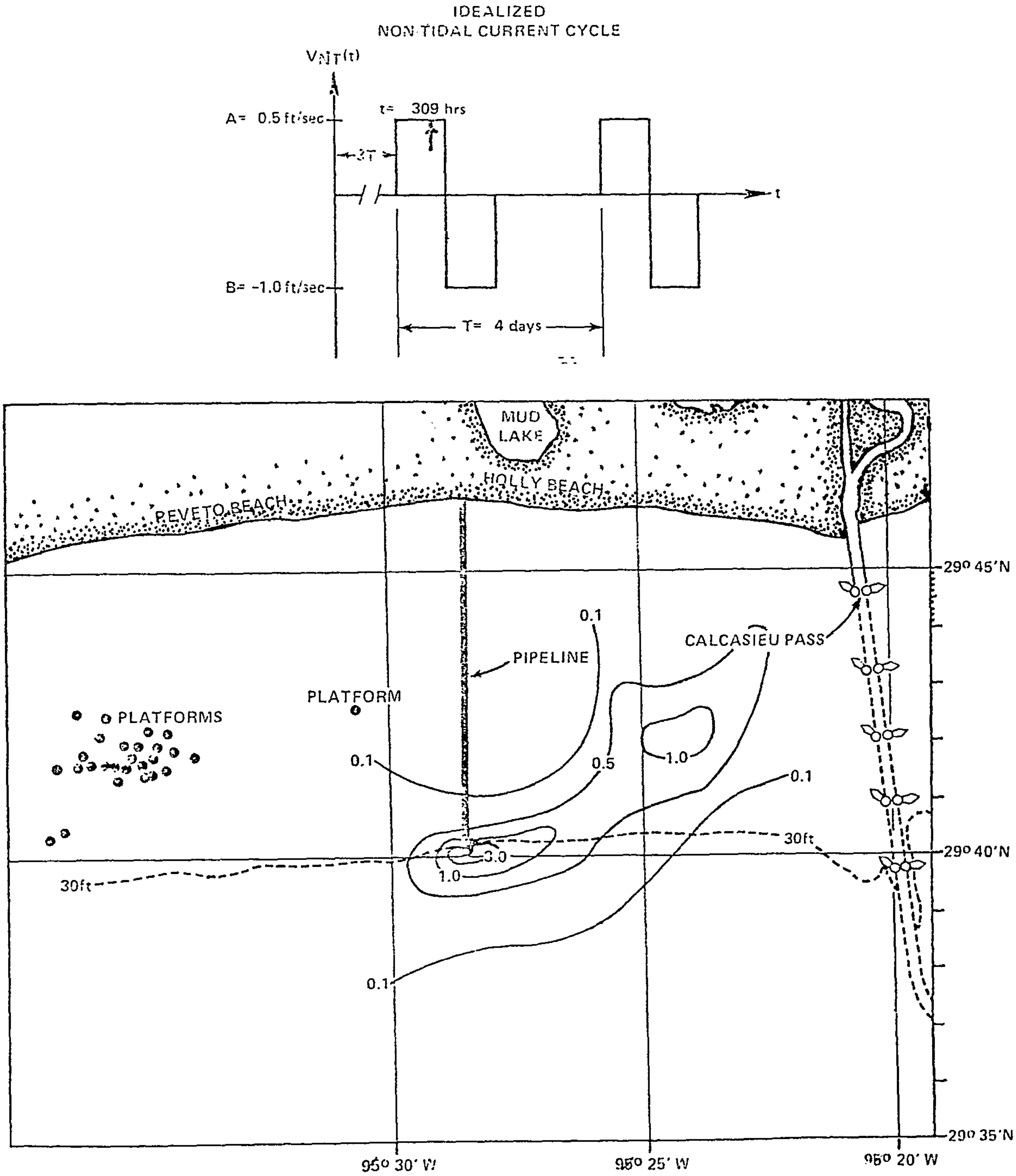


Fig. C.3-5 Predicted Far Field Excess Salinity (ppt) Calculation
at Mid-depth H=30ft
Base Case

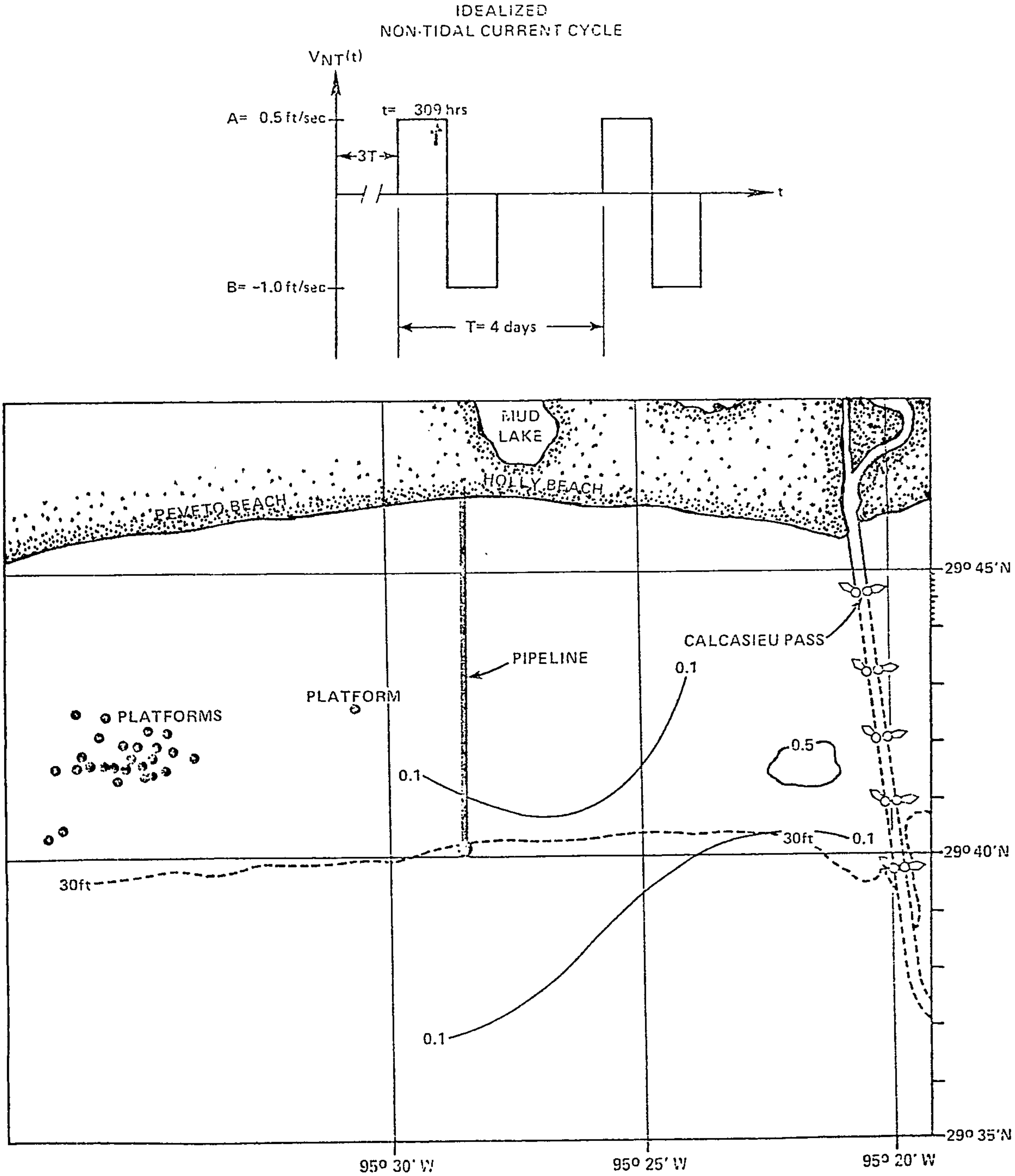


Fig. C.3-6 Predicted Far Field Excess Salinity (ppt) Calculation at the Surface H=30ft
Base Case

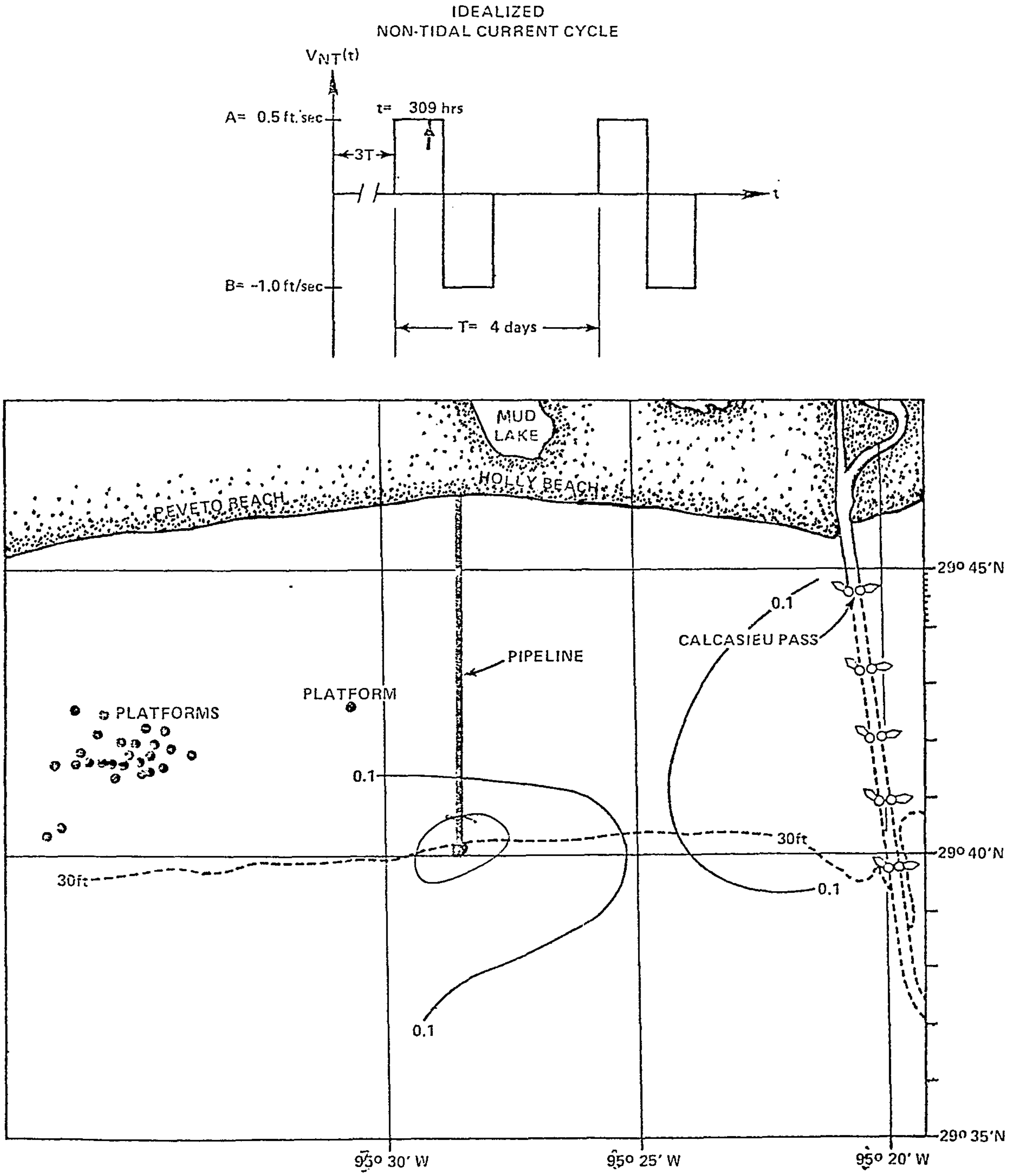
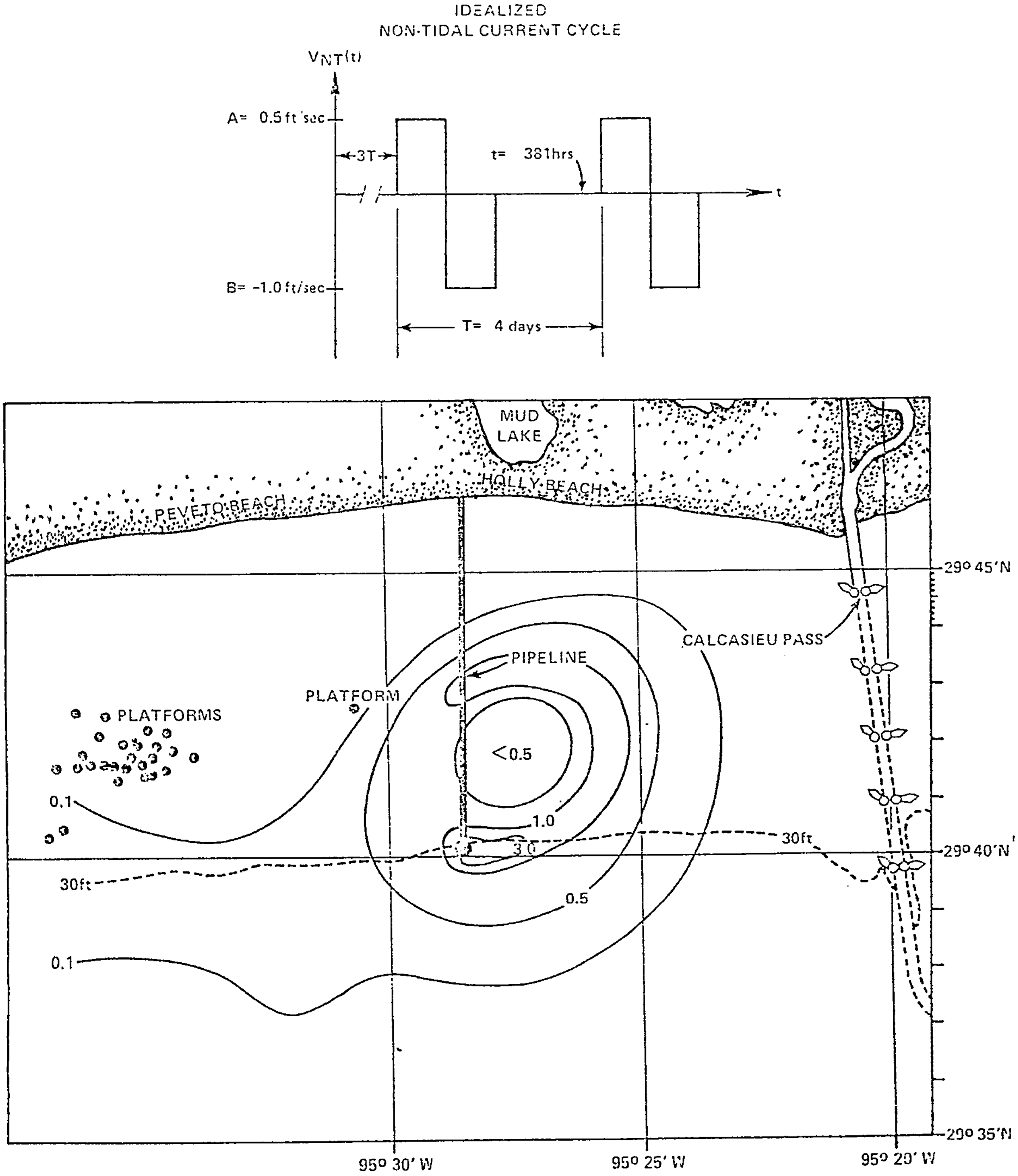


Fig. C.3-7 Predicted Far Field Excess Salinity (ppt) Calculation at Bottom H=30 ft Base Case



The variation of exposed bottom area with excess salinity level for the base case is presented in Figure C.3-8. As indicated in the figure, an area of approximately 5.2 x $10^7 ft^2$ (1200 acres) would be exposed to salinities in excess of 1 ppt. The variation of exposed bottom area with excess salinity under stagnation conditions is presented in Figure C.3-9. As expected, for any given salinity level a larger bottom area is involved, with approximately 1.6 x $10^8 ft^2$ (3700 acres) exposed to salinities in excess of 1 ppt.

In addition to the runs with the MIT model based on estimated currents, runs were made with the model based on oceanographic and meteorological data gathered in a field study (September-February 1977) conducted for this EIS. The results from these runs are detailed in Appendix U.2. These results largely confirm the qualitative findings of the earlier analyses. In general salinity plume orientations are east-west (alongshore) and most likely drifting to the west. No more than 1860 and 207 acres would experience salinities greater than 1 and 3 ppt as a typical case.

Brine-Seawater Chemical Interactions

Items which relate to the magnitude of impacts with the disposal area include:

- salinity increases
- temperature increases
- brine composition
- changes in calcium to magnesium ratio
- heavy metal concentration increases
- changes in chemical speciation

Salinity increases have been predicted and excess salinity contours presented in the preceding subsection (NOAA, 1977). The problems of "salinity shock" produced by large salinity increases over very short time periods are of a concern. Temperature increases are also a potential concern. However, use of a brine pond or alternate holding system would reduce brine temperature to essentially ambient seawater temperature at the disposal site.

Actual brine composition would be determined at the time when the leaching process begins. Prediction of the brine composition from existing data on leach water and salt compositions has been performed using the approach given in Figure C.3-10. Results appear in Appendix D.15, in the forms indicated in the figure. The prediction was made using the MINEQL chemical equilibrium model described in the same appendix.

Changes in free unbound concentrations of seawater components at various excess salinity contours from 10 to 159.4 ppt have been predicted for calcium and magnesium as well as other components including the heavy metals and data presented in Appendix D.15. Model predictions of the chemical speciation of seawater and seawater-brine mixtures corresponding to a set of excess salinity contours are given in the same appendix.

Fig. C.3-8 Bottom Impact Areas (ft²) vs Excess Salinity (ppt)
at Various Times for Run 7.
Base Case

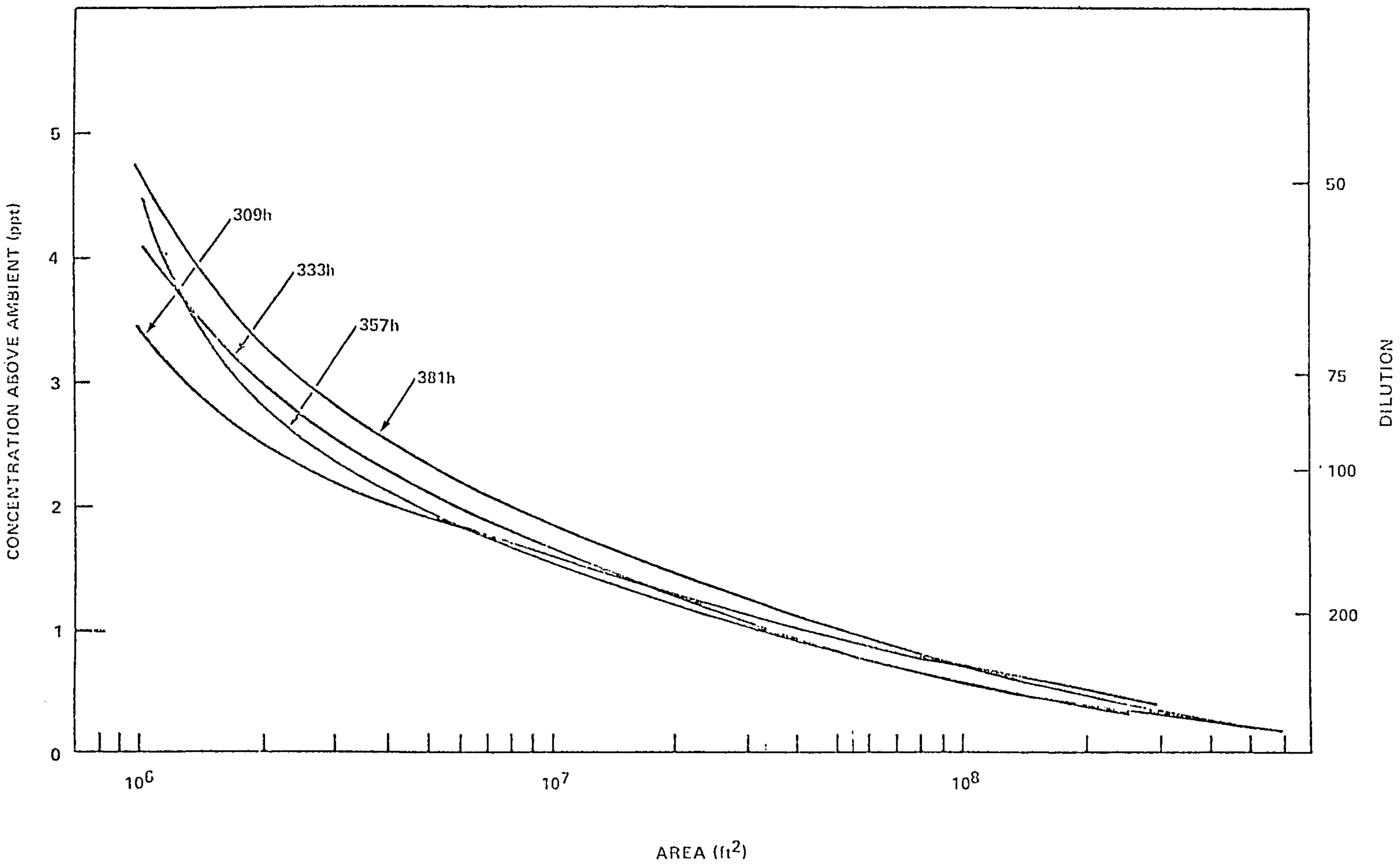


Fig. C.3-9 Bottom Impact Areas (ft²) vs Excess Salinity (ppt) at Various Times for Run 8. 16 Day Current Cycle

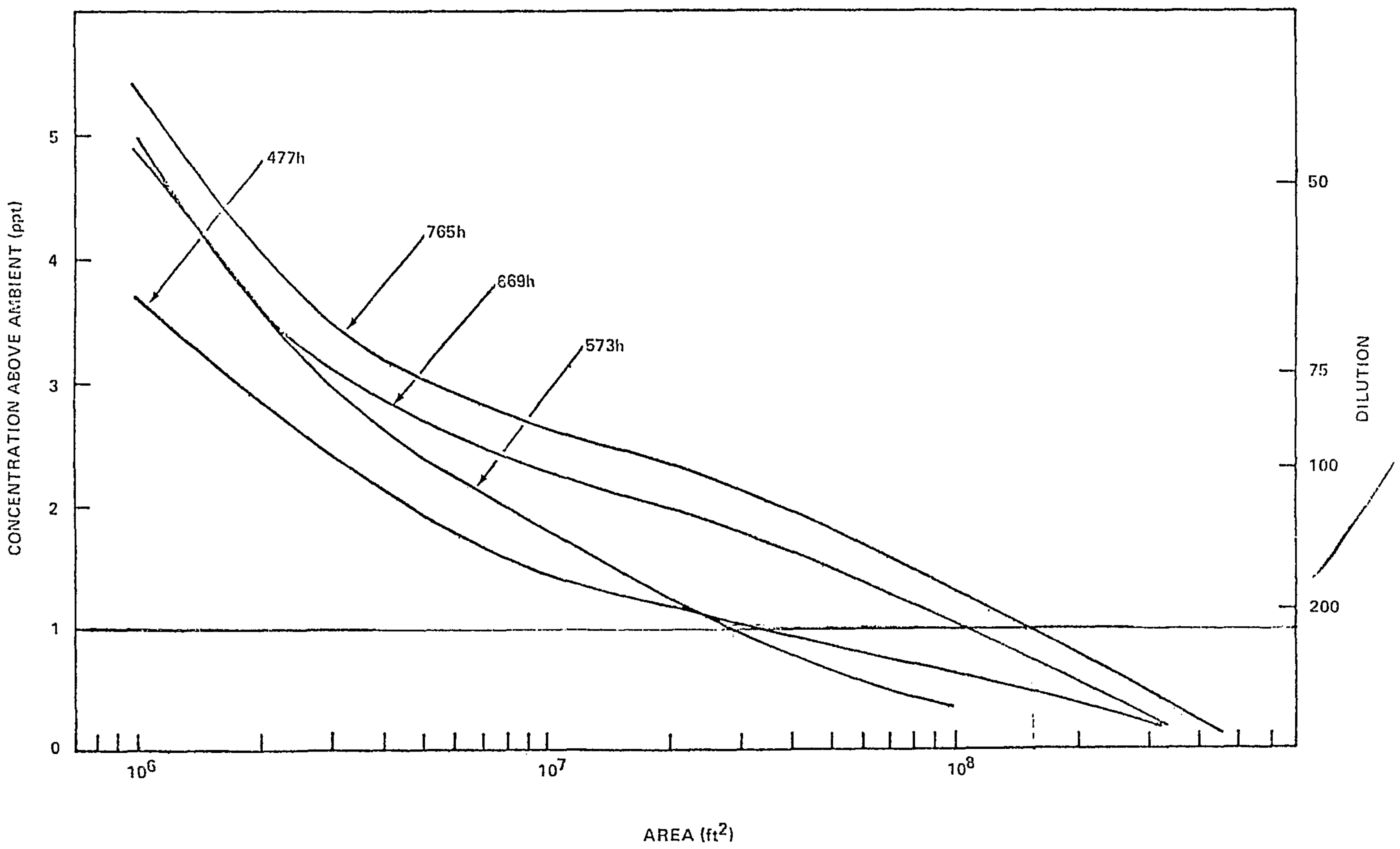
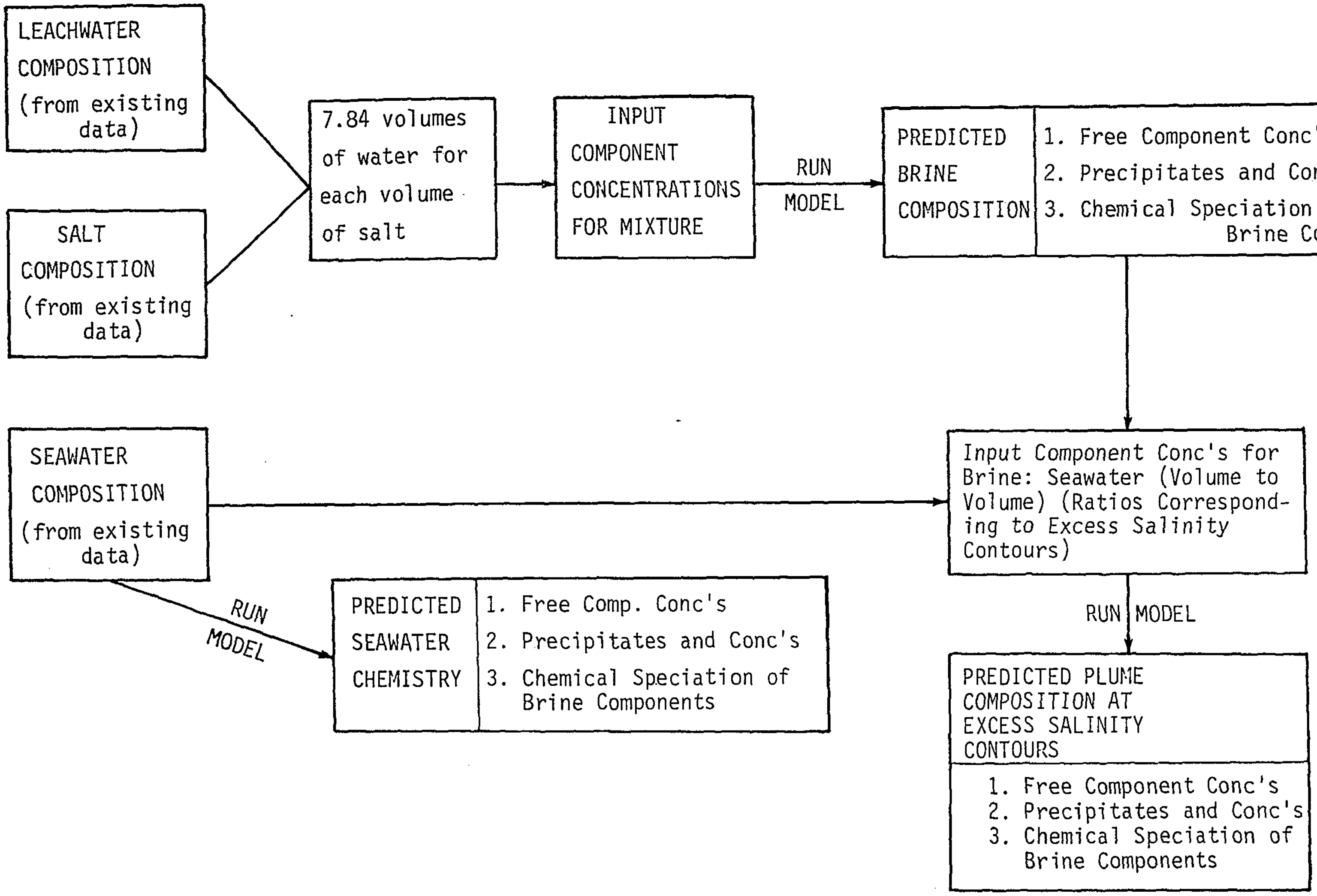


Fig. C.3-10 SCHEMATIC DIAGRAM OF INTERACTION STUDY INPUTS AND RESULTS



Environmentally significant changes in chemical composition predicted to occur in brine-seawater mixtures include:

- Ratio of free concentrations of magnesium and calcium remained relatively constant with changes in the excess salinity.
- Free concentrations of heavy metals generally declined with increasing excess salinity.
- Speciation of the heavy metals changed with increasing excess salinity to give greater amounts of chloro-complexes and other soluble species.
- The types of precipitates remained relatively constant across the excess salinity scale with concentrations of most precipitates increasing with salinity increases.

These predictions dictate a number of conclusions:

- Changes in calcium to magnesium free concentration ratios appear to be small. This is significant because changes in this ratio can be detrimental to marine organisms.
- The availability of heavy metals to marine organisms may be increased or decreased by predicted formation of chloro-complexes at higher salinities.
- The number and types of precipitates predicted remained essentially constant as the excess salinity increased with increasing amounts of most precipitated compounds at higher salinities.

Impacts from the brine disposal would consist chiefly of the effects of the gross salinity increases within the brine plume, with the rate of salinity increase being an important factor (see discussion of the ecological impacts). Only minimal impact should be felt from concentration or speciation changes of the heavy metals. Free component concentrations of magnesium and calcium are predicted to vary only slightly with increasing salinity suggesting that the calcium to magnesium ratio would not change appreciably (assuming free forms are the most important biologically). Formation of increased amounts of dissolved and precipitated solids would occur. Most of these solids would tend to have an affinity for the surface of existing particulants causing particulate growth of an undetermined amount. Formation and possible settling of these particulants could have an influence on the sessile marine life in the disposal area (See ecological impacts).

Dredging Operations

The construction of an additional docking facility at the Sun Oil Terminal on the Neches River would require a significant amount of dredging. Dredging operations would also be necessary in laying pipelines for the transport of raw water, oil, and brine. Such pipelines would cross a number of different water bodies including:

- Sabine River
- Neches River
- Cow Bayou
- Black Bayou
- Black Lake
- Stark's Canal First and Second Bayou, and Hog Island Gully
- Calcasieu Ship Channel
- Marshes

The impacts on the Sabine River, Neches River, Cow Bayou, Black Bayou, and Black Lake, resulting from dredging operations related to the laying of the oil pipeline from West Hackberry to the Sun Oil Terminal, have been discussed in an earlier document (FEA, 1977). For the sake of brevity, subsequent discussion is limited to dredging operations which were not covered by the earlier document. The impacts which may result from these operations are listed in Table C.3-1. See Table C.3-2 for a summary of dredging information and expected impacts for the West Hackberry site expansion.

Dredging in the Neches River. The proposed new docking facility at the Sun Oil Terminal would require dredging and disposal of close to 2,000,000 cubic yards of sedimentary material. Hydraulic dredging would be used. At the site of the dredging activity, there would be an inevitable increase in turbidity* as a

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*Turbidity is a measure of the amount of light that will pass through a liquid and describes the degree of opaqueness produced by a suspended particulate material. In contrast to turbidity, measurement of suspended solids quantifies the actual amount of particulate material in the water.

TABLE C.3-1

GENERAL IMPACTS ASSOCIATED WITH DREDGING OPERATIONS

Impact	Major Controlling Factors
(1) Turbidity Increase	Type, number and size of dredges in operation. Skill of dredge operators. Duration of dredge operation. Bottom sediment characteristics. River flow conditions.
(2) COD Increse/DO Decrease	COD content of bottom sediments.
(3) Release of Aquatic Nutrients/Creation of Eutrophic Conditions	Phosphorus and nitrogen content of bottom sediment.
(4) Release of Sulfides	Amount of sulfides (from sour crude oils) in sediment.
(5) Release of Pesticides and/or Toxic Hydrocarbons	Content of pesticides and petrochemicals in the bottom sediments. Nature and composition of bottom sediments.
(6) Toxic Metals	Levels of toxic metals in the sediment and the water column. Concentration of substances which can complex and/or precipitate these metals. (Such as sulfides or sulfates)
(7) Loss of Wetlands Habitat	Amount controlled by volume of spoil, density (densification of spoil) and stacking depth in disposal areas

TABLE C.3-2

SUMMARY OF DREDGING INFORMATION AND EXPECTED IMPACTS OF DREDGING FOR THE WEST HACKBERRY SITE EXPANSION

Location	System*	Amount of Dredged Material (yd^3)	Dredge** Type	Expected*** Impacts
Neches River	Terminal (dock)	2,000,000	H	all (1-7)
Marshes	BDP (proposed)	790,000	B	(1),(2), & (3)
Calcasieu Lake & West Cove	BDP (proposed)	407,000	B	(1) & (2)
Long Point Bayou	BDP (proposed)	2,000	B	(1) & (2)
West Cove Canal	BDP (proposed)	1,000	B	(1),(2), & (3)
West Fork	BDP (proposed)	64,000	B	(1),(2), & (3)
Unnamed Bayou	BDP (proposed)	10,000	B	(1),(2), & (3)
Starks Canal	BDP (alternate)	1,500,000	B	(1),(2), & (3)
First Bayou	BDP (alternate)	5,000	B	(1) & (2)
Second Bayou	BDP (alternate)	5,000	B	(1) & (2)
Hog Island Gully	BDP (alternate)	5,000	B	(1) & (2)
Marshes	BDP (alternate)	---	B	(1),(2), & (3)
Black Lake	RWP (proposed)	111,000	B	(1),(2), & (3)
ICW	RWP (proposed)	5,000	B	all (1-7)

*BDP is a brine disposal pipeline. These will be used in later tables.
RWP is a raw water pipeline.
** H represents Hydraulic Dredging, B represents Bucket Dredging.
*** Numbers refer to numbered list of general impacts in the preceding table.

result of the turbulence created by the dredge. If the bottom sediments are polluted, the release of a fraction of these pollutants during dredging cannot be avoided. Thus, the probable severity of the impact must be established. Most researchers have concluded that the dredging operation, using modern techniques, has little long-term effect on the water overlying the sediments (Slotta and Williamson, 1974; Windom, 1972; Windom, 1975; May, 1973; Saila, et al, 1971). This appears to be the case even when the sediments are highly polluted. These investigators report that some dredging activities increase water turbidity and other parameters to a very minor degree up to a mile from the dredge site under certain conditions. Of primary concern is the possibility of (1) an increase in turbidity, (2) a reduction of dissolved oxygen due to the increase of chemical oxygen demand for the oxidation of dredged materials, (3) the release of aquatic nutrients, (4) the release of toxic sulfides, (5) the release of pesticides or nonpesticide toxic hydrocarbons, and (6) the release of toxic metals.

(1) Turbidity

The physical composition of the bottom sediments in the vicinity of the dredging site is probably sandy, with clay, silt, and organic debris also present. The variation of settling velocity* with type of sediment is shown in Figure C.3-11. As indicated in the figure, a clay particle with a diameter of 2µm would have a settling velocity of approximately 0.003 mm/sec, compared to o.3 mm/sec for a silt particle with a diameter of 20µm, and 20 mm/sec for a fine sand particle with a diameter of 200µm. The period of time in individual particle remains in a turbidity plume and the distance downstream the particle is transported while in the plume are both approximately inversely proportional to the settling velocity. Thus a turbidity plume composed of clay particles could in theory persist for a distance of several miles, while a plume composed of sand particles might extend less than 10 feet.

Hydraulic dredges use revolving cutterheads and cause some localized turbidity. However, a large percentage of the sediment-laden water near the operating cutterhead is sucked into the dredge and discharged with the dredge material into the disposal area. The size and duration of the turbidity plume would depend upon the number and size of the dredges operating in the area, the skill of the dredging operators, the length of time during which dredging occurs, bottom sediment characteristics, and river flow conditions. A measurable increase in turbidy would be expected at a distance

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*Settling velocity is the maximum downward speed a particle would achieve if released in a body of water and permitted to fall without restrictions.

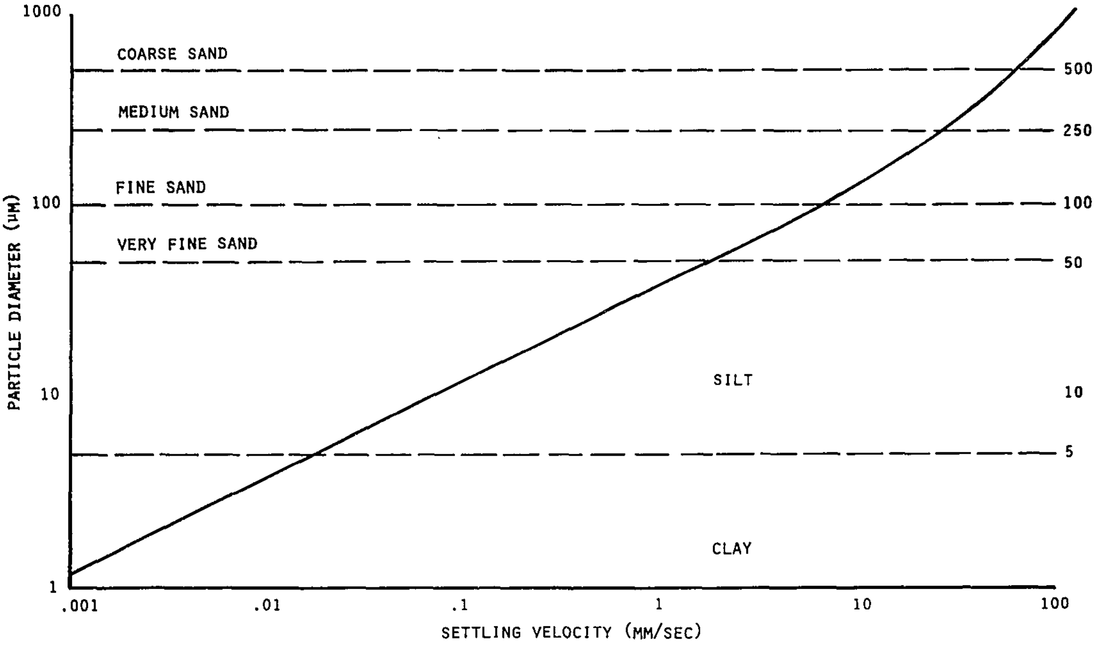

Figure C.3-11 Variation of Settling Velocity with Particle Diameter distance as great as one mile downstream from the dredging site. Dredging is projected to occur over a period of up to two months. The last of the larger suspended particles would settle out soon after dredging ceases, probably within a few minutes. Silt and clay particles might be suspended or perhaps resuspended for longer periods. Clay is likely to be a major component of the dredged spoil since the dredging would extend to depths as great as 47 feet. The clay particles would be transported halfway down into the Sabine Lake. Eventually, through ebb tides, a portion of the sediment would be transported into the Gulf. The time required for movement of material into the Gulf is unknown. Such increases in turbidity should have little if any adverse long-term impact on water quality of the surface water system. Sabine Lake has been and is presently the recipient of much dredge spoil along its western edge (Slotta and Williamson, 1974).

(2) Dissolved Oxygen

The COD of the sediment was in excess of recommended criteria in two of three samplings, Table D.5-9. Additional samples before and during dredging also indicate that dissolved oxygen concentration temporarily decreases when dredging takes place. This decrease occurs because many materials in the sediment are readily oxidized, thus consuming the dissolved oxygen in the water. These results indicate that the dredging operation associated with the program would very likely increase the COD in the water column.

(3) Aquatic Nutrients

During dredging the possible release of phosphorus and various forms of nitrogen (nitrates, nirites, and ammonia) is a concern. The release of these materials can induce unfavorable changes, especially in estuarine water bodies. They tend to encourage the growth of a large aquatic biomass, typical of euthropic* conditions. There is no data on phosphorus for the sediment, but the Total Kjeldahl Nitrogen (TKN) has been measured as shown in Table D.5-9. The TKN in the bottom sediment as indicated in Table B.3-8 exceeds the unofficial recommended criteria.

(4) Sulfides

Sulfides can come from many sources, and are particularly prevalent in sour crude oils as H_2S. High levels of oil and grease were detected in the sediment, as noted in Section B.3.1.2. These oil and grease contaminants may be derived in part from

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*Eutrophic refers to the condition of a water body which is rich in dissolved nutrients but often shallow and with a seasonal oxygen deficiency.

sour crude oil, and in such a case some sulfides would be present and could produce an increase in the concentration of sulfides in the water during dredging operations. As discussed in paragraph (6) on toxic metals, however, such sulfides in the presence of heavy metals tend to form insoluble salts. The formation of insoluble salts would tend to reduce the level of sulfides, possibly offsetting the increase resulting from the presence of sour crude oils. Anoxic conditions in the water system can produce identical results.

(5) Pesticides and/or Toxic Hydrocarbons

There is little agricultural activity near the reach of the river under consideration; thus, extensive use of pesticides probably has not taken place. Water quality data for Sabine Lake indicate general absence of pesticides. For this reason the bottom sediment is probably not polluted with pesticides. The release of pesticides into the water column due to dredging is therefore unlikely.

The heavily industrialized Port Arthur-Beaumont region, which is primarily petrochemically based, is probably responsible for the high oil and grease values in the sediment samples of Table D.5-9. The presence of high oil and grease values suggests that other crude oil constituents and waste water pollutants such as PCB's and phenols could be present. The dredging operations could potentially release some of these into the water column.

(6) Toxic Metals

As already noted in Table B.3-7, the water quality data in Table D.5-9 indicates the levels of cadmium and mercury were in excess of the suggested EPA criteria. Levels of copper and lead also pose possible problems. The sediment tests taken at the same time indicated that the levels of TKN, COD, oil and grease, and zinc were in excess of the unofficial recommended criteria (Slotta and Williamson, 1974). In the data taken six months later (Table D.5-9), however, when the river flow rate was increased significantly, the cadmium concentration in the water was well within the EPA criteria both before and during the dredging operations. The zinc and copper levels were not measured during the same time period. It was also observed that during dredging operations the levels of nickel and chromium increased while the concentrations of lead, cadmium and mercury actually decreased in the water, in comparison to the levels measured before dredging operations started. The latter is characteristic of "heavier" metals (lead and mercury), which are generally less soluble, and are adsorbed on the suspended solids' active surfaces or combine with sulfides to form insoluble salts.

The "lighter" metals, like nickel, chromium and zinc, are more soluble and thus less likely to adsorb on the suspended solids. Thus dredging could increase the concentrations of lighter metals, potentially exceeding the suggested values, while the concentration of heavy metals would generally be reduced.

(7) Summary

An increase in turbidity and chemical oxygen demand (resulting in decreases in dissolved oxygen levels) would be expected. A significant portion of the pipeline trench would be dredged through the spoil and shoal areas off the main channel. This portion of the dredging operation would generally release greater amounts of toxic materials. A slight increase in certain "lighter" metals in the water would be expected, but the more toxic, "heavier" metals concentration would be slightly reduced. These effects would reduce* the water quality somewhat during dredging and for a period of several days after the completion of the dredging operations.

Dredging at Stark's Canal, First and Second Bayou, and Hog Island Gully. The alternate brine disposal line (dry land route) would cross First and Second Bayous and Hog Island Gully. These streams all have a depth of less than 2 feet and are 60 feet or less in width. Thus they are scarcely distinguishable from the surrounding marshes. The pipeline burial across these streams would be by push-ditch methods. The impact would be very localized and relatively insignificant (about 5,000 cubic yards of dredged material involved). The specific impacts such as release of toxic materials would be similar to that for the Black Lake dredging operation.

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*Both Texas and Louisiana establish site-specific guidelines governing water quality during dredging, as part of the dredging permit issued by the state. Because such guidelines have not yet been established at the sites discussed in this document, it is not possible to state whether or not the guidelines would be met.

The majority of dredging would be for pipeline burial in Stark's Canal. The pipeline would run along the canal bottom for approximately 15.9 miles. This would involve about 1,500,000 cubic yards of dredged material. However, the dredged material would be returned to the pipeline burial trench, and no wetlands habitat would be permanently lost. The dispersed sediments and any desorbed toxic materials would remain in contact with the water column for a longer period of time than would occur in the rivers. Thus a greater potential for damage to aquatic lifeforms would occur. Major impacts would include effects of dissolved oxygen decreases, turbidity increases and also release of aquatic nutrients.

Dredging in Calcasieu Ship Channel. An alternate brine pipeline route would run from West Hackberry site east to the west bank of the Calcasieu Ship Channel and then south along the spoil banks to the Gulf of Mexico. Whenever possible the pipeline excavations would be on dry spoil bank. However, there are numerous cuts at openings across the spoil areas totaling about 1.1 miles. An estimate of the amount of dredged material would be involved for these crossings is on the order of 1,000,000 cubic yards. The impacts related to the temporary increase in turbidity and temporary decrease in dissolved oxygen would be similar to that for the Neches River dredging. However, the release of toxic materials, (heavy metals such as mercury and industrial pollutants such as phenols) would be expected to be more serious in the Calcasieu Ship Channel. Concentrations of these materials exceed the EPA criteria the Calcasieu Ship Channel elutriates as indicated in Table B.3-4. Thus, some release of toxic materials could be expected due to dredging operations.

Dredging in Marshes. Pipeline construction would require dredging across marshes. The dredging would probably be by a push-ditch method utilizing a dragline mounted on a marsh buggy carriage on a tracked vehicle.

The dredging would be similar to that for crossing of a shallow lake. A narrower ditch would be cut producing less spoil materials. The marsh buggy tracks could produce pronounced changes on the marsh surface, particularly in the areas of floating marsh, where floating vegetation may be permanently damaged.

The resulting turbidity plume and reduction of dissolved oxygen concentrations would be more closely confined to the dredging site than for dredging of a lake or stream. Because of the absence of appreciable currents, the turbidity increase and dissolved oxygen decrease would be intensified in a more localized area. Release of toxic materials into the water column cannot be predicted, as water and sediment quality data for the marshes are not available.

Disposal of Dredged Material. Current designs generally call for disposal in a confined area adjacent to the streams. The land in such areas is primarily marshes. Standard practice would call for retention of excess water by means of a weir* for sufficient time to allow most of the suspended material to settle out. A drainage ditch would channel overflow water from the disposal area back into the bayous or rivers. Thus, in addition to having an impact on the confined disposal area, the disposal operation would also have an impact on the original body of water. Site-specific impacts of the disposal operations are provided in the discussion which follows.

Impact on Neches River Disposal Area

The impact on the Neches River disposal area is assessed by determining how polluted the dredged material is. The level of pollution of the dredged material may be estimated from a study of available sediment and water quality data.

Basic concerns are (1) an increase in turbidity of the water, (2) a significant release of aquatic nutrients, (3) the depression of dissolved oxygen levels, (4) the release of toxic sulfides, (5) the release of toxic metals, (6) the release of pesticides or non-pesticide toxic hydrocarbons trapped with the bottom sediments, or (7) the loss of wetlands habitat. The greatest impact from increased turbidity and suspended solids of the aquatic resources would occur from disposal of the dredged materials. The relative impacts of the suspended solids on the aquatic systems is in part determined by the methods of disposal and the distance the slurry must be piped.

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*A weir is a vertical partition or obstruction in an open channel over which water flows.

(1) Turbidity

The dredging operation would involve a hydraulic dredge with cutterhead. The dredged material would be transported via pipeline to the disposal site. The use of a hydraulic dredge would tend to mix more water with the dredged material. Piping the mixture more than 1000 feet would also tend to break up the clay lumps into smaller particles. Thus, within the confined disposal area, a large increase in turbidity would occur.

(2) Aquatic Nutrients

The potential for release of water-quality-degrading nutrients, especially phosphorus and nitrogenous compounds, to the water during disposal of the dredged material is a real concern. As noted previously, no data on phosphorus in the sediment are available, but TKN data are available and exceed the unofficial recommended criteria. Formation of ammonia from available nitrogen (TKN) has been noted as a potential problem. The primary concern is the development of an extensive increase in the growth of aquatic biomass such as algae which in turn tends to produce euthropic conditions, especially for a confined area.

(3) Dissolved Oxygen

The COD of the sediment exceeds the unofficial recommended criteria as previously noted. Based on experience of the Corps of Engineers in the Intracoastal Waterway (ICW), it would appear likely that the sediments would release oxygen-demanding substances. The disposal of dredged materials in a confined area and retention of the associated water for sufficient time would avoid a harmful depression of dissolved oxygen (DO) levels in adjoining waters which would occur if oxygen-demanding sediments were released into them. If the oxygen-demanding sediments are dispersed adequately into a shallow retention area where the overlying water may undergo atmospheric reoxygenation, then the effect would be to satisfy the oxygen demand without risking a water quality problem. The growth of algae in a confined area, stimulated by the release of nutrients from the sediments, would further aid in satisfying oxygen demand, since algae produce oxygen during photosynthesis. Algae do consume oxygen during periods of darkness, but the total amount consumed is less than the total amount produced. A significant increase in DO in confined disposal areas has been observed (Windom, 1972).

(4) Sulfides

As noted earlier, the levels of oil and grease in the sediment exceed the unofficial recommended criteria; thus, some hydrogen sulfide may be present, as it is a constituent of sour crude oil. It is assumed here that a portion of the oil and grease in the Neches River sediment contains crude oil constituents from both sweet and sour crudes, originating from oil spills at or near the Sun Terminal. Thus, in the disposal operation some release of sulfides would be expected. If heavy metals are present, as previously noted, sulfides tend to combine with the metals to form insoluble salts. This process would tend to offset the release of sulfides from the oil and grease.

(5) Toxic Metals

As discussed earlier the concentrations of heavy metals in water usually decreases when suspended matter is present. Thus, while the concentration of zinc exceeds the unofficial recommended criteria in some samples from the Neches River no increase in the level of zinc in the water is expected. However, based on data (Table D.5-9) taken before and after dredging in the Neches River, the concentration of chromium and nickel may increase in the disposal area waters.

(6) Pesticides and Toxic Hydrocarbons

Due to the absence of large agricultural areas that require spraying, high levels of pesticides are not anticipated to be present in the sediment. Thus the release of pesticides at the disposal site should not be significant.

The high levels of oil and grease found in sediments, as noted earlier, indicates the potential for release of toxic hydrocarbons. Toxic phenols which can come from crude oil and the waste water from petrochemical plants are of particular concern. The quantities of oil and grease suggest that phenols and other toxic hydrocarbons are present and would be released.

(7) Loss of Wetlands Habitat

The confined Neches River disposal area would receive approximately 2,000,000 cubic yards of dredged material as a result of dock construction. Based on the assumption that the spoil can be stacked to a mean height of two feet, this volume of spoil would require approximately 670 acres of disposal area. This area would generally be in the vicinity of the Neches River as regulated by Corp. of Engineer permits. Essentially all available disposal sites in this region currently consist of brackish marshes. Thus, the loss of wetlands habitat would amount to essentially all of the 670 acres.

Summary

The impact of the dredged material on the disposal site would consist of increases in turbidity, possibly TKN, and chemical oxygen demand (COD), possibly leading to a decrease in DO. The flow of surface water in the marsh may also be affected, depending on the location and design of the disposal area. The loss of wetlands habitat would amount to 54 to 62 acres. The impact of the dredging disposal operation can be localized and minimized by employing the most recent dredging technology (Saila, et al, 1971; Hershman, 1973; Basco, et al, 1974; Chen, et al, 1976).

Impact on Neches River Due to Effluent from the Disposal Area(s).

Because a contained disposal area would be used, during the fill years most of the containment structure would hold turbid water and a turbid, aqueous solution of dredged solids from the dredging site. This water must be discharged from the disposal area back into the river, since in most cases it represents 80 to 95 percent of the total volume of materials pumped into the containment structure. The impact of this excess water on the Sabine River would vary according to the quality and volume of the receiving water and the quality and quantity of the dike effluent. If care is taken in the design of the confinement area so that the sediment transport waters were returned to the waterway after sufficient time for suspended solids to be deposited and nutrients to be removed by algae, but before the algae population becomes senescent and dies, then the returning transport water would be of good quality with low suspended solids, high oxygen, and low nutrient content. Under these circumstances, the confined disposal area would serve much like an oxidation pond similar to those used for many years to treat municipal and industrial organic wastes. Current practice requires that the level of total suspended solids be less than 8 grams per liter at the exit spillway from the confined disposal area (Keesecker, 1976).

Impact on Stark's Canal, First and Second Bayous, and Hog Island Gully Disposal Areas. The dredging method would involve use of dredged spoil for back-fill after pipeline burial. No additional impact due to disposal requirements are anticipated.

Impact on Calcasieu Ship Channel Disposal Areas. The disposal site would consist of the shallow waters of West Cove and other portions of Calcasieu Lake adjacent to the pipeline route. The site would be confined by means of a containment dike. The impacts on the disposal area would be somewhat different from those at the Neches River disposal site because of the use of a portion of the lake instead of a marsh.

An increase in turbidity, a decrease in DO, and the possible release of toxic materials (mercury and phenols) are likely to occur in the disposal area.

Impacts on West Cove and Calcasieu Lake Due to Effluent from the Calcasieu Ship Channel Disposal Areas. The use of shallow lake waters with a containment dike for a confined disposal area is generally not as effective as the use of a marsh with a dike (Vick, 1977). Due to wind-and tidal-generated wave action more contact occurs between the spoil within the disposal area and the surrounding water bodies. Thus effluents may leave the disposal site associated with the Calcasieu Ship Channel dredging before sufficient time has elapsed for the settling of suspended solids and the removal of nutrients by algae. This would tend to produce a relatively greater impact on surrounding water bodies.

Grading, Excavation, and Filling

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

The site preparation and construction activity would involve a significant amount of earth movement during a 5-month period. Approximately 200 acres of land would be disturbed. Based on the analysis presented in Appendix D.15 approximately 3220 tons or 3180 cubic yards of sediment would be washed into the surface water system during the 5-month period as a result of erosion of this disturbed land by rainfall. Of this total, as shown in Figure C.3-12, 2758 tons would be deposited in Black Lake with the remaining 462 tons entering Black Lake Bayou. Because the soil involved would be a silt loam, the minimum rate of settling would be .018 mm/sec.

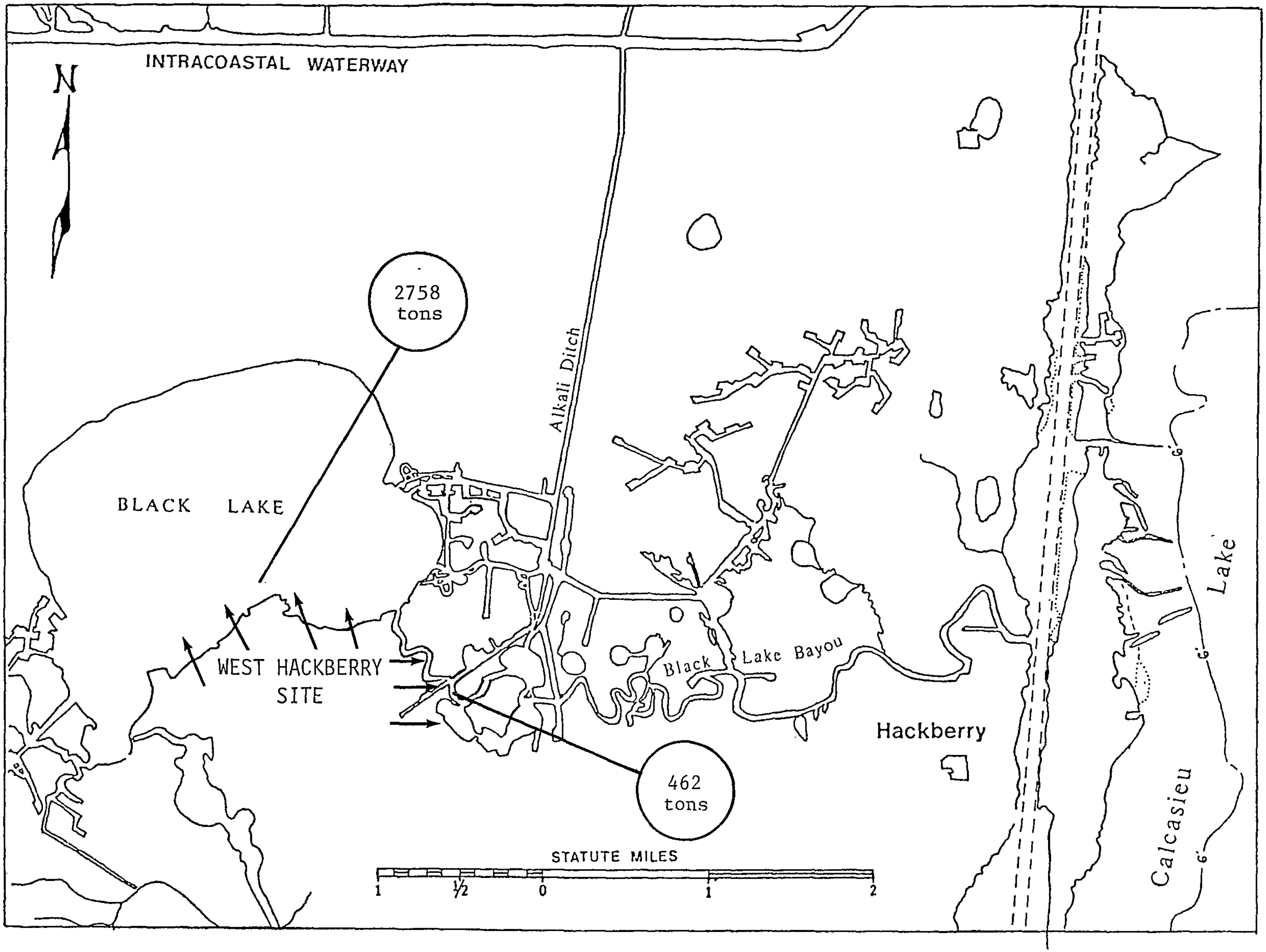

Figure C.3-12 Sediment Transport in the Vicinity of West Hackberry

Based on the analysis provided in Appendix D.16, the introduction of such sediment into Black Lake would increase the average level of suspended solids in the lake by 1.21 ppm. This increased level would persist for essentially the entire 5-month period.

For the case of Black Lake Bayou the analysis presented in Appendix D.16 indicates that the introduction of 462 tons of sediment would increase the average level of suspended solids in the bayou by 5.88 ppm. This increased level would continue for essentially all the 5-month period.

Pollutants of Miscellaneous Construction Activities

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

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

Of these, petroleum products, herbicides and pesticides, and fertilizers appear to be the best-known and best-documented sources of chemical pollution. Pollution from petroleum products generally occurs from improper disposal of waste materials such as crankcase oil and various cleaning solvents, leakage of fuels and oil from storage facilities, and damaged or improperly maintained vehicles; fuel spills during equipment refueling operations; and the use of oils for dust control on highways. Herbicides and/or pesticides are used on some construction sites to control undesirable vegetation, insects, and rodents. The primary causes of pollution from the use of these chemicals are in the improper use, handling, and disposal of waste materials. Fertilizers are extensively utilized in the revegetation. of areas affected by grading operations. Like herbicides and pesticides, the primary causes of damaging pollution are improper use, i.e., applying too much fertilizer or improper preparation of the ground surface prior to application.

The biological pollutants which generally enter receiving streams and other water bodies as a result of construction activities are bacteria, fungi, worms, viruses, and other less prevalent organisms. Biological pollution is primarily a result of poor sanitary conditions at a construction site-- generally improper disposal of human wastes, garbage, and other organic material. The disturbance, exposure, and subsequent erosion of surface soils that contain bacteria and other organisms are contributing factors. Regardless of their origin, biological pollutants have an adverse effect on water quality. The degree of impact depends on the use of the water and the nature of the biological organisms. The pollutants of major concern are the pathogenic organisms associated with human wastes.

Prediction of the impact of such chemical and biological contaminants is not practical because of the human element involved, and the current lack of detail relating to facility design. This type of pollution, however, can be minimized by proper instruction of personnel coupled with good housekeeping practices.

C.3.1.2.2 Subsurface Water

Current design for the West Hackberry SPR facility does not involve use of the shallow aquifers as a source of leaching water nor use of the deeper aquifers as a brine disposal site. Thus the subsurface water system should experience no impact as a result of site preparation or facility construction.

C.3.1.3 Air Quality

C.3.1.3.1 Sources of Emissions

The construction of the proposed oil storage facility at West Hackberry would result in combustion and fugitive emissions along the brine pipeline right-of-way and at the dome and Sun Terminal locations. Many of these emissions would be insignificant and would exert a negligible impact on local ambient air quality. A summary of the types of sources existing during site construction activities is listed in the following:

- Site Preparation
- Unpaved Roads
- Paved Roads
- Heavy-Duty, Diesel-Powered Equipment
- Light-Duty Vehicles
- Drill Rigs
- Storage Tank Preparation
    a. Surface Grinding
    b. Paint and/or Primer Application

The degree of construction activity would depend on existing site conditions. The construction of access roads or the extension of existing roads would result in fugitive dust emissions during initial grading operations. These emissions would continue during subsequent daily use if access roads are not paved. Fugitive dust emissions would also be generated during construction due to site preparation activities such as landclearing and grading.

Vehicular emissions during site construction activities would arise due to the use of heavy-duty construction equipment such as bulldozers, caterpillars and graders. Emissions due to the use of normal, light-duty vehicles such as pickup trucks and automobiles are also anticipated. Drill rigs would be used during construction in drilling new wells. Emissions emanating from the above sources include particulates, sulfur oxides (SO_x and SO_2), carbon monoxide (CO), non-methane hydrocarbons (NMHC), nitrogen oxides (NO_x and NO_2), and small amounts of aldehydes and organic acids. Actual emission strengths would be a function of fuel use preference, that is, gasoline or diesel.

A final source of construction emissions involves the grinding and subsequent painting of the large storage tanks. The painting of these tanks would comprise a significant source of hydrocarbon vapors during application. This activity may be repeated during the operational phase as a part of routine site maintenance activities.

The following paragraphs describe the development of short- and long-term emission rates suitable for use (1) in the subsequent impact analysis and (2) in a comparison of the relative importance of each of the construction sources. Appendix E contains a listing of the short- and long-term emission rates for those sources included in the mathematical modeling analysis while Table C.3.-3 lists the annual tonnage emissions for all sources.

Site Preparation

The extent of fugitive dust emissions during construction operations is dependent largely upon the soil silt content and the aridity of the site climate. The USEPA has developed an approximate emission factor for construction operations of 1.2 tons of fugitive dust per acre of construction per month of activity. This factor is based upon moderate activity levels, moderate silt content and a semiarid climate. As such, this factor should be conservative for use in coastal Louisiana where the climate is humid and the soil is wet and marshy. At West Hackberry, the dome site would comprise 160 acres, while 130 acres would be utilized at the Sun Terminal. In addition, 126 acres of dry land right-of-way are required for pipeline construction.

For the purpose of calculations, it is assumed that the emissions are continuous during the construction phase and that they could be conservatively represented by point sources. Pipeline emissions were not modeled, as they occur very diffusely and sporadically over long distances, and their resultant impact on local ambient air quality is felt to be insignificant. The nature of these sources do not prove amenable to short-term modeling analysis; hence, the emissions are only included in the annual calculations.

Unpaved Roads

The use of unpaved roads during the construction phase would result in fugitive dust emissions. The USEPA (1976) has also developed a relationship suitable for the development of an emission factor for fugitive dust losses resulting from vehicular traffic over unpaved surfaces.

Table C.3-3

Annual Tonnage Emission Rates from Construction At West Hackberry Expansion

Source or Activity	Annual** Emissions (Tons)				
	HC	Pa	SO_2	NO_2	CO
Site Preparation	-	5990	-	-	-
Unpaved Roads	-	295	-	-	-
Paved Roads	-	0.7	-	-	-
Heavy Duty, Diesel Powered Equipment(1)	0.5	0.3	0.5	7.4	1.4
Light-Duty Vehicles	0.3	0.05	0.01	0.5	3.8
Surface Grinding Tanks	-	3.1	-	-	-
Painting - Tanks(2)	5.3	-	-	-	-
Total - Construction	16	6298	9	134	32

* Includes construction activities at dome and terminal sites and along brine pipeline right-of-way

** If activity persists for less than a year (e.g. painting - tanks) than total emissions for this shorter period are listed

1. The dome and terminal sites considered as independent construction sites of equal magnitude.
2. Two coats of paint

Table C.3-4

Typical Usage Factors* of Equipment in Public Works Construction

Equipment	Construction Phase					Average Usage Factor Per Equipment Per Construction Period
	Clearing	Excavation	Foundation	Erection	Finishing	
Off-Highway Truck	.16(2)**	.16	.4(2)	.2(2)	.16(2)	.47
Wheeled Loader	.3	.4	.2	-	.16	.18
Tracklaying Loader	.04	.4	.04	-	.04	.08
Scraper	.08	-	.2	.08	.08	.10
Roller	-	-	.01	.5	.5	.22
Motor Grader	.08	-	-	.2	.08	.08
Wheeled Dozer	.17(2)	.4(2)	.2	-	.16(2)	.26
Miscellaneous	.4	.5	.6	.5	.4	.50
Fraction of hrs. at site for each phase	.14.	.14	.29	.29	.14	

*Fraction of the hours at the site per item.

**Numbers in parenthesis represent average number of items in use, if the number is greater than one. Blanks indicate zero or very rare usage.

TABLE C.3-5

Emission Factors* for Heavy-Duty, Diesel-Powered Construction Equipment

POLLUTANT	TRACKLAYING TRACTOR	WHEELED TRACTOR	WHEELED DOZER	SCRAPER	MOTOR GRADER	WHEELED LOADER	TRACKLAYING LOADER	OFF-HIGHWAY TRUCK	ROLLER	MISCELLANEOUS
CO	175	973	335	660	97.7	281	72.5	610	83.5	188
HC**	50.1	67.2	106	284	24.7	84.7	14.5	198	24.7	71.4
NO_2	685	451	2290	2820	478	1090	265	3460	474	1030
Aldehydes	12.4	13.5	29.5	65	5.5	18.8	4.0	51.0	7.4	13.9
SO_2	62.3	40.9	158	210	39	82.5	34.4	206	30.5	64.7
Particulate	50.7	61.5	75	184	27.7	77.9	26.4	116	22.7	63.2

*grams per hour **exhaust hydrocarbons

A sample calculation based upon a typical silt content of 12 percent for a gravel road, an average vehicle speed of 30 mi/hr and typical regional rainfall trends yields an emission factor of 6.9 pounds per vehicle mile for the West Hackberry site. Forty percent of this material would comprise very large (>30 μM) particles which can be ignored. The annual tonnage emission rate contained in Table C.3-4 is based upon an average daily road usage rate in terms of vehicle-miles. At West Hackberry, there would be 2.4 miles of access roads at the dome site and approximately 2 miles of access roads at the Sun Terminal. It is assumed that half the roads are paved at each location and that 150 employees use the roadways. The annual tonnage emission rate can then be calculated by assuming that each employee travels twice the access road distance daily during a 260-day work year. These sources are only expected to have a very local impact on ambient air quality and have not been included in the modeling analysis.

Paved Roads

Paved roads are also a minor source of particulate emissions. Cowherd and Mann (1974) have developed fugitive dust emission rates for vehicular usage of paved surfaces. These rates are dependent upon local land use factors and vary from about 1 to 15 grams per vehicle mile of particles less than 30 μm in diameter. The impact of this source is negligible and has not been included in the present modeling analysis. The calculation of the annual tonnage emission rate presented in Table C.3-3 is based upon the assumptions discussed in the preceding paragraph and an emission factor of 7.5 grams per vehicle mile.

Heavy-Duty, Diesel-Powered Construction Equipment

Exhaust emissions can be anticipated due to the use of heavy-duty construction equipment. Annual tonnage emission rates have been calculated based upon typical equipment usage factors which are provided in Table C.3-4 and emission factors developed by the USEPA (1976) and presented in Table C.3-5. The equipment usage factors presented in Table C.3-4 are representative of a public works construction site for five distinct phases (EPA, 1971).

The USEPA (1976) has indicated that at a distance of 100 meters from a highway, annual NO_2 concentrations would not be altered and one-hour CO concentrations would be no greater than 40 $\mu g/m^3$. As a result, combustion emissions from these sources, as well as from the light-duty vehicle sources discussed in the following section, are expected to have a minimal impact on the ambient air quality and are not included in the modeling analysis. Annual tonnage emission rates for these sources are included in Table C.3-3 based upon 2000 hours of annual vehicle operation.

Light-Duty Vehicles

Exhaust emissions can also be anticipated at each of the proposed sites due to the use of automobiles and light-duty, gasoline-powered trucks by employees. The assumptions necessary for the development of emission factors are the same as those employed in the preceding paragraphs on the use of onsite roads with the addition of the assumption that a 50/50 split exists between automobiles and light-duty trucks. The emission factors recommended by the USEPA (1976) for calendar year 1972 vehicles are presented in Table C.3-6 and are used to develop the site-specific emission rates.

Surface Grinding - Tanks

During the construction phase, it is anticipated that the storage tanks would be blasted with abrasives prior to the application of light-colored paint. The use of abrasives results in the emission of fugitive dust. Approximately 1 percent of the applied material is emitted in this manner (Segal, 1976). Assumptions necessary for the determination of an annual tonnage emission rate for this source include: (1) the abrasives application rate, (2) total tank surface area, and (3) the actual work rate. Calculations of particulate ground level concentrations are made for short-term averaging periods using a point-source assumption.

Table C.3-6

Summary of Routine Vehicular Emissions*

VEHICLE DESCRIPTION	CO	HC**	NO_2	SO_2	Particulate
Automobile	36.9	3.0	4.6	0.1	0.5
Light-Duty Gasoline-Powered Trucks	42.8	3.4	5.3	0.2	0.5

* grams per mile

**exhaust hydrocarbons

Painting - Tanks

The application of paint to the SPR storage tanks during the construction phase would result in the emission of hydrocarbons due to evaporative losses. The rate of emission is dependent upon the same variables as discussed for surface grinding of the tanks except for the actual emission factor for paint application. The USEPA (1976) recommends an emission factor of 1120 lbs. of hydrocarbons per ton of paint applied. Short-term modeling calculations have been made using a point source approximation. This assumption has a small impact on the accuracy of the results, particularly over the short-term, resulting in slightly conservative predictions close to the source. The short-term emission rates for this activity are listed for West Hackberry in Appendix E. It is assumed that two coats of paint would be applied. Annual tonnage emission rates are presented in Table C.3-3.

C.3.1.3.2 Emission Control Technologies

The major emissions from the SPR program sources are hydrocarbons from loading and ballasting operations at the marine terminals. Other hydrocarbon emissions include evaporative losses from surge-storage tanks, leaks from pumps and valves, vapors from pressure-release devices, and evaporative losses from the brine disposal pond. Essentially, no emissions would be encountered from the underground storage of the crude oil because of the passive nature and closure of this storage.

Hydrocarbon emission control technology for marine terminal crude oil transfer operations is a young technology, faced with a unique set of problems. It differs from the conventional closed-cycle vapor control system used in petroleum industry in that the presence of air in vented hydrocarbon (HC) vapors presents a potential explosion hazard. Also, it differs from the tank truck loading operation because much higher flow rates are experienced in marine terminal operations.

Although the safety and design problems associated with vapor control technology for marine terminal operation are not thought to be technologically insurmountable, solving these problems would, however, involve considerable design modification and engineering effort in terms of retrofitting the existing available systems.

The cumulative loading rate of a single crude oil tanker is often as high as 40,000 barrels per hour, which is equivalent to approximately 4,000 standard cubic feet per minute of displaced vapors. The strategy for control of this displaced vapor involves collecting the vapor and conveying it to shoreside vapor control units. Two systems are required: a vapor collection system and a vapor control unit.

Vapor Collection System

Shoreside facilities generally have dockside coupling flanges connected to pipelines emanating from a pumping facility. Standard cargo hoses couple the shore manifold to the pipe header on board a tank ship. Pipe runs on shore vary greatly from crude oil terminal to terminal, depending on site capacity and customary vessel types being handled.

Tankers and barges are generally designed with loading/unloading lines from the bottom of each tank. The lines gather at a central header and connection flange, and on-board cargo pumps.

Venting is usually provided in existing tank ships and barges. During loading and unloading, ullage* caps are generally open as well as vents, so vapors escape or air is drawn in at both places.

A case-by-case analysis would be required to determine exact design changes to modify existing venting facilities so that hydrocarbon vapor could be collected. Generally, two systems would require modification: (1) ullage monitoring system, so open ullage caps or cargo hatches would not provide a possible escape route, and (2) the disposition of vapors collected by the vent line. Cargo hatches must be sealed to prevent the escape of HC vapor other than at the vent line.

Ullage is presently determined visually during vessel on- and off-loading, largely due to the simplicity of a float system in the tank. More sophisticated and possibly more troublesome with respect to reliability would be an electromechanical or electronic level sensing system. Such a system would require fairly rigid calibration and maintenance cycles, and possibly limit flexibility of tanker service.

Vapor Control Systems

There are several types of vapor control systems that could be potentially applied to terminal operation. These include flame oxidation, absorption, compression-refrigeration-condensation, and adsorption.

Flame Oxidation

The most straightforward way to remove HC vapor without recovering the product is by flame oxidation. This can be accomplished by three similar oxidation devices:

1. Direct Flame Flares

The cheapest route available for converting entrained HC vapors to CO_2 and water is to use direct flame flare. A flame flare used at the marine terminal would take displaced HC vapor from the vapor collection system (VCS), and burn them at the end of a tall flare pipe. Continuous steam is required to suppress smoke, and additional fuel such as

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*The term "ullage" refers to the distance between the cargo liquid level and the rim of the vent cap.

natural gas may be required to bring temperatures to the optimum flammable range. Both of these systems require external sources of fuel. Smokeless flares are generally of two types, elevated flares and ground-level flares. Flares are elevated in order to safely dissipate the heat released and diffuse any vapors that may be emitted. Flaring of vapors collected from marine terminal transferring operations would necessarily be removed from any cargo-handling activities and would be elevated for safety reasons.

Smoke is a by-product of incomplete combustion. Smokeless combustion can be achieved if there are(1) sufficient fuel values in the gas mixture to obtain the minimum theoretical combustion temperature, (2) adequate combustion air, and (3) adequate mixing of the fuel and air. Smokeless flares require the gas mixture to be saturated with hydrocarbons satisfying the above three conditions. A saturator recirculates the vapors with the volatile hydrocarbon product to achieve saturation for smokeless combustion. In some cases, propane is used to enrich the collected vapors beyond the upper explosive range.

Smokeless combustion is obtained in an elevated flare by the injection of an inert gas to the combustion zone to provide turbulence and inspirate air. The most commonly used air-inspirating material for an elevated flare is steam. Flaring vented gases can create combustion products of sulfur dioxide and nitrogen oxides if sufficient sulfur and nitrogen are present in the vapors.

2. Direct Flame Afterburner

There have been safety concerns to the use of an external flame flare proximate to the crude oil transfer operations. Uncertainties about external flame systems in a transfer area can be circumvented by using an internal combustion device, such as the direct flame afterburner.

3. Catalytic Afterburner with Direct Flame Preheater

A catalytic afterburner with direct flame preheating is a possible alternative to the direct flame afterburner described previously.

The catalytic afterburners are designed much like direct flame types, but employ a solid active surface whereon the combustion reaction takes place, usually at a significant lower temperature than would be required for combustion by direct flame. Since they can be operated at temperatures much lower than those required for direct flame combustion, catalytic afterburners have the advantage of lower fuel costs in some applications.

Absorption

The absorption vapor recovery unit involves the passing of a vapor loaded gas steam through a packed bed absorber unit. The absorption solution is usually a lean oil, used as feed material to a refinery cat-cracker. In a third typical lean oil system, hydrocarbon vapors from the terminal are displaced through a packed absorber column where they are absorbed by cascading lean oil at atmospheric temperature and pressure. Stripped air is vented from the top of the absorber column. The enriched hydrocarbon is returned to storage. Lean oil for the absorber is generated by heating gasoline from the storage tanks and evaporating off the light ends. The separated light ends are compressed, condensed, and returned to storage, and the lean oil is stored separately for use in the absorption column.

The overall efficiency of absorber is a matter of some uncertainty with respect to the crude vapor application. Most designs are currently rationalized on an efficiency versus worth of material recovered basis, and consequently are applied to refined product handling. Efficiencies of 95-99 percent are rarely justified. On this basis, systems may typically be certified for up to 85 percent.

Compression-Refrigeration-Condensation (CRC)

The principle of CRC operation is based on the condensation of HC vapors by compression and refrigeration. Incoming vapors are first contacted with recovered liquid product in a saturator, and are saturated beyond the flammability range. The saturated vapors are then compressed in a two-stage compressor with an intercooler. Condensate is withdrawn from the intercooler prior to second-stage compression. The compressed vapors are passed through a condenser where they are cooled,condensed, and returned along with condensate from the intercooler to the gasoline storage tank. Hydrocarbon-free air is vented from the top of the condenser.

Operating conditions vary with the manufacturer, with temperatures ranging from -10°F to 30°F and pressures ranging from 85 psig to 410 psig. Approximately 95 percent control efficiency is estimated for an average CRC system.

Carbon Adsorption

In a carbon adsorption unit (approximately 90 percent efficiency), hydrocarbon loaded vapors are passed through a carbon bed, and the hydrocarbon constituents in the vapors are removed by adsorption onto the carbon. Adsorption is an exothermic (heat releasing) reaction which could present significant safety problems. In addition, as the carbon bed becomes saturated with hydrocarbons, the bed must be reclaimed. The reclaiming unit and its own vapor recovery unit presents a high-capital-cost facility.

Operational Control Strategies

Besides the vapor collection and vapor control systems described above, various operational control strategies can be utilized to minimize the hydrocarbon emissions.

The following describes the physical parameters and operational activities that affect the total hydrocarbon emissions from the SPR program. Based on these activities, specific control strategies might be taken to minimize hydrocarbon emissions.

(1) The total hydrocarbon emissions from the SPR program is a function of the number of transfers that the crude oil undergoes. Therefore, by minimizing any unnecessary ship-to-ship, barge-to-barge, or ship-to-barge transfers, the SPR program hydrocarbon emissions can be reduced.

(2) The Reid Vapor Pressure (RVP) of the crude oil has a significant effect on the total hydrocarbon emissions from both the transfer and storage operations. If possible, lower RVP crude oil could be procured for the SPR program as one means to reduce hydrocarbon emission.

(3) The major emission source from tanker transfers of crude oil to shore facilities does not occur during the actual transfer, but during the following ballasting operation of the empty tanker. This is due to the displacement of hydrocarbon vapors from the empty tanker. Minimizing dock-side ballasting of unloaded tankers by performing the majority of the ballasting on the high seas would help prevent local emissions.

C.3.1.3.3 Current Regulations

Current regulations restricting air pollutant emissions from all operations necessary for the development and use of the SPR facilities can be grouped into emissions regulations and ambient air quality standards.

Emission Regulations: Federal

The USEPA has set New Source Performance Standards (NSPS) limiting allowable emissions for certain indsutrial facilities. These include standards for petroleum refineries and storage vessels for petroleum liquids. The NSPS for storage vessels would impact the SPR project as it applies to vessels with a capacity greater than 40,000 gallons (950 barrels). This regulation does not apply to pressure vessels, subsurface caverns, porous rock reservoirs, or underground tanks under some conditions.

The federal regulations for the storage of liquid volatiles (40 CFR Part 60, Subpart K)* are as follows:

- If the true vapor pressure (TVP) of the petroleum liquid, as stored, is equal to or greater than 78 mm Hg (1.5 psia) but not greater than 570 mm HG (11.1 psia), the storage vessell shall be equipped with a floating roof, a vapor recovery system or its equivalent.
- If the TVP of the petroleum liquid as stored is greater than 570 mm Hg (11.1 psia), the storage vessel shall be equipped with a vapor recovery system or its equivalent.

The SPR program would employ floating roofs on all tanks in compliance with the above regulations.

In December 1976, USEPA adopted an "emission offset" policy as part of its "new source review" procedures. Under this policy new sources are required to show that their emissions plus reductions in emissions from existing sources required under the State Implementation Plan equal a net decrease in emissions. That is, the new source should not delay progress in achieving the National Ambient Air Quality Standard (NAAQS). However this regulation applies only to permanent onshore

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*The EPA is proposing to require double seals on external floating roof tanks for which construction is commenced after May 18, 1978, FR Vol. 43 No. 97, p. 21616.

facilities and is expected to exclude new sources with "potential" emissions totaling less than 100 tons/year. During the initial implementation of the SPR, the EPA determined that the offset policy did not apply to SPR facilities due to the temporary and intermittent nature of its associated emissions. DOE is currently coordinating with EPA to determine to what extent the precedent established by this decision is applicable to other SPR sites. DOE has been further advised by EPA that the offset policy is under review and that a clarification will be forthcoming in the near future. DOE will take any necessary actions consistent with clarification.

Emission Regulations: State

Texas. In a review of the Texas Implementation Plan, the USEPA determined that the plan was inadequate for attainment and maintenance of the NAAQS for particulates in Houston, Galveston, and other areas, and directed the state to submit a revised plan. The USEPA also promulgated amendments to the current plan such that a permit to construct a new source in the Houston-Galveston AQCR would not be issued unless the TACB determined that the source would emit reactive hydrocarbons at a rate of less than 3 lb/hr and less than 15 lb/day. Texas Regulation V, concerning the storage and handling of volatile hydrocarbon compounds, requires floating roofs and/or vapor recovery systems for storage vessels of volatile hydrocarbon compounds with capacities larger than 420,000 gallons (10,000 barrels). Until recently crude oil containers were exempt from this requirement. Under special conditions, variances may be granted to crude oil storage vessels with a storage capacity of 10,000 barrels or less. Ship and barge loading and unloading is currently exempt from emission controls and no restrictions are foreseen for crude; however, gasoline emissions would probably be regulated soon.

Although there is no hydrogen sulfide (H_2S) NAAQS, Rule 203 of Texas Regulation II states that no source may emit H_2S such that net ground level concentration is exceeded: (1) 0.08 ppm averaged over any 30-minute period if the downwind concentration of H_2 affects a property used for residential, business or commercial pruposes, or (2) 0.12 ppm if it affects only property used for other than residential, recreational, business or commercial purposes, such as industrial property and vacant tracts and range lands not normally occupied by people.

During the construction phase and, to a lesser extent, during the operational phase of the program, the SPR project would have to comply with Rule 104 of Texas Regulation I. This rule states that in any Standard Metropolitan Statistical Area, where the NAAQS for particulate matter are exceeded, no fine material may be handled, transported or stored without taking precautions specified in the regulation. This rule also requires measures to prevent particulates from being airborne when a road is used, constructed, altered or repaired. Typical particulate abatement techniques include application of water or oil to unpaved surfaces or the requirement of reduced vehicular speeds.

Several states, including Texas and Louisiana, have differentiated between "reactive" hydrocarbons and "low-reactive" hydrocarbons. This approach was used as a modeling tool to determine the amount of hydrocarbon emission reductions required to attain the oxidant standard. However, recently USEPA has found that almost all non-methane hydrocarbons are photochemically reactive and that low-reactivity hydrocarbons eventually form as many photochemical oxidants as the highly-reactive hydrocarbons. Therefore, the policy regarding hydrocarbon reactivity may soon be modified.

Louisiana. The Louisiana State Implementation Plan regulates new sources of volatile hydrocarbon compounds; however, crude oil has been considered virtually unreactive in the formation of oxidants and is thus exempt (LACC Regulation 22.10). The LACC has indicated, however, that a possible modification to LACC Regulation 22.10 to make this regulation consistent with the Federal NSPS would require floating roofs and vapor recovery systems for tanks of the capacity presently being considered for the SPR project. Louisiana also requires the control of fugitive dust losses in the manner described previously by regulations set by the State of Texas.

Louisiana currently has no regulations controlling ship and barge loading and unloading operations and currently does not anticipate implementing any such regulations. Should the USEPA deem such controls necessary for the AQCR to attain and maintain the NAAQS, the USEPA may promulgate regulations for these operations. Louisiana's Implementation Plan was declared inadequate by the USEPA for attainment and maintenance of the primary NAAQS for photochemical oxidants and a revised plan was submitted by the State in December, 1977.

Ambient Air Quality Standards

The NAAQS which are listed in Table C.3-7, establish primary and secondary standards. The primary standards have been set to protect the public health. The secondary standards protect the public welfare from any known or anticipated adverse effects of a pollutant, including effects on soils, water, crops, vegetation, man-made materials, animals, wildlife, weather, visibility, climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being.

The State of Texas had not enacted any air quality regulations more stringent that the existing Federal Regulations given in Table C.3-7 with the exception of the additional regulation of H_2S mentioned earlier. Although Louisiana has promulgated stricter standards than the NAAQS, the stricter standards are not presently actively enforced. This is a direct result of their intent of making the State Standards consistent with Federal limits in the near future. Table C.3-8 shows Louisiana Ambient Air Quality Standards which are in addition to those adopted shown in Table C.3-7.

In 1974 the USEPA developed standards for the prevention of significant deterioration. These standards regulate SO_2, and total suspended particulates in a manner dependent upon existing levels of ambient air quality. The area classifications are as follows:

Class I:	Any change in air quality would be considered significant.
ClassII:	Deterioration normally accompanying moderate well-controlled growth would be considered insignificant.
Class III:	Deterioration up to the National Standards would be considered insignificant.

In August 1977, the Clean Air Act Amendment made provisions in the significant deterioration standards, (Table C.3-9) to consider other pollutants including hydrocarbons, carbon monoxide, photochemical oxidants and nitrogen oxides. The Amendment required EPA to conduct a study and to promulgate regulations within two years to prevent the significant deterioration of air quality which would result from the emission of these other pollutants.

The amendment also allowed variances from the Class I sulfur dioxide increments to be granted for up to 18 days a year. Such a variance can be granted through the approval of the state governor and the federal land manager. Should these two offices disagree on the advisability of such a variance, the final decision would be left to the President and would not be subject to judicial review. Variances of 8 and 15 percent from increments for both SO_2 and particulates in Class II areas will be allowed in low and high terrain areas, respectively.

Table C.3-7

National Ambient Air Quality Standards(a)

Pollutant	Averaging Time	Primary Standards	Secondary Standards
Particulate Matter(b)	Annual (Geometric mean)	75 $\mu g/m^3$	60 $\mu g/m^3$
	24-hour	260 $\mu g/m^3$	150 $\mu g/m^3$
Sulfur Dioxide	Annual (Arithmetic mean)	80 $\mu g/m^3$ (0.03ppm)	
	24-hour	365 $\mu g/m^3$ (0.14 ppm)	
	3-hour	---	1300 $\mu g/m^3$ (0.5 ppm)
Carbon Monoxide	8-hour	10 $\mu g/m^3$ (9 ppm)	Same as Primary
	1-hour	40 $\mu g/m^3$ (35 ppm)	
Photochemical Oxidants(c)	1-hour	160 $\mu g/m^3$ (0.08 ppm)	Same as Primary
Hydrocarbons(d) (nonmethane)	3-hour	160 $\mu g/m^3$ (0.24 ppm)	Same as Primary
Nitrogen Dioxide	Annual (Arithmetic mean)	100 $\mu g/m^3$ (0.05 ppm)	Same as Primary

(a) All standards (other than annual standards) are specified as not to be exceeded more than once per year. The measurement methods are also specified as Federal Reference Methods. The air quality standards and a description of the reference methods were published on April 30, 1971 in 42 CFR 210, recodified to 40 CFR 50 on November 25, 1972.

(b) The secondary annual standard (60 $\mu g/m^3$) is a quide to be used in assessing implementation plans to achieve the 24-hour secondary standard.

(c) Expressed as ozone by the Federal Reference Method.

(d) This NAAQS is for use as a guide in devising implementation plans to achieve oxidant standards.

Table C.3-8

Louisiana Ambient Air Quality Standards in Addition to NAAQS(a)

Pollutant	Averaging Time	Primary Standards	Secondary Standards
Dustfall	1 month	20 tons/sq. mile	---
Coeffient of Haze	Annual (Geometric mean)	0.6 coh/1,000 linear feet	---
	Annual (Arithmetic mean)	0.75 coh/1,000 linear feet	---
	24-hour	1.50 coh/1,000 linear feet	---
Sulfur dioxide	Annual (Arithmetic mean)	---	60 $\mu g/m^3$ (0.03 ppm)
	24-hour	---	260 $\mu g/m^3$ (0.10 ppm)
Sulfur Acid Mist, Sulfur Trioxide or any combination thereof	Annual (Arithmetic mean)	80 $\mu g/m^3$ (0.03 ppm)	---
	24-hour	365$\mu g/m^3$ (0.14 ppm)	---
Total Oxidants	Annual (Arithmetic mean)	58.8$\mu g/m^3$ (0.03 ppm)	58.8$\mu g/m^3$
	4-hour	98.0$\mu g/m^3$ (0.05 ppm)	58.8$\mu g/m^3$ (0.05 ppm)

(a) All standards (other than annual standards) are specified as not to be exceeded more than once per year. The measurement methods are also specified as Federal Reference Methods. The air quality standards and a description of the reference methods were published on April 30, 1971 in 42 CFR 210, recodified to 40 CFR 50 on November 25, 1972.

Table C.3-9

Standards for the Prevention of Significant Deterioration in a Class II Area

POLLUTANT	CONCENTRATION LIMITS[1] ($\mu g/m^3$)		
	3-HOUR[2]	24-HOUR[2]	ANNUAL
Particulates	---	30	10[3]
SO_2	700	100	15

1. Mean values (arithmetic except as noted).

2. Second highest value observed.

3. Geometric mean.

C.3.1.3.4 Ambient Air Quality Impact

The following paragraphs discuss the results of the modeling analysis and ambient air quality impact conducted for each significant source at West Hackberry during the construction phase. The modeling consists of: (1) the use of the model PTMAN to predict the frequency of occurrence of violations of applicable standards and the distribution of pollutant concentrations at downwind receptor locations and (2) the prediction of annual centerline pollutant ground level concentrations by the model CDM utilizing nearby historical meteorological data.

This approach is employed for all identifiable sources except those which have a negligible impact on air quality (e.g., the salt dome storage cavity) or those whose erratic nature makes the use of the Gaussian modeling approach irrelevant over a short-term averaging period. Many of the activities planned for the construction phase are indicative of this latter type of source. For example, fugitive dust losses due to the use of heavy-duty construction equipment during site preparation are spread over a large area and occur intermittently at variable emission rates. Such a source cannot be reliably modeled over the short-term; however, it can be reasonably included in the annual modeling analysis through the use of CDM in conjunction with simplifying point-source assumptions. Other sources have been discussed solely in terms of annual tonnage emission rates. Sources handled in this manner included: (1) the use of paved and unpaved roads, and (2) the use of heavy and light-duty vehicles.

Unabated annual emissions for these latter sources are presented in Table C.3-5 of Section C.3.1.3.1. The use of paved and unpaved roads accounts for less than 5 percent of the construction phase particulate emissions and the vast majority of this total (e.g., 300 ton/year) is represented by the use of unpaved surfaces. These emissions can be further minimized by the use of control methods with efficiencies ranging from 25 percent to 80 percent (EPA, 1976). Control techniques include the application of water, chemical treatment and speed control. The latter approach can be quite effective. The impact of these emissions is quite local (i.e., 40 percent of the total would fall off within 0.5 km radius) and is in compliance with primary (260 $\mu g/m^3$) air quality standards for particulates.

Combustion contaminants would result during construction due to the use of heavy and light duty vehicles. As indicated in Table C.3-6 of Section C.3.1.3.1 this activity would account for a small portion of the combustion contaminants emitted during construction. The impact of these sources would be well dispersed over the construction areas and the overall impact in terms of ambient air quality would be insignificant.

The modeling indicates that the 3-hour standard for non-methane hydrocarbons would be violated within one kilometer of the source with a maximum annual frequency of approximately 1 percent.

During the construction phase, the storage and treatment tanks would be painted. Prior to painting, the tank surfaces would be prepared through the application of surface abrasives. Short-term modeling indicates that the 24-hour particulate standard would be violated out to a downwind distance of 1 kilometer, or well within probable plant site boundaries. The application of paint would result in a violation of the 3-hour NMHC standard out to a downwind distance of approximately 4 kilometers as indicated in Figure C.3-12. Figure C.3-12 represents conditions at the Sun Terminal, but the distribution is also pertinent to the dome site. The maximum frequency of violation would amount to roughly 1 percent of the time annually and would occur to the west of the dome and Sun Terminal sites. The predicted frequency of violations is based upon the use of annual meteorological data. The actual painting process would require less than one month at each location, and the actual impact would be a function of the meteorological conditions. The indicated violations may be limited to within the probable plant site boundaries.

Long-term or annual pollutant ground-level concentrations would be insignificant for construction phase activities with the exception of large scale land clearing operations at the dome and Sun Terminal locations. Calculations have been performed for these locations using a point-source approximation. The modeling results are presented in Figures C.3-13 and C.3-14; they indicate that the Federal primary standard for particulates would be exceeded within approximately 1 kilometer of the construction areas at both locations. These violations would be limited to within the probable plant site boundaries. In addition, the calculations are based upon unabated emission rates. The USEPA (EPA, 1976) indicates that an effective water spraying program would reduce emissions by 50 percent. Such a program is planned for the West Hackberry construction sites, and it is anticipated that the resultant level of particulate emissions would be in compliance with the applicable standards.

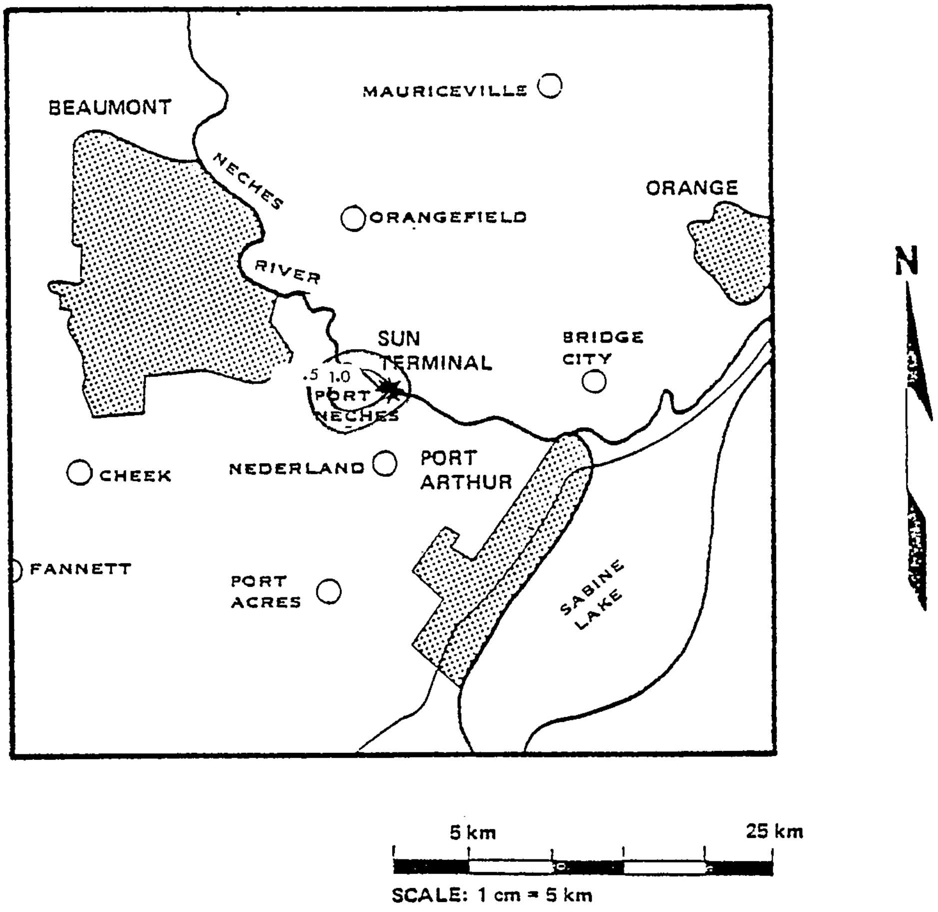

Fig. C.3-12 Annual Frequency of Occurrence (%) of Violations of the 3-hour NMHC Standard for Tank Painting at the Sun Terminal for all Texoma Sites During the Construction Phase*

*Distribution would be identical at the West Hackberry Dome Site

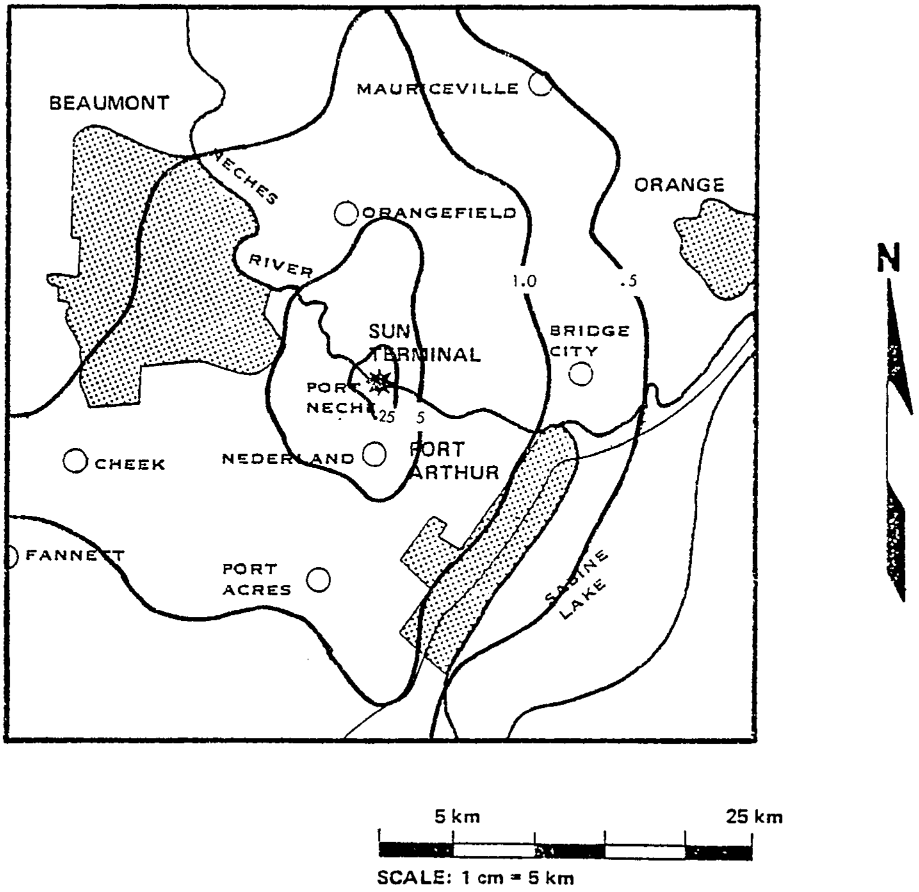

Fig. C.3-13 Annual Average Particulate Ground Level Concentrations (μg/m^3) for the Sun Terminal for all Texoma Sites During the Construction Phase

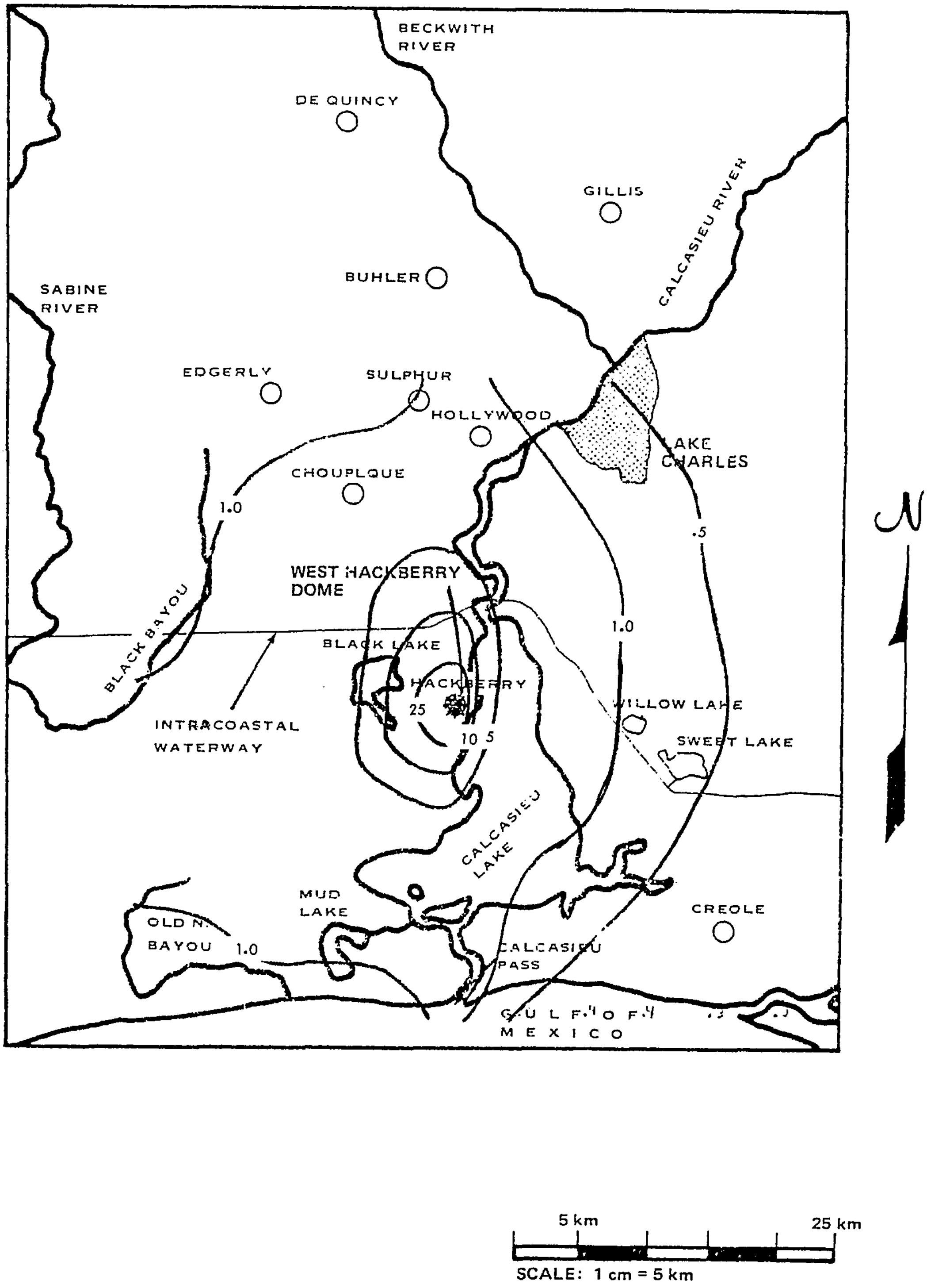

Fig. C.3-14 Annual Average Particulate Ground Level Concentrations ($\mu g/m^3$) for the Dome Site During the Construction Phase at West Hackberry

In summary, the construction of SPR facilities at the West Hackberry dome and Sun Terminal sites would probably not result in offsite violations of the applicable ambient air quality standards. With the possible exception of the painting of the project storage and treatment tanks, all indicated violations would be within the probable plant site boundaries. Maximum construction-phase impact on local ambient air quality can be attributed to: (1) tank preparation and (2) land preparation activities. The remainder of the construction phase sources are mobile and are fairly widely distributed. As a result, their impact on ambient air quality tends to be very local and of a short duration. Such sources include vehicular usage and are conservative in that they do not include the use of abatement techniques.

C.3.1.4 Noise

Construction activity associated with the West Hackberry proposed expansion site contribute to acoustical impacts for residential, recreational, farming, and other land-use areas in the Hackberry and West Hackberry area during the site preparation. The principal areas which have been identified for construction activities are:

1. Oil Storage Site Area
2. Pipeline Corridors
3. Terminal and Dock Area.

An assessment of noise impacts at these locations is given in the paragraphs which follow. For an explanation of terminology, propagation model, and noise impact guidelines, see Appendix F.

Oil Storage Site Area

The proposed expansion area for the West Hackberry site would require fifteen (15) additional caverns on the 160 acres adjacent to the ESR site, approximately 1.8 miles of new roadways, and pipeline connections to the additional caverns. No new construction is planned for central plant facilities, pumps, pump buildings, tankage, control building, etc. The current plan would have the facilities constructed for the ESR serve also for the expansion area. The contributing noise source at the storage site area during site preparation would be air compressors, trucks, diesel engines, drill rigs, concrete mixers and general construction-related equipment. Noise levels typical of this equipment are given in Table F-2 of Appendix F. The evaluation of the construction noise sources indicates that diesel engines would provide the most consistent source of noise and that drilling equipment will create the peak sound levels. The areas adjacent to the storage site are sparsely populated marshlands. Assuming both day and night time drilling activity of two drill rigs, it is estimated that the equivalent sound level contribution (L_{eq}) of the site preparation activity would be no more than 55 decibels (dB) at 2,000 feet from the center of the site. The contribution of storage-site construction activity to annual day-night levels (L_{dn}), assuming 6 months of drilling activity, is estimated to be no more than 55 dB at 2,000 feet from the center of the site.

Pipeline Corridors and Brine Disposal Area

The oil distribution pipeline between West Hackberry and the Sun Oil Company terminal at Nederland, Texas would serve also for the expansion of West Hackberry storage site. Therefore, no new pipeline corridor construction activity for oil distribution will be required for the West Hackberry site expansion.

The proposed brine pipeline is 29 miles in length; an alternative route is 27 miles. Pipeline construction consists of: (1) excavation; (2) laying of pipe; (3) welding, and (4) finishing operations. Except at the town of West Hackberry and at the Gulf coastline the areas traversed by these proposed pipeline routes are largely uninhabited regions. Tables F-2 and F-3 in Appendix F show equipment typical for pipe construction equipment. Assuming daytime activity only, it is estimated that pipeline construction noise would contribute no more than 55 dB to the equivalent sound level (L_{dn}) at a distance of 500 feet from the pipeline right-of-way. The annual (L_{dn}) levels along the pipeline are not expected to be affected because of the relatively short period of construction activity at specific sites.

Terminal and Dock Area

Although a new tanker dock would not be specifically required for the SPR program, an assessment of one additional new tanker dock is being included in this document. The new dock would be adjacent to similar docks Nos. 3 and 4 currently under construction of the Neches River at the Sun Terminal. The construction of an additional dock and terminal facilities would contribute to the general noise of unloading operations at existing terminal on the Neches River. The predominant dock and terminal construction noises are expected to be from pile driving and diesel engine operations. Table F-2 in Appendix F shows sound levels typical of this equipment. It is estimated that noise from construction would contribute 64 dB at approximately 2000 feet from the dock construction site.

Summary of Noise Impacts

Noise impacts from the construction associated with the site preparation for the West Hackberry expansion are summarized in Table C.3-10.

Table C.3-10 Summary of Sound Level Contributions (dB) from Construction Activities for the West Hackberry Expansion

Construction Site	L_{eq}	L_{dn}	Distance from Center of Site
Storage Site Area	<55	<55	2,000'
Pipeline Corridors*	<55	<55	500'
Terminal and Dock Area*	64	<55	1,800'

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* Assumes daytime activity only.

C.3.1.5 Species and Ecosystems

C.3.1.5.1 Displacement/Leaching Water System Impacts

Dredging in Black Lake would destroy benthic fauna where the pipeline trench is to be located. The loss is not expected to be significant because the location of the pipeline trench would be within the area previously disturbed by the laying of the oil pipeline. Benthic organisms which would be killed include clams; polychaeta worms; amphipod crustaceans; nematode worms; microscopic organisms such as protozoans, rotifers, harpacticoid copepods, diatoms, bacteria, and fungi; and perhaps a few crabs and shrimp. Visually-oriented fish and other mobile animals (white and brown shrimp, blue and other crabs, Atlantic croaker and menhaden) would temporarily vacate the area of the dredging activity and the more turbid portions of the turbidity plume. Feeding would also decrease in these areas as the denuded bottom would have few organisms suitable as fish food for several months. For a short period, the nutrients placed in the water column due to the agitation of the bottom substrate would stimulate planktonic and epiphytic plant growth. This increase in productivity, however would not be great enough to offset the losses where the trench is dug. It is expected that one to two years would be required for the stabilization and recolonization of the bottom habitat.

North of the lake, pipeline construction would impact 20 acres of marshland/open water habitat. Release of specific toxic materials into the water column cannot be predicted as water and sediment quality data for the marshes are not available. However, because of the absence of appreciable currents, the turbidity increase and dissolved oxygen decrease would be intensified at the construction site. Vegetation which would be affected consists mainly of black rush and wiregrass.

An important concern in the pipeline construction would be the integrity of the levee which would be crossed between the marsh and the dry land management area north of the marsh. Blowouts, which are large breaches in levees, would have a disastrous effect on the biota of the pasture by allowing saline water to flow into the area. The breaches normally occur as a result of storm damage, but inappropriate construction techniques can also bring about similar impacts. As a worst case, if a blowout occurs in the levee separating the marshes north of Black Lake with the pasture, recovery of the management area vegetation may take as long as 3 years.

Except for the possibility of blowouts, impacts to dry land management area would be less severe than to any other ecological habitat through which the pipeline would cross. During the digging of the pipeline trench, cattle would be excluded from the immediate area and, during the winter, waterfowl would not feed where pipelaying activities are taking place. During the hunting season in November and December, this area is normally opened for 15 to 20 hunters for approximately 10 out of 50 days (Lowery, 1977). Construction over this area during these months would disrupt this recreational activity. Disposal of the spoil from the burial of the raw water pipelines would also result in direct destruction of organisms in the management area. Pasture plants (eastern baccharis, macartney rose, rattlebox, bladder pod, yankeeweed, smutgrass, bushy broomsedge, and others) and trees (live oaks, tallow trees, hackberry, and prickly-ash) would be the vegetation affected. Soil animals such earthworms, insects, protozoans, and mites; soil fungi; soil bacteria; and soil algae would also be affected.

Noise, construction activity, and the overall increase of human activity would discourage use of the dry land areas by wildlife such as song and field birds, rabbits, opossums, skunks, and raccoons. A small number of bird and mice nests and perhaps nests of other small mammals would probably be destroyed. Some individual small terrestrial vertebrates such as toads, salamanders, box turtles and lizards would be killed.

Even though the construction right-of-way is 75 feet, the only area to receive a significant impact would be a strip approximately 25 feet wide where the pipeline trench is dug and the temporary spoil bank is located. After the soil is replaced in the trench and reseeded with grasses, approximately 6 months to one year would be required for recovery of the area depending on the time of year of construction. Assuming a 25-foot wide strip along the pipeline route would be unavailable for food production for cattle, approximately 15.6 acres would be excluded from use.

The excavation of 117,500 cu. yds. of material for the intake and barge slips on the Intracoastal Waterway would increase the amount of solids suspended in the water column. The size of the turbidity plume from this activity would depend on several environmental factors which would be interacting during the time of construction (i.e. tides, input from freshwater streams, winds, barge traffic, etc). Visually-oriented fish such as Atlantic croaker, and the sea trout which were found in numbers at least as great as found in offshore coastal waters would temporarily vacate the area. The blue crab was also found in large numbers and would also be adversely affected by increased turbidity. Benthic organisms, such as the marsh clam, would suffer increased mortality due to siltation. In general, however, because of the relatively poor aquatic environment in the Intracoastal Waterway, the proposed additional dredging would not significantly affect the biota in the area.

C.3.1.5.2 Brine Disposal System Impacts

Proposed Brine Disposal Route

Ecological impacts of construction of the brine dispoal system include direct destruction of organisms, general disturbance of wildlife, and habitat degradation due to dispersed sediments and contaminants. Brine lines connecting the storage cavities onsite at West Hackberry salt dome would be laid together with raw water and oil distribution lines. The impacts of constructing the onsite brine pipelines would be the same as those already discussed above in connection with leaching/displacement water pipelines (Section C.3.1.5.1)

Impacts on biota from construction of the brine line to the Gulf from the storage site would be significant because of their extent and duration. They constitute disruption along much of the length of a unique estuarine area for a period estimated at more than a year. Time periods required for biotic recovery presented in the stepwise description of construction impacts to biota below are conservative estimates, although not definitive worst cases.

Construction of the brine line from the central plant to the east would destroy nonmobile and slightly mobile pasture organisms in the path of the pipeline and increase erosion and sedimentation. The pasture organisms present are similar to those described above in relation to the storage site (Section C.3.1.5.1). The marsh and canal system in the vicinity of the dome would assimilate the small and transient increased sediment load with little effect on the organisms present. The marsh vegetation is dominated by black rush and wiregrass. White and brown shrimp, blue and other crabs, Atlantic croaker, red drum, menhaden, clams and polychaete worms, are present (along with other animals) in the canal-marsh system during at least some parts of the year.

Pipeline construction across small drainage channels in this section of the route would probably cause slight increases in turbidity and sedimentation in the adjacent channels with which the drainage channel connects. Sediment transport would occur in conjunction with rain. The increased turbidity could reduce production by submerged aquatic plants while the associated nutrient enrichment could ultimately stimulate plant production. Submerged plants are not prevalent and are largely limited to a few benthic algae. Some fish probably would avoid the area of increased turbidity, and benthic animals might be physiologically harmed or their microhabitats degraded by deposition of sediment. Aquatic impacts would be small and short-term. Trees which are prevalent in the area include such species as live oaks, chinaberry, hackberry, prickly-ash, and tallow trees. Eastern baccharis and maccartney rose are part of the shrubbery vegetation. Pasture grasses include species such as goatweed, Indian grass, prairie wildgrass, Bermuda grass, smutgrass, and others. Soil animals such as earthworms, insects, protozoans, and mites; soil fungi; soil bacteria; and soil algae would be killed by constructing the pipeline through dry land areas. Although bushes and trees would require several growing seasons to recover to pre-construction conditions, a ground cover of weeds, grasses, and shrubs would probably be well established by the end of one growing season.

Increases in the sediment load where the line would cross aquatic environments would directly impact benthos, fish and plankton (including migratory larval forms). In addition, the dredging would initially destroy most of the benthic organisms along the pipeline route. Such benthos, fish, and plankton are listed above in connection with Stark's Canal and water channels to the north of Stark's Canal.

Construction of the brine line to the west of the Calcasieu Ship Channel would impact organisms in the marshland and marsh channels in West Cove of Calcasieu Lake; and in dry grassland, sandy areas and marshes near the coast.

Land denuded of vegetation along this north-south section of the brine route would be re-vegetated within 1 to 2 years. Direct impacts to plankton and benthos would be relatively short-lived away from the dredged area, but effects on future population sizes, age structures, and dynamics could persist for two years or longer. The food of estuarine fish could be somewhat reduced in amount, which could bring about a slight decline in their numbers. On the other hand, enrichment of the impacted estuarine waters with plant nutrients would be expected to stimulate primary production (formation of new material by plants). Subsequently, secondary production (growth and reproduction by animals, bacteria, and fungi) would also be stimulated. These production increases could offset losses caused by direct destruction and degradation of water quality caused by pipeline construction. However, different species would be affected by the different changes in different ways, and the structure of the impacted biological communities would probably also change slightly.

Commercially important species present along the pipeline route where it runs along the ship channel in Calcasieu Lake include shrimp, crabs, menhaden, spotted seatrout and red and black drum. Many other species of fish are present besides the commercially important ones. Oysters and flounder are present in West Cove. The plankton is partly composed of young stages of fish, shrimp, and crabs. The edge and shallow areas of Calcasieu Lake are more productive than the highly disturbed ship channel area. Commercially important species pass through and are taken from the ship channel and other parts of the lake in large quantities, but in many cases their growth occurs close to or in marsh areas. Oysters and flounders are well established in West Cove and are an exception. Ducks, coots, wading birds, shorebirds, gulls, and terns are present in the area with the latter three groups being more common nearer the Gulf coast. Waterfowl and wading birds are much more numerous in Sabine National Wildlife Refuge along the Stark's Canal than along the ship channel. Predatory, song, and field birds also visit or nest on the islands in the vicinity. Birds, mammals and other mobile and vertebrates on islands along the brine disposal route would be disturbed and displaced during construction. This would mainly be a result of increased noise and human activity. Some nests, resting places and less mobile vertebrates such as toads and salamanders would undoubtedly be destroyed. These impacts would be short-lived and would affect few of the region's vertebrates. Mammals present include representatives of dry land and wetland habitats. Furbearing and nonfurbearing animals such as rabbits, skunks, raccoons, opossums, minks, muskrats, nutria, mice, and rats would be affected.

The vegetation in marsh areas and in marsh and dry land areas on St. John's Island contains plants such as wiregrass, rattlebox, roseau and switchcane. Revegetation after pipeline burial through areas containing such vegetation would probably occur within one growing season although another season or more might be required for complete recovery. Soil organisms such as those previously listed would be killed along the entire route by construction through dry land areas. Benthic organisms everywhere along the brine line route would probably reattain former levels in and on impacted estuarine sediments within two years.

For the remainder of the route, a considerable amount of marshland, grassy areas above the beach, the beach itself, and the floor of the Gulf of Mexico would be impacted. Buff-breasted Sandpipers, Golden and Upland Plovers, Long-billed Curlews, geese, and Water and Sprague's Pipets visit priarie areas in the vicinity as migrants or during overwintering. Organisms in the roadside grass and coastal grass areas would probably be reestablished along the pipeline route within one year.

South across Highway 82 the brine pipeline would cut through a band of tall coastal grasses on a slight ridge above the beach. This, and associated animal life probably would recover within one year. Wildlife, particularly shorebirds, would be disturbed both in these coastal grasses and the beach to the south. Gulls and terns are other common birds in this area.

Construction of the 7-mile brine line in the floor of the Gulf would eliminate a maximum of approximately 42.5 acres of non-mobile and slightly mobile benthic organisms. These include bivalves, gastropods, echinoderms, tube-building worms, sea anemones, and sea pansies. These organisms would rapidly recolonize the area after the pipeline was buried. Repopulation would require less than a year, although some changes in community composition could persist longer.

Turbidity resulting from suspension of bottom materials dislodged during and after pipeline burial would temporarily reduce phytoplankton and benthic algae production for a short period. Some of the benthic organisms near the route could be affected by sediment settling during and for a relatively short period after construction. Such sediment, if taken in by filtering benthic animals, could interfere with their feeding and respiration. Release of the chemical nutrients from these sediments may have a slight stimulating effect on phytoplankton after turbidity has diminished close to the pipeline.

General right-of-way total approximately corresponding to main ecosystem categories are presented in Table A.4-3 in Appendix A.

Alternative Brine Pipeline Route

The alternative brine pipeline route to the Gulf leads to the same diffuser location by a different path, as discussed in Section B.3.1.5.2. The route to the South beyond the initial section which is coincident with the proposed line, will place the line in the Stark's Canal for most of its length. Prior to reaching the canal the pipeline will parallel State Highway 27 for approximately one mile. The route along this highway is an artificially maintained habitat consisting of a mowed easement with occasional small shrubs. After refilling and reseading of the pipeline ditch, this area will essentially revent to the same habitat type as existed before the ditch was dug. For the next 15.9 miles, the pipe will be placed in the Stark's Canal. Both during and after pipeline construction, this canal would be subjected to greatly increased turbidity and sedimentation until the bottom and road bank had restabilized.

A direct destruction of organisms and sediment dislodgement would occur along the path of the pipeline segment constructed to the Starks Canal. Organisms destroyed by construction of this segment would include those in pasture, in a brushy drainage channel, in farmland, in marsh, and in two water channels. The pasture organisms include grasses such as switchgrass, signal grass, goatweed, Indian grass, big bluestem, prairie wildgrass, and Bermuda grass. Soil animals such as earthworms, insects, protozoans, and mites; soil fungi; soil bacteria; and soil algae would also be affected. The brush along the drainage channel includes shrubs and small trees. The farmland through which the pipeline would be laid is cultivated in soybeans or cattle feed crops such as hay or grain.

Noise, construction activity, and the overall increase of human activity in the area would discourage use of the area by wildlife such as song and field birds, rabbits, opossums, skunks, and raccoons. A small number of bird and mice nests would probably be destroyed. Some individual small terrestrial vertebrates such as toads, salamanders, box turtles, and lizards would also be killed.

The dominant marsh plants in this part of the route (north of Starks Canal) are the same as those described for the proposed route. Such plants and some of the insects and snails which feed on them would be killed. Benthic organisms such as clams; polychaete worms; nematode worms; amphipod crustaceans; barnacles; microscopic organisms such as protozoans, rotifers, harpacticoid copepods, diatoms, bacteria, and fungi; crabs; shrimp; and macroscopic algae would be killed by construction of the pipeline through the marsh and water channels of the area. Birds and mammals of the kinds described below for the vicinity of Starks Canal would be disturbed by construction activities.

Laying the pipeline in Starks Canal would kill organisms in a strip down the bottom of the canal and a strip along the roadside next to the canal where the dredge spoil would be temporarily placed before being used as backfill material. The list of benthic organisms present at the bottom of the Canal includes the forms listed above for water channels and marsh areas to the north.

The Canal would be subjected to greatly increased turbidity and sedimentation, both during and after construction, until the bottom and roadbank had restabilized. The bank would probably revegetate within one growing season, but the grass species present might not completely return to the earlier composition for an additional year or two.

Increased suspended solids in the Starks Canal and associated turbidity would not be confined to the Canal but would also be manifested to some degree in lateral canals connecting to the West Cove of Calcasieu Lake and the interior of Sabine National Wildlife Refuge. Some of the increased sediment load may even be carried into West Cove and the refuge marshes. This seems unlikely to occur to any large extent because of the probable high amount of muck in the Starks Canal sediments.

Bottom organisms, plankton, and fish in the Canal, particularly bottom organisms, would be adversely affected. Fish would lose a food source and the use of the affected area for a time. Bottom organisms are sensitive to deposition of sediment on the substrate they inhabit, and probably would experience high mortality. Sublethal effects such as reduction in or temporary cessation of reproduction and slowed growth also are likely. Formation of a distinct layer of sediment on the bottom would disturb sessile (permaneltly attached) adult bottom animals (e.g., moss animals, sponges, barnacles) and reduce or eliminate cover and food for some of the smaller animals present on or near the bottom. Increased suspended solids may disoreint migrating fish and invertebrates.

Increased turbidity resulting from sediment suspension during brine pipeline construction would reduce phytoplankton and benthic algae production. This reduction would be temporary and possibly would be regained after the water cleared because inorganic nutrients would have been released from the dredged sediments. Phytoplankton production is not very important in the Canal's foodwebs and consists mainly of sporadic increases of diatoms or dinoflagellates. Benthic algae are uncommon.

It is estimated that complete recovery of biota from laying the pipeline would occur within two years. The recreational value of a state scenic highway (Louisiana Highway 27) and the Sabine National Wildlife Refuge bordering it would be diminished during most of the recovery period. Birds and other wildlife would be disturbed by noise and construction activities during the actual construction period. A certain period would be required for the physical traces of the construction to disappear and an additional period for the biotic community to recover. Waterfowl that attract human visitors would not be as likely to visit the area and fishing and crabbing would be reduced during these periods.

Herons, egrets, ibis, and spoonbills frequent the Canal vicinity. In winter, ducks and coots are present. Thousands of birds and mammals would be affected by the pipeline in any season. The mammals of the area include furbearers such as muskrat, mink, otter, nutria, and raccoons. Other birds present besides water birds include owls and hawks.

Aquatic impacts similar to those produced in the Refuge would be caused by construction of the brine line in Starks Canal along the western side of Mud Lake. There are no connections from the Canal to Mud Lake and it would not be directly impacted. A large elbowed excavated area continguous with the Canal on the west and containing water would be impacted to an undetermined degree. The impacts would, however, be similar in kind to those which would result within the Canal proper. Starks Canal is bordered largely by pastureland in this stretch of the route. Birds and other wildlife frequenting the pastures would be disturbed by construction activities, but only for a relatively short time. The animals present in this area are similar to those described for nonwetlands to the north of the Refuge.

Waterfowl and aquatic organisms would also be impacted in the shallow marshy arm off Starks Canal through which the pipeline would pass. Full recovery would probably occur within two years. This part of the route is bordered by pasture. The wildlife and livestock present would be disturbed only during construction. Any portion of the pipeline would probably not be under construction for more than two weeks, including backfilling.

Benthic biotic communities along the pipeline route in the Gulf of Mexico would be reestablished at former levels at the beach crossing point in a fraction of a year. The kinds of organisms present in this part of the alternative route are discussed above in connection with the end section of the proposed route. The organisms at the ends of the routes are similar.

C.3.1.5.3 Impacts at or from the Storage Location

Construction at the central plant of new roads into the storage field would cause impacts in addition to those described in connection with other subsystems (e.g., brine disposal, raw water supply, and oil distribution).

Some forty acres on the SPR site would be cleared of the pasture vegetation present to construct the central plant. This plant would be built to serve both the Early Storage Program and the storage proposed in this document. This land would be covered by buildings and other structures. The organisms of the original pasture community would be lost for at least the lifetime of the storage project. Some 160 additional acres, also grazing land, would be disturbed to varying degrees during the pipeline and road construction on the site. The pasture organisms present are listed above in Section C.3.1.5.1.

Potential beef cattle production of approximately 40 to 60 cow-calf units*per year would be lost for at least the project lifetime. This is figured on the basis of the 1 to 1½ cow-calf

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*cow-calf unit = one brood cow and her calf.

units/acre average cattle production in the area determined by Knox and Oakes (1976a, 1976b). The corresponding dollar value of a total 40-acre loss based on a 6-year (1970-75) average for calf values of $272/acre/year (Knox and Oakes, 1976a) is $10,880 per year. As a worst case, 160 additional acres would not support beef cattle production for a year. Thus, a total of 200 acres would be removed from production during the first year after construction, but most of 160 acres of this total would be available thereafter. The monetary loss of beef production during the first year after construction, based on 200 acres, is estimated at $54,400. An additional 180 acres would have been impacted by the ESP.

Another source of impacts from the construction site would be the sediment washed into nearby bodies of water. The amount of this sediment is estimated at 3,220 tons of sediment over the 5-month construction period, with a ratio of about 6 to 1 between sediment going into Black Lake and that which would go into the Black Lake Bayou Canal system (2,758 tons to 462 as discussed in Section C.3.1.2.1.3). Erosion would also continue after construction and would slow as denuded areas over pipelines are revegetated. Sediment would be introduced in pulses occurring during and after rainfall. At least some of the sediment would contain fine particles which would probably remain suspended for some time. Much of the clay material may form a light flocculent in the brackish water. Flocculent masses would be loose, watery agglomerations which would easily be distributed by currents and which would settle on the bottom during periods of slack water. This sediment should be enriching to the lake-marsh-bayou system, which is adapted to large mineral, sediment, and humic material introductions. Humic materials comprise organic matter in soils. An unequal stimulation of different components of the biotic community is probable. For instance, there might be algal blooms which occurred long before any evident stimulation of growth by marsh plants along the shore of the lake and animals which use these plants as food would be affected accordingly. Also, burrowing animals and decomposers (bacteria and fungi) in food chains based on the type of organic matter in the introduced sediment would increase, whereas animals such as shrimp and crabs, which require larger food would not increase as much.

Short-term turbidity increases would possibly temporarily inhibit primary production in the water column on occasion. Contaminants such as herbicide or insecticide residues or spilled hydrocarbons would stress the biota in the aquatic system.

C.3.1.5.4 Oil Distribution System Impacts

Impacts on biota which would be associated with construction of the oil distribution system have been discussed in the West Hackberry Pipeline Design Change Environmental Assessment Amendment (FEA, 1977), and will only be summarized here. Marshes, dry land, spoil banks, woodlands, roads, and water and waterways would be impacted.

Lost marsh primary production along the oil pipeline route to the Sun Oil Terminal was estimated at up to 2.73×10^6 Kg. Losses of economically important secondary producers were estimated at $27,900. Potential monetary losses to agriculture on dry land along the oil pipeline route were estimated at $17,408. Some 210 acres of spoil area of unknown productivity would have its ground cover and associated animal life destroyed by construction of the oil distribution line. Other animal life would be disturbed. There would be a permanent loss of 32 acres of woodlands along the oil pipeline route and 62 acres would be cleared overall. Habitat for wildlife would be lost with the elimination of the woodlands, but early successional vegetation and associated wildlife would become established in the 30 acres which were not lost permanently. Construction of the pipelines across roads would have a very slight biological impact stemming from increased erosion and sedimentation. Some 30 water bodies would be impacted by construction of the oil lines. Benthic fauna would be destroyed; fish, benthos and plankton would be affected by increased turbidity. Hydrocarbon residues from oil pipelines cut during construction of the ESR oil pipeline would be a minor source of contamination in Black Lake for a short period of time.

C.3.1.6 Natural and Scenic Resources

The impact on natural and scenic resources would be relatively minor unless the alternate brine pipeline route were selected. This brineline would parallel scenic State Highway 27 for a distance of all miles through Sabine National Wildlife Refuge. During the construction of this brineline, there would be a localized disturbance along this highway due to the activity of construction crews. This disturbance, with its associated noise and activity, would cause waterfowl to retreat into the marsh away from the vicinity of the road. When this occurs, the waterfowl which represent the most conspicuous wildlife of the marshes, would not be accessible for public viewing. This impact would be short-term as the effect would be restricted to the immediate vicinity and time of construction. Construction of the other components of the facility are not expected to affect the surrounding natural and scenic resources appreciably.

Nibletts Bluff State Park, located 10 miles north of the oil pipeline route in Louisiana (See Figure B.2.28) is situated far enough from construction areas so that no impacts are anticipated to this park.

C.3.1.7 Archaeological, Historical, and Cultural Resources

It has been determined that there is a low probability for archaeological sites in the vicinity of the proposed and alternate West Hackberry brine pipelines. At the present time an extensive archaeological survey is underway, covering the West Hackberry dome and its associated pipelines. After the results of this survey have been compiled, the appropriate procedures would be initiated for compliance with the National Historical Preservation Act of 1966 and Executive Order 11593.

C.3.1.8 Socioeconomic Impacts

C.3.1.8.1 Employment

Construction activities for the expansion of oil storage facilities at West Hackberry would employ several hundred people for a relatively short period of time. Labor requirements for the construction period are shown in Figure C.3-15.

During the initial 6-month period of work at the storage site, practically all the construction of buildings, surge ponds and roads, and the installation of equipment would be completed. In addition to these activities, the drilling of wells for 15 new solution cavities, and the leaching of those cavities would be started. The labor force at the salt dome would reach a peak level of about 200 workers during the third and fourth months of activity. Drilling and leaching activities would operate continuously, employing about 30 workers on each of two evening shifts. The peak number of workers on site during the day, therefore, would reach about 140.

It would take approximately four months to lay the brine pipeline from the salt dome to the disposal area in the Gulf of Mexico. This includes time allocated to survey the route and to dredge areas where the pipeline would be submerged. The pipeline crew would be divided into teams to perform the following tasks: clearing the right-of-way, preparing ditches, welding and coating the pipe, covering the pipeline, and restoring the right-of-way. Seven miles of pipeline would be laid in the Gulf of Mexico, requiring a crew that would work on a barge. Approximately 140 to 180 workers would be employed on the pipeline crews.

The total demand for workers at the project during the initial 6 months of construction would reach about 380. The majority of these would be drawn from the extended Lake Charles metropolitan area, which has a civilian labor force of about 57,000 persons (Louisiana Department of Employment Security, 1976). Of the labor supply, about 29 percent or 16,530 are in the occupational categories of craftsmen, foremen, machine, and vehicle operators (Census, 1970). Assuming an unemployment

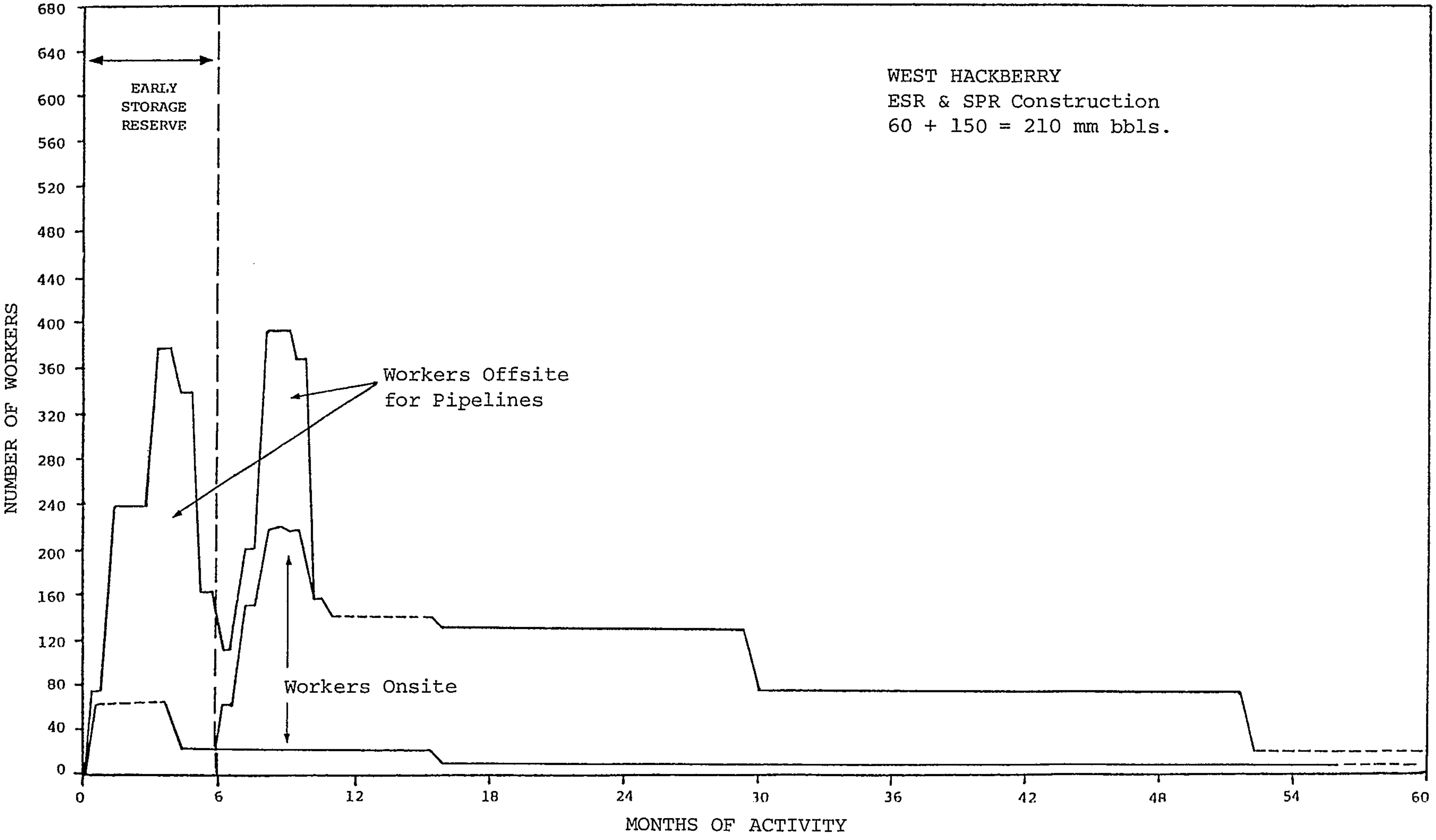

Figure C.3-15 Labor Requirements at the West Hackberry Site rate among these workers of 6 percent, nearly 1,000 skilled workers would be available. It is not uncommon for construction workers in the region to commute as many as 50 miles to a job that lasts for only several months, so it could be expected that some workers at the site or on the pipeline would commute from parishes adjacent to Calcasieu and Cameron Parishes. If all 380 workers were drawn from Cameron and Calcasieu Parishes, the unemployment rate (which in February 1976 was 8.6 percent) would fall by 0.6 percent for the short period of initial construction.

The additional port facilities to be built by Sun Oil at their terminal in Nederland are not part of the proposed Federal facilities. Because their construction period could coincide with the early period of construction at West Hackberry, however, the labor needs at Nederland are important to consider. Three oil tanks, a dock for loading and unloading oil tankships, and pump stations to be used for pumping oil to the West Hackberry storage facility would be built at the Nederland terminal. Construction would take nearly a year, but the labor force requirements would peak at about 110 during the third month. Assuming that work started simultaneously at both West Hackberry and Nederland (a "worst case" assumption), then the combined employment needs would reach nearly 500 workers. The Nederland facilities would draw workers from the Beaumont-Port Arthur-Orange metropolitan area which has a civilian labor force of about 166,000 and an average unemployment rate of 7.1 percent (Texas Employment Commission, 1976). Utilization of 110 workers from this labor pool would briefly reduce the unemployment rate by 0.1 percent.

After the initial period of construction at West Hackberry, the labor force would be reduced to about 120 persons. Approximately 46 of these workers would be drilling access wells, a task which would continue until the 25th month of activity on site. Another 50 to 55 workers would be engaged in the leaching of the storage caverns, which continues through the 41st month. Both of these tasks require the workers to work in shifts; therefore, the day labor force would amount to about 60 workers while the drilling lasted, and drop to about 40 until the leaching and initial fill were complete. This estimate includes workers engaged in maintenance activities and in monitoring the flow of oil into the caverns.

C.3.1.8.2 Land Use

The oil storage site at West Hackberry would be expanded from the 220 acres developed in the Early Storage Program to 380 acres. The additional land needed to expand the storage capacity would be west of the area previously developed. The land is presently used for pasture.

The village of Hackberry, which is 3 miles east of the storage site is expected to grow at a rate of about 10 percent every 10 years. Almost all of the urban expansion is expected to develop north and south of the present commercial area, along Route 27. The storage facility would be separated from Hackberry by about two miles of rural land, primarily pasture, with stands of trees surrounding individual houses. Use of the West Hackberry dome would not prohibit any anticipated urban growth, and would not interfere with continued use of adjacent lands for agricultural purposes.

Land north of the salt dome is being used for oil production. Since oil and gas are generally found around the periphery of salt domes, the use of the land on the dome surface would not preclude further development of the oil field.

The alternate brine pipeline would follow existing rights-of-way toward the Gulf of Mexico. It would be laid along the west side of Highway 27 which is part of a scenic route through the coastal area, and the construction of the pipeline would mar the aesthetic value of the route until the vegetation along the pipeline right-of-way is restored. Futhermore, it would cross the Sabine National Wildlife Refuge, where it would follow the course of the Starks Canal. Crossing the Refuge is not prohibited, but a special permit to do so would be required. The pipeline would cross Highway 82. The Louisiana Department of Highways would be consulted in connection with the crossing of both Highway 82 and Route 390, which lies just south of Hackberry.

Construction of the alternate pipeline across the shore and in the shallow water offshore would reduce the value of the beach area. Holly Beach lies about half a mile east of the proposed right-of-way, and is a resort area. The right-of-way would be a restricted area during the construction period, which would last a few weeks. Stationing equipment off-shore for laying the 7 remaining miles of pipeline would interfere with the aesthetic appearance of the shore, but would not preclude the use of adjacent waters for commercial or recreational purposes.

C.3.1.8.3 Traffic

The impacts of project construction on local traffic patterns would be basically of three kinds: the increased number of vehicles on the roads carrying workers and materials to the site, the disruption of traffic while pipelines are being laid beneath the road bed, and the additional tankers bringing oil into the docks at Nederland.

The most severe instance of increased traffic would occur if all workers drove to the site in their own vehicles. There could be as many as 140 cars going to the site bringing the day work shift, 30 cars leaving the site with one night shift, about 160 members of the pipeline crew going to the right-of-way immediately adjacent to the site, and about 20 trucks carrying supplies and equipment to the site. It is more likely, however, that about one-third of the vehicles would carry more than one worker, making the shift time traffic reach a peak level of 245 going one direction and 25, the opposite way.

Except for workers recruited from Hackberry and other areas of Cameron Parish, all the labor and materials for the project would enter the parish on Louisiana Highway 27 (the segment west of Calcasieu Lake). They would go west on Route 309 a distance of nearly a mile, then turn north to the salt dome. The impact of project traffic on these roadways has been calculated for the short-term period of heavy traffic (225 vehicles for on-site workers and pipeline crew, 25 vehicles for each of two evening shifts, and 40 trucks, all making two passages per day) and for the 12-month period beginning at the start of activities on-site. The recorded daily average number of vehicles on these roads (Louisiana Department of Highways, 1971), and the percentage of increased traffic due to the construction activities at West Hackberry, are shown as follows.

	Recorded Traffic	Peak Period Increase	12-Month Average Increase
Louisiana Highway 27 (western section)	1,430*	47%	16%
Route 390	550	122%	41%
County road to the site	290	231%	77%

After the initial year of construction, the number of vehicles' using these roads to travel to and from the West Hackberry site would continue to decline. During the final phase of construction, a period of about 14 months when the storage caverns are being leached and filled, the increase in local traffic due to the project would be about 21 percent on Route 390 and 40 percent on the county road leading to the site.

Disruption of traffic would occur while the brine pipeline is laid across Route 390 and Louisiana coastal Highway 82. While Route 390 has an average daily traffic of 550 vehicles near the turnoff to the site, it is used more frequently as it approaches Highway 27. At its junction with this larger highway, Route 390 has an average of 1,370 vehicles daily. Highway 82 at the point where the pipeline would cross, had an average daily count of 780 vehicles in 1971, which increased to 1,100 in 1975. In both instances, alternate roads to use as detours for the traffic are not available. Traffic would probably be made to move single-file in one direction at a time along a temporary path adjacent to the highway while the pipe was laid under the main road bed. This disruption would last several days at each highway crossing.

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* A 1975 traffic count recorded 2,070 vehicles passing in this section of Highway 27, but did not include traffic counts at the other two roads. Using the 1975 count the traffic increases would be 32 percent at the peak level, and 11 percent over the 12-month period. It can be assumed that the increased traffic on Highway 27 between 1971 and 1975 would not necessarily indicate a commensurate increase in traffic along the other two roads.

Tankers bringing oil to the Sun Terminal for the initial fill at West Hackberry would use three sections of the Sabine-Neches Waterway. The Sabine Pass section, which extends from the Gulf of Mexico to the upper end of Sabine Pass, had a traffic load in 1975 that included 1,295 tanker trips.* The Port Arthur section, from the Sabine Pass to the mouth of the Neches River, had a traffic load that included 1,377 tanker trips. The Beaumont (Neches River) section of the waterway extends from the mouth of the Neches River to a point about 20 miles up the river, and was used for 689 tanker trips (Commerce, 1975).

The following table showing the annual increase in tanker traffic on these sections of the Waterway is based on the assumption that each tanker holds a maximum of 365,000 barrels of oil. The monthly schedule and pumping rate conforms to the timetable given for Section A.4.6. The first 16 months of this timetable reflect the development and initial fill of the West Hackberry storage caverns that are designated as part of the Early Storage Reserve. From the 18th month through the 50th month, the tankers would be supplying oil for the expansion of that site.

	Additional Tanker Trips	Sabine Pass Port Arthur Increase	Neches River Increase
7th - 16th month	130	12%	23%
18th - 36th month	234	12%	23%
36th - 50th month	136	9%	17%

C.3.1.8.4 Housing and Public Services

Although there would be a sufficient number of skilled workers within commuting distance of the West Hackberry site and unemployed at the time, to fill the labor needs of the project, it is probable that some of these workers would select other jobs or be unavailable to the project

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* These are "round trips." Where the number of outbound vessels does not match the number of inbound vessels, the inbound traffic was used to determine the number of "trips." Ship traffic in 1975 was reduced from the three preceding years, but is close to the average from 1969 through 1975.

for other reasons. Assuming that only 20 percent of the unemployed skilled workers of the area were hired for the construction of West Hackberry, about 60 workers would be expected to move into the region, attracted by the job openings. This represents about 15 percent of the peak labor requirements.

Taking into consideration the short duration of the peak labor need, the relative size of towns and cities, and the availability of housing as well as the proximity of local towns to the West Hackberry site, a distribution of these workers can be made. Approximately 35 may settle in Lake Charles, 15 in Sulphur, and as many as 10 in Hackberry.

Due to the short duration of the peak construction period, and the greater availability of rental units than homes for sale, these newcomers would probably rent their homes or apartments. The effect of this would be scarcely noticeable in Lake Charles where the vacancy rate among rental units would drop less than one percent. In Sulphur, where the population expanded from 13,551 in 1970 to about 18,500 in 1975, the assumption has been made that the building of homes has almost kept pace with the growth in population and that the availability of rental units has declined slightly from the 1970 figure of 12.3 percent to a level of 10 percent. The effect of the additional project workers moving into Sulphur would decrease the availability of housing further by about one percent. In both cities, the small increase in demand is not likely to cause any change in the cost of rental units.

Hackberry is primarily a rural community, and for that reason, it cannot be expected to have a sizeable number of rental units. Workers and their families who move into Hackberry are likely to be those who stay for the full three to four years of construction. They can be expected to purchase or build homes in the area. The growth represented by about 10 families moving there would constitute a 3 percent increase over the expected growth by 1980. The combination of the workers' families and the expected growth of the community may cause crowding in the Hackberry school and precipitate the construction of additional classroom space.

Injuries to workers occurring in the course of construction activities would increase admission to two area hospitals. Workers injured at or near the site would be taken to West

Calcasieu-Cameron Hospital in Sulphur. This facility has an average admission rate of about 125 persons per week and an occupancy rate of between 75 and 80 percent. Its present facilities would probably be adequate for handling most accidents which occur in the course of the work. Workers injured in the course of laying the brine pipeline to the Gulf of Mexico could be taken to the South Cameron Memorial Hospital. It does have an emergency care unit, but it is small (there are only 27 beds), and its admission rate averages about 15 per week (American Hopsital Association, 1975). Accidents that inflict serious injuries on multiple persons may require the evacuation of some of them to hospitals in Sulphur and Lake Charles.

Increased activity at the site during construction and heavy traffic on the roads to and from the site at the beginning and end of the day work shifts would increase demands on existing police services.

C.3.1.8.5 Economy

The local economy of the area would be impacted by the project. The wages earned by local workers and part of the costs of materials and supplies would be additional income for the area and would circulate within the region, creating the multiplier effect.

The payroll of workers on the project would reach a peak level during the first six months of construction, then diminish gradually until the storage facilities were completed. The following table shows the approximate average payroll levels that would be reached during various segments of the West Hackberry project:

Early Storage Reserve

1st through 6th month: $475,000 per month

SPR Expansion

7th through 12th month: $497,000 per month
13th through 18th month: $321,000 per month
19th through 30th month: $258,000 per month
31th through 50th month: $150,000 per month

The monthly payroll would reach high levels of between $700,000 and $800,000 during months 8 through 10 when pipelines are being laid. The payroll levels are based on an assumed average worker wage of $2,000 per month.

The overall economic gain of the SPR to the region is based on a combination of workers' income and the local purchase of services, materials, equipment, and supplies for the project. Expenditures that would be made totally within the region include those for site preparation, well drilling, the laying of the brine pipeline, power installation, construction of surface facilities, the leaching of the storage caverns, and the pumping of oil to the site. In addition, about half of the procurement of material and equipment could be made in the region. The amount that this would bring into the region during project construction would be about $150,300,000.

The increase in local spending stimulated by the additional regional income is considered to be a secondary economic gain. The total income supplied by project expenditures and these secondary gains can be estimated by applying the regional economic multiplier. In this case, the multiplier for the Lake Charles area (2.04) would be used. The result is an increase in local earnings of $306,600,000. (Appendix M provides a technical discussion of economic base analysis.)

In order to put these monetary amounts into perspective, they can be compared with regional earnings projected for 1980. Since contractors and suppliers throughout a region that includes the Lake Charles BEA area and the Beaumont-Port Arthur-Orange BEA area,* would be competing for portions of the work, these two areas together comprise the economic region that would be impacted by the project. The total of the SPR expenditures and secondary spending would amount to 7 percent of the combined earnings in these two BEA areas in 1980. Considering only these two standard metropolitan areas, the earnings attributable to the project would constitute a 12 percent gain over the anticipated 1980 level.

While most of the SPR purchases of materials and equipment would be concentrated in the first year of construction, economic imput to the area and secondary stimulation to local businesses would extend over several years. The total

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* The Lake Charles BEA (Bureau of Economic Analysis) area is comprised of 14 parishes; the Beaumont-Port Arthur-Orange area is comprised of 7 counties.

economic gain stemming from the oil storage project would represent a 39 percent increase over the anticipated growth in earnings between 1980 and 1985 for the two combined BEA areas, and 65 percent over the expected growth in earnings of the two metropolitan areas over the same period of years.

C.3.1.8.6 Government Revenues

There would be some sources of additional local governmental revenues attributable to the construction of the project and some loss of revenues from other sources. State, parish, and city revenues would be increased indirectly by the generally higher level of economic activity in the area. This activity stems from project construction through the purchase of pipeline, building materials, and various services.

The wages earned by workers employed by the construction tasks is a quantifiable aspect of this higher level of economic activity. Assuming that an average of 20 percent of each worker's pay is withheld for Federal income taxes, social security, and worker's benefits plans, and that of the remaining wages, about 6 percent were put into a savings account, the remainder would be spent in ways that would be taxed by local governmental agencies. The sales tax alone, which in Louisiana includes a 3 percent state tax, 1 percent parish tax, and 1 percent city tax, would contribute about $219,000 to state, parish, and city revenues in the first year, $131,000 in the second year, $92,000 in the third year, and $68,000 in the fourth year of construction.

Materials and equipment purchased specifically for use and installation at the Federal facility would not be subject to local sales tax. Similarly, Federal ownership of the site and pipeline rights-of-way would exempt these properties from local taxation.

C.3.2 Impact from Operation

C.3.2.1 Land Features

C.3.2.1.1 Geomorphology

Operation and maintenance activities would have no impact on geomorphology (topography, drainage patterns) at the West Hackberry storage site or along the oil or brine pipeline routes. Maintenance dredging at the docks would be required. This would alter the bathymetry at the docks, and spoil disposal would alter topography at the disposal site. Disposal of the spoil material would result in minor geomorphic impact in the disposal area.

C.3.2.1.2 Soils

Routine operation and maintenance is not expected to result in any impacts to soil characteristics at the storage site, along either the oil or brine disposal pipeline routes, or at the terminal and dock facilities. Accidental spills of oil or brine could, however, cause the soil in contact with oil to be incapable of supporting vegetation. (See discussion of oil spills in Section C.2.1.)

C.3.2.1.3 Stratigraphy, Geologic Structure, and Mineral Resources

No impact on the stratigraphy, geologic structure or oil production on the flanks of the dome would occur during normal operation and maintenance activities.

Future salt production in the area of the new storage caverns would not be compatible with the SPR program. Also, sulfur (if any exists in the cap rock above the expansion site) could not be mined.

C.3.2.2 Water

The operation and maintenance of the West Hackberry facility would produce certain impacts on the water environment. Subsequent discussion dealing with these impacts is organized in two parts as follows:

- Surface Water
- Subsurface Water

C.3.2.2.1 Surface Water

Withdrawal of Displacement Water From the Intracoastal Waterway

The only significant impact on the supply or availability of surface water would result from the withdrawal of water for the displacement operation. The maximum rate of withdrawal would be 1.47 million bpd (barrels per day) or 42,900 gpm (gallons per minute). The period of withdrawal would extend over a minimum of 150 days (5 months). The same discussion of impacts presented in Section 4.3.2.1 for the withdrawal of leaching water would also apply for the withdrawal of displacement water (see also Appendix D.27).

During displacement, oil may be simultaneously withdrawn from both West Hackberry and Sulphur Mines. In order to predict the impact of water withdrawal from the proposed intake location on the ICW, the MIT Water Quality Network Model (Harleman, et al, 1976), as described in Appendix D-14, was utilized. Detailed results from the use of the model are presented in Appendix D.27. The results indicate that for the given conditions, the surface heights of the ICW would not be appreciably altered during withdrawal of displacement water. In addition, changes in flow velocities would be small (0.03 ft/sec or less) throughout the ICW.

Using computer modeling to simulate conditions of high salinity in the Sabine River and Calcasieu Ship Channel, a salinity increase of less than 0.05 ppt was indicated for the withdrawal point. The largest salinity increase observed anywhere in the ICW was less than 1 ppt. Predicted salinities along the ICW before and after the withdrawal operation are presented in Appendix D.27.

Withdrawal of Displacement Water from Black Lake

If water were withdrawn from the alternate location on Black Lake this would affect both the supply (or availability) and quality of the surface water in the lake. The point of withdrawal, as indicated in Figure C.3-1, would be on the southern side of Black Lake about 2000 feet west of Black Lake Bayou.

If Black Lake served as the sole source of displacement water, and if the lake were completely isolated from other water bodies, the withdrawal rate previously noted would lower the water level of the lake 8.64×10^{-2} ft/day (as explained in Appendix D.12). Because the lake is connected with both Calcasieu Ship Channel via Black Lake Bayou and with the ICW (Intracoastal Waterway) via Alkali Ditch, the actual rate of fall of water would be much less than the value noted. As indicated in Figure C.3-1 induced currents in both the bayou and the ditch would serve to replenish the water withdrawn from the lake. Thus, as in the case of the leaching operation, essentially all of the replenishment water would actually come indirectly from the Calcasieu Ship Channel and the ICW.

In order to predict the impact of the withdrawal process for displacement water, a numerical solution of the equations governing the flow of water in an estuarine system has been obtained. The MIT Water Quality Network Model (Harleman et al, 1976), which is described in Appendix D-14, has been used for this purpose. The detailed results generated by the model are presented in Appendix D-12. These results indicate that, under normal environmental conditions the surface height of Black Lake would be depressed approximately .17 feet during the withdrawal process. Induced flow effects in Black Lake Bayou would increase flood tide currents by approximately .13 ft/sec while reducing ebb tide currents by a similar amount. Likewise in Alkali Ditch flood tide currents would be increased by approximately .11 ft/sec with ebb tide currents reduced by the same amount.

Because of its greater depth alkali Ditch would supply the major portion of the replenishment water to Black Lake. Such water would be fresher than that passing through Black Lake Bayou. Thus the salinity of Black Lake would decrease approximately 1.3 ppt during the withdrawal process. Likewise the salinity of Alkali Ditch would decrease, along with salinity in that portion of Black Lake Bayou between its junction with Alkali Ditch and Black Lake. In that portion of Black Lake Bayou east of its junction with Alkali Ditch, however, the salinity would increase by as much as 3.2 ppt due to the intrusion of the saltier water from the Calcasieu Ship Channel. The impact of such salinity changes on species and ecosystems is provided in Section C.3.1.5.1.

In addition to normal environmental conditions involving lunal (diurnal tides) special consideration must be given to wind-driven tides. Under certain meteorological conditions, normally associated with the passage of a front, winds in the area may persist in one direction for periods as long as one week (Coleman, 1977). In such a situation the water level in Calcasieu Lake may be depressed (or elevated) 2 to 3 feet below (or above) its normal value. At Hackberry, the maximum depression observed in the period from 1944 to 1976 amounted to approximately 2 feet below mean sea level and persisted for approximately 3 days (Dement, 1977). An analysis has been performed with the Network Model to determine the effects of such a depression of water level in both the Calcasieu Ship Channel and the Intracoastal Waterway. The results of such an analysis are also presented in Appendix D-12. Such results indicate that under the influence of a wind-driven tide the level of

Black Lake would temporarily drop approximately .86 feet. This drop, combined with the drop of .17 feet resulting from the withdrawal process, would produce a total decrease in the water level of 1.03 feet. The lake is reported to have a mean depth of four feet, but in the vicinity of the withdrawal point it may be much shallower. In such shallow regions, a drop on the order of one foot could be significant. Because the wind-driven tidal effect should not persist for more than three days, however, any exposure of portions of the lake bottom would only last a similar time period. Clearly such exposure would be due primarily to the wind-driven tidal effect which is a natural phenomenon.

Withdrawal of Displacement Water from Calcasieu Ship Channel

The Calcasieu Ship Channel has also been proposed as an alternate source of displacement water for the West Hackberry site. In order to predict the impact of the withdrawl process for displacement water, a numerical solution of the equations governing the flow of water in an estuarine system has been obtained using the MIT Water Quality Network Model (Harleman, 1976), which is described in Appendix D-14. The detailed results generated by the model are presented in Appendix D-13. These results indicate that under normal environmental conditions the surface height of the Calcasieu Ship Channel would be depressed approximately .01 feet due to the withdrawal of displacement water. In Calcasieu Lake changes in flow velocities would also be small with a maximum change of .02 ft/sec occurring in the southeastern portion of the lake. In West Cove, changes in flow velocities would amount to approximately .03 ft/sec. In both Calcasieu Lake and West Cove the velocity changes appear to be closely linked to changes in salinity and are probably not the result of induced flow effects associated with the withdrawal process.

Throughout the Calcasieu Ship Channel the withdrawal process produced very little change in salinity. Actually at the end of the 150-day withdrawal process the salinity was generally on the order of .2 ppt less than the salinity prior to withdrawal. Similar decreases ranging as high as 2 ppt in Calcasieu Lake and 4 ppt in West Cove were observed. These decreases in salinity are not considered to be the result of the withdrawal process but instead are primarily the result of the existence of nonequilibrium conditions (with respect to salinity) in portions of the water network at the time the withdrawal of displacement water commenced.

Brine Disposal

Unless a concurrent leach and fill construction technique is used, during initial fill (and any subsequent refill) at West Hackberry, 265 ppt brine would be discharged at a rate of 175,000 bpd or 5100 gpm for a period of 1200 days. Current design calls for the disposal of the brine by means of discharge into the Gulf of Mexico, using the same brine disposal system as used during the leaching operation. The general disposal area in the Gulf is indicated in Figure C.3-8.

The brine discharged during the fill process would be 15 percent more saline (265 ppt) than that discharged during leaching (230 ppt). The rate of discharge, however, would be less than 15 percent of the rate during leaching. Therefore the impact produced by the brine disposal during fill would in general be less than that already described in Section C.3.1.2.1 for leaching.

The displacement operation would vary from the leaching operation only in the placement of excess salinity contours within the brine plume and the size of the plume. Thus the discussion presented in Subsection C.3.1.2.1 concerning chemical composition at excess salinity contours for the leaching operation is equally applicable to the displacement operation. Data is given in Appendix D.15 for the chemical composition at various excess salinity contours.

Discharge of Treated Ballast Water

As noted in Section A.4.4.1 each tanker prior to receiving oil at the tanker dock would discharge a volume of ballast water amounting to 20 percent of its total capacity. This water would normally have been pumped into the tanker while at sea and therefore would be saline (30 ppt). The ballast water, after discharge from the tanker, would pass through the existing ballast water treatment system which is designed to conform to Texas water quality standards (Texas Water Quality Board, 1976). Texas standards require that no visible film of oil be produced on the water surface. The concentration of oil necessary to produce such a film is not precisely established but available experimental data (Hornstein, 1973) suggest that such a film becomes visible when the oil concentration is approximately 5 to 10 ppm*. The salinity of the water would not be affected by the treatment process. The treated ballast water would be discharged into the Neches River at a rate of 10.92 ft^3/sec or 168,000 bpd**.

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* This concentration includes both dissolved and emulsified oils.

** This rate of discharge is based on the assumption that 60 percent of the oil removed from the storage facility would be transported by tanker from the Sun Oil Dock.

As described in Section A.4.4.1, the treated ballast water would enter the Neches River via a small ditch on the southern bank of the river. The dimensions of this ditch are not specified at this time nor is its total discharge rate or the flow velocity of the discharged fluid. In order to obtain some estimate of the impact, the ditch was assumed to contain only the treated ballast water from the tankers associated with the transport of oil from the West Hackberry facility. Thus the discharge rate was taken as 10.92 ft^3/sec with a salinity of 30 ppt and an oil concentration of 7.5 ppm. The river flow velocity was taken at 0.765 ft/sec Gulfward based on the minimum flow rate reported during the water year 1975 (USGS, Texas, 1975). The river depth was assumed to vary from 5 feet near the shore to 40 feet in the navigation channel. The behavior of the resulting plume was modeled by means of a computer program utilizing the general solution of the diffusion equation for a finite moving medium (Hinze, 1959). By means of images, the top and bottom of the river and the river banks were accounted for. The program was used to compute the distribution of oil and salinity downstream of the ditch. Figures C.3-16 and C.3-17 present the computed contours for oil concentration on the river bottom and river surface respectively. In similar fashion, Figures C.3-18 and C.3-19 present the corresponding plots of isohalines (lines of constant salinity). Figures C.3-16 through C.3-19 can be interpreted as planar views of the Neches River. The ballast water discharge ditch is located on the southern bank of the river and river flow is Gulfward.

On the river bottom as indicated in Figure C.3-21, oil concentration values of 7.5 ppm would occur as far as 950 feet downstream of the ditch. The oil concentration would exceed 1 ppm for a distance of approximately 7600 feet downstream.

On the river surface oil concentrations of 7.5 ppm, as shown in Figure C.3-22,are encountered as far as 960 feet downstream. Concentration in excess of 1 ppm occur as far as 7900 feet downstream. On both the river bottom and surface no concentration greater than 1 ppm occurs beyond roughly 40 feet from the southern bank of the river.

The isohalines shown in Figure C.3-18 for the river bottom indicate that salinities of 30 ppt persist as far as 950 feet downstream. Salinities greater than 4 ppt are encountered for a distance of 7600 feet downstream.

On the river surface, as shown in Figure C.3-19, the 30 ppt isohaline extends downstream 960 feet. Salinities in excess of 4 ppt occur as far as 7900 downstream.

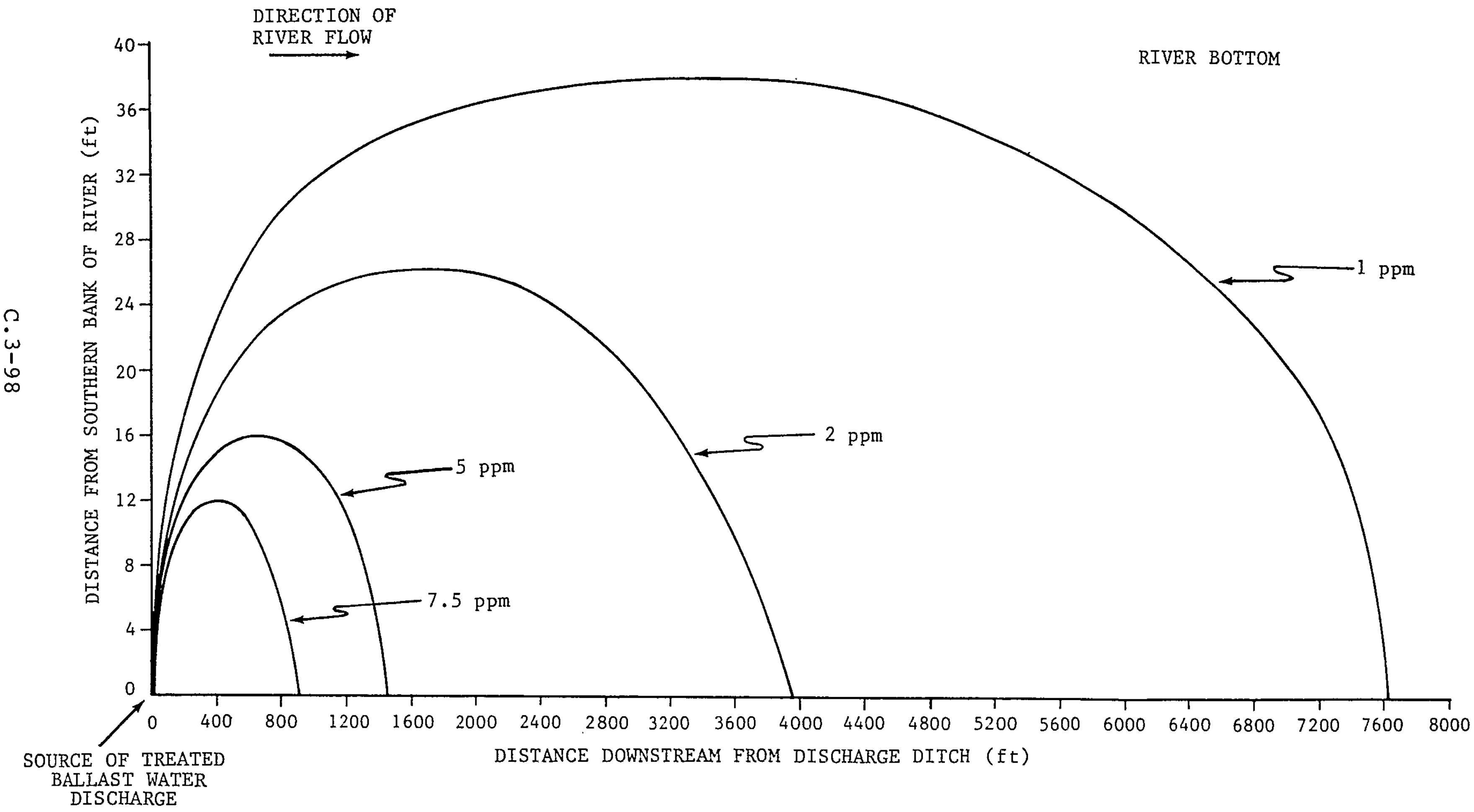

Figure C.3-16 Computed Oil Concentration along Bottom of Neches River

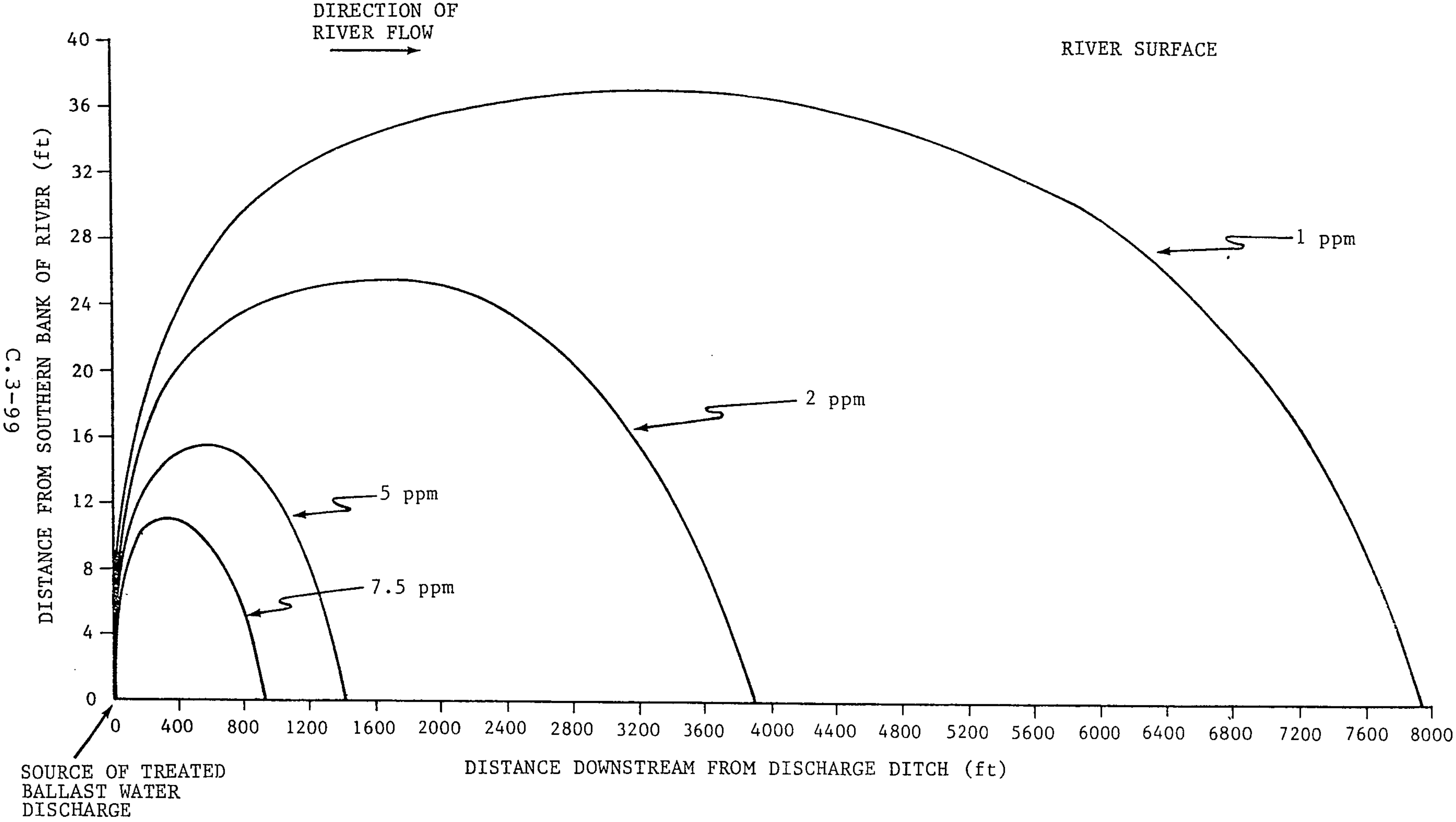

Figure C.3-17 Computed Oil Concentration on Surface of Neches River

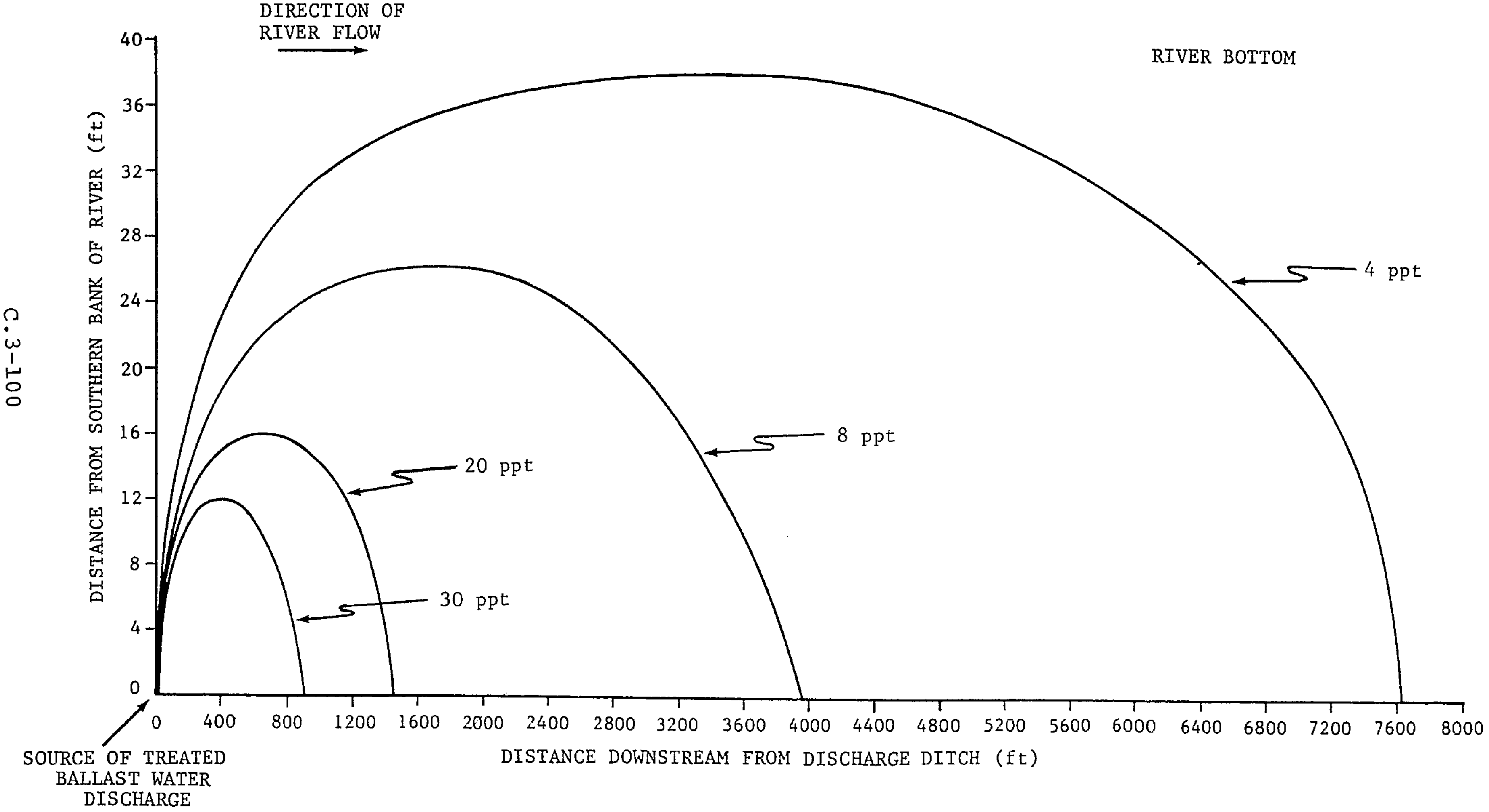

Figure C.3-18 Computed Salinity on Bottom of Neches River

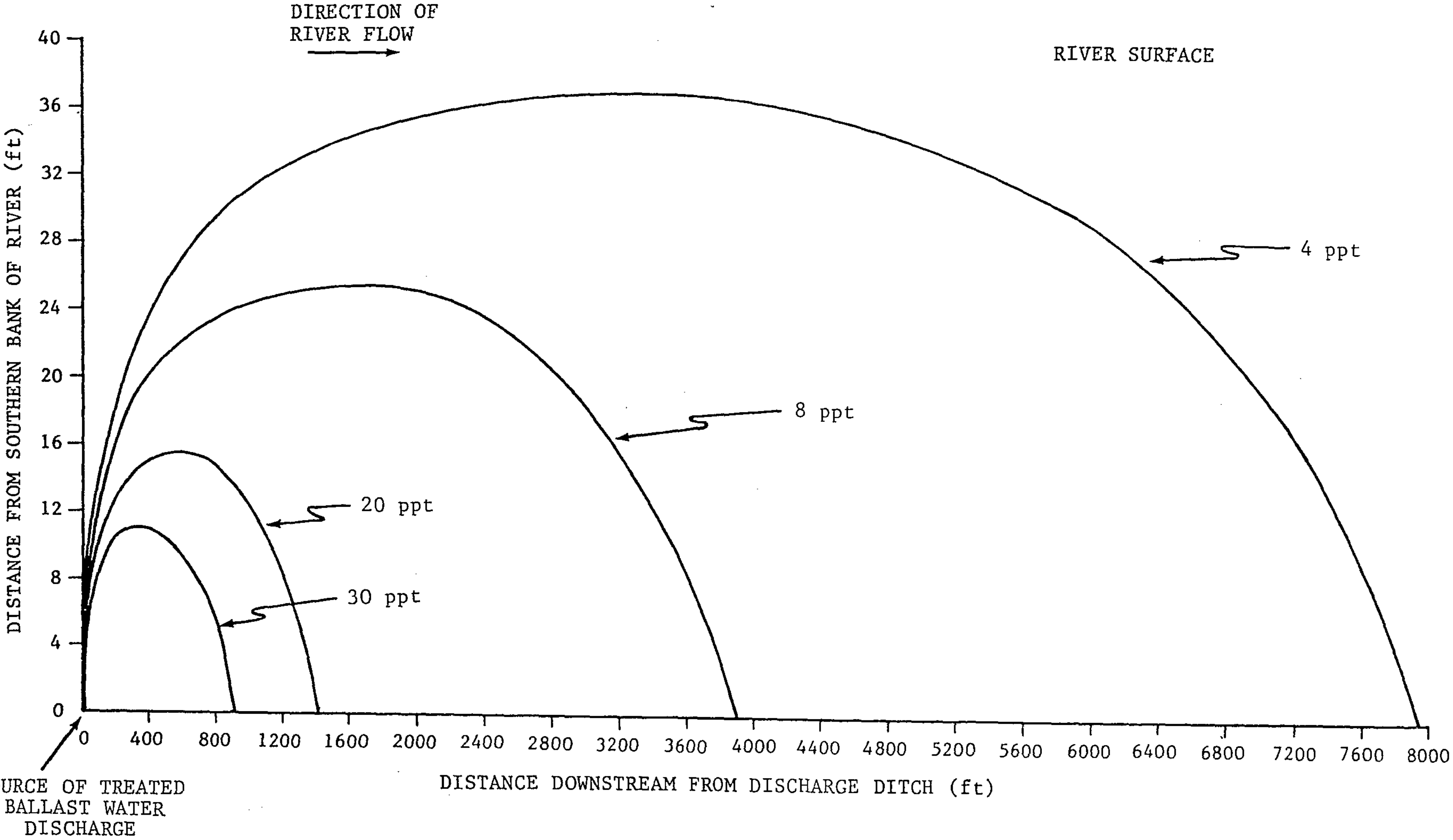

Figure C.3-19 Computed Salinity on Surface of Neches River

The total area* exposed to a given (or greater) concentration of oil is presented as a function of oil concentration in Figures C.3-20 and C.3-21 for the river bottom and surface, respectively. Figures C.3-22 and C.3-23 provide similar data for the total area* exposed to a given (or greater) level of salinity. In each case, an area of approximately 8000 square feet or less is exposed to the maximum levels of oil and salinity.

The cross sectional area** of the portion of the river affected by the discharge of treated ballast water would be less than 0.1 percent of the total cross sectional area of the river. A mixing region of this size would be well within Texas State Water Standards. Thus, the discharge of treated ballast water into the Neches River would have a minor impact on the river.

Pollutants of Miscellaneous Maintenance Activities

Numerous solid and liquid products, both organic and inorganic, used in the maintenance and operation of the facility, are a source of chemical and biological water pollution. The major sources of maintenance-related pollution are generally similar to those present during the construction of the facility as described in Section C.3.1.2.1. The magnitude of such sources, due to maintenance and operations are in general smaller than those resulting from construction.

C.3.2.2.2 Subsurface Water

Current design for the West Hackberry SPR facility does not involve use of the shallow aquifers as a source of displacement water nor use of the deeper aquifers as a site for brine disposal. Thus the subsurface water system should experience no impact as a result of facility operation.

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* In the horizontal plane.
**In the vertical plane.

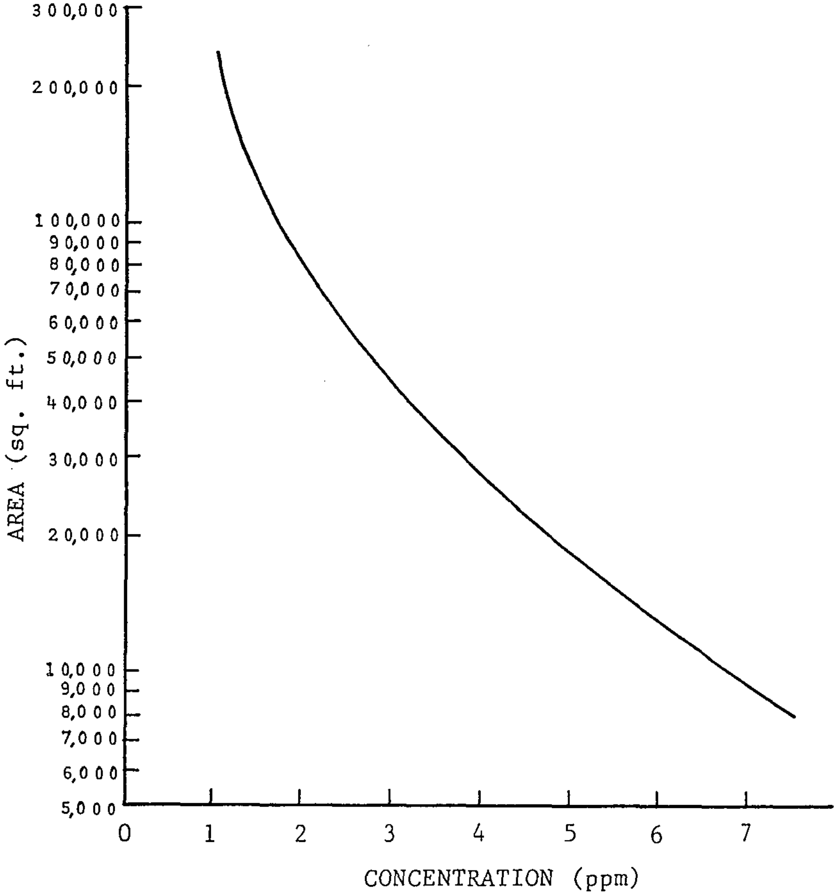

Figure C.3-20 Variation of Exposed Area with Oil Concentration Along Bottom of Neches River.

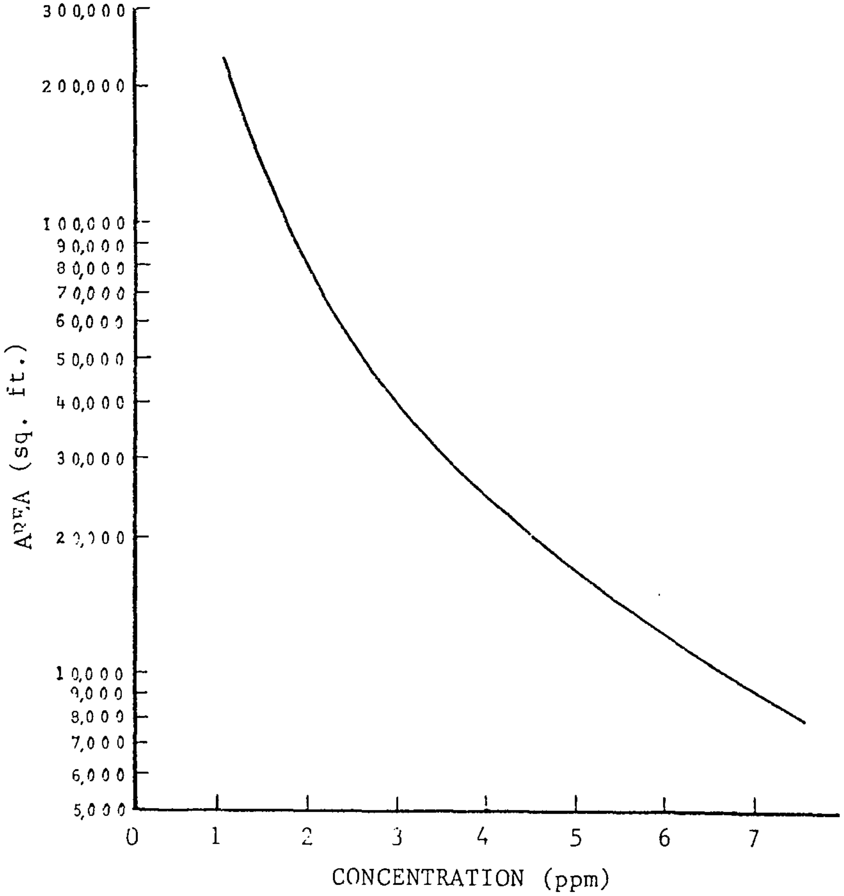

Figure C.3-21 Variation of Exposed Area with Oil Concentration on Surface of Neches River

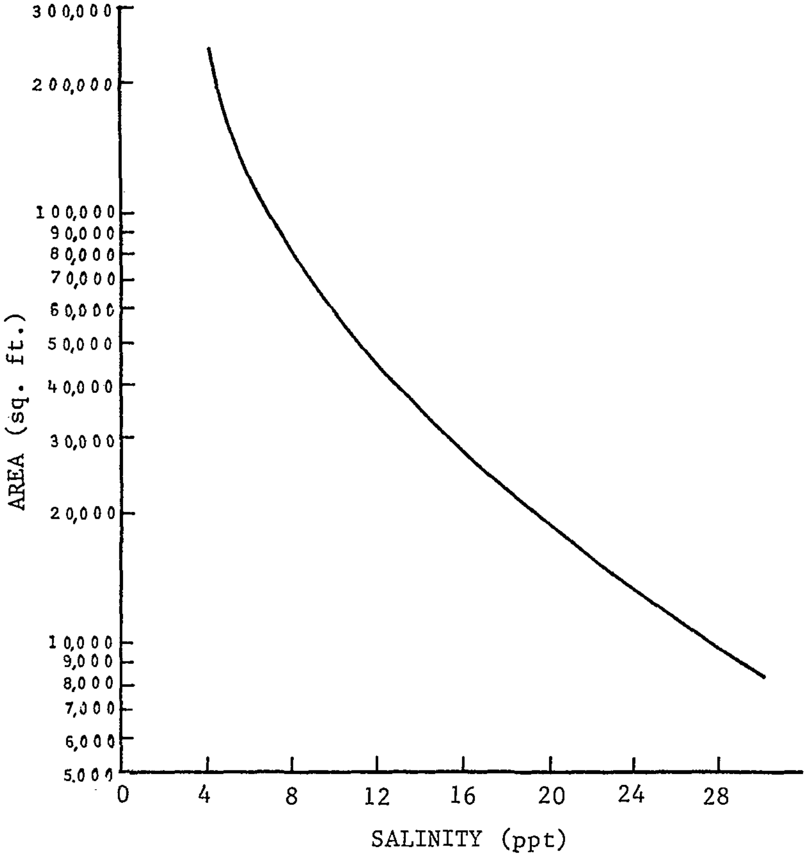

Figure C.3-22 Variation of Exposed Area with Salinity Concentration Along Bottom of Neches River.

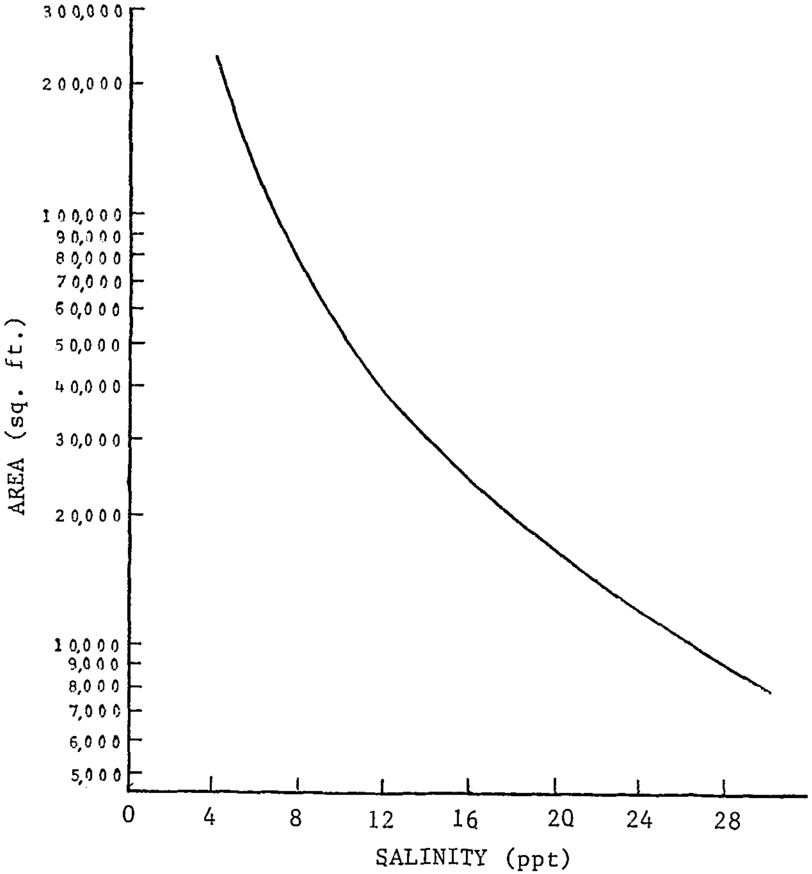

Figure C.3-23 Variation of Exposed Area with Salinity Concentration on Surface of Neches River.

C.3.2.3 Air Quality

C.3.2.3.1 Sources of Emissions

The emission sources from operational activities at West Hackberry include (1) the offloading of crude oil from tankers at Sun Terminal during fill, (2) the loading of the oil onto tankers during withdrawal, and (3) the emissions from dissolved hydrocarbons which are present in the brine discharged during refill. The majority of the pollutant emissions associated with these activities would entail evaporative losses of gaseous hydrocarbons from exposed liquid surfaces of crude oil. In this analysis, it is conservatively assumed that all of these emissions are in the form of reactive non-methane hydrocarbons (NMHC).

Other operational phase emissions include vehicle exhausts and fugitive dust due to the routine operation of project vehicles. Combustion contaminants would also occur during the unloading and loading of ocean-going tankers since ship boilers must operate to supply shipboard power. The following sections would categorize project emissions in terms of: (1) tanker loading, unloading, and ballasting; (2) tanker and tug engines; (3) surge-storage and ballast treatment tanks; and (4) pipeline pumps seals and valves.

The following paragraphs describe the development of emission rates for operational phase activities at the West Hackberry dome and terminal sites. Short- and long-term emission rates are listed in Appendix E for those sources included in the modeling analysis while annual tonnage emission rates are presented for all sources in Table C.3-11. An evaluation of the emissions from brine is given in Appendix N. Vehicular and fugitive dust emissions due to the operation of light-duty vehicles on site roadways are assumed to be the same as that indicated in Table C.3-3 of Section C.3.1.3.1 for construction phase activities and are not included in this discussion.

TABLE C.3-11
Annual Tonnage Emission Rates for Expansion of West Hackberry by 150 mmb

Source or Activity	Annual Emissions (Tons)				
	HC	Particulate	SO_x	NO_x	CO
Site					
Brine Ponds*	210				
Valves & Seals	7.5				
20,000 bbl (standing loss)	0.5				
Surge Tanks** (working loss)	47.3+				
3,000 bbl Blanket Oil Tank	0.1				
Total	265.3				
Terminal - Fill Phase					
Surge (standing loss)	10.7				
Tanks** (working loss)	10.8				
Valves and Seals	3.2				
Tanker Ballasting	112.5				
Tanker Engine	4.4	32.1	445.4	144.8	2.7
Tug Engine	2.4	5.4	2.2	3.7	3.2
Total	144.0	37.5	447.6	148.5	5.9
Terminal - Withdrawal Phase					
Tanker Loading	1040				
Surge Tanks (standing loss)	10.7				
Tanks** (working loss)	25.5				
Ballast Treat (standing loss)	3.6				
ment Tanks** (working loss)	5.3				
Valves and Seals	3.2				
Tanker Engine	1.71	12.2	169.1	54.8	1.0
Tug Engine	2.4	5.4	2.2	3.7	3.2
Total	1092.4	17.6	171.3	58.5	4.2

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*Fill Phase Only: the values are the maximum predicted at any time during use. The initial fill is expected to be only a small fraction of this amount.

**Working losses interact with the standing storage losses, such that the resultant emission is less than the sum of these values.

+Emissions in fill phase.

Tanker Loading

The loading of tankers during the operational phase of the program would be a major source of hydrocarbons due to evaporative losses. 150,000,000 barrels of crude oil would be distributed during the 150-day drawdown period with an assumed 60 percent of the total being shipped from the Sun Terminal facility by 65,000 dwt (450,000 barrel) tankers.

The average hydrocarbon emission factor used for ship loading of crude oil is 0.55 lb/1,000 gallons. This emission factor was derived based on a modified analytical procedure using API (API, 1976) and Exxon (EPA, 1976) gasoline data. For estimating crude oil emission factors, the procedure employs correction factors for both arrival and generation components of the hydrocarbon vapor concentration previously derived from gasoline data. These emission factors are described in detail in Appendix E.

The short-term flow rate of oil by tanker may be substantially larger than the projected daily average of 600,000 barrels per day at Sun Terminal. Bad weather may prohibit open sea operations or mechanical breakdowns could result in dead time, requiring increased flow rates in order to insure that drawdown can be completed in 150 days. In the Gulf Coast region, a weathering factor of 2 is often included in estimates of such operations (NOAA, 1975) and a factor of 1.5 does not seem unreasonable for these operations. As a result, short-term tanker emission rates are based upon a maximum projected daily flow rate which is 150 percent of the average rate. The annual emission rate has been developed by assuming that the total mass of hydrocarbon emissions calculated for a period of a year occurs continuously over that period. PTMAN and CDM runs have been made for this source based upon the emission rates listed in Appendix E.

Loading the VLCCs to tankers occurs sufficiently far offshore that the associated emissions have not been modeled. However, the annual tonnage emission rate is listed in Table C.3-11 for this activity based upon an initial fill rate of 175,000 barrels per day.

Tanker Ballasting

All oil would be delivered to the Sun Terminal during the initial fill by 45,000 dwt (320,000 bbl) tankers over a 32 month period. These tankers would have received their cargo from VLCC's in a lightering operation conducted 50 miles or further offshore. During unloading at Sun Terminal, the tankers would take on ballast water prior to putting out to sea. This results in the displacement of substantial amounts of hydrocarbon vapors which accrue in the ship's tanks during the unloading process. A tanker ballasting emission rate of 0.42 pounds of hydrocarbons per 1,000 gallons of crude capacity taken onboard has been utilized based upon the data discussed in the paragraph on tanker loading. It is assumed that tankers normally take on 20 percent of their capacity as ballast. Calculations are based upon a daily delivery rate of 175,000 barrels of crude oil per day during the initial fill. A weathering factor of 1.5 has been incorporated in the development of short-term emission rates discussed in the paragraph on tanker loading.

Short- and long-term model calculations have been made for tanker ballasting using a point source approximation. The omission of the ship's structure wake effect may result in a small overprediction of NMHC ground-level concentrations close to the source.

Tanker Engines

Tanker boilers are continuously fired, resulting in combustion emissions during all operations. Emission factors have been developed on a fuel consumption basis, where tanker fuel is non-volatile Bunker C fuel oil (#6 fuel oil). Table C.3-12 summarizes the emission factors developed by Esso Research and Engineering Company (Esso, 1974).

Tanker engines would be in operation at variable boiler capacities during both the loading and unloading processes. Boiler activity can be classified as either: (1) discharge cargofull capacity; (2) hotelling or (3) maneuvering. During cavity fill operations, tankers would unload utilizing full boiler capacity. At the Sun Terminal, unloading would proceed at an average rate of 20,000 barrels per hour based upon pump capacities. Utilizing the project 320,000 barrel tanker size for cavity fill, each tanker would require 16 hours of unloading time. After the tankers unload, they would take on 20 percent of their capacity as ballast prior to putting out to sea. Ships boilers would be in the hotelling mode during ballasting operations. This would require 6.4 hours at the

TABLE C.3-12

Emission Factors for Tanker Boilers

POLLUTANT	POUNDS/BARREL FUEL	POUNDS/TON FUEL**
SO_2	6.4(S)*	44.7(S)*
NO_2	4.36	29.1
Particulate	0.966	6.44
HC	0.134	0.893
CO	0.084	0.560

* S = % Sulfur; for 2% Sulfur, SO_2 = (6.7)(2) - 13.4 #/bbl.

** 8 # fuel/gallon and 2240 #/ton.

indicated pumping rate. During the loading phase, ships would take on crude oil at an average rate of 60,000 bbls/hour with boilers in the hotelling mode for 7.5 hours based upon a tanker size of 450,000 barrels. These tankers would discharge their ballast water at full boiler capacity prior to loading in an operation requiring 3 hours. Finally, the tankers would maneuver in port for approximately 4 hours per terminal visit resulting in a total loading time of 14.5 hours and an unloading time of 26.4 hours.

Emission rates are estimated on the basis of fuel consumption rates during specific operations. Fuel consumption rates for 70,000 DWT tankers have been estimated by Pacific Environmental Services, Inc. (PEPA, 1976). Tankers delivering SPR crude oil would be 45,000 DWT in size while 65,000 DWT tankers would be used for distribution. However, fuel consumption rates for 70,000 DWT tankers would be employed in the present analysis. Fuel consumption rates for tankers under three typical operating conditions are estimated as follows: 1) discharging cargo and ballast would consume 2.4 tons/hour; and 2) maneuvering in port would consume 2.3 tons/hour; and 3) hotelling, which employs 10%-15% of full power, would consume 0.33 tons/hour. See Figure C.3-13. Sea passage fuel consumption rates have not been included because boiler emissions would be dispersed over large distances which would have a negligible effect on local ambient air quality.

Table C.3-14 provides the emission rates which result for each phase of boiler operation. Annual tonnage emission rates, presented in Table C.3-11, can then be calculated based upon the projected number of terminal visits during the loading and unloading phases required to satisfy a daily delivery rate of 175,000 barrels per day and a tanker distribution rate of 600,000 barrels per day. These emissions were not included in the modeling analysis as the impact of these buoyant sources on local ambient air quality would be insignificant.

Tug Engines

Tugs would be required to assist both tankers and barges during maneuvering operations. Combustion contaminants would result due to engine operation. The emission rates for tugs depend upon the number of tugs required for ship or barge assistance, the rated horsepower and the duration of assistance. The average fuel consumption underway as reported by USEPA (EPA, 1976) is 0.34 pounds of diesel fuel per horsepower per hour (#/hp-hr). All tugs use diesel fuel and it is assumed the sulfur content is 0.275 percent. For the purpose of computing

TABLE C.3-13

Tanker Boiler Fuel Consumption Rates

OPERATION	TONS/HOUR*
Discharging cargo and ballast at full capacity	2.4
Maneuvering in port	2.3
Hotelling**	0.33

* Ton = 2,240 pounds
** 10-15% of full power

TABLE C.3-14

Tanker Boiler Emission Rates*

POLLUTANT	TANKER OPERATION		
	Discharging Cargo & Ballast	Maneuvering	Hoteling
SO_2	27.1	26.0	3.72
NO_2	8.80	8.44	1.21
Particulate	1.95	1.87	0.27
HC	0.27	0.26	0.04
CO	0.17	0.16	0.02

* Grams per second

pollutant emissions from tugs, the following relationship (Table C.3-15) has been developed which gives the combined horsepower requirements (all tugs used) for tanker assistance (PESI, 1976).

For 70,000 DWT tankers, the total tug horsepower requirements are calculated to be 3,000 hp, provided by two tugs of 1,500 hp each. Therefore, 510 #fuel/tug/hour of assistance is required. Table C.3-16 provides emission rates prepared by PESI (PESI, 1976) for tug assistance for this size of tanker.

Annual tonnage emission rates based upon the projected number of tanker visits are presented in Table C.3-11. Two tugs would assist the tankers during maneuvering operations. These slightly buoyant emissions would not be included in the modeling analysis based upon the rationale discussed in the preceding paragraph.

Storage and Treatment Tanks

Evaporative hydrocarbon losses can be anticipated at the West Hackberry dome and terminal sites due to standing storage losses from the surge storage tanks and the ballast water separation tanks. There would be three 200,000 bbl surge storage tanks and two 55,000 bbl ballast treatment tanks at the Sun Terminal facility. At the dome site, there would be one 20,000 barrel surge storage tank and one 3,000 barrel blanket tank. The surge storage tanks constitute the major contributor at each location. The emission rate as calculated utilizing the relationship presented by the American Petroleum Institute (API, 1962) is a function of many variables including: (1) thank diameter; (2) color of tanks; (3) type of tanks; (4) type of fuel; (5) temperature; (6) wind speed and (7) crude true vapor pressure (TVP). The SPR tanks would employ modern floating roofs and would be painted light grey or aluminum to minimize temperature variability. Emissions are considered to be continuous and a TVP of 4 psia was assumed for long-term calculations and 5 psia for short-term analyses. During withdrawal of crude oil from the tanks, they would continue to be a source of evaporative losses due to clingage of oil to the tank sides. Techniques exist for the development of emission rates due to clingage losses; however, the present analysis employs the simplifying assumption that the tasks continuously emit hydrocarbons due to standing storage losses. This assumption is not felt to significantly alter the results of the air quality impact analysis. An additional assumption made in the analysis is that all tanks evaporate as an all-oil body. In the case of the ballast water treatment tanks, the oil will sit on top of the water and be directly exposed to evaporative losses.

TABLE C.3-15

Tug Horsepower Requirements Based Upon Projected Tanker Size

TANKER SIZE (DWT)	HORSEPOWER REQUIREMENTS (hp)
70,000 - 80,000	3,000
120,000 - 150,000	4,000
165,000 - 188,000	6,000

TABLE C.3-16

Maximum Emission Factors for Tug Boats

POLLUTANT	LBS/HR OF ASSISTANCE*
SO_2	5.61
NO_2	9.54
Particulate	13.6
HC	6.12
CO	8.16

* Total hp = 3,000

Short- and long-term emission rates utilized in the subsequent modeling analysis are present in Appendix E. For modeling analyses, the tank farms are assumed to be point sources. The omission of the building wake correction factor would yield slightly conservative results close to the point of emission. Annual tonnage emission rates are presented in Table C.3-11 and are based on the conservative assumption that the tanks emit continuously for the entire period. This could occur during initial fill which is scheduled to last for 32 months but is unlikely during the 150-day drawdown phase.

Pump Seals and Valves

Liquid crude oil losses from pump seals and valves would constitute a hydrocarbon emission source at the pump houses established near the dome and terminal sites. Pipeline flange leaks are negligible (Jones, 1973). Emission factors have been developed through derivations based on measurement programs. These factors are summarized in Table C.3-17. The higher factors used in the draft of this EIS were based on tests at refineries in the Los Angeles Air Basin involving product rather than crude oil.

In estimating losses from SPR pump seals and valves, all pumps are assumed to have two seals. An average of 6.25 valves per pump is assumed based on estimates for the Alaskan Crude Oil Delivery Terminals in California of 50 valves for eight pumps (PESI, 1976).

The necessary variable for the determination of the emission rates for these sources is simply the number of pumps. At West Hackberry, a pump house is located at the dome site and at the Sun Terminal. There would be 14 pumps at the former location and 6 pumps at the Sun Terminal. Once again it is conservatively assumed that these sources emit at a continuous rate over an annual period. Short- and long-term modeling calculations have been performed for these point sources.

TABLE C.3-17

Emission Factors for Pump Seals and Pipeline Valves

Pump Seals*	1.13 #/day/seal
Pipeline Valves**	0.108 #/day/valve

* Adjusted for handling crude oil, based on original measurement data obtained at refineries in the Los Angeles Air Basin by H.R. Jones (1973).

** Derived from USEPA publication AP-4B, Air Pollution Engineering Manual, 2nd Edition, page 691.

C.3.2.3.2 Air Quality Impact

Annual tonnage emission rates have been developed for all operational phase sources. In addition, modeling analyses have been conducted for substantial sources or those who may result in a violation of applicable air quality standards. The modeling approach consists of two steps: (1) short-term modeling utilizing the model PTMAN, and (2) annual or long-term modeling utilizing the Climatological Dispersion Model (CDM). Both models utilize joint frequency distributions of the key dispersion meteorological parameters in the form of STAR data (described earlier). STAR data for Lake Charles, Louisiana has been used to represent onsite conditions at West Hackberry and the Sun Terminal in West Nederland, Texas.

Short-term modeling is conducted utilizing the model PTMAN. This model represents a modification of the USEPA's model PTMTP to accept unlimited hourly data in the form of STAR programs. This permits the development of percentage frequency of occurrence values for desired pollutant ground-level concentrations for a one-hour averaging period. In this manner, the frequency with which a given pollutant level (e.g., an applicable air quality standard) is exceeded can be determined at downwind receptor locations. This permits the development of isopleths of the frequency of standards violations. For intermediate averaging periods (1 to 24 hours), the technique can be applied by employing equivalent one-hour pollutant concentrations utilizing the technique recommended by Turner (1970) relating pollutant ground-level concentrations for different averaging periods. Long-term modeling using CDM yields isopleths of annual pollutant ground level concentrations suitable for direct comparison with applicable air quality standards.

The following paragraphs discuss the results of the modeling analysis conducted for each significant source at West Hackberry during the operational phase. The modeling consists of (1) the use of the model PTMAN to predict the frequency of occurrence of violations of applicable standards, and the distribution of pollutant concentrations at downwind receptor locations, and (2) the prediction of annual centerline pollutant ground level concentrations by the model CDM utilizing nearby historical meteorological data.

The operational phase of the program would consist of three types of activity: (1) initial fill, (2) drawdown, and (3) refill. All crude oil would be delivered to the Sun Terminal by tankers during the initial fill and refill phases. During the 150 day drawdown, 60 percent of the oil would be distributed by tanker, while the remainder would be distributed by overland pipelines. Evaporative losses of hydrocarbons would emanate from exposed surfaces of crude oil during each project phase The largest volume of hydrocarbon emissions would be associated with ship crude oil handling activities during loading and unloading. There would be concomitant evaporative hydrocarbon losses from the Sun Terminal tank facilities as well as the terminal pump house. At the dome site, additional evaporative hydrocarbon losses would emanate from onsite tanks and the dome pump house. Combustion contaminants could also be anticipated at the Sun Terminal due to boiler emissions from the dockside tankers and from tug engines during tanker assistance. Annual tonnage emission rates for these sources are contained in Table C.3-11. Additional emissions would occur during the operational phase due to the use of paved and unpaved roads by light-duty vehicles. Estimates of annual tonnage emission rates for these sources can be obtained in Table C.3-3 of Section C.3.1.3.1; however, the overall impact of these sources on ambient air quality would be insignificant.

Short-term modeling calculations have been performed for project hydrocarbon emissions at both the dome and terminal sites. The calculations are based upon concomitant emissions at each location from all sources including tankers, tanks and pump houses. In addition, two separate scenarios were modeled at the Sun Terminal to handle both ship loading and unloading phases The results of the modeling analyses are contained in Figures C.3-24 and C.3-25. At the dome site, short-term NMHC ground level concentrations would exceed the 3-hour standard 0.5 km downwind from the brine holding pond during oil refill due to release of dissolved hydrocarbons in the brine (See Appendix N). This would be a localized air quality problem and would be confied within the site boundaries. However, during tanker loading and unloading operations at the Sun Terminal, the standard would be violated. Figure C.3-24 indicates that during tanker loading during the distribution phase, the 3-hour NMHC standard would be violated 1 percent or more of the time annually out to downwind distances in excess of 25 kilometers. The maximum impact would occur to the west of the terminal, where violations of the standard would occur 5 or more percent of the time annually out to a downwind distance of approximately 10 kilometers. During ship ballasting operations following the completion of tanker unloading, Figure C.3-25

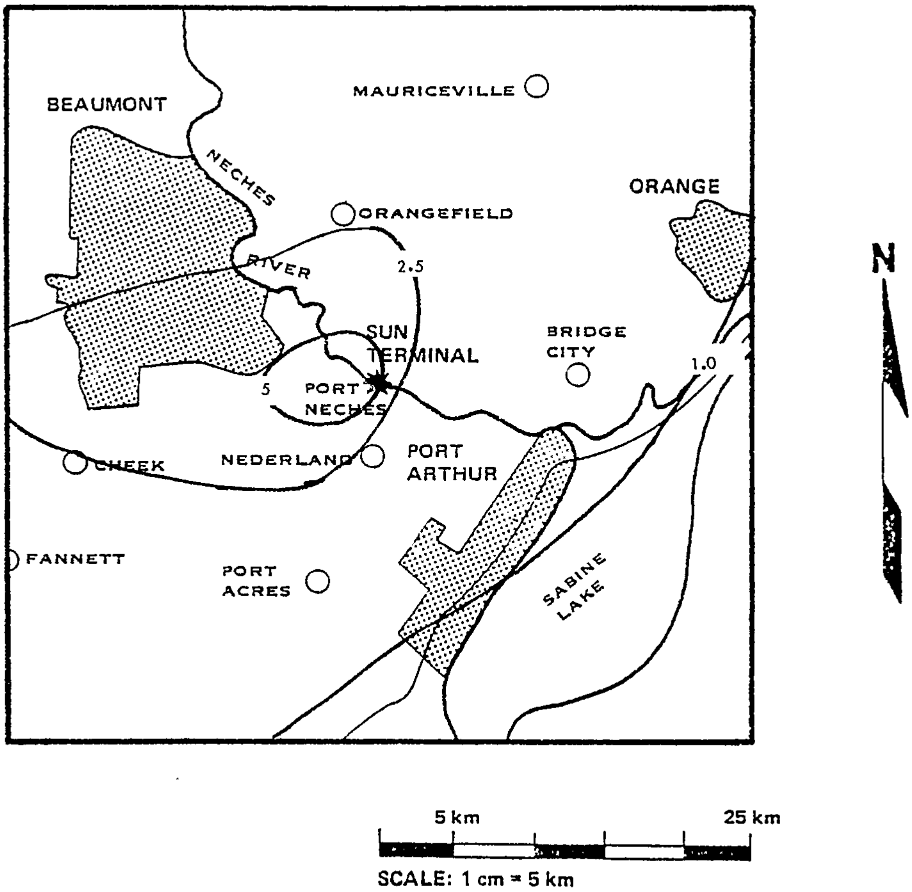

Figure C.3-24 Annual Frequency of Occurrence (%) of Violations of the 3-hour NMHC Standard at the Sun Terminal for Tanker Loading During the Operational Phase for the West Hackberry site.

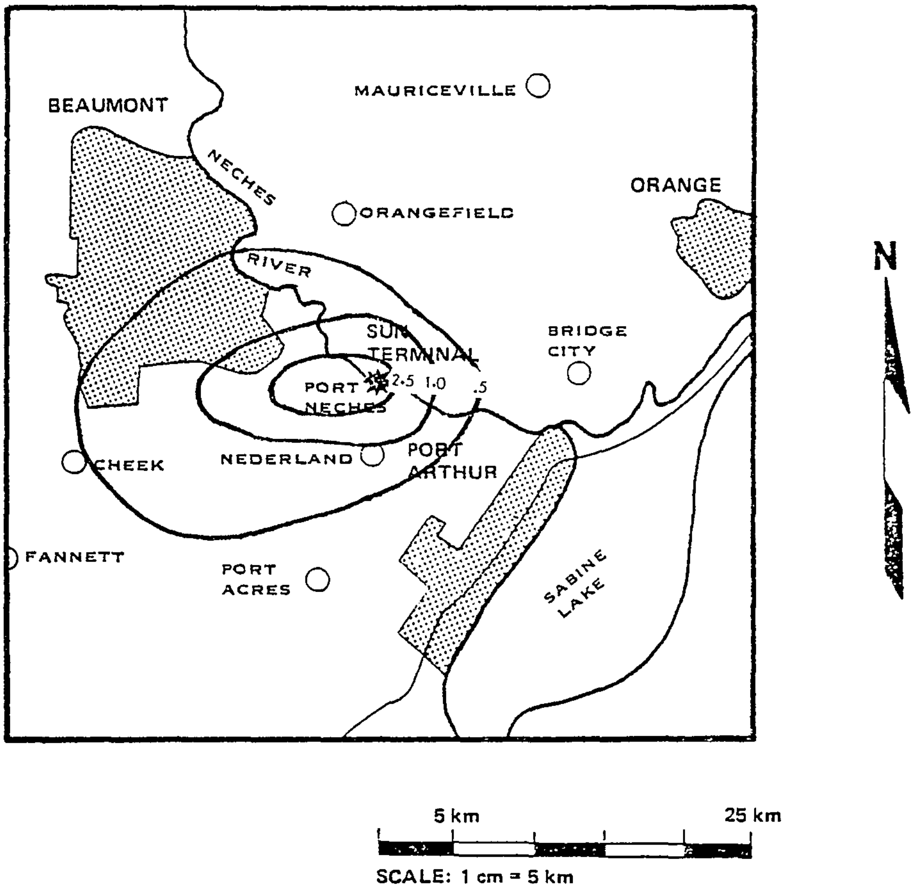

Figure C.3-25 Annual Frequency of Occurrence (%) of Violations of the 3-hour NMHC Standard at the Sun Terminal for Tanker Ballasting During the Operational Phase for the West Hackberry site.

indicates that the applicable standard would be violated out to a downwind distance of approximately 20 kilometers with the maximum impact occurring west of the facility where the frequency of violation is in excess of 2.5 percent annually. The calculations are conservative in that they do not include the minor additional dilution attributable to structural wake effect. The approach also assumes that the 3-hour standard for NMHC would be violated during the applicable 6 to 9 a.m. period with a frequency equal to that during the annual period.

Annual NMHC ground level concentrations have also been calculated for the dome and terminal sites. Figure C.3-26 provides the results of this analysis for the Sun Terminal. This calculation is based upon the conservative assumption that both the fill and drawdown phases could occur, at least in part, during the same annual period. The results of the calculation indicate that annual ground level concentrations would be generally less than 5 $\mu g/m^3$. Similar calculations were performed for the dome site and are presented in Figure C.3-27. Annual NMHC concentrations would be generally less than 0.34 $\mu g/m^3$ downwind of the dome site sources.

The USHEW (HEW 1970) indicates in the criteria document for hydrocarbons that a good relationship exists between the 6 to 9 a.m. NMHC concentrations and the maximum 1-hour afternoon oxidant reading at a given station. This supposition is a cornerstone of the modified rollback techniques for achieving compliance with the Federal Primary Standard for O_x. Figure C.3-28 illustrates this relationship based upon data collected at CAMP stations. The possible impact of the hydrocarbon emissions emanating from the SPR facilities on local oxidant levels can be estimated by utilizing Figure in conjunction with predicted short-term NHMC ground level concentrations. The calculations indicate that values in excess of 160 $\mu g/m^3$ would occur over a fairly large geographical area. Figure C.3-28 suggests that maximum daily 1-hour average O_x ground level concentrations in excess of the Federal Primary Standard might occur at stations where violations of the 3-hour NMHC standard are predicted in Figures C.3-24 and C.3-25. However, such a prediction is probably overly conservative as local oxidant levels reflect regional emission trends, and are not presently felt to be related to local sources (HEW 1970, FR 1976).

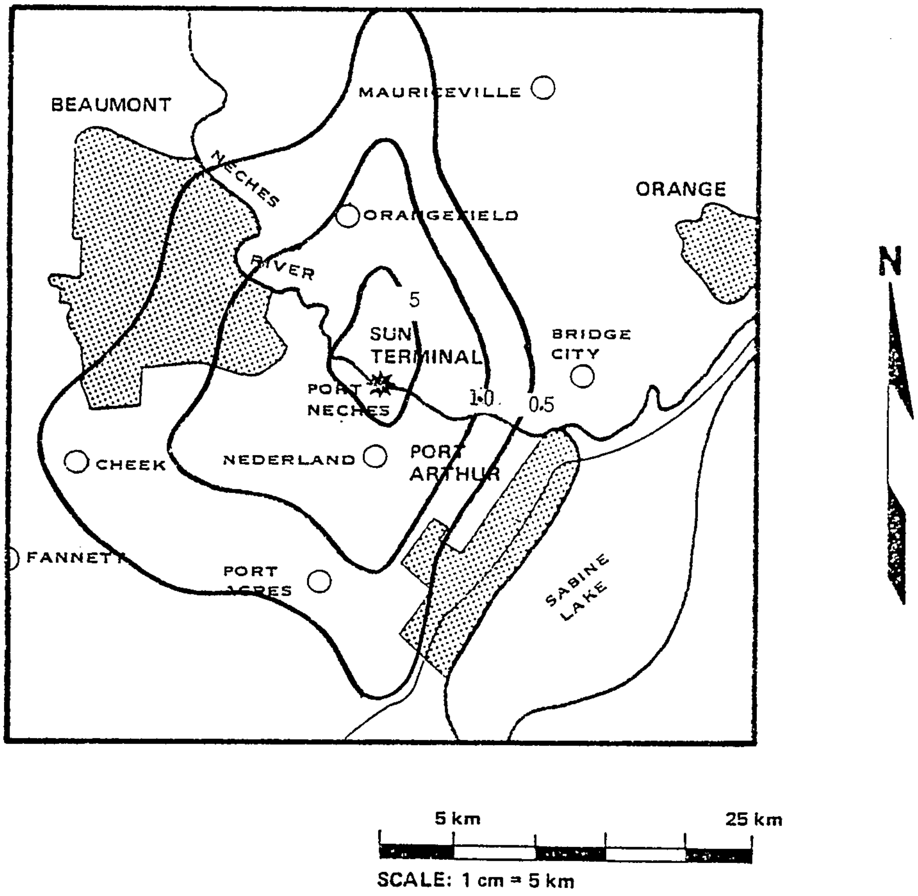

Figure C.3-26 Annual Average NMHC Ground Level Concentrations ($\mu g/m^3$) at the Sun Terminal During the Operational Phase for the West Hackberry site.

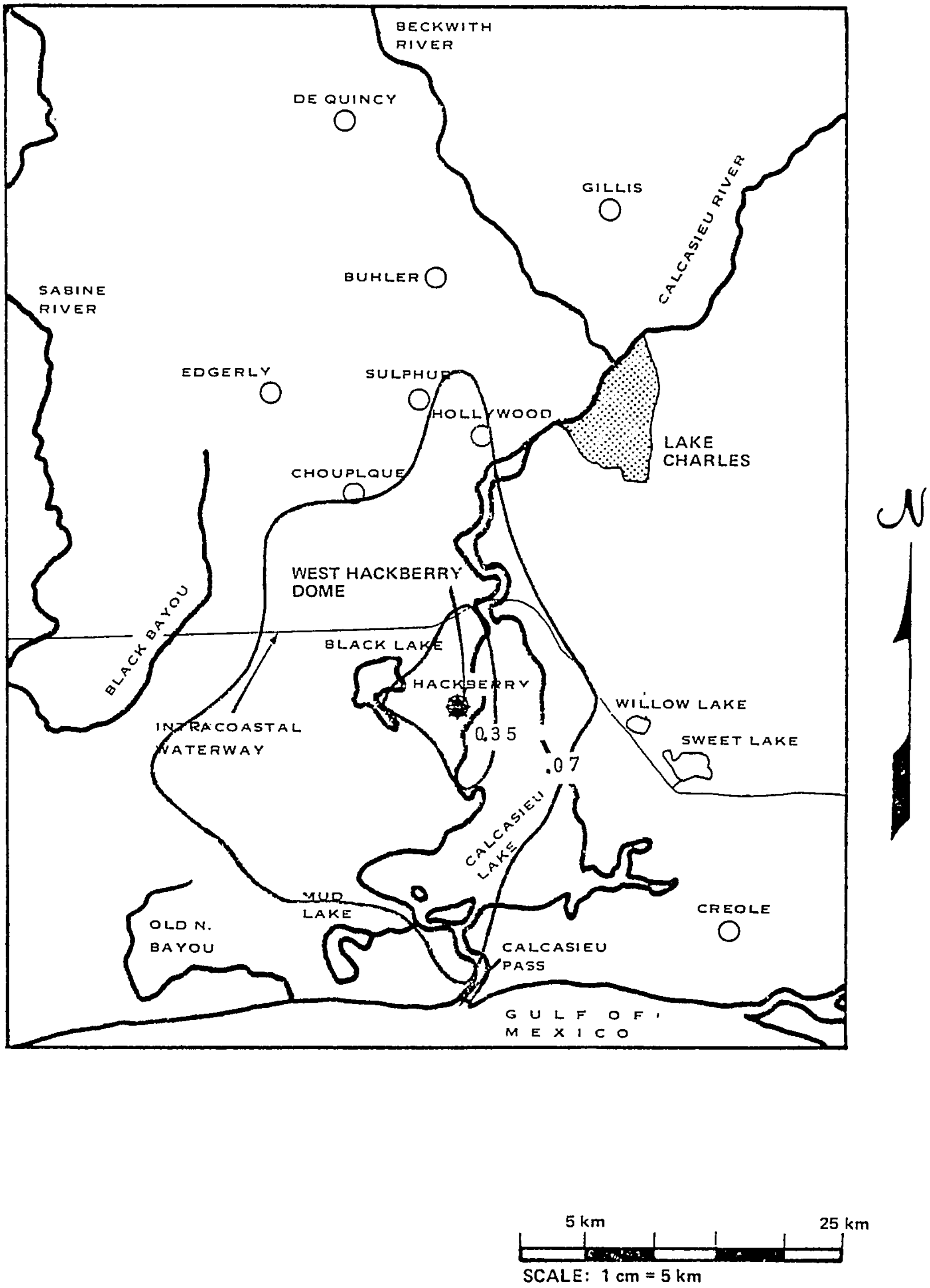

Figure C.3-27 Annual Average NMHC Ground Level Concentrations ($\mu g/m^3$) at the Dome Site During the Operational Phase for the West Hackberry site.

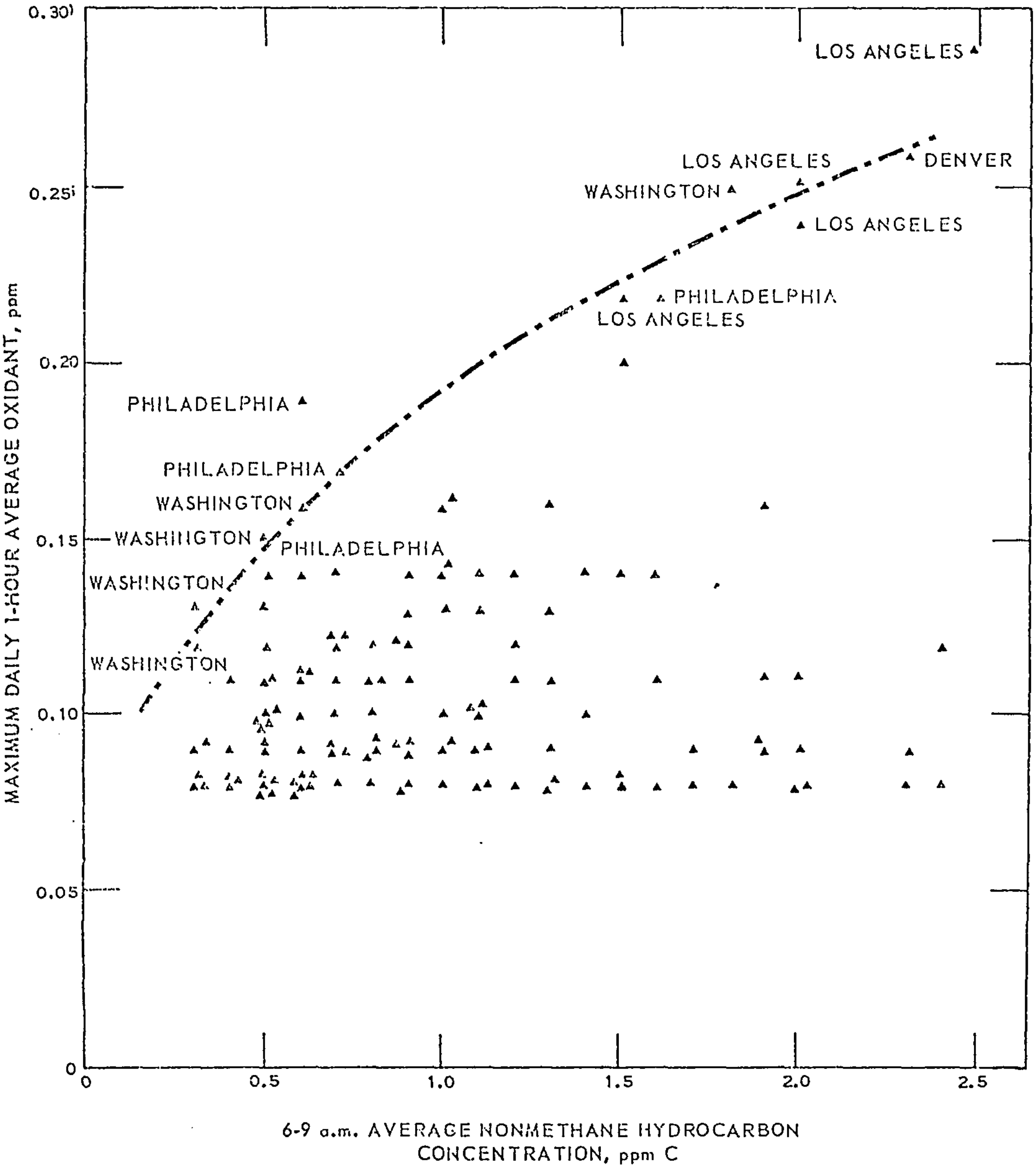

Figure C.3-28 Maximum daily oxidant as a function of early morning nonmethane hydrocarbons, 1966-1968 for CAMP Stations; May through October 1967 for Los Angeles Basin.

In summary, the West Hackberry dome and Sun Terminal facilities would be the principal sources of NMHC and, to a lesser extent, combustion contaminants. Violations of the 3-hour standard for NMHC are predicted downwind of the Sun Terminal facility. The calculations are based upon modified emissions data for gasoline and do not incorporate abatement technology for the control of evaporative losses of hydrocarbon vapors due to shipboard handling of crude oil. Tanker loading and ballasting emissions dominate the site emission levels as it is unlikely that the other sources would independently violate the NMHC standard outside plant site boundaries. The use of efficient vapor control technology in conjunction with shipboard activities would significantly reduce the impact of the terminal facility on regional ambient air quality. However, in present form, the level of hydrocarbon emissions at the Sun Terminal is probably insufficient to have an important impact on regional levels of photochemical oxidant. The actual magnitude of this impact remains difficult to quantify. The annual tonnage emission rate for the West Hackberry expansion is relatively small in comparison to regional hydrocarbon emission levels in this region of heavy petrochemical activity. This fact, coupled with the presently accepted rationale that local oxidant levels are not directly related to emission strengths from local, isolated sources, indicates that it is unlikely that the proposed facility would have a significant impact on observed levels of photochemical oxidant. The facility would not result in violations of standards for other contaminants.

C.3.2.4 Noise

During operations at the West Hackberry expansion site, the primary noise generation would be from pumps associated with the fill and discharge operations. The pumps would be placed in some noise-dapening enclosure on the West Hackberry site. Fill operations are planned to take place over a 32-month period. The first 18 months at a rate of 175,000 barrels/day; the remaining 14 months at a fill rate of 131,000 barrels/day. During a national supply interruption, oil would be withdrawn over a period of 150 days. A total of 5 fill/discharge cycles are planned for the life of the facility.

The analysis of pump noise at the West Hackberry Site (Ref. Final Impact Statement - West Hackberry Salt Dome FES 76/77-4) estimated increase noise levels at the site perimeter of no more than 3 dB during the period of operation. The effect of the site expansion at West Hackberry would be to increase the duration of the noise from fill operations from 10 months to 32 months.

Some increase in terminal and tanker operations can be expected at the Sun Terminal on the Neches River. It is estimated that during fill/discharge operations tanker loading and unloading noise would increase 20 percent. The major noise associated with the operations would be from tanker traffic, tanker pumps discharging crude oil, tanker loading pumps, and pipe transfer pumps.

The pumps for both tanker loading and pipeline transfer to the storage area would be electrically powered and would be housed in a pump house on the terminal site. Additional noise from the increase in diesel engines powering the tankers and tanker discharge pumps operation would contribute negligibly to the existing ambient levels.

Summary of Noise Impacts

During fill and/or discharge operations, there would be noise generated from the continuous operation of pumps at both the storage and terminal facilities. The noise is expected to be continuous day and night during these operations; however, since the pumps at both the storage and terminal facility would be placed in a noise-dampening enclosure, it is anticipated that there would be a negligible impact on existing ambient levels in the vicinity of these facilities from operations.

C.3.2.5 Species and Ecosystems

C.3.2.5.1 Displacement Water System Impacts

The greatest impacts on biota of withdrawal of displacement water from the ICW would be the loss of organisms in the water. This would be particularly important with respect to loss of plankton standing crop, detritus, and nutrients. The smaller organisms, dissolved material in suspended material in up to 2,277 million barrels of water could be removed from the ICW over the life of the project. However, since the ICW is a flow-through system these losses would be readily replaced and the impact from this source is expected to be minimal. A much smaller (non-significant) impact would probably result from impingement of organisms (entrapment against intake screens).

Alternate Withdrawal Location: Black Lake

The continuous reduction in plankton standing crop, detritus, and plant nutrients resulting from water withdrawal would progressively reduce the production base of Black Lake. Food (detritus and plankton) that would have been available for benthic animals and decomposer microorganisms; nekton; and, through food chains, other nekton and aquatic birds, would be greatly reduced. This would be especially important over the 38-month leaching interval. Economically important species in the Black Lake-associated aquatic system including the adjacent private management area could be significantly reduced. Production by marsh grasses and other higher plants, epiphytic and benthic algae, and phytoplankton would be reduced by the loss of mineral nutrients in the leaching and displacement water.

The types of organisms taken in with water and killed would include: zooplankters (such as young stages of shrimp and crabs, menhaden, mollusks, polychaetes, and barnacles; copepods; rotifers; and protozoans), bacteria, yeasts and algae (generally diatoms or dinoflagellates). The general order of quantities of such organisms are estimated below.

Total densities for zooplankton in Black Lake are approximately 540 animals/liter, with 40 of the animals in this figure being larger forms over 1 mm long. These estimates are based upon values for similar estuarine conditions in the Delaware Estuary (Green, 1968) and a rotifer survey in the Calcasieu Estuary (Vancil, 1967). Phytoplankton and zooplankton production values (418 g and 25 g net dry wt of organic matter per square meter per year respectively) are presented for a south Louisiana estuary by Day et al. (1973). Average zooplankton standing crop was estimated at 2.5 g dry wt of organic matter/m^2. Average bacterial standing crop was estimated at 9.5 x 104 cells/ml. Average number of yeast cells were 470 cells/ml. Suspended matter was measured by one investigator at approximately 35 to 42 g/m^3, of which about 50 percent was organic matter. Dissolved carbon was determined at 4 g/m^3.

Assuming the foregoing values, some 2.33 x 10^{14} zooplankters, 4.11 x 10^{26} bacterial cells, 2.03 x 10^{24} yeast cells, 1.81 x 10^{7} kg of suspended material (50 percent organic matter) and 1.73 x 10^{6} kg of dissolved organic carbon would be lost to the aquatic system in and around Black Lake over the course of leaching and five oil displacements. The loss, in terms of zooplankton biomass, would be approximately 1.08 x 10^{6} kg, while the loss of algal biomass expected to be slightly greater than the zooplankton loss.

Black Lake, Alkali Ditch, Black Lake Bayou and its associated canals and the impounded area west of Black Lake are harvested for shrimp and crabs. One estimate (Lowery, 1977) of a total shrimp catch valued at several million dollars per year is dependent on the Black Lake area. There are estimates of a total harvest of 20,000 pounds of shrimp a night from Alkali Ditch, and as many as 50 boats a night have been reported to fish this canal on certain nights (White and Boudreaux, 1977). About 25,000 pounds of blue crab were harvested from the impounded area to the west of Black Lake during 1976 and about 10,000 pounds have been harvested through July in 1977 (Lowery, 1977). The young crabs supporting this production migrated through the Black Lake system. Menhaden are also known to use the Black Lake area on a large scale. Black Lake itself has been proposed to be a classified as a shrimp staging area surrounded by nursery areas (White and Boudreaux, 1977) and is recognized as being important for shrimp migration. Withdrawal of young stages of these fisheries species during leaching and displacement would not significantly reduce the catch in the Black Lake System. Any reduction, however, would not be permanent because of the great reproductive potential of these species as indicated in Appendix R.

Significant new production of organic detritus to replace that which would be entrained could require up to a year after cessation of withdrawal. Zooplankton and benthic animals are dependent on the detritus to a high degree. Reproductive rates of animals depend on food intake. Their numbers would not increase to prewithdrawal levels until detritus became abundant again. Organisms other than plankton found in and near Black Lake are discussed under the impacts of constructing the leaching/displacement water system (Section C.3.1.5.1).

Some of the nutrients lost in water used for leaching and displacement would be replaced by nutrients in the freshwater inflow into the area. The flushing rate of this part of the estuary would be a main determinant of the replacement of these nutrients. It presumably would require no more than part of the wettest season (late winter or spring) for replacement if seasonal salinity changes are used as an indicator. However, it might not clear during summer, which is a period of low freshwater inflow. Stone et. al. (1973), mention a purging time of more than 8 years for the northern part of Barataria Bay, a very different Louisiana estuary from the Calcasieu Estuary. The estimated maximum interval for replacement of mineral nutrients in and around Black Lake is one year. Even if this flushing time is underestimated, mixing processes would be expected to have distributed nutrients into the area by this time.

There would be no permanent change to the structure of the biological community in Black Lake and associated water bodies because no significant changes in salinity should result from the withdrawal of displacement water (see Section C.3.2.2.1 and Appendix D.12).

Since replacement water would come from such a large surrounding volume of water, a relatively high concentration of contaminants (e.g., metals, pesticides) in certain locations would produce a significant concentration increase in Black Lake. Increases in mercury, PCB's, and certain pesticides could be especially stressful to animals at the tops of food chains, even if concentrations in the water are low since these materials can be biologically accumulated.

Impingement on the water intake screens would present little hazard to animals since the intake velocity is low, or to larger plants since they are unlikely to be floating free near the intake. A reduction in the surface level of Black Lake of less than 0.2 feet, as explained in Section C.3.2.2.1, would not affect the area biota significantly.

C.3.2.5.2 Brine Disposal System Impacts

During normal leaching and fill operations impacts to biota would largely be restricted to the diffuser area in the Gulf of Mexico. While accidental releases could occur from the brine surge and settling tank or brine disposal pipelines, these are improbable. Flow in the brine disposal system would be monitored and pumping stopped in the event of a leak. Harm to biota would be localized in the immediate vicinity of the break. Recovery of biota from brine spills which resulted in brine uptake by soil or marsh sediments would require many years if remedial measures were not taken. After a spill occurred, chemicals would be applied to the brine contaminated area to help reduce the effects of the spill. This action would reduce the recovery time to an estimated 5 to 10 years. The full development of biota and humic materials in and on this soil would require an additional period, perhaps another 5 years. Only a few acres would be likely to be impacted by a single release of brine on land. Slow leaks, such as from corrosion, would probably not be detected unless damage to biota was conspicuous. Damage to biota from high salinities stems mainly from excessive water loss upon exposure to the salt. Dissolved materials which penetrate into organisms which come in contact with the brine can alter the organisms' body chemistry. Toxic effects, including mortality, would be expected from accidental releases of so highly saline a solution as the brine. Sublethal effects could include such manifestations as reduced growth and reproduction and altered, less adaptive behavior. Adverse effects of a release into water which naturally shows high salinity fluctuations would not be as pronounced as a release into lower salinity areas.

Most saltwater organisms in the Gulf are adapted to the average calcium-magnesium ratio of 1:3. Oil field brine, however, has a reversed calcium-magnesium ratio of 5:1. When the LC50* concentrations (over 96 hours) were determined for oil field brine for 10 freshwater fish and 10 freshwater invertebrates, they were found to be 3.47 ppt and 21.6 ppt respectively (Clemens and Jones, 1956). Several of these species have a range which extends into coastal waters. Brine produced by Oil Corporation at West Hackberry has a calcium-magnesium ratio of more than 76 to 1.

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*LC50 - the concentration over a period of time during which 50 percent mortality occurs

NOAA (1977) estimated dilution of brine in the far field, where natural processes of water circulation and diffusion are dominating, with the MIT transient plume model. The environmental assumptions included a diffuser location in 30 ft of water, 6 miles offshore, in the Gulf of Mexico and model input of diurnal, rotary tidal currents and idealized longshore currents. The model simulated observed phenomena of a small mean downcoast (westward) current, wind and current reversals following the passage of a weather system and periods of calm (except for tides). The base nontidal cycle was: current upcoast 1 day, current downcoast 1 day, and slack 2 days. A variation was used in which all periods were increasd by a factor of 4. At worst, this results in a period of 8 days. Concentrations were calculated for 4 times during the cycles. These were: (1) the end of the period of upcoast current, (2) the end of the period of downcoast current, (3) the middle of the slack period, and (4) the end of the slack period. The extremes of bottom area which would experience salinity increases of 1 ppt or more under the given conditions are estimated at approximately 758 to 1,263 acres for the base case and 643 to 3,673 acres for the case with the 8 day slack period. The bottom area of 3,673 acres corresponds to the end of the 8 days of slack. Increases would be maintained during 38 months of leaching and subsequent fill period of 40 months each. Less than 23 acres of the bottom would show an increase of 5 ppt or above, within which moderate to severe impacts would probably occur to benthic organisms, based on findings by Mackin (1973). No migration routes for fish organisms or plankton are known to be within this zone of increase.

Mackin (1973) reported that marine fishes, other mobile animals in the water column, and current transported forms were apparently not affected by discharge of oil field brine. The time spent in a zone of high salinity was too brief for long-lasting impacts. Mobile animals would be expected to avoid areas in which high salinities were not tolerable.

With the high concentrations of brine which would be disposed of from the West Hackberry storage facility, impacts to benthic organisms in an area around the discharge would be expected, based on Mackin's studies. Three impact zones would be distinguishable. The first zone would be one of destruction of most organisms next to the discharge points. Bacteria may be an exception. This zone would be about 200 feet across. The organisms which would be most affected by the release would be marine worms and mollusks. Around this zone of destruction would be one of a reduction in species and individuals and one in which stunted development of the organisms present might be apparent. This zone was estimated to extend between about 100 to 300 feet around a point source. A bottom area of about 200 feet along the diffuser would occupy about 14 acres and one between 200 feet and 600 feet wide would occupy about 56 acres. Beyond the second zone, a narrow third zone, perhaps no more than 50 feet across, in which marine biota show increased production, would be established.

The mixture of dissolved solids in brine is more toxic than salinity composed of ions in the same proportions as seawater (Johnson, 1974: Schmitz, et al., 1967). Toxicity of oil field brine to white shrimp, which have a wide tolerance to seawater derived salinity, was 100 percent at 42.0 ppt (Johnson, 1974). Records presented by NOAA (1977) indicated that natural salinity variation during the year in the proposed diffuser area is about 7 ppt (between 30 and 37 ppt).

The brine would be heated while in the storage cavities to a maximum of 150°F but generally less than 120°F. Because of the insulating properties of the pipe coatings the brine would enter the Gulf as a heated effluent (assuming little heat loss while the brine is in the brine pond). Rapid dilution in the near field would mean that the only organisms very close to the diffuser would be affected (see Appendix I).

C.3.2.5.3 Impacts at or from the Storage Location

Impacts from the site during the operations phase of the facility would stem from maintenance and the other human activity there. During filling or displacement, machinery noise would increase, and wildlife in the area would be disturbed. Some animals would adjust to this noise after a certain period. The periodic mowing of vegetation would disturb wildlife, but would also attract some species which prefer a short-grass habitat. The dust and hydrocarbons which would be produced as a result of vehicular traffic would have a negligible effect on most biota. Releases of chemical and biological contaminants would not occur on a large scale and most discharges could be easily controlled.

C.3.2.5.4 Oil Distribution System Impacts

Ecological Impact of Oil Spills

Oil-related risks associated with the expansion of the West Hackberry facility involve accidental releases from tankers, pipeline ruptures and accidental spills, and ballast water discharges at Sun Terminal. Such releases pose potentially adverse impacts to marshes and bayous bordering the West Hackberry site, the Neches and Sabine Rivers, the Intracoastal Waterway, Sabine Lake and Black Lake, and the marshes and other land along the pipeline route.

Background Pollution: Neches River

The Sun Terminal at Nederland, Texas, is located approximately 8 miles upstream of the point where the river empties into Sabine Lake. Available data indicate that the Neches River, in the vicinity of the Sun Terminal, exhibits evidence of pollution from biological, industrial, and commercial sources. Contamination with heavy metals and oil and grease and the high COD and low dissolved oxygen levels indicate that the area is most likely biologically degraded at the present time.

Background Pollution: Sabine Lake

Sabine Lake is an extensive estuarine body of water occurring between the mouths of the Sabine and Neches Rivers and Sabine Pass. The upper part of the lake is river influenced with salinities generally less than 10 ppt. The lower part of Sabine Lake is an open bay that is influenced by tidal interchange with salinities ranging from 16 to 20 ppt.

Concern has been raised because of the recent decline in the quality of Sabine Lake and its associated marshes as fish and wildlife habitat. The major causes have been cited as industrial and municipal pollution, urbanization, industrial development, and the construction and maintenance of the Sabine-Neches Waterway (Stephens, 1974). Portions of the Sabine and Neches Rivers have been used for many years for industrial and municipal effluent disposal. Spoil deposition, erosion, and runoff of dredged materials into the lake has resulted in increased turbidity and reduction of benthic organisms. The major portion of the bottom of Sabine Lake, which was originally sand-covered, is now covered with mud.

Potentially Impacted Organisms and Habitats

The diversity of organisms and habitats in and surrounding Sabine Lake is substantial. The likelihood of oil significantly impacting particular habitats varies with location and size of spill, season and other factors. Organisms, for a variety of reasons (physiology, behavior, etc.), vary in their susceptibility to oil pollution. Plankton and mobile organisms such as fish, shrimp, and birds are the groups most likely to contact an oil spill first. Benthic and sediment-dwelling forms may be affected if oil sinks to the bottom after a tanker spill or a spill from a pipeline into the Sabine or Neches Rivers. Intertidal and marsh areas can be affected if oil reaches shore, and breeding areas of birds and mammals occur in marsh areas near the shore.

The area around Sabine Lake is an important overwintering ground for a tremendous variety of migratory bird species. Sabine National Wildlife Refuge which contains extensive wintering grounds borders the western margins of the lake. This refuge, which is at the southern end of the Mississippi Flyway, is an important national resource and harbors large populations of migratory species.

Oil Spills in Aquatic Environments

Oil spills in the Neches or Sabine Rivers, Sabine Lake, Black Lake, and other inland water bodies would impact various species depending upon the particular location and the specific behavior of the spilled oil. General effects of oil on biota are discussed in Appendix H and are not repeated here. Particular species likely to be impacted are identified in Chapter 3.0, and specific impacts associated with an oil spill from the crude oil pipeline from West Hackberry to Sun Terminal are discussed in a supplement to the West Hackberry FES 76/77-4 (FEA, 1977b).

A spill that would contaminate portions of Black Lake are of particular concern because Black Lake is an active area for sport fishermen also an important area for commercially important menhaden and brown shrimp (Rocca, personal communication). White shrimp (P. _sertiferus_) are marginal producers here, and crab (_Callinectes sapidus_) fishing is a recent but active industry.

Canals, bayous, and other water connectors are important migration routes for juvenile shrimp and fish. Alkali Ditch serves such a purpose and also has commercially important redfish and flounder in it (Rocca, personal communication). Marshes bordering the ditch and Black Lake have the long-nosed killifish (*Fundulus similis*), variegated cyprinedon (*Cyprinedon variegatus*), and mosquitofish (*Gambusia affinis*). Crude oil concentrations required to produce acute mortality and other effects for several of these species are indicated in Table C.3-17. Data on lethal crude oil concentrations are available for some blue and fiddler crabs (See Appendix H). Planktonic forms such as *Chlamydomonas* spp., *Acartia tonsa*, and brown shrimp larvae are present in these water bodies. Lethal oil concentrations for these species are listed in Table H.1 in Appendix H.

An oil spill would rapidly form a surface slick and, unless contained, would eventually be deposited in the marshes and along the shoreline of Black Lake. This oil would very likely produce localized reductions in aquatic life in Black Lake. It is anticipated that most species of fish would avoid spilled oil and, unless trapped in coves or bayous where escape routes are shut off, fish populations would not suffer extensive losses.

Impacts to bird populations are difficult to predict because of their transient nature. Bird mortality due to oil coating is well documented and a discussion of the mechanisms of oil toxicity is provided in Appendix H. Black Lake and the West Hackberry site are utilized by a large number of bird species. Migratory diving and wading birds, which by virtue of their extensive use of marshes and water bodies, would be particularly susceptible to an oil spill.

Above ground shoots of marsh vegetation that are oil coated would die back in approximately 3 to 10 days. Production of new shoots would be exptected after 3 weeks, and recovery of both plants and animal populations would be relatively rapid.

Table C.3-17 The Effects of Various Types of Oil on Fish. Oil concentration levels in water, test conditions, and specimen localities are indicated.

Taxa	Oil Type	Oil Concentration (ppm)	Effects	Conditions	Specimen Locality
Menidia beryllina	S. Louisiana crude	7,600	TLm24*	oil in water dispersions (lab)	Galveston, Texas
(tidewater silverside)[1]	Kuwait crude	20,000	"	"	"
	#2 fuel oil	260	"	"	"
Fundulus similis	S. Louisiana crude	6,610	"	"	"
(longnosed killifish)[1]	Kuwait crude	17,500	"	"	"
	#2 fuel oil	48	"	"	"
Cyprinodon variegatus	S. Louisiana crude	80,000	"	"	"
(sheepshead minnow)[1]	Kuwait crude	>80,000	"	"	"
	#2 fuel oil	250	"	"	"
Brevoortia spp. (menhaden)[2]	Empire Crude Oil Mix	250**	smaller fish lost equilibrium; eaten by larger fish	estuarine pond	coastal Mississippi
Gambusia affinis (mosquitofish)[2]	Empire Crude Oil Mix	250**	no apparent ill effects	"	"
Lebistes reticulatus[3]	Louisiana crude	40,000	TLm24	static bioassay	------
(common guppy)	Mississippi crude	40,000	no adverse effects over 30-day period	"	------

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[1] J.W. Anderson, Laboratory Studies on the Effects of Oil on Marine Organisms: An overview. American Petroleum Institute Publication 4249, 1975. 82 p.

[2] J.S. Lytle, Fate and Effects of Crude Oil on an Estuarine Pond, pp. 595-600. Proceedings of the Joint Conference on Prevention and Control of Oil Spills, March 25-27, 1975.

[3] D. Ahearn, et al. 1971 as reported by J.H. Stone and J.M. Robbins. Louisiana Superport Studies, Report 3 of the Center for Wetlands Resources, LSU, Baton Rouge. 1973.

*TLm = median tolerance limit; number indicates hours of exposure

**estimate of oil concentration at low tide

Ecological Impacts of Oil Pipeline Spills

The pipeline route from the West Hackberry site to the Sun Terminal at Nederland, Texas is bordered by extensive areas of intermediate and brackish marshes, spoil deposition areas, and some cleared, agricultural lands. The pipeline would parallel the Intracoastal Waterway for 15½ miles and would cross the southern portion of Black Lake, the Sabine and Neches Rivers, Cow Bayou, and several smaller water bodies. Oil pipeline ruptures can be expected to vary in impact depending on the amount of oil leakage, where it occurred, and the habitat type in which it occurred.

An oil pipeline rupture on dry land would impact primarily invertebrates and plants. Effects on soil organisms (collembola, mits, nematodes, earthworms, etc.) and plants can be expected to be severe, but very localized in the immediate area of the spill. The oil would be eventually degraded and/or leached away over a period of years. Based on an oil spill of 1000 bbls (which is larger than the median spill size of 850 bbls of crude oil), a soil porosity of 30 percent and assuming an oil penetration depth of 3 feet or less, it is expected that 1 to 3 acres of soil would be oil saturated. The exact coverage depends on soil types, viscosity of oil, pipeline pressure, soil moisture, and other factors. If oil reaches the water table which along the pipeline route is approximately 3 feet deep, slow discharge of oil into a body of water (the Intracoastal Waterway, Black Lake, Sabine River, Neches River, or the bordering marshes) via the water table may occur. Thus, a spill of approximately 1,000 bbl can act as a source of low-level contamination for several years. The U.S. Coast Guard may decide to take steps to prevent seepage of this oil into navigable waters. One method that is frequently employed is to dig a trench near the point of entry into such a water body, and when oil collects (generally after rains) it can be pumped off.

Effects of Cleanup Operations

Containment and cleanup operations of oil spills from tankers at dock facilities and spills from oil pipeline ruptures are the responsibility of the polluter. The U.S. Coast Guard must be notified whenever a spill occurs, and an On-scene Coordinator oversees cleanup operations and takes whatever steps necessary to assure appropriate cleanup operations are implemented. The use of emulsifiers and other chemical agents has been virtually discontinued and would have to be approved on the scene by the U.S. Coast Guard. Mechanical removal procedures (booming, skimming, and pumping) would ameliorate the potentially harmful effects of an oil spill and would not be a significant source of negative biological impact. Sorbent materials are generally used at a dock or on open water after most of the oil has been removed by pumping and skimming. Biological effects of cleanup operations at docks and in open water are generally minimal.

Cleanup operations in marshes, on beaches, and along river banks would involve removal of damaged vegetation and dead animals as well as oil removal. Such operations would result in trampling and other detrimental effects on vegetation within and adjacent to the oil coated areas however, properly supervised cleanup operations would generally produce only minor impacts in and near an oil spill area. The use of heavy equipment would result in more extensive impacts, and in certain areas could result in soil erosion. Since toxic chemical cleansing agents would not be used, vegetative regrowth would be rapid.

The cost of cleaning up an oil spill in a marsh is approximately $90 to $120 per barrel. The cost of cleaning up a river or lake is generally less.

The amount of sorbent materials used in any given oil spill situation is highly variable. One sorbent material that is used for relatively viscous oils will recover as much as 1 barrel of oil per 10 lbs of sorbent. After the oil is removed, such materials are generally transported to designated landfill sites for disposal.

Ecological Impacts of Release of Treated Ballast

As discussed in Section C.3.2.2.1 each tanker, prior to receiving oil at the Sun Terminal tanker dock, would discharge a volume of dirty ballast water into ballast treatment facilities onsite. After treatment the ballast would be discharged into the Neches River. This discharge would temporarily increase oil and salinity concentrations in the receiving waters. Increases in oil and salinity concentrations which would be found downstream of ballasting operations in the water have been computed for a discharge of 168,000 bpd. Figures C.3-16 and C.3-17 indicate that there would be an increase in oil concentration from 7.5 ppm at the discharge point to 1 ppm at approximately 8,000 feet downstream of the discharge. Figures C.3-23 and C.3-24 indicate that there would be salinity increase ranging from 30 ppt at the discharge point to 4 ppt at approximately 8,000 feet downstream of the discharge point.

The oil distribution system has been designed for a total withdrawal time of 150 days. However, ballast discharge would only occur intermittently during this period and an exposure time of 150 days for organisms exposed to the concentrations illustrated in Figures C.3-16, C.3-17, C.3-18, and C.3-19 would be worst case estimates.

Crude oil concentrations of 5 to 10 ppm, which are virtually identical to release concentrations, have been shown in laboratory studies to inhibit the growth of three Gulf Coast species of phytoplankton, Isochrysis galbana, Cyclotella nana, and Glenodinium halli, after 72 hours exposure (Anderson, 1975) These concentrations of crude oil are not known to produce mortality or detectable stress in zooplankton and benthic fauna populations, although the eggs of some fish species are killed by chronic exposure to low oil concentrations. The eggs of one fish species, the Sand Sole, experienced between 80 percent and 100 percent mortality in the laboratory at crude oil concentrations of 10 ppm (Vaughan, 1973) which is slightly higher than the proposed discharge concentration. Assuming the eggs of Gulf Coast fish species are equally sensitive, then the immediate area around the ballast water outfall would be unsuitable as fish breeding ground. Adult fish are not harmed by these concentrations (Anderson, 1975).

Concentrations of oil and grease levels have been taken for three points upstream of the Sun Terminal. These values are presented in Appendix D. They indicate that oil levels in the river water are 16 ppm upstream of the ballast water discharge point. Since ballast water is currently discharged at Sun Terminal, oil levels may be even higher at this point. As a result of the ballast treatment operations the aquatic environment near the discharge point is probably biologically degraded and estimates of a maximum increase of 7.5 ppm for an area of 8,000 square feet or less is not expected to significantly alter conditions of this part of the river. A worst case estimate would predict impacts to phytoplankton species and an elimination of this area as a fish breeding ground.

The effects of the increased salinity of the ballast water would be limited to organisms in the immediate vicinity of the outfall. Mobile organisms such as fish which prefer freshwater would temporarily emigrate from the discharge area. Saline-sensitive benthic organisms should be few in number near the discharge point because of present operation of the ballast treatment facility. At most, less than it would be subject ot water in excess of 4 ppt (See Figures C.3-23 and C.3-24). Because of past experience, operation of the ballast treatment facility at Sun Terminal is not expected to contribute appreciably to the currently altered condition of the aquatic environment at the docks.

C.3.2.6 Natural and Scenic Resources

Normal operation of the West Hackberry facility would not have an adverse impact on the Sabine National Wildlife Refuge. However, if a break occurred in either of the two proposed brinelines, the resulting brine spill diffusing through the soil would have a significant effect on the surface vegetation. A release of brine would increase salinity values in aquatic systems of the marsh in the proximity of the pipeline break. This change in salinity close to the break would be expected to be beyond the tolerance levels of the marsh vegetation which would cause a die-off of plant life in this area. The extent of this die-off would vary depending on the amount of brine spilled, with a large spill creating an unsightly mass of dead vegetation in an otherwise living marsh environment. Recovery may take 10 years or longer.

C.3.2.7 Archaeological, Historical, and Cultural Resources

It has been determined that there is a low probability for archaeological sites in the vicinity of the proposed and alternate West Hackberry brine pipelines. At the present time an extensive archaeological survey is underway, covering the West Hackberry dome and its associated pipelines. After the results of this survey have been compiled, the appropriate procedures would be initiated for compliance with the National Historical Preservation Act of 1966 and Executive Order 11593.

C.3.2.8 Socioeconomic Impacts

Operation of both the ESR and SPR expansion programs have, for the most part, similar activities and impacts. For this reason, the following discussion on operational impacts will treat both programs as essentially similar. The main difference between them is that the expansion is basically a program with a larger scope.

C.3.2.8.1 Employment

The labor requirements of the storage facility would remain essentially static during periods of standby. In the event that it became necessary to withdraw the oil, additional workers would be needed at the oil terminal. Extra workers would also be required there during the period when the caverns were refilled with oil.

The standby work crew would consist of about 20 people. Some of these would work during the evening and night shifts, but the majority would be on the site during the day. The crew would include pump mechanics, electricians, instrument workers, laborers, and supervisors. They would be charged with maintaining the facility, monitoring the gages, and periodically testing the equipment to keep it in good working order.

During a five month period of oil withdrawal, about 23 employees would be needed at the oil terminal. Since the withdrawal would occur only when oil imports were suspended, it is expected that workers normally employed in off-loading the foreign oil shipments, would be used at the docks to load oil from the storage facility and at the Texoma pipeline terminal to monitor the flow of oil from storage to inland refineries.

The refilling of the storage caverns would almost certainly take more than five months, but probably not more than two years. While the number of employees at the storage site remained about the same as during the standby period, 10 to 15 workers would be needed at the terminal to off-load oil from tankers into the pipelines leading to the storage facility at West Hackberry. The workers detailed to the oil storage program would be full-time employees of the Sun Oil Terminal, so the personnel required at the docks during oil withdrawal and cavern refilling would not represent new positions created by the project.

C.3.2.8.2 Land Use

The expansion of the West Hackberry dome would not appreciably change land use patterns of the area. The community of Hackberry is not expected to grow rapidly, and its growth potential is restricted by the wetlands which surround it and by the limited supply of fresh water. Urban areas north of the salt dome are growing rapidly, particularly the city of Sulphur. Even after 25 years, however, the boundaries of that city would not extend as far as the salt dome because a band of wetlands about 5 miles wide forms a natural barrier between the more heavily populated area and the salt dome.

The physical structures on site and the activities associated with the operation of the storage facility are not significantly different in character from the structures and activities presently on site for brine extraction from the dome. Therefore, the use of the land for oil storage would probably not affect long-term land values nor make adjacent lands less desirable for the purposes for which they are currently used.

C.3.2.8.3 Traffic

The number of vehicles moving to and from the site during operation would be small. The approximately 10 to 15 workers who would be at the site during the day shift would commute from Hackberry and towns in Calcasieu Parish. The number of additional vehicles using the roads leading to the site would not differ significantly from the present number.

During a period when oil is removed from storage because of an interruption in foreign oil supplies, tanker traffic in the Sabine-Neches Waterway would not be significantly increased. Most of the normal tanker traffic results from the importation of crude oil. A substantial reduction in such imports would offset the number of tankers required to distribute 60 percent of the oil stored at West Hackberry. About 307 tanker trips would be used to distribute the oil over a 5 month period.

The storage facility would be refilled at a slower rate than it was emptied. Refill would be extended over a 40 month period. About 156 tanker trips during each of the first 3 years and 52 trips in the 4th year would accomplish this task. The effect of these tanker trips in addition to normal traffic on the waterway would amount to an increase of 12 percent along the Sabine Pass and at Port Arthur, and 23 percent in the Neches River.

C.3.2.8.4 Housing and Public Services

When the construction of the facilities is completed and the labor requirements at the site are substantially reduced, there would be effects on housing that reflect this change. Some of the workers who moved into the area for the construction period would probably move away, increasing the availability of local housing. Where this occurred in Lake Charles and Sulphur, the effects may not be noticeable because these housing units made available would be only a small fraction of the normal turnover in housing units.

Construction workers moving out of Hackberry would create a more noticeable housing transition. Workers who would be at the site for the operation of the facility would create a demand for some of the housing being made available as construction workers leave, but there would be a short-term impact affecting others in the community who may be selling homes at that time.

Since the work force required for operation of the facility is quite small and the size of it would remain stable, there would be no appreciable impact of operation on public services provided in the local area. Workers would be needed at the docks in Nederland when the oil is removed from storage and when it is replaced, but it can be assumed that these workers would be permanent employees of the Sun Oil Terminal, and the work would not create additional jobs or increase demand for public services.

C.3.2.8.5 Economy

The direct economic impacts of facility operation would be very small. The greater economic importance of the oil storage facility at West Hackberry would be its value in mitigating the adverse effects to the local area of an interruption in foreign oil supplies.

Since the permanent staff on site would be small, the payroll would amount to only about $45,000 per month. Additional expenses incurred for supplies and parts, power, transportation, and contingencies would raise the cost of the storage operation to about $93,000 per month. This amount can be considered as money brought into the local area, and the local economic multiplier can be applied to indicate the extent of economic gains in earnings as a result of the circulation of the money. Application of the multiplier indicates a yearly increase in local earnings of about $2,277,000. This represents a gain of less than one percent over the anticipated earnings of the combined Lake Charles and Beaumont-Port Arthur-Orange standard metropolitan statistical areas in 1985.

During a period of oil withdrawal from the storage caverns, additional workers would be hired at the storage site to assure smooth, safe, and continuous operation of the intake water system, oil pumps, and pipelines. At the oil terminal in Nederland, workers normally employed in offloading tankers bringing in supplies of foreign oil could be used for loading oil from the storage reserves, and the net effect there would not be an increase in dock workers. Costs of withdrawal would be in the vicinity of $520,000 per month for up to 5 months.

Refill costs, excluding the purchase of the oil itself, would amount to about $250,000 per month over the refill period. The pumping rate is lower, reducing the power costs, and the number of workers at the storage site would be reduced to nearly the level needed during the standby period.

In the event that an interruption in foreign oil supplies should occur, the economic impact to the Lake Charles and Beaumont-Port Arthur-Orange areas would be great. Oil refineries and petrochemical plants constitute the major manufacturing industries of the area, and these industries imported over 18 million tons of crude oil in 1975 alone. A foreign embargo would result in the partial shutdown of refineries and petrochemical plants, and a consequent loss of jobs in the area. These adverse effects would be mitigated by use of the storage reserve. While much of the oil would be shipped to other parts of the nation, the local handling and more immediate availability of the stored oil would be an advantage to the region.

C.3.2.8.6 Government Revenues

The operation of the facility would have very little effect on local government revenues. There would be no local tax revenue from the use of the land as a Federal facility, nor would there be any income from the extraction of the oil since it would be taken from storage rather than primary oil production. Since the oil would almost certainly be sold to oil companies which are registered wholesalers, this sale would be exempt from state sales tax.

The local governmental agencies would benefit from the maintained general economic health of the region during an interruption in foreign oil supplies. The tax revenue from workers wages during standby operations is a quantifiable aspect of the general contribution of the project to local economy and subsequent increase in local governmental revenues. This contribution is only about $20,000 per year, but would be added to those tax revenues derived from increased property value and increased sales indirectly attributable to the project.

C.3.3 Impact Due to Termination and Abandonment

After termination of the SPR program, if the facility was not to be used for any other government purpose, it would be disposed of in accordance with applicable laws and regulations.

C.3.4 Relationship of the Proposed Action to Land Use Plans, Policies, and Controls

The West Hackberry site lies in Cameron Parish, and is outside of any city boundaries. There are no zoning restrictions governing the use of the land. The Parish Police Jury does regulate construction in flood plains and flood hazard areas. The site, however, lies on high ground and is susceptible to damage only in the very severe storms. The use of parish road rights-of-way for pipelines, and the laying of pipelines across parish roads and canals are regulated by the Police Jury, so they would be consulted regarding the proposed brine disposal pipeline which would cross the parish road leading to the site, and would also cross the small canals that lead from Calcasieu Lake into the interior marshlands west of the lake.

The planning for the brine disposal pipeline to the Gulf of Mexico would also involve state agencies. Where state highways would be corssed, the Louisiana State Department of Highways would be consulted. The Louisiana State Land Office has jurisdiction over state-owned lands that might be crossed, including the bottoms of lakes and navigable waters. If the proposed brine disposal pipeline were used, the State Land Office would be consuted regarding the right-of-way through Calcasieu Lake. Regardless of which pipeline route is selected, the State Land Office would have jurisdiction over the beach and the offshore area which would be crossed by the pipeline.

The Imperial Calcasieu Regional Planning and Development Commission has prepared a general future land use plan for the five adjacent parishes in southwestern Louisiana, including Cameron Parish. This plan projects land use in 1990 and focuses primarily on the expansion of urban areas in the region. There is no change in land use indicated for the West Hackberry site which is shown as agricultural land bounded on three sides by marshes, mineral extraction areas, and Black Lake. Use of the site for oil storage would be compatible with the land use plans for the area.

The U.S. Army Corps of Engineers has jurisdiction over surface water bodies and adjoining wetlands. The construction of the brine pipeline through wetlands between the site and the Gulf of Mexico would require a permit from the Corps of Engineers. Similarly, a permit would be required from them in order to construct the raw water intake structure in Black Lake.

C.3.5 Summary of Adverse and Beneficial Impacts

There would be little or no impact on geomorphology or drainage patterns as a result of grading and filling at West Hackberry. Only minor topographic changes would occur from spoil deposition. These changes would be temporary in marshes because the spoil would be used as backfill material. Removal of 2 million cubic yards of material from the Neches River to create a new dock site would alter the depth of that section of the river. Some minor soil erosion would be associated with site construction. Brine pipeline burial could alter drainage characteristics of upland soil types. There would be no impacts to stratigraphy or geologic structure except for the salt mass itself and extraction of other minerals and petroleum off the flanks of the dome would not be affected.

Withdrawal of leaching water would cause negligible induced velocities and changes in salinity in the ICW, even during the maximum withdrawal rate of 1.47 million bpd.

From 1800 to 3700 acres of ocean bottom would experince a 1 ppt increase in salinity as a result of offshore brine disposal.

Dredging for a new tanker dock would release light metals into the water column; heavier metal would become absorbed by suspended solids which would be stirred up by dredging activities. On balance, the water would be degraded but for only a short time.

Site preparation would result in a significant, short-term increase in fugitive dust emissions. Increased traffic would contribute to these emissions, but effects would be localized and the total contribution relatively small. Exhaust emissions would produce a minimal impact to the existing air quality.

The grinding of tanks would violate the 24-hour particulate standard at 1 kilometer, and painting tanks would violate the 3-hour NMHC Standard at 4 kilometers (1 percent of the time annually).

Increased noise levels would be relatively insignificant.

Construction activities would destroy floral and faunal components onsite, along pipeline routes, and at spoil disposal sites. Biota would rapidly recover along pipeline routes, but habitat would be permanently lost where buildings, tanks, ponds, and wellheads are constructed. Spoil depositio results in permanent alternation of the biotic community. On balance, temporary losses of biological productivity and disruption to wildlife from construction activities are relatively minor and habitats would recover. Construction of proposed brine disposal pipeline would not harm the recreatio value of the area except for minor, short-term aesthetic impa along the Calcasieu Ship Channel and in some marshlands and beach. However, construction of the alternate brine disposal pipeline bordering Highway 27 through the biologically sensit Sabine National Wildlife Refuge would disturb bird population near the road. The recreational value of this natural resour would be reduced only during the construction period.

There are no known archaelogical or historical sites in the vicinity of the West Hackberry dome that would be impacted by site construction.

A maximum demand for approximately 400 workers would occur as a result of SPR construction for the West Hackberry site, would not strain the available labor supply.

Use of the West Hackberry dome would not affect land use plans in the area, although crossing the Sabine National Wildlife Refuge would require a permit.

Traffic would increase on local roads and would nearly double on the county road to the site. Ship traffic would experience a moderate increase.

Payroll would reach levels of $700,000 per month for a short period. Material and equipment procurement would amount to $150,300,000. Local spending would increase and government revenues would likewise increase as a result of money flow associated with the SPR construction.

Operational impacts are generally not as significant as construction activities except for oil and brine spills, and certain air quality impacts.

Oil or brine spills can produce significant environmental damage. Of particular concern would be an oil spill in Sabine Lake or in marshes and brine spills from the alternat brine disposal pipeline along Highway 27. Barren patches of ground could be created by such brine spills and the effects would be relatively long-term.

Release of treated ballast water would impact several acres of the Neches River.

Hydrocarbon emissions associated with loading and offloading tankers would violate the 3-hour NHHC Standard 1 percent of the time at downwind distances in excess of 25 kilometers.

C.4 ALTERNATIVE SITE-BLACK BAYOU

C.4.1 Impact on Site Preparation and Construction

C.4.1.1 Land Features

C.4.1.1.1 Geomorphology

Since the storage site at Black Bayou is marsh covered, the fifteen storage wells proposed would be constructed on elevated platforms. Therefore, no fill would be required and there would be no alteration of landforms or drainage patterns. For the central plant, however, nine to ten acres would be filled to a height of eight feet, which would be a significant topographic change for the marsh area.

The required dredging of new canals would be a significant topographic impact as would the disposal of the estimated 125,000 cubic yards of spoil over fifteen acres. This dredging would also alter the flow pattern in existing waterways.

The oil distribution system for Black Bayou would require construction of a 14,000-foot pipeline from the storage site to the pipeline between the ESR at West Hackberry and the Sun terminal at Nederland, Texas. There would be a temporary alteration of the topography during pipeline construction. The material dredged from the marsh along the pipeline route would be stacked on the banks of the trench being dug. After the pipeline is laid, the spoil is used to backfill the trench, thereby restoring the flat topographic character of the marsh. Similar temporary construction impacts would occur during the construction of the 3,500 foot raw water supply pipeline. For both pipelines, the dredging of trenches, even though backfilled, could alter surface drainage patterns adjacent to the pipeline.

The brine disposal system would require that a twenty-five-mile pipeline be built from the storage site to the diffuser in the Gulf of Mexico. The entire route covers marsh but the topographic impact during construction is minor and temporary. As above, drainage patterns would be temporarily altered.

No additional construction is required at the Sun Terminal for distribution of oil from Black Bayou; therefore, there would be no impacts to landforms or drainage patterns at Sun Terminal.

C.4.1.1.2 Soils

Soils impacts at the Black Bayou storage site would be severe where new canals must be dredged for access to cavern well platforms, and the central plant areas where ten acres of fill is required. In the canals the clay subsoil of the Harris soil would be exposed and the spoil would probably be used at the central plant as fill. The Harris soils at the central plant would be buried by Harris soil from other areas. The fill area would significantly affect the drainage pattern of the marsh surrounding it.

Harris soils are found along the oil pipeline route from Black Bayou to the West Hackberry/Nederland ESR pipeline. During construction, vertical mixing and destruction of internal structure of these soils would occur along the route.

The twenty-five-mile brine disposal line would have impact on the soils, similar to the oil pipeline - vertical mixing and disruption of internal soil structure. The subsoil mixed with surface layers would leave a path of soil slightly different from undisturbed Harris soil. This is probably of no geological consequence.

No additional construction is required at the Sun Terminal except for a new tanker dock which has already been evaluated for impacts to soils.

C.4.1.1.3 Stratigraphy, Geologic Structure and Mineral Resources

There would be no impacts to stratigraphy or geologic structure during construction at the Black Bayou storage site, along any of the pipeline routes or at the terminal and dock facilities. Part of one structural element (the salt dome) would be removed during cavern construction, but this does not alter the description of stratigraphic or structural conditions. Construction activities at the storage site would not have an impact on the availability of oil produced along the flanks of the Black Bayou dome. No mineral extraction is occurring above the area of the proposed caverns.

C.4.1.2 Water

Site preparation and construction at Black Bayou would produce certain impacts on the water environment. Subsequent discussion dealing with these impacts is organized into two parts as follows:

- Surface Water
- Subsurface Water

C.4.1.2.1 Surface Water

The impacts on the surface water system in the vicinity of Black Bayou can be summarized as follows:

Construction Activity	Change in Water Supply	Change in Water Quality
Withdrawal of Leaching Water	X	X
Disposal of Brine		X
Dredging Operations		X
Disposal of Dredged Materials		X
Grading, Excavation, and Filling		X
Miscellaneous Construction Activities		X

Withdrawal of Leaching Water from Black Bayou

The withdrawal of water for the leaching operation would have some effect on both the supply (or availability) and quality of surface water. The point of withdrawal, as indicated in Figure C.4-1 would be on the main channel of Black Bayou, approximately 2.3 miles south of the junction of Black Bayou Cutoff with the ICW and approximately 16 miles upstream of the junction of Black Bayou with the East Pass of the Sabine River. The rate of withdrawal would be 1.03×10^6 bpd or 30,000 gpm. The period of withdrawal would extend over 1140 days (38 months).

If Black Bayou served as the sole source of leaching water and if the bayou were completely isolated from other water bodies, the withdrawal rate previously noted would lower the mean water level of the bayou .344 ft/day (as explained in Appendix D.17). Because the bayou is connected with both the Sabine River and with the ICW, the actual rate of fall of water would be less than the value noted. As indicated in Figure C.4-1, induced currents would serve to replenish the water withdrawn from the bayou. Thus, it can be seen that essentially all of the replenishment water would actually come indirectly from the Sabine River or the ICW.

In order to predict the impact of the withdrawal process for leaching water on the surface water system a numerical solution

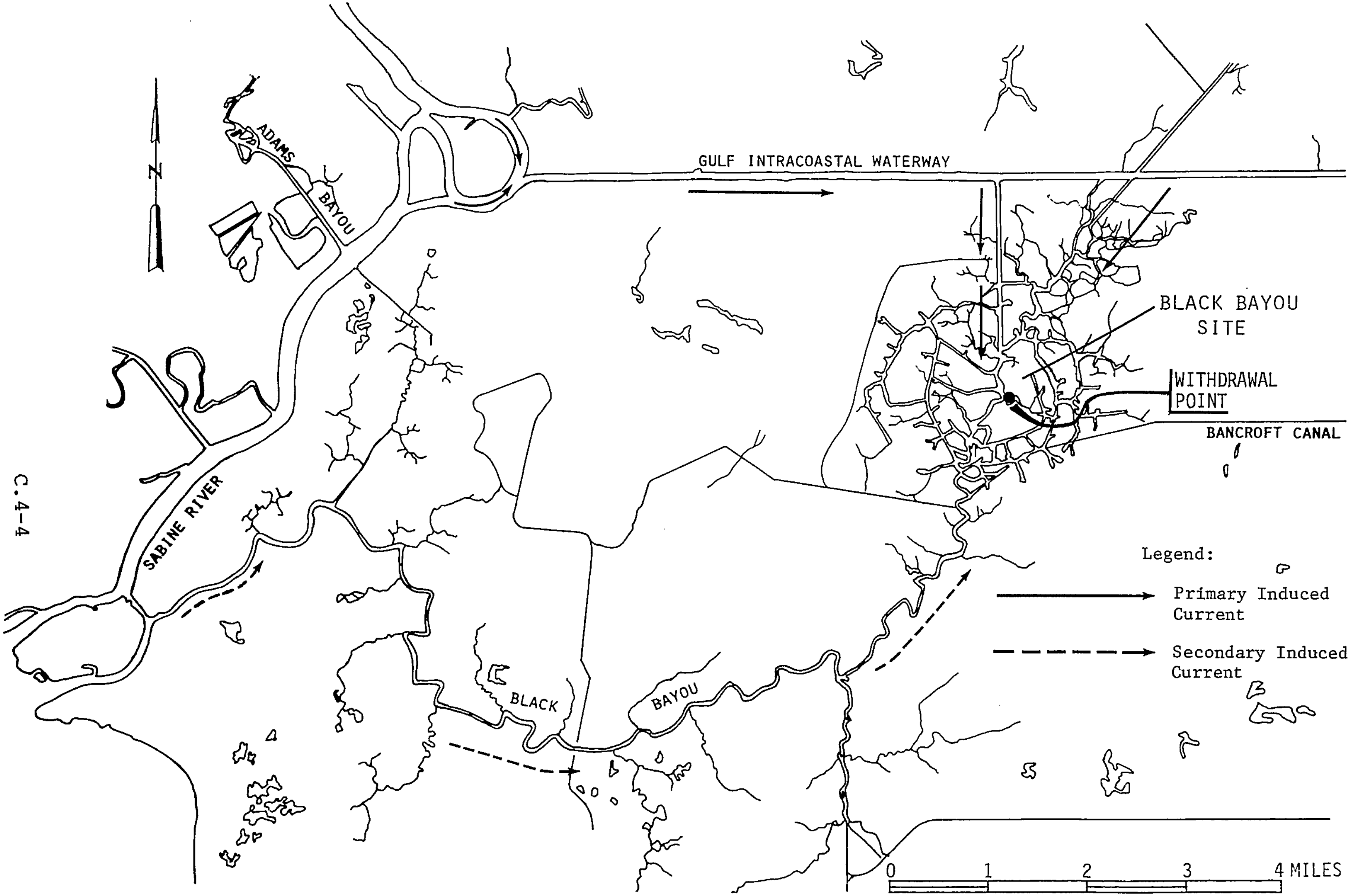

Figure C.4-1 Induced Currents in Surface Water System near Black Bayou of the equations governing the flow of water in an estuarine system must be obtained. The MIT Water Quality Network Model (Harleman et al, 1976), which is described in Appendix D-14, has been used for this purpose. To reduce the amount of computation, however, the model has been set up only for the case of withdrawal of water for displacement purposes, as discussed in Section C.4-2.2.1. Because the withdrawal rate during leaching is less than that during displacement the effects during leaching should be less than those during displacement.*

Based on the model results presented in Section C.4.2.2.1, and in Appendix D.17 the withdrawal of leaching water would depress the level of Black Bayou in the vicinity of the withdrawal point less than .06 feet. Induced flow effects in Black Bayou would produce current changes of less than .15 ft/sec while in Black Bayou Cutoff such changes would amount to less than .08 ft/sec. In the vicinity of the withdrawal point, the salinity in Black Bayou would increase less than 1 ppt during the withdrawal process. A decrease in salinity in Black Bayou Cutoff would be expected. In general, Black Bayou and Right Prong would experience an increase in salinity due to more salty water being drawn from the East Pass of the Sabine River. The maximum increase in salinity in these water bodies would be less than 2.5 ppt.

In addition to impacts associated with water level, currents, and salinity certain other impacts must be considered. As noted in the preceding discussion the ICW represents a replenishment source via Black Bayou Cutoff. The limited water quality data for the ICW described in Section B.3.1.2.1 indicates that the level of phosphorus, arsenic, mercury, toxaphene, lindane, heptachlor, aldrin, chlordane, dieldrin, endrin, and O,P'-DDT exceed the EPA numerical criteria. In addition, the levels of oil and grease, heptachlor,epoxide, methoxychlor, P,P'-DDT, P,P'-DDE, O,P'-DDE, O,P-DDD, and P,P'-DDD pose possible problems. Because the ICW would serve as a replenishment source for Black Bayou, the contaminants previously noted would be introduced into the bayou via Black Bayou Cutoff.

Water quality for the Sabine River has been discussed in Section B.3.1.2.1. As indicated in Table B.3-7, the level of cadmium and mercury exceed the EPA numerical criteria for marine water constituents, and concentrations of copper and zinc may pose possible problems. Because the Sabine River would serve as the source of a portion of the replenishment water, some of the preceding contaminants in the river would be transported into Black Bayou.

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*The leaching process occurs over a longer period of time but the changes in salinity, water depth and flow velocity should be less than those produced by the withdrawal of displacement water.

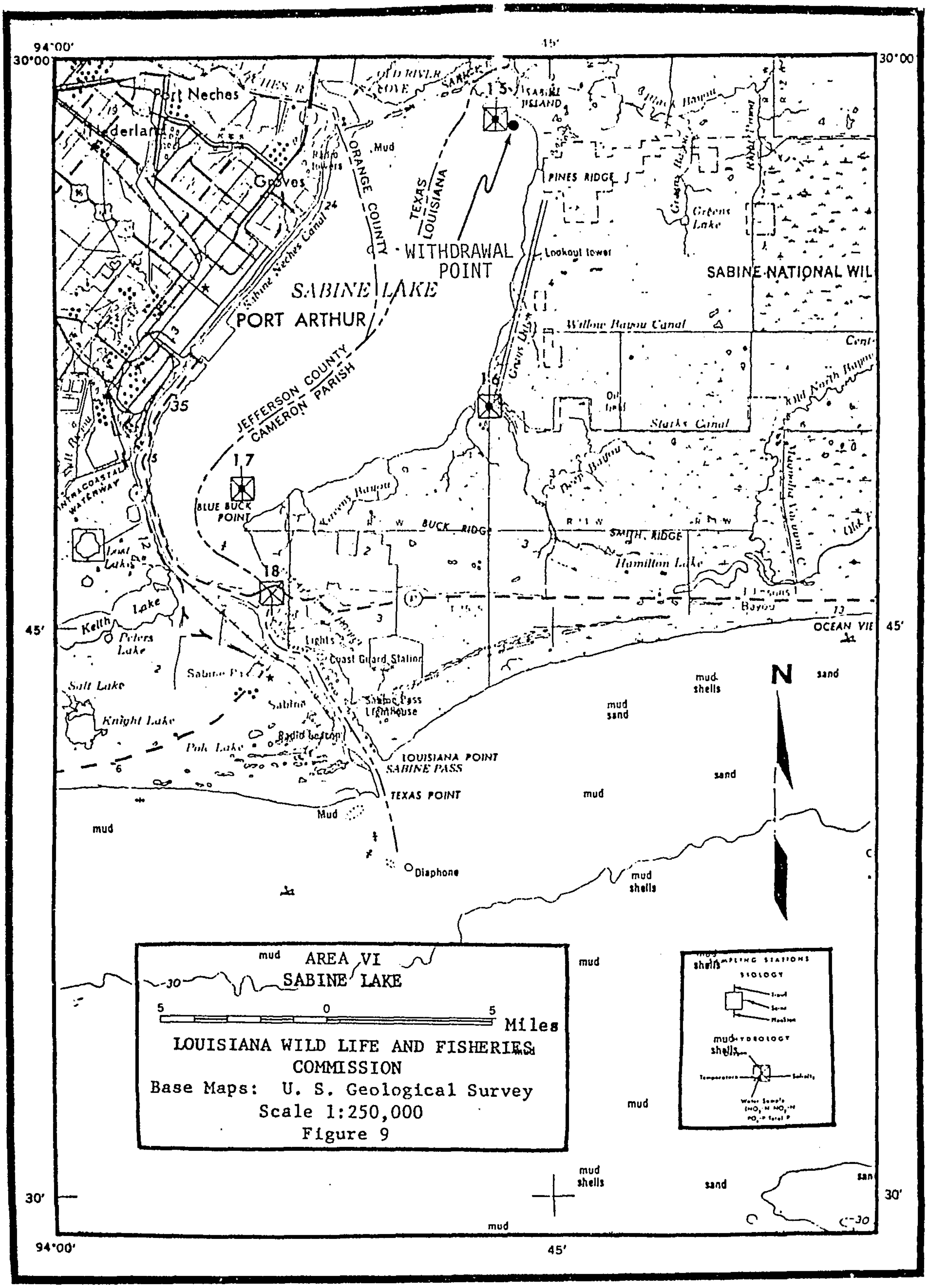

Figure C.4-2. Sabine Lake as Source of Water for Black Bayou

Brine Disposal

During the leaching process at Black Bayou 230 ppt brine would be discharged at a rate of 1.18 million bpd or 34,500 gpm for a period of 1144 days. Current design calls for the disposal of the brine by means of discharge into the Gulf of Mexico. The general disposal area in the Gulf is indicated in Figure C.4-3.

The disposal site is similar to that to be used for the West Hackberry facility. Therefore, the proposed specific criteria for the diffuser for Black Bayou are very similar to those proposed for West Hackberry (National Oceanic and Atmospheric Administration. 1977). These criteria are as follows:

- Diffuser location - approximately 7.5 miles south of that portion of the coast line near Hamilton Lake
- depth of water - approximately 30 feet
- diffuser length - 3070 feet
- diffuser orientation - perpendicular to coast
- number of diffuser ports - 52
- distance between ports - 59 feet
- diameter of ports - 3 inches
- orientation of port riser - 90° to ocean bottom
- port exit velocity - 25 ft/sec

An analysis of the impact of the operation of this diffuser on the Gulf of Mexico has been performed. The results of this analysis indicate that the impacts at the Black Bayou site in the Gulf are very similar to those at the West Hackberry disposal site. As described in Appendix U, the exposed bottom area for excess salinities greater than 1 ppt would amount to less than 1960 acres. For excess salinities greater than 3 ppt the exposed bottom area amounted to less than 104 acres.

Dredging Operations

As described earlier, pipeline burial would be fifteen feet beneath navigable stream bottoms and four feet beneath other stream bottoms.

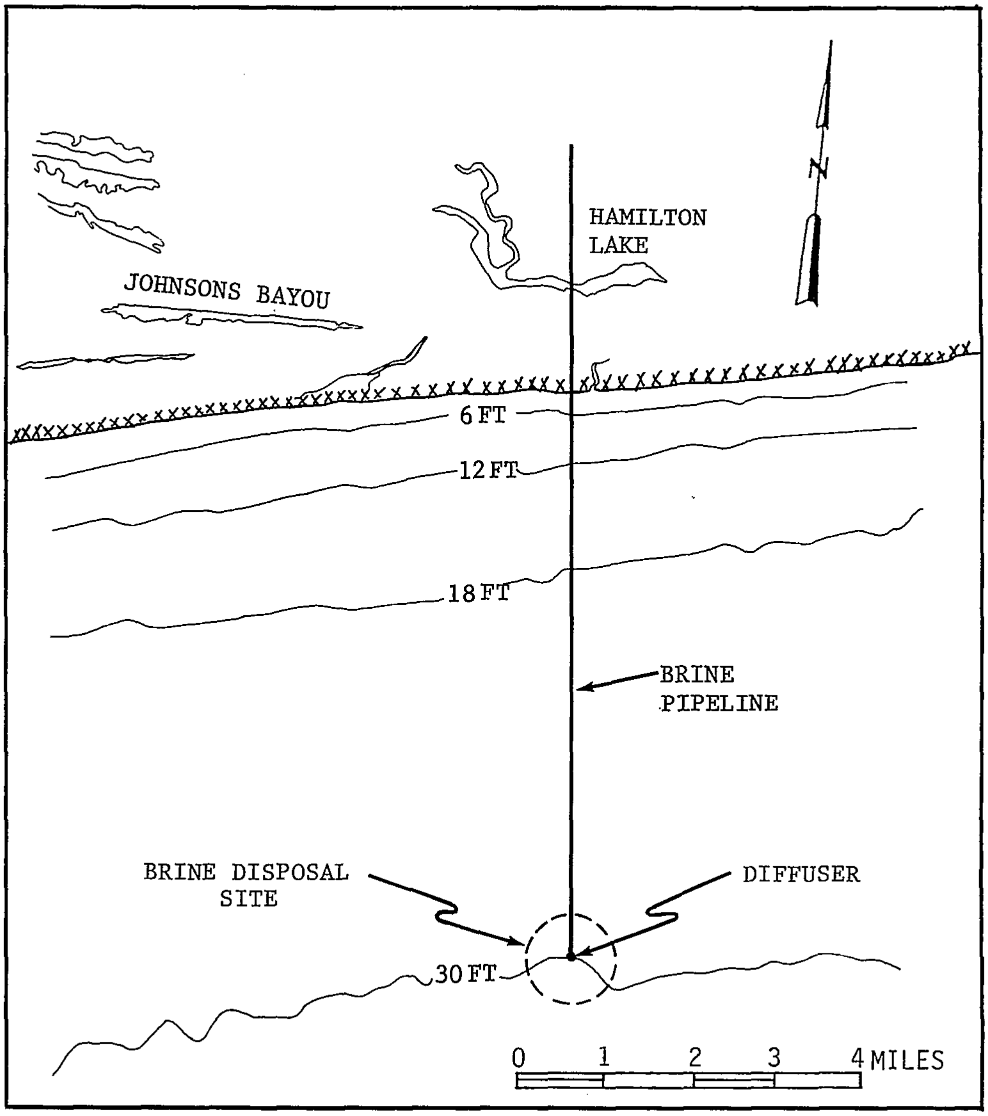

Figure C.4-3 Brine Disposal Site for Black Bayou

Dredging in Black Bayou.* Dredging in Black Bayou (associated with the construction of the Black Bayou facility) would consist of construction of new canals for access to storage wells requiring removal of approximately 125,000 cubic yards of dredged material. Also dredging would be necessary for about 300 feet of stream crossings for the oil pipeline spur and additional 200 feet for stream crossings by the brine disposal pipeline. For such crossing about 96,000 cubic yards of dredged material would be moved. Impacts of the dredging operation would be comparable with those for dredging of Black Bayou near the ICW as described earlier in Section C.3.1.2.1 for the West Hackberry oil pipeline.

Dredging in Marshes (South of Black Bayou Dome across Sabine National Wildlife Refuge). Considerable dredging and/or burial of pipeline would take place along the existing Transcontinental Gas Pipeline right-of-way across the Sabine National Wildlife Refuge. This area consists almost entirely of marshland with one to two feet of water depth. Dredging along this 18-mile route would be largely by push-ditch method. About 1,700,000 cubic yards would be moved during the dredging operation. This dredged material would be used to back-fill the trench after the pipeline is in place. The impact of such dredging would generally resemble that already described in Section C.3.1.2.1.

Disposal of Dredged Material.

Disposal would be in a confined area adjacent to the dredging site as discussed in Section C.3.1.2.1. The land areas involved are primarily marshes. The impacts would include the impact of dredged material on the confinement area and the impact of effluent from the disposal area on the adjacent stream(s). Site specific impacts are discussed in the following paragraphs.

Impact on Black Bayou Disposal Area. The impact on the disposal area would be similar to that discussed earlier for the Cow Bayou (Section C.3.1.2.1). The degree to which desorption of pollutants would occur cannot be predicted with precision at this time without sediment and water quality data. The release would be similar to that for Cow Bayou. However, the level of toxic pollutants in the sediment in Black Bayou should be significantly less than at Cow Bayou, and a smaller impact would be anticipated. A loss of wetlands habitat would be involved and amounts to about 62 acres.

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*Oil and brine disposal pipeline routes cross several forks of Black Bayou and tributaries. These are considered as one dredging operation. (The conditions are similar enough so that the impacts would be the same.)

Impact on Black Bayou Due to Effluent from Disposal Areas. The impact on Black Bayou due to the effluent from spoil disposal areas is anticipated to be similar to that for Cow Bayou (Section C.3.1.2.1).

Impact on Marsh (South of Black Bayou) Disposal Area. No long-lasting impact is anticipated as dredged material would be used to back-fill the pipeline trench. No permanent loss of wetlands habitat is involved.

Grading, Excavation, and Filling

The site preparation and construction activity would involve a significant amount of earth movement during a five-month period. Approximately fifteen acres of land would be disturbed. Based on the analysis presented in Appendix D.15, approximately 99 tons or 97.8 cubic yards of sediment would be washed into the surface water system during the five-month period as a result of erosion of this disturbed land by rainfall. As shown in Figure C.4-4, all 99 tons would be deposited in Black Bayou. Because the soil involved would be a silt loam the minimum rate of settling would be .018 mm/sec as shown in Figure B.3-9.

Based on the analysis provided in Appendix D.16, the introduction of such sediment into Black Bayou would increase the average level of suspended solids by 0.99 ppm. The increased level would persist for essentially the entire five-month period.

Miscellaneous Construction Activities

Two general types of pollutants (chemical and biological) can be generated during construction activities at Black Bayou. A complete list of the types of chemical pollutants is given in Section C.3.1.2.1. In general, most problems with chemical pollutants arise from excessive or improper use of industrial and agricultural chemicals on or near the construction site. Additional problems arise from improper storage and disposal operations. A more detailed discussion of sources of chemical pollutants is given in Section C.3.1.2.1.

Biological pollutants are generally the result of poor sanitary conditions at a construction site. As a result, bacterial, viral and other organisms are detrimental to water quality and other organisms. A major concern arises from release of pathogenic organisms associated with human waste.

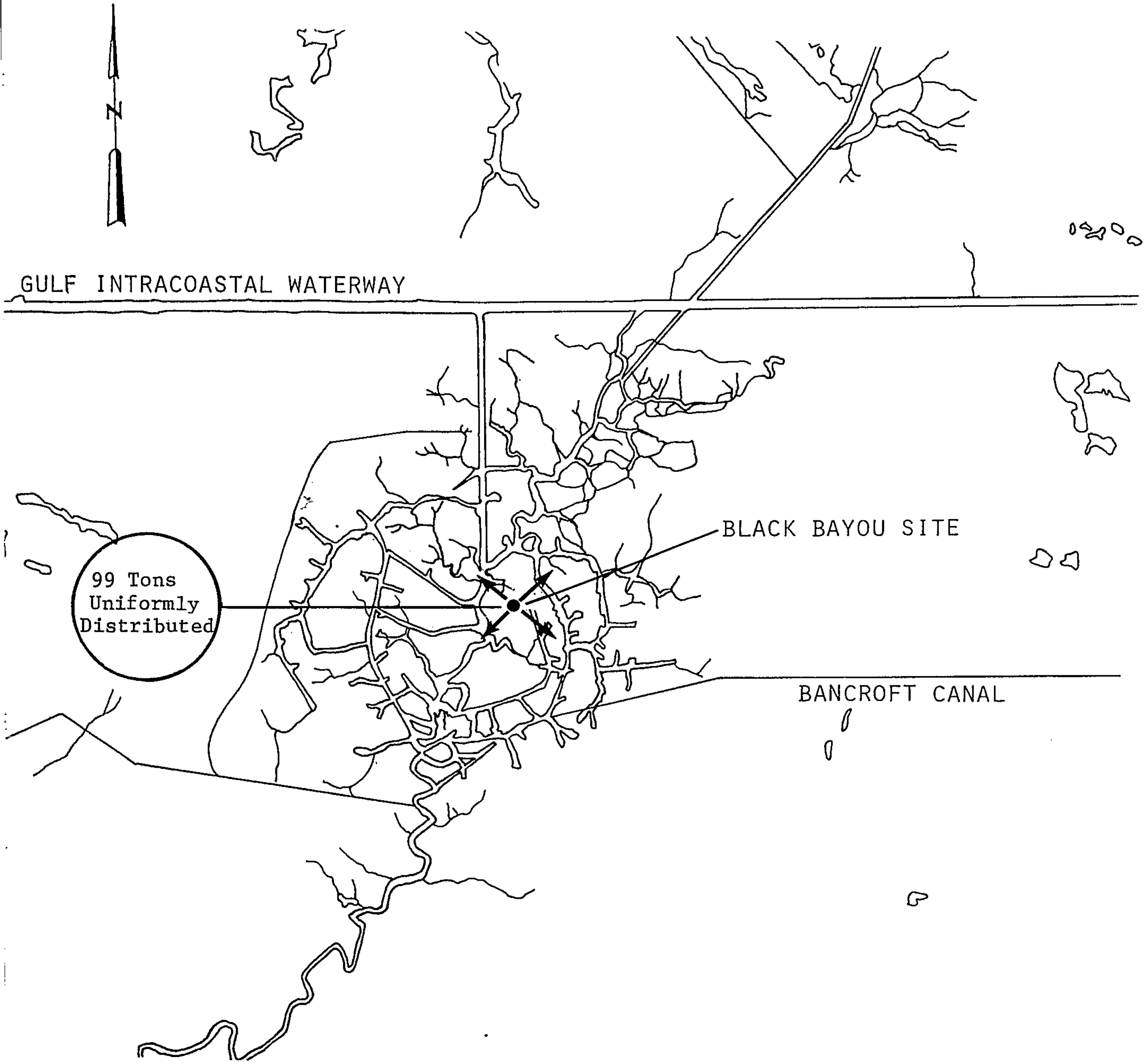

Figure C.4-4 Sediment Transport in the Vicinity of Black Bayou

Prediction of impacts due to these types of biological and chemical pollutants is not feasible because of the human element involved and the present lack of detailed design information. In any case the degree of pollution can be minimized by thorough training of construction personnel and adherence to reasonable housekeeping practices.

C.4.1.2.2 Subsurface Water

Current design for the Black Bayou SPR facility does not involve use of the shallow aquifers as a source of displacement water nor the use of the deeper aquifers as a site for brine disposal. Thus the subsurface water system should experience no impact as a result of site preparation or facility construction.

C.4.1.3 Air Quality

C.4.1.3.1 Sources of Emissions

The construction of the proposed oil storage facility at Black Bayou would result in combustion and fugitive emissions along the pipeline right-of-way and at the dome and Sun Terminal locations. Many of these emissions would be insignificant and would exert a negligible impact on local ambient air quality. A summary of the types of sources existing during site construction activities is:

- Site Preparation
- Unpaved Roads
- Paved Roads
- Heavy-Duty, Diesel-Powered Equipment
- Light-Duty Vehicles
- Drill Rigs
- Storage Tank Preparation
  a. Surface Grinding
  b. Paint and/or Primer Application

A detailed discussion of these emission sources and their characteristics is contained in Section C.3.1.3.1. Annual tonnage emission rates from these sources are summarized in Table C.4-1.

C.4.1.3.2 Emission Control Technologies

The emission control technologies that would be applicable to Black Bayou SPR facilities are the same as those described in Section C.3.1.3.2.

C.4.1.3.3 Emission Regulations and Standards

The emission regulations and standards applicable to Black Bayou SPR facilities are discussed and contained in Section C.3.1.3.3.

C.4.1.3.4 Air Quality Impact

The short-term and long-term modeling approaches utilized in the assessment of Black Bayou air quality impacts are the same as those discussed in Section C.3.1.3.4.

TABLE C.4-1

Annual Tonnage Emission Rates
At Black Bayou During Construction*

Source or Activity	Annual** Emissions (Tons)				
	HC	Pa	SO_2	NO_2	CO
Site Preparation	-	5249	-	-	-
Unpaved Roads	-	269	-	-	-
Paved Roads	-	0.6	-	-	-
Heavy Duty, Diesel Powered Equipment(1)	0.5	0.3	0.5	7.4	1.4
Light-Duty Vehicles	0.3	0.05	0.01	0.5	3.5
Drill Rigs	9.9	9.0	8.1	126	27
Surface Grinding Tanks	-	3.1	-	-	-
Painting - Tanks(2)	5.3	-	-	-	-
Total - Construction	16	5531	9	134	32

* Includes construction activities at dome and terminal sites and along pipeline right-of-way

** If activity persists for less than a year (e.g. painting - tanks) than total emissions for this shorter period are listed

1. The dome and terminal sites considered as independent construction sites of equal magnitude.
2. Two coats of paint

The greatest impact on local ambient air quality during construction would be due to tank preparation and land preparation activities. At the dome three small tanks would be required (See Figure A.5-6, Appendix A), while three 200,000 barrel oil surge tanks would be required at the Sun Terminal, regardless of which candidate site or sites are developed. Short-term modeling of tank surface preparation indicates that the 24-hour particulate standard would be exceeded out to a downwind distance of one kilometer or well within probable plant site boundaries. The application of paint would result in exceeding the three-hour NMHC standard out to a downwind distance of approximately four kilometers as indicated in Figure C.4-5. Figure C.4-5 presents conditions at the Sun Terminal, but the distribution is also pertinent to the dome site. The maximum frequency of violation would amount to roughly 1 percent of the time annually, and would occur to the west of the dome and Sun Terminal sites. The predicted frequency of violations is based upon the use of annual meteorological data. The actual painting process would require less than one month at each location, and the actual impact would be a function of the meteorological conditions during that period. Depending upon actual meteorological conditions, the indicated violations may be limited to within the probable plant site boundaries.

Long-term or annual pollutant ground level concentrations would be insignificant for construction-phase activities, with the exception of large-scale land-clearing operations at the dome and Sun Terminal locations. The modeling results are presented in Figures C.4-6 and C.4-7, and they indicate that the Federal Primary Standard for particulates would be exceeded within approximately 1 and 2 kilometers of the construction areas at the Sun Terminal and dome site, respectively.

The remainder of the construction phase sources are mobile and are fairly widely distributed. As a result, their impact on ambient air quality tends to be very local and of short duration. Such sources include vehicular usage and fugitive dust losses from project roadways.

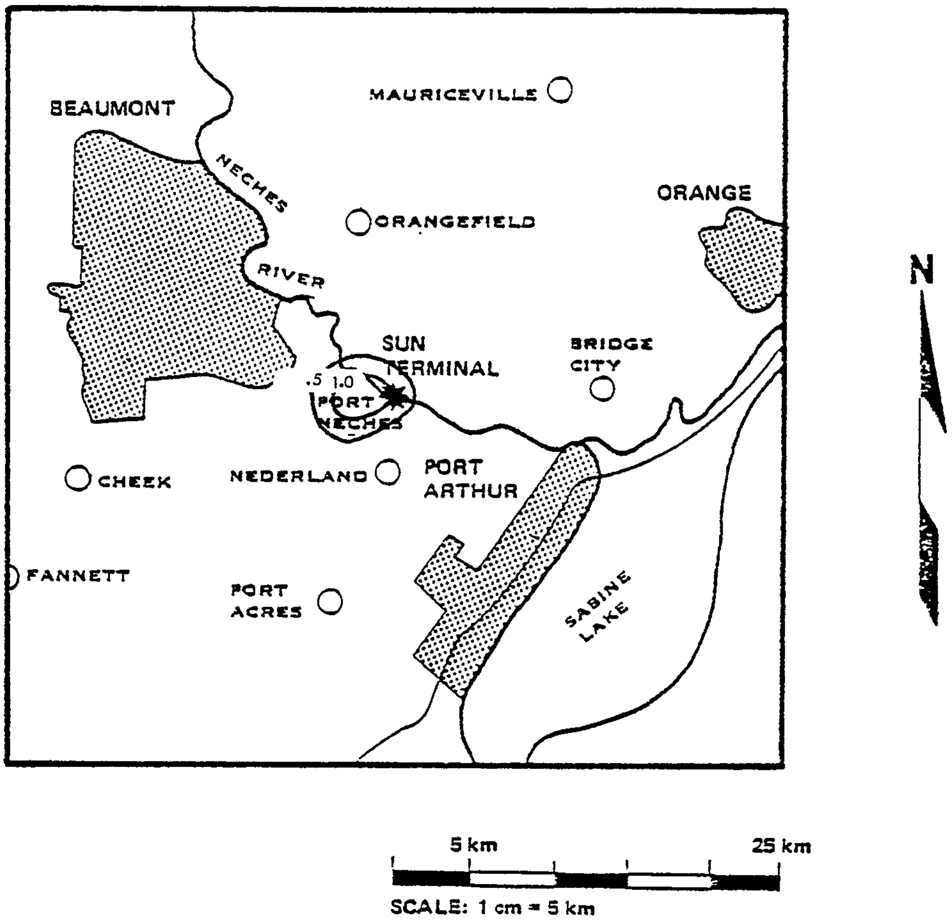

Figure C.4-5. Annual Frequency of Occurrence (%) of Violations of the 3-hour NMHC standard for Tank Painting at the Sun Terminal for all Texoma Sites During the Construction Phase*

Distribution will be identical at the Black Bayou Dome Site

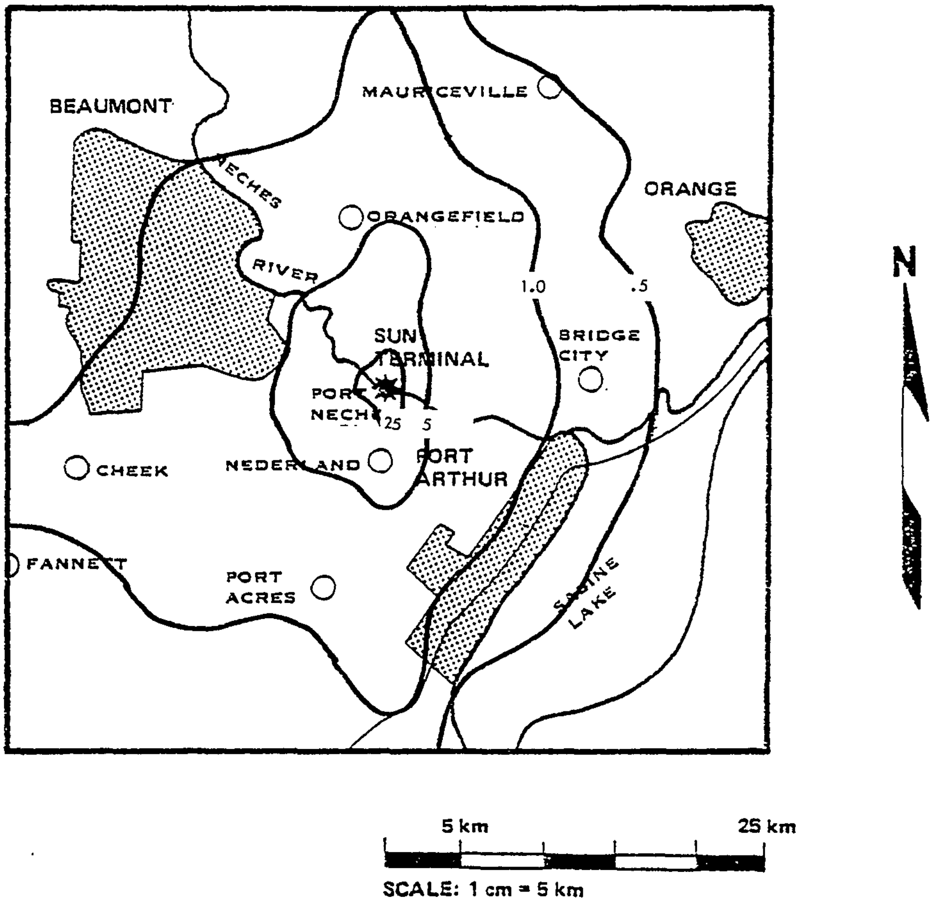

Figure C.4-6. Annual Average Particulate Ground Level Concentrations (μg/m^3) for the Sun Terminal for all Texoma Sites During the Construction Phase

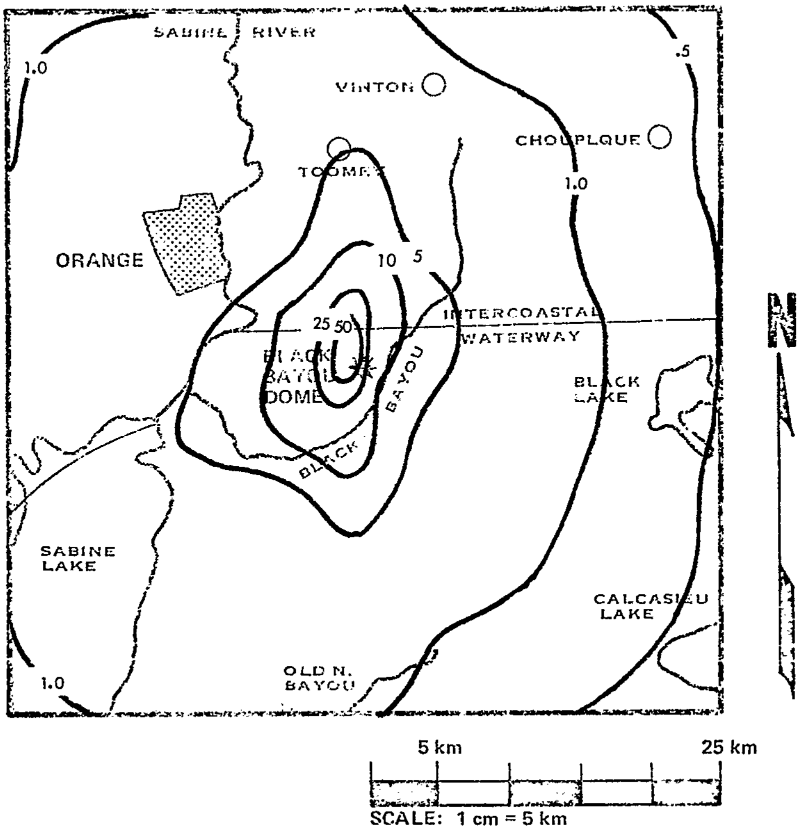

Figure C.4-7. Annual Average Particulate Ground Level Concentrations ($\mu g/m^3$) for the Dome Site During the Construction Phase at Black Bayou.

C.4.1.4 Noise

Construction activity associated with the development of the Black Bayou alternative site for the SPR programs may affect ambient noise levels at the storage site and in adjacent areas where construction would be on-going in conjunction with the site preparation. The principal areas which have been identified for construction activities are:

1. Oil Storage Site Area
2. Pipeline Corridors
3. Terminal and Dock Area.

An assessment of noise impacts at these locations is given in the paragraphs which follow. For an explanation of terminology, the sound propagation model, and noise impact guidelines, see Appendix F.

Oil Storage Site Area

The development of Black Bayou as an alternative to the proposed expansion of the West Hackberry ESR would require creation of fifteen (15) caverns on 230 acres located eight miles southeast of Orange, Texas. The existing site is undeveloped marshland and would require construction of an equipment barge, dock, and central plant facilities which would include office, control, pump, repair and laboratory buildings. It is estimated 91,000 cubic yards of fill would be required. The contributing noise sources at the storage site area during site preparation would be trucks, earth-moving equipment, compressors, drilling rigs, concrete mixers and general construction-related equipment. Noise levels typical of this equipment are given in Table E-2 of Appendix F. The evaluation of the construction noise sources indicates that diesel engines would provide the most consistent source of noise and that drilling equipment would create the peak sound levels. The areas adjacent to the storage site are mostly sparsely populated marshlands. Assuming both day and night time drilling activity of two drill rigs, it is estimated that the equivalent sound level contribution (L_{eq}) of the site preparation activity would be no more than 55 decibels (dB) at 2,000 feet from the center of the site. The contribution of storage site construction activity to annual day-night levels (L_{dn}) assuming 6 months of drilling activity is also estimated to be no more than 55 dB at 2,000 feet from the center of the site.

Pipeline Corridors

Two major pipeline systems are being proposed for servicing the Black Bayou site. One of approximately twenty-seven miles would be required for brine disposal. The brine disposal pipeline leads south to the Gulf of Mexico. The route covers 0.3 miles dry land with the remainder through marsh and water. A second pipeline proposed for oil distribution extends 2.7 miles entirely through marsh and inland water to the north of the storage site. The areas traversed by these pipelines are largely uninhabited wetlands, and it is unlikely that residential land use would be affected.

Tables F-2 and F-3 in Appendix F show equipment typical of pipe construction. Assuming daytime activity only, it is estimated that pipeline construction noise would contribute no more than 55 dB to the equivalent sound level (L_{dn}) at a distance of 500 feet from the pipeline right-of-way. The annual (L_{dn}) levels along the pipeline are not expected to be affected because of the relatively short period of construction activity at specific sites.

Terminal and Dock Area

The Sun Terminal and dock at the Nederland developed under the ESR development at West Hackberry would also be used for the Black Bayou site. No changes in terminal and dock construction from those required by the expansion at the West Hackberry are anticipated. Noise assessment for that expansion is contained in Section C.3.1.4.

Summary of Noise Impacts

Noise impacts from the construction associated with the site preparation for the Black Bayou are summarized in Table C.4-2.

Table C.4-2 Summary of Sound Level Contributions (dB) from Construction Activities for the Black Bayou Alternative

Construction Site	L_{eq}	L_{dn}	Distance from Center of Site
Storage Site Area	<55	<55	2,000'
Pipeline Corridors*	<55	<55	500'

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* Assumes daytime activity only.

C.4.1.5 Species and Ecosystems

C.4.1.5.1 Displacement/Leaching Water System Impacts

Construction of the intake sump and installation of intake structure pilings in the eastern side of Black Bayou would result in the direct destruction of the benthic organisms present where the sump was made and where the pilings were emplaced. The spoil would destroy marsh organisms in the spoil disposal area.

Burial of pipelines passing to the central plant and between the central palnt, and the storage cavern locations would also result in direct destruction of marsh organisms. Increases in suspended sediments caused by excavating, increased erosion along the backfilled pipeline routes, and run-off from spoil in the disposal area would occur. This would increase turbidity in and enrich the local ecosystem with nutrients. Pollutants or naturally occurring chemically reactive or toxic materials could also be released from the sediments. The marsh along pipeline routes would probably revegetate within two years and vegetation would be expected to establish itself on unsubmerged spoil within two years. Increased turbidity would reduce primary production of submerged plants and chemically reactive materials such as oxygen-demanding substances would briefly perturb submerged biota. The nutrients added from construction of the water system would be a relatively small quantity compared to the amount naturally present and would be readily dispersed except perhaps at the dredge disposal area. Materials may drain from disposal areas for years.

Plants in the marsh include such species as alligator-weed, bulltongue, spikerush, bullwhip, marshhay cordgrass, *Paspulum virginatum*, soft rush, roseau, and three cornered grass. Benthic animals in the area include mollusks, oligochaetes, polychaetes, shrimp, crabs, amphipods, and Diptera such as midge larvae. Some benthic, epiphytic, and periphytic algae are also present.

C.4.1.5.2 Brine Disposal System Impacts

The brine pipelines onsite would run parallel with the water supply and oil distribution pipelines. Impacts on biota associated with laying similar lines at Black Bayou salt dome have been discussed in the preceeding section (C.4.1.5.1 Displacement/Leaching Water System Impacts).

Construction of the disposal pipeline south to the Gulf of Mexico from the central plant across marshland, water channels, and open water would directly destroy vegetation in the pipeline path, disturb and displace wildlife, and temporarily disturb the environment by increasing erosion and sedimentation. The effects of sediment are discussed further on in the section.

Approximately 351 acres of marshland, 3.6 acres of inland water and 42.5 acres offshore in the Gulf of Mexico would be disturbed by construction of the brine pipeline. The marshland consists of alternating areas of the brackish and intermediate marsh types, with total amounts of each type being about the same. Most of the types of organisms present before construction would be expected to be reestablished within two years.

A crude approximation of lost production can be obtained by applying production rates measured by Day et al.(1973). These estimates assume that all rooted plants and benthic and epiphytic algae within the rights-of-way were sacrificed and a maximum of two years were required for recovery. Recovery would be a dynamic process occurring over the two year period; therefore, the calculated productivity loss would be overestimated. In addition, all organisms on the right-of-way would not be destroyed. Gross primary production of marsh grass was estimated at 8,418 $g/m^2/yr$ and that for benthic algae and epiphytes at 32.2 $g/m^2/yr$ for a total of 8,450 g dry wt of organic matter/m^2/yr. This comes to an estimated 24,006,966 kg dry wt of organic matter total lost gross marsh production in the rights-of-way. This gross primary production would have sustained animals and microorganisms as well as the plants themselves, with some also being exported to sediments and inshore and offshore open water areas. Gross primary production (benthic plants) in 3.6 acres of estuarine open water over 2 years at 698 g dry wt of organic matter/m^2/yr. (Day et al., 1973) comes to 20,378 kg. Commercially important shrimp, crabs, and fish and recreationally important waterfowl are dependent upon the gross primary production cited above, but the amounts of such dependent secondary production are not known. The area is part of the vast nursery system which sustains the very high regional fisheries production.

Birds, mammals, reptiles, and amphibians typical of the Refuge are found along the brine disposal route and up into the Black Bayou site itself. The birds include a great variety of both water and land species. The general categories include: loons, grebes, pelicans, cormorants, herons, storks, ibises, spoonbills, geese, ducks, ospreys, falcons, rails, quail, hawks, gallinules, plovers, gulls, terns, doves, wrens, kingfishers, tanagers, kinglets, swallows, hummingbirds, sparrows and others. Gulls, pelicans and shorebirds are more common near the coast. Mammals along both the brine disposal line and near the site include nutria, muskrat, mink, otter, raccoon, rabbits and deer. The red wolf, an endangered species, may be present along the brine line route. Reptiles present include snakes, turtles, lizards, and the American alligator. Amphibians present include salamanders, frogs, and toads. Benthic animals include more brackish water forms and fewer freshwater ones away from the storage site toward the coast. Shrimp, crabs, brackish-water mollusks, polychaetes, and barnacles become more prevalent while oligochaetes, insect larvae and freshwater clams and snails disappear. Fish present near the storage site are mainly freshwater forms somewhat tolerant of salinity such as largemouth bass, sunfish, and channel and blue catfish. Toward the coast, such forms are gradually superseded by forms more typical of brackish water, such as Gulf killifish, sailfin mollies, menhaden, and red drum.

Sediment exposed or dislodged by dredging would probably not be dispersed greatly from the pipeline right-of-way since marsh substrates have a high muck content (Chabreck, 1972). However, biochemical oxygen demand of the sediments would probably be high. During construction the sediments would be placed on top of marsh vegetation after dredging and before backfilling, crushing and smothering the oxygen-using organisms underneath them. Turbidity resulting from suspended solids would probably remain high during the period of construction (perhaps a week or two in a given area) and subsequently as water motions resuspended some of the topmost sediments which had been backfilled. Turbidity would reduce plant primary production and feeding of some animals. Siltation would interfere with the respiration, feeding, and behavior of benthic organisms and the settling and attachment of larval stages of such organisms. Reduced oxygen would inhibit the metabolism of organisms subjected to it and, if too low, would be toxic to many species.

Sediment along the brine disposal route would eventually decline to normal levels for the marshes. This would occur together with the establishment of biota. The more easily dispersed materials, which would make up the bulk of the suspended solids, would probably be dispersed within several months. Concomitant with this dispersal, water in the general vicinity would be somewhat enriched and the biological communities present would be temporarily stimulated, showing increased productivity.

Near the coast the brine line would cross low sandy ridges (cheniers) and Highway 82, and go across the sand beach into the Gulf of Mexico floor. A slight amount of pasture or cultivated land could also be crossed in this vicinity. These dry land areas would be expected to revegetate within one to two years. However, it could take several years for vegetation of the original type to be well developed. This vegetation includes trees (i.e., hackberry, chinaberry, prickly ash), cactus, and brush. Small areas of pasture or cropland which were impacted would be usable within a year after construction.

As in the construction of the other parts of the pipeline, birds and wildlife near the coast would be temporarily disturbed and displaced by the increased human activity and noise in the area. Birds of the area include gulls, pelicans, terns, shorebirds, and field and songbird species. Mammals include rabbits, mice, skunks, opossums and others. Many of the less mobile vertebrate and invertebrate animals, along with their nesting areas, would be sacrificed along with the vegetation. Toads and salamanders are examples of less mobile vertebrates. Soil animals such as earthworms, insects, protozoans and mites would be affected. Some soil bacteria, soil fungi, and soil algae would also be killed. Construction impacts to the beach and shore biota and organisms of the Gulf of Mexico would be as described for the brine line from the proposed storage facility (West Hackberry). These were discussed in Section C.3.1.5.2.

C.4.1.5.3 Impacts at the Storage Location

Plant and animal life would be affected to varying degrees by the construction of the central plant, the access canals, an equipment barge dock and barge slip, the leach/displacement water system, and the brine and oil pipeline construction. Pipeline construction impacts have already been discussed in relation to leaching and displacement impacts (Section C.4.1.5.1). Impacts of constructing the intake sump and platform were discussed in the same section.

The central plant would be constructed upon a landfilled area of about 10 acres. This would obliterate the non-and little mobile marsh organisms, such as mollusks, oligochaetes, polychaetes, amphipods, and midge bivae, in the entire 10 acres for the live of the storage project and beyond. It would also create increased sediment levels in the adjacent marsh and nearby canals for a limited time. The gross primary production loss assumed for these 10 acres is 9750 g dry wt of organic matter/m^2/year or 394,582.5 kg/year. The rate of 9.750/m^2/year is for marsh within 50 m of a channel. This would come to at least 9,864,562.5 kg over a period of at least 25 years. These primary production values represent the energy for sustaining the plants and animals present in the marsh area of 10 acres and a certain left over amount which would be exported to the surrounding waterways and consolidated into sediments in the area. Dispersal of the suspended solids resulting from filling would result in a relatively small impact on biota in the area around the central plant location since the materials used would be selected for low mobility under the wetland conditions.

Dredging of the access canals and equipment barge slip and construction of the equipment barge dock would impact organisms in additional areas of marsh and in the canals on the site. Organisms similar to those described for the central plant area which lie in the direct path of the dredging would be destroyed and organisms of peripheral wetland and canal areas would be affected by increased suspended solids. Effects would result from increased in turbidity: settling of suspended sediments; intake of sediment materials by aquatic animals; and changes in water chemistry such as lowered dissolved oxygen, increased hydrogen sulfide, and increased plant nutrients.

Since site preparation would extend over five months, and drilling operations and associated canal traffic would continue into the nineteenth month of the facility; increasing water turbulence, high suspended solid levels would probably not begin to decline to normal until after this period. Also, since the amount of dredging is relatively large compared to the total area of the site, and dredged material would probably be disposed of in the immediate vicinity, probably all of the surface water onsite and even around the site would show appreciable increases in suspended solids. The influence of withdrawal of raw water for leaching upon suspended solids during this period is unclear. Probably most of the dredged sediment would be organically rich material which would not stay in suspension readily. However, a certain component would probably be composed of fine material. Such material has been noted to still be detectable up to 1,300 feet from a canal dredging discharge, although this distance was unusual (Mackin, 1962). Assuming a radius of 1,300 feet across an approximate circular site, another 1,300 feet is estimated to extend across the area peripheral to the site in which suspended solids might appreciably be increased. Thus, this 48.8 total acres would experience the suspended material increases. area is largely a mixture of marsh and open water with marsh making up somwhat over half.

All animals and vegetation in approximately 7.4 acres of marsh would be destroyed in creating access canals. Similar organisms would be destroyed in the ten acres of marsh given over to a spoil disposal area. Marsh gross primary production of 1.7 x 10 kg would be lost in the total of 17.4 acres over the 25 years of the storage project. This would have been the basis in large measure for the standing crop of organisms and secondary production which would have been supported. This is an overestimate for gross primary production loss, since plants would appear on spoil in the disposal area. This spoil bank community would be much less productive than that of the marsh; however, there is no good basis to estimate productivity of the spoil bank community.

Biota on approximately 0.5 acre of canal bottom would be destroyed with construction of the barge slip, along with the biota on 0.5 acre or more of dry land where the spoil would be deposited. Gross primary production (benthic plants) destroyed in the 0.5 acres of the barge slip would require up to 2 years to recover. Animals associated with the substrate or vegetation in these areas would also be killed. Examples of these biota are given earlier in this section (C.4.1.5).

Less than 2,825 kg dry wt of organic matter gross primary production would be lost as a result of direct destruction during construction of the slip, based on a value of 698 g dry wt of organic matter/m^2/yr for gross primary production by benthic plants in open water in a Louisiana estuary obtained by Day, et al. (1973). The gross primary production loss resulting from disposal of the dredge spoil produced in constructing the barge slip, would be approximately 2,248 kg dry wt of organic matter; based on average world gross primary production values for grassland (Odum, 1971) and an assumed loss for 2 years. The spoil would probably be revegetated within two years.

Organisms would be killed from filling, dredging, and spoil disposal, while the remaining organisms in the 459.7 acre area would experience increases in suspended solids. Most of the increase in suspended solid levels from a transient high-level source would occur within a few hundred feet of the source. However, in this case the sources are assumed to be distributed throughout the entire general site area, which is considered to be circular with a radius of 1,300 feet. The multiple sources in this large area would act for a prolonged period. Therefore, the suspended solid levels might be expected to build up in the site vicinity beyond a distance of a few hundred feet from it.

Estimates of biotic losses given below are a worst case which considers that complete interference with aquatic biota would occur in 459.7 acres, 60 percent being marsh, and 40 percent open water, and that such impacts would be operative up to six months after cessation of drilling (25 months after beginning construction). Production and respiration from Day et. al. (1973) were applied. Up to an estimated 2,056,088 kg of dry weight of organic matter of gross primary production could be lost under these assumptions. This value includes gross primary production in open water, and by epiphytes in the marsh. Total respiration by animals and bacteria in marshland is estimated to consume 1,131 g dry wt of organic matter/m^2/year. It is estimated that 864 g dry wt of organic matter/m^2/year was used in bacterial and animal respiration in sediments, and the water column in estuarine open waters. The rate for respiration in the marsh includes a slight contribution from invertebrate groups which include both aquatic and terrestrial forms. These respiration values are summed through trophic levels and are estimates of food utilization by the entire biotic community except for the plants.

An estimated 2,628,072 kg dry wt of organic matter would have been utilized by animals and bacteria in the assumed impacted marsh area of approximately 275.8 acres. An estimated 1,337,495 kg dry wt of organic matter would have been utilized in the assumed impacted open water area of 183.9 acres Examples of the animals and plants representive of these marsh and open water areas are presented earlier in the section (C.3.1.5) and below.

Sampling of the ICW during March in the Black Bayou area gave higher standing crop values for benthos (mollusks, oligochaetes, polychaetes, amphipods, and Diptera) of 1,794.19/m^2 with a corresponding biovolume value of 6.01 ml/m^2. These quantities correspond to 1,335 x 10^6 benthic animals with a biovolume of 4,473 liters. Phytoplankton and zooplankton sampling on the ICW at the same part of the ICW as the benthic animals were sampled and at the same time of year gave highest densities of 68,042/m^3 and 1,855/m^3, respectively. These values are low since relatively coarse mesh nets were used. They would correspond to 50,639.802 x 10^6 cells and 1,403 x 10^6 animals, respectively, for 183.9 acres if the average water depth were 1 m. The phytoplankton and zooplankton were freshwater assemblages. Mobile animals included in trawl samples were: Atlantic croaker, blue catfish, channel catfish, hogchoker, blue crabs and white shrimp. Average biomass/unit effort (10-minute trawl) was 821.2 g, with that for white shrimp being 34.3 g. The average number of individuals per trawl was 79.5 Potential losses of plankton attributed to construction impacts perhaps would virtually overlap with losses resulting from entrainment with leaching water. In other words, plankton would be drawn from a greater area during leaching than would be adversely impacted by construction.

Nutrient enrichment would stimulate production in the marsh and aquatic community. This would occur peripherally to the highest levels of suspended sediments. A minor impact may be that organic detritus which is stirred up by dredging may temporarily be made more available to mobile consumers (U. S. Army Corps of Engineers, 1976). New open water habitat would be created by construction of the access canals and barge slip. Populations of benthic infauna could be well established within six months after sedimentation and other stresses are at reduced levels.

Short-term sedimentation of dredged material has been reported to eliminate as much as 70% of the average number of benthic organisms in a covered area and to cause a great reduction in the number of species present (Cronin et al., 1970; Sailla et al., 1971). Burrowing animals are not generally killed by being covered by sediments one time and may be favored by it. Wildlife such as waterfowl, mammals, and reptiles would be disturbed on and displaced from the site by increased noise, human activity, and habitat disruption during the months of construction activities.

C.4.1.5.4 Oil Distribution System Impacts

Organisms would be destroyed in the path of the oil lines which would be laid in Black Bayou Cutoff. Dredging would occur along 1.9 miles of channel in a strip perhaps 20 feet wide over a period of no more than a few weeks. The total area in which there would be excavation, assuming the above values, would be approximately 4.61 acres. Benthic standing crop and production would be lost for an indefinite period. New populations of organisms will probably become established within six months (U. S. Army Corps of Engineers, 1976), but full recovery to the pre-dredging community structure could require two years or longer. A complete loss of benthic gross primary production for one year in 4.61 acres is estimated at 13,022 kg dry wt of organic matter. Food use (respiration) by benthic animals, nekton, and bacteria which would be eliminated in 4.61 acres over one year, is estimated at 11,013 kg dry wt of organic matter. These estimates are based on determinations by Day et al. (1973). A standing crop of benthic animals of approximately 33.53×10^6 organisms with a corresponding volume of approximately 112.35 liters is estimated. This estimate is based on ICW data obtained by the U. S. Army Corps of Engineers (1975).

Suspended solid levels would be raised in the Black Bayou Cutoff for a period during and after the oil lines were laid. These levels would probably subside rather quickly as backfilled dredged material stabilized and organisms became established on and in it. This would probably progressively return the suspended solid levels toward predredging levels, with those levels being reattained within no more than a few months. The suspended sediment levels would be disproportionately higher the nearer in time it was to when the pipelines had been constructed. These increases in suspended solids would probably be tolerated well since high levels would be present for only a relatively short time. Nutrient additions to the aquatic system in the vicinity would stimulate primary and dependent secondary production so that the deleterious impacts of the initial high sediment loads were partly compensated.

The 0.8 mile of marsh on the site through which the oil distribution lines would pass, would be disturbed by other construction activities in the area. Effects of suspended solids generated by construction in this segment has been discussed in connection with onsite impacts in Section C.4.1.5.3. Burial of the oil lines in this section of the route would destroy non- and little mobile biota such as marsh grasses, epiphytic organisms, and benthic organisms in the excavation path and kill and injure some of the organisms to the sides of the burial trench. Deleterious impacts to biota along the sides

of the actual trench would result from mechanical injury from vehicles which guided the pipeline when it was emplaced and from temporary storage of excavated sediment. The extent of impacts is unclear. Assuming that one-half of the vegetation and other biota were destroyed, and recovery was half completed within a year and finished in two years, standing crop and productivity would be lost in 7.2 acres over the equivalent of a year. Estimated gross primary production losses (marsh grasses and epiphytes) would be 312,441 kg dry wt of organic matter. This estimate is based on an average for gross primary production of Day et al.'s (1973) figures for streamside, inland, and average over entire marsh. The estimated loss of food used by bacteria and marsh animals is 21,970 kg dry wt of organic matter. Examples of the organisms discussed in connection with the oil distribution system are presented earlier in connection with the other
cussed in this section (C.4.1.5).

A summary of these impacts from constructing the oil distribution lines plus those from additional segments connecting to the West Hackberry salt dome is presented in Section C.3.1.5.4. It is 25.3 miles along the pipeline route to Sun Oil Terminal from the junction of the ICW and Black Bayou Cutoff. Impacts on biota along approximately three miles of dry land, and impacts on marsh biota along approximately 13.2 miles, should be subtracted from the values in the summary in Section C.3.1.5.4 for the analysis to apply to the oil distribution pipelines from Black Bayou Cutoff on to Nederland.

C.4.1.6 Natural and Scenic Resources

The brineline from the Black Bayou facility would cross the marshland within the Sabine National Wildlife Refuge. The proposed route would follow an existing pipeline corridor for approximately 11 miles through the marsh. Because of the type of pipeline construction proposed for the marsh (See Section B.5.5.2) the impact on the natural and scenic resources of the refuge during construction is considered to be minimal and temporary.

Nibletts Bluff State Park, located 10 miles north of the oil pipeline route in Louisiana (see Figure B.2-28),is situated far enough from construction areas, so that no impacts are anticipated to occur to this park.

C.4.1.7 Archaeological, Historical, and Cultural Resources

Three archaeological sites have been found in the vicinity of the Black Bayou brine pipeline, two of which would require additional study if Black Bayou were to be developed. If the Black Bayou site were chosen as an SPR facility, a more intensive archaeological survey would be initiated which would comply with the National Historical Preservation Act of 1966 and Executive Order 11593.

C.4.1.8 Socioeconomic Impacts

C.4.1.8.1 Employment

During construction of the proposed Black Bayou storage facility, a substantial number of workers would be hired for a short period of time. The manpower curve for construction activities is shown on Figure C.4-8. The peak manpower level occurs in the second and third months of activity and results primarily from the labor requirements for laying pipelines for brine disposal, raw water intake, and connection to the crude oil pipeline along the Intracoastal Waterway. The surveying of the route and the laying of the pipeline was concentrated in the first three months of activity so that leaching of the storage caverns could begin in the fourth month.

The marsh terrain would require the use of barges for part of the pipeline laying onshore, and for all pipeline work offshore. Laying pipeline from a barge takes more time than laying pipeline on dry land. The labor estimates assume that two crews would work simultaneously, one on land, and one on a barge. Each crew would be comprised of 120 to 180 workers.

Construction of buildings and installation of equipment at the storage site would be completed during the initial six months. A peak manpower level for activity at the site is 260 workers, occurring in the fourth month. Wells to the individual caverns would be made by using two drill rigs on barges, and one land rig. Continuous drilling would require the crews to work in shifts, reducing the number of personnel on site during the day to about 200 during the peak period, and about 100 during the rest of the time. About thirty workers would be at the site during the evening shift and another thirty during the night shift.

The majority of workers would be in the skilled trades. Pipefitters, welders, and equipment operators would be hired from the region. Since the access road to the site is about midway between the metropolitan districts of Sulphur and Lake Charles on one side, and Orange and Port Arthur on the other, workers could be drawn from both areas. Workers would also be hired from Vinton, but it is not large enough to supply all the labor needs of the project. Construction of the brine disposal pipeline through the remote areas of Cameron Parish would employ people of that area.

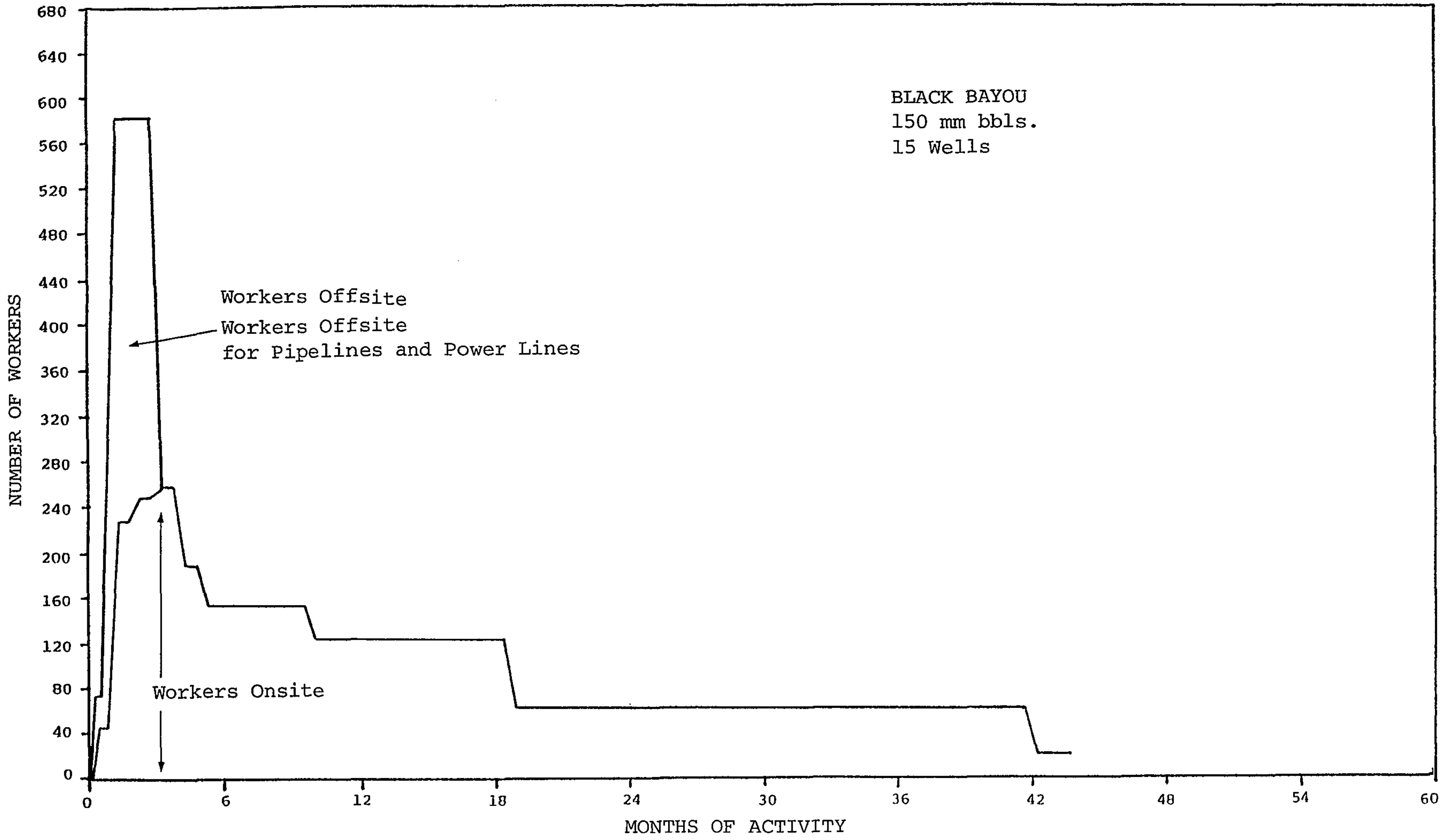

Figure C.4-8 Labor Requirements at the Black Bayou Site

The effect of drawing the peak level of workers from Calcasieu and Cameron Parishes, and Orange and Jefferson Counties would be to reduce the unemployment rate in these areas. Assuming that the 1970 recorded distribution of craftsmen, foremen, and equipment operators among the whole labor force has remained unchanged, and that about 4 out of 5 of the unemployed workers in these categories would select other jobs or be unsuitable for hiring, the peak labor needs of the project could be met almost entirely from Calcasieu Parish, Cameron Parish, and Orange County. Unemployment in Calcasieu Parish would drop from 8.6 percent to 8.1 percent; in Cameron Parish, from 8.2 percent to 7.7 percent; and in Orange County from 7.7 percent to 7.1 percent. Because Jefferson County is farther from the site, fewer workers would be drawn from the area, affecting the unemployment rate less than 0.1 percent. However, workers in Jefferson would be employed by the expansion of the oil port facilities at Nederland.

After the completion of the brine disposal pipeline and the construction of surface facilities at the salt dome, the labor force would be reduced to levels of 160 and 120 workers over a period of a year, then stabilize at about sixty workers for two years. Most of these workers would be engaged in drilling and leaching the caverns, both of which tasks would be done in shifts. The resulting number of workers on the site during the day would be in the range of fifty to sixty until the drilling is complete, and thirty to forty during the two years of concurrent leach and fill.

C.4.1.8.2 Land Use

Since the land around the periphery of the Black Bayou salt dome is currently being used for oil production by the Shell Oil Company, the construction of tanks, wellheads, pumphouses, and similar structures would not constitute an alteration of the existing land use patterns.

The canals that would be dredged through the marsh at the dome to provide access to wellheads would be extensions of an existing canal network that crosses the dome. The spoil disposal sites would be designated by the Corps of Engineers permit application and the impacts associated with spoil banks would be minimized through the use of the best available dredging technology.

agricultural lands. Spoil deposition on wetlands would affect the ecology of the immediate area, but would not in itself significantly reduce the recreational value of the marshlands which extend over the vast majority of the land in this portion of the parish.

Construction of the brine disposal pipeline would have a temporary adverse effect on land use. Although the pipeline route follows an existing right-of-way for a gas pipeline, the movement of heavy equipment and daily transport of workers through the wildlife refuge would be at variance with the intended use of the land, and a permit would have to be obtained to allow the construction. South of the refuge, Highway 82 would be crossed near Johnson's Bayou, and the Louisiana Highway Department would be consulted regarding procedures to be followed to maintain use of the roadway while pipeline is laid beneath it. The beach between the highway and the Gulf of Mexico would also be crossed. Scenic value of the beach would be marred by the presence of heavy machinery, the noise, and the activity associated with the laying of the pipeline, but the effect would last no longer than several days.

C.4.1.8.3 Traffic

Traffic in the area would be affected by workers commuting to and from the site, equipment and materials being brought by barges to the site, and by the laying of the brine pipeline under Highway 82 near the coast.

All the workers employed at the salt dome and the pipeline laying crew working near the dome would travel to and from their work via a parish road leading from Route 108 to Cameron Farms, and a smaller roadway along the Bancroft Canal. Most of those who commute from Calcasieu Parish and from Orange and Jefferson Counties would also use Interstate 10 as well as Route 108. Assuming that a third of the vehicles would carry more than one worker, the percentage of increased traffic along the roadways would be as follows:

	Recorded Traffic	Peak Period Increase	12 Month Average Increase
Interstate 10 at Vinton	8,800*	8%	3%
Route 108 South	180	405%	169%
Gum Cove Road	140	521%	217%

There is a free ferry where the parish road crosses the Intracoastal Waterway. It can carry up to nine passenger cars, and takes about fifteen minutes to make a complete round trip, including time for loading and unloading. It would not be feasible to have all the workers ferried across in their own vehicles, so arrangements would have to be made to either transport them in buses from the ferry to the site, or to install a bridge at the crossing.

After the peak traffic period was reached, the average number of vehicles traveling to and from the site would decrease to about 55. This represents an increase of less than one percent on the Interstate, 30 percent on Route 108, and 40 percent on the parish road.

Heavy materials and equipment would be brought to the site on barges using the Intracoastal Waterway between the Sabine and Calcasieu Rivers, and the Black Bayou Cutoff Channel. Assuming that during the initial construction period, about fifty barges were required to bring drilling rigs, dredges, cranes, concrete, pipeline and other materials, and equipment to the site, there would be a 10 percent increase in traffic along this section of the Intracoastal Waterway. The Black Bayou Cutoff Channel is used by Shell Oil to transport equipment and supplies for its oil production activities, and while its use by barges going to the oil storage project would constitute a major increase in its traffic, such use could be accommodated without impairing its serviceability to present users.

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* A 1975 traffic count recorded 11,200 vehicles along the Interstate Highway in this vicinity, but did not include traffic counts on the other two roads. Using the 1975 count, the traffic increases would be 7 percent at the peak period, and 3 percent over the 12 month period. Increased use of the Interstate Highway would not necessarily indicate a commensurate increase in use of the other two roads.

When the brine disposal pipeline is laid beneath Highway 82 east of Johnson's Bayou there would be some disruption of traffic along the road. The number of vehicles using this highway daily averaged 790 in 1971 and, while this section of the road was not monitored in the 1975 update, the traffic count on Highway 82 east of the proposed crossing recorded a daily average of 1,100 vehicles. The highway is an evacuation route for people living along the coast to use in the event of a hurricane, so vehicles would be allowed to pass while the pipeline is being laid under the road bed. There are no parallel roads that would serve as detour routes.

Ship traffic in the Sabine-Neches Waterway would also be impacted. The quantity of oil to be stored at Black Bayou is equal to the amount of oil designated for the expansion of West Hackberry. If the construction and fill of the Black Bayou dome were to begin 6 months after construction started for the early storage facility at West Hackberry, the impact on ship traffic to supply oil for the initial fill would be the same as is shown in the table in Section C.3.1.8.3 for the West Hackberry facility expansion.

Considering the Black Bayou site by itself, and using the timetable shown in Section A.5.6 for its construction and fill, the yearly increase in tanker trips on the different sections of the waterway would be as follows:

	Additional Tanker Trips	Sabine Pass Port Arthur Increase	Neches River Increase
10th - 28th month	220	12%	23%
28th - 42nd month	136	9%	17%

C.4.1.8.4 Housing and Public Services

Job openings created by the project are expected to attract about 15 percent of the peak labor force from outside the local region, bringing nearly ninety workers into the area. Considering the relative size and proximity of towns and cities near the site, and the availability of housing in them, an estimated thirty-five workers may seek housing in Lake Charles, twnety-five in Orange, fifteen in Sulphur, and fifteen in Vinton.

The impact on housing availability in the three cities would be quite small and would probably not affect rental costs. It can be assumed in all four localities that because the homeowner vacancy rate is below 3 percent, the workers would move into rental units. The availability of rental units would be reduced by less than one percent in both Lake Charles and Orange, and would decrease by about one percent in Sulphur. The availability of housing in Vinton is very limited. The 1970 count of available housing units found only 2 for sale and 17 for rent. Although the town has grown significantly since 1970, it is reasonable to assume that some of the workers moving there would rent land for a mobile home in which to live during their employment.

Workers who incurred minor injuries at the site could be brought to the community hospital at Vinton. More serious injuries, particularly those affecting workers laying pipeline through the remote marsh area of Cameron Parish would need to be evacuated by helicopter ambulance services operating out of Lafayette and Houston.

The additional activity at the site during construction, and the congestion on roadways leading to the site would place an additional burden on the police services in the area.

C.4.1.8.5 Economy

The regional economy would benefit from the additional income to workers and from the supply of a large part of the materials and equipment needed by the project.

The average payroll of workers employed by construction of the facility is shown as follows:

1st through 6th month: $611,700 per month
7th through 12th month: $286,700 per month
13th through 18th month: $244,000 per month
19th through 42nd month: $127,000 per month

During the second and third months of construction when pipelines are being laid, the payroll will reach a peak of $1,160,000 per month. The payroll levels are based on an asssumed average wage of $2,000 per month.

The total of all expenditures for materials, equipment, and construction services for building the facilities would be approximately $193,900,000 of which over 80 percent, or $160,400,000 would be spent in the region. Because Black

Bayou is halfway between Lake Charles and the Beaumont-Port Arthur-Orange urban complex, the economic multipliers of these two metropolitan centers have been averaged, resulting in a factor of 2.05. Application of the multiplier, based on the assumption that the money spent for the oil storage construction circulates in the area, results in an estimated increase in local earnings of $328,800,000.

Because of the location of the proposed site midway between the urban centers of two economic regions (the BEA area of Lake Charles and the BEA area of Beaumont-Port Arthur-Orange) the increase in local earnings can be expected to be shared by these regions. The increase would constitute a 7 percent gain over the local earnings anticipated for 1980 in the two regions combined. The economic activity induced by the project, if considered to be confined to the standard metropolitan statistical areas within these regions, would amount to a 13 percent increase over the level expected to be reached in 1980.

The anticipated growth in local earnings between 1980 and 1985 is naturally much smaller than the total earnings of 1980. Comparing the additional earnings which would accrue to the two adjacent BEA regions because of the SPR project at Black Bayou, to the anticipated growth in earnings shows that regional growth in earnings would be increased by 39 percent. Growth in earnings of the metropolitan areas would be increased by 65 percent between 1980 and 1985.

C.4.1.8.6 Government Revenues

In the event that the Black Bayou dome is chosen for an oil storage site, there would be some impacts on local government revenues. Apart from expenses incurred in arranging transportation facilities across the Intracoastal Waterway so that workers could travel to and from the site more easily, there would be no appreciable cost to Cameron and Calcasieu Parishes. There would be a loss of revenue associated with the transfer of property at the dome to Federal ownership since Federal lands are exempt from property tax.

On the whole, local governments would benefit from the increase in general economic activity derived as a secondary effect of the construction work. While it would be conjectural to estimate the amount of governmental revenue resulting from such activity, the taxes from workers' spending, which constitutes a part of that activity, can be estimated. Following the assumptions used for the West Hackberry estimates, that approximately 20 percent of each worker's wages are withheld for Federal income taxes and that 6 percent of the remainder is saved, state sales taxes would apply to the spending of the balance of the remainder. In both Louisiana and Texas, a 5 percent sales tax would apply to most items. Such taxes on workers wages would contribute about $203,000 in the first year, $84,000 in the second year, $29,000 in the third year, and $14,000 in the remaining six months of construction. This revenue would be divided between Louisiana and Texas depending primarily on the residence of the workers.

C.4.2 Impact from Operation

C.4.2.1 Land Features

C.4.2.1.1 Geomorphology

Operation and maintenance activities would have no impact on geomorphology (topography, drainage) at the Black Bayou storage site or along the oil or brine pipeline routes. Maintenance dredging at the barge dock at the storage site would be required, this would alter the bathmetry at the docks, and alter the topography at the spoil disposal site. Disposal of the spoil material would result in minor geomorphic alteration in the disposal area.

C.4.2.1.2 Soils

Routine operation and maintenance is not expected to result in any impacts to soil characteristics at the storage site, along either the oil or brine disposal pipeline routes, or at the terminal and dock facilities. Accidental spills of oil or brine could however result in the impact that soil in contact with oil would be incapable of supporting vegetation (See discussion of oil spills in Section C.2.1).

C.4.2.1.3 Stratigraphy, Geologic Structure, and Mineral Resources

No impact on the stratigraphy, geologic structure or oil production on the flanks of the dome is expected to occur during normal operation and maintenance activities.

Future salt production in the area of the new storage caverns would not be compatible with the SPR program. Also, sulphur (if any exists in the cap rock above the expansion site) could not be mined.

C.4.2.2 Water

The operation and maintenance of the Black Bayou facility would produce certain impacts on the water environment. Subsequent discussion dealing with these impacts is organized in two parts as follows:

Surface Water

Subsurface Water

C.4.2.2.1 Surface Water

The impacts on the surface water system in the vicinity of Black Bayou can be summarized as follows:

	Change in	
Operation or Maintenance Activity	Water Supply	Water Quality
Withdrawal of Displacement Water	X	X
Disposal of Brine		X
Disc harge of Treated Ballast Water		X
Miscellaneous Maintenance Activities		X

Withdrawal of Displacement Water from Black Bayou

The rate of withdrawal of displacement water would be almost identical to the withdrawal for leaching discussed earlier. The withdrawal rate of 1.05 x 10^6 bpd or 30,680 gpm is only slightly larger than the withdrawal rate for the leaching operation. If Black Bayou were completely isolated from all other water bodies, such a withdrawal rate would lower the water level at a rate of .351 ft/day. Because the bayou is connected with the ICW and the Sabine River, the actual rate of all of water level would be substantially reduced. As indicated in Figure C.4-1, induced currents would serve to replenish the water withdrawn from the bayou.

In order to predict the impact of the withdrawal process for displacement water on the surface water system a numerical solution of the equations governing the flow of water in an estuarine system must be obtained. The MIT Water Quality Network Model (Harleman et al, 1976), which is described in Appendix D.14, has been used for this purpose.

Based on the model results presented in Section C.4.2.2.1, and in Appendix D.18, the withdrawal of leaching water would depress the level of Black Bayou in the vicinity of the withdrawal point approximately .06 feet. Induced flow effects in Black Bayou would produce current changes of approximately .15 ft/sec while in Black Bayou Cutoff such changes would amount to approximately

.08 ft/sec. In the vicinity of the withdrawal point, the salinity in Black Bayou would increase less than 1 ppt during the withdrawal process. A decrease in salinity in Black Bayou Cutoff would be expected. In general, Black Bayou and Right Prong would experience an increase in salinity due to more salty water being drawn from the East Pass of the Sabine River. The maximum increase in salinity in these water bodies would be less than 2.5 ppt.

None of the impacts resulting from the withdrawal of leaching water under normal environmental conditions appear significant.

Withdrawal of Displacement Water from Sabine Lake

The Calcasieu Ship Channel has been proposed as an alternate source of displacement water for the Black Bayou site. In order to predict the impact of the withdrawal process for displacement water, a numerical solution of the equations governing the flow of water in an estuarine sytem has been obtained using the MIT Water Quality Network Model (Harleman, 1976), which is described in Appendix D.14. The detailed results generated by the model are presented in Appendix D.19. These results indicate that under normal environmental conditions the surface height of Sabine Lake in the vicinity of the withdrawal point would not be depressed a measurable amount during the withdrawal process. The salinity in the vicinity of the withdrawal point would decrease less than 0.5 ppt. Throughout most of the lake, changes in tidal or river currents would not be measurable.

Brine Disposal

During the refill process at Black Bayou 165 ppt brine would be discharged at a rate of 175,000 bpd or 5100 gpm for a period of 857 days. C urrent design calls for the disposal of the brine by means of discharge into the Gulf of Mexico, using the same brine disposal system as used during the leaching operation. The general disposal area in the Gulf is indicated in Figure C.4.-3. The impact of brine disposal during refill would be similar to that occurring during leaching. Because the rate of discharge is smaller during refill the size of the brine plume would be smaller than that produced during leaching.

C.4.2.3 Air Quality

C.4.2.3.1 Sources of Emissions

The emission sources at Black Bayou from operational activities include (1) the offloading of crude oil from tankers at Sun Terminal during fill, (2) the loading of oil onto tankers during withdrawal, and (3) the emissions from dissolved hydrocarbons which are present in the brine discharged during oil refill. A detailed discussion of emission rates associated with each source is contained in Section C.3.2.3.1. Short- and long-term emission rates at Black Bayou are listed in Appendix E for those sources included in the modeling analysis while annual tonnage emission rates are presented for all sources in Table C.4-3. An elevation of the emissions from brine appears in Appendix N.

C.4.2.3.2 Air Quality Impact

This section discusses the results of the modeling analysis conducted for each significant source at Black Bayou during the operational phase. Detailed descriptions of operational activities and modeling approaches are contained in Section C.3.2.3.2.

Short-term modeling calculations have been performed for project hydrocarbon emissions at both the dome and terminal sites. The calculations are based upon concomitant emissions at each location from all sources including tankers, tanks and pump houses. In addition, two separate scenarios were modeled at the Sun Terminal to handle both ship loading and unloading phases. The results of the modeling analyses are contained in Figures C.4-9 and C.4-10. At the dome site, short-term NMHC ground level concentrations would exceed the three-hour standard 0.5 KM downwind from the brine holding pond during oil refill due to release of dissolved hydrocarbons in the brine (See Appendix N). This would be a localized air quality problem and would be confined within the site boundaries. However, during tanker loading and unloading operations at the Sun Terminal, the standard would be exceeded. Figure 1 indicates that during tanker loading during the distribution phase, the three-hour NMHC standard would be violated 1 percent or more of the time annually out to downwind distances in excess of twenty-five kilometers. The maximum impact would occur to the west of the terminal, where violations of the standard would occur five or more percent of the time annually out to a downwind distance of approximately ten kilometers. During ship ballasting operations following the completion of tanker unloading, Figure C.4-10 indicates that the applicable standard would be exceeded out to a downwind distance of approximately twenty kilometers with the maximum impact occurring west of the facility where the frequency of violation is in excess of 2.5 percent annually. The calculations are conservative in that they do not include the minor additional dilution attributable to structural wake effect.

Table C.4-3 Annual Tonnage Emission Rates for Development of Black Bayou to 150 mmb

Source or Activity	Annual Emissions (Tons)				
	HC	Particulate	SO_x	NO_x	CO
Site					
Brine Ponds*	210				
Valves & Seals	5.9				
20,000 bbl (standing loss)	0.5				
Surge Tanks** (working loss)	47.3+				
3,000 bbl Blanket Oil Tank	0.1				
Total	263.8				
Terminal - Fill Phase					
Surge (standing loss)	10.7				
Tank** (working loss)	10.8				
Valves and Seals	3.2				
Tanker Ballasting	112.5				
Tanker Engine	4.4	32.1	445.4	144.8	2.7
Tug Engine	2.4	5.4	2.2	3.7	3.2
Total	144.0	37.5	447.6	148.5	5.9
Terminal - Withdrawal Phase					
Tanker Loading	1040				
Surge Tanks (standing loss)	10.7				
Tanks** (working loss)	25.5				
Ballast Treat (standing loss)	3.6				
ment Tanks** (working loss)	5.2				
Valves and Seals	3.2				
Tanker Engine	1.7	12.2	169.1	54.8	1.0
Tug Engine	2.4	5.4	2.2	3.7	3.2
Total	1092.4	17.6	171.3	58.5	4.2

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*Fill Phase Only: the values are the maximum predicted at any time during use. The initial fill is expected to be only a small fraction of this amount.

**Working losses interact with the standing storage losses, such that the resultant emission is less than the sum of these values.

+Emissions in fill phase.

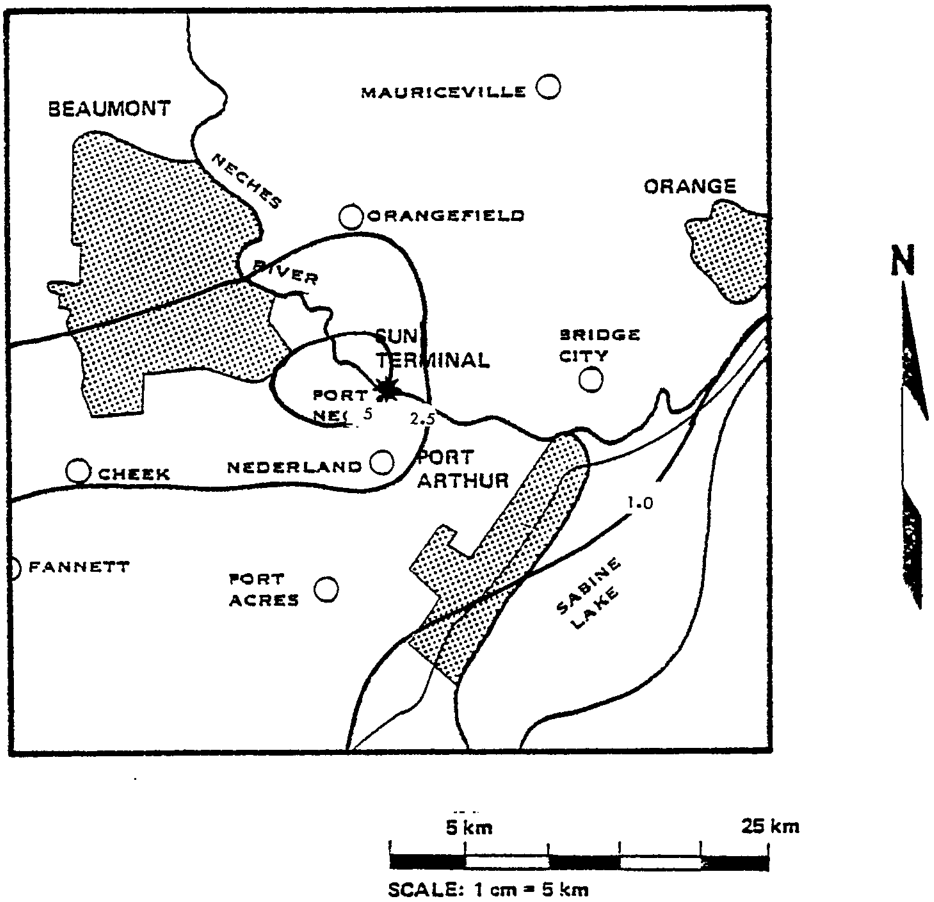

Figure C.4-9 Annual Frequency of Occurrence (%) of Violations of the 3-hour NMHC Standard at the Sun Terminal for Tanker Loading During the Operational Phase at Black Bayou.

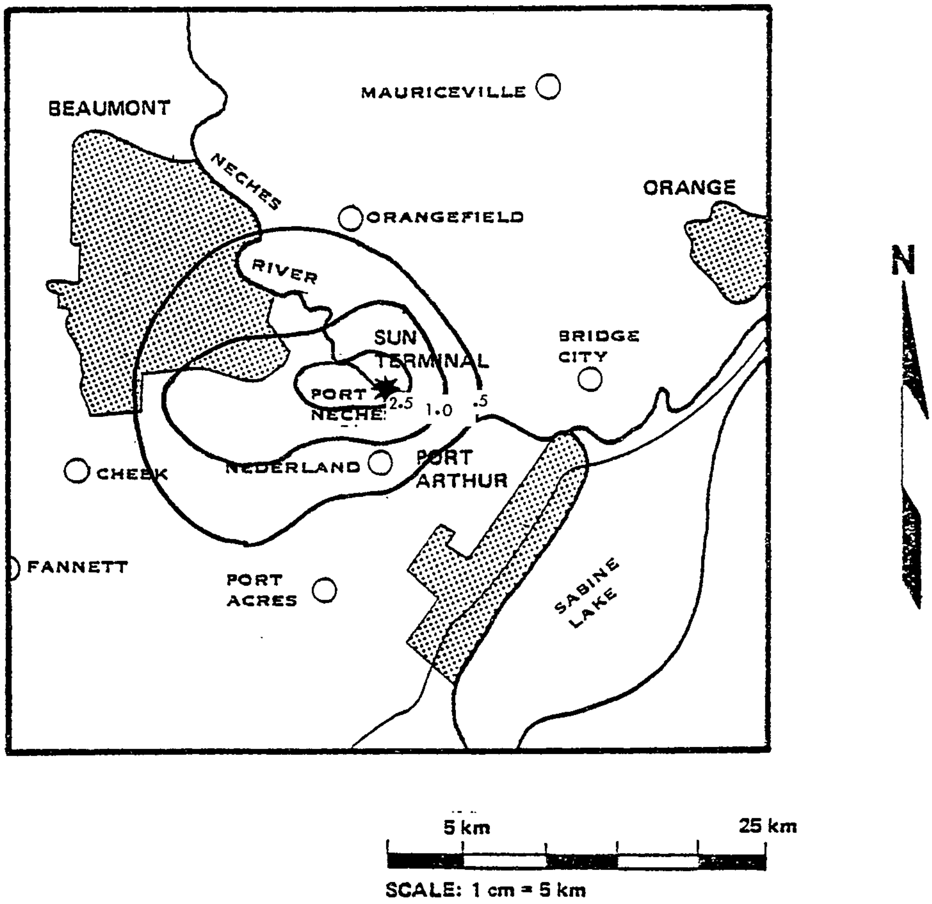

Figure C.4-10 Annual Frequency of Occurrence (%) of Violations of the 3-hour NMHC Standard at the Sun Terminal for Tanker Ballasting During the Operational Phase at Black Bayou.

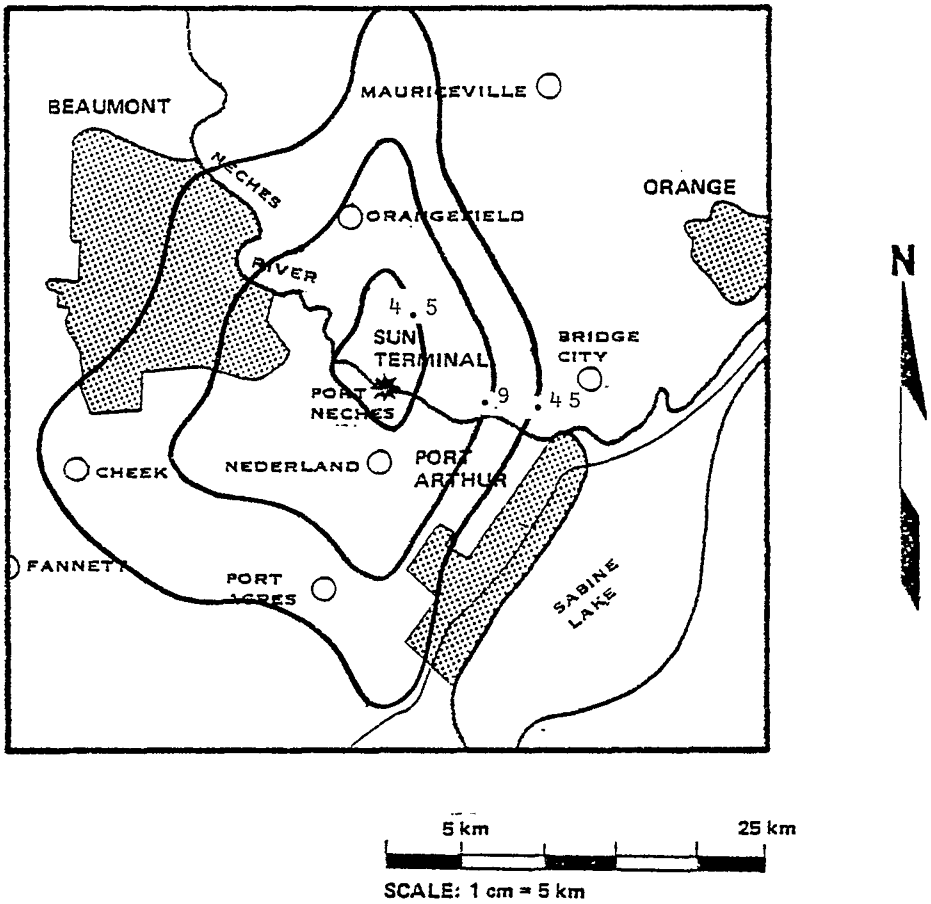

Figure C.4-11 Annual Average NMHC Ground Level Concentrations ($\mu g/m^3$) at the Sun Terminal During the Operational Phase at Black Bayou

Annual NMHC ground level concentrations from various activities have also been calculated for the dome and terminal sites. Figure C.4-11 provides the results of this analysis for the Sun Terminal. This calculation is based upon the conservative assumption that both the fill and drawdown phases could occur, at least in part, during the same annual period. The results of the calculation indicate that annual ground level concentrations would be generally less than $4.5\mu g/m^3$. Similar calculations were performed for the dome site and are presented in Figure C.4-12. Annual NMHC concentrations would be generally less than $0.45\mu g/m^3$ downwind of the dome site sources.

In summary of the air quality impact, the Black Bayou dome and Sun Terminal facilities would be significant sources of NMHC, and to a lesser extent, combustion contaminants. Violations of the three-hour standard for NMHC are predicted on site for the dome facility and downwind of the Sun Terminal facility. Tanker loading and ballasting emissions dominate the site emission levels as it is unlikely that the other sources would independently violate thw NMHC standard outside plant site boundaries. The use of efficient vapor control technology in conjunction with shipboard activities would significantly reduce the impact of the terminal facility on regional ambient air quality. However, in present form, the level of hydrocarbon emissions at the Sun Terminal is probably insufficient to have an important impact on regional levels of photochemical oxidant. The annual tonnage emission rate for the Black Bayou development is relatively small in comparison to regional hydrocarbon emission levels in this region of heavy petrochemical activity. The facility would not result in violations of air quality standards for other contaminants.

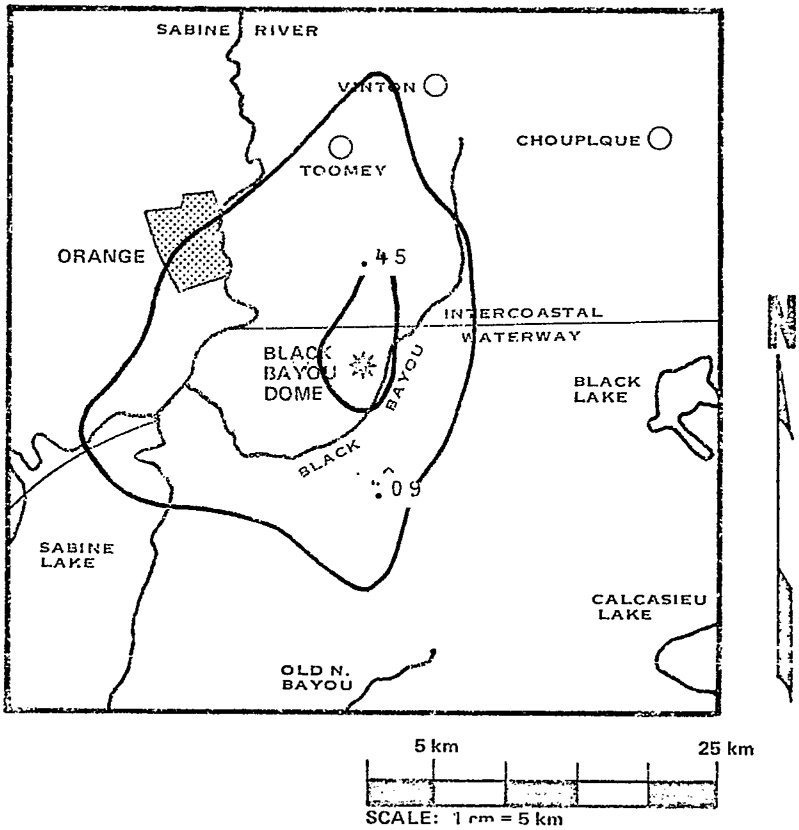

Figure C.4-12 Annual Average NMHC Ground Level Concentrations ($\mu g/m^3$) at the Dome Site During the Operational Phase at Black Bayou.

C.4.2.4 Noise

During operations at the storage site, the primary noise generation would be from pumps associated with the fill and discharge operations which are located in pump houses on the Black Bayou site. Fill operations are planned to take place over a 32 month period. The first 18 months at a rate of 175,000 barrels/day; the remaining 14 months at a fill rate of 131,000 barrels/day. During a national supply interruption, oil would be withdrawn over a period of 150 days. A total of 5 fill/discharge cycles are planned for the life of the facility.

The analysis of pump noise for a site of similar operation and ambient levels, West Hackberry Site (Ref. Final Impact Statement - West Hackberry Salt Dome), estimated increase noise levels at the site perimeter of no more than 3 dB during the period of operation.

Some increase in terminal and tanker operations can be expected at the Sun Terminal on the Neches River. It is estimated that during fill/discharge operations tanker loading and unloading would increase 20 percent. The major noise associated with the operations will be from tanker traffic, tanker pumps discharging crude oil, tanker loading pumps, and pipe transfer pumps.

The pumps for both tanker loading and pipeline transfer to the storage area will be electrically powered and would be housed in a pump house on the terminal site. Additional noise from the increase in diesel engines powering the tankers and tanker discharge pumps operation will contribute negligibly to existing ambient levels.

Summary of Noise Impacts

During fill and/or discharge operations, there would be noise generated from the continuous operation of pumps at both the storage and terminal facilities. The noise is expected to be continuous day and night during these operations, however, since the pumps at both the storage and terminal facility would be enclosed in pumphouses, it is anticipated that there will be a negligible impact on existing ambient levels in the vicinity of these facilities from operations.

C.4.2.5 Species and Ecosystems

C.4.2.5.1 Displacement/Leaching Water System Impacts

The largest impact on biota of withdrawal of leaching and displacement water from the Black Bayou channel would result from entrainment of organisms and nutrients (being taken in along with the water). There would also be significant impacts from lateral displacement in the connected water bodies. Much smaller, probably negligible impacts would result from impingement of organisms (entrapment against the intake screens). Impacts from lowering the local surface water level would probably be small. The local surface water is an extensive shallow water system which would be very sensitive to change in the water level; however, replenishment of the water losses from the system would be rapid enough so that any lowering at all would be difficult to demonstrate. This is especially true since water is moved into and out of the system on a large scale by tides. Whether new pollutants would be introduced in the water which replaced that which would be withdrawn cannot be determined with available data.

Impacts from withdrawal of water for leaching would overlap those from increases in suspended sediments resulting from construction (25 months assumed) during twenty months and there would be no overlap for eighteen months. The ratio of water withdrawn during the overlap period to that in the area of impact from construction, assuming a water depth in this latter area of one meter, is estimated at about 160 to 1. Standing crops are relatively small and production rates and turnover times are high among plankters. It would take an estimated 3.75 days to replace the water volume which was exposed to continuing high suspended solid levels during the period of overlapping impacts from withdrawal of leaching water and construction. Average turnover time for the plankton community probably is greater than 3.75 days. There would also be indeterminate losses of production along with the standing crop losses resulting from entrainment. Nutrients would also be entrained and lost, but no measurement of nutrient levels are available for the area. The direct effects on plankton from leaching water withdrawal would be expected to exceed and include those from construction during the period of overlapping impacts. The water withdrawn during the twenty months of overlap would probably not entrain all of the suspended sediment being generated on site at the same time since tidal currents would distribute the sediment irregularly. Impacts would occur to plankton from construction alone during five months, but would be overridden by entrainment impacts subsequently. Impacts from construction on the site would affect nekton, benthos, and wildlife, both before and during the first twenty months of leaching. Gross primary production by phytoplankton represents about 46 percent of the total in open estuarine water areas studied by Day et al. (1973). Zooplankton food use accounts for about 12 percent of the total food used by bacteria and animals. More than 15,251,140 x 10^6 phytoplankters and more than 422,509 x 10^6 zooplankters would be lost, based on U. S. Army Corps of Engineer's phytoplankton and zooplankton densities determined for the ICW in the Black Bayou area. These values are quite low since nets with a relatively coarse mesh were used. If smaller forms were present, they were largely missed. The densities which might have been determined with finer nets could have been double what were obtained or even greater. The additional biomass which would have been obtained with finer nets probably would not have been more than double that obtained with the coarse nets. It is estimated that during each displacement, more than 2,036,156 x 10^6 phytoplankters and more than 56,409 x 10^6 zooplankters could be killed. Large numbers of microorganisms and large amounts of organic and inorganic nutrients would also be lost from the aquatic system in the area during and because of leaching and displacement.

Zooplankton present in the ICW near Black Bayou include: copepods, cladocera, rotifers, ostracods, and miscellaneous forms according to U. S. Army Corps of Engineers determinations (1975). Copepods present include Eurytemora affinis, Diaptomus sp., and Eucyclops agilis. The Cladocera include Bosmina coregoni, Daphnia pulex, Chydorus sphaericus, Alona monacantha, Eurycercus lamellatus, and unidentified species. The rotifers include Brachionus bidentata, Keratella cochlearis, Asplanchna sp., Lecane luna, and an unidentified species. Phytoplankton present include diatoms, blue-green algae, green algae, and yellow-green algae. The diatoms include Navicula spp., Cyclotella, sp., Melosira granulata, small unknown pennates, Nitzschia senata, Melosira varians, and Synedra ulna. The blue-greens include Anabaena sp., Chroococcus sp., and Nostoc sp. The green algae is Shroderia setigera and the yellow-green (Chysophyceae) is Dinobryon sp.

Production losses resulting from withdrawal of organisms along with the displacement and leaching water would occur out of time phase since the organisms responsible for production would be withdrawn progressively over long time intervals. Entrainment of plankton determined by withdrawal rates would occur continuously during leaching and oil displacements. Production losses caused by lateral displacement of small mobile and non-mobile organisms into new environmental settings and conditions presumably would be diffused into a large surrounding area. Since such impacts would be diffused, they would be difficult to demonstrate. Nonetheless, they may be important when taken altogether.

A further consideration is that meroplankton* passing into the Black Bayou aquatic system would probably be withdrawn with leaching and displacement water. This could result in a reduction in fish and shellfish in the area. This impact cannot be estimated, since there are no quantitative data for the area available on such migration or on the postlarval stages of these animals.

As discussed in Section 4.4.1.2.1, salinity changes could be induced during leaching/displacement water withdrawal. The prevailing freshwater inflows into the surface water system are assumed to be from the dry land and fresh marsh areas nearby, and the Sabine River flow to the west, to which the area is connected by the ICW. The slightly brackish to freshwater area at the site would be mainly resupplied from the ICW during summer low flow in the Calcasieu River as the surrounding water was progressively withdrawn, and this water was replaced. Since the area is tidal such flows would not be continuous, but would be net effects. Salinity at the surface in the Sabine River somewhat above its intersection with the ICW attains high values (20 ppt) but more often is very low (fresh). The condition here is assumed to be similar to that in the Black Bayou vicinity with a smaller range of fluctuations occurring at Black Bayou. Salinities may be increased slightly by water withdrawal during leaching and displacement during periods of small tidal amplitude when there is low freshwater flow. When the tides are stronger, they would be the dominating factor regardless of withdrawal if freshwater inflow levels were low. When freshwater inflow levels were higher, however, freshwater would replace the freshwater which was withdrawn. Because of the movement of such large masses of water within the Black Bayou associated system, withdrawal of water should have little accumulative impact on salinity levels. Consideration of the normal salinities in the Sabine River near its junction with the ICW, and the normal tidal regime suggests that increased salinity would not be increased by more than two or three parts per thousand for more than a week under ordinary limiting conditions. However, any such increases would have an impact in other areas as well as Black Bayou since the water would have a certain residence time in the estuary.

Occasional salinity increases on the order of and for the suggested maximum interval given above probably would not be injurious to most benthos, nekton and rooted marsh plants in the area. However, functioning of the organisms most sensitive to salinity would be impaired temporarily. Such organisms would recover if not stressed for too long.

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*Meroplankton - Animals which are adapted to planktonic existence only during the first stages of their life cycles.

If induced salinity increases occurred with great enough frequency, species composition and community productivity would probably be altered. Planktonic organisums would be transported with the water they are in and presumably would not be subjected to as rapid a change in salinity as other organisms.

Water quality in the ICW is degraded by high levels of phosphorous, pesticides, arsenic, mercury, and oil and grease. Cadmium, mercury, zinc, and copper are at high levels, compared to recommended EPA criteria, in the Sabine River. Such pollutants would be introduced into the Black Bayou system along with replenishment water during water withdrawal resulting from leaching and oil displacement. Most of these contaminants are toxic materials which would stress the aquatic and marsh biota in the area. Phosphorous is a nutrient which could stimulate excessive plant growth. This could reduce ecological balance in the biological communities of the area ecosystems; that is, it could promote development of an increased biomass but with a reduction in the number of important species, leading to a simpler biological system.

Mercury and hydrocarbon pesticides can be concentrated through food chains. The potential may be present for commercially important animals as well as other animals to accumulate such materials to a significant extent.

The biota of the Black Bayou site is generally typical of the coastal waters of the northern Gulf of Mexico at the 30-foot contour interval. This is particularly true of the phytoplankton, zooplankton and demersal nekton communities whose species compositons are readily comparable to those found along the Louisiana-Texas coastline. Standing crops for these communities are also roughly comparable to those elsewhere in this region. The benthic community on the other hand is dominated by a limited number of species most of which are typical of degraded conditions such as associated with oil spillage. A significant finding is that standing crop for the benthic community is low.

The phytoplanktonic community is dominated by a mixture estuarine and marine diatoms. This probably reflects the mixing of estuarine waters from Calcasieu Pass with offshore marine waters. Species composition varies dramatically from month to month but *Skeletonema*, *Coscinodiscus centralis*, *Biddulphia* spp. *Rhizosolenia imbricata*, *R. robusta*, *Chaeotoceros currisetum*, and *C. affine* are typical dominants. Interestingly September and December were wholly dominated by just one or two species (particularly *Skeletonema*) while October and November showed a diverse, equitably distributed species composition. Dinoflagellate numbers, as expected, were low for this time of year.

The zooplankton at Black Bayou brine disposal site, as with the other disposal areas studied during September through December, 1977, had many copepods as its main dominants. Acartia (a calanoid), calanoid sp. 1, calanoid sp. 3, nauplii (larvae), Corycaeus (a cyclopoid), Euterpina (a Harpacticoid), Okopleura (a tunicate), Oithona (a cyclopoid), and Temora were among these dominants. This location is of high quality with respect to zooplankton abundance, with the abundances being of a similar order of magnitude to average combined densities at West Hackberry and Big Hill.

The species composition of the nekton community is fairly constant from month to month, and is typical of Louisiana-Texas coastal waters. Standing crop varies markedly from month to month, but these fluctuations appear to be driven by random variation in the populations of the top dominant species, Acetes americanus, a sergestid shrimp, and Anchoa mitchilli, the Bay Anchovy. An influx of species during November probably reflects the fall offshore migration of estuarine summering forms.

The benthic community is almost wholly dominated by either the marine worm (polychaete) Magelona sp. (October, November, December) or the clam Mullinia lateralis (September). In both cases the second ranked species was only about half as abundant as the top dominant. Such a community structure is typical of environmentally degraded conditions. This is supported by the remarkably low standing crop in the benthic community. Both Mullinia and Magelona are known to be indicator species for degraded environments.

The most severely impacted region would be that nearest the diffuser port where highest salinities overages would be encountered. Based on MIT transient plume model, utilizing limited real world current observations for the Black Bayou site, for typical current regimes no more than 104 acres would be enclosed by the 3 ppt excess salinity isohaline. If total mortality within this region is assumed, about 1.3 x 10^6 benthic individuals/acre would be eliminated. In the context of the broadly distributed nearshore benthic community, this is not a significant impact. Beyond the 3 ppt isohaline brine impacts on the benthic community would be expected to be minimal. However, it should be pointed out that persistent exposure of the sediments to even very dilute brine may result in uptake of various heavy metal species. This would result in elevated mortalities beyond the near field. Inasmuch as the planktonic and demersal organisms are either quickly carried through the diffuser site, or can otherwise avoid this region, impacts on these communities would be slight.

C.4.2.5.2 Brine Disposal System Impacts

Impacts on biota from operation of the brine disposal system would be essentially the same as those described in connection with brine disposal at West Hackberry. These impacts are discussed in Section C.3.2.5.2.

C.4.2.5.3 Impacts at the Storage Location

Impacts to biota from activities which would occur onsite during the operations phase of the storage facility would occur on only a small scale. During filling or displacement, machinery noise and road traffic would increase. Some of the animals initially disturbed in the area by these changes would adjust after a certain period. Air pollutants would be increased slightly, and waste materials and chemicals used in pest control could become small sources of water pollutants. Most release of contaminants into water could easily be controlled.

C.4.2.5.4 Oil Distribution System Impacts

As previously indicated, generic principles of oil spill effects on biota are discussed in Appendix H. Because much of the crude oil pipeline route for the Black Bayou site would be common to the West Hackberry pipeline route, only those impacts which might result from a break in the connector line or are otherwise germane to the Black Bayou site are considered. Potential impacts associated with the common segment of the crude pipeline are not repeated here.

Shell Oil Company is actively drilling for oil off the flanks of the salt dome and has been removing oil from this site for several years. Activities such as canal construction, road and building construction, well pad siting and other activities have undoubtedly altered the biological character of the Black Bayou site. However, wildlife is very abundant on and near the site, and the marshes appear to be prime wildlife habitat. Alligators line the canal and bayous adjacent to the site, and waterfowl are especially abundant and diverse.

Because of the location of the pipeline, an oil spill from the crude oil connector line would form a slick on the surface waters of Black Bayou Cutoff, Black Bayou, and possibly in the canals associated with Black Bayou. Oil would very easily and rapidly be carried into the marshes where recovery is more difficult than on open water. Assuming an oil holding capacity* of marshland of 25 barrels of oil per acre, it is obvious that several acres of marsh could be contaminated (depending on the amount of oil spilled). A 1,000 bbl spill would, based on this assumption, cover 40 acres of marsh. Dimished vegetation and pollution of surface waters would significantly degrade the habitat of wildlife such as nutria, muskrat, mink and beaver and waterfowl (herons, egrets, ibises, and gallinules). The shoots of marsh vegetation would be killed or damaged by being coated with oil. Benthic organisms would also be killed or damaged if contacted by the oil. Effects are expected to be relatively short term with recovery of vegetation starting within a month and wildlife habitat restored, assuming proper cleanup procedures are employed, within one to two years.

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*oil-holding capacity - the ability of soils to absorb oil for a period of time.

C.4.2.6 Natural and Scenic Resources

Normal operation and maintenance of the Black Bayou facility is not considered to have an adverse impact on the Sabine National Wildlife Refuge. In the case of a break in the brine-line during operation, the resulting brine spill could have a significant impact on the scenic and natural resource values of a localized area of the refuge. Changes in the salinity of aquatic systems due to an accidental release could significantly limit vegetation. This vegetation loss would in turn dramatically reduce both the number and variety of animals in the vicinity of the release. This would result not only in a decrease in the scenic value of an area, but also more importantly it would do harm to the natural resource values as discussed in Section C.4.2.5.2.

C.4.2.7 Archaeological, Historical, and Cultural Resources

Three archaeological sites have been found in the vicinity of the Black Bayou brine pipeline, two of which would require additional study if Black Bayou were to be developed. If the Black Bayou site were chosen as an ESR facility, a more intensive archaeological survey would be initiated which would comply with the National Historical Preservation Act of 1966 and Executive Order 11593.

C.4.2.8 Socioeconomic Impacts

C.4.2.8.1 Employment

The operation of the storage facilities would employ about 20 workers at the site. Some would be skilled craftsmen such as mechanics, electricians, and instrument men. Others would do the maintenance work around the site and keep records of the work being done. Pumps would be tested periodically, and the pipeline right-of-way would be inspected from the air to detect any evidence of damage.

There would be workers at the site on a 24-hour basis, working in shifts.

C.4.2.8.2 Land Use

The Black Bayou salt dome lies in a remote section of Cameron Parish. The ground surface of the dome and the surrounding land are marshes. Although the site is nineteen miles inland from the Gulf of Mexico, it is considered to be in a flood hazard area. The site access road is reached via a parish road which ends three to four miles past its junction with the access road.

These factors indicate that the current land use patterns of the lands around the site are not likely to change during the life of the project. The future land use plans developed for Southwest Louisiana by the Imperial Calcasieu Regional Planning and Development Commission show the site and adjacent areas designated as being used for industrial purposes, a category which includes mineral extraction. The use of the land for the proposed oil storage facility would conform to this plan. Coastal zone management plans are being developed by the Louisiana State Planning Office, but specific regulations governing development in this area have not been formulated. Although Calcasieu Parish, which lies just north of Cameron Parish, has authority to pass zoning restrictions on development outside of city limits, such power has not been delegated to Cameron Parish.

In the event that part of the Gum Cove ridge, which is located five miles east of the site, were selected as a recreational park, the presence of the storage facility would not interfere with the aesthetic value of the park.

C.4.2.8.3 Traffic

During the operation of the storage facility, workers traveling to and from the site would constitute the major impact on roadway traffic. The portion of Route 108 leading south from Vinton would have an average daily traffic flow about 22 percent higher than that recorded in 1971, and the Gum Cove Road traffic flow would be 29 percent higher.

During a period when oil is withdrawn from the storage caverns, tankers normally used to bring foreign oil to refineries in the Beaumont and Port Arthur area would be diverted to distribute oil from the Black Bayou dome. The impact on tanker traffic along the Sabine-Neches Waterway would be insignificant.

Refilling the caverns at Black Bayou, however, will increase traffic on the waterway. The period of refill for Black Bayou alone would be only twenty-eight to thirty months, but the Early Storage Reserve caverns at West Hackberry, which holds sixty million barrels, would be filled, extending the period of increase to forty months. Tanker traffic along the Sabine Pass and at Port Arthur would be increased by 12 percent, and such traffic on the Neches River would be increased by 23 percent.

C.4.2.8.4 Housing and Public Services

Some of the workers who moved into the region to take jobs during the construction of the project can be expected to move out again when the construction is complete. This situation would probably have no noticeable effect in Lake Charles, Orange, and Sulphur where the availability of housing was altered by only one percent or less when workers moved in. Effects would be greater in Vinton because of the smaller scale of the housing market.

It can be expected that some workers who were employed in the leaching of the caverns and in maintenance of the facility during the 3 to 4 years of construction would be retained during the standby phase of operations. Because of their more permanent status, however, they would be purchasing and building homes for themselves and their families. Most of the workers employed at the site during the operation phase would live in Vinton, the urban center closest to the site, although it is about twenty miles away.

Assuming the average size of a worker's family was four, and that all 20 workers employed during operations were new residents of the town, the incremental increase in the population of the town over the 1980 projected population of 4,300 would be less than 2 percent. The increased need for public services to accommodate these workers and their families would be very small.

C.4.2.8.5 Economy

Economic impacts during the storage phase of the Black Bayou facility would be on a scale similar to a small business enterprize. There would be expenditures for payroll, supplies and parts, transportation and contingencies. Payroll would amount to about $45,000 per month of a total expenditure of $125,000 per month.

Assuming that the total amount contributes indirectly to further economic activity, the economic multiplier (2.05) can be applied. The product would be an increase in local earnings of $3,075,000. This represents a gain of less than one percent over the anticipated 1985 level of earnings for the Lake Charles and Beaumont-Port Arthur-Orange standard metropolitan statistical areas.

During a period of oil withdrawal, the additional workers required and the increased power costs for pumping oil would raise the site expenditures to a level of about $520,000 per month. This amount would be spent for the duration of the interruption in foreign oil supplies or up to five months.

After the supply interruption, the caverns would be refilled at a cost that lies between the normal standby level and the oil withdrawal level, and would probably be approximately $250,000 per month. This does not include the cost of the oil itself.

The use of Black Bayou as a storage site would primarily benefit the town of Vinton. It is there that many of the workers would live during the operational phase, because it is the closest town. Vinton is about twenty miles from the site, and the trip is slowed by having to use the ferry to cross the Intracoastal Waterway, and by the condition of the road that stretches for about five miles along the Bancroft Canal.

C.4.2.8.6 Government Revenues

In general terms, the storage project by itself would not generate revenues for the local governments. The site would not be taxed, nor would the capital improvements on the site. Most of the oil companies who would be buying the oil from the Federal government during an emergency that required its withdrawal from storage, would be registered wholesalers, and the sale of the oil would be exempt from local sales tax.

There would be gains in local government revenues derived from the secondary economic effects. The major portion of this would be from the increase in local earnings. Revenues from sales tax alone, applied to the spending of wages of workers employed permanently at the site, would amount to a contribution of about $20,000 per year.

C.4.3 Impact Due to Termination

After termination of the SPR program, should the facility not be used for any other government purposes, the project would be shut down in accordance with applicable laws and regulations. At Black Bayou, the sensitive nature of the site would dictate that environmental concerns associated with marshlands be fully considered prior to termination.

C.4.4 Relationship of the Proposed Action to Land Use Plans, Policies, and Controls

The use of lands for the development of the Black Bayou site as an oil storage facility would involve the participation of several parish, state, and Federal agencies for approvals and permits.

Except for a portion of the oil distribution pipeline that would cross into Calcasieu Parish to intersect the ESR oil distribution pipeline from West Hackberry to Nederland, the Black Bayou facility would lie wholly within Cameron Parish. The parish has authority to restrict construction in flood hazard areas, excavation of canals, and pipeline crossings over parish roads, ditches and waterways. Approval of such activities is forwarded to the U.S. Corps of Engineers which has authority to grant permits for them. Cameron Parish does not have zoning regulations restricting the use of lands needed at the site or along piepline rights-of-way.

Part of the wetlands and all of the offshore land used for the brine disposal pipeline and diffuser are Louisiana state lands. For this reason the Louisiana State Land Office would be consulted regarding the use of rights-of-way across these lands. The pipeline would cross State Highway 82 near the Gulf coast, so the State Highway Department would be consulted regarding the arrangements for laying the pipeline beneath the road bed.

The land use plans for the Black Bayou site, as prepared by the Imperial Calcasieu Regional Planning Commission, indicate no change from current land use patterns through the year 1990. The site is shown on the land use map as an area for mineral extraction, a usage that falls within the category of "Urban and Built-Up" land. Oil and gas production fields are in this category. Usage of the site for oil storage would be compatible with this land use designation.

The brine disposal pipeline would cross the Sabine National Wildlife Refuge. This land is owned by the Federal government. Although an existing right-of-way would be followed, permission to cross the refuge would have to be granted by the U.S. Department of Interior.

The project would require the use of wetlands for pipeline corridors, and would necessitate dredging canals to provide access to wellheads. These activities generally require approval from the Corps of Engineers. It is also the responsibility of the Corps to approve the use of lands where dredge spoil would be deposited.

C.4.5 Summary of Adverse and Beneficial Impacts

Table 5.2-2 in Chapter 5 contains a detailed summary of the adverse and beneficial impacts associated with site preparation and construction at the Black Bayou site. In Section C.3.5 the impacts of the proposed site, West Hackberry, were summarized. Only the major differences between the proposed and the alternate site are discussed here.

The Black Bayou disposal pipeline would traverse the Sabine National Wildlife Refuge and other sensitive marshlands but would be located in a designated pipeline corridor, whereas no such corridor exists at West Hackberry. The location of the offshore diffusors would also be different and impacts would not be identical to the West Hackberry location.

Construction of canals onsite would result in significant local alternations of drainage patterns. The placement of storage wellheads on platforms over the marsh rather than on landfill would reduce the amount of permanent damage to the marshland; however, the resulting absence of containment dikes around the wellheads could pose serious problems in the event of a minor oil leak which would otherwise be contained by dikes. On the other hand, a major spill at the site such as a sheared wellhead would be detrimental to the sensitive marsh environs regardless of whether the wellheads are diked.

Because of the wet nature of the site, dust emissions would be restricted to roads and small fill areas.

Transportation may be a serious problem in that traffic on local roads would be greatly increased and access to the site is limited. Workers would have to cross the ICW via the Gum Cove Ferry to get to the site.

C.5 ALTERNATIVE SITE - VINTON

C.5.1 Impact on Site Preparation and Construction

C.5.1.1 Land Features

C.5.1.1.1 Geomorphology

The well heads for the six proposed storage caverns at Vinton would be located on dry land; therefore, there are no requirements for filling. Also, the roads that would be built for access to the wells would require a minumum of grading and filling. These activities would not have an impact on the land forms at the site.

The construction of the raw water supply system from the Vinton Canal would not result in significant alteration of landforms.

A retention dike would be constructed around surface tanks, the brine pond, and the raw water pond. This would constitute a permanent, though minor, change in topography.

Construction of the oil pipeline from Vinton to the pipeline between the West Hackberry ESR facility and the Sun Terminal at Nederland would have minor temporary impacts to landforms. The pipeline trench would be backfilled to restore original land contours. Little or no impact to drainage patterns is expected.

The brine disposal design specifies that ten injection wells would be used. Six of those wells would require an elevated platform 30 feet square and 8 feet high above the surrounding marsh. No fill is required for these platforms; therefore, there would be no impact on topography. The other 4 wells would require access roads, but since they are located on dry prairie land there would be minimal grading and little or no filling.

Additional construction beyond that discussed for the proposed site is not required at the Sun Terminal for oil distribution from Vinton. Therefore, there would be no additional impacts to landforms or drainage to those already discussed.

C.5.1.1.2 Soils

Only minor impacts to soils would be experienced during the construction of well heads and service roads,and impacts would be confined to the Vinton construction site. On-site pipeline construction would result in mixing of the surface and subsurface layers of the Morey-Beaumont soils present. These soils are poorly drained; therefore, this disturbance would not affect any soil structure critical to drainage.

The construction of dikes, brine pond, and raw water pond would destroy the internal structure of the soil but not change its composition.

The oil distribution pipeline from Vinton is routed along the boundary of marsh and dry land; therefore, there are two soil associations that would be impacted along this route: the Morey-Beaumont and the Harris-fresh water marsh. The impact that would occur would be a mixing of the surface and subsurface layers and destruction of the structure of these two soils, but the impacts would be confined to the pipeline trench.

The brine disposal system would also impact the Morey-Beaumont and the Harris-fresh water marsh soil association. Impacts of pipeline construction on soils would be similar to those discussed above for the oil pipeline.

Construction impacts associated with a new tanker dock at Sun Terminal have already been discussed (Section C.3.1.1) and are not repeated here.

C.5.1.1.3 Stratigraphy, Geologic Structure and Mineral Resources.

There would be no impacts to stratigraphy or geologic structure during construction at the Vinton storage site, along any of the pipeline routes or at the terminal and dock facilities. It is understood that part of one structural/stratigraphic element (the salt dome) would be removed during cavern construction, but this does not alter the description of stratigraphic or structural conditions. Construction activities at the storage site would not have an impact on the availability of oil produced along the flanks of the Vinton dome. No mineral extraction is occurring within the area of the proposed caverns.

C.5.1.2 Water

Site preparation and construction at Vinton would produce certain impacts on the water environment. Subsequent discussion dealing with these impacts is organized in two parts as follows:

- Surface Water
- Subsurface Water

C.5.1.2.1 Surface Water

Each impact on surface water supply or quality can be identified by the activities producing the impact as follows:

Type of Impact	Produced By
Change in Water Supply	Withdrawal of Leaching Water
Change in Water Quality	Withdrawal of Leaching Water
	Dredging Operations
	Grading, Excavation, and Filling
	Miscellaneous Construction Activities

Water Supply

A significant impact on the supply or availability of surface water would result from the withdrawal of water for the leaching operation. The point of withdrawal, as indicated in Figure C.5-1, would be from the Vinton Canal about 1.13 miles east of Ged Lake. The rate of withdrawal would be 3.43×10^5 bpd (barrels per day) or 1.00×10^4 gpm (gallons per minute). The period of withdrawal would extend over 1144 days (38 months).

If Vinton Canal served as the sole source of leaching water, and if the canal were completely isolated from other water bodies the withdrawal rate noted previously would lower the water level of the canal .615 ft/day (as explained in Appendix D.18). Because the canal is connected with the ICW, the actual rate of fall of water would be less than the value noted. As indicated in Figure C.5-1, induced currents would serve to replenish the water withdrawn from the canal. Thus, it can be seen that essentially all replenishment water would come indirectly from the ICW.

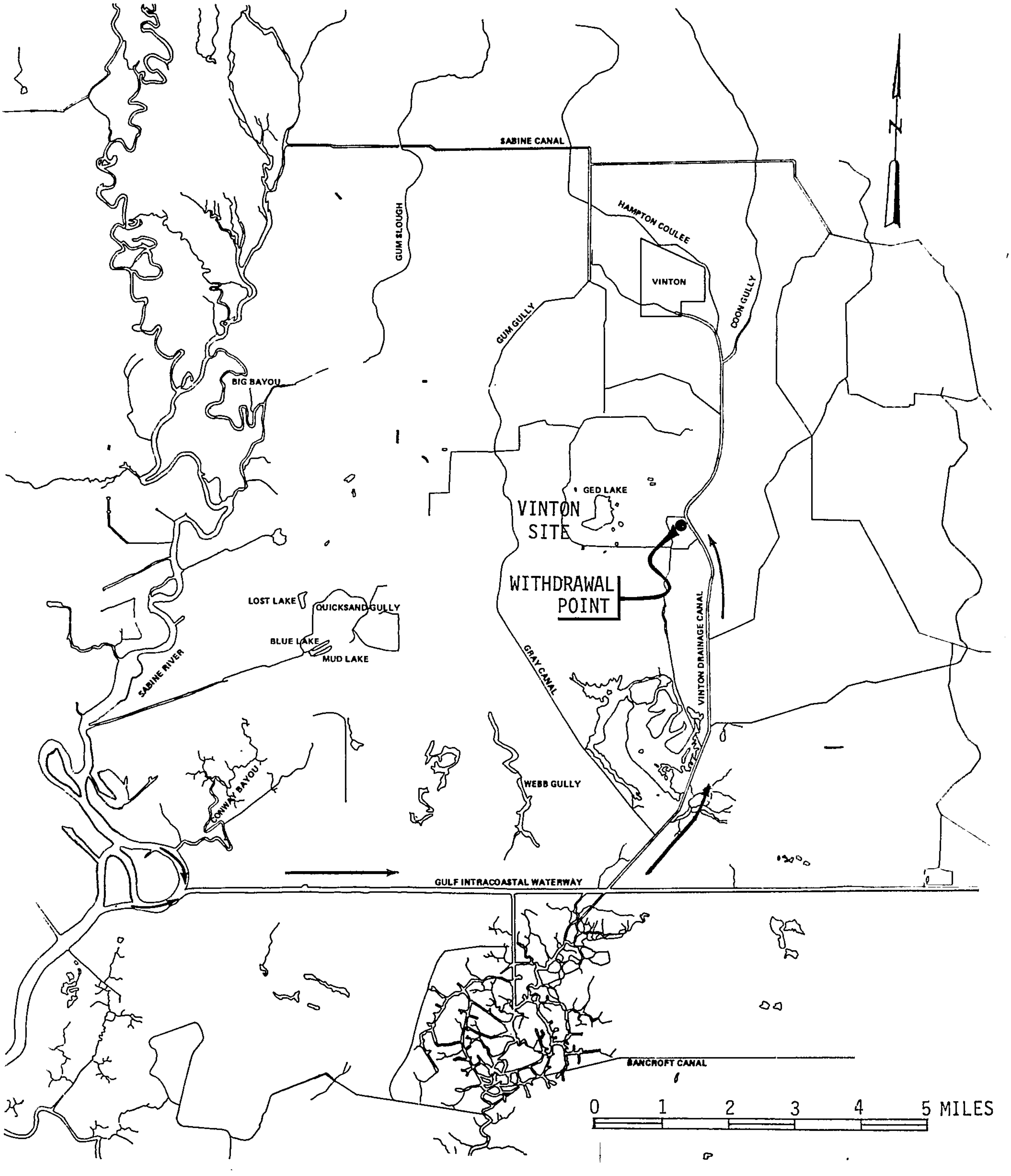

Figure C.5-1 Induced Currents in Surface Water System near Vinton

If all replenishment water comes from the ICW via Vinton Canal under steady-state conditions, a current of 0.0929 ft/sec would be induced in Vinton Canal, flowing northward from the ICW to the withdrawal point. To sustain this current, as explained in Appendix D.18, the water level at the withdrawal point would drop 0.0146 feet below the water level at the junction of the ICW and Vinton Canal. In the segment of the ICW between the Sabine and Calcasieu Rivers, flow is generally from west and east, and it appears that induced flow caused by withdrawal of water in the Vinton Canal would tend to add to the existing flow of the ICW. Replenishment water for the ICW would come primarily from the Sabine River.

Existing flow rates in the ICW are not well-defined. Flow rates in the Sabine River*, however, as reported in Section B.3.1.2.1, ranged from 774 ft^3/sec to 40,700 ft^3/sec during the period October 1974 through September 1975, with a mean value of 14,210 ft^3/sec. The withdrawal rate at Vinton (22.3 ft^3/sec) is less than 3% of the minimum flow in the river.

Water Quality

As noted previously, the surface water system would be affected by four activities as follows:

- Withdrawal of Water for Leaching
- Dredging Operations
- Grading, Excavation, and Filling
- Miscellaneous Construction Activities

Withdrawal of Water for Leaching. The water quality within Vinton Canal is clearly dependent upon the quality of the water entering from the replenishment sources. Water quality for the ICW has been discussed in Section B.3.1.2.1. As indicated in Table B.3-6, near the junction of the Vinton Canal**, the water in the channel exceeded the EPA numerical criteria+ for phosphorus, arsenic, mercury, toxaphene, lindane, heptachlor, aldrin, chlordane, dieldrin, endrin and O,P'-DDT. In addition, the level of oil and grease, heptachlor, epoxide, methoxychlor and DDT compounds appeared to pose a possible problem. If the ICW should be the initial replenishment source for Vinton Canal, any such contaminants in the waterway would be transported into Vinton Canal.

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* At Ruliff, Texas

**The mouth of Black Bayou is located between Sample Station 7 and Mile 16.5 as shown in Figure D.4-1.

+For marine aquatic life - given in Appendix D.3.

Although a numerical salinity value is not available for Vinton Canal, the salinity is thought to be low,as the canal is being used for the commercial harvest of freshwater catfish (Rocca, 1977). Withdrawal of water from the Vinton Canal would tend to increase the salinity by drawing water from the ICW. The effect would be most significant during the dry season.

Dredging Operations. The dredging would not involve crossings of any navigable streams for the Vinton site. Therefore, the pipeline dredging would be for burial four feet below the stream bed(s) and bucket dredging would be used.

Dredging in Gray Canal

The oil pipeline crossing would require pipeline burial across the 50-foot wide canal. The canal is not navigable at this point, so a depth of 4-5 feet below the canal bottom would be required. The dredged material involved amounts to only about 1,000 cubic yards. Considering the small size of the canal at this point, the dredged material would likely be used as backfill for the trench after the pipeline is in place. For this operation the impact should be minimal. The increase in turbidity and other effects should be localized and of short duration.

Dredging in Marshes (South of Vinton Dome)

Construction of the brine disposal lines to the injection wells would require dredging across approximately 7,000 feet of marsh. This would be a push-ditch type of operation and would not require a disposal site. About 125,000 cubic yards of material would be involved and would be utilized for backfill operations. The impact would be similar to that expected for the dredging for the Black Bayou brine disposal pipeline; however, the magnitude of this operation would be much smaller. No permanent loss of wetlands habitat would be involved and the impact would be temporary.

A permanent barge canal would be constructed. The total amount of dredge spoil, 241,000 cubic yards, would be disposed of along the banks of the canal. Thirty-five acres of marsh would be permanently lost.

Grading, Excavation, and Filling. The site preparation and construction activity would involve a significant amount of earth movement during a 5-month period. Approximately 30 acres of land would be disturbed. Based on the analysis presented in Appendix D.16, approximately 630 tons or 622.2 cubic yards of sediment would be washed into the surface water system during the 5-month period as a result of erosion of this disturbed land by rainfall. As shown in Figure C.5-2, all 630 tons would be deposited in Ged Lake. Because the soil involved would be a silt loam, the minimum rate of settling would be .0186 mm/sec, as shown in Figure C.3-9.

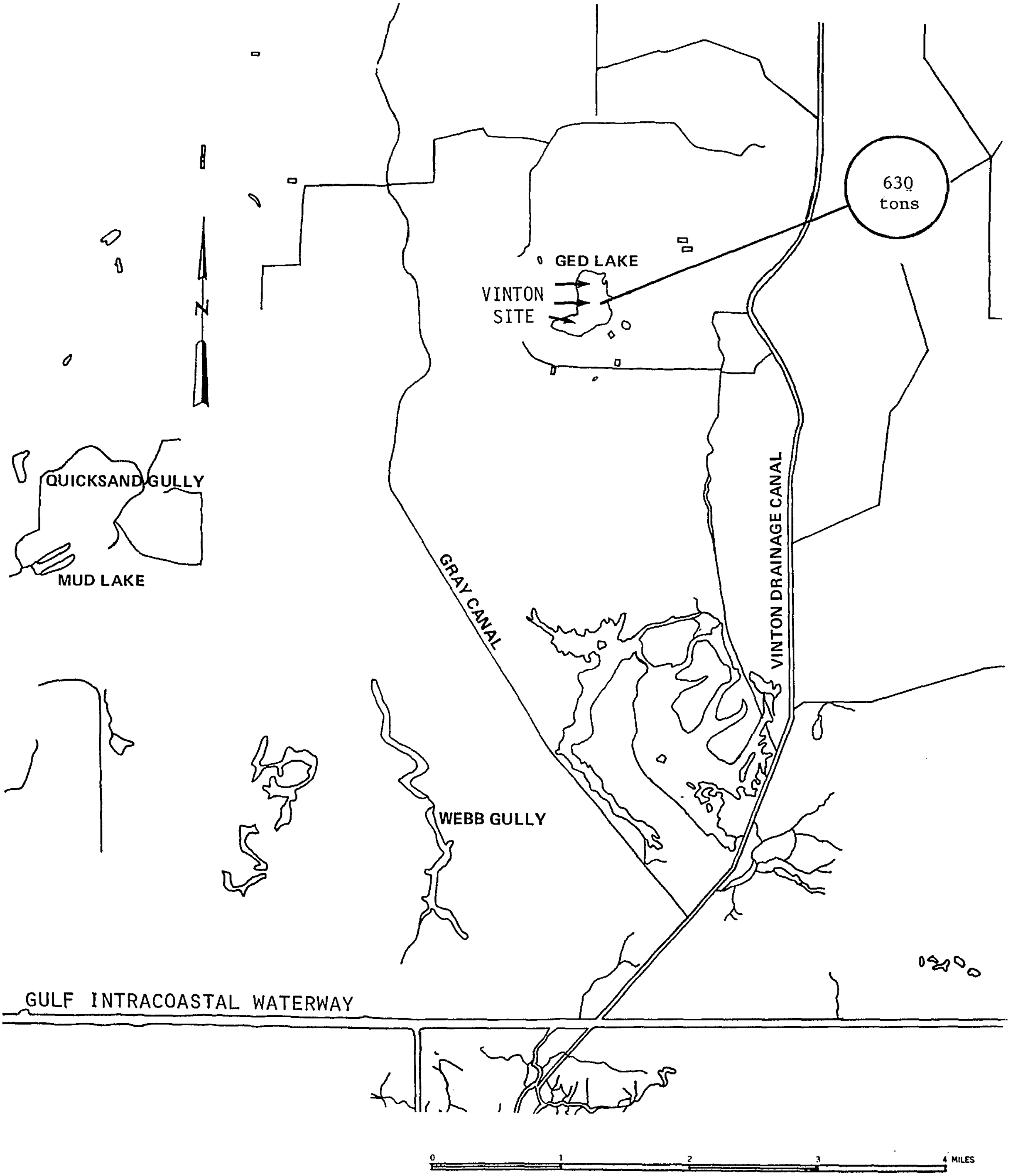

Figure C.5-2 Sediment Transport in the Vicinity of Vinton

Based on the analysis provided in Appendix D.16, the introduction of such sediment into Ged Lake would increase the average level of suspended solids by 7.56 ppm. The increased level would develop over the initial 20 days of the site preparation and construction activity, and would persist for the remainder of the 5-month period. These higher levels would decrease light penetration and also alter the water temperature.

Miscellaneous Construction Activities. Two general types of pollutants (chemical and biological) can be generated during construction activities at Vinton. A complete list of the types of chemical pollutants is found in Section C.3.2.3.2. In general, most problems arise from excessive or improper use of industrial and agricultural chemicals on or near the construction site. Additional problems arise from improper storage and disposal operations.

Biological pollutants are generally the result of poor sanitary conditions at a construction site. As a result, bacterial, viral, and other organisms can be carried into the nearby water bodies. These pollutants are detrimental to water quality and other organisms. A major concern arises from release of pathogenic organisms associated with human waste.

Prediction of impacts due to these types of biological and chemical pollutants is not feasible because of the human elements involved and the present lack of detailed design information. In any case, the degree of pollution can be minimized by thorough training of construction personnel and adherence to reasonable housekeeping practices. If such practices are utilized there would be no significant impact.

C.5.1.2.2 Subsurface Water

The only significant impact on the subsurface water system would result from the injection of brine into the deep aquifers. During the process of leaching at the Vinton facility, 230 ppt brine would be produced at a rate of approximately 395,000 bpd or 11,500 gpm over a 38-month period. Current design calls for the disposal of the brine by means of 10 brine-injection wells, as described in Section A.6.4.1.4. Injection depths would range from 3,000 to 7,000 feet. The location of the brine disposal field is indicated in Figure C.5-3.

The disposal of the brine from the leaching process at the Vinton site would involve 39,500 bbl/day (1150 gpm) per well. This injection rate is approximately seven times the re-injection rates

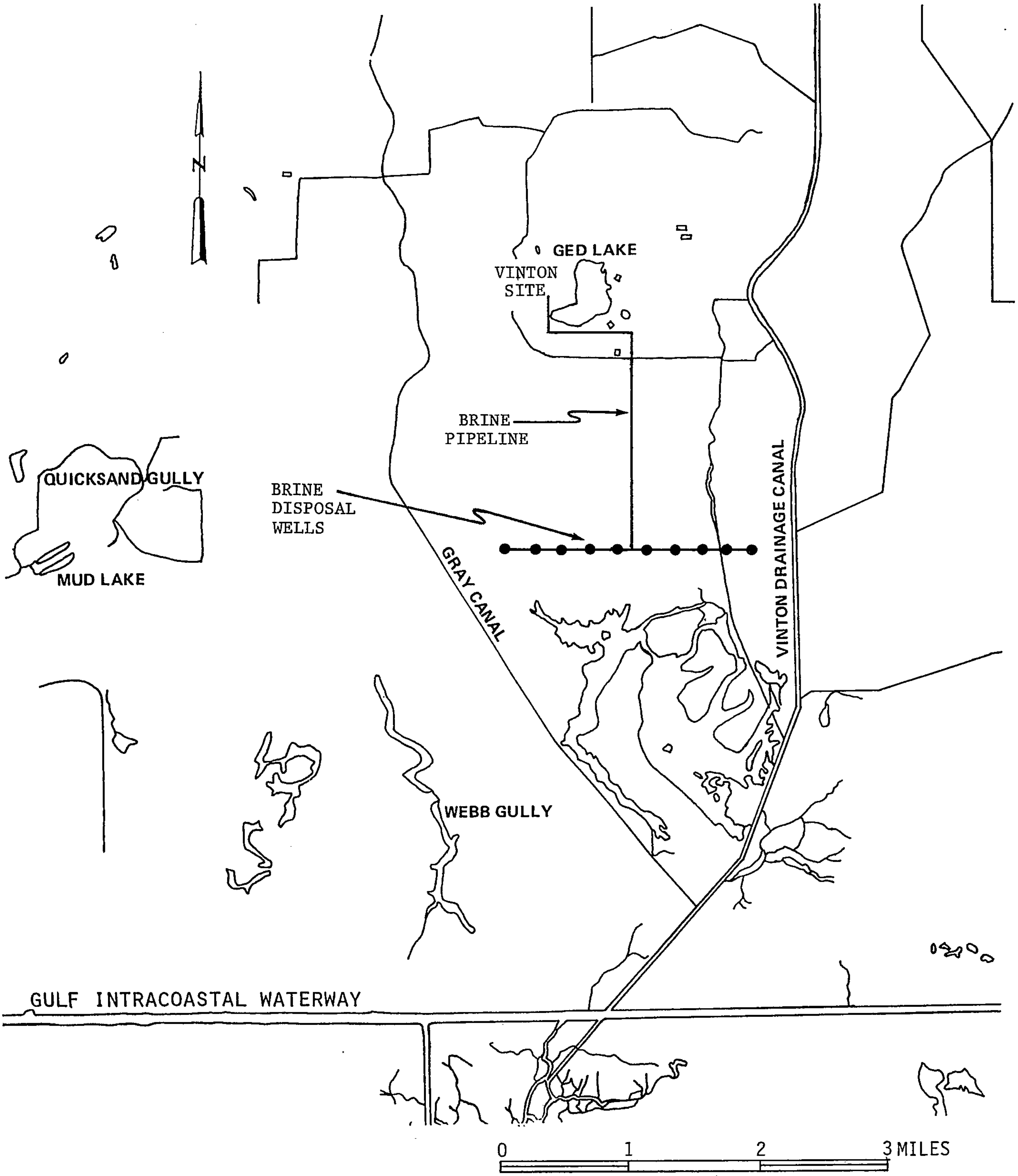

Figure C.5-3 Brine Disposal Site for Vinton for the East Texas oil fields (McWilliams, 1972). The potential environmental impacts associated with subsurface brine disposal are:

- contamination of fresh ground water or surface water
- earthquakes
- interference with oil and gas production

Contamination of Fresh Ground Water or Surface Water. Under certain conditions due to either aquifer fracture or leakage, fresh ground water or fresh surface water may be contaminated by the brine injected into the deep aquifer. Subsequent discussion is concerned with such possibilities.

The Possibility of Aquifer Fracture

A reservoir satisfactory for subsurface waste disposal must possess adequate volume and have impermeable strata above and below the storage layer. Excessive pressure buildup could lead to fracture of such strata and loss of containment. Pressure buildup depends upon:

- the aquifer size,
- the pumping rate,
- the quantity of waste fluid,
- the aquifer porosity,
- the aquifer permeability, and
- clogging agents in the waste such as colloids or materials which support bacterial growth.

In some areas, lateral interconnections between aquifers provide very large reservoir capacities. Such interconnections may often be demonstrated by electric well logs* in separated wells.

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*Electric logs are strip charts plotting electrical resistivity of the earth versus depth, thus idenfifying types of geological strata. One log is normally generated for each well drilled.

Negative indications by electric log data (such as those encountered at the current site) do not prove that reservoir capacity is small but strongly suggest caution in estimating capacity.

As noted in Section B.3.3.2.2, correlation* of individual sands in the brine disposal area was not possible. In the interval between 3000 and 7000 feet, however, sand beds with thicknesses from 100 to 150 feet were detected. The lateral extent of each such sand and the interconnections between sands are unknown. It appears reasonable to assume, however, that at least ten separate sand beds occur in the depth interval under study. Based on such assumptions for each injection well there would be a separate sand at least 100 feet thick.

As described in Appendix D.19 an analysis has been carried out to determine the pressure buildup in an aquifer 100 feet thick due to the injection of brine. The assumed characteristics of the aquifer are provided in Table C.5-1. As noted in the table the horizontal area of the aquifer was not held constant. Instead, a series of values were used, ranging from 3 to 40 square miles. The objective in using a series of values was to determine the minimum size aquifer capable of accepting the brine at the rate already noted, without risk of aquifer fracture. In carrying out the analysis, allowance was also made for the additional brine to be injected into the sand during each fill cycle. During the entire period the aquifer was assumed to be totally isolated from other aquifers, essentially representing the worst case.

The results of the analysis as presented in Figure C.5- 4, indicate that the aquifer must have a minimum horizontal area of approximately 32 square miles to avoid aquifer fracture. In order to provide some margin of safety a 36-square mile aquifer is necessary. The transient pressure buildup for such an aquifer at the bottom of the well bore is depicted in Figure C.5-5. As indicated in the figure the pressure would continuously increase during the injection process, reaching a maximum value of 3543 psig after 1144 days. With the cessation of injection the pressure would begin to decrease, reaching an equilibrium value of 3266 psig after 55 days. Because the aquifer is assumed to be isolated

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*The correlation of sand beds consists of studying the electric logs from a number of wells in a given area and determining whether or not within some specific interval of depth the same sand bed is present at several different well sites. The average thickness and horizontal dimensions of the sand bed can be approximately established in this manner.

Table C.5-1. Characteristics of Pliocene-Miocene Aquifers in the Vicinity of Vinton.

Individual Reservoir Characteristics	
Horizontal Area	3-40 square miles
Depth	5,000 feet
Thickness	100 feet
Initial Pressure	2,500 psig
Normal Pressure Gradient	.5 psi/ft
Fracture Pressure Gradient	.75 psi/ft
Temperature	54°C (130°F)
Porosity	33%
Permeability	1.00 darcies
Well Conditions	
Diameter	10 inches
Surface Flow Rate	39,500 bpd
Fluid Properties	
Viscosity	0.5 centipoises
Compressibility (effective)*	10^{-5} psi
Density	10.0 pound/gal

*Includes water and rock

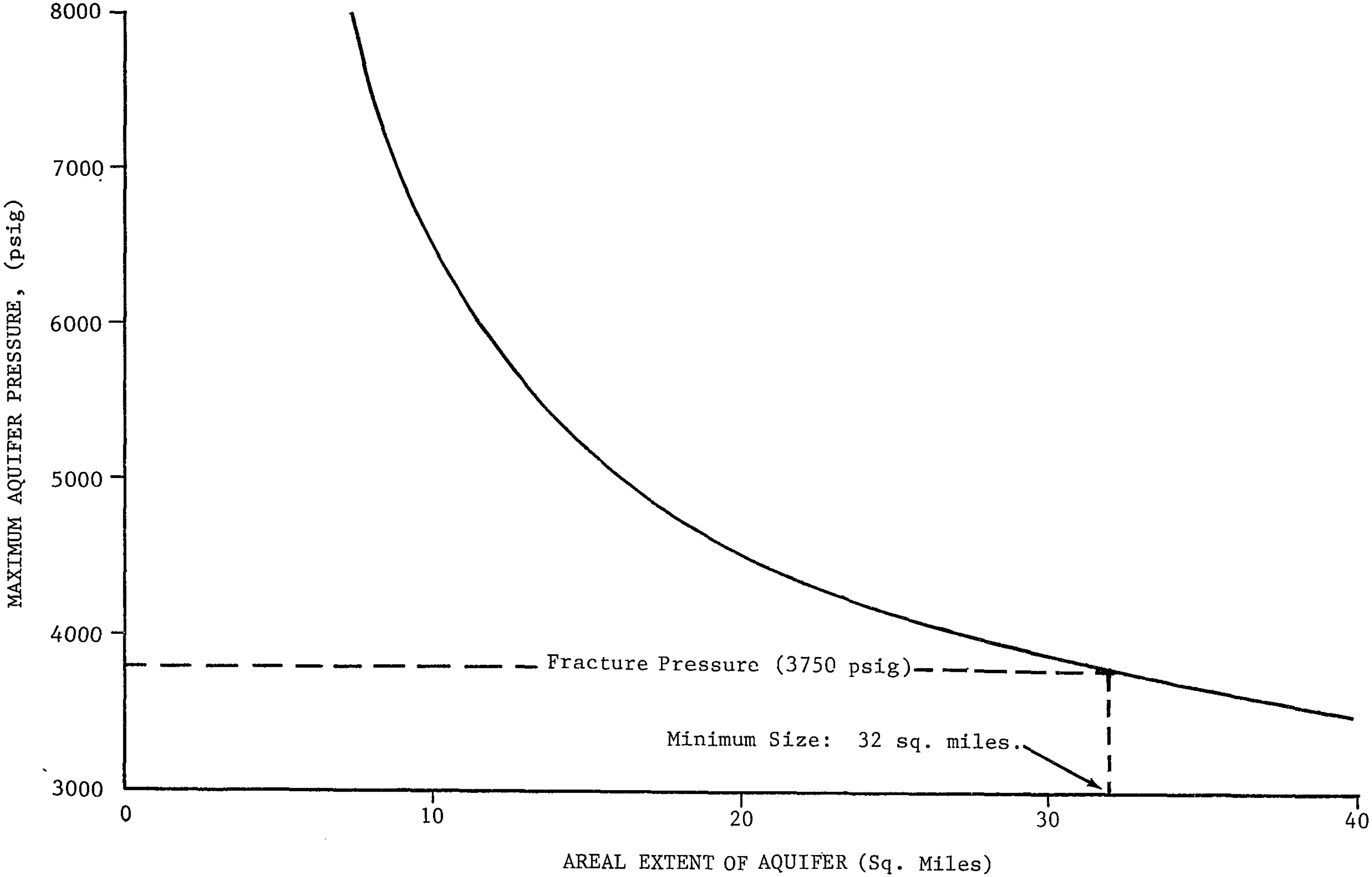

Figure C.5-4 Maximum Aquifer Pressure Versus Areal Extent of Aquifer

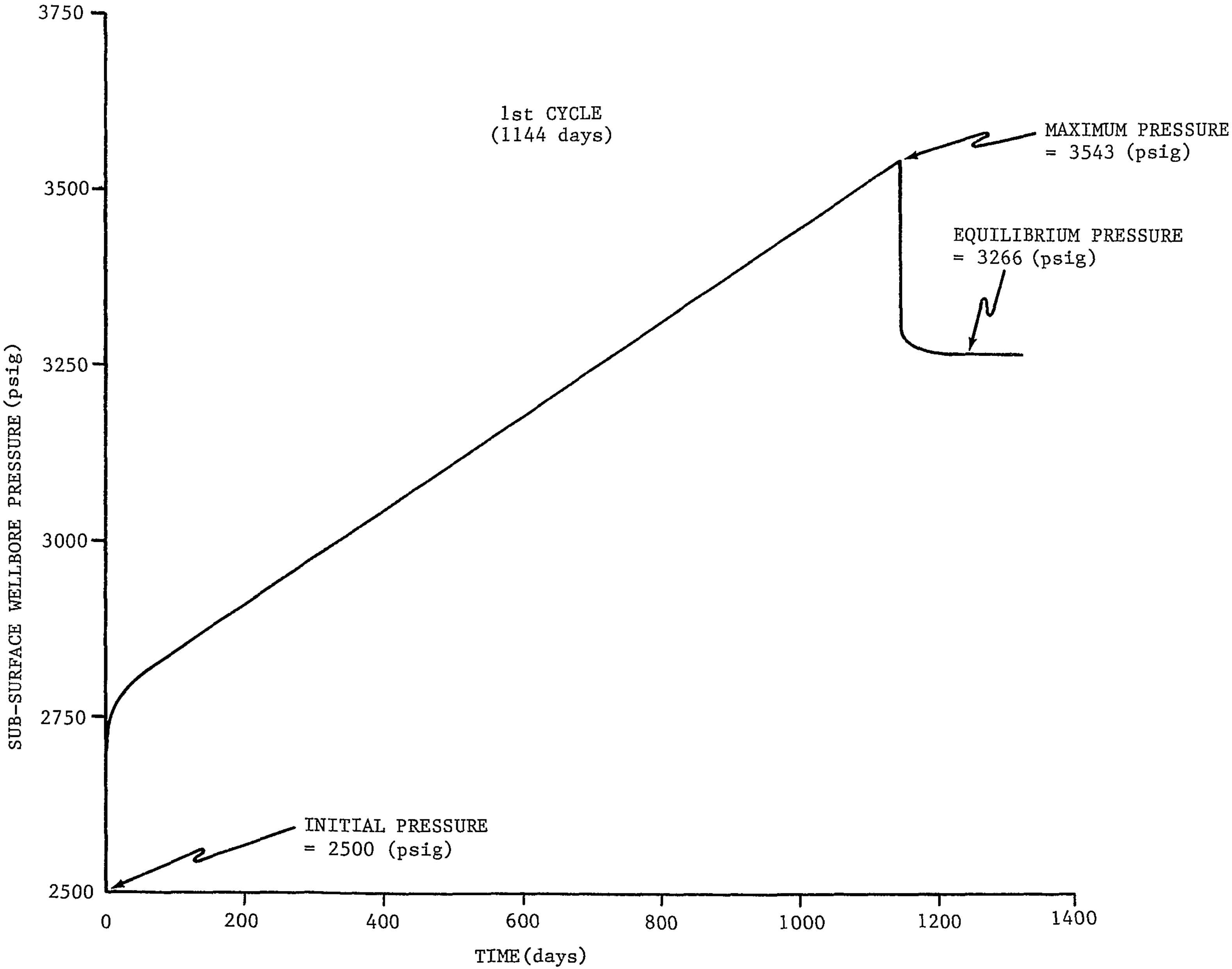

Figure C.5-5 Pressure History at Bottom of Wellbore in 100-Foot Thick Sand (36 Square Mile Area) During Leaching Operation this equilibrium pressure would be maintained until brine injection is resumed during subsequent refill cycles, described in Section C.5.2.2.2.

In arriving at the preceding results certain assumptions pertaining to well-clogging were made. First, no deposit of slightly insoluble material in the brine was assumed present to clog up the porous formations about the well bottoms. (The brine settling tank may eliminate this problem.) It was also assumed that no biological growth would render the porous sands impermeable.

The assumptions noted were necessary because of the current lack of data to permit more detailed computations. Such computations cannot be performed until complete chemical and biological analyses have been conducted on the brine to be injected and also on the water with the aquifer. Such analyses are necessary because of three potential problem areas:

(1) Incompatibility of waters

(2) Water-sensitive formations

(3) Water quality considerations

A discussion of these problem areas is provided in Appendix D.20.

In summary, with respect to the possibility of aquifer fracture, the available data indicate that the deep aquifers are suitable for brine disposal if the sands (100-foot or thicker) within such aquifers extend over thirty six-square miles or greater. Additional study would be necessary to establish the actual extent of such sands.

The Possibility of Aquifer Leakage

In addition to contamination by aquifer fracture, fresh ground water may be contaminated by leakage through unknown aquifer connections or faults, poorly plugged abandoned wells, and well blowout. Surface water is most likely to be contaminated through poorly plugged abandoned wells or well blowout. The danger of blowout may be minimized by using dense mud as a plugging agent if the hazard is known.

As noted in Appendix D.21, the possibility exists that brine injection could cause pollution of shallow fresh ground water zones if abandoned wells near the Vinton facility permit flow to shallow aquifers (such as the Chicot aquifer) from the brine injection zone. This could occur if the old well casings are corroded and are therefore open in both the fresh water aquifers and brine injection zones. Within two miles north of the disposal site 61 abandoned wells are located, and within one to two miles south of the site, two such wells are located.

Prior to brine injection,the records of all abandoned wells within a 3.5-mile radius of the disposal site should be examined. Any well whose record suggests the use of improper plugging procedures should be replugged. Based on the assumption that the preceding steps are followed, the worst case envisioned would involve leakage through an undetected crack in the plug of one of the abandoned wells. An analysis is presented in Appendix D.21, for such a case, with a crack .01 inches wide and extending over 25% of the well bore perimeter. The results of the analysis indicate that the total amount of leakage into shallow, fresh water aquifers (400 - 800 feet deep) would be less than 1400 barrels of brine over a period of 3000 days. This amount of brine is not considered significant.

In summary, if an adequate system of checking the records of abandoned wells in the vicinity of the Vinton site is followed and if improperly plugged wells are identified and replugged, the possible impact of leakage should be minimal.

Earthquakes. Earthquakes may be induced by faults being lubricated by fluid injection. There is documented evidence of earthquakes being triggered as a result of subsurface injection of fluid accompanied by an increase in injection reservoir pressure. The two known cases of this phenomenon have occurred in Colorado in an area of high natural rock stress. One occurred near Denver and was associated with a disposal well that injected liquid waste from the Rocky Mountain Arsenal. The other occurred near Rangly, Colorado and was associated with a water flood in the Rangly oil field. The mechanism causing the earthquake is not well understood. However, all those who have studied the problem agree that the existence of high natural earth stress as in Colorado, Wyoming, and California is a prerequisite. In the Texas-Louisiana Gulf Coast the natural earth stress is low. This region is a tectonically relaxed area characterized almost exclusively by normal faulting (no reverse or overthrust faults). Numerous water flood and liquid waste injection sites have been in operation along the Louisiana-Texas Gulf Coast for many years without reported occurrences of earthquakes. Therefore, it would appear that earthquake occurrence in the vicinity of the Vinton Dome is highly unlikely.

Interference with Oil and Gas Production. Brine disposal at Vinton should not adversely affect existing oil and gas production. The proposed zone of brine injection, from 3,000 to 7,000 feet, lies within the oil and gas producing interval (1,900-11,720 feet). Those areas with the greatest density of producing wells are generally one to two miles or more north of the proposed line of disposal wells*. The design of the disposal wells must preclude inadvertant injection of brine into oil and gas reservoirs, according to Louisiana law. The same state rules and regulations prohibit intentional injection, except when prescribed procedures are followed. When such procedures are satisfied, the brine serves as a water drive for the reservoir. Thus, if the injection well design satisfies Louisiana law no reduction in oil and gas production would occur. There exists the possibility, however, that the rate of production and lifetime of individual wells might be changed. Thus, some wells might provide a greater yield than originally projected, while others provide a lesser yield. Further study is necessary to resolve this question.

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*Thirty-five producing oil and gas wells are located one to two miles north of the disposal site.

C.5.1.3 Air Quality

C.5.1.3.1 Sources of Emissions

The construction of the proposed oil storage facility at Vinton would result in combustion and fugitive emissions along the pipeline right-of-way and at the dome and Sun Terminal locations. Many of these emissions would be insignificant and would exert a negligible impact on local ambient air quality. A list of emission sources existing during site construction activities follows:

- Site Preparation
- Unpaved Roads
- Paved Roads
- Heavy-Duty, Diesel-Powered Equipment
- Light-Duty Vehicles
- Drill Rigs
- Storage Tank Preparation
  a. Surface Grinding
  b. Paint and/or Primer Application

A detailed discussion of these emission sources and their characteristics is contained in Section C.3.1.3.1. Annual tonnage emission rates from these sources are summarized in Table C.5-2.

C.5.1.3.2 Emission Control Technologies

The emission control technologies that would be applicable to Vinton SPR facilities are the same as those described in Section C.3.1.3.2.

C.5.1.3.3 Emission Regulations and Standards

The emission regulations and standards applicable to Vinton SPR facilities are discussed and contained in Section C.3.1.3.3.

C.5.1.3.4 Air Quality Impact

The short-term and long-term modeling approaches utilized in the assessment of Vinton air quality impacts are the same as those discussed in Section C.3.1.3.4.

Table C.5-2

Annual Tonnage Emission Rates At Vinton During Construction*

Source or Activity	Annual** Emissions (Tons)				
	HC	Pa	SO_2	NO_2	CO
Site Preparation	–	3730	–	–	–
Unpaved Roads	–	202	–	–	–
Paved Roads	–	0.5	–	–	–
Heavy Duty, Diesel Powered Equipment(1)	0.5	0.3	0.5	7.4	1.4
Light-Duty Vehicles	0.2	0.03	0.01	0.3	2.6
Drill Rigs	9.9	9.0	8.1	126	27
Surface Grinding Tanks	–	3.1	–	–	–
Painting - Tanks(2)	5.3	–	–	–	–
Total - Construction	16	3945	9	134	31

* Includes construction activities at dome and terminal sites and along pipeline right-of-way.

** If activity persists for less than a year (e.g. painting - tanks) than total emissions for this shorter period are listed

1. The dome and terminal sites considered as independent construction sites of equal magnitude.
2. Two coats of paint

The greatest impact on local ambient air quality would be due to tank preparation and land preparation activities. At the dome three small tanks would be required (See Figure A.6-6, Appendix A), while three 200,000 barrel oil surge tanks would be required at the Sun Terminal, regardless of which candidate site or sites are developed. Short-term modeling of tank surface preparation indicates that the 24-hour particulate standard would be exceeded out to a downwind distance of 1 kilometer, or well within probable plant site boundaries. The application of paint would result in exceeding the 3-hour NMHC standard out to a downwind distance of approximately 4 kilometers as indicated in Figure C.5-6. Figure C.5-6 presents conditions at the Sun Terminal, but the distribution is also pertinent to the dome site. The maximum frequency of violation would amount to roughly 1 percent of the time annually, and would occur to the west of the dome and Sun Terminal sites. The predicted frequency of violations is based upon the use of annual meteorological data. The actual painting process would require less than one month at each location, and the actual impact would be a function of the meteorological conditions during that period. Depending upon actual meteorological conditions, the indicated violations may be limited to probable plant site boundaries.

Long-term or annual pollutant ground level concentrations would be insignificant for construction-phase activities with the exception of large-scale land-clearing operations at the dome and Sun Terminal locations. The modeling results are presented in Figures C.5-7 and C.5-8, and they indicate that the Federal Primary Standard for particulates would be exceeded within approximately 1 kilometer of the construction areas at the Sun Terminal and dome site, respectively.

The remainder of the construction phase sources are mobile and are fairly widely distributed. As a result, their impact on ambient air quality tends to be very local and of a short duration. Such sources include vehicular usage and fugitive dust losses from project roadways.

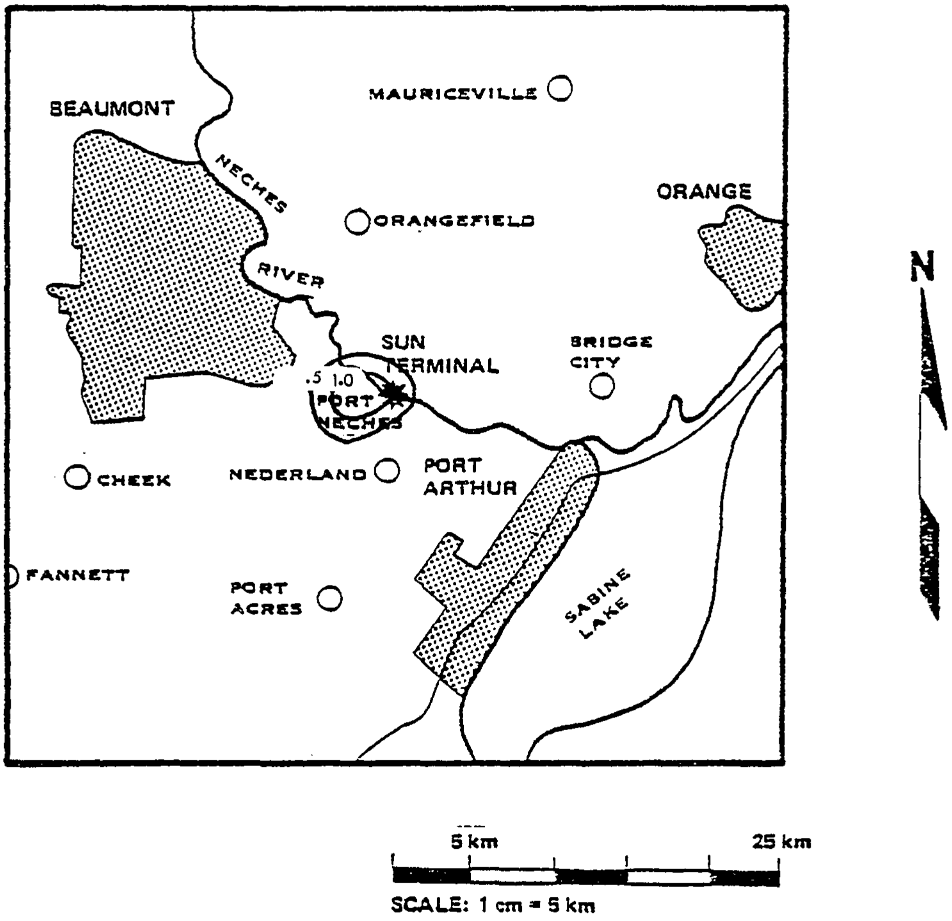

Figure C.5-6. Annual Frequency of Occurrence (%) of Violations of the 3-hour NMHC Standard for Tank Painting at the Sun Terminal for all Texoma Sites During the Construction Phase*

*Distribution will be identical at the Vinton Dome Site

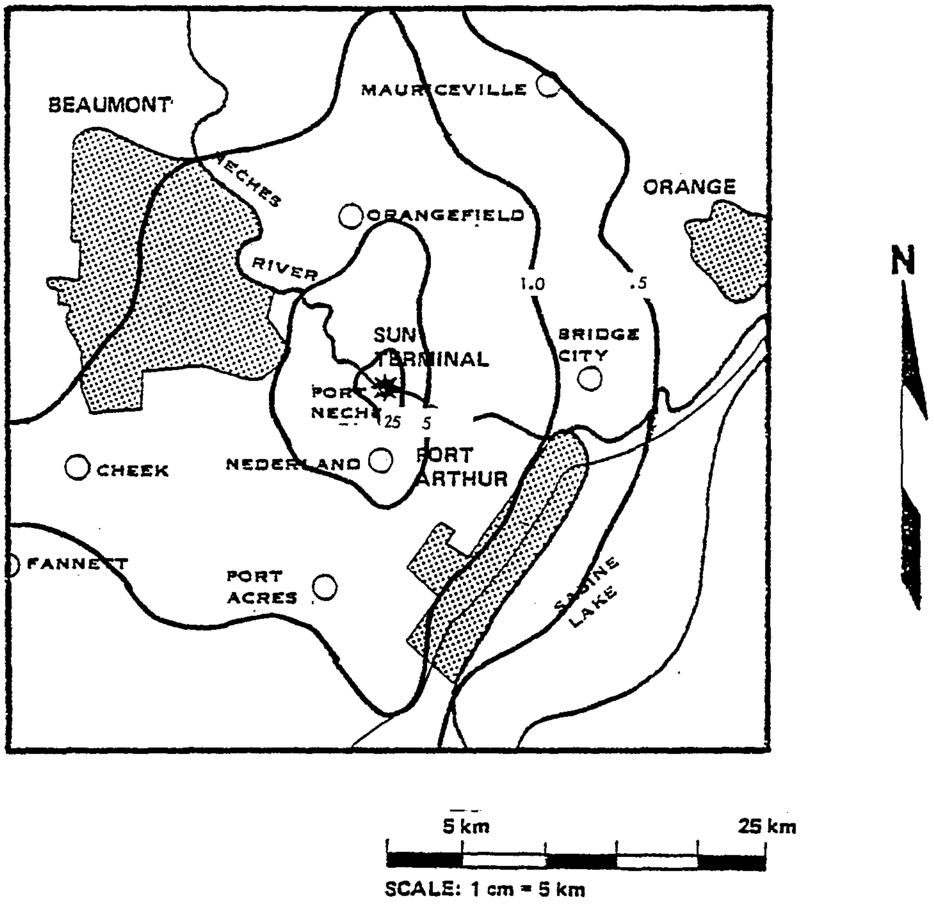

Figure C.5-7 Annual Average Particulate Ground Level Concentrations ($\mu g/m^3$) for the Sun Terminal for all Texoma Sites During the Construction Phase

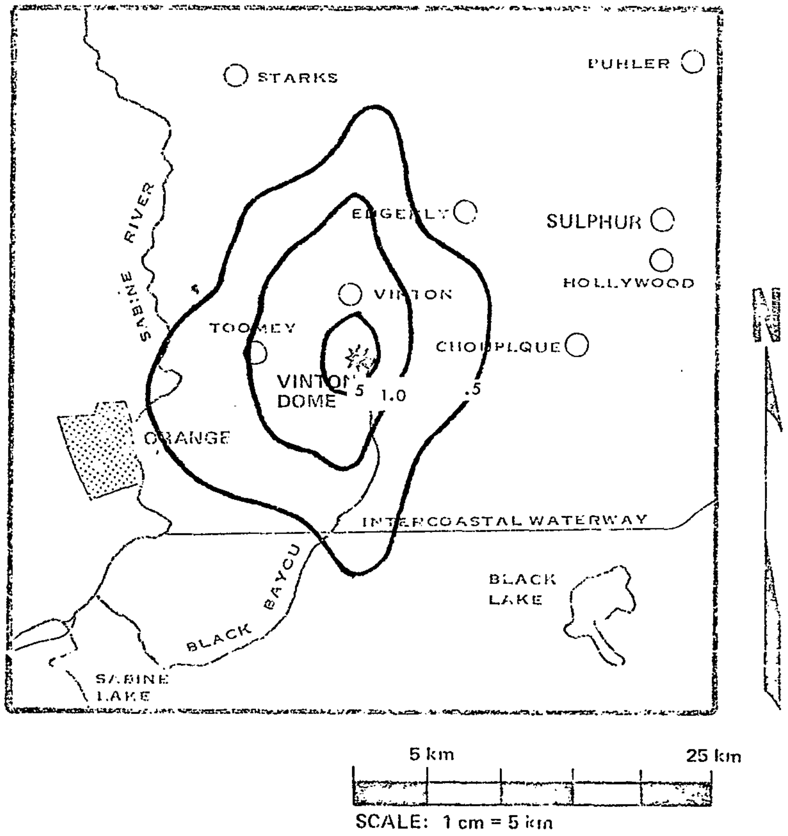

Figure C.5-8 Annual Average Particulate Ground Level Concentrations (µg/m^3) at the Dome Site During the Construction Phase at Vinton.

C.5.1.4 Noise

Construction activity associated with the development of the Vinton salt dome alternative to the West Hackberry expansion may affect ambient noise levels at the storage site and in adjacent areas where construction would be required in conjunction with the site preparation. The principal areas which have been identified for construction activities are:

1. Oil Storage Site Area
2. Pipeline Corridors
3. Brine Disposal Area
4. Terminal and Dock Area

An assessment of noise impacts at these locations is given in the paragraphs which follow. For an explanation of terminology, propagation model, and noise impact guidelines, see Appendix F.

Oil Storage Site Area

The development of Vinton salt dome as an alternative to the proposed expansion at West Hackberry would require creation of six caverns on a 240-acre site located approximately 3 miles south of Vinton, Louisiana. The existing site is undeveloped and would require construction of a control plant which would include office, control, pump, repair and laboratory buildings. Approximately one mile of roadway construction is planned requiring a minimum of clearing and grading. Raw water intake would require some dredging at the Vinton drainage canal approximately one mile east of the site. The contributing noise sources at the storage site area during site preparation would be trucks, earthmoving equipment, compressors, drilling rigs, impact equipment, concrete mixers and general construction related equipment. Noise levels typical of this equipment are given in Table F-2 of Appendix F. The evaluation of the construction noise sources indicates that diesel engines would provide the most consistent source of noise, and that impact and drilling equipment would create the peak sound levels.

Assuming 24-hour drilling activity of two drill rigs, it is estimated that the equivalent sound level contribution (L_{eq}) of the site preparation activity would be no more than 55 decibels (db) at 2,000 feet from the center of the site. The contribution of storage site construction activity to annual day-night levels (L_{dn}) assuming 6 months of drilling activity is estimated to be no mroe than 55 db at 2,000 feet from the center of the site. There is an estate house owned by the Gray family located west of the lake and just north of the salt dome. It is likely that construction activity would affect ambient noise levels on the Gray property during site preparation.

Pipeline Corridors

The construction of three pipelines would be required for servicing the Vinton storage site. A 7-mile long pipeline would be used for oil distribution and would connect with the proposed West Hackberry-Sun Terminal pipeline at a point southwest of the Vinton dome. Other pipelines required would be for water supply (1.5) miles and for brine disposal (2.75 miles). The areas traversed by the proposed pipeline are on solid ground so that conventional pipeline construction techniques would be employed. Table F-2 in Appendix F shows noise levels for equipment typically used for pipeline construction. Assuming daytime activity only, it is estimated that pipeline construction noise would contribute no more than 55 db to the equivalent sound level (L_{dn}) at a distance of 500 feet from the pipeline right-of-way. The annual (L_{dn}) levels along the pipeline are not expected to be affected because of the relatively short period of construction activity at specific sites.

Brine Disposal Area

The current plan for brine disposal would require the 10 brine disposal wells be drilled at a site (see Figure C.5-1) approximately 2 miles south of the oil storage area. It is anticipated that drill-rig equipment would be employed day and night during drill operations. In addition, dredging operations would require a barge canal for access. The amount of material to be removed for the canal would be about 241,000 cubic yards. Noise levels from conventional drilling equipment reach levels of 95 dbA at 50 feet. The construction activity for the brine disposal area is scheduled to occur over a 15-month period. The noise impact ($L_{dn} > 55$) is estimated to extend approximately 1800 feet from the drilling sites; however, the drilling sites are in remote areas and noise from the activity should have little effect on residences.

Terminal and Dock Area

The Sun Terminal and dock at Nederland developed under the ESR development at West Hackberry would also be used for the Vinton site. No changes in terminal and dock construction from those required by the expansion at the West Hackberry are anticipated. Noise assessment for that expansion is contained in section C.3.1.4.

Summary of Noise Impacts

Noise impacts from the construction associated with the site preparation at Vinton are summarized in Table C.5-3.

Table C.5-3. Summary of Sound Level Contributions (db) from Construction Activities for the Vinton Alternative

Construction Site	L_{eq}	L_{dn}	Distance from Center of Site
Storage Site Area	<55	<55	2,000'
Pipeline Corridors*	<55	<55	500'
Brine Disposal Area	<55	<55	1,800'

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* Assumes daytime activity only.

C.5.1.5 Species and Ecosystems

C.5.1.5.1 Displacement/Leaching Water System Impacts

The intake structure for the displacement/leaching water system would be located in a small inlet dredged from the west bank of the Vinton drainage canal. This inlet would be adjacent to a light-duty road which runs from the vicinity of the dome to the canal. The area around this road where it meets the Vinton Canal has already been significantly altered by grading operations. The intake station, including the dredged canal, would require one acre of land.

When construction of the intake structure begins, grasses and small shrubs which are presently growing on the spoil banks would be killed. This vegetation represents an early successional stage of plant growth which invaded disturbed areas. An additional area, 100 to 200 ft surrounding the intake station, would also be secondarily altered due to construction activities around the site. Most of this area would revegetate with native grasses in the following growing season.

A major but localized and short-term impact in the creation of the inlet would be the removal of approximately 8,060 cubic yards of material, resulting in temporarily increased turbidity in the water of the canal. Although the canal is classified as tidal (i.e., under tidal influences) with a generally north to south flow, there is very little surface water movement. This would cause suspended solids from inlet dredging to settle out very slowly. Fish species such as sunfish (Lepomis spp.) and bass (Micropterus spp.)which inhabit the canal would be repelled by this particulate pollution until tolerable conditions are regained, generally within 3-4 weeks after dredging and construction ceases.

The raw water system pipeline from the intake structure to the central plant area would involve the initial removal of vegetation from 20 acres of surface land. Of this 20 acres, 4.4 acres is now being used as pastureland, 9.8 acres is covered in native grasses and shrubs and 5.8 acres is forested. Potential beef cattle production resulting from the removal of the pastureland is estimated at a loss of $272/acre/year or $1,197 for one year. After revegetation of the altered pastureland with grasses, the area would again be productive for cattle raising. The 9.8 acres of native grasses and shrubs, much of which borders a light duty road, is a highly productive habitat for nesting, feeding and protection for numerous species of small songbirds and rodents. During construction the vegetation would be removed, making the area essentially unusable to wildlife. Much the same situation would occur with the removal of the 5.8 acres of forest cover. Existing forest land in the tidal basin areas is rapidly diminishing due mainly to these areas' being converted to agricultural uses. These forested areas are utilized by several species of wood warblers, vireos, and nuthatches. These birds do not frequent marshes or grassland.

C.5.1.5.2 Brine Disposal System Impacts

The brine disposal area is located approximately two miles south of the dome and would be composed of a linear array of ten wells spaced at 1000-foot intervals. Adjacent to the wells, a 2.2 mile-long barge canal would be constructed for drilling and servicing in the well area. No land fill would be required for the well head platforms, but a considerable amount of earth movement is anticipated in digging the 1.5 mile brine line connecting the wells and digging the 2.2-mile servicing canal. Approximately 241,000 cubic yards of material would be removed during the construction of the servicing canal, and the disposal of this dredged material along the banks of the canal would require 35 acres of marsh. Siltation and turbidity of marsh waters would occur during construction of the canal, with the greatest impacts directed to benthic forms which would experience suffocation. Mobile forms such as adult insects, water snakes, and small fish would temporarily move out of the area until the turbidity subsides, when they would again return. When the connection between the servicing canal and the Vinton canal is completed, it is anticipated that the turbid waters in the service canal would disperse into the Vinton canal both north and south from the point of connection. The impacts related to this dispersal would be similar in quality and magnitude to the digging of the raw water intake inlet located 1.5 miles north of the service canal.

The brine pipeline would be laid parallel to the leaching/displacement line for a distance of 1.25 miles after the lines leave the plant area. The impacts described in Section C.5.1.5.1 for this common route would apply here also. After the brine line leaves the common route with the leaching/displacement line it would pass through 1.5 miles of grassland and shrub habitat arriving at the disposal well area. Approximately twenty-five acres of dry land would be altered by construction of the brine pipeline. Of this twenty-five acres, eleven acres are in the common right-of-way with the leaching/displacement line and fourteen acres are included in the single line to the brine field. During construction of the brine disposal field, six acres of dry land and twenty-two acres of marsh would be altered. The six acres of dry land are in grassland and shrubs which blend into the twenty-two acres of fresh water marsh.

Impacts related to construction of pipelines in marsh and grassland have been described in detail in Sections C.3.1.5 and C.4.1.5. In general, earth-moving activities in the marshland south of the dome would increase turbidity and add nutrients to the aquatic environment. This influx of nutrients is expected to increase phytoplankton, periphyton, and macrophyte production where they are not covered by fill. Benthic invertebrates in the turbid waters would be affected to varying degrees. Snails and bivalve mollusks would experience gill abrasion due to the particles in suspension, and could suffocate if covered with silt. Fish tend to move out of the area to less turbid environments. Movement back into marsh water not appreciably affected by siltation would occur within three to four weeks after dredging and construction ceased.

C.5.1.5.3 Impacts at or from the Storage Location

The land surrounding the dome and the dome area itself has been appreciably altered by human activity. Most of the area is currently being used for recreation and pastureland and is essentially unusable to most native wildlife. Construction at the storage location would therefore provide impacts to an environment dominated by human and domestic animal use.

Because of the nature of construction activities, people not directly involved in the project would be excluded from the storage site area. It is anticipated that this action would restrict use of the residential houses on the dome. Horses and cattle which are presently on the dome would also be excluded from the immediate area of activity. A total of sixty acres of land would be required for the actual storage site location, but since recreational and construction activities are rarely compatible, the impacts from construction (i.e., noise and air pollution) would probably make the entire area near the lake unusable for recreational pursuits. Cattle and horses could still graze on the periphery of the area, outside the construction site.

A major impact to Ged Lake is anticipated from earth-moving activities during construction. It has been calculated that approximately 630 tons of soil would be deposited in the lake as a result of run-off from erosion. Turbidity and siltation of the lake during construction would not affect the domestic animals which utilize the lake for a water supply, because they would already have been restricted from the area. After construction is completed, the excess soil deposited in the lake would need to be removed in order to regain the original depth and volume.

C.5.1.5.4 Oil Distribution System Impacts

During construction of the oil pipeline, 51 acres of dry land and 39 acres of marsh are included in the right-of-way for the pipeline route to its junction with the ICW. Of the 51 acres, 9.1 acres is currently being used as pastureland and 41.9 acres is a grassland-shrub habitat. For a one-year period, construction in the pastureland would remove 9.1 to 13.7 cow calf units per acre (Knox and Oates, 1976a). Since pastureland produces an average of $272 worth of beef per year, this would result in a monetary loss of $2,475. In the grassland-shrub habitat, removal of the vegetation would have detrimental effect on many species of songbirds (i.e., warblers, wrens, and sparrows) and small mammals which use the area by reducing the food and cover available.

Where the pipeline would cross Gray's Canal there would be a temporary siltation and turbidity to the water. Benthic fauna in the immediate area would be destroyed, while fish and other mobile forms would temporarily move out of the area.

With a pipeline right-of-way of 150 feet, 39 acres of marsh would be directly affected by construction. At an average productivity for these grasses of 2,500 Kcal/m^2/yr, this loss of acreage represents a loss of primary production of 1.01 x 10^7 Kcal/yr (Odum, 1971). Section C.3.2.5 discusses in detail the effects of pipeline construction through marsh areas and the West Hackberry Pipeline Design Change Environmental Assessment (FEA, 1977) outlines the impacts of the continuation of the Vinton oil distribution pipeline bordering the Intracoastal Waterway to Sun Terminal.

C.5.1.6 Natural and Scenic Resources

Site preparation and construction on the Vinton dome would be close to several large houses and stables. These buildings are part of the scenic ranch complex which surrounds the dome. It is undetermined at this time what the disposition of these buildings would be. They are not occupying sites presently proposed for wellheads, pumps, or other facilities.

Nibletts Bluff State Park, located 10 miles north of the oil pipeline route in Louisiana (See Figure B.2-28) is situated far enough from construction areas so that no impacts are anticipated to occur to this park.

C.5.1.7 Archaeological, Historical, and Cultural Resources

During the cultural resources survey of the Vinton dome, several significant sites were identified. If these sites were to be studied further, a test excavation program is recommended to determine the precise extent of the sites and the significance of the remains. In addition, if the site were to be chosen as an SPR facility, a more intensive archaeological survey would be initiated which would comply with the National Historical Preservation Act of 1966 and Executive Order 11593.

C.5.1.8 Socioeconomic Impacts

C.5.1.8.1 Employment

The plans for the proposed oil storage facility at the Vinton salt dome are significantly different from those for the other sites. There would be only six storage caverns compared with 15 newly leached ones at West Hackberry and Black Bayou, and the facility would contain 1/3 as much oil. Among the four alternative sites, this is the only one which would use injection wells to dispose of the brine resulting from the creation of the cavities and from the displacement of oil. Because of these differences, the employment profile is somewhat different.

A maximum level of about 360 workers would be employed in the construction of the project. This peak level would occur in the second month of activity at the site, as shown on Figure C.5-9. The peak level results primarily from the hiring of the pipeline crew which would be laying pipeline to the brine disposal field, to the raw water intake structure, and to the oil distribution pipeline connection.

The peak labor needs of the project could be met easily by workers available in the region. If all the workers were drawn from Calcasieu Parish and Orange County alone, and only 15 percent of the available skilled workers were selected, the unemployment rate in Calcasieu Parish could be reduced by 0.4 percent, and in Orange County, by 0.5 percent.

The major function employing workers at the site and nearby in the brine disposal field would be the drilling of wells. One drill rig would be used at the salt dome for a period of eighteen months, and another, mounted on a barge, would be used at the brine disposal field for fifteen months. The maximum employment level at the storage site and brine disposal field would be about 165. Of this number, those assigned to the drill rigs would be working in shifts, so that there would be only about 130 workers at the site during the day shift, and nearly twenty during each of the two night shifts.

The construction of surface facilities would be completed in the first five months. Drilling activities would be completed by the 20th month. After that time, only 30 to 40 persons would be needed at the site to monitor the leaching of the caverns and the concurrent filling with oil. This final period of the construction phase would last for about two years.

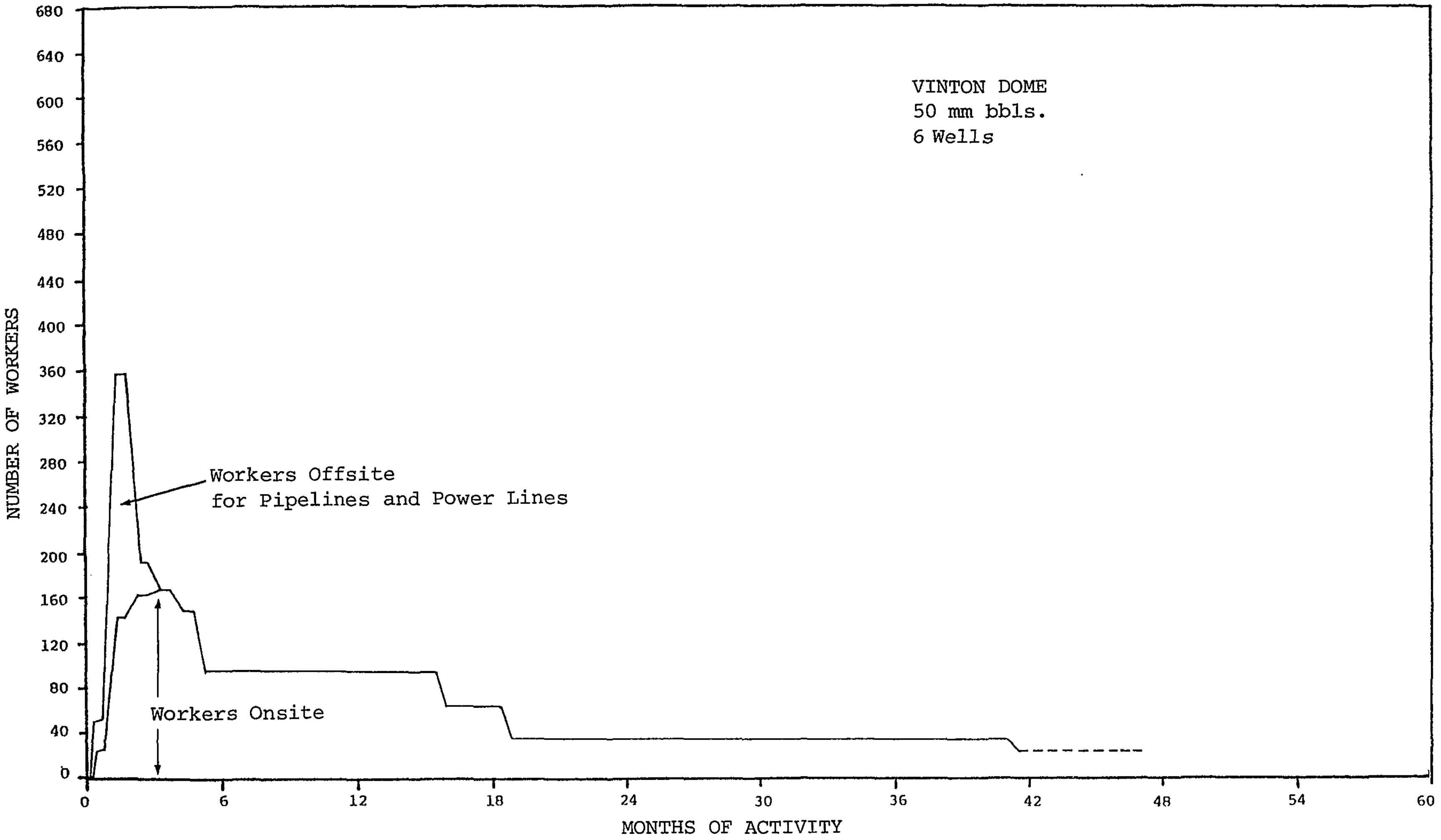

Figure C.5-9 Labor Requirements at the Vinton Site

C.5.1.8.2 Land Use

The construction of oil storage facilities at the Vinton dome would have impacts on both the site and the pipeline corridors. The land proposed to be used for the surface facilities (the ponds, tanks, pumphouse, transformer and other structures) is part of the Gray Estate. There is one year-round residence on the land, with about seven or eight barns, sheds and other utility buildings around it. Two vacation homes are situated on the small hill overlooking Ged Lake. Five people are currently living in the large house, and six to eight additional people come occasionally to the homes on the hill. There are oil wells pumping at scattered locations around the estate. The oil field has been productive since its discovery in 1910.

If the Vinton dome were selected as an oil storage site, 160 acres over the dome would be purchased. The existing homes would be either moved or demolished; the barns and other storage buildings would be destroyed. The oil wells are assumed to lie around the periphery of the salt dome, and would be left to continue operating. The historic post office would remain, separated from the oil storage facilities by the lake. However, noise and traffic resulting from construction activities would detract from the scenic value of the landmark.

The construction of the pipelines would last for about a month. The pipeline leading to the Vinton Drainage Canal would cross through farmland, pasture, and forested areas. Use of these lands would be interrupted by pipeline construction. The brine disposal field lies primarily in a marsh area, and the pipeline leading to it would cross pasture and marsh. The oil distribution pipeline, which follows the right-of-way of the Transcontinental Gas Pipe Line Corporation to intersect with the SPR oil pipeline along the Intracoastal Waterway, would also cross marshlands. Construction activities would mar the wilderness aspect of these marshes, but this would be a transitory effect. The oil pipeline would also cross the Intracoastal Waterway.

The proposed storage site and its associated pipelines lies in Calcasieu Parish. Although this parish has the authority to restrict development in areas outside city limits through parish-wide zoning, the area that would be affected by the construction activities is in an area that has not yet been classified for zoning purposes.

C.5.1.8.3 Traffic

There would be three kinds of impact on traffic. One would result from the commuting patterns of construction workers traveling to and from the site; another would result from laying the oil distribution pipeline across the Intracoastal Waterway; and the third would result from additional tankers bringing oil to Nederland to fill the Vinton caverns.

Except for those workers living in Vinton and Carlyss, the construction work force would come to the site via Interstate 10, where it would exit at Vinton and take the Ged Road south. Assuming that a quarter of the workers traveled with another worker, there could be as many as 270 commuter vehicles traveling to the site during the months of peak employment plus about 20 trucks. Since the pipelines to be constructed would be reached by using the Ged Road, it would bear the traffic of all workers, materials and suppliers going to and from the project. The impact of increased usage of these two roadways is as follows:

	Recorded Average Daily Traffic	Peak Period Increase	12 Month Average Increase
Interstate 10 (at Vinton)	8,800*	7%	3%
Ged Road	60	967%	367%

The Ged Road is maintained by Calcasieu Parish. It has one lane in each direction and is surfaced with crushed shell. The road ends at the Gray Estate and is used primarily by residents who live along the road and by workers who maintain the oil pumps and pump stations near the site.

After the initial year of construction, during which an average of 110 vehicles would be traveling to and from the site, the traffic level would decrease to about 35 vehicles going each way. Traffic induced by the project would reach this lower level in the twentieth month of activity and remain at that level for about two years.

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* A 1975 traffic count recorded 11,200 vehicles along the Interstate Highway in this vicinity, but did not include traffic counts on the other two roads. Using the 1975 count, the traffic increases would be 7 percent at the peak period, and 3 percent over the twelve-month period. Increased use of the Interstate Highway would not necessarily indicate a commensurate increase in use of the other two roads.

When the oil distribution pipeline is laid across the Intracoastal Waterway, it would be buried at a depth sufficient so that it would not interfere with shipping or with the periodic maintenance dredging of the channel. This section of the Waterway bears a yearly traffic load of about 5,200 self-propelled vessels going eastward and about the same number going westward, (Waterborne Commerce, 1975).* The number of such vessels passing both ways at the crossing averages about 28 daily. Arrangements would have to be made to permit the passage of these vessels and their barges during the periods that the pipeline was being laid beneath the channel.

Additional tanker trips required to bring oil to the dock facilities in Nederland for filling the caverns would increase traffic in the Sabine-Neches Waterway. The Vinton dome would be a smaller facility than those proposed for development of the West Hackberry and Black Bayou domes. Initial fill would be extended through the 42nd month of construction, allowing for a lower fill rate. The yearly increase in tanker traffic over the fill schedule would be as follows:

	Additional Tanker Trips	Sabine Pass Port Arthur Increase	Neches River Increase
10th - 28th month	78	4%	8%
28th - 42nd month	46	3%	6%

This schedule assumes that each tanker would unload 410,000 barrels of oil. Also, it excludes the traffic imposed by the initial fill of the Early Storage Reserve caverns at West Hackberry; their fill would be completed before the first month shown on this schedule.

C.5.1.8.4 Housing and Public Services

Since the employment needs of the project could be met by workers available within commuting distance, it is

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* The traffic count records the barges, which are non-self-propelled, separately from the towboats and tugboats that move them, resulting in a total vessel count that is over 20,000.

unlikely that a significant number of additional workers would migrate into the towns and cities nearby for the purpose of working on the construction of the proposed facility at the Vinton Dome. For this reason, the construction activities are not expected to have an impact on local housing. Even if as many as 15 percent of the workers required during the peak level of employment were to move into Calcasieu Parish and Orange County, the impact would be very small. These fifty-four workers and their families would be distributed among Lake Charles, Sulphur, and Orange, where housing units are more plentiful than in the small towns and villages, and in each case the reduction in availability of housing units would be less than one percent.

Because the area could supply the total labor needs, the impact on public services would be limited to those effects associated with the concentration of workers at the site. The small community hospital at Vinton would be used to take care of workers receiving minor injuries that required medical care. Parish police may be called upon more frequently than normal to assist with the traffic congestion associated with workers and materials moving to and from the construction site.

C.5.1.8.5 Economy

The economy of the region would benefit from the additional earnings of its workers and from the supply of a substantial portion of the materials and equipment for construction of the facilities.

The payroll of the construction work would average out according to the following schedule:

1st through 6th month:	$336,700 per month
7th through 12th month:	$188,000 per month
13th through 18th month:	$166,700 per month
19th through 42nd month:	$ 66,500 per month

During the second month, when the pipelines are being laid and the labor force reaches its maximum level, the payroll would reach a peak of about $718,000 paid in the course of the month. These payroll levels are based on an assumed average worker wage of $2,000 per month.

Materials, equipment, and labor, combined for the various tasks in the construction work, would cost a total of approximately $90,000,000. Of this amount, over 80 percent would be spent within the local region, bringing in about $74,000,000 to the local economy directly. The Vinton dome, like the Black Bayou one, is located about midway between the major cities of the Lake Charles BEA area and the Beaumont-Port Arthur-Orange BEA area, so the economic gains derived from the project would benefit both economic regions.

The average of the economic multiplier of both regions is 2.05. When this is applied to the total amount expended in the region, the resulting $151,700,000 is the earnings derived both directly and indirectly from the proposed construction. This amount would be an increase over the anticipated 1980 level of earnings for the combined economic regions of three percent. The earnings of just the major metropolitan areas within these regions are lower, so that if all the earnings derived from the project were to accrue to the cities, it would represent an increase of 6 percent over the 1980 anticipated level.

Most of the direct project expenditures would be made in the first year or two on site, but the indirect effects of the circulation of money would last longer. For this reason it is appropriate to compare the gain in earnings derived from the project with the anticipated gain in earnings of the local area between 1980 and 1985. The added earnings would represent a gain of 19 percent over the anticipated growth in earnings for the combined BEA regions and of 32 percent over that of the combined Lake Charles and Beaumont-Port Arthur-Orange standard metropolitan areas.

C.5.1.8.6 Government Revenues

The choice of the Vinton dome as an oil storage site would produce some effects that would lessen local government revenues and other effects that would augment the revenues. The former effect would be confined primarily to the result of the transfer of land at the site and along pipeline corridors from private ownership to Federal ownership. Federally-owned lands are exempt from local taxation.

A portion of the local increase in earnings derived both directly and indirectly from the project would contribute to local governmental revenues. While the indirect earnings contribution would be difficult to estimate, the contribution of that portion of direct earnings which consists of workers wages can be computed. Using the method applied in the discussion of West Hackberry and Black Bayou whereby about 20 percent of the wages would be witheld, and 6 percent of the remainder would be saved, the amount derived from sales tax on the balance is as follows. Applying a tax rate of 5 percent, the contribution to local revenues would be $118,000 in the first year, $52,000 in the second year, $15,000 in the third year, and $7,500 in the remaining six months of construction. As at Black Bayou, this revenue would be divided between Louisiana and Texas according to the residence of the workers employed by the construction project.

C.5.2 Impact from Operation

C.5.2.1 Land Features

C.5.2.1.1 Geomorphology

Operation and maintenance activities would have no impact on geomorphology (topography and drainage patterns) at the Vinton storage site or along the oil or brine pipeline routes.

C.5.2.1.2 Soils

Routine operation and maintenance is not expected to result in any impacts to soil characteristics at the storage site, along either the oil or brine disposal pipeline routes, or at the terminal and dock facilities. Accidental spills of oil or brine could, however, result in the impact that soil in contact with oil would be incapable of supporting vegetation (See discussion of oil spills in Section C.2.1).

C.5.2.1.3 Stratigraphy, Geologic Structure, and Mineral Resources

No impact on the stratigraphy, geologic structure, or oil production on the flanks of the dome is expected to occur during normal operation and maintenance activities.

Future salt production in the area of the new storage caverns would not be compatible with the SPR program. Also, sulphur (if any exists in the cap rock above the expansion site) could not be mined.

C.5.2.2 Water

The operation and maintenance of the Vinton facility would produce certain impacts on water environment. Subsequent discussion dealing with these impacts is organized in two parts as follows:

- Surface Water
- Subsurface Water

C.5.2.2.1 Surface Water

Each impact on surface water supply or quality can be identified by the activities producing the impact as follows:

Type of Impact	Produced By
Change in Water Supply	Withdrawal of Displacement Water
Change in Water Quality	Withdrawal of Displacement Water Discharge of Treated Ballast Water Miscellaneous Maintenance Activities

Water Supply

The only significant impact on the supply or availability of surface water would result from the withdrawal of water for the displacement operation. The point of withdrawal at Vinton Canal would be the same as for the leaching operation (Figure C.5-1). The rate of withdrawal would be 3.50×10^5 bpd (barrels per day) or 1.02×10^4 gpm (gallons per minute) over a period of 150 days (5 months). This withdrawal rate is only slightly larger than the withdrawal rate for the leaching operation.

If the Vinton Canal were completely isolated from all other water bodies, such a withdrawal rate would lower the mean water level of the canal at a rate of .626 ft/day (as explained in Appendix D.18). Because the canal is connected with the ICW, the actual rate of fall of water would be less. The final water level in the Vinton Canal in the vicinity of the withdrawal point would be less than 0.02 feet below the water level in the ICW. As indicated in Figure C.5-1, induced currents in the ICW would serve to replenish the water withdrawn from the canal. Because flow in the ICW is generally from west to east, the Sabine River would appear to be the ultimate replenishment source. The flow rates in the river, as noted in Section C.3.1.2.1, are at least 33 times greater than the withdrawal rate on the Vinton Canal. Thus, the available water supply in the Sabine River would be reduced by 3% or less.

Water Quality

As noted previously, the surface water system would be affected by three activities as follows:

- Withdrawal of water for displacement
- Discharge of treated ballast water
- Miscellaneous maintenance activities

Withdrawal of Water for Displacement. The withdrawal of water from Vinton Canal for the displacement operation would be almost identical to the withdrawal for leaching. The only change would be a very small difference in withdrawal rates (3.50×10^5 bpd for withdrawal versus 3.43×10^5 for leaching) and the shorter duration of 5 months mentioned earlier. Thus, the impacts would be essentially the same except for the shorter time period. Generally some increase in the salinity of Vinton Canal would be anticipated along with possible increases in contaminants as presented in Section C.5.1.2.1 on withdrawal for leaching operations.

Discharge of Treated Ballast Water. This operation would occur at or near the Sun Oil Terminal and would increase the levels of salinity and oil in the Neches River. A full discussion is presented in Section C.3.2.2.1.

Miscellaneous Maintenance Activities. Two general types of pollutants (chemical and biological) can be generated during maintenance activities. A complete list of the types of chemical pollutants is found in Section C.3.2.2.1. In general, most releases of these pollutants arise from excessive or improper use of industrial and agricultural chemicals on or near the construction site. Additional releases can arise from improper storage and disposal operations. A more detailed discussion of sources of chemical pollution was given earlier.

Biological pollutants are generally the result of poor sanitary conditions at a maintenance facility. As a result, bacterial, viral, and other organisms can be carried into the nearby water bodies. These pollutants are detrimental to water quality and consequently to aquatic life forms. A major concern arises from release of pathogenic organisms associated with human waste.

Prediction of impacts due to these types of biological and chemical pollutants is not feasible because of the human element involved and the present lack of detailed design information. In any case, the degree of pollution can be minimized by thorough training of maintenance personnel and adherence to reasonable housekeeping practices.

C.5.2.2.2 Subsurface Water

Current design plans for the operation of a Vinton facility involve the use of deep aquifers as a site for brine disposal. During each refill cycle at the Vinton facility, 265 ppt brine would be displaced by crude oil at a rate of approximately 59,500 bpd or 1740 gpm over a 28-month period. Four refill cycles are envisioned over a period of approximately 15 to 20 years. Current design calls for the disposal of the brine by means of 10 brine-injection wells, as described in Section A.6.4.1.4. Injection depths would range from 3000 to 7000 feet. The location of the brine disposal field is indicated in Figure C.5-3.

The disposal of the brine from the refill process at Vinton would involve 5950 bpd (174 gpm) per well. This injection rate is approximately equal to the reinjection rates for the East Texas oil fields (McWilliams, 1972).

The potential environmental impacts associated with subsurface brine disposal, as previously discussed in Section C.5.1.2.2, are:

- contamination of fresh ground water or surface water
- earthquakes
- interference with oil and gas production

Contamination of Fresh Ground Water of Surface Water

Either aquifer fracture or aquifer leakage, as already discussed in Section C.5.1.2.2, could cause the contamination of fresh ground water or fresh surface water. Although the rates of injection during the refill process are only 15 percent of those used during the leaching process, certain effects appear to be cumulative in form and thus warrant further consideration.

The Possibility of Aquifer Fracture. The same analysis described in Section C.5.1.2.2, for predicting the response of the deep aquifer to the injection of brine during leaching, has been used for analyzing the aquifer response to brine injection during the refill process. The same physical characteristics of the aquifer have generally been assumed. As before, because the horizontal extent of the aquifer is unknown, a series of different areas have been used. The aquifer has been assumed to be totally isolated from other sands. The initial pressure in the aquifer was set equal to the final equilibrium pressure produced during the leaching process.

the results of the analysis indicated that for a sand bed 100-feet thick, the minimum horizontal area to accommodate four refill cycles would be 32 square miles. In order to provide some margin of safety, a 36-square mile aquifer is required. The transient pressure buildups for such an aquifer at the bottom of the well bore is depicted in Figure C.5-10. As indicated in the figure, during each refill process the pressure would continuously increase throughout the 28-month period. Upon cessation of injection the pressure decreases, reaching equilibrium after 20 days. This equilibrium pressure is maintained until the resumption of injection as part of the next refill cycle. At the end of the fourth refill cycle, the maximum pressure was 3647 psig and the final equilibrium pressure was 3606 psig.

In summary, if the 100-foot sands in the deep aquifers have sufficient areal extent (approximately 36 square miles), such aquifers can accept the brine without risk of aquifer fracture. The actual extent of such sands, however, is not known and should be determined.

The Possibility of Aquifer Leakage. The problem of aquifer leakage is discussed in Section C.5.1.2.2 in some detail. As noted in that discussion, if adequate procedures are followed in checking the records of abandoned wells, and in replugging such wells if necessary, the resulting impact of leakage due to an improperly plugged well is not significant. This conclusion also applies to the case of leakage during the injection of brine discharged during the refill cycles.

Interference with Oil and Gas Production

As discussed in Section C.5.1.2.2, during the leaching process brine injection should have no adverse effect on the overall production of oil and gas in the vicinity of the Vinton dome. The performance of individual wells, however, may be affected. For the same reasons as given for the leaching process, during the refill process brine injection should have no adverse effect on the overall production of oil and gas, but may change the performance of individual wells.

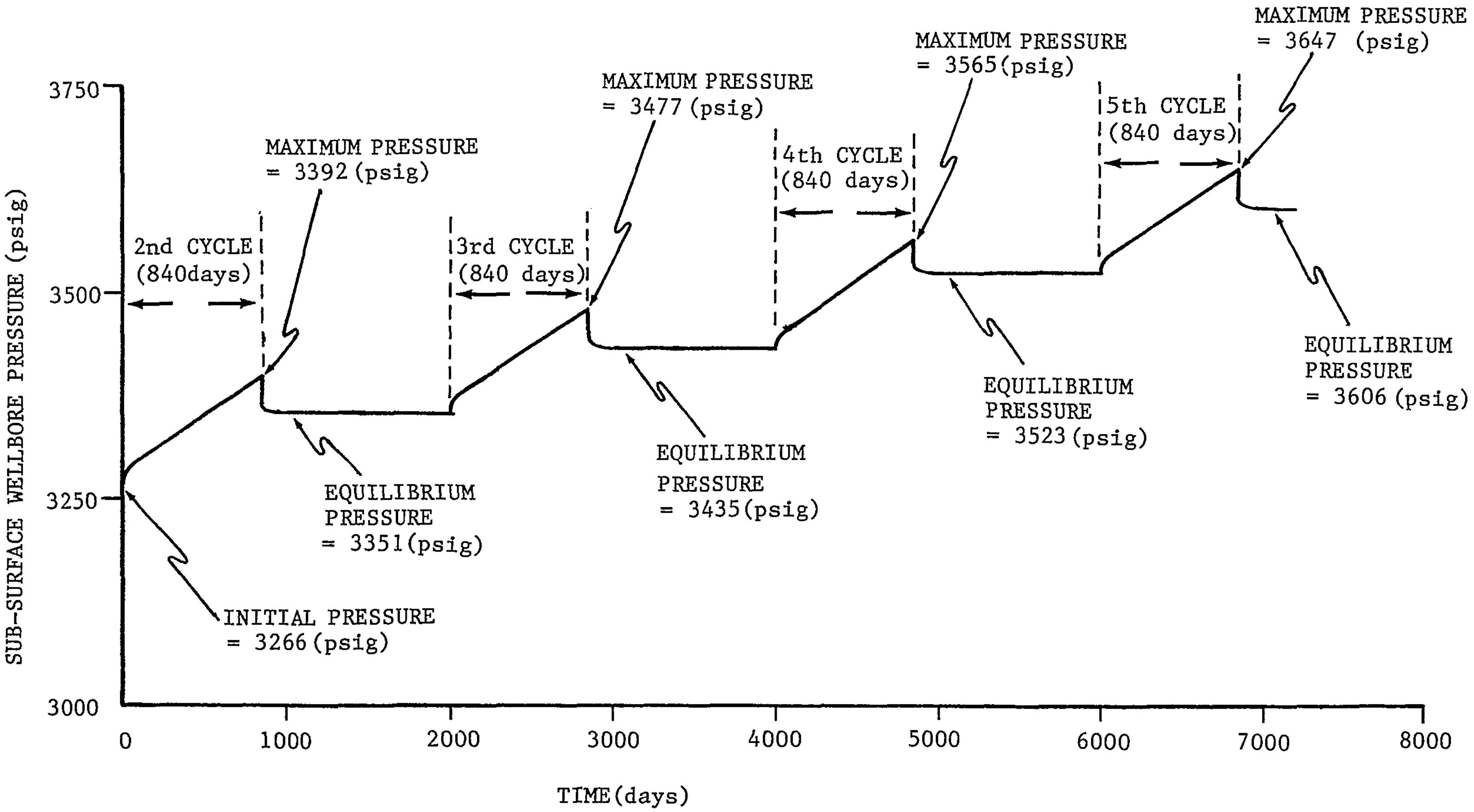

Figure C.5-10 Pressure History at Bottom of Wellbore in 100-Foot Thick Sand (36 Square Mile Area) During Fill Cycles

C.5.2.3 Air Quality

C.5.2.3.1 Sources of Emissions

The emission sources at Vinton from operational activities include (1) the injection of crude oil into the salt dome cavities, (2) the subsequent extraction of the oil at a future date as required, and (3) the emissions from dissolved hydrocarbons which are present in the brine discharged during oil refill. A detailed discussion of emission rates associated with each source is contained in Section C.3.2.3.1. Short- and long-term emission rates at Vinton are listed in Appendix E. An evaluation of the emissions from brine is given in Appendix N. Those sources included in the modeling analysis while annual tonnage emission rates are presented for all sources in Table C.5-4.

C.5.2.3.2 Air Quality Impact

This section discusses the results of the modeling analysis conducted for each significant source at Vinton during the operational phase. Detailed descriptions of operational activities and modeling approaches are contained in Section C.3.2.3.2.

Short-term modeling calculations have been performed for project hydrocarbon emissions at both the dome and terminal sites. The calculations are based upon concomitant emissions at each location from all sources including tankers, tanks, and pump houses. In addition, two separate scenarios were modeled at the Sun Terminal to handle both ship loading and unloading phases. The results of the modeling analyses are contained in Figures C.5-11 and C.5-12. At the dome site, short-term NMHC ground level concentrations would be in compliance with the 3-hour standard. However, during tanker loading and unloading operations at the Sun Terminal, the standard would be exceeded. Figure C.5-11 indicates that during tanker loading during the distribution phase, the 3-hour NMHC standard would be violated 1 percent or more of the time annually out to downwind distances ranging from 10 to 20 kilometers. The maximum impact would occur to the west of the terminal, where violations of the standard would occur 2.5 or more percent of the time annually out to a downwind distance of approximately 15 kilometers. During ship ballasting operations following the completion of tanker unloading, Figure C.5-12 indicates that the applicable standard would be exceeded out to a downwind distance of approximately 10 kilometers, with the maximum impact occurring west of the facility where the frequency of violation is in excess of 1 percent annually. The calculations are conservative in that they do not include the minor additional dilution attributable to structural wake effect.

Annual NMHC ground level concentrations have also been calculated for the dome and terminal sites. Figure C.5-13 provides the results of this analysis for the Sun Terminal. This calculation is based upon the conservative assumption

Table C.5-4 Annual Tonnage Emission Rates for Development of Vinton to 50 mmb

Source or Activity	Annual Emissions (Tons)				
	HC	Particulate	SO_X	NO_X	CO
Site					
Brine Ponds*	70				
Valves & Seals	4.8				
20,000 bbl (standing loss)	0.5				
Surge Tanks**(working loss)	15.8+				
3,000 bbl Blanket Oil Tank	0.1				
Total	91.2				
Terminal - Fill Phase					
Surge (standing loss)	10.7				
Tanks** (working loss)	3.6				
Valves and Seals	1.9				
Tanker Ballasting	37.5				
Tanker Engine	1.5	10.7	148.5	48.3	0.9
Tug Engine	0.8	1.8	0.7	1.2	1.0
Total	56.0	12.5	149.2	49.5	1.9
Terminal - Withdrawal Phase					
Tanker Loading	346				
Surge Tanks (standing loss)	10.7				
Tanks** (working loss)	8.5				
Ballast Treat (standing loss)	3.6				
ment Tanks** (working loss)	1.8				
Valves and Seals	1.9				
Tanker Engine	0.6	4.1	56.8	18.4	0.3
Tug Engine	0.8	1.8	0.7	1.2	1.0
Total	373.9	5.9	57.5	19.6	1.3

*~~Fill Ph~~ase Only: the values are the maximum predicted at any time during use. The initial fill is expected to be only a small fraction of this amount.

**Working losses interact with the standing storage losses, such that the resultant emission is less than the sum of these values.

+Emissions in fill phase.

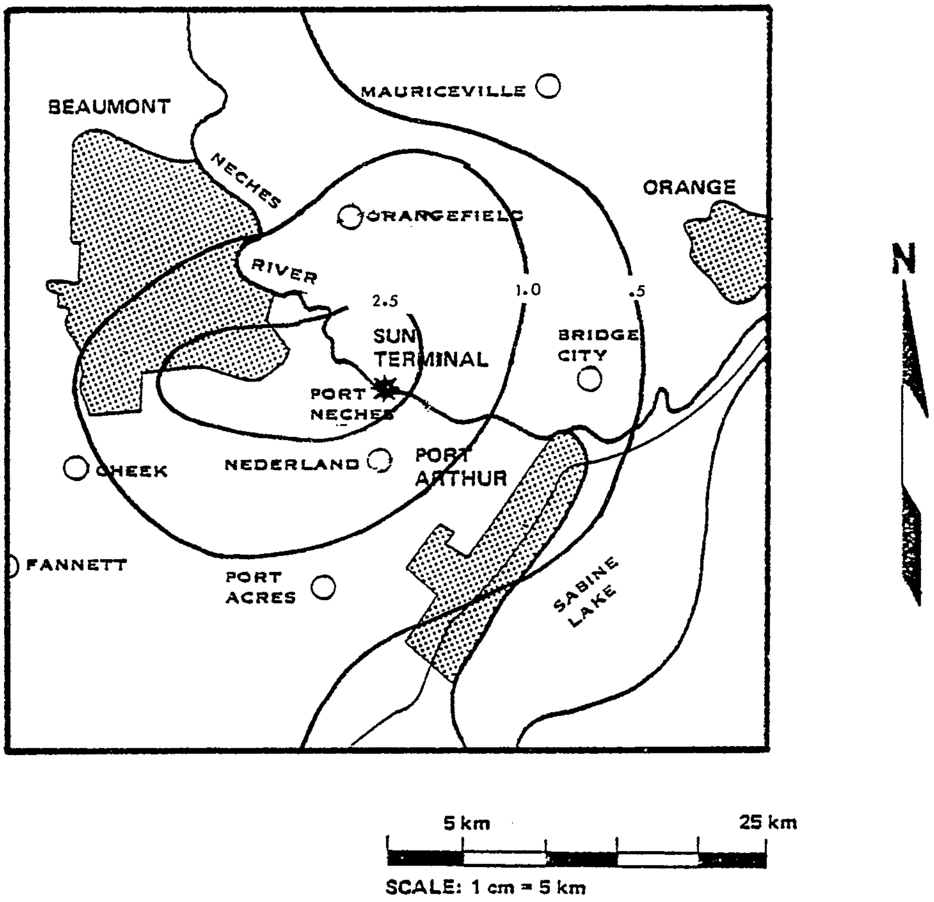

Figure C.5-11 Annual Frequency of Occurrence (%) of Violations of the 3-hour NMHC Standard at the Sun Terminal for Tanker Loading During the Operational Phase at Vinton.

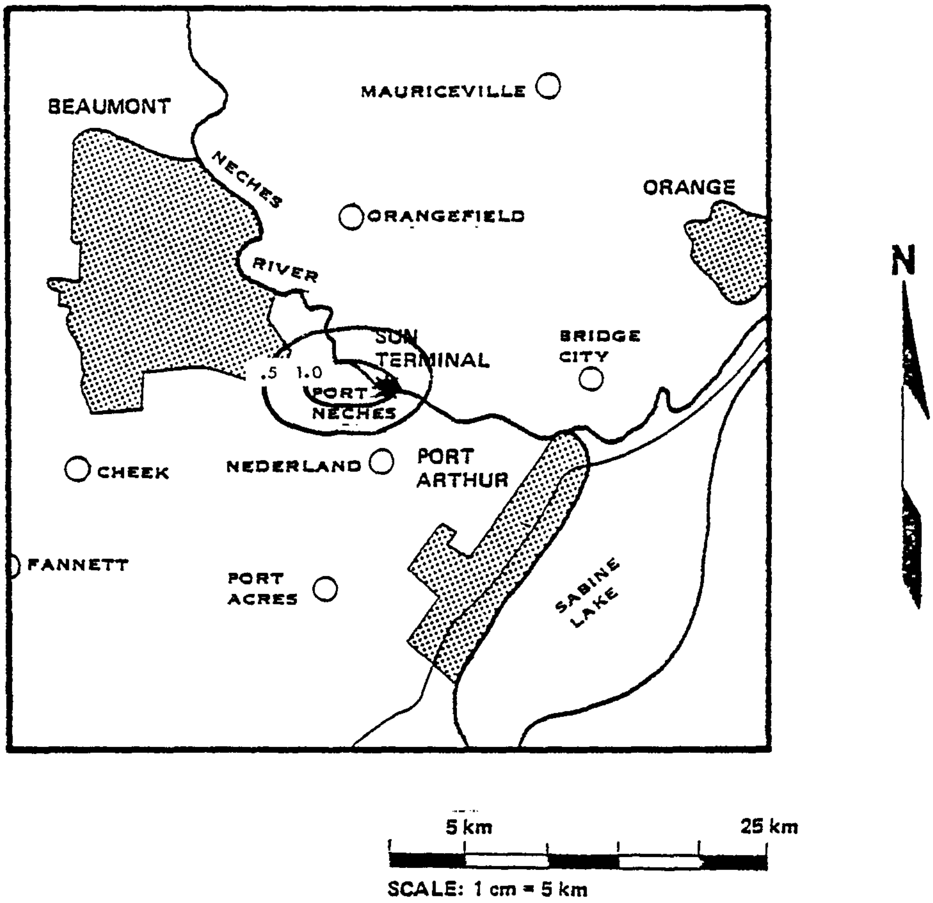

Figure C.5-12 Annual Frequency of Occurrence (%) of Violations of the 3-hour NMHC Standard at the Sun Terminal for Tanker Ballasting During the Operational Phase at Vinton.

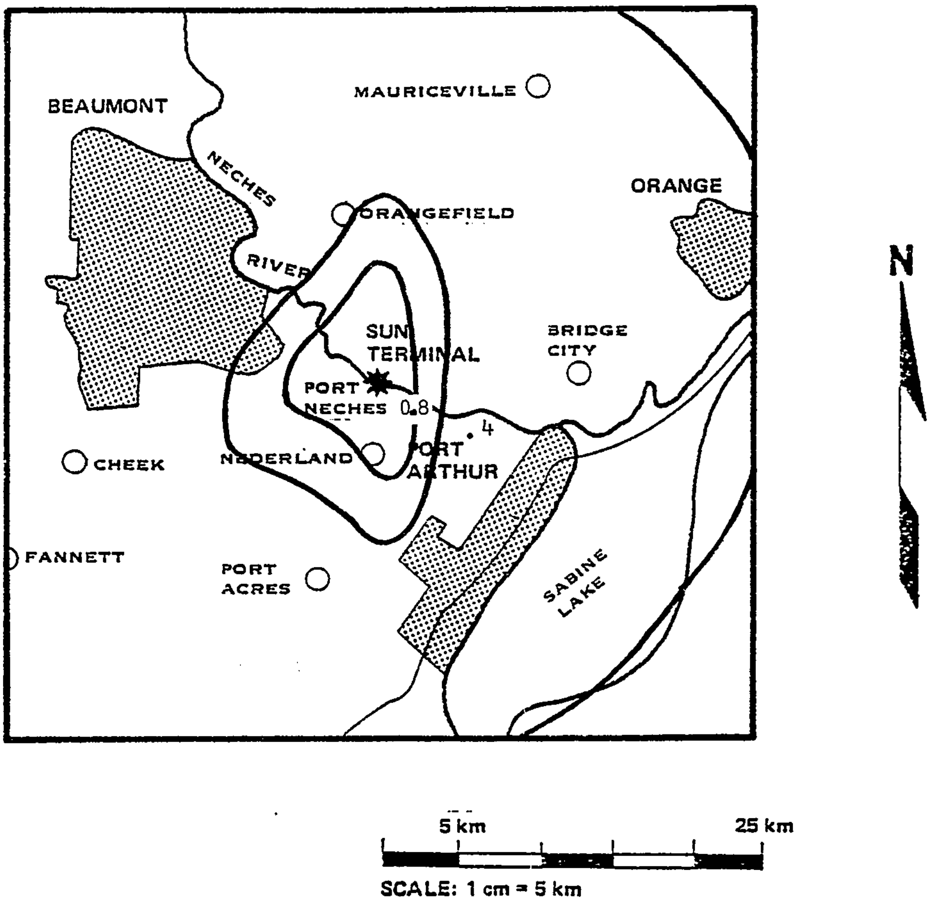

Figure C.5-13 Annual Average NMHC Ground Level Concentrations ($\mu g/m^3$) at the Sun Terminal During the Operational Phase at Vinton.

that both the fill and drawdown phases could occur, at least in part, during the same annual period. The results of the calculation indicate that annual ground level concentrations would be generally less than .8$\mu g/m^3$. Similar calculations were performed for the dome site and are presented in Figure C.5-14. Annual NMHC concentrations would be generally less than 0.1 $\mu g/m^3$ downwind of the dome site sources.

In summary of the air quality impact, the Black Bayou dome and Sun Terminal facilities would be significant sources of NMHC and, to a lesser extent, combustion contaminants. Violations of the 3-hour standard for NMHC are predicted downwind of the Sun Terminal facility. Tanker loading and ballasting emissions dominate the site emission levels as it is unlikely that the other sources would independently violate the NMHC standard outside plant site boundaries. The use of efficient vapor control technology in conjunction with shipboard activities would significantly reduce the impact of the terminal facility on regional ambient air quality. However, in present form, the level of hydrocarbon emissions at the Sun Terminal is probably insufficient to have an important impact on regional levels of photochemical oxidant. The annual tonnage emission rate for the West Hackberry expansion is relatively small in comparison to regional hydrocarbon emission levels in this region of heavy petrochemical activity. The facility would not result in violations of air quality standards for other contaminants.

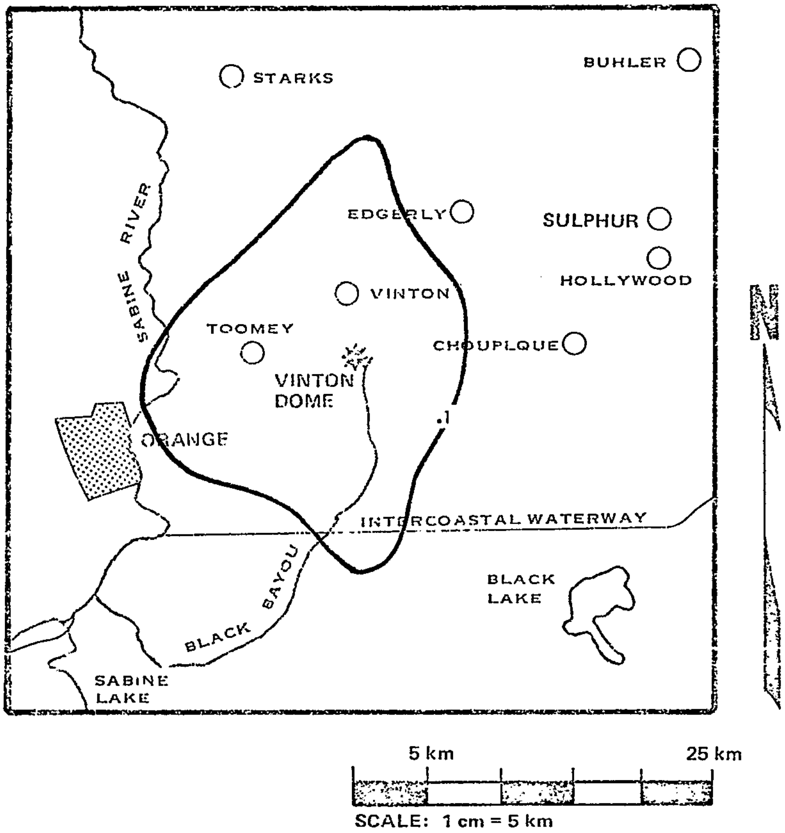

Figure C.5-14 Annual Average NMHC Ground Level Concentrations ($\mu g/m^3$) at the Dome Site During the Operational Phase at Vinton.

C.5.2.4 Noise

During operations at the storage site, the primary noise generation would be from pumps associated with the fill and discharge operations which are located in pump houses on the West Hackbery site. Fill operations are planned to take place over a 32-month period. The first 18 months at a rate of 58,300 barrels/day; the remaining 14 months at a fill rate of 43,750 barrels/day. During a national supply interruption, oil would be withdrawn over a period of 150 days. A total of 5 fill/discharge cycles are planned for the life of the facility.

The analysis of pump noise for a site of similar operation and ambient levels, West Hackberry (Ref. Final Impact Statement - West Hackberry Salt Dome), estimated increased noise levels at the site perimeter of no more than 3 db during the period of operation.

Some increase in terminal and tanker operations can be expected at the Sun Terminal on the Neches River. It is estimated that during fill/discharge operations tanker loading and unloading would increase 20 percent. The major noise associated with the operations would be from tanker traffic, tanker pumps discharging crude oil, tanker loading pumps, and pipe transfer pumps.

The pumps for both tanker loading and pipeline transfer to the storage area would be electrically powered and would be housed in a pump house on the terminal site. Additional noise from the increase in diesel engines powering the tankers and tanker discharge pumps operation would contribute negligibly to existing ambient levels.

Summary of Noise Impacts

During fill and/or discharge operations, there would be noise generated from the continuous operation of pumps at both the storage and terminal facilities. The noise is expected to be continuous day and night during these operations, however, since the pumps at both the storage and terminal facility would be enclosed in pumphouses, or other sound attenuating structures it is anticipated that there would be a negligible impact on existing ambient levels in the vicinity of these facilities from operations.

C.5.2.5 Species and Ecosystems

C.5.2.5.1 Displacement/Leaching Water System Impacts

Impacts from this system at the Vinton site are essentially the same as those listed for the Black Bayou site. These involve entrainment of organisms in the intake water and lateral displacement of water in connected water bodies. The water in the Vinton canal at the raw water intake differs from Black Bayou, in that the former flows through grassland habitat and is located further inland, while Black Bayou is located in marshland closer to the coast. Although both areas are classed as being under tidal influences, the Vinton Canal probably has a stronger fresh-water influence due to a more frequent north-to-south flow which is fed by several fresh water tributaries.

Once withdrawal of water is begun, the fresh water north of the intake and the brackish-to-fresh water from the ICW would act as replenishment sources for the drawdown. During high tidal influences, more saline water could be drawn further into the canal than had been drawn in the past. If salinity changes were great enough, several freshwater fish species in the Vinton Canal [i.e., sunfish (*Lepomis* spp.) and catfish (*Ictalurus* spp.)] would be repelled by the more saline waters and forced into areas of the stream further north. A general description of the impacts associated with salinity intrusion can be found in Section C.4.2.5.1.

C.5.2.5.2 Brine Disposal System Impacts

The greatest potential impact for adverse environmental effects would result from an accidental brine spill at a wellhead or a break in a pipeline. The magnitude of the impact would depend on the size of the spill and the location. The effects of an accidental spill are described in detail in Section C.3.2.5.2. Basically, the toxic effects on organisms would range from death due to excessive water loss or alteration of body chemistry to reduced growth and reproduction.

The brine wells for the Vinton facility would be of sufficient depth that biota would not be affected by brine intrusion into subsurface waters. The injection depth would be between -1500 and -7000 feet msl in Miocene sands containing only saline water. The sands are isolated from adjacent aquifers so that contamination of usable fresh water is not anticipated.

C.5.2.5.3 Impacts at or from the Storage Location

Impacts at the storage site would result mainly from machinery operation producing noise and hydrocarbon emissions. Since the Vinton dome area is currently being used as a recreational retreat, impacts of this sort would be highly significant. Due to the proximity of the storage location to the presently existing buildings, it is doubtful whether the buildings and land around the site would continue to be used while the facility is in operation. The levels of noise and types of odors produced by the facility would be incompatible with current recreational pursuits.

Cattle and horses would be allowed to graze beyond the fenced, restricted area of the facility. Noise levels would not be so great that they would cause these grazing animals to move away from the area.

C.5.2.5.4 Oil Distribution System Impacts

The Vinton salt dome site is characterized by a variety of freshwater habitats in comparison with the brackish to saline water habitats surrounding West Hackberry and Black Bayou salt domes. The Vinton site is also an upland site with an oil pipeline system which would traverse several acres of dry land before connecting with the West Hackberry ESR pipeline on the ICW.

An oil spill in Ged Lake, the Vinton Drainage Canal, or in the numerous irrigation ditches which connect with the Vinton Drainage Canal would impact freshwater biota. Water birds and mammals which frequently enter the water, such as muskrats and nutria, could come into contact with the oil. Birds with fouled feathers would lose buoyancy and body heat. Ingestion of the oil during preening would also be harmful, producing physiological disturbances. Mammals would not be as adversely affected since they have fatty deposits which function to retain heat and are not dependent on their fur for buoyancy. However, loss of food and habitat would be detrimental to all the types of animals cited. Benthic invertebrates such as chironomid (fly) larvae and oligochaete worms could be covered by sedimented oil or affected by reduced oxygen diffusion into the water body. Oil-coated bottom organisms could be smothered. Vertebrates which live underwater would probably avoid the oil unless they are trapped. Recovery would be rapid except that oil which settles to the sediment may act as a source of low level re-contamination for several years. This contamination would reduce recolonization by benthic organisms.

C.5.2.6 Natural and Scenic Resources

Normal operation and maintenance of facilities on the Vinton dome is not anticipated to have any adverse impacts on the natural and scenic resources of the area.

C.5.2.6 Archaeological, Historical, and Cultural Resources

During the cultural resources survey of the Vinton dome, several significant sites were identified. If these sites were to be studied further, a test excavation program is recommended to determine the precise extent of the sites and the significance of the archaeological remains. In addition, if the site were to be chosen as an SPR facility, a more intensive archaeological survey would be initiated which would comply with the National Historical Preservation Act of 1966 and Executive Order 11593.

C.5.2.8 Socioeconomic Impacts

C.5.2.8.1 Employment

About 15 workers would be employed at the storage site during the operation of the facility. They would work in shifts so that the instrument panel would be monitored continuously and personnel would be on hand to take care of any emergency situation. Mechanics, electricians, craftsmen and maintenance workers would be at the site during the day to test the equipment and keep it in good working order.

C.5.2.8.2 Land Use

The Vinton Salt Dome is only about three miles from the town of Vinton. Although Vinton's population is only about 3,500, it is expected to reach over 5,000 by 1990. Most of the residential expansion will probably occur westward, toward Toomey and Niblett Bluff. Eventually, the town will spread southward as well, closing in the distance between the present municipal boundaries and the proposed storage site.

The Vinton Drainage Canal, which is the proposed source of water for leaching the storage caverns and for displacing the oil when oil is removed, is a navigable channel, connected to the Intracoastal Waterway. Barge loading facilities are located on the Drainage Canal and are currently used to ship oil and marine shell. Although there are no major manufacturing plants in Vinton now, it is likely that industries will locate here in the future. It is also quite probable that they will tend to build in the area south of Vinton, near the drainage canal, and will prompt development in the vicinity of the proposed storage site.

A similar situation in which the candidate site for oil storage was within 3 to 4 miles of a town, was observed at the West Hackberry site. In that case, however, it was concluded that the growth of the community would not present a disparity in land use. The Town of Vinton, however, is presently a larger community than Hackberry, and is likely to grow more rapidly because: (a) it is located on a major Interstate Highway, (b) it is located on a railroad track that has freight service, (c) it has a more plentiful supply of fresh water, (d) it is in an area less prone to receive hurricane and flood damage, and (e) it lies relatively close to the large industrial center of Beaumont, Port Arthur, and Orange, Texas.

C.5.2.8.3 Traffic

During the operation of the storage facility, a daily average of only about 16 vehicles would be traveling to and from the site. This would constitute a 53 percent increase over current usage of Ged Road, but would have no significant impact on the Interstate Highway.

When the oil is withdrawn from the Vinton dome, tankers normally bringing foreign oil into ports along the Neches River could be used to distribute the oil that is not transported via the major private pipelines. The net impact may be a reduction in ship traffic along the Sabine-Neches Waterway, since only about 73 tanker trips would be needed to carry oil from the Vinton dome.

During refill, 58,000 barrels per day would be pumped back to the Vinton dome. This refill, by itself, would take 28 months, during which tanker traffic in the Waterway would increase by 4 percent in the Sabine pass and at Port Arthur, and 8 percent in the Neches River. If both the Early Storage Reserve caverns at West Hackberry (holding 60 million barrels of oil) and the new caverns at the Vinton dome (50 million barrels) were refilled simultaneously, about 128,475 barrels per day would be unloaded at the docks. This would create an increase in tanker trips of 9 percent in the Sabine Pass and at Port Arthur, and 17 percent in the Neches River.

C.5.2.8.4 Housing and Public Services

Because of the permanency of the positions offered by the operation of the facility, it can be expected that all or nearly all of the 15 workers employed at the site would be residents of Vinton. If as many as all 15 of these workers were hired from other communities and moved into Vinton, the effect would be small. Assuming that the size of the average worker's family was four, it would mean that the town had 60 new residents. This represents only slightly more than a one percent increase over the anticipated population of 4,300 at that time.

However, the number of housing units available in Vinton would need to be increased to accommodate the project workers as well as the anticipated growth. The 1970 census listed only 2 homes for sale and 17 for rent at that time. Unless substantial housing development occurred, the project workers would be expected to either commute to the site from larger cities or live in mobile trailer homes until new permanent housing units were completed.

C.5.2.8.5 Economy

The storage project proposed for the Vinton dome is the smallest of those currently under consideration in this region. The impacts on the local economy would also be smaller at the Vinton dome than at the other sites. The payroll of the permanent employees at the Vinton dome would amount to only about $32,000 per month. The combination of payroll and other expenses incurred for the maintenance and repair of the facility would amount to about $77,000 per month.

The incremental increase in local earnings gained directly and indirectly can be ascertained by applying the economic multiplier (2.05). The resultant figure, $157,850 represents only a fraction of a percent of the anticipated 1985 level of earnings in the Lake Charles and Beaumont-Port Arthur-Orange standard metropolitan statistical areas.

During a period of oil withdrawal from the site, the level of expenditure from the project would rise to about $347,000 per month. This increase is attributable to the hiring of additional workers and the need for additional spare parts as machinery is worn or damaged in use. This level of site expenditures would continue for no longer than 5 months.

After foreign oil supplies are resumed, the storage caverns would be refilled. The refill period would extend over two years during which the cost of the facility, excluding the purchase of the incoming oil, would be approximately $160,000 per month.

Use of the Vinton dome would have a strong effect on the town of Vinton. Most of the workers employed at the storage site would be residents of the town since it is only about 3 miles away and is a growing community.

C.5.2.8.6 Government Revenues

As at the other sites previously discussed, use of the Vinton dome would not directly contribute to local government revenues because, as a federally-owned facility, its land and capital improvements would be tax exempt.

Indirectly, however, the local governments would receive monetary inputs from the economic activity that the storage facility generates. Taxes paid by workers is one example of this indirect contribution. Their input from sales tax alone would contribute about $14,500 to local governmental treasuries per year.

C.5.3 Impact Due to Termination

After termination of the SPR program, if the facility was not to be used for any other government purpose, it would be disposed of in accordance with applicable laws and regulations.

C.5.4 Relationship of the Proposed Action to Land Use Plans, Policies, and Controls

A variety of parish, state, and federal agencies have jurisdiction over the lands that would be used if the Vinton site were developed as an oil storage facility.

The site and its related pipelines and brine disposal field lie in Calcasieu Parish. The approval of the Parish Police Jury would be required prior to laying the raw water pipeline across the Ged Road. Unlike other parishes in the region, Calcasieu Parish has the authority to direct development outside of city boundaries through the Comprehensive Zoning Law of Calcasieu Parish, enacted in 1962. Work is currently underway to complete the classification of properties in the parish. The major emphasis in this effort is to allow for the planned growth of urban areas. Lands which would be affected by the proposed facilities at the Vinton site, the brine disposal field and the pipeline corridors have not yet been classified for zoning regulations.

Land use plans for this area have been prepared by the Imperial Calcasieu Regional Planning and Development Commission. These plans indicate that most of the anticipated growth of the town of Vinton will occur west of the present urban area and remain north of Interstate Highway 10. This highway has limited access and provides a barrier between the lands on either side. Some industrial growth is expected to occur along the Vinton Drainage Canal where basic port facilities have been built. The land use plans indicate that the Vinton site is in an area classified as land used for mineral extraction. This use is not expected to change by 1990. The extraction refers to the production of oil occurring around the periphery of the dome. Lands south of the site in the brine disposal field area are designated as agricultural lands in the future land use map. Use of the site for oil storage would not conflict with continued use of the adjacent lands for their established purposes.

The oil distribution pipeline would cross through wetlands southwest of the salt dome. Where public lands would be crossed, the Louisiana State Land Office would be consulted regarding the right-of-way for the pipeline.

The U. S. Corps of Engineers also has jurisdiction over activities in wetlands areas. Construction of pipelines is one of the activities requiring a permit from the Corps. Their permission would also be required for the building of a water intake structure on the side of the Vinton Drainage Canal.

C.5.5 Summary of Adverse and Beneficial Impacts

Table 5.2-2 in Chapter 5 contains a detailed summary of the adverse and beneficial impacts associated with site preparation and construction at the Vinton site, and these impacts are not repeated. In Section C.3.5 the impacts of the proposed site, West Hackberry, were summarized. Only the major differences between the proposed and the alternate site are discussed here.

The major difference between Vinton and the proposed site at West Hackberry is the projected oil storage capacities of the two domes. Vinton, which would only hold 50 million barrels, would have one-third the capacity of an expanded West Hackberry site. Impacts, while not necessarily a direct function of the projected oil storage capacity, would generally be less extensive at Vinton.

Another difference is tht the Vinton site is partially covered by a large lake, Ged Lake. Construction activities on site would tend to impact freshwater biota rather than terrestrial forms.

Brine, rather than being disposed at sea, would be injected into an underground aquifer. Calculations indicate that this aquifer must be at least 32 square miles (if 100 feet in average thickness) and should be 36 square miles in extent to allow a safety margin otherwise the aquifer would fracture. Testing is required to determine if aquifers in the region provide this amount of injection capacity.

C.6 ALTERNATIVE SITE - BIG HILL

C.6.1 Impact on Site Preparation and Construction

C.6.1.1 Land Features

C.6.1.1.1 Geomorphology

Since the Big Hill storage site is dry land, no filling would be required for roads or well pads. Dikes would be constructed for brine and raw water ponds as well as for surface tanks. The dikes would be the only alteration of the natural topography at the site.

Construction of the oil pipeline to the Sun Terminal at Nederland would have no permanent impacts to land forms or drainage patterns along the route. Similarly, construction of either the raw water supply or brine disposal pipeline would have no permanent effects on the land forms or drainage patterns.

Other than the pipeline connection to the existing facilities, no construction of additional facilities beyond those discussed for the proposed site is proposed at the Sun Terminal; therefore, there would be no geomorphic impacts.

C.6.1.1.2 Soils

Only minor impacts to soils would be experienced during the construction of wellheads and service roads and would be confined to the construction site. On-site pipeline construction would result in mixing of the surface and subsurface layers of the Hockley silt loam present. This soil has medium runoff and internal drainage. Disturbance of the soil structure during construction could have only a minor effect on this runoff and drainage characteristic. The construction of the brine pond, raw water ponds, and dikes around tanks would have similar impacts on the soil.

Construction of the oil distribution pipeline from Big Hill to the Sun Terminal would disturb several soil types - the Morey-Crowley-Hockley association and the Beaumont-Morey association predominantly and minor areas of Harris-made land association and Salt Water Marsh-Tidal marsh association. These soils range from very slow to moderate permeability. Their disturbance in the pipeline trench would result in the destruction of soil structure and alteration of drainage characteristics. Surface and subsurface mixing would also occur.

The brine disposal pipeline would impact the Morey-Crowley-Hockley soil association, the Harris-made land soil association and the Sabine Sabine coastal lands soil association. Impacts would be confined to the pipeline trench and would include disturbance of soil structure and mixing of surface and subsurface layers. These impacts could alter drainage characteristics of the first two soils, whereas the Sabine soil would remain well drained.

The raw water pipeline would impact the Morey-Crowley-Hockley soil association and the Harris-made land soil association. The impacts would be similar to those just described. No construction of facilities at the Sun Terminal are proposed. No soil impacts would therefore result from the use of Big Hill as a crude oil storage facility.

C.6.1.1.3 Stratigraphy, Geologic Structure, and Mineral Resources.

There would be no impacts to stratigraphy or geologic structure during construction at the Big Hill storage site, along any of the pipeline routes or at the terminal and dock facilities. It is understood that part of one structural element (the salt dome) would be removed during construction, but this does not alter the description of stratigraphic or structural conditions. Construction activities at the storage site would have no impact on the availability of oil produced along the flanks of the West Hackberry dome. No mineral extraction is occurring within the area of proposed expansion; therefore, no construction impacts on salt or sulfur mining are anticipated.

C.6.1.2 Water

Site preparation and construction at Big Hill would produce certain impacts on the water environment. Subsequent discussion dealing with these impacts is organized in two parts as follows:

- Surface Water
- Subsurface Water

C.6.1.2.1 Surface Water

Each impact on surface water supply or quality can be identified by the activities producing the impact as follows:

Type of Impact	Produced By
Change in Water Supply	Withdrawal of Leaching Water
Change in Water Quality	Withdrawal of Leaching Water
	Disposal of Brine
	Dredging Operations
	Disposal of Dredged Material
	Grading, Excavation, and Filling
	Miscellaneous Construction Activities

Water Supply

The only significant impact on the supply or availability of surface water would result from the withdrawal of water for the leaching operation. The point of withdrawal, as indicated in Figure C.6-1, would be on the ICW, either about 1500 feet east of the junction with Spindletop Ditch or about 3000 feet east of the junction with Salt Bayou. The rate of withdrawal would be 6.86×10^5 bpd (barrels per day) or 2.00×10^4 gpm (gallons per minute). The period of withdrawal would extend over 1144 days (38 months).

If the ICW served as the lone source of leaching water, and if the waterway were completely isolated from other water bodies*, the withdrawal rate previously noted would lower the water level of the waterway .067 ft/day (as explained in Appendix D.22). Because the waterway is connected with Salt Bayou, Star Lake and Spindletop Ditch in the vicinity of the raw water intake(s), and with Galveston Bay and the Port Arthur Canal (part of Sabine-Neches Canal) at

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*Between Galveston Bay and the Port Arthur Canal.

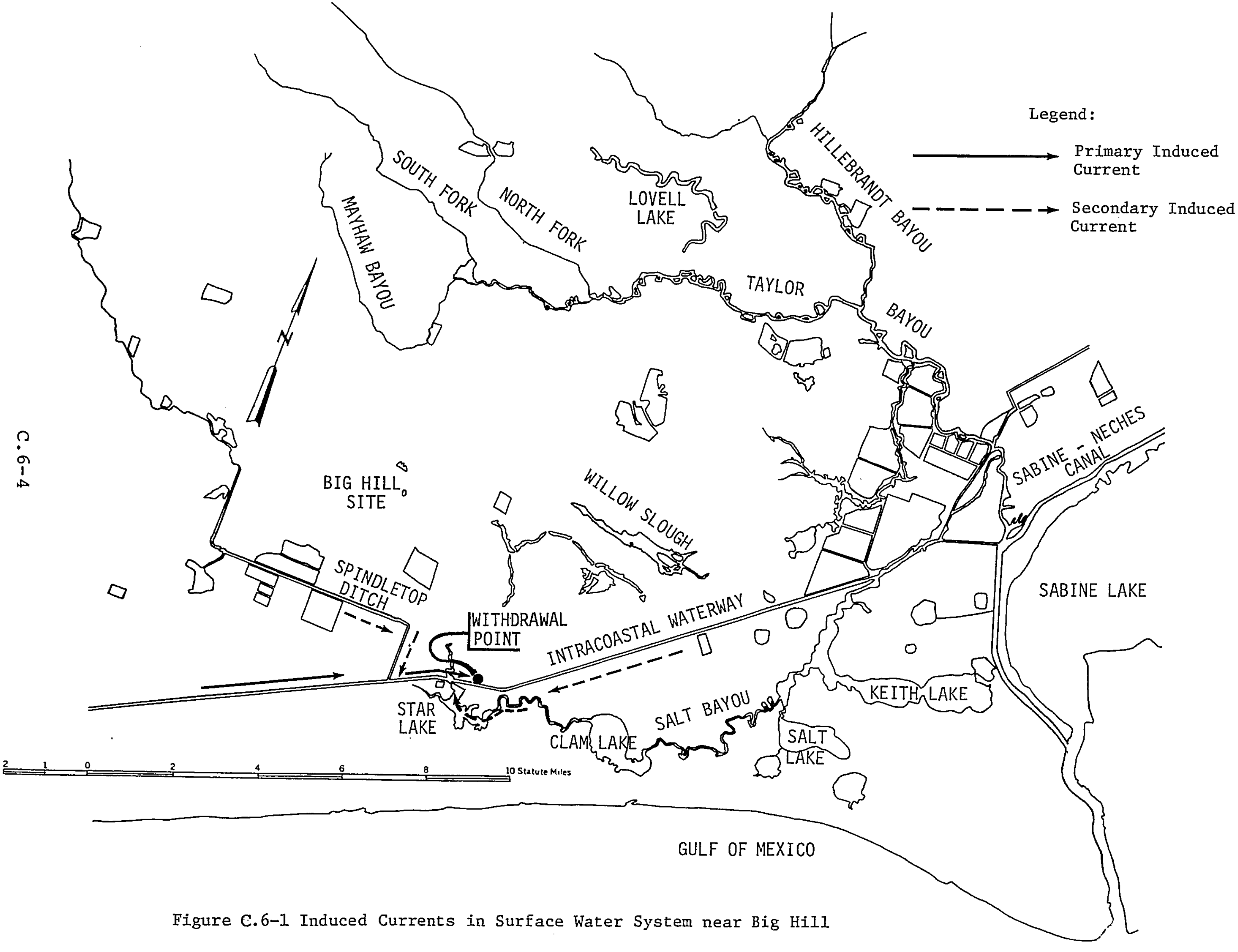

Figure C.6-1 Induced Currents in Surface Water System near Big Hill its ends, the actual rate of descent of water would be somewhat less than the value noted. As indicated in Figure C.6-1, induced currents in the ICW and adjoining streams would serve to replenish the water withdrawn from the waterway. Thus, the ICW should serve as the major replenishment source with a lesser contribution from streams flowing into the ICW.

Flow in the segment of the ICW under consideration is generally from west to east. The withdrawal process would cause an increase of .0124 ft/sec to this existing current. No appreciable impact on the supply of surface water in the area is anticipated.

Water Quality

As noted previously, the surface water system would be affected by six activities as follows:

- Withdrawal of Water for Leaching
- Brine Disposal
- Dredging Operations
- Disposal of Dredged Material
- Grading, Excavation, and Filling
- Miscellaneous Construction Activities

Withdrawal of Water for Leaching. The water quality in the ICW is dependent upon the quality of water flowing into the waterway from Galveston Bay and to a lesser extent upon the relatively small amount of water entering from other sources*. Withdrawal of water would not significantly alter the relative amounts of water entering the ICW from existing sources. Thus, the water quality in the ICW would still reflect the water quality of Galveston Bay and to a lesser degree that of other sources. Specific water quality data for the ICW in the vicinity of the raw water intake is not available at this time. Salinity at the east end of this segment of the ICW is about 15 ppt** and at the west end about 18 ppt. Salinity near the intake site(s) as calculated from specific conductance was less than 2 ppt when measured in March, 1977. Higher salinities would be expected for other seasonal conditions.

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*These other sources include streams such as Salt Bayou and Spindletop Ditch.

**Salinity as calculated from specific conductance.

Based on the available information, the intake of water should not have a significant impact on levels of contaminants in the ICW. Likewise, no significant change in salinity of the ICW or any other water bodies is anticipated.

Brine Disposal. During the leaching process at Big Hill 230 ppt brine would be discharged at a rate of 789,000 bpd or 23,000 gpm for a period of 1144 days. Current design calls for the disposal of the brine by means of discharge into the Gulf of Mexico. The general disposal area in the Gulf is indicated in Figure C.6-2.

The disposal site is similar to that to be used for the West Hackberry facility. Therefore, the proposed specific criteria for the brine diffuser for Big Hill are very similar to those proposed for West Hackberry. These criteria are as follows:

- Diffuser location - approximately 4 miles southeast of that portion of the coastline near Star Lake
- depth of water - approximately 30 feet
- diffuser length - 3070 feet
- diffuser orientation - perpendicular to coast
- number of diffuser ports - 52
- distance between ports - 59 feet
- diameter of ports - 2.45 inches
- orientation of port riser - 90° to ocean bottom
- port exit velocity - 25 ft/sec

An analysis of the impact of the operation of this diffuser on the Gulf of Mexico has been performed as described in Appendix U. The results of this analysis indicate that the impacts at the Big Hill site in the Gulf to be similar to but less than those at the West Hackberry disposal site. Because the rate of discharge at Big Hill is only two-thirds that of West Hackberry, the magnitude of the impact is somewhat reduced. The bottom area exposed to excess salinities greater than 1 ppt amounted to less than 724 acres. The bottom area exposed to excess salinities greater than 3 ppt amounted to less than 52 acres.

Dredging Operations. The dredging operations associated with pipeline construction of the Big Hill facility would consist almost entirely of bucket dredging (except perhaps in the ICW). Depth of burial at stream crossings would be a minimum of twelve

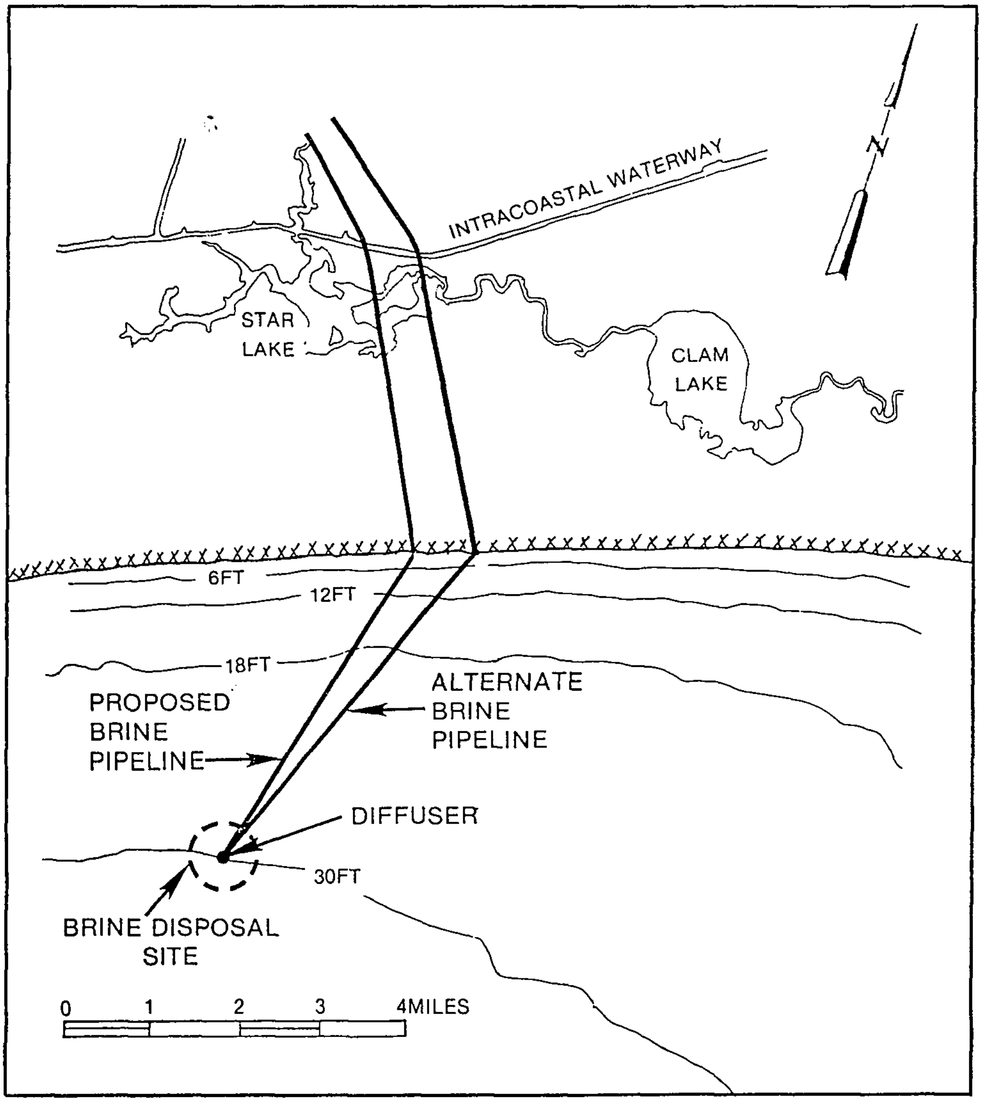

FIGURE C.6-2 **BRINE DISPOSAL SITE FOR BIG HILL** feet for navigable streams and 4 feet for other stream crossings. Figure C.6-2 presents the proposed and alternate brine pipeline routes under consideration for Big Hill.

Dredging in South Fork, Taylor Bayou

The crossings for either of the oil pipeline routes would be approximately 250 feet and would require removal of about 5,000 cubic yards of dredged material. The sediment analyses for Taylor Bayou indicate significant contamination (Section B.3.4.2.1). COD and TKN levels exceed the recommended criteria. This suggests that dredging would depress the dissolved oxygen levels and also cause some release of nutrient materials into the water column. However, these are short-term effects and should be expected to cease a few days after the dredging operation ceases. Also, proper operation of bucket dredging equipment can minimize turbidity increases. More lasting impacts might be caused by release of toxic pesticides or industrial chemicals from the dredged material. The sediment in Taylor Bayou is contaminated with the very slowly degrading and highly toxic PCB compounds. Some release of these would be anticipated during dredging. This could cause minor increases in the ingestion of these materials by aquatic lifeforms and thus, to some degree, increase the accumulation of PCB's in the food-chains. However, no long-lasting detrimental impact is expected from this dredging operation. Oil and grease are often associated with other industrial pollution. These also influence the desorption of pesticides (and probably other organic materials) from sediments. Because DDT and other pesticides are soluble to a much greater extent in oil than in water (a partition coefficient* of about 1×10^6 has been determined for P,P'-DDT), the occurrence of oil and grease in the sediment tends to lessen the amount of pesticides desorbed into the water column during dredging (Hartung and Klinger, 1970). Figure C.6-3 charts the uptake of DDT by sediments in an artifical river containing 1.24 ppb of DDT in water.

Dredging in North Fork, Taylor Bayou

The oil pipeline crossing of this stream occurs at a point where the width is about 125 feet. The dredging operation would involve dredging of about 3,200 cubic yards of material. The impacts discussed for South Fork, Taylor Bayou are equally applicable to this dredging operation.

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*This partition coefficient is defined as the ratio of the concentration of P,P'-DDT in the oil to the concentration of P,P'-DDT in the water.

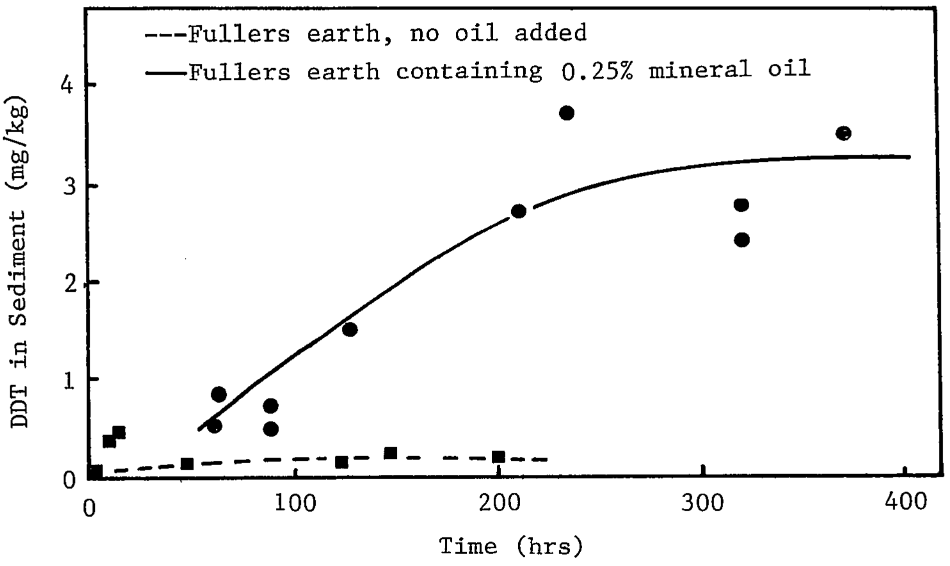

Figure C.6-3 Uptake of DDT by sediments in an artificial river containing 1.24 ppb DDT in water

Dredging in Lovell Lake

An oil pipeline (Route 2) would cross Lovell Lake. The crossing would be about 500 feet across and require removal of approximately 10,000 cubic yards of dredged material. No water or sediment quality data are available for Lovell Lake. However, it is expected that the water and sediment quality in Lovell Lake is comparable to that in Taylor Bayou and its tributaries. Thus, the impact of dredging should also be similar except that because of fewer currents in the lake the impact should be more intense for a more localized area.

Dredging in Hillebrandt Bayou

Both oil pipeline routes would cross Hillebrandt Bayou. The stream width at the point of crossing would be about 250 feet and approximately 25,000 cubic yards of dredged material would be involved. The water and sediment data (Section B.3.4.2.1) are much the same as for Taylor Bayou. Excessive levels of COD, TKN, lead, zinc and PCB's are present in the sediment. Thus as for earlier cases some release of toxic materials would be expected. However, the major impact would continue to be the transient increase in turbidity and decrease in dissolved oxygen.

Dredging in Taylor Bayou

An oil pipeline (Route 1) would require dredging across a 250-foot stream bed. The operation would involve removal of approximately 25,000 cubic yards of dredged material. The same impacts are involved as at the North and South Forks and at Hillebrandt Bayou.

Dredging in the ICW

Either of the brine disposal lines would require dredging in the ICW. The crossing(s) would be about 300 feet. The amount of dredged material would be approximately 52,500 to 60,000 cubic yards. In addition, dredging of about 8040 cubic yards of sediment would be required for the raw water intake connection. Water and sediment analysis data indicate high phosphorous levels in the water column and high levels of COD and nitrogen containing substances in the sediments. Thus dredging can be expected to increase turbidity, release oxygen-consuming materials resulting in lower dissolved oxygen levels, and also to release nitrogenous materials, possibly causing increases in biological production, further depleting oxygen levels.

Dredging in Salt Bayou

Brine disposal lines would cross Salt Bayou. Either crossing would be about 200 feet and require dredging of approximately 20,000 cubic yards of dredged material. The impacts would be comparable to those for the ICW. As the degree of pollution in Salt Bayou is very similar to that for the ICW, the most significant impacts would also be the transient increase in turbidity and decrease in dissolved oxygen. These impacts would dissipate a few days after the completion of dredging. However, the damage to the biota would be greater in Salt Bayou, as indications are that Salt Bayou has not been previously disturbed as has the ICW (Robertson, 1977).

Dredging in Spindletop Ditch

Dredging in Spindletop Ditch could involve either or both a raw water intake pipeline and a brine disposal pipeline. Either would require a crossing of about 200 feet and removal of approximately 20,000 cubic yards of dredged material (both lines). Water and sediment analysis currently available, indicates high levels of organic nutrients in both the water column and the sediments. High conductivity values and the presence of oil and grease in the sediments indicate that oil production wastes probably enter the ditch. The impacts due to dredging would be a transient turbidity increase, oxygen depletion, and releases of nutrients and oil and grease.

Dredging in Marshes

Both freshwater pipeline routes and both brine disposal pipeline routes would cross marshes south of the Big Hill Salt Dome. Depending on the routes between 9.0 and 11.7 miles of pipeline would cross these marshes. The dredging would be the push-ditch type, using dredged material for back-fill. The amount of dredged material would be about 843,750 to 1,096,875 cubic yards. The impacts of this dredging operation would be localized very close to the actual dredging operation. Major impacts would be increases in turbidity and nutrient levels accompanied by decreases in the dissolved oxygen level. These impacts would last only a short time after the dredging and back-fill operations. No long-term impacts are anticipated.

Disposal of Dredged Material. Dredged material would be disposed of in confined areas near the dredging sites. Most of the land area involved would be marshes. The general impacts to be expected are discussed in detail in Section C.3.1.2.1. These include impact of the spoil on the confinement area and the impact of effluent from the disposal area on the streams.

Impacts Due to Effluent from the Disposal Areas

The spoil confinement sites are located near the water bodies from which the spoil is removed. As discussed in Section C.3.1.2.1, effluent from these disposal areas is normally returned to the adjacent water body. Such a practice tends to reintroduce some desorbed contaminants into the neighboring water bodies.

Major contaminants likely to return to nearby waterbodies would consist mainly of organic nutrients. Some minor impacts such as turbidity increases, dissolved oxygen depletion, and possibly some release of oil and grease would also occur.

Grading, Excavation, and Filling. The site preparation and construction activity would involve a significant amount of earth movement during a 5-month period. Approximately 140 acres of land would be disturbed. Based on the analysis presented in Appendix D.15, approximately 1,427 tons of 1,409 cubic yards of sediment would be washed into the surface water system during the 5-month period as a result of erosion of this disturbed land by rainfall. Of this total, as shown in Figure C.6-4, 1,053 tons would be deposited in Spindletop Marsh and possibly Salt Bayou Marsh to the sourth. The remaining 374 tons would be transported to the north. A portion of this sediment would be deposited in Willow Slough,which drains into Willow Slough Marsh to the east. The remainder would ultimately pass into Mayhaw Bayou to the northwest. Because the soil involved would be a silt loam, the minimum rate of settling would be .018 mm/sec as shown in Figure C.3-9.

The introduction of such sediment into these water bodies would slightly increase the average level of suspended solids. This increased level would persist for essentially the entire five-month period.

Miscellaneous Construction Activities. Two general types of pollutants (chemical and biological) can be generated during construction activities at Big Hill. A complete list of the types of chemical pollutants is found in Section C.3.1.2.1. In general, most releases of the pollutants arise from excessive or improper use of industrial and agricultural chemicals on or near the construction site. Additional releases can arise from improper storage and disposal operations.

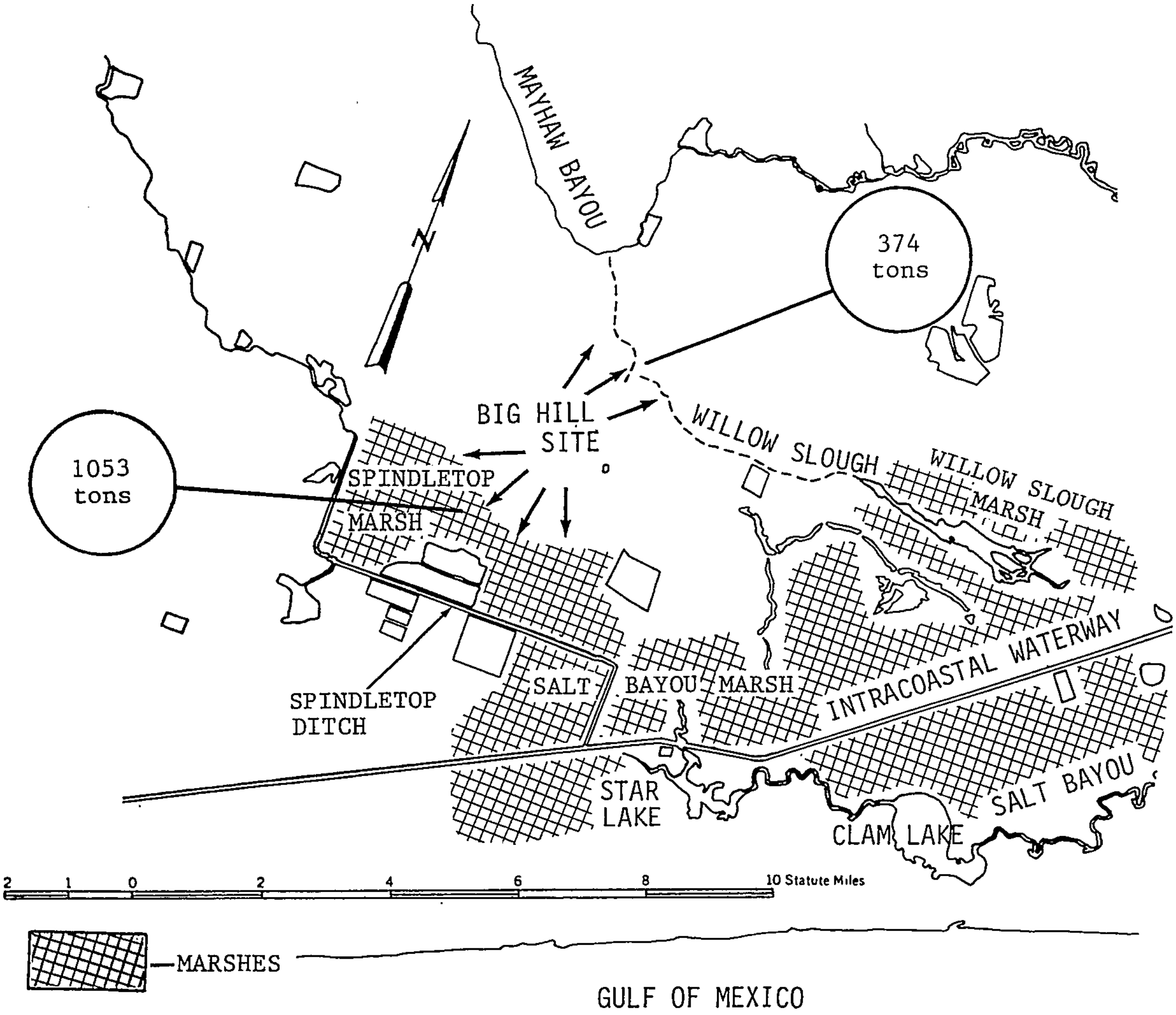

Figure C.6-4 Sediment Transport in the Vicinity of Big Hill

Impact on Disposal Areas

Confined disposal sites would be required for dredged material from the following bodies of water:

- South Fork Taylor Bayou
- North Fork Taylor Bayou
- Lovell Lake
- Hillebrandt Bayou
- Taylor Bayou
- ICW
- Salt Bayou
- Spindletop Ditch
- Marshes

Spoil disposal sites would normally be located near or adjacent to the body of water being dredged. Earlier discussions of the impact on spoil disposal areas are applicable to these sites. Some impact due to the sediment contamination is expected at each site. However, the general impacts due to contamination of sediments should be less of a factor for Salt Bayou, where biological collection of invertebrates indicates good water quality (Robertson, 1977).

A major impact of spoil disposal operations is the loss of wetlands habitats. The following is a summary of the wetlands habitat losses which would be expected:

Disposal Site+	Loss of Wetlands Habitat (Acres)*
South Fork Taylor Bayou	0.5
North Fork Taylor Bayou	0.4
Lovell Lake	1.0
Hillebrandt Bayou	2.6
Taylor Bayou	2.6
ICW	6.2-7.0**
Salt Bayou	2.1
Spindletop Ditch	2.1

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*This is based on the assumption that the spoil material would be deposited to a depth of two feet in disposal areas.

**ICW data includes dredging for raw water intake facility.

+The spoil disposal sites are located near the water bodies named in the table.

Biological pollutants are generally the result of poor sanitary conditions at a construction site. As a result, bacterial, viral and other organisms can be carried into the nearby water bodies. These pollutants are detrimental to water quality and other organisms. A major concern arises from release of pathogenic organisms associated with human waste.

Prediction of impacts due to these types of biological and chemical pollutants is not feasible because of the human element involved and the present lack of detailed design information. In any case, the degree of pollution can be minimized through proper disposal practices.

C.6.1.2.2 Subsurface Water

Current design for the Big Hill facility does not involve the use of shallow aquifers as a source of leaching water nor the use of the deeper aquifers as a site for brine disposal. Thus the subsurface water system should experience no impact as a result of site preparation or facility construction.

C.6.1.3 Air Quality

C.6.1.3.1 Sources of Emissions

The construction of the proposed oil storage facility at Big Hill would result in combustion and fugitive emissions along the pipeline right-of-way and at the dome and Sun Terminal locations. Many of these emissions would be insignificant and would exert a negligible impact on local ambient air quality. A list of the types of emission sources existing during site construction activities follows:

- Site Preparation
- Unpaved Roads
- Paved Roads
- Heavy-Duty, Diesel-Powered Equipment
- Light-Duty Vehicles
- Drill Rigs
- Storage Tank Preparation
  a. Surface Grinding
  b. Paint and/or Primer Application

A detailed discussion of these emission sources and their characteristics is contained in Section C.3.1.3.1. Annual tonnage emission rates from these sources are summarized in Table C.6-1.

C.6.1.3.2 Emission Control Technologies

The emission control technologies that would be applicable to Big Hill SPR facilities are the same as those described in Section C.3.1.3.2.

C.6.1.3.3 Emission Regulations and Standards

The emission regulations and standards applicable to Big Hill SPR facilities are discussed and contained in Section C.3.1.3.3.

C.6.1.3.4 Air Quality Impact

The short-term and long-term modeling approaches utilized in the assessment of Big Hill air quality impacts are the same as those discussed in Section C.3.1.3.4.

Table C.6-1

Annual Tonnage Emission Rates At Big Hill During Construction*

Source or Activity	Annual** Emissions (Tons)				
	HC	Pa	SO_2	NO_2	CO
Site Preparation	-	12,571	-	-	-
Unpaved Roads	-	269	-	-	-
Paved Roads	-	0.6	-	-	-
Heavy Duty, Diesel Powered Equipment(1)	0.5	0.3	0.5	7.4	1.4
Light-Duty Vehicles	0.3	0.05	0.01	0.5	3.5
Drill Rigs	9.9	9.0	8.1	126	27
Surface Grinding Tanks	-	3.1	-	-	-
Painting - Tanks(2)	5.3	-	-	-	-
Total - Construction	16	12,853	9	134	32

* Includes construction activities at dome and terminal sites and along pipeline right-of-way

** If activity persists for less than a year (e.g. painting - tanks) than total emissions for this shorter period are listed

1. The dome and terminal sites considered as independent construction sites of equal magnitude.
2. Two coats of paint

Maximum construction-phase impact on ambient quality can be attributed to tank preparation and land preparation activities. Short-term modeling of tank surface preparation indicates that the 24-hour particulate standard would be exceeded out to a downwind distance of 1 kilometer or well within probable plant site boundaries. The application of paint would result in exceeding the three-hour NMHC standard out to a downwind distance of approimxately 4 kilometers as indicated in Figure C.6-5. Figure C.6-5 presents conditions at the Sun Terminal, but the distribution is also pertinent to the dome site. The maximun frequency of violation would amount to roughly 1 percent of the time annually, and would occur to the west of the dome and Sun Terminal sites. The predicted frequency of violations is based upon the use of annual meteorological data. The actual painting process would require less than one month at each location, and the actual impact would be a function of the meteorological conditions during that period. Depending upon meteorological conditions, at the time, the indicated violations may be limited to within the probable plant site boundaries.

Long-term or annual pollutant ground level concentrations would be insignificant for construction phase activities with the exception of large-scale land-clearing operations at the dome and Sun Terminal locations. The modeling results are presented in Figures C.6-6 and C.6-7, and they indicate that the Federal Primary Standard for particulates would be exceeded within approximately 1 and 2 kilometers of the construction areas at the Sun Terminal and dome site, respectively. These violations could be eliminated through the use of an effective watering program as suggested by USEPA (EPA 1971).

The remainder of the construction-phase sources are mobile and are fairly widely distributed. As a result, their impact on ambient air quality tends to be local and of a short duration. Such sources include vehicular usage and fugitive dust losses from project roadways.

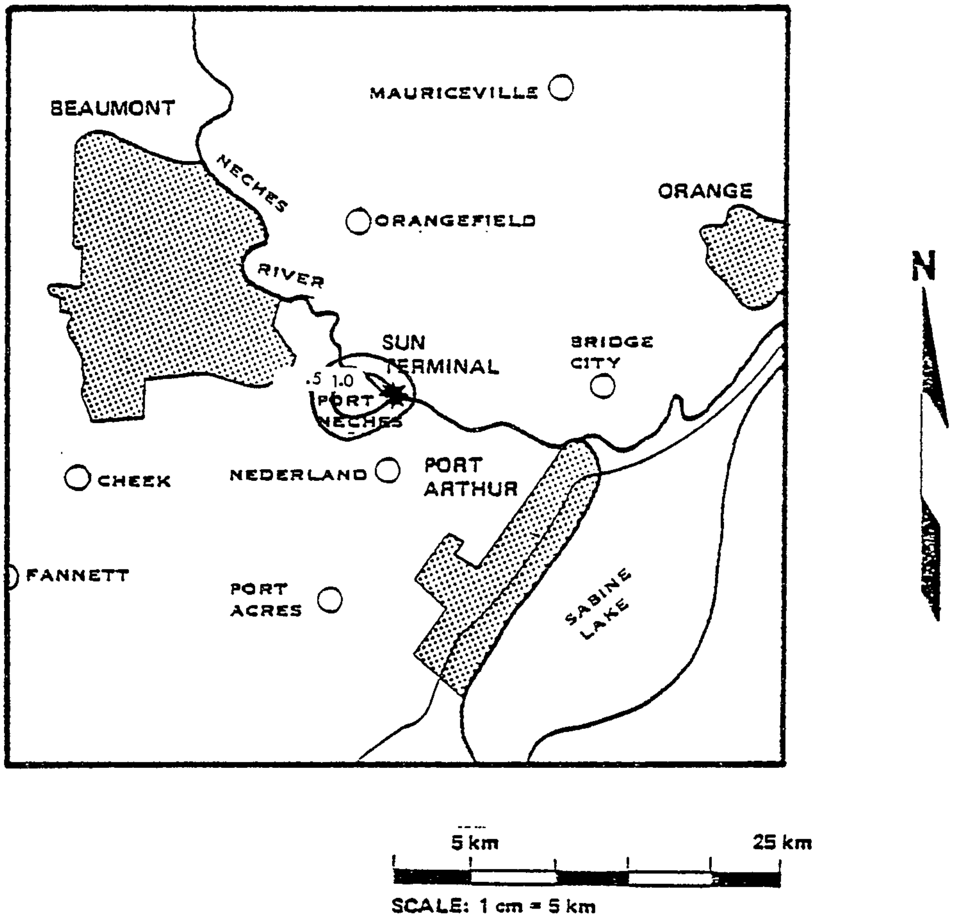

Figure C.6-5 Annual Frequency of Occurrence (%) of Violations of the 3-hour NMHC Standard for Tank Painting at the Sun Terminal During the Construction Phase at Big Hill*

*Distribution will be identical at the Dome Site

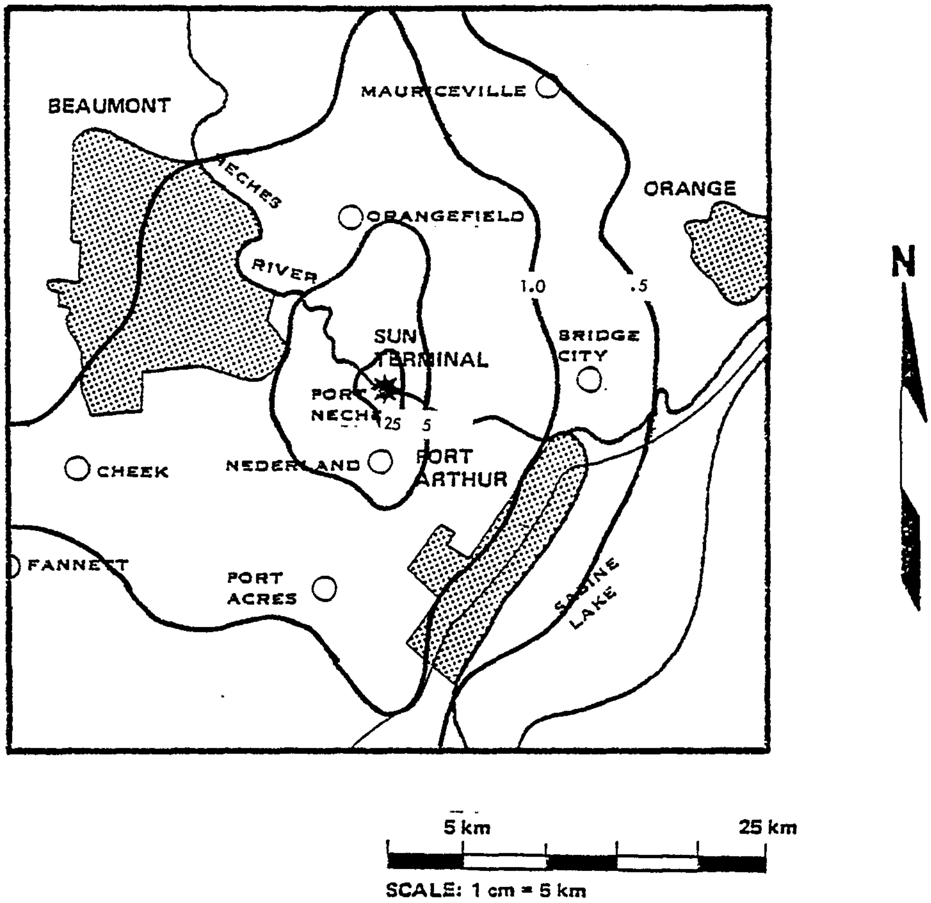

Figure C.6-6 Annual Average Particulate Ground Level Concentrations (μg/m^3) for the Sun Terminal for all Texoma Sites During the Construction Phase

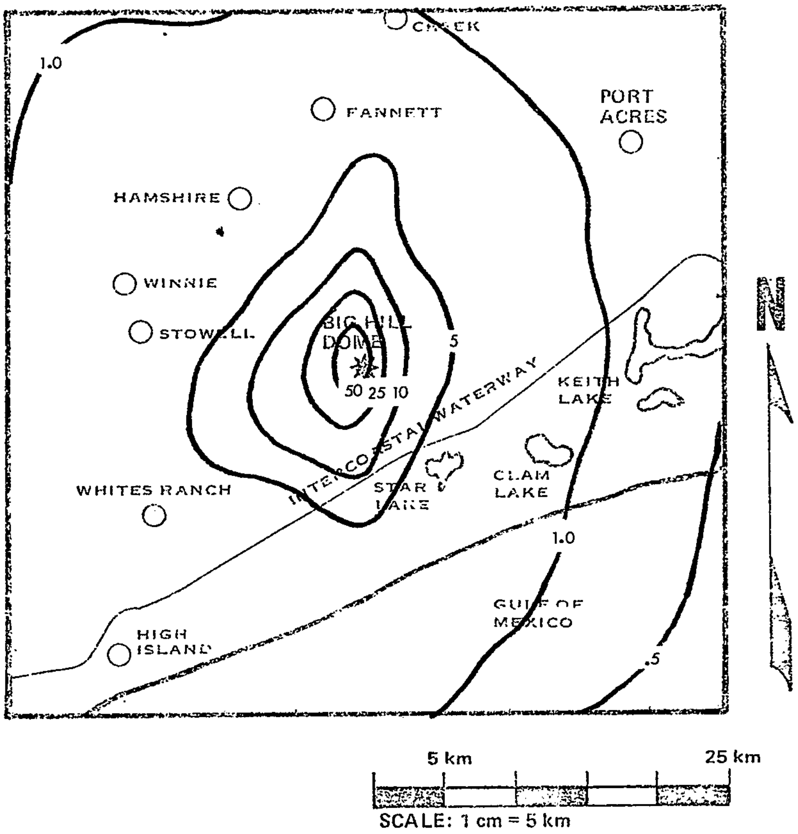

Figure C.6-7 Annual Average Particulate Ground Level Concentrations (µg/m^3) at the Dome Site During the Construction Phase at Big Hill.

C.6.1.4 Noise

Construction activity associated with development of the Big Hill salt dome alternative to the West Hackberry expansion may affect ambient noise levels at the storage site and in adjacent areas where construction will be required in conjunction with the site preparation. The principal sites which have been identified for construction activities are:

1. Oil Storage Site Area
2. Pipeline Corridors
3. Terminal and Dock Area.

An assessment of noise impacts at these locations is given in the paragraphs which follow. For an explanation of terminology, propagation model and noise guidelines, see Appendix F.

Oil Storage Site Area

The development of the Big Hill salt dome as an alternative to the proposed expansion of the West Hackberry ESR would require creation of twelve caverns on a 600-acre site approximately twenty-six miles southwest of Nederland, Texas. The existing site, which is on solid dry ground would require construction of a central plant which would include office, control, pump, repair and laboratory buildings. Approximately 1.5 miles of new roadway would be needed. The contributing noise sources at the storage site area during site preparation would be trucks, earthmoving equipment, compressors, drilling rigs, impact equipment,concrete mixers and general construction-related equipment. Noise levels typical of this equipment are given in Table F-1 of Appendix F. The evaluation of the construction noise sources indicates that diesel engines would provide the most consistent source of noise and that impact and drilling equipment would create the peak sound levels. The areas adjacent to the storage site are mostly sparsely cattle grazing land. Assuming both day and night time drilling activity of two drill rigs, it is estimated that the equivalent sound level contribution (L_{eq}) of the site preparation activity would be no more than 55 decibels (dB) at 2,000 feet from the center of the site. The contribution of storage site construction activity to annual day-night levels (L_{dn}) assuming six months of drilling activity is estimated to be no more than 55 dB at 2,000 feet from the center of the site.

Pipeline Corridors

Three major pipeline constructions would be required for servicing the Big Hill storage site. One of approximately twenty-six miles would be used for oil distribution. The proposed oil pipeline would terminate at the Sun Terminal to the northeast. A second pipeline construction of 13.2 miles would be required for brine disposal. The third pipeline of approximately six miles would be used to bring raw water from the ICW to the storage site. Except for short stretches of the oil distribution pipeline, the areas traversed by these proposed pipeline routes are largely uninhabited regions. Tables F-2 and F-3 in Appendix F show typical equipment for pipeline construction. Assuming daytime activity only, it is estimated that pipeline construction noise would contribute no more than 55 dB to the equivalent sound level (L_{eq}), at a distance of 500 feet from the pipeline right-of-way. The annual (L_{dn})levels along the pipeline are not expected to be affected because of the relatively short period of construction activity at specific sites.

Terminal and Dock Area

The Sun Terminal and dock at Nederland, developed under the ESR development at West Hackberry, would also be used for the Big Hill site. No changes in terminal and dock construction from those required by the expansion at West Hackberry are anticipated. Noise assessment for that expansion is contained in Section C.3.1.4.

Summary of Noise Impacts

Noise impacts from the construction associated with the site preparation for the West Hackberry expansion are summarized in Table C.6-2.

Table C.6-2. Summary of Sound Level Contributions (dB) from Construction Activities for the Big Hill Alternative

Construction Site	L_{eq}	L_{dn}	Distance from Center of Site
Storage Site Area	<55	<55	2,000'
Pipeline Corridors	<55	<55	500'

C.6.1.5.1 Displacement/Leaching Water System Construction Impacts

Water would be used to leach the cavities in the Big Hill salt dome and to displace the stored crude oil during withdrawal. The proposed water source is the Intracoastal Waterway at a point 5.0 miles southeast of the dome.

Proposed

Dredging of 8,060 cubic yards would be required for the intake station. Dredging would eliminate marsh and spoil bank plants and animals in its path and increase suspended sediments. The resulting turbidity would reduce plankton and epiphyte productivity in adjacent areas. Dredge spoil would smother vegetation and benthic organisms. Marsh plants such as *Paspalum vaginatum*, wiregrass, bullwhip, three-cornered grass, bulltongue, and alligator-weed and spoil bank plants such as roseau, eastern baccharis, willows, broomsedge, rattlebox, rushes, and marsh elder would be affected. Some snails and insects on these plants would be killed. Such soil organisms as protozoa, insects, bacteria, algae, fungi, and worms would also be killed. Epiphytes in the area include various green, red, and blue-green algae. Phytoplankton of the area include diatoms, green algae, blue-green algae, and dinoflagellates, while the zooplankton include copepods, cladocerans, rotifers, and larvae of the phantom midge. Benthic animals in the marsh include forms such as midge larvae, oligochaete worms, amphipods, clams, crabs, sponges, isopods, moss animals, shrimp and barnacles.

The size of the area which would be covered by dredged material is 1.8 acres. The gross primary productivity of the marsh is about 8,450 g. dry wt. of organic matter/m^2/year for both marsh grass and epiphytes (Day et al. 1973). Vegetation on that area of the marsh covered by spoil would be destroyed. This means that approximately 6.2×10^4 kg/yr. would be lost if vegetation were not reestablished. Noise and increased human activity would force mobile wildlife, especially birds, to evacuate the area temporarily. Rapid reestablishment of benthic organisms (within 6 months) where dredging occurs is anticipated. Phytoplankton and zooplankton productivity would return to normal due to a lessening of turbidity after settling occurs, and mobile animals should return soon after construction is complete (within 2 to 3 months).

Another impact of constructing the displacement water system would be destruction of organisms along the path of the pipeline linking the intake station to the storage site. This destruction would occur in a strip of indefinite width which would extend through 1.5 miles of former prairie and 4 miles of marsh. It is estimated that the strip would be narrower than the permanent right-of-way of 50 ft on dry land and the equivalent of one-half the constructed right-of-way of 150 ft in the marshes. The biota on less than 9 acres of dry land and in slightly over 36 acres of marshland would be destroyed, according to these estimates. The types of marsh organisms which would be killed have been discussed above in connection with construction of the intake station.

According to the Soil Conservation Service, it is estimated that 10 percent of former prairie grassland is natural vegetation, 30 percent is pastureland, and the rest is cultivated for rice production. Assuming this is representative for the pipeline route, then 5.4 acres of rice cropland, 2.7 acres of cattle pasture, and 0.9 acre of natural vegetation would be impacted. The cost of the disturbance to the rice crop for one year would be approximately $1,242. The loss of potential beef production on the pastureland is valued at $734 for one year (Knox and Oakes, 1976*). Grazing would return to normal in the right-of-way within a two-year period. The estimated economic loss would total less than $3,000.

Pastureland plants in the area include some naturally occurring marsh and prairie species as well as introduced kinds such as ryegrass, white clover, Bermuda grass, dallisgrass, and legumes. Natural prairie vegetation of the area includes bluestem, Indian grass, switchgrass, prairie wildgrass, huisache, and mesquite. The types of soil organisms which would be affected have been listed above in connection with effects on the spoil bank biological community of constructing the intake station.

Wildlife and marsh and field birds would be disturbed and briefly displaced during construction. The disturbance would be of short duration, probably lasting no more than two weeks in a given location. The wildlife involved includes typical small mammals such as rabbits, skunks, opossums, muskrats, snakes, lizards, alligators; marsh birds such as herons, egrets, ducks, and geese, and amphibians such as frogs and salamanders would be disturbed. Deer might also be affected. Some nests and resting places would be destroyed or altered by construction and some less mobile vertebrates would be killed.

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*Based on a six-year average for the area of $272/acre/year for calf production.

As mentioned, the primary displacement pipeline would impact approximately 36 acres of marshland. Typical marshlands in the Gulf coast have a gross primary productivity of 8,450 g dry wt. of organic matter/m2/year. Thus, there would be a temporary production loss over a period of up to 2 years of 2.4 x 10^6 kg. (Day et al. 1973). Approximately half of the standing vegetation productivity would be available for tidal export. Using a minimum direct value of marsh byproducts (fish, shellfish, recreation, etc.) estimated at $100 per acre (Gosselink, et al. 1974), losses would amount to $3,600 per year assuming that complete loss of fisheries or recreational usage of the entire right-of-way acreage. Assuming an "ecological life-support value" of $4,100 per acre as postulated by J. G. Gosselink and others (1974), the losses associated with pipeline construction would be $148,000 per year. The "ecological life support value" is a translation from energy use in the marshland into monetary terms. The biota of the areas affected by the pipeline construction would probably recover within 1-2 years.

Alternative

Construction of the alternative displacement/leachwater system would have the same kinds of species and ecosystem impacts as the primary system except for disturbances associated with the pipeline right-of-way. Construction of the alternative pipeline would impact less than 34 acres of prairie grassland, and 12.5 acres of marshland. Using the same assumptions for the alternative pipeline that were used for the proposed pipeline, this means a loss in prairie grassland of $4,754 in rice crop per year and $2,774 per year in calf production. In the marshland, the gross primary production loss would total 8.6 x 10^5 kg for two years of construction related impacts. The estimated fisheries loss at $100/acre/year (Gosselink et al. 1974) would be $1,250 per year. The maximum estimated "ecological life-support value" loss to the marsh area associated with construction of the alternative pipeline through the marsh would be $51,250 per year at $4,100/acre/year (Gosselink et al. 1974). The biota of the areas affected by the pipeline construction would probably change within 1-2 years.

C.6.1.5.2 Brine Disposal System Construction Impacts

The proposed method of brine disposal for the Big Hill salt dome site would be via release into the Gulf of Mexico. The surge pond and pump system are part of the central plant facilities and construction impacts associated with them are discussed in Section C.6.1.5.3.

Proposed

As discussed in Appendix A.7.4, the proposed pipeline for brine disposal would be an 36-inch diameter lined steel pipe which would cross 1.7 miles of prairie grassland, and 7.3 miles of marshland before reaching the Gulf of Mexico. The pipeline would be in the same right-of-way as the displacement/leach water pipeline until it crossed the ICW, and impacts to this point would be the same. The diffuser would be located 3.5 miles off-shore and biota in the Gulf would be impacted over this distance by burial of the brine line and diffuser.

The permanent right-of-way would be 50 feet on dry land. This would amount to approximately 10 acres over 1.7 miles. According to the Soil Conservation Service, it is estimated that 60 percent of former prairie grassland is cultivated in rice, 30 percent is pastureland for cattle, and 10 percent is natural vegetation. This would amount to a gross production loss of $1,380 for rice ($230/acre/year) and $876 for calf production ($272/acre/year) or a total loss of approximately $2,196 per year for the first year. It is estimated that it would take up to two years for pasture to return to normal, so the total production loss for dry land is estimated at $3,012. This would only be an additional net production loss of $303, due to the fact that the brine disposal pipeline would be in the same right-of-way as the displacement/leach water pipeline. The types of organisms which would be impacted by construction of the pipeline on dry land have been discussed above in connection with impacts from construction of the water supply line (Section C.6.1.5.1).

It is estimated that biota in approximately 66.4 acres of marsh would be destroyed by construction of the proposed brine disposal pipeline. This equals half of the construction right-of-way. This would cost a gross primary production loss of 2.3×10^6 kg/year, using productivity values of Day et al. (1973). The maximum estimated loss over up to two years is 4.6×10^6 kg dry wt of organic matter, and, because the the brine disposal pipeline is located in the same right-of-way as the displacement water pipeline, the net increase for the brine disposal pipeline is 2.2×10^6 kg/year. Using the minimum direct value of marsh byproducts ($100/acre/year (Gosselink, et al. 1973) the net loss to the ecocystem would amount to $3,040 for each year of the two year construction period. The maximum net "ecological life support value" loss is estimated at $249,280 over two years. Also mobile wildlife including waterfowl, alligators, and small mammals would temporarily emigrate from the construction area due to noise. This would probably cause slight stress in the form of negative behavior reactions from existing wildlife in these areas.

Such animals would be similarly disturbed along the rest of the route as far as the Gulf. In the process of reaching the Gulf, the brine line would cross both the ICW and sandy beaches. Impacts associated with the ICW would include direct elimination of immobile benthic forms due to the laying of the pipeline, emigration of mobile nektonic forms due to increases in suspended sediments, and stresses on organisms which are not mobile enough to move from the areas affected by the increases in suspended solids. Near sandy beaches, vegetation and animals such as waterfowl (shore birds), crabs, and beach-dependent fish would all be disturbed from the laying of the brine line. But, because of the frequent shifting of the beach materials and the behavior and physiological characteristics of the organisms that reside there, a relatively rapid recovery of biota in this ecosystem is anticipated. (For a more indepth discussion of impacts related to shore life see Section C.3.1.2.5).

Toward the coast the marsh plant species composition gradually shifts so that waterhyssop, saltgrass, and wiregrass become more important. Species near the ICW were discussed in connection with the water supply system (Section C.6.1.5.1). Batis, saltgrass, and oystergrass dominate on and near the coast. This change in species is paralleled by changed in benthic organisms and fish species. Benthic organisms near the ICW were discussed in connection with the water supply system (Section C.6.1.5.1). Toward the coast the variety and numbers of mollusks, crabs, other crustaceans, polychaete worms and certain others increase. These habitats toward the coast serve as especially good nursery areas for economically important species such as white and brown shrimp and blue crabs. Fish species near the ICW include salinity-tolerant freshwater forms such as largemouth bass, sunfish, channel catfish, and buffalo and mosquito fish. Toward the coast they include such forms as killifish, mollies, menhaden, and red drum and nearly all of the species present farther inland are missing. Marsh biota would be expected to be fully reestablished within two years after the destruction caused by pipeline construction.

Once the pipeline reaches the Gulf, an area up to 50 feet wide by 4 miles long (30.3 acres) would be temporarily disturbed by pipeline burial. This disturbance would force mobile nektonic and benthic animals to emigrate from the immediate area for a short time. Alterations in populations of mobile animals along the immediate vicinity of the route are expected to last no more than six months. A slight increase in turbidity would reduce primary production, but this also would be restricted to the immediate route area and should be evident for no more than six months. Immobile or nearly immobile benthic animals (Polychaetes, phoronids, pelecypods) and benthic algae would be eliminated where the bottom is trenched. In all cases given above the effects of pipeline burial would occur and disappear within 2 years. The magnitude of these disturbances is insignificant when compared to the large area of similar Gulf environment which would remain undisturbed. Large populations of organisms are available on the Gulf bottom which would colonize the disturbed portion of the Gulf within a 6 month period.

Alternative

Production losses which would be associated with construction of the alternative brine disposal pipeline differ from those which would be associated with the proposed pipeline. However, the types of organisms which would be impacted are the same. The alternative pipeline would traverse 4.4 miles of former prairie grassland and 4.2 miles of marshland. The loss of production on former prairie grassland is valued at $5,520 for rice production over one year and $6,528 for calf production over two years, giving a total of $12,048. The alternative brine disposal pipeline would run in the same right-of-way as the alternative leach/displacement water pipeline as far as the ICW. The estimated additional farm production losses on dry land associated with the alternative route as compared to the primary route would have a value of $9,036. The estimated farm production losses on the south side of the ICW, where the pipeline would not run together with the water supply line, are valued at $1,746.

The gross primary productivity losses for the 38.2 acres of marsh which it is estimated would be impacted, would total 2.6 x 10^6 kg. dry wt of organic matter for the two-year maximum construction impact period (assuming 8,450 g dry wt organic matter/m^2/year for marsh grass and epiphytes taken together). The loss of marsh gross primary productivity would be greater with the proposed brine disposal route than with the alternative by 2.0 x 10^6 kg dry wt of organic matter. At approximately $100/acre/year for fishery and recreational value (Gosselink, et al. 1974), the loss of 38.2 acres is valued at $3,820/year. Assuming an "ecological life support value" of $4,100/acre/year (Gosselink, et al, 1974), the value of the marshland losses would be $156,620/year. The estimated value of marsh losses associated with construction of the proposed brine disposal pipeline would exceed that associated with construction of the alternative by $2,800 and $116,020 for assessments based on fishery/recreational uses and "ecological life support value" respectively.

C.6.1.5.3 Impacts at or from the Storage Location

The proposed Big Hill storage site is located in a prairie-pastureland ecosystem. Agricultural productions is carried out in outlying areas but not at the site itself. Cattle roam freely over the site and the naturally occurring grass species are kept short by grazing. The environmental setting of the site is described in detail in Section B.3.4.5.3.

Because the area has been used extensively for oil and gas production, access to the dome already exists. However, it would be necessary to construct approximately 2 miles of road for access to wellheads. Roads would be covered with shell, gravel, or asphalt shortly after construction and any impact, with the exception of permanent loss of primary productivity, would be temporary and insignificant.

A total of 230 acres of pastureland would be fenced surrounding the site. This acreage would include the central plant area and the wellheads. Because the area would be enclosed, cattle grazing on the site would be discontinued for the life of the project. Mowing would replace grazing for keeping the grass short,and therefore, it is not expected that the fencing of the storage site would bring about a change in species composition by succession.

Construction activities would discourage use of the site by wildlife and would possibly destroy a small number of rabbit and other small animal burrows. Since the area is currently used for grazing, it is unlikely that any ground nesting birds have established residence on the dome. Construction related noise levels would have only a slight impact on species at the site. During construction the maximum noise impact radius would be 2,000 feet from the center of the site. Assuming this was the case, the noise levels would be undetectable outside of a 1/2 mile limit around the site. There would be no noise impacts to the waterfowl and other wildlife populations that winter in the marshlands to the south of the dome. There would be a slight noise impact to the species which inhabit the prairie and pasture areas immediately surrounding the storage site. This impact could stimulate migration of certain species of birds and mammals and could inhibit nesting activities within a 2,000-foot radius of the center of the site.

The primary impact to species and ecosystems would result from increased turbidities in surface waters in the vicinity of the dome. Earth-moving during the 5-month construction period would result in 1409 cubic yards of sediment being washed into Spindletop Marsh, Salt Bayou Marsh, Willow Slough and Mayhaw Bayou (see Section C.6.1.2.1). This increase in turbidity would cause a temporary reduction in primary productivity in these water bodies due to decreased light penetration. Mobile aquatic forms would avoid turbid areas. These impacts would be temporary and these aquatic ecosystems would return to their normal level of primary and secondary productivity within one month of the termination of construction.

Following construction of the site facilities, exposed soil would be sodded, seeded, or covered with shell or gravel. Sedimentation and erosion and the associated biological impacts would not persist.

C.6.1.5.4 Oil Distribution System Impacts

The proposed primary oil pipeline, Route #1, and the proposed alternative pipeline, Route #4, are illustrated in Figure B.3-42. The environmental setting of both the primary and alternative pipeline routes is described in Section B.3.4.5.4. The acreage which would be required for construction of each of these pipelines is listed in Table C.6-3. Table C.6-3 also presents the loss of primary productivity which would result from construction of both the primary Route, #1, and the alternative Route, #4.

Primary Route, #1

Construction of pipeline #1 would effectively remove up to 213.6 acres of prairie-farmland community present in the pipeline right-of-way. Of this 213.6 acres, approximately 11 percent remains as native prairie grassland, 10 percent is pastureland, 22 percent is rice producing land, 1 percent is hay producing and 1 percent produces soy beans. The remainder of this acreage is fallow fields or farm buildings and grounds.

Rice rats, cotton rats and other small mammals which are common to the prairie-farmland ecosystem will be impacted by the removal of their habitat and ground cover. Pipeline

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*Percents estimated from Bureau of Census (1974) statistics.

Table C.6-3 Annual Loss of Primary Productivity - Big Hill Oil Distribution Pipelines

Route	Vetetation Type	Miles	Construction Right-of-Way	Operation Right-of-Way	Acres Construction	Acres Operation	Net Primary Productivity	
							Kcal/m^3/yr	Total Kcal/yr
#1	farm and prairieland	23.5	75 feet		23.5 prairie		2,500[1]	2.4x10^8
					21.3 pasture		2,500[1]	2.2x10^8
					47.0 rice		2,300[1]	4.3x10^8
					2.1 soy		2,400[1]	2.0x10^7
					2.1 hay		1,680[2]	1.4x10^7
				50 feet		15.7 prairie		1.6x10^8
						14.2 pasture		1.5x10^8
						31.3 rice		3.1x10^7
						1.4 soy		1.4x10^7
						1.4 hay		9.3x10^6
	fluvial woodland	2.25	75 feet		20.5		6,296[3]	5.2x10^8
				50 feet		13.6		3.5x10^8
	swamp	0.25	150 feet		4.5		4,560[3]	8.3x10^7
				50 feet		1.5		2.8x10^7
#4	farm and prairieland	22	75 feet		21.4 prairie			2.2x10^8
					19.4 pasture			2.0x10^8
					42.7 rice			3.9x10^8
					1.9 soy			1.8x10^7
					1.9 hay			1.3x10^7
				50 feet		14.3 prairie		1.5x10^8
						12.9 pasture		1.4x10^8
						28.5 rice		2.8x10^7
						1.3 soy		1.3x10^7
						1.3 hay		8.5x10^6
	fresh marsh	1.25	150 feet		22.7		6,072[4]	5.6x10^8
				50 feet		7.6		1.9x10^8
	swamp	0.25	150 feet		4.5		4,560[4]	8.3x10^7
				50 feet		1.5		2.8x10^7

(1) Odum (1971)
(2) Odum (1959)
(3) Day (Unpublished)
(4) Day (1973)

construction through these areas would also result in the displacement of members of several bird species. Avian inhabitants of this ecosystem which would be displaced include Bobwhite, Killdeer, European Starling, and Savannah and Field Sparrows. Rice fields are used by many migrating species of geese and ducks for feeding. Construction activities and associated noise would result in the displacement of these species. Predator species which would avoid the pipeline route during construction include coyote, marsh hawks, American Kestrel and Turkey Vulture.

In addition to alteration of prairie and farmland, the construction of Route #1 would also eliminate 20.5 acres of fluvial woodland and 4.5 acres of swamps. The construction of pipeline through fluvial woodland and swamp would have longer lasting impacts than the construction through prairie-farmland systems. Compared to the grasses, crops, and other annual species which dominate prairie-farmlands, the fluvial woodland and swamp vegetation is dominated by tree species (see Section B.2.5.1.4). Primary productivity is greater in swamps and fluvial woodlands than in grassland systems, as indicated in Table C.6-3, and recovery time would be greater.

Mink are important residents of the cypress-tupelo swamp system. White-tailed deer are common to the fluvial-woodland ecosystem. Both of these species would be affected by loss of habitat due to pipeline construction. Other species which would be impacted by habitat loss include swamp rabbit, gray squirrel, skunks, opossum, armadillo and predators such as bobcat, and red and gray foxes.

The loss of 20.5 acres of fluvial woodland and 4.5 acres of cypress-gum swamp forest would represent the loss of less than 1 percent of the timber acreage in Jefferson County. Revegetation of these portions of the pipeline route by grasses, weeds and other pioneer species would stimulate immigration of animal species from surrounding prairie and farmland ecosystems.

Pipeline #1 would cross four freshwater streams between the Big Hill site and Sun Terminal. Pipeline burial across North and South Fork Bayous, Lovell Lake, and Hillebrant Bayou would result in the loss of 2.75 acres of stream and lake bottom.

Dredging operations would destroy all immobile benthic organisms in the dredge area, including midge, mosquito and gnat larvae, may fly, and dragon fly nymphs. The numbers of individual organisms impacted by dredging on 2.75 acres would range from 9.0 x 10^6 during the early spring months, to 7.5 x 10^6 during the summer. These values were established for several shallow freshwater lakes in south-central Louisiana which are biologically similar to these in the project area (Lantz, 1974). This would be a temporary loss of organisms important in food webs as fish food and as organic material consumers (detritivores). The impact is only of minor local significance in view of the total acreage of freshwater ecosystems in the project area.

The fish in these waters can be expected to emigrate from areas of pipeline burial and inhabit nearby undisturbed areas. An estimate of loss for one year, based on the work of Lantz (1974) indicates a total loss of 685 lbs. for 2.75 acres.

Pipeline burial across stream beds would have two additional impacts. There would be an increase in suspended sediments downstream of the pipeline crossing. This increased turbidity would reduce light availability to phytoplankton and could lower primary productivity downstream of construction.

Phytoplankton productivity would be greatly reduced as lower light levels occur due to turbidity increases, other factors remaining constant. Turbidity increases would be less inhibiting in areas not immediately adjacent to construction activity. Plankton production has been recorded for southern Louisiana wetlands at 418 g net dry wt of organic matter/m^2/year for phytoplankton and 25 g net dry wt of organic matter/m^2/year for zooplankton (Day, et al, 1973). Maximum impact on plankton production would occur if pipeline burial occurred in spring because of seasonal plankton blooms. An inhibition of phytoplankton growth would occur for a maximum of several months during and after construction. Considering the large fresh water area and the flushing characteristics of the interconnected bayous, change in plankton production resulting from turbidity would be relatively minor. Algal population increases could be stimulated by increased mineral nutrient wash-in (May 1973), but impacts would be temporary.

The second set of impacts would result from the release of nutrients, pesticides and/or heavy metals from the substrate. These impacts have been discussed in Section C.6.1.2.1.

Alternate Route #4

The impacts which would be associated with the construction of alternative oil distribution pipeline Route #4 would be similar to the impacts associated with Route 1. The acreage which would be impacted and primary productivity for these acreages are presented in Table C.6-3.

Route 4 differs from Route 1 primarily in that it would cross no fluvial woodland ecosystem but would affect approximately 4.5 acres of freshwater marsh. The freshwater marsh system is valuable for high primary productivity and contribution of organic material to the food chains in adjacent aquatic environments. Fresh-marsh macrophytic species have been discussed in Section B.2.5.1.1.

Construction activities through 4.5 acres of freshwater marsh would eliminate the aquatic macrophytes growing on these acres. Phytoplankton productivity would also be severely affected. Turbidity from pipeline burial would decrease the light availability and therefore the associated phytoplankton productivity in an area larger than the 4.5 acres immediately impacted by construction activities. The figure for production loss, presented in Table C.6-3 is, therefore, a conservative one.

Wildlife associated with the fresh marsh would emigrate as a result of construction related noise and activity and loss of habitat. However, it is expected that these species would repopulate the area upon completion of construction and reestablishment of the marsh grasses. The construction of Route 4 would impact 1.4 acres of fresh water stream bed, crossing Taylor Bayou and Hillebrant Bayou. The impacts would be similar to those impacts from stream crossing described in Route 1.

The impacts which would be associated with construction activities at the Sun Terminal have been presented in Section C.3.1.5.4.

C.6.1.6 Natural and Scenic Resources

The proposed brinelines from the Big Hill facility would cross agricultural land and marsh south of the dome. Because of the type of pipeline construction proposed in Appendix A.7.5.2, the impact on the natural and scenic resources of the refuge is considered to be minimal and temporary.

C.6.1.7 Archaeological, Historical, and Cultural Resources

Although no archaeological sites were identified on Big Hill dome or near the associated pipeline routes, it has been mentioned earlier that a more in-depth cultural resources survey would have a high probability of uncovering areas of significant value. If the Big Hill site were chosen as an SPR facility, this more intensive archaeological survey would be initiated which would satisfy the requirements of the National Historical Preservation Act of 1966 and Executive Order 11593.

C.6.1.8 Socioeconomic Impacts

C.6.1.8.1 Employment

The construction of oil storage facilities at Big Hill and the related pipelines and electrical transmission lines would employ several hundred workers for a short time, but only about 60 workers would be employed for the full 42-month construction period. At its peak level, the number of workers at the site would reach about 165. Construction tasks off the site in laying pipeline, assembling pump stations, and building transmission lines would employ an additional 360 workers in the third month, raising the peak manpower level to over 520. Labor requirements over the full term of construction are shown in Figure C.6-8. In this figure, the labor needs of the expansion of the Sun Oil Terminal in Nederland, shown by a dotted line, are superimposed upon the labor needs of the project because they would both be drawing from the same labor pool.

During the first 6 months, the surface facilities at the salt dome would be completed. The drilling of wells into the salt would be started, using 2 drill rigs and about 23 workers on each rig, drilling in shifts. Leaching, which would employ about 45 workers, would begin in the fourth month and would also be done in shifts. Because of the shift work, the number of workers onsite during the daytime would be about 135 during the third month, when the employment level reaches its peak, and about 50 from the 6th month through the 19th month when most of the drilling is being done.

At least two crews would be employed to lay pipeline for the Big Hill site. One crew would lay the brine disposal pipeline and diffuser off-shore in the Gulf of Mexico by assembling the sections of pipeline on a barge and sinking them to the floor of the sea. The pipelines laid on-shore could be done by a single crew. Both pipelines could be laid in about two and a half months. When both pipeline crews are engaged simultaneously, their combined labor force would total about 300 workers. This accounts for the major portion of the labor requirements in the third month of construction.

The Big Hill salt dome is located in Jefferson County and most of the workers would be drawn from the labor pool within the county. The total civilian labor force of the county is about 119,900 workers. Of this number, about 30 percent are craftsmen, foremen, and equipment operators. The unemployment rate

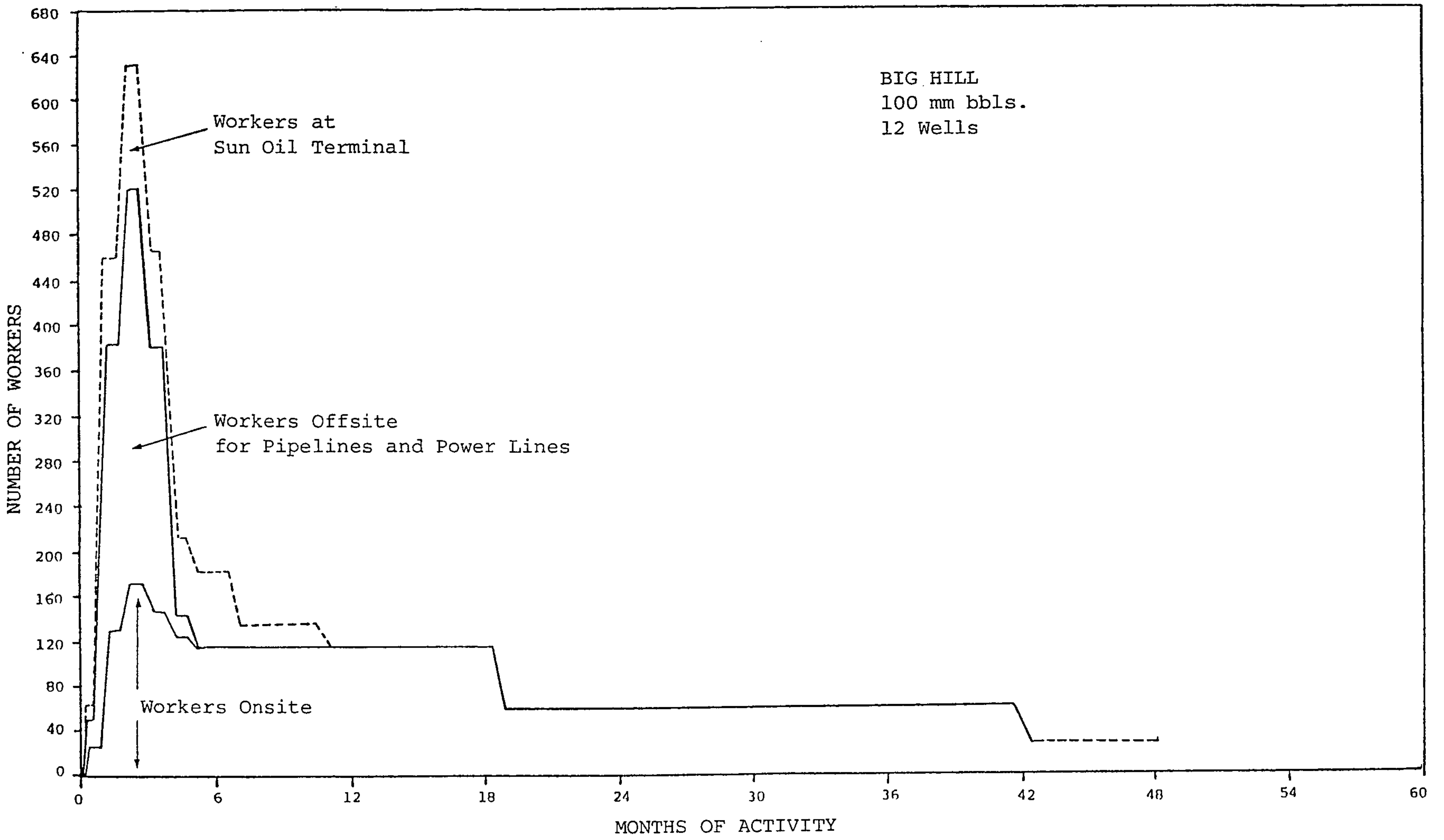

Figure C.6-8 Labor Requirements at the Big Hill Site in 1976 averaged 6.6 percent. Considering these factors and a 20 percent selection from the supply of available skilled workers, about 475 workers could be drawn from the county. By a similar analysis, Chambers County, with a labor force of 5,200 and average unemployment rate of 2.6 percent could be expected to contribute up to 25 workers. Workers from Orange County would have to commute 40 to 50 miles to the site, but would probably make up the remaining 140 to 150 workers. The effective reduction in unemployment resulting from this use of workers during the peak labor period would be as follows: Jefferson County, a reduction of 0.4 percent; Chambers County, 0.5 percent; and Orange County 0.5 percent. During the 12 months following the initial period of construction of pipelines and surface facilities, all the labor needs of the project could be met by the labor pool of Jefferson County, reducing the unemployment rate by only about 0.1 percent.

C.6.1.8.2 Land Use

The land at Big Hill is currently being used to raise cattle. There are productive oil wells around the periphery of the dome, and Pure Oil Company is using two salt solution cavities in the dome to store liquified petroleum gas (LPG). The Pipkin ranch is located here, and includes one residence as well as adjacent utility buildings. Construction of surface facilities for oil storage here would not require the removal of the residence and its adjacent buildings, but the people living here would be subjected to all the traffic of workers and material suppliers using the roadway that passes by the house, and the construction noise. Their view westward from the house would be dominated by the oil surge tank which is to be approximately 40 feet high and 60 feet in diameter.

The site lies outside of any city boundaries and therefore is not subject to any zoning restrictions governing construction. Although land use maps indicate the site to be in an agricultural land area, use of the site for oil storage would not constitute a significant change from its current use for oil production.

The construction of the various pipelines needed for the facility extends the project's use of land beyond its site boundaries. For example, the proposed raw water intake pipeline leads from the site to the Intracostal Waterway, and the pipeline would be laid along that same right-of-way and continue into the Gulf of Mexico. These pipelines would cross 1.5 miles of prairie which is used for grazing, and the remaining 4 miles to the Waterway and 3.5 miles beyond it through coastal marshes.

The oil distribution pipeline leading from the site to the Sun Terminal in Nederland would be 27 miles long and would cross a more varied terrain. It would cross several major highways, and the Texas Highway Department would be consulted regarding these crossings. The proposed route follows a roadway which does pass through sparsely settled areas east of the town of Hamshire and another settled area along Hillebrandt Bayou. While these are presently very rural communities, they are expected to become more densely populated in the next 15 years. At that time, rules may be passed by these communities governing the maintenance of rights-of-way through them.

C.6.1.8.3 Traffic

Local traffic patterns would be affected in several ways during construction of the proposed facilities. First, traffic would increase over roadways leading to the site as workers, equipment, and materials are transported. Also, there would be short-term disturbance to traffic along roads and the Intracoastal Waterway during construction of the required pipelines. Third, tankers bringing oil to the docks at Nederland would increase traffic on the waterways.

During the peak time, slightly over 400 workers could be traveling to the site and its adjacent land to build surface facilities and start the pipelines. Unlike the other candidate sites in Louisiana, there is a strong likelihood that different roads would be used in traveling to and from the site. Workers from Beaumont, Vidor, and other communities almost directly north of the site would probably travel on Interstate 10 almost to Winnie, then turn east on Route 73 to the Big Hill access road. Workers from Port Arthur, Bridge City, and Orange would travel west on Route 73 to the access road. Those workers living in Winnie, Stowell, and other parts of Chambers County may cut through the fields on small county roads and arrive at the site without using Route 73.

For purposes of analysis, it is assumed that three-fourths as many workers would come from the Port Arthur area as from the Beaumont area, due to the difference in size between the sets of communities. As in the analyses of traffic for the other sites, it is also assumed that about one quarter of the workers would travel as a passenger in another worker's vehicle. The resulting configuration indicates approximately 185 cars and trucks moving to the site from the Beaumont area, and another 140 moving there from Port Arthur. If they all use the same shell-surfaced road leading from Route 73 to the site, the resulting increase in daily traffic would be approximately as follows:

	Recorded Traffic	Peak Period Increase	12 Month Average Increase
Interstate 10 (between Beaumont and Rt. 73)	14,100*	3%	1%
Route 73 west of access road	3,000	12%	5%
Route 73 east of access road	2,790	10%	4%
Big Hill access road	175	371%	143%

After the initial 12 months of construction at Big Hill, the number of vehicles using these roads would continue to decline. Traffic congestion along the access road would be somewhat lessened by the fact that many of the people on site would be working in shifts. During the 2 year period following the 19th month, only 55 workers would be traveling to the site. Their impact on the traffic along the highways would be negligible; their impact on the Big Hill acess road would amount to a 66 percent increase in its use.

A slowdown of the normal traffic flow would occur when the various pipelines are laid across main highways and the Intracoastal Waterway. The oil distribution pipeline would cross Route 73 and the West Port Arthur Road, both of which have a traffic volume of from 3,000 to 3,700 vehicles, as well as Route 365, Memorial Freeway, and Twin City Highway, each of which have a traffic volume in the range of 13,000 to 17,000 vehicles daily. Where possible, detours would allow the traffic to bypass the roadway affected by construction. The oil pipeline would also cross the Southern Pacific Railway and the Kansas City Southern Railway.

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* This is the lowest of several traffic counts along this section of the highway, ranging from the 14,100 used in this analysis to 16,350 nearer Beaumont. These are 1973 traffic flow figures.

The brine pipeline would cross a less inhabited and less traveled section of the county. The traffic volume on Highway 87, which must be crossed near the Gulf coast, is only about 630 vehicles per day. No parallel road close by could function to use as detour routes, however, so the road must be kept passable while construction activities are underway. The brine pipeline would also cross the Intracoastal Waterway which, in this section, has a controlling depth of 10 feet. (Project depth is 16 feet, so the pipeline would be laid at a depth that would not interfere with this latter depth.) This section of the Waterway has a traffic flow of 9,500 to 9,800 self-propelled vessels passing in each direction, or 19,300 per year, total. This is an average of about 53 vessels per day. These vessels and their tows would be allowed to pass while the pipeline is constructed and laid beneath the channel.

The Sabine-Neches Waterway would bear an increase in tanker trips when oil is brought in to fill the storage caverns. Filling would begin in the 10th month of activity at the dome, and would continue through the 42nd month. The yearly increase in tanker traffic on affected shipping channels during the initial fill period would be as follows:

	Additional Tanker Trips	Sabine Pass Port Arthur Increase	Neches River Increase
10th - 28th month	157	8%	15%
28th - 42nd month	91	6%	11%

C.6.1.8.4 Housing and Public Services

There are enough workers that have the construction skills needed and that live in Jefferson County to meet the labor force requirements of the project. Assuming, however, that reports of the size of the construction project were spread into adjacent regions, up to about 15 percent of the workers hired for both the Sun Oil Terminal expansion and the storage project may be workers migrating into the area. This represents nearly 100 workers.

Based on the relative size of cities and towns in the area, housing availability, and proximity to the construction sites, the 100 workers migrating to the area would be distributed approximately as follows: 40 settling in

Beaumont, 30 in Port Arthur, up to 10 in Nederland, and 20 in the Winnie-Stowell area. The effect of this would change the availability of housing in Beaumont and Port Arthur by less than one percent. Because Nederland is much smaller than its two neighboring cities, the effect would be more noticeable. There, the vacancy rate among rental units could drop by slightly over one percent.

The largest impact would be felt in the Winnie-Stowell area. In 1970 Winnie, the larger of the two communities, was an unincorporated village with a population of 1,543. Since the census was taken, it has probably grown to about 1,700. Assuming it had housing characteristics similar to those of Chambers County as a whole, it would not have housing units available to accommodate workers and their families who wished to move here. They may be able to rent or purchase lots where they could park a trailer house until they were able to build or obtain more permanent housing.

Despite the temporary difficulty in housing workers in the Winnie-Stowell area, these workers and their families would probably not constitute more than a 5 percent increase in the community's population. There is a small medical center in Winnie that could be used by the new residents as well as by workers injured in construction accidents. The Winnie-Stowell Volunteer Fire Department has two ambulances as well as three pumper trucks. While these governmental services are close to the site, they lie across the county line. Jefferson County police services and the Texas State Highway Patrol would be called upon if assistance were needed in securing the site or in alleviating traffic congestion at the beginning and end of the day work shift. Workers seriously injured in the course of laying pipelines through the coastal marshes between Route 73 and the Gulf waters as well as off-shore, could be evacuated via the helicopter ambulance service which is operated out of Houston.

C.6.1.8.5 Economy

Since the labor supply for the construction of project would come primarily from within the region, workers'earnings would stay and circulate there. A large portion of the materials, supplies, and equipment would also be purchased from the region. Because of the site's proximity to the Houston-Galveston area, some of the materials would probably be shipped from there.

The payroll of the workers would be at its highest level during the first six months of activity. It would then diminish and stabilize at a lower level while the caverns are being leached and filled. The average payroll levels for work on the oil storage facilities (not including the Sun Oil Terminal expansion) at periodic intervals would be as follows:

1st through 6th month:	$520,500 per month
7th through 12th month:	$218,000 per month
13th through 18th month:	$218,000 per month
19th through 42nd month:	$114,500 per month

In the third month, when the work force reaches its highest level, the payroll will peak at $1,050,000 for that month. At that same time, the payroll of workers employed in the expansion of the oil terminal would contribute an additional $220,000. Average payroll for the construction work at the terminal would be as follows:

1st through 6th month:	$142,700 per month
7th through 12th month:	$ 60,000 per month

These payroll levels are based on an assumed average worker wage of $2,000 per month.

The total cost of the facilities planned for construction at Big Hill would be approximately $129,900,000. In addition to workers' payrolls, this figure includes design, materials, equipment, and similar costs. Of this amount, close to 90 percent would be spent within the region. This sum, about $114,500,000, represents a direct increase in local earnings attributable to the project.

This direct increase would generate earnings in other businesses as direct suppliers purchase goods from other sources to maintain their inventories. The total of direct and indirect gains to local earnings is determined by application of the local economic multiplier. In the case of Big Hill, it is appropriate to use the multiplier of the Beaumont-Port Arthur-Orange BEA area, which is 2.06. The full amount of local earnings that the project would generate is about $235,900,000.

To some degree, these gains in earnings would be diffused into the Houston area, because it is only about 60 miles away as well as into the Lake Charles area. The Beaumont-Port Arthur-Orange area itself, however, is sufficiently large and its industrial development is sufficiently concentrated in those products and services that would be needed by the project, that most of the gains in earnings would remain within this BEA area. Therefore, unlike the Louisiana sites, the gains in earnings derived from the proposed project can be compared with the anticipated earnings of the Beaumont-Port Arthur-Orange BEA area alone. The project-generated earnings would raise anticipated earnings of 1980 by 12 percent in the 7 counties of this BEA area, and by 13 percent in just the standard metropolitan statistical area alone.

The gains would not, however, be concentrated into one year, but would be extended over a period of about five years. For this reason, the gains in earnings derived from the project can be compared to the anticipated growth in earnings within this BEA region from 1980 to 1985. The increase in earnings produced by the project would constitute a 58 percent gain over the anticipated growth during that period in the whole BEA region, or a 64 percent gain if it is concentrated within the Beaumont-Port Arthur-Orange metropolitan area.

C.6.1.8.6 Government Revenues

If Big Hill were chosen as an oil storage site, some of the land currently part of the Pipkin ranch would be purchased by the Federal government. This would make the land and its capital improvements exempt from local property taxes, but apart from this effect, no other direct loss of local governmental revenues is anticipated.

There would be increased governmental revenues attributable to the increase in local earnings generated by the construction of the project. While it is very difficult to accurately estimate the supplemental revenue derived from business earnings, the fraction of such earnings which represents wages paid to construction workers at the site can be used to compute part of the gains to local governmental revenues. While the wages of workers employed by the Sun Oil Company to expand their dock facilities has been estimated, they are not being included here. The figures presented can thus be compared with those given for the alternative sites. Using the methodology discussed for the other sites, the contribution to local revenues that the Big Hill construction would yield would be approximately $166,600 in the first year, $75,000 in the second year, $51,600 in the third year, and $25,800 in the remaining 6 months of construction. Most of this revenue would go to the State of Texas and to Jefferson and Orange Counties.

C.6.2 Impact from Operation

C.6.2.1 Land Features - Big Hill

C.6.2.1.1 Geomorphology

Operation and maintenance activities would have no impact on geomorphology (topography and drainage patterns) at the storage site or along the oil or brine pipeline routes.

C.6.2.1.2 Soils

Routine operation and maintenance is not expected to result in any impacts to soil characteristics at the storage site, along either the oil or brine disposal pipeline routes, or at the terminal and dock facilities. Accidental spills of oil or brine could however result in the impact that soil in contact with oil would be incapable of supporting vegetation (see discussion of oil spills in Section C.2.1).

C.6.2.1.3 Stratigraphy, Geologic Structure, and Mineral Resources

No impact on the stratigraphy, geologic structure or oil production on the flanks of the dome is expected to occur during normal operation and maintenance activities.

Future salt production in the area of the new storage caverns would not be compatible with the SPR program. Also, sulfur (if any exists in the cap rock above the expansion site) could not be mined.

C.6.2.2 Water

The operation and maintenance of the Big Hill facility would produce certain impacts on the water environment. Subsequent discussion dealing with these impacts is organized in two parts as follows:

- Surface Water
- Subsurface Water

C.6.2.2.1 Surface Water

Each impact on surface water supply or quality can be identified by the activities producing the impact as follows:

Type of Impact	Produced By
Change in Water Supply	Withdrawal of Displacement Water
Change in Water Quality	Withdrawal of Displacement Water Disposal of Brine Discharge of Treated Ballast Water Miscellaneous Maintenance Activities

Water Supply

The only significant impact on the supply or availability of surface water would result from the withdrawal of water for the displacement operation. The point of withdrawal as indicated in Figure C.6-1 would be the ICW near Star Lake. The rate of withdrawal would be 7.0×10^5 bpd (barrels per day) or 2.04×10^4 gpm (gallons per minute). The period of withdrawal would extend over 150 days (5 months). The rate of withdrawal is only slightly greater than the withdrawal rate for the leaching operation.

If the ICW served as the lone source of water, and if the waterway were completely isolated from other water bodies*, the withdrawal rate previously noted would lower the water level of the waterway .068 ft/day (as explained in Appendix D.22). Because the waterway is connected with Salt Bayou, Star Lake and Spindletop Ditch in the vicinity of the raw water intake(s), and with Galveston Bay

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*Between Galveston Bay and the Port Arthur Canal.

and the Port Arthur Canal (part of Sabine-Neches Canal) at its ends, the actual rate of fall of water would be somewhat less than the value noted. As indicated in Figure C.6-1 induced currents in the ICW and adjoining streams would serve to replenish the water withdrawn from the waterway. Thus, it can be seen that the ICW should serve as the major replenishment source with a lesser contribution from streams flowing into the ICW.

Flow in the segment of the ICW under consideration is generally from west to east. The withdrawal process would tend to cause an increase of .0126 ft/sec to this existing current. No appreciable impact on the supply of surface water in the area is anticipated.

Water Quality

As noted previously, the surface water system would be affected by four activities as follows:

- Withdrawal of water for displacement
- Brine disposal
- Discharge of treated ballast water
- Miscellaneous maintenance activities

Withdrawal of Displacement Water. The water quality in the ICW largely depends upon the quality from Galveston Bay and to a lesser degree upon water entering from streams such as Spindletop Ditch and Salt Bayou. The effect of water withdrawal would be the increased flow of water into the waterway from Galveston Bay. In view of the available water quality data for the ICW near Big Hill, there is no reason to believe that any significant change would occur due to withdrawal of water for displacement.

Brine Disposal. During the refill process at Big Hill 265 ppt brine would be discharged at a rate of 119,000 bpd or 3740 gpm for a period of 840 days. Current design calls for the disposal of the brine by means of discharge into the Gulf of Mexico, using the same brine disposal system as used during the leaching operation. The general disposal area in the Gulf is indicated in Figure C.6-2. The impact of brine disposal during refill would be similar to that occurring during leaching. Because the rate of discharge is smaller during refill the size of the brine plume would be smaller than that produced during leaching.

The brine discharged during the refill process would be 15% more saline (265 ppt) than that discharged during leaching (230 ppt). The rate of discharge, however, would be 15% of the rate during leaching. Therefore, the impact produced by the brine disposal during refill should in general be less than that already described in Section C.6.1.2.1 for leaching.

Discharge of Treated Ballast Water. All discharge of treated ballast water would occur at or near the Sun Oil Terminal on the Neches River. A description of the impacts of such discharges is provided in Section C.3.2.2.1.

Miscellaneous Maintenance Activities. Two general types of pollutants (chemical and biological) can be generated during maintenance activities. A complete list of the types of chemical pollutants is found in Section C.3.2.2.1. In general most problems arise from excessive or improper use of industrial and agricultural chemicals on or near the maintenance site. Additional problems arise from improper storage and disposal operations.

Biological pollutants are generally the result of poor sanitary conditions at a maintenance facility. As a result, bacterial, viral and other organisms can be carried into the nearby water bodies. These pollutants are detrimental to water quality and other organisms. A major concern arises from release of pathogenic organisms associated with human waste.

Prediction of impacts due to these types of biological and chemical pollutants is not feasible because of the human element involved and the present lack of detailed design information. In any case the degree of pollution can be minimized by thorough training of maintenance personnel and adherence to reasonable housekeeping practices.

C.6.2.2.2 Subsurface Water

Current design for the Big Hill SPR facility does not involve use of the shallow aquifers as a source of displacement water nor use of the deeper aquifers as a site for brine disposal. Thus the subsurface water system should experience no impact as a result of facility maintenance or operation.

C.6.2.3 Air Quality

C.6.2.3.1 Sources of Emissions

The emission sources at Big Hill from operational activities include: (1) the injection of crude oil into the salt dome cavities, (2) the subsequent extraction of the oil at a future date as required and (3) the emissions from dissolved hydrocarbons which are present in the brine discharged during oil refill. A detailed discussion of emission rates associated with each source is contained in Section C.3.2.3.1. Short- and long-term emission rates at Big Hill are listed in Appendix E for those sources included in the modeling analysis while annual tonnage emission rates are presented for all sources in Table C.6-4. An evaluation of the emissions from brine appears in Appendix N.

C.6.2.3.2 Air Quality Impact

This section discusses the results of the modeling analysis conducted for each significant source at Big Hill during the operational phase. Detailed descriptions of operational activities and modeling approaches are contained in Section C.3.2.3.2.

Short-term modeling calculations have been performed for project hydrocarbon emissions at both the dome and terminal sites. The calculations are based upon concomitant emissions at each location from all sources including tankers, tanks and pump houses. In addition, two separate scenarios were modeled at the Sun Terminal to handle both ship loading and unloading phases. The results of the modeling analyses are contained in Figures C.6-9 and C.6-10. At the dome site, short-term NMHC ground level concentrations would be in compliance with the 3-hour standard. However, during tanker loading and unloading operations at the Sun Terminal, the standard would be exceeded. Figure C.6-9 indicates that during tanker loading during the distribution phase, the 3-hour NMHC standard would be violated 1 percent or more of the time annually out to downwind distances in excess of 25 kilometers. The maximum impact would occur to the west of the terminal, where violations of the standard would occur 5 or more percent of the time annually out to a downwind distance of approximately 7.5 kilometers. During ship ballasting operations following the completion of tanker unloading, Figure C.6-10 indicates that the applicable standard would be exceeded out to a downwind distance of approximately 5 to 15 kilometers with the maximum impact occurring west of the facility where the frequency of violation is in excess of 2.5 percent annually. The calculations are conservative in that they do not include the minor additional dilution attributable to structural wake effect.

Annual NMHC ground level concentrations have also been calculated for the dome and terminal sites. Figure C.6-11 provides the results of this analysis for the Sun Terminal. This calculation is based upon the conservative assumption

Table C.6-4 Annual Tonnage Emission Rates for Development of Big Hill to 100 mmb

Source or Activity	Annual Emissions (Tons)				
	HC	Particulate	SO_X	NO_X	CO
Site					
Brine Ponds*	140				
Valves & Seals	5.4				
20,000 bbl (standing loss)	0.5				
Surge Tanks** (working loss)	32+				
3,000 bbl Blanket Oil Tank	0.1				
Total	178				
Terminal - Fill Phase					
Surge (standing loss)	10.7				
Tanks** (working loss)	7.3				
Valves and Seals	1.9				
Tanker Ballasting	75.5				
Tanker Engine	2.9	21.4	269.9	96.5	1.8
Tug Engine	1.6	3.6	1.5	2.5	2.1
Total	99.9	25.0	298.4	99.0	3.9
Terminal - Withdrawal Phase					
Tanker Loading	693				
Surge Tanks (standing loss)	10.7				
Tanks** (working loss)	17.0				
Ballast Treat (standing loss)	3.6				
ment Tanks** (working loss)	3.5				
Valves and Seals	1.9				
Tanker Engine	1.1	8.2	113.6	36.9	0.7
Tug Engine	1.6	3.6	1.5	2.5	2.1
Total	732.4	11.8	115.1	39.4	2.8

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*Fill Phase Only: the values are the maximum predicted at any time during use. The initial fill is expected to be only a small fraction of this amount.

**Working losses interact with the standing storage losses, such that the resultant emission is less than the sum of these values.

+Emissions in fill phase.

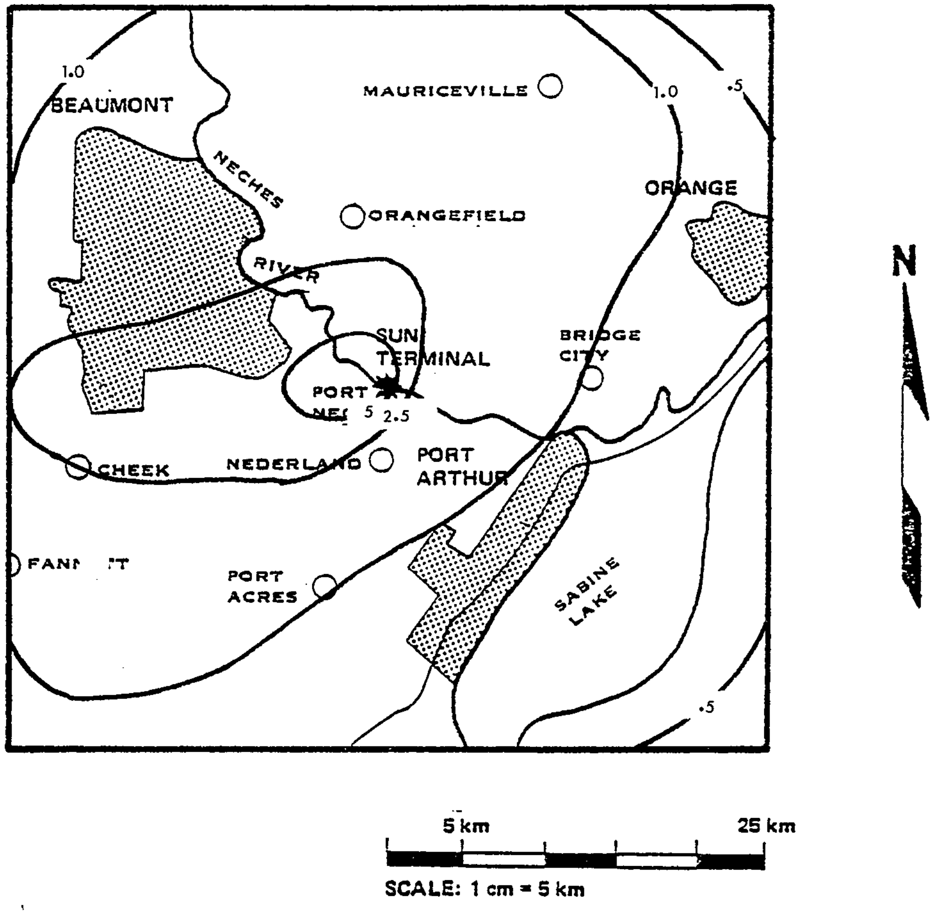

Figure C.6-9 Annual Frequency of Occurrence (%) of Violations of the 3-hour NMHC Standard at the Sun Terminal for Tanker Loading During the Operational Phase at Big Hill.

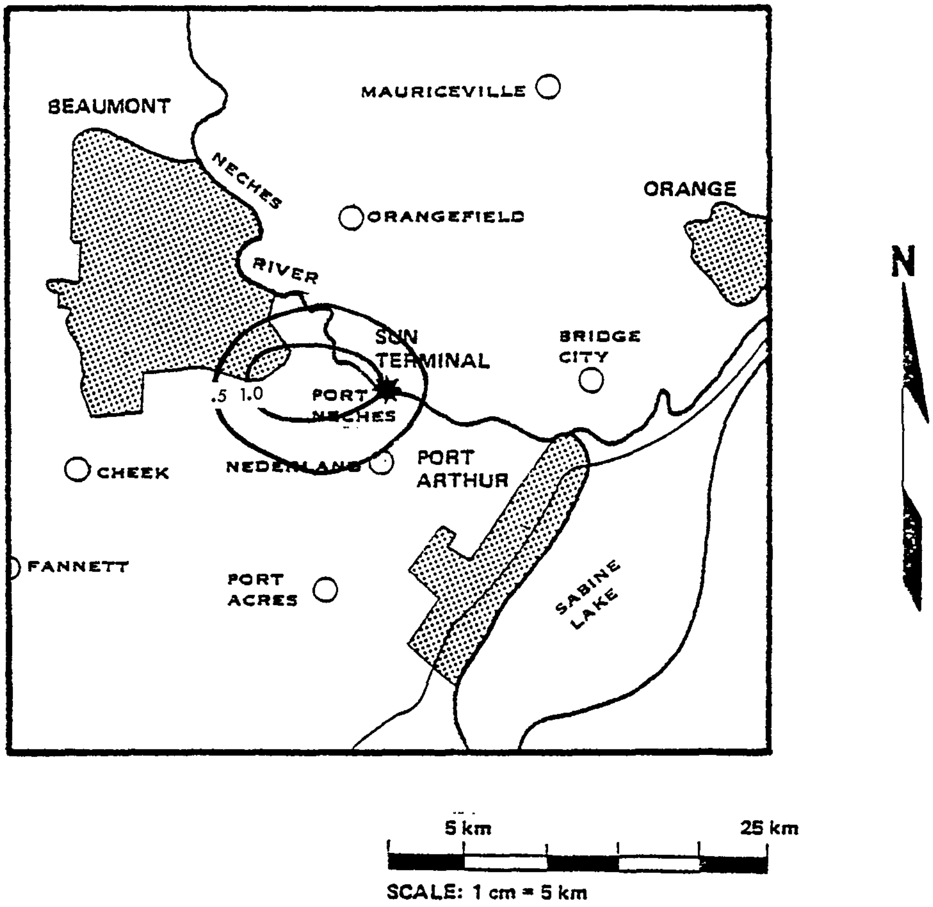

Figure C.6-10 Annual Frequency of Occurrence (%) of Violations of the 3-hour NMHC Standard at the Sun Terminal for Tanker Ballasting During the Operational Phase at Big Hill.

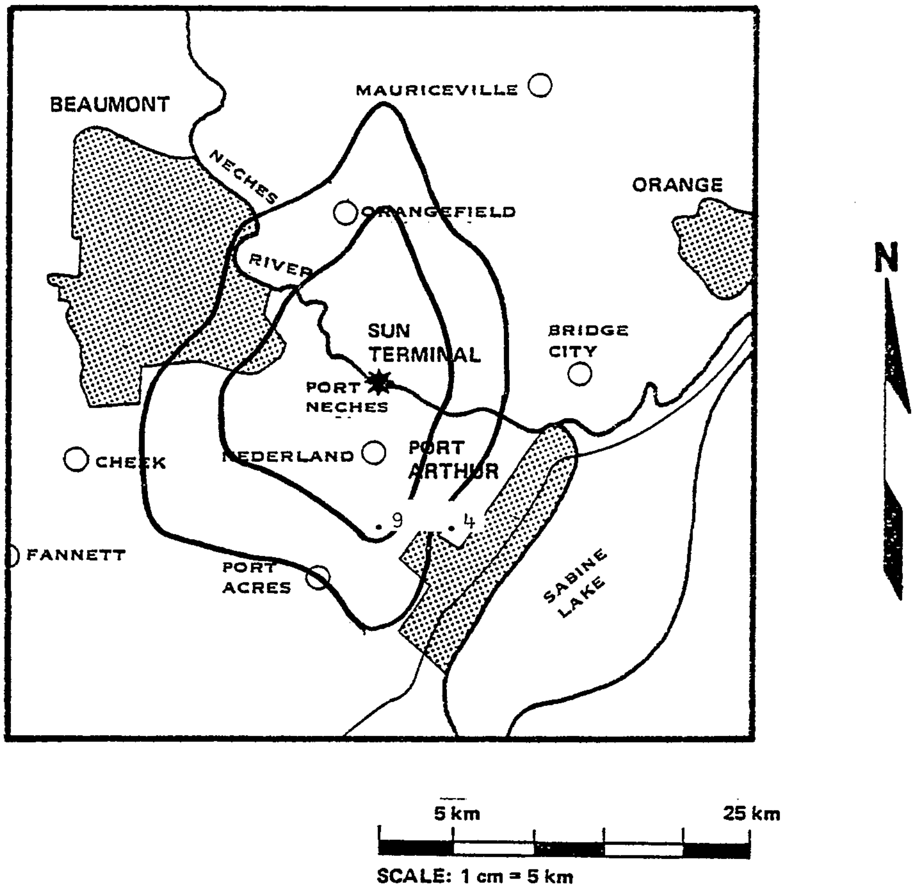

Figure C.6-11 Annual Average NMHC Ground Level Concentrations ($\mu g/m^3$) at the Sun Terminal During the Operational Phase at Big Hill.

that both the fill and drawdown phases could occur, at least in part, during the same annual period. The results of the calculation indicate that annual ground level concentrations would be generally less than.9 $\mu g/m^3$. Similar calculations were performed for the dome site and are presented in Figure C.6-12. Annual NMHC concentrations would be generally less than 0.15$\mu g/m^3$ downwind of the dome site sources.

In summary of the air quality impact, the Big Hill dome and Sun Terminal facilities would be significant sources of NMHC, and to a lesser extent, combustion contaminants. Violations of the 3-hour standard for NMHC are predicted downwind of the Sun Terminal facility. Tanker loading and ballasting emissions dominate the site emission levels as it is unlikely that the other sources would independently violate the NMHC standard outside plant site boundaries. The use of efficient vapor control technology in conjunction with shipboard activities would significantly reduce the impact of the terminal facility on regional ambient air quality. However, in present form, the level of hydrocarbon emissions at the Sun Terminal is probably insufficient to have an important impact on regional levels of photochemical oxidant. The annual tonnage emission rate for the West Hackberry expansion is relatively small in comparison to regional hydrocarbon emission levels in this region of heavy petrochemical activity. The facility would not result in violations of air quality standards for other contaminants.

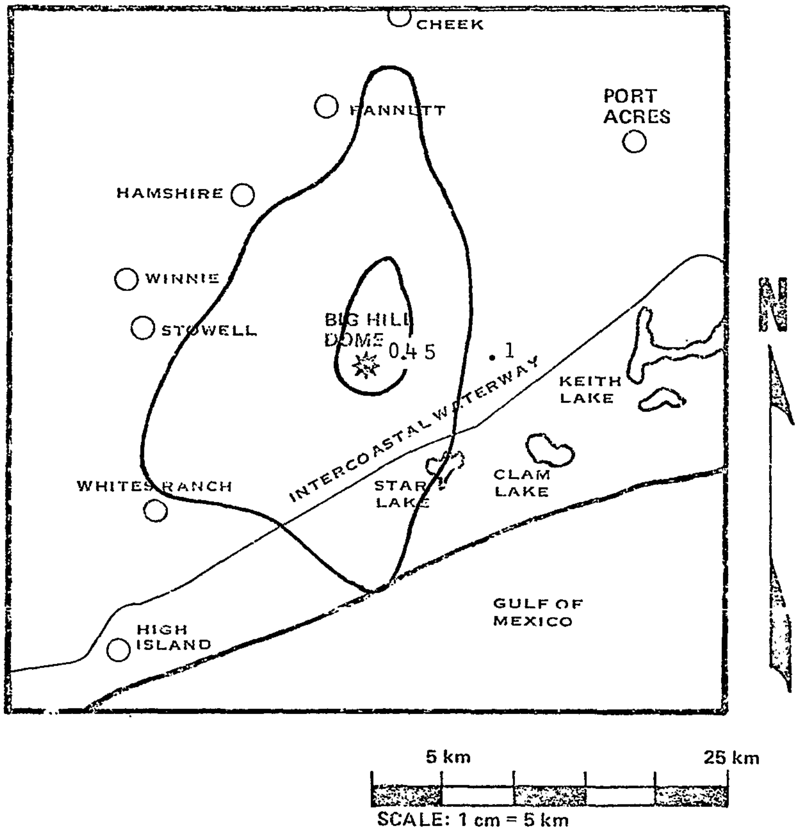

Figure C.6-12 Annual Average NMHC Ground Level Concentrations ($\mu g/m^3$) at the Dome Site During the Operational Phase at Big Hill.

C.6.2.4 Noise

During operations at the storage site, the primary noise generation would be from pumps associated with the fill and discharge operations which are located in pump houses on the Big Hill Site.

The analysis of pump noise for a site of similar operation and ambient levels, West Hackberry Site (Ref. Final Impact Statement - West Hackberry Salt Dome), estimated increase noise levels at the site perimeter of no more than 3 dB during the period of operation.

Some increase in terminal and tanker operations can be expected at the Sun Terminal on the Neches River. It is estimated that during fill/discharge operations tanker loading and unloading would increase 20 percent. The major noise associated with the operations would be from tanker traffic, tanker pumps discharging crude oil, tanker loading pumps, and pipe transfer pumps.

The pumps for both tanker loading and pipeline transfer to the storage area will be electrically powered and would be housed in a pump house on the terminal site. Additional noise from the increase in diesel engines which power the tankers and tanker discharge pumps operation would contribute negligibly to existing ambient levels.

Summary of Noise Impacts

During fill and/or discharge operations, there would be noise generated from the continuous operation of pumps at both the storage and terminal facilities. The noise is expected to be continuous day and night during these operations, however, since the pumps at both the storage and terminal facility would be enclosed in pumphouses, it is anticipated that there would be a negligible impact on existing ambient levels in the vicinity of these facilities from operations.

C.6.2 Operation and Maintenance

C.6.2.5 Species and Ecosystems

C.6.2.5.1 Displacement/Leaching Water System Operational Impacts

The main direct impacts associated with the intake station would include entrainment of plankton (organisms drawn in) and impingement (entrapment against the intake screen). Secondary effects on ecological structure would result from losses of living, and nonliving organic material from the aquatic system and lateral displacement of organisms transported with water masses.

Proposed

The intake structure would be located on an inlet off the northern spoil bank of the ICW. Organisms which would be entrained are: phytoplankters (such as diatoms, and other algal forms); zooplankters (such as copepods, cladocerans, and rotifers); larval fish; and larval and postlarval benthic organisms (including blue crabs and penaeid shrimp). Virtually all organisms entrained in the intake water would be killed. The estimated losses of phytoplankton and zooplankton associated with a maximum water use for leaching and displacement of 1307 mmb during the life of the project would be 16,896,870 x 10^6 and 460,652.15 x 10^6 individuals respectively, based upon Corps of Engineers (1975) density determinations for the ICW in western Calcasieu Parish, southwestern Louisiana. These determinations are cited in Section C.4.1.5.3.

The effects on the numbers of individuals in the different species present would be variable depending on the life history characteristics of these species. Numbers within rapidly reproducing and maturing, short-lived species would probably be affected relatively little, whereas species which are planktonic only during early life stages and require longer to mature would be more adversely affected.

The continuous withdrawal of water over 38 months during leaching would probably greatly deplete the numbers of long-lived species from that part of the ICW from which water was taken. The effects during a 5-month displacement interval would be much less, since the dispersal of young is a yearly occurrence for most of the longer-lived animal species which would be concerned. Their populations would be reestablished within a year.

Withdrawal of nutrients contained in entrained water and organisms would also be of greater importance during the 38 months of leaching than a 5-month displacement period since the nutrients would be introduced in the water which replaced that which was withdrawn. The regional reduction in limiting nutrients would probably be small enough so that reductions in primary (plant) and secondary production (animals and decomposing organisms) from this source would be slight.

The types of organisms which would be entrained are important parts of aquatic food webs. Changes in species composition and numbers in the area influenced by water withdrawal would affect the animals which were not susceptible to entrainment. Different plankton assemblages would probably be present in the different water masses transported toward the intake structure. Such differences cannot be predicted with present area knowledge; however, there is no reason to suspect great variation in food availability from this source.

The number of impinged organisms would depend on the flow rate, size of the screen apparatus and intake location. The intake systems would be fitted with a 1/2 inch mesh screen and the intake velocity of the water would be 0.5 feet per second or less. It is doubtful that a severe impingement problem would occur. Animals incapable of passing through the screen presumably would be mobile enough to escape. Intakes are designed to produce a low inflow velocity and thus prevent impingement. Frequent cleaning would prevent clogging which can create stronger currents across the intake screen.

In addition to the above-mentioned impacts, there would be an occasional disturbance to wildlife along the pipeline route to the dome due to periodic inspection or maintenance. It would also be expected that waterfowl as well as small mammals would avoid the area surrounding the pumping station due to operation noise.

Alternative

Similar impacts to biota are expected from the alternative displacement/leachwater system.

C.6.2.5.2 Brine Disposal System Operational Impacts

Proposed

During facility operation, the pumping of brine through the pipeline to the Gulf of Mexico would especially impact organisms in the area of the diffuser. Impacts associated with the pipeline corridor would arise from occasional inspections of the pipeline right-of-way which would disturb wildlife (waterfowl, small mammals, amphibians and reptiles) on an infrequent basis. These disturbances would be relatively minor subsequent to construction clearing.

Impact concerns related to the actual disposal of brine in the Gulf of Mexico would be caused by the high temperature of the brine and the high salinity of brine. Brine flowing from the cavities may reach a temperature of between 100° and 150°F, the brine would cool in the brine surge pond and as it traversed the length of the pipeline. Assuming worst-case conditions were: (1) no heat loss occurred in the surge pond, (2) temperature of the brine was a maximum of 150°F and (3) the winter water temperature was 60°F, the temperature at the top of the sediments directly above the burial pipeline would rise less than 4°F. The temperature increase would be less during summer months. It is likely that temperatures would be raised much less than this 4° maximum. The additional heat from this pipeline would have little significant effect on the biota in the marsh water. Benthic organisms in the marsh sediment would experience some additional heat, but little, if any, stress would be experienced as a result of the elevated brine temperatures. (Appendix I).

The biota of the Big Hill site is generally typical of the coastal waters of the northern Gulf of Mexico at the 30-foot contour interval. This is particularly true of the phytoplankton, zooplankton and demersal nekton communities whose species compositons are readily comparable to those found along the Louisiana-Texas coastline. Standing crops for these communities are also roughly comparable to those elsewhere in this region. The benthic community on the other hand is dominated by a limited number of species most of which are typical of degraded conditions such as associated with oil spillage. A significant finding is that standing crop for the benthic community is low.

The phytoplanktonic community is dominated by a mixture estuarine and marine diatoms. This probably reflects the mixing of estuarine waters from Sabine Pass with offshore marine waters. Species composition varies dramatically from month to month but *Skeletonema*, *Coscinodiscus centralis*, *Biddulphia* spp. *Rhizosolenia imbricata*, *R. robusta*, *Chaeotoceros currisetum*, and *C. decipiens* are typical dominants. Interestingly September and December were wholly dominated by just one or two species (particularly *Skeletonema*) while October and November showed a diverse, equitably distributed species composition. Dinoflagellate numbers, as expected, were low for this time of year.

The dominant species at Big Hill were all copepods except one. This situation is similar to that of the other proposed disposal locations. Average combined zooplankton densities at Big Hill were of a similar order of magnitude distributed similarly over time compared to the same kinds of densities at the other proposed disposal sites. As with the West Hackberry and Black Bayou proposed disposal areas, Big Hill has a fairly well-developed, productive zooplankton community. It appears somewhat less rich than the others in terms of dominants.

The species composition of the nekton community is fairly constant from month to month, and is typical of Louisiana-Texas coastal waters. Standing crop varies markedly from month to month, but these fluctuations appear to be driven by random variation in the populations of the top dominant species, Acetes americanus, a sergestid shrimp, and Anchoa mitchilli, the Bay Anchovy. An influx of species during November probably reflects the fall offshore migration of estuarine summering forms. The sea bob, Xiphopenaeus krogeri, also showed high population densities. This is a locally important commercial shrimp species, whose distribution is restricted to locations just westward (downstream) of major estuarine passes.

The benthic community is almost wholly dominated by either the marine worm (polychaete) Magelona sp. (October, November, December) or the clam Mullinia lateralis (September). In both cases the second ranked species was only about half as abundant as the top dominant. Such a community structure is typical of environmentally degraded conditions. This is supported by the remarkably low standing crop in the benthic community. It should be noted that the depressed standing crop at Big Hill is in part due to the presence of extensive clay outcrops (Beaumont formation). On the other hand, both Mullinia and Magelona are known to be indicator species for degraded environments so that there is little doubt that the benthic environment is in fact degraded.

Disposal of brine at Big Hill would have its greatest impact on the benthic community. Components of this community are generally sedentary and would be unable to avoid exposure to the high density brine as it sinks toward the bottom. The most severely impacted region would be that nearest the diffuser port where highest salinities overages would be encountered. Based on MIT transient plume model, utilizing limited real world current observations for the Big Hill site, no more than 52 acres would be enclosed by the 3 ppt excess salinity isohaline. If total mortality within this region is assumed, about 49 x 10^6 benthic individuals/acre would be eliminated. In the context of the broadly distributed nearshore benthic community, this is not a significant impact. Beyond the 3 ppt isohaline brine impacts on the benthic community would be expected to be minimal. However, it should be pointed out that persistent exposure of the sediments to even very dilute brine may result in uptake of various heavy metal species. This will result in elevated mortalities beyond the near field. Inasmuch as the planktonic and demersal organisms are either quickly carried through the diffuser site, or can otherwise avoid this region, impacts on these communities should be slight.

The impact of the actual disposal of brine would have minimal effects on non-benthic organisms in the marine environment. Mackin (1973), who worked on oil field brine discharges, reported that marine fishes, other mobile animals, and current-carried forms apparently are not affected by high salinity discharges in large water bodies. Their time in traversing the zone of high salinity is too brief for long-lasting impacts. All available data indicate that free-swimming animals which prefer lower salinity levels would avoid the brine discharge area with no apparent difficulty. Mackin reported that, if brine concentrations are great enough, an effect on benthic organisms can be measured. Where salinities are increased by 5 ppt or more, the effect on sessile or slightly mobile organisms with narrow salinity tolerances could be moderate to severe.

Given a substantial salinity increase (5 to 10 ppt), three impact zones would develop. The first zone would be an area of near total destruction. Phoronids, pelecypods, and polychaetes would be destroyed; bacteria may be an exception.

In the second, or transition zone, a reduction in the number of species and individuals would occur. Stunted development would also probably be detectable. The extent of the zones would vary depending on dilution factors. Mackin believed this zone extended from approximately 100 to 300 feet in a large body of water.

The third impact zone would be an area of stimulation of the marine community. Bacteria, yeasts, fungi, and phytoplankton numbers would be increased. Minter (1965) and Mackin (1950) reported heavy phytoplankton and algal productivity near the edge of a transition zone. Increased productivity of organisms near the bottom of the food chain would elicit corresponding increases in primary consumers (zooplankton and filter feeders such as polychaetes and pelecypods) and higher level consumers (starfish, most fish, other predators).

The impact of offshore brine disposal should not be significant except for the localized destruction of the benthic fauna in the immediate vicinity of the diffuser. There should be negligible effects on total production of the coastal area.

Alternative

Impacts on biota from brine disposal via the alternative brine disposal line would be similar to those described for disposal via the proposed pipelines. Maintenance impacts would also be similar.

C.6.2.5.3 Impacts at or from the Storage Site

Impacts which would result from the operation of the facilities at the storage site are expected to be small. Small mammals and ground nesting birds would be periodically disturbed by mowing the 230 acres within the fenced area. Noise levels would be minimal, and no impacts from noise are expected to affect the surrounding marsh and agricultural lands.

C.6.2.5.4 Oil Distribution System Impacts

Impacts which would be associated with the operation of the oil distribution pipeline system would be small. A 50-foot right-of-way would be maintained along the length of the route. This would require periodic mowing and would prohibit the reintroduction of tree and shrub species. The annual loss of productivity along Routes 1 and 4 during the operational phase of the program is listed in Table 4.6-3.

C.6.2.6 Natural and Scenic Resources

Normal operation and maintenance of facilities on the Big Hill dome is not anticipated to have any adverse impacts on the natural and scenic resources of the area. In the case of a break in the brineline during operation, the resulting brine spill could have a significant impact on the natural resource value of marshland south of the dome. The effect would be localized in the vicinity of the break and would consist of a severe limitation of vegetation and subsequent dispersal of animals from the affected area.

C.6.2.7 Archaeological, Historical, and Cultural Resources

Although no archaeological sites were identified on Big Hill dome or near the associated pipeline routes, it has been mentioned earlier that a more in-depth cultural resources survey would have a high probability of uncovering areas of significant value. If the Big Hill site were chosen as an SPR facility, this more intensive archaeological survey would be initiated which would satisfy the requirements of the National Historical Preservation Act of 1966 and Executive Order 11593.

C.6.2.8 Socioeconomic Impacts

C.6.2.8.1 Employment

The operation of the storage facilities would employ 15 to 20 workers at the site. They would be skilled mechanics, instrument men, electricians and other craftsmen as well as laborers and maintenance personnel. Pumps and other equipment would be operated periodically, the pipeline rights-of-way would be inspected from the air, and there would be routine painting of the tanks, buildings, and outdoor equipment to prevent damage from rust and weathering. The facility would be staffed on a 24-hour basis.

C.6.2.8.2 Land Use

Operation of the storage facility would affect land use only in the immediate vicinity of the site. This land is currently used in a combination of cattle-raising and oil production. Use of the dome as a storage site would not preclude continued use of the adjacent land around the periphery of the dome for oil and gas exploration and production. Pipelines from the storage cavern wellheads to the main plant facilities would be buried, permitting continued use of the field as grazing land. Use of the dome for oil storage would not significantly change the character of the existing land use patterns.

It is unlikely that urban expansion would envelop the site during the lifetime of the project. The large urban centers closest to the site, Beaumont and Port Arthur, are both about 25 miles away, ~~respectively,~~ but their expansions will be diffused to the north and east, leaving the agricultural lands south of Route 73 relatively unchanged. The Winnie-Stowell community is only 8 to 10 miles from the proposed storage site. While these towns are growing rapidly now, their population is presently so small that their growth is not expected to present a future conflict between the community development and the use of Big Hill for oil storage.

C.6.2.8.3 Traffic

Workers, service trucks, and the occasional delivery of supplies to the site would be the cause of any impact on traffic during the operational standby phase of the project. Approximately 22 vehicles could be expected to be traveling to and from the site daily. This would constitute about a one percent increase over the 1973 volume of traffic on Route 73 and a 25 percent increase over the volume of traffic on the Big Hill access road. There would be no appreciable impact on the volume of traffic on Interstate Highway 10.

At the times when oil is withdrawn from the storage caverns, tanker traffic associated with the distribution of oil would partially offset the decrease in tanker traffic resulting from the interruption in foreign oil imports. The caverns would be refilled when oil imports resumed, however, resulting in an incremental increase in tanker traffic. This increase would amount to 8 percent over the normal traffic flow along the Sabine Pass and Port Arthur, and 15 percent along the Neches River.

C.6.2.8.4 Housing and Public Services

The impact on housing of the operational phase of the project would be less than that experienced by the region during construction. It is likely that part of the staff employed at the storage site during the leaching of the caverns and initial fill would remain employed there. Newly hired workers may either commute from Beaumont and Port Arthur or settle in the small communities nearer the Big Hill site. If some workers who moved into the Winnie-Stowell area during construction of the project were to leave, this would make housing units available there. The population of Winnie is projected to grow rapidly enough so that if as many as 10 to 15 housing units were vacated at the end of the construction period, it would not seriously depress housing values.

Assuming that some fire control and security systems were installed as part of the site facilities, impacts on the public services of local governments would be less than those incurred during the construction of the project, and would be very small. Security personnel on site would cooperate with the Jefferson County Sheriff's office in matters related to the protection of the facility.

C.6.2.8.5 Economy

The operation phase of the Big Hill storage project would have very little effect on the economy of the area. About 20 persons would be permanent employees at the site, and would generate a payroll of about $45,000 per month. This payroll, together with expenses of supplies, repair parts, power, and similar items would bring the cost of the facility during standby to a total of about $93,000 per month.

Applying the economic multiplier for the local BEA area (2.06), the total of direct and indirect gains in local earnings would be $191,600. This amount would be less than a tenth of a percent of the anticipated level of earnings for the area in 1985.

When oil is withdrawn from the caverns, additional workers would be hired at the site, and there would be a greater need for replacement parts and supplies. The cost of operating the facility during a period of withdrawal would be about $520,000 per month. This level of expenditure would be maintained for no more than 5 months.

The storage caverns would be refilled after foreign imports are resumed. The refill phase, excluding the cost of the oil itself, would require an expenditure in the vicinity of $250,000 per month over a period of about 2 years.

While the operation of the storage project at Big Hill would have a small impact relative to the economy of the geographic area which includes Beaumont, Port Arthur and Orange, it would have a larger impact on the small, rural communities like Winnie, Stowell, and Hamshire which are close to the site. It is probable that most of the permanent employees would be residents of these communities, and the economic activity generated by the facility operation would make a sizable contribution to the relatively small economy of these communities.

C.6.2.8.6 Government Revenues

Federal ownership of a portion of the land at Big Hill would make it exempt from property taxation for the duration of the project. The storage of oil would not generate government revenues locally except through the increased economic activity that it produces in the region.

Wages paid to workers is one form by which economic activity is induced. The normal spending of these wages alone would generate about $20,000 per year in state and local sales tax. While the loss in property tax would occur in Jefferson County, a significant portion of the taxes paid by facility employees may go into Chambers County if the workers live in Winnie and Stowell, which are 8 to 10 miles from the site rather than in Beaumont and Port Arthur which are 25 to 30 miles from the site. This effect, however, would not be significantly greater than the currently common effect induced by workers who have jobs in Jefferson County but live in the adjacent counties.

C.6-3 Impacts Due to Termination

After termination of the SPR program, if the facility were not to be used for any other government purpose, it would be disposed of in accordance with applicable laws and regulations.

C.6.4 Relationship of the Proposed Action to Land Use Plans, Policies, and Controls

The use of lands in southeast Texas for the development of the Big Hill site as an oil storage facility would involve several local, state and Federal agencies because of their jurisdictional interests in these lands.

The site and all its related pipelines would lie in Jefferson County. The county does not have the authority to pass any zoning regulations restricting development in areas outside of city limits, so use of the land at Big Hill would not be in conflict with any zoning. The county does, however, require that a permit be obtained for the use of county road rights-of-way, including crossing these roads. The oil distribution pipeline leading from the storage site northeastward to Nederland would follow county roadways for part of the distance, and cross several other county roads.

Within the county are several drainage districts. Where pipelines would cross these ditches, permission to do so would be needed from the local drainage district.

A number of state agencies have jurisdiction over specific lands and specific uses of the land. One of these is the Texas Railroad Commission, which has authority to regulate most of the activities associated with oil and gas exploration and development. It is this commission which would hold hearings on the issue of the use of the Big Hill site for storage of oil.

The brine disposal pipeline would cross through coastal wetlands and extend offshore into the Gulf of Mexico. The establishment of a right-of-way or use of an existing one through state-owned portions of the coastal wetlands is regulated by the Texas General Land Office and the Texas School Land Board. It is the policy of the Land Office to require certain tests to assure the quality of the pipeline and pipeline welds, and specific measures to assure the protection of the environment. These measures have been incorporated into the specifications for the construction of the pipeline. The Corps of Engineers also has jurisdiction over construction in wetlands, including the laying of pipelines.

Where pipelines would cross state highways, the Texas Department of Highways and Public Transportation would be consulted with regard to permits for the crossing, and special arrangements to provide for the maintenance of normal traffic flows.

Land use plans for this area have been prepared by the Southeast Texas Regional Planning Commission. These plans indicate a growth of the urban areas north and east of the site, but no change from current land use patterns at the site. The site is shown to be agricultural land. Use of the site for oil storage would not preclude continued use of adjacent land for agriculture.

C.6.5 Summary of Adverse and Beneficial Impacts

Table 5.2.2 in Chapter 5 contains a detailed summary of the adverse and beneficial impacts associated with site preparation and construction at the Big Hill site and these impacts are not repeated. In Section C.3.5 the impacts of the proposed site, West Hackberry, were summarized. Only the major differences between the proposed and the alternate site are discussed here.

The major difference between Big Hill and the proposed West Hackberry site would be that a new crude oil pipeline would be required to Big Hill to Sun Terminal. The pipeline route for the West Hackberry site would be built as a part of the ESR; thus, a new route would not be required. The 25 mile pipeline route required for Big Hill would require major construction activities.

Brine disposal associated with cavern leaching at Big Hill would be discharged into the Gulf of Mexico but at only two-thirds the rate for West Hackberry. Impacts would probably be less at Big Hill.

The location of the Big Hill site in Texas would mean that a different labor pool would be drawn upon for construction and operation support, and governmental revenues would be increased primarily in Texas rather than in Louisiana.

C.7 CONSIDERATIONS OFFSETTING ADVERSE ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTIVITY

The United States possesses abundant natural resources and yet is dependent upon the importation of large quantities of fuels. It has become increasingly dependent upon petroleum imports, which now constitute approximately 35 to 45 percent of the nation's oil consumption and account for 20 percent of the total domestic energy usage. In 1974 the annual cost of these imports was over $25 billion.

In the past twenty-five years, the United States has experienced four sudden denials of oil imports for various reasons by oil-exporting countries. Not, however, until the oil embargo of 1973-74 did the nation find itself without the capacity and resources to offset the interruption of oil imports. This embargo reduced the quantities of petroleum exported to the United States by approximately 2 million barrels per day for 19 weeks and caused world prices for crude oil to escalate.

Although the economic impacts of these events on the United States economy are still under study and debate, most of the macroeconomic study estimates of the repercussions of supply denial and simultaneous price increases tend to indicate a Gross National Product (GNP) loss of approximately $35-45 billion (Holcombe, 1974; Bennet, 1974). Although not all of this GNP loss can be ascribed to the embargo, the interruption contributed significantly to increases in the consumer and wholesale price indices. In addition, the GNP loss was reflected in higher unemployment and stagnation in several sectors, including automobile sales and housing starts, which exacerbated the economic downturn believed to have started in late 1973. During this period, the embargo prevented real growth that probably would have stabilized unemployment and provided a stronger base for eventual economic recovery.

The United States is now more vulnerable to a petroleum supply interruption than it was in the fall of 1973. In responding to that interruption, many relatively easy steps to conserve energy were taken, and significant improvements in energy efficiency have been achieved. Higher energy prices, natural gas shortfalls, and continued uncertainty about the availability and prices of alternative forms of energy have induced many energy users to restrict their energy consumption and emphasize more effective energy management practices. However, additional improvements would require substantial investment, longer lead times, and even more intensive energy management. Moreover, the program to convert oil- and gas-fired utilities and industrial plants to coal will have converted many plants to coal, which will largely preclude further conversion to coal during a future supply interruption. Some estimates have shown that a future supply interruption of the magnitude of the one in 1973-74 could cause a reduction in GNP that, in terms of employment impact, would be equivalent to the loss of jobs for 2 million workers. Economic effects would not be limited to some geographical areas or industries but would affect the entire nation.

Standby supplies of petroleum have been proposed repeatedly as a way to buffer the impact of future supply interruptions. The National Petroleum Council (NPC) (1975), Ford Foundation (1974), and the Energy Laboratory at the Massachusetts Institute of Technology (MIT) (1974), have all recommended this action. In addition, the International Energy Program (IEP) agreement, which the United States has entered into with 17 other energy importing countries, provides for the establishment of this type of reserve. Although the western European countries and Japan have developed stockpiles, the only appreciable stocks in the United States are working inventories.

The concern voiced by these organizations as well as the public, in addition to the nation's formal commitments to the IEP, provided strong impetus for passage of the Energy Policy and Conservation Act of 1975 (P.L. 94-163), which provides for the creation of the Strategic Petroleum Reserve. The expansion of the West Hackberry salt dome storage facility would provide 150 million barrels of the SPR requirement.

C.8 SUMMARY

Impacts are summarized in detail in Chapter 5.0 and major differences between each of the alternate sites and the proposed site have been discussed in Sections C.3.5, C.4.5, C.5.5, and C.6.5. Differences in facility designs are summarized in Table 2.8-1 in Chapter 2.0.

Land use impacts would be relatively minor at the proposed and alternate sites. Construction of canals for wellhead access at Black Bayou and Vinton would alter drainage patterns.

Land use impacts would be relatively minor at the proposed and alternate sites.

At West Hackberry, salinity intrusion may be a problem associated with the cavern leaching and oil displacement operations. This would not pose a significant problem at the alternate sites.

Brine disposal would be into the Gulf of Mexico for all sites except Vinton. Brine would be injected into subsurface aquifers which must have approximately 36 square miles (times 100 feet thick) capacity. Aquifer capacity has not been determined and the ability to use the Vinton site will remain in question until this is determined or an alternative means of brine disposal is found.

Brine pipelines for West Hackberry and Black Bayou would cross the Sabine National Wildlife Refuge, and in the case of West Hackberry would parallel in scenic highway. The brine pipelines for Big Hill would also cross sensitive marsh areas.

Site access would be relatively difficult at Black Bayou because workers must cross the ICW via the Gum Cove Ferry.

Big Hill would require a new crude pipeline system which would be significantly longer than the connector lines to the West Hackberry ESR pipeline. Substantial construction activities would be associated with the Big Hill crude oil pipeline.

The capacities of the alternate sites would mean that Black Bayou would be a direct substitution for expansion of West Hackberry. Both Big Hill and Vinton would be required to fulfill a total 150 million barrels of crude oil storage.

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