

# Assessment of the Texas Deepwater Terminal

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The results of a study conducted to assess the vitality of a Texas deepwater port are presented. The two major issues in the study were the financial feasibility of such a project and the role of the state of Texas in its development. A deepwater oil terminal at Freeport, Texas, would greatly influence refinery activity along the Texas Gulf Coast. An analysis of many factors indicates that predicted demands for crude oil in the Gulf Coast area would justify a 0.6 million m<sup>3</sup>/d (3.75 million bbl/d) facility. A facility of this size would provide an average transportation cost saving of \$3.78/m<sup>3</sup> (\$0.60/bbl) through the use of very large crude carriers instead of smaller tankers. Over a 30-year pay-out period, given operating costs of \$3.3 billion and a capital investment of \$1.2 billion (1980 dollars), a projected total cost saving of \$18.4 billion would be realized. The construction and operation of the offshore terminal facility are expected to bring economic benefits to the local area. The number of jobs that would be created by the offshore terminal and the related expansion of the refinery and petrochemical industry would provide increased opportunities for employment. Use of supertankers instead of conventional small tankers would reduce the number of collisions in the vicinity of ports and harbors. Depending on the average size of the operating fleet, the probability of a collision for supertankers could be one-sixth that for smaller vessels. The results of the analysis indicate that an offshore deepwater terminal on the coast of Texas is practicable.

Crude oil will continue to be the primary source of energy in this country for many years. To meet the projected demand for crude oil, a substantial amount will have to be imported in very large crude carriers (VLCCs) or "supertankers". Such large ships require ports with average depths of 30 m (100 ft) or more; no major U.S. or Gulf Coast port has the required depth.

An alternative to a deepwater port is an offshore deepwater terminal that consists of platforms with flexible pipeline connections that allow a supertanker's crude oil cargo to be pumped to onshore tank storage facilities.

Seadock, Inc., a private consortium, was created by interested parties to develop an offshore terminal off the Texas coast. The Louisiana Offshore Oil Port (LOOP), a similar consortium, is developing a deepwater port off the coast of Louisiana. In February 1978, representatives of Seadock informed the U.S. Department of Transportation (DOT) that they would not pursue any further the development of a deepwater port off the Texas coast. In March, the governor of Texas signed an executive order establishing the Texas Deepwater Port Authority and thereby authorizing the state of Texas to pursue the issue of whether or not a deepwater port for Texas is practicable.

This paper provides an assessment of conditions pertinent to the development of a Texas deepwater terminal. Critical factors are analyzed, and their effects are noted.

## ASSESSMENT OF CURRENT CONDITIONS

From the many positions taken on the energy issue, one pervasive fact emerges: The United States continues its dependence on imported crude oil. The increasing development of offshore oil production, the uncertainty of the large Mexican oil reserve, the production and movement of Alaskan oil, and the development of other domestic energy sources all influence levels of im-

ported crude oil. Collectively, these factors influence the locations and methods by which imported crude oil enters the United States.

## Status of Seadock

The U.S. Deepwater Port Act of 1974 provided that Congress "authorize and regulate the location, ownership, construction, and operation of deepwater ports in waters beyond the territorial limits of the United States." In December 1975, Seadock submitted to DOT a detailed application that called for a deepwater terminal in the Gulf of Mexico 42 km (26 miles) offshore from Freeport, Texas (1). The facilities proposed included offshore platforms, single-point moorings, and a connecting pipeline to an onshore storage facility. Initial (1980) throughput capacity was projected to be 0.4 million m<sup>3</sup>/d (2.5 million bbl/d) and planned expansion (by 1990) to be 0.67 million m<sup>3</sup>/d (4.2 million bbl/d). Total project cost at the time of application was estimated to be \$658 million for the initial phase and \$208 million for the expansion. These cost projections have since escalated drastically.

Partly because of the many federal agencies that are involved in the licensing of deepwater ports, the review of the application took about a year. During that period, testimony was obtained from a variety of sources in a number of public hearings. Finally, in December 1976, the Secretary of Transportation released his decision on Seadock's application. That decision (2) included the following passage:

For the reasons set forth in this document I have decided to issue a license to Seadock but only subject to certain conditions to preserve and enhance the environment, and to protect and promote competition. In reaching this decision, I have relied heavily—as the Act intends me to do—on the advice and recommendations of other Federal and State agencies and on the views of the public as they have been expressed through the public hearing process.

The Secretary further acknowledged that these certain conditions created special obligations with which Seadock must comply or else not accept the license and abandon the project.

By July 1977, three of the nine member companies—which represented 52 percent ownership interest in Seadock—had withdrawn. Exxon (22 percent), Gulf Oil (15 percent), and Mobil (15 percent) withdrew because of what they considered excessive government interference with the licensing process, overregulation, and the open-endedness required for the permit. The president of Seadock, Hugh L. Scott, stated that government "vendettas against the oil companies" also played a large part in the withdrawals (3). Scott offered little hope that the remaining project members (City's Service Company; Continental Pipe Line Corporation, a unit of Continental Oil Company; Phillips Investment Company, a unit of Phillips Petroleum Company; Crown-Seadock Pipe Line Corporation, a unit of Crown Central Petroleum Corporation; Dow Chemical Company; and Shell Oil Company, controlled by the Royal Dutch-Shell Group) would proceed with the project. He

stated that the company did not have the financial resources to complete the project as planned and, since membership had been open for the last four years with no new participants, there was only an outside chance of survival.

The withdrawing oil companies objected to specific actions taken by the U.S. Department of Justice and the Federal Trade Commission (FTC) in the licensing. Both had identified possible antitrust violations concerning discriminatory practices in the area of nonowner use, which prompted inclusion of the following provision in the decision of the Secretary of Transportation (2): "The Secretary can compel expansion of capacity an additional 25 percent in a situation where demand is evidenced by commitments of shippers for throughput. . . ."

In the same context, a provision was included to allow any shareholder to authorize the corporation to expand. Also included were provisions calling for Interstate Commerce Commission (ICC) regulation of not only the deepwater port rates but also the connecting pipelines from shore facility to refinery "to ensure that all shippers through the port have access to common carrier pipelines and that the policies applicable to the port are not frustrated downstream." Another provision called for the dissolution of the corporate subsidiary veil, which, in effect, would make the parent companies totally liable for damages that result from oil spills (2).

Scott has interpreted these provisions as representing the "classic case of government overregulation and regulatory duplication" as well as an attempt "to start down the road of divestiture" (3, p. 13). In a recent article by Burka (4), it is suggested that LOOP resolved the same issues whereas Seadock did not pursue a compromise. LOOP, however, is composed of different companies (Texaco, Shell Oil, Ashland Oil, Murphy Oil, and Marathon Pipeline Company), and half of its imported oil is destined for refineries in the Midwest. Burka further suggests that the "Big Three" were under no pressure to compromise since alternatives to a deepwater terminal—lightering and transshipment—provided the large oil companies with relatively equal economic advantages. In conclusion, Burka offers the prophecy that, "If Seadock survives, it will be Big Oil that saves it; if it dies, it will be Big Oil that kills it" (4).

#### Position of the State of Texas

When it became apparent that Seadock would not survive, a special session of the 65th Texas Legislature in July 1977 passed Senate Bill (SB) 7, "an act relating to the licensing, acquisition, construction, maintenance, operation, and financing of deepwater port facilities". The enabling legislation authorized the state to seek a federal license similar to that granted to Seadock should that consortium decide not to proceed. The general provisions of SB 7 are as follows:

1. Texas urgently needs an offshore deepwater port that is capable of accommodating supertankers for the importation of crude oil and other fluid commodities that may be carried in ships of that size.
2. It is most desirable for private enterprise to own, construct, and operate such an offshore port.
3. In the absence of any active and workable plan by private enterprise to develop a deepwater offshore port, the state of Texas should construct such a facility, which should be self-supporting and whose design, construction, and operation should be carried out by private companies under contract.
4. Protecting the environment is essential to the

proper operation of such a port.

5. The credit of the state of Texas shall not be pledged to finance such a port.

6. The Texas Deepwater Port Authority should be created to implement this policy.

The recent creation of the Texas Deepwater Port Authority was tied to a decision by the governor that "no active and viable plan to develop a deepwater, offshore port by private enterprise exists in Texas" (5). A decision to establish the Texas Deepwater Port Authority was made only when Seadock officially announced a decision to reject the license.

Therefore, the main issue before the authority is to determine whether a deepwater port is workable. Several main elements are (a) the continued role of Texas and its petrochemical industry in a national energy plan, (b) the projected demand for crude oil, (c) financial implications, and (d) other pertinent issues, such as environmental quality.

#### OCEAN TRANSPORTATION AND MOVEMENT OF CRUDE OIL

In general, any tanker heavier than 145 455 Mg (160 000 tons) is considered a VLCC (tanker weights in this paper are given in deadweight units). The Tatillus, a 500 000-Mg (550 000-ton) tanker, represents the upper boundary of these tankers and is often referred to as an ultralarge crude carrier (ULCC). For example, a 250 000-Mg (275 000-ton) tanker is only twice as long, twice as wide, and twice as deep as a 19 091-Mg (21 000-ton) tanker, but it carries 13 times as much oil. Other benefits of VLCCs are reduced labor requirements and unit operating costs. Figure 1 (6, p. 5) shows the relative size of tankers and their drafts.

Modern techniques have resulted in lower construction and operating costs per deadweight ton for VLCCs than for smaller vessels. For example, in 1975 the cost of constructing a 22 727-Mg (25 000-ton) tanker was about \$550/Mg (\$500/ton) or \$46.25 million. On a voyage from the Middle East to Europe, the ratio in cubic meters of fuel delivered to fuel consumed for a 250 000-Mg (275 000-ton) tanker is 28:1 whereas a 45 455-Mg (50 000-ton) vessel for it is only about 13:1.

There are more than 150 deepwater loading and unloading facilities throughout the world. The United States, however, does not have a major port that is capable of receiving a fully laden VLCC and relies principally on vessels no larger than a fully loaded 45 455 Mg (50 000 tons). In effect, this limits savings in transportation because lightering or transshipment is required before the vessels enter U.S. ports.

#### Projected Demand for Crude Oil

Of the 2.6 million m<sup>3</sup>/d (16.4 million bbl/d) of refinery capacity located throughout the United States, approximately 25 percent is located in the state of Texas. The development pattern of the refineries is rather dispersed since 25 of the 51 Texas refineries are confined to an 81-km (50-mile) deep coastal strip that extends from Mexico to Louisiana and the remaining 26 installations are spread over the rest of the state.

The number of refineries in a specific area, whether it be coastal or inland, is a partial consideration. The capacities of these various units describe the actual dispersion of refining in Texas (7) (1 m<sup>3</sup> = 6.28 bbl):

Capacity (million m <sup>3</sup> /d)	Number of Refineries	
	Inland Texas	Coastal Texas
0-7.94	21	7
8.09-15.9	4	5
16.0-23.8	0	5
24.0-31.7	0	2
31.8-39.7	0	0
39.8-47.6	0	1
47.7-55.5	0	4
55.5	0	2
Total	25	26

These data indicate that the refineries of the Texas inland district generally tend to have capacities of less than 7.94 million m<sup>3</sup>/d (50 million bbl/d). Only 4 of the 25 refineries have capacities greater than 7.94 million m<sup>3</sup>/d, and only one approaches 19.9 million m<sup>3</sup>/d (100 million bbl/d). Since the inland refineries are generally smaller in capacity, most of the total capacity is found in the coastal district. Of the total state capacity of 0.67 million m<sup>3</sup>/d (4.23 million bbl/d), only 0.089 million m<sup>3</sup>/d (0.56 million bbl/d), or 13 percent of all Texas refining capacity, is located inland. In addition, all of the crude oil supplied to these refineries is of domestic origin; the majority is supplied by Texas sources.

In the coastal refining district, 19 of the 26 refineries have daily capacities in excess of 7.94 million m<sup>3</sup>/d (50

million bbl/d) and 7 have capacities greater than 39.7 million m<sup>3</sup>/d (250 million bbl/d). Refineries located inland use only domestic oil. The coastal district refineries use 60 percent domestic crude and 40 percent imported oil.

The location of the proposed deepwater terminal is in the vicinity of 86 percent of the total capacity of the coastal refineries. As Figure 2 (8, p. 6) shows, approximately 19 percent of total U.S. refining capacity is concentrated in this 242-km (150-mile) long coastal strip, known as the primary impact area.

The recently completed 77-cm (30-in) diameter Seaway pipeline, which starts at Freeport, Texas, and terminates in central Oklahoma, provides an even broader impact area. With the merger of the primary and secondary impact areas, a deepwater port in Freeport could conceivably service 26 percent of total U.S. crude oil refining capacity.

To project future refining capacity and the corresponding demand for crude oil, several existing demand forecasts were evaluated. Each forecast was attached to a possible scenario. The first forecast, referred to as the historical scenario, involves a continuance of current trends whereby demand is maintained at its current rate (9). The second involves an all-out effort to use all measures at hand to conserve energy and create as small a total demand as possible. This is called the Office of Energy Programs (OEP) scenario (9). The third demand forecast represents the most likely future and is referred to as the Exxon scenario (10).

The three scenarios are characterized by different rates of crude oil importation through the Texas coast (see Figure 3). Although over the short run (1 to 10 years) the variance between different trends is slight, over the long run (1 to 25 years) the differences between the scenarios become significant. A review of these rates verified our concern for considering more than one forecast in assessing the demand for a deepwater port.

#### Historical Scenario

The historical scenario involves the maintenance of current trends with no regard to conserving energy through a lessened demand. The currently available oil supply is assumed to be unconstrained for the foreseeable future. Demand is characterized by dwindling domestic production contrasted with continually rising imports of crude oil.

#### OEP Scenario

The OEP scenario recognizes the energy shortage and the gradual reduction of the importation of crude oil. Unlike the historical scenario, this scenario emphasizes conservation. It is assumed that demand for crude oil will increase through 1985 and then slowly decrease and that adjustments will be made to the use of alternative energy sources such as coal, solar energy, geothermal, and nuclear power. Additional savings will be obtained by using more efficient machines.

In this scenario, a low deepwater throughput capacity is estimated to be needed. An analysis of the relative demand shows that a throughput capacity of approximately 0.3 million m<sup>3</sup>/d (2 million bbl/d) would be required through the year 2000.

#### Exxon Scenario

In this study, the Exxon scenario is considered the most likely. Although it follows the general pattern of the

Figure 1. Relative size of tankers.

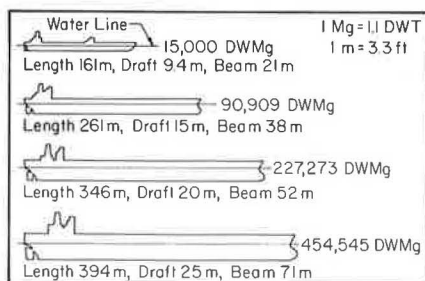


Figure 2. Current refining capacity in general marketing area of Seadock in millions of cubic meters per calendar day.

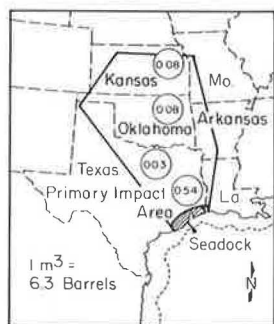
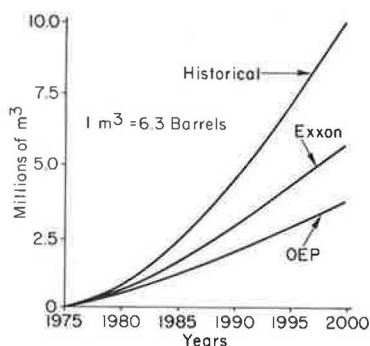


Figure 3. Predicted total cumulative importation of crude oil into Texas by scenario.





OEP scenario, it allows for the attainment of generally higher levels of imported crude oil.

The Exxon scenario is characterized by a higher level of imports than the OEP scenario. The OEP scenario is the result of stringent conservation, whereas the price of oil and the introduction of synthetic fuels are the influencing factors in the Exxon scenario. The Exxon scenario reflects an increase in domestic production through the location of new fields which would allow more stable domestic production through the year 2000.

According to the Exxon demand forecast, a 630 000- $\text{m}^3/\text{d}$  (4 000 000- $\text{m}^3/\text{d}$ ) capacity deepwater port would be required.

#### Growth of Refinery Capacity in Texas

The projection of refinery growth in the state of Texas is a function of several factors (1):

1. Declining production of U.S. crude oil,
2. The need for imported crude oil to satisfy U.S. demands,
3. The recent inability of the oil industry to build new refineries on the East Coast because of local and state opposition, and
4. The tendency for any industry to continue to locate where it is already concentrated (agglomeration).

These factors represent the most visible of the influences that affect refinery growth. Based on these four factors, the following assumptions were made with regard to the development of refineries on the Texas coast:

1. There will be growth in refinery capacity.
2. Since recent attempts of the oil industry to build new refineries on the East Coast have met with considerable state and local opposition, Gulf Coast oil could continue to be refined locally and then transported to the East Coast.
3. Since crude oil will continue to be imported, new refining capacity will be expanded in areas that are likely to receive most of the imported oil. The Gulf Coast is considered a likely area for crude oil imports and refinery expansion.

To facilitate this study it was estimated that approximately half of all new refinery construction would occur on the Gulf Coast. The percentage of all Gulf Coast refinery capacity currently located in Texas was found to be 61.2 percent. By multiplying the Gulf Coast growth factor by the Texas percentage of Gulf Coast capacity, the Texas Gulf Coast growth factor was estimated to be 30.6 percent of total U.S. growth. Therefore, of every 1 million  $\text{m}^3/\text{d}$  of refinery capacity added to the U.S. total, 306 000  $\text{m}^3/\text{d}$  is forecast to be located on the Texas Gulf Coast.

#### Availability of Domestic Crude

The historical and Exxon scenarios contained forecasts of oil demand that could be satisfied from domestic production, given no new reserves. The difference between the historical and OEP scenarios enabled the development of an estimate of new domestic oil reserves to be discovered.

To determine the total Texas share of the domestic crude to be refined in Texas, an adjustment was made to the different projections. This adjustment was determined through analysis of a data base provided by the Texas Energy Advisory Council. The percentage of

Texas and other domestic crude oil processed in Texas refineries amounted to 22.2 percent of the total national demand. It was assumed that Texas would maintain the same share of production of crude oil from fields already in use and that none of the new domestic oil finds would be located in or near Texas. Therefore, U.S. oil field production was multiplied by a factor of 0.222 to provide the domestic crude allotment to the Texas oil refineries.

#### Texas Import Capacity

The estimated Texas refinery capacity available for imported crude oil equals the state's total refinery capacity less that required for refining domestic crude. In the development stages of this analysis, this relation proved to be a problem in the balancing of domestic and imported oil supplies. It was necessary to review estimates of national demand and determine the amount of fall-off in the demand for crude oil. The amount of fall-off was proportioned to the Texas refineries that use the Texas share of total national refinery capacity.

#### Mexican Oil

The impact of Mexican crude oil is important and required consideration. A major impact in this study involved the assessment of the change in transportation cost as a result of the close proximity of Mexican oil sources to the Texas coast. The majority of the crude oil being imported into the Texas coastal region currently originates in fields located halfway around the world; the new Mexican fields represent a possible major source of crude oil located approximately 1600 km (1000 miles) from the Texas coast.

Shipping patterns in the world market could change and could create a market for smaller tankers because of (a) the location of the U.S. market and (b) the effect of the large continental shelf near the Yucatan peninsula on the draft of tankers that enter Mexican harbors.

Since it could take 5 to 10 years to develop the Mexican reserves, their effect on a Texas deepwater port is not considered critical. In addition, a deepwater port could still be an important facility if it diverted small tankers from the harbor channels and thereby reduced the possibility of near-shore collisions.

#### Impact of Alaskan Crude Oil

Another consideration involves shipping Alaskan crude oil to the West Coast of the United States and then transporting it by pipeline to Texas for refining. This could have a major impact on the amount of oil imported to the Texas coast. Two potential alternatives were considered: (a) shipping surplus crude oil to the Gulf Coast by the Panama Canal and (b) extending an existing gas pipeline between Arizona and New Mexico to Long Beach, California, and Midland, Texas, for movement of surplus crude oil to the Texas Gulf Coast refineries for processing.

Currently officials in California argue against the conversion of the existing gas pipeline to a carrier of crude oil. One argument suggests that Mexico may export natural gas to Texas and that the currently existing gas pipeline might be used to transport gas to California. In addition, California environmentalists are opposed to tankers unloading crude oil in California waters, and the use of smaller tankers for long-distance movements and the use of the Panama Canal make the first alternative undesirable.

## FEASIBILITY OF STATE FINANCING

Based on an assessment of future demand for crude oil, it can be argued that the financial issues have not been addressed. To facilitate this analysis three levels of capacity were considered. The financial analysis in this paper is based on the information contained in the Seadock 1975 application for license (1).

The initial step was to update Seadock data and capital investment costs. Typical onshore construction, or approximately half of the total project investment, was projected by using an 8 percent compounded rate. The other half of the capital cost was considered offshore construction and was projected by assuming a 13 percent annual growth rate characteristic of offshore experience.

Seadock reported their projected total capital investment and operating and maintenance estimates (in 1975 dollars) over the six- to seven-year construction phase, and that was adjusted to future 1980 dollars, as given in Table 1.

One major factor that affects the profitability or even usefulness of Seadock is the difference in cost between conventional tankers and VLCCs. "World scale 100" shipping rates are used as a basis for negotiating the cost of contracts between fleet owners and shippers. VLCCs in a normal market could be expected to receive contracts at 60 percent of world-scale rates, whereas conventional 36 363- to 45 455-Mg (40 000- to 50 000-ton) tankers would pay around 125 percent of scale rates (1). This is the result of many factors, from reduced crew size to drastically reduced fuel consumption per cubic meter of oil shipped (11, 12).

For purposes of estimation, it was assumed that 70 percent of the imported crude oil would come from the Persian Gulf, 28 percent from West Africa, and 2 percent from North Africa (1). In terms of a VLCC carrying crude oil from the Persian Gulf to Houston, Texas, shipment of oil would cost approximately \$13.64/m<sup>3</sup> (\$2.17/bbl) in 1980 dollars. The cost for the same crude oil transshipped by VLCC to Freeport, Bahamas, and then shipped to Houston by conventional tankers would be \$17.28/m<sup>3</sup> (\$2.75/bbl) in 1980 dollars. The current oversupply of VLCCs makes lightering about \$0.32/m<sup>3</sup> (\$0.05/bbl) cheaper than the projected Seadock fees, which are discussed later (4).

To calculate the actual saving, several other items must be considered. The following charges were based on the original estimates in Seadock's license application and were updated to 1980 dollars. Offloading charges are computed by dividing estimated annual revenue by annual throughput level for each of three cases. The transshipment cost was estimated by Seadock at \$1.25/m<sup>3</sup> (\$0.20/bbl) and converted into 1980 dollars at \$1.82/m<sup>3</sup> (\$0.29/bbl). Likewise, the Seadock estimate of \$0.94/m<sup>3</sup> (\$0.15/bbl) for onshore private docks along the Texas Gulf Coast is increased to \$1.39/m<sup>3</sup> (\$0.22/bbl).

To compare estimated costs of a deepwater port with costs of transshipment to a refinery dock, the cost of new pipelines to connect the offshore port with users of the facility must be considered (see Table 2). In addition, consideration should be given to using underground salt domes rather than aboveground tank farms as storage reservoirs for the imported oil. The U. S. Department of Energy plans to spend \$7.6 billion to store 79.4 million m<sup>3</sup> (500 million bbl) of oil in salt domes in Texas and Louisiana. Of this \$7.6 billion, \$6.2 billion is for the purchase of oil and \$767 million for construction [or approximately \$7300/L (\$27 891/gal) of oil, excluding the purchase price] (13, p. 11). At this level, it can be assumed that the salt dome in Louisiana was preferred by LOOP partly because of the overall cost

advantage. Environmental problems such as disposal of brine may be very difficult to resolve. Because of these risks, this analysis assumes the use of a conventional tank farm, as envisioned by Seadock.

Table 3 gives the projected transportation cost savings for a 0.6 million m<sup>3</sup>/d (3.75 million bbl/d) facility based on the original estimates by Seadock (5). Table 4 gives a comparison of projected transportation cost savings for a facility at three levels of capacity. Each savings estimate was computed in a fashion similar to that used in Table 3. These unit savings are the basis for the following transportation cost savings (1), which are given in 1980 dollars (1 m<sup>3</sup> = 6.28 bbl):

Total Throughput Capacity (million m <sup>3</sup> /d)	Projected 30-Year Transportation Cost Savings (\$000s)	Average Transportation Cost Savings (\$000s)
0.397	11 821 479	394 049
0.595	18 375 858	612 528
0.83	25 894 410	863 147

The construction of the 0.6 million m<sup>3</sup>/d facility, which has a projected 30-year transportation cost savings of \$18.4 billion at an operating cost of \$3.26 billion and capital investment of \$1.2 billion, offers apparent inducements for private investment.

### Bond Financing

The financing requires the issuance of tax-exempt revenue bonds, which may be secured either by a pledge of revenues of the authority, by the revenues associated with leases or contracts, or by other revenues specified by board resolution or indenture. Alternatives are available to the Texas Deepwater Port Authority with respect to how the bonds will be secured. One method would be to attempt to issue the bonds backed solely on the projected revenues. The acceptance of such security would most likely require a higher interest rate. Alternatively, the state could seek to have the major oil company users guarantee the debt through the operating lease agreement, "take or pay" contracts, or simply an inclusion in the indenture to the effect that the oil companies guarantee the issue. This third method was recently used effectively in a tax-exempt issue of marine terminal revenue bonds by the city of Valdez, Alaska. The principal and interest payments on the bonds are payable from pipeline lease revenues and guaranteed by the Standard Oil Company and the British Petroleum Company, Ltd. The state of Texas could set up a similar arrangement for financing its deepwater terminal, offering interested parties depreciation and investment-tax-credit incentives along with the associated less expensive financing.

Data given in Table 5 are based on Seadock projected volumes, capital investment, and operating and maintenance costs adjusted for inflation to 1979 dollars (1). The figures are for a facility with a 0.6 million m<sup>3</sup>/d (3.75 million bbl/d) capacity attained in the third year of operation. Note that projected throughput is depicted in the volume column of the tables and is a critical factor in the calculation of the tariff. The tariff figures have been calculated by dividing total yearly costs by yearly volume. No provision has been made for any additional return in these tariff figures. It is important to note that the table is intended to present relative numbers regarding the construction and operation of a deepwater terminal.

Four tariff schedule plans were generated, and their



**Table 1. Capacity of Seadock terminal.**

Total Throughput Capacity (million m <sup>3</sup> /d)	Total Capital Investment		Thirty-Year Average Annual Cost	
	1975 Dollars	1980 Dollars	1975 Dollars	1980 Dollars
0.397	517 010 000	856 107 000	52 881 667	77 700 000
0.595	728 310 000	1 205 995 000	74 097 337	108 873 000
0.667	812 480 000	1 345 370 000	86 904 333	127 691 000

Note: 1 m<sup>3</sup> = 6.28 bbl.**Table 2. Estimated cost of pipeline distribution system from Seadock to refineries along Texas Gulf Coast.**

Item	Diameter (cm)	Estimated Length (km)	Estimated Cost (\$'000s/km)	Total Cost (\$'000s)
Distribution				
Freeport, the Bahamas, to Houston, Baytown, Texas City, Beaumont, and Port Arthur, Texas	103-123	363	1185	164 565
Beaumont to Lake Charles, Texas, and others	62-77	129	829	41 141
Freeport, the Bahamas, to Sweeney, Texas, and others	41-51	40	474	7 347
Total				213 053
Pumping station, delivery facilities, etc.				66 120
Total				279 173

Note: 1 cm = 0.39 in; 1 km = 0.62 mile.

**Table 3. Comparative shipping costs: Seadock versus transshipment for facility with capacity of 0.6 million m<sup>3</sup>/d.**

Crude Oil Source	Cost Item	To Seadock, to Refineries	To Freeport, Bahamas; to Houston, Texas; to Refineries	Cost Savings for Crude Shipped Through Seadock (\$/m <sup>3</sup> )	Percentage Shipped From Source <sup>a</sup>	Total Cost Savings (\$/m <sup>3</sup> )
Persian Gulf	VLCC <sup>b</sup>	11.38	10.63			
	Handling charge	-	1.82			
	Transshipment <sup>c</sup>	-	3.33			
	Offloading	1.57	1.38			
	Pipeline transport <sup>d</sup>	0.57	0.13			
	Total	13.52	17.29	3.77	70	2.64
West Africa	VLCC <sup>b</sup>	6.29	5.35			
	Handling charge	-	1.82			
	Transshipment <sup>c</sup>	-	3.33			
	Offloading	1.57	1.38			
	Pipeline transport <sup>d</sup>	0.57	0.13			
	Total	8.43	12.01	3.59	28	1.01
North Africa	VLCC <sup>b</sup>	6.29	5.66			
	Handling charge	-	1.82			
	Transshipment <sup>c</sup>	-	3.33			
	Offloading	1.57	1.38			
	Pipeline transport <sup>d</sup>	0.57	0.13			
	Total	8.43	12.32	3.90	2	0.13
Total cost savings for all crude transported through Seadock						3.78

Notes: 1 m<sup>3</sup> = 6.28 bbl.

All dollar amounts are given in 1980 dollars.

<sup>a</sup>Seadock estimate.<sup>b</sup>Estimated cost of transport by 227 273-Mg tankers at 60 percent of world scale 100.<sup>c</sup>Estimated cost of transport by 36 360-45 450-Mg tankers at 125 percent of world scale 100.<sup>d</sup>From Seadock on ship tanker to Gulf Coast refineries or from private oil dock to refineries.**Table 4. Cost savings for offshore terminal (at various facility capacities) versus transshipment.**

Facility (million m <sup>3</sup> /d)	Cost Savings (\$/m <sup>3</sup> )			
	From Persian Gulf	From West Africa	From North Africa	Total
0.40	0.065	0.024	0.0016	0.090
0.60	0.067	0.025	0.0032	0.095
0.67	0.073	0.027	0.0032	0.103

Notes: 1 m<sup>3</sup> = 6.28 bbl.

All dollar amounts are given in 1980 dollars.

relative merits were compared. The four schedules were as follows:

1. Assuming uniform principal payments beginning year 1 for 20 years [average tariff = \$1.27/m<sup>3</sup> (\$0.2022/bbl) over 20 years or a present worth value of 0.0899],

2. Assuming uniform principal payments beginning year 3 for 17 years [average tariff = \$1.31/m<sup>3</sup> (\$0.2072/

bbl) over 20 years or a present worth value of 0.0884],

3. Assuming tariff held constant after first three years [average tariff = \$1.36/m<sup>3</sup> (\$0.2154/bbl) over 20 years or present worth value of 0.0868], and

4. Assuming constant tariff for years 1 to 10 and 11 to 20 [average tariff = \$1.35/m<sup>3</sup> (\$0.2151/bbl) or a present worth value of 0.0867].

Figure 4 shows the comparison of resultant tariff schedules.

Plan 1 showed a tariff that would result if debt principal payments were begun immediately on operation, whereas plan 2 delayed the initial principal payment for three years. Plan 3 delayed any principal payment for four years and made the tariff approximately constant after the third year of operation. Plan 4 held one constant tariff through the 10th year and another constant tariff from the 10th to the 20th year (Table 5).

In each of the first three plans, the low volumes associated with startup produced relatively high tariffs

Table 5. Constant tariffs for years 1 to 10 and 11 to 20 of operation of deepwater terminal.

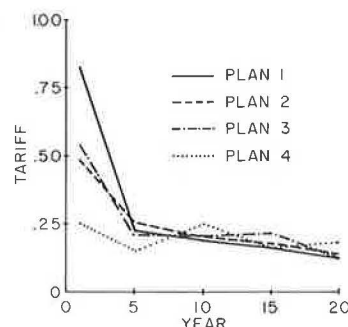
Calendar Year	Year of Operation	Volume (000s m <sup>3</sup> /d)	Total Capital Investment (\$000s)		Annual Operating and Maintenance Costs (\$000s)	Principal (\$000s)	Long-Term Debt (Short-Term Debt) Interest <sup>b</sup>	Total Cost (\$000s)		Tariff <sup>c</sup> (\$/m <sup>3</sup> )	Present Value <sup>a</sup> (\$/m <sup>3</sup> )	Cumulative Short-Term Debt <sup>d</sup> (\$000s)
			Annual	Present Value <sup>a</sup>				Annual	Present Value <sup>a</sup>			
1979	-2		44 864	49 350								
1980	-1		438 924	438 924								
1981	1	79.4	345 741	314 310	68 310	-	30 237	98 457	89 506	1.58	1.43	52 832
1982	2	159	238 873	197 415	101 016	-	51 645 + (4 227)	157 088	129 825	1.58	1.30	118 670
1983	3	317.5			131 586	-	66 775 + (9 494)	207 855	156 165	1.58	1.18	144 025
1984	4	429			135 831	-	66 775 + (11 522)	214 128	146 252	1.58	1.07	111 778
1985	5	444			133 994	-	66 775 + (8 942)	209 711	130 214	1.58	0.98	65 989
1986	6	460			132 158	-	66 775 + (5 279)	204 212	115 272	1.58	0.89	5 576
1987	7	476			130 294	76 235	66 775 + (446)	273 750	140 477	1.58	0.81	-
1988	8	476			127 369	84 371	62 010	273 520	127 706	1.58	0.73	-
1989	9	476			124 444	92 569	56 737	273 750	116 097	1.58	0.67	-
1990	10	476			121 519	101 279	50 952	273 750	105 542	1.58	0.61	-
1991	11	476			181 580	41 563	44 622	204 765	71 768	1.18	0.41	-
1992	12	476			115 655	47 086	42 024	204 765	65 244	1.18	0.37	-
1993	13	476			112 730	52 954	39 081	204 765	59 313	1.18	0.34	-
1994	14	476			109 791	59 202	35 772	204 765	53 921	1.18	0.31	-
1995	15	476			106 866	65 828	32 071	204 765	49 019	1.18	0.28	-
1996	16	476			103 941	72 867	27 957	204 765	44 563	1.18	0.26	-
1997	17	476			101 016	80 346	23 403	204 765	40 512	1.18	0.23	-
1998	18	476			98 077	88 307	18 381	204 765	36 829	1.18	0.21	-
1999	19	476			95 152	96 751	12 862	204 765	33 481	1.18	0.19	-
2000	20	476			92 227	109 044	6 815	208 086	30 931	1.2	0.18	-
Total		8552.9	1 068 402	1 000 000	2 260 556			4 030 287	1 742 637	1.36	0.55	

Notes: 1 m<sup>3</sup> = 6.28 bbl.

All dollar amounts are given in 1979 dollars.

<sup>a</sup>Ten percent end-of-year discounting.<sup>b</sup>Interest rate of 6.25 percent.<sup>c</sup>Total cost ÷ volume for year.<sup>d</sup>Short-term interest rate of 8 percent.

Figure 4. Tariff schedule plans.



for the first three years of operations in comparison with later years. Plan 1 resulted in the lowest average tariff over the 20-year life of the facility; however, when the present values of total annual costs and tariffs were compared, plan 3 showed the lowest average tariff. Plan 3 also offered the advantage of a tariff that was constant except in the first three years.

Constant tariffs throughout the life of the facility would offer advantages, and plan 4 was formulated to attempt to provide such. To meet fixed expenses with the first year's low throughput volumes, without charging a high tariff, additional capital must be employed. The additional funds could be obtained as part of the original long-term debt, or they could be obtained on a short-term basis. Plan 4 assumes the short-term funds requirement is satisfied by short-term debt financing. No principal payments are made until the seventh year, and the short-term debt accumulated in the first three years is paid off in the fourth through the seventh year. This financing alternative produces tariffs that closely approximate the average tariff figures in plan 3, and the constant tariffs provide obvious planning advantages to the customers of the terminal. The constant tariff would also prevent companies from delaying participation until after the first years of higher tariffs.

Each of the plans shows average tariffs that indicate potential savings in shipping costs utilizing a deepwater

terminal. Since these tariffs are based on a break-even operation, it may be argued that the oil companies would receive no return for the risk they would incur by guaranteeing the required debt financing. The Texas Offshore Terminal Commission answered this argument in the following way (14, p. 2):

It is still to the primary interest of the oil companies that the product of their industry be marketable at the lowest cost at the retail level. There would be no profit or loss to the oil companies in this segment of the production chain if (the terminal were) publicly financed. Thus, this segment should be of no consequence to the companies so long as they can still sell and make a profit at retail. Public financing will aid in providing the lowest cost at the final destination of the product.

Oil companies may feel, however, that the demand for their product is sufficiently inelastic to discount such a rebuttal. It should also be noted that different crude oil customers incur different transportation costs and that any comparison is necessarily made on an average at best. This preliminary analysis, however, does show that it may be in the best interest of consumers to construct the deepwater terminal, and a more detailed financial analysis is justifiable.

## CONCLUSIONS AND RECOMMENDATIONS

Based on the information currently available, the projections and analysis performed in this study indicate that there is justification for a Texas deepwater port. The projected demand for crude oil and the financial feasibility of a deepwater terminal as well as the associated favorable economic and environmental impacts indicate the desirability of the facility.

As the only high-volume supplier of crude oil in the area, a deepwater port off Freeport, Texas, will greatly influence refinery activity along the Texas Gulf Coast. The predicted demands for crude oil in this area indicate that a facility with a capacity of 0.6 million m<sup>3</sup>/d (3.75 million bbl/d) could be justified.

The financial analysis indicates that the transportation cost savings are attractive. A 0.6 million m<sup>3</sup>/d facility could provide a transportation cost savings of \$3.78/m<sup>3</sup> (\$0.60/bbl). Over a 30-year payout period, it was projected that a total cost savings (in 1980 dollars)

of \$18.4 billion, operating costs of \$3.3 billion, and a \$1.2 billion capital investment could be realized.

Bond financing alternatives were explored with an investigation of tariffs required to offset the port costs. Table 5 establishes constant tariffs for the first and second decades of the terminal's operations. Tariffs of \$0.2500 and \$0.1870, respectively, are assessed. Investigations showed average tariffs of \$1.26-\$1.39/m<sup>3</sup> (\$0.20-\$0.22/bbl).

The impact on the Texas Gulf Coast if a deepwater terminal is not built is difficult to evaluate. Among a number of considerations are the following:

1. The projected demand for crude oil could be satisfied by transshipment or lightering. The projected Seadock cost savings associated with a deepwater port would become an added economic burden on the petrochemical industry that would undoubtedly be passed on to the consumer.

2. LOOP might be drastically expanded and tied into the projected Seadock area by new pipelines, which would create a shift in economic activities in the Gulf Coast region.

3. Crude oil demand in the Seadock import area might not be met, and this would adversely affect one-third to half of the petrochemical plants in the United States.

In view of the findings provided in this assessment, it is recommended that the Texas Deepwater Port Authority expedite the establishment of the offshore port. The initial study should be a detailed financial and operational analysis. The net benefit of the port would be nationwide and should promote a return to marine transportation for the United States.

#### ACKNOWLEDGMENT

This paper represents a program initiated in 1971 by the Department of Civil Engineering, University of Texas at Austin. Once every three years, a multidisciplinary graduate course in marine and waterway transportation is offered that concentrates on pertinent issues that face the state of Texas. Much of the background investigation and the assessments contained in this paper resulted from studies performed in these courses. I wish to acknowledge the following graduate students for their contribution: Roberto Arciniegas, R. Ashley Lindstedt, Gerald Menefee, Jr., Roger S. Vaughan, and Sergio Villaflores.

An investigation of this nature obviously requires timely and accurate information as well as access to

data and pertinent reports. I wish to express my appreciation to Joe Moseley, formerly with the Texas Coastal and Marine Council and now with the Texas Deepwater Port Authority, for his participation in this study. A very special thanks is extended to Danny Burger of the Municipal Advisory Council of Texas for his review of the bond financing schemes.

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*Publication of this paper sponsored by Committee on State Role in Waterborne Transportation.*

## Time-Based Multicriteria Evaluation Model of User Charges

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The results of a study conducted to develop a model of waterway user charge impacts and test the model on a case study region are summarized. The model developed is a Markov decision theory model with an implied transition period of five years. The transition probabilities were es-

timated subjectively based on a state space defined by change in freight traffic movement. Reward estimates were based on multiple criteria such as change in shipping costs and change in equity. The rewards were developed from a variation on the rank-based expected-value method of