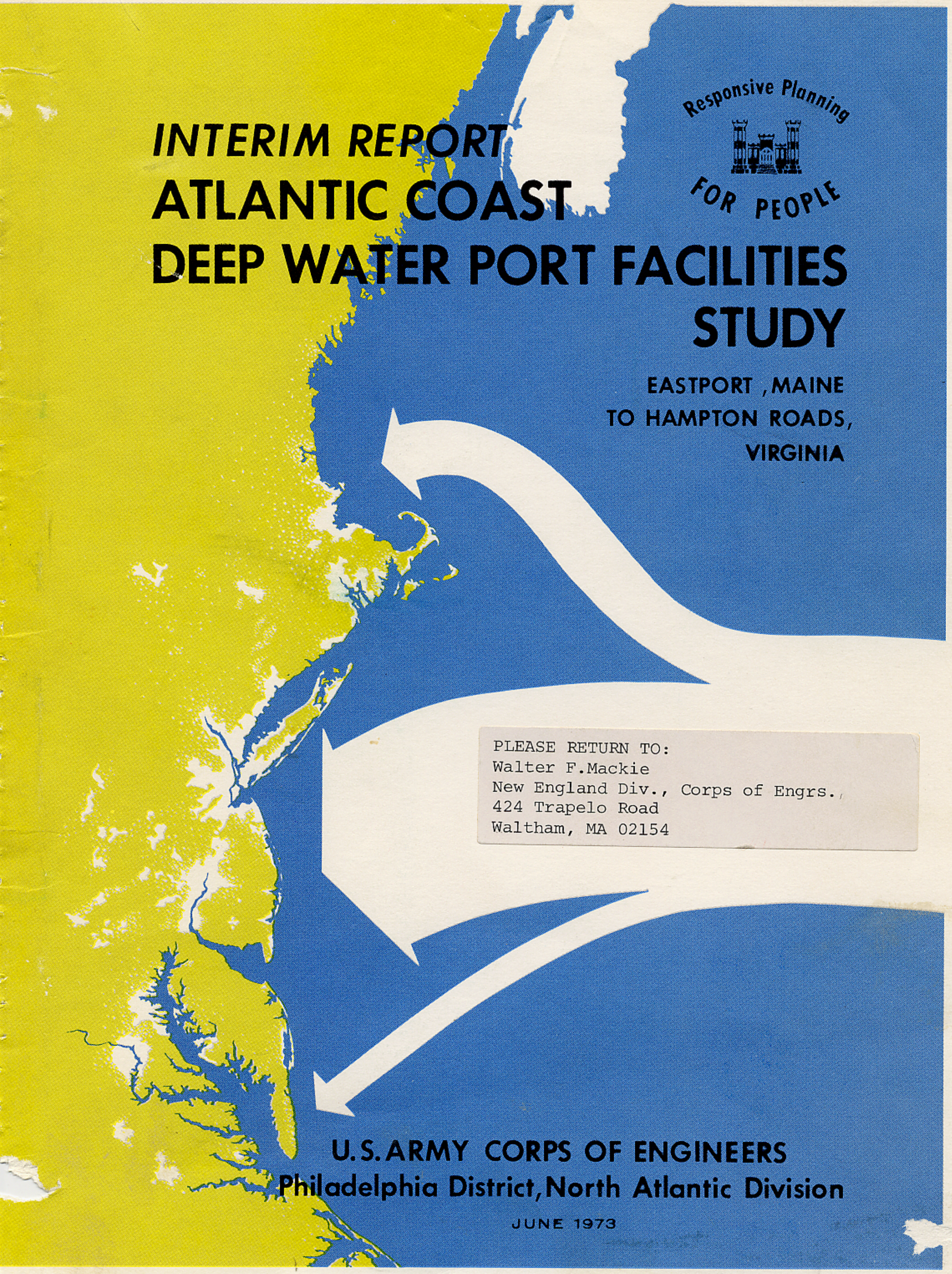
INTERIM REPORT

ATLANTIC COAST DEEP WATER PORT FACILITIES STUDY

Responsive Planning FOR PEOPLE

EASTPORT, MAINE TO HAMPTON ROADS, VIRGINIA



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LIST OF PLATES

AUTHORITY

The United States runs on oil and will continue to do so through the end of this century. Although the American economy's needs were satisfied from domestic sources in the past, current projections indicate that by the year 2000, as much as one half of the projected crude oil requirements of the United States may have to be imported. This trend is particularly significant to the North Atlantic Region,* a fuel deficit area which in 1970 consumed 19 percent of the United States' energy requirements and accounted for 70 percent of the petroleum products used along the entire Atlantic Coast.

North Atlantic refineries are now supplied by crude oil shipped mainly from the Gulf of Mexico and Venezuela. However, trade patterns are changing and the Persian Gulf and North Africa are likely to become the North Atlantic's principal sources of supply. In that event, the journey from oil field to refinery will be considerably lengthened, an event which will exert pressure to achieve transportation economies. Such economies can be achieved through use of vessels larger than those currently in use on existing American oil trade routes. Construction and operation of these super tankers has been made possible by technological advances in design, control and propulsion. Economic and social pressures generated by growing energy demands have made that possibility a reality. Today, tankers of 200,000 deadweight tons (DWT) or more are commonplace and dry bulkers of comparable size are appearing in ever increasing numbers.

Since many of these ships draw 67 to 75 feet of water, their safe operation requires channel and harbor depths of 80 to 100 feet. Although facilities have been developed in several foreign countries to accommodate such large vessels, none have been developed in the United States. This disparity has caused a growing concern about possible adverse effects upon our Nation's economy, security and standard of living and the possibility of environmental damage to coastal reaches as vessel traffic along them increases. A manifestation of this concern was the following resolution adopted on 27 October 1971 by the United States Senate Committee on Public Works:

"Resolved BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under the provisions of Section 2 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the reports of the Chief of Engineers on commercial navigation channels and harbors along the Atlantic Coast between Eastport, Maine and Hampton Roads, Virginia, with a view to determining the most efficient, economic and logical means of developing facilities to accommodate very large bulk cargo carriers including, but not limited to, offshore facilities. In carrying out this study, consideration shall be given to a governing organization and financing methods to construct, operate and maintain such regional facilities serving more than one of these areas as may be found desirable, to ensure equitable benefits to such areas. Further, in carrying out this study, the Corps of Engineers shall cooperate with and coordinate its efforts with all affected Federal Departments, agencies, and instrumentalities, including the President's Council on Environmental Quality, the Environmental Protection Agency, and all other interested parties, public and private, and, in addition, shall ensure that any project proposals include appropriate measures for the protection and/or enhancement of the environment."

Congressional concern about providing navigation facilities to meet the needs of the national economy was also expressed in a resolution adopted on 2 December 1970 by the House Committee on Public Works calling for a review of previous reports on Delaware River ports. Certain regional aspects of the Delaware River study are common with the more comprehensive aspects of this regional report on the Atlantic Coast. This report is in partial compliance to that authority. However, complete response to the House resolution will be undertaken in a separate interim report dealing with specific problems of waterborne commerce on the Delaware River.

PURPOSE OF THE STUDY

This interim study responds to the foregoing Senate Committee resolution and in part to the House Committee resolution by:

*Region includes States of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, Rhode Island, Vermont, the eastern shore of Virginia and the eastern half of New York and Pennsylvania.

1. Determining the best means of developing facilities for very large bulk carriers in terms of efficiency, economy, and logic.
2. Considering methods for a governing organization and financing construction, operation and maintenance of such facilities.
3. Identifying measures needed to ensure that environmental values of affected areas are protected and/or enhanced.

Implicit in these functions is the need to select a course of action which would best supply the needs of the total public interest.

All courses of action considered in this study were formulated with respect to their effects on four areas; (1) environmental quality; (2) regional economic development; (3) social well-being; and (4) national economic efficiency. These areas were treated in accordance with current Federal water resource development policies as stated in Senate Document Number 97, 87th Congress, 2nd Session; Sections 122 and 209 of Public Law 91-611; and the Proposed Principles and Standards for Planning Water and Related Land Resources of the Water Resources Council, published in the Federal Register on 21 December 1971.

RELATED REPORTS AND STUDIES

The above resolutions cited previous reports of the Chief of Engineers. Most significant among them were the Baltimore Harbor and the York and Pamunkey Rivers studies. Those studies and a number of other navigation studies closely related to this interim study were reviewed. They included:

Portland Harbor, Maine
Boston Harbor, Massachusetts
New Haven Harbor, Connecticut
East River and Steinway Creek, New York
New York and New Jersey Channels, New York & New Jersey
Delaware River Channel Dimensions and Anchorages, Delaware, Pennsylvania and New Jersey
Norfolk Harbor and Channels, Virginia

Investigations of specific needs for facilities to accommodate very large bulk carriers in those studies will be fully coordinated with this more comprehensive survey. When completed, those studies will be consistent with the regional framework developed in this study.

This is one of three regional deep water port facilities studies being conducted by the Corps of Engineers. One, under authority of a Senate Public Works Committee resolution, examines the need for deep draft facilities along the Gulf Coast between Brownsville, Texas and Tampa, Florida. The other responding to a House Public Works Committee resolution, considers the feasibility of such facilities on the Pacific Coast.

Other Federal agencies have studied and are continuing to study the deep water port problem. These include the U.S. Maritime Administration's study, "Offshore Terminal System Concepts", and studies sponsored by the Council on Environmental Quality to consider environmental effects of super tankers. Their data, and those of other Federal and non-Federal agencies that have studied the problems of deep draft vessels, have been used in this study.

ASSUMPTIONS

This study is based upon the following assumptions:

1. The economy of the United States, and that of its North Atlantic Region, will continue to expand throughout this century.
2. That expanding economy will create correspondingly greater demands for energy. As a result, petroleum consumption in the U.S. will grow at an average rate of 4.4 percent a year for the period 1970 to 1980 and 2.2 percent per year from 1980 to 2000.
3. The principal sources of crude oil to be used to meet the North Atlantic Region's demands for energy lie in North Africa and the Persian Gulf, regardless of whether deep water terminals exist in the Northeastern United States.
4. Petroleum shippers will continue to have the option of lightering in the coastal waters of the United States.
5. The capacity of refineries in the North Atlantic Region will be about the same, regardless of whether deep water terminals are developed in the Northeastern United States. Those refineries will continue to be located in the Arthur Kill, Delaware River and York River areas.

METHODOLOGY

The Senate Committee's resolution requires that the reporting officers determine the most efficient, economic and logical means of accommodating very large bulk carriers in the North Atlantic Region. To meet that objective, the following sequential analysis was used:

1. The immediate and projected demand to the year 2000 for deep draft facilities in the North Atlantic Region was estimated in terms of both commodity movements and quantities expected.
2. Certain general plans of action for meeting or lessening the immediate and projected demands were postulated and analyzed, and the most promising selected for more detailed analysis.
3. Criteria were specified in terms of the purpose of this study to determine the most promising of the many alternative solutions to the deep water port problem.

4. Within the parameters of the most promising general plan of action, certain more specific alternatives were formulated and analyzed to establish a relatively small number of potentially viable solutions to the problem.

5. Alternatives thus chosen were developed into conceptual plans which then were analyzed in detail to permit selection of an apparent best solution and to make clear the trade-offs involved in departing from that particular solution.

6. The apparent best solution was verified against the plans of action arrived at in step 2.

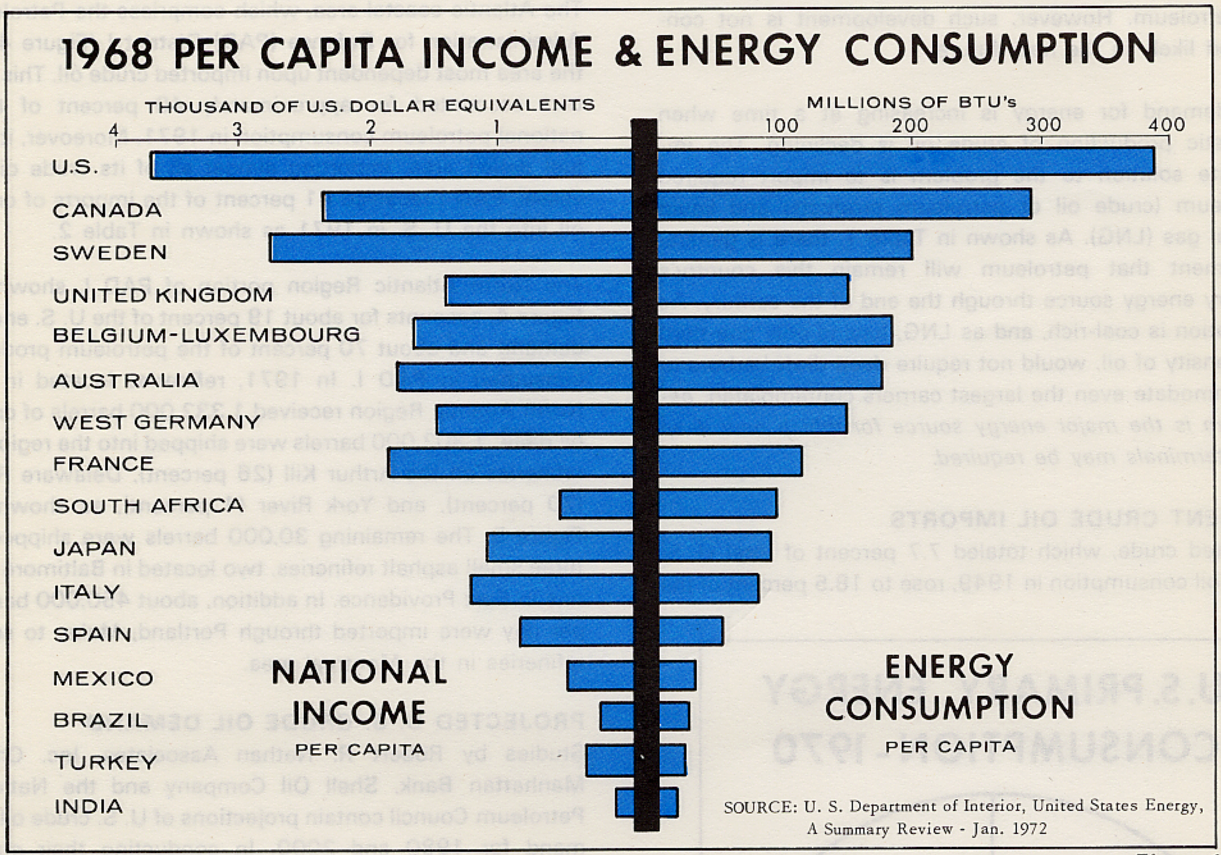


Figure 1

GENERAL

In the United States, as in the rest of the world, energy consumption has been in proportion to per capita income (Figure 1). America has been able to maintain a high standard of living through the years only by continual withdrawals from finite reserves of raw materials and energy. As a result, the nation now stands at a crossroads. To maintain the present standard of living without seriously degrading the quality of American life, national resources must be conserved and used wisely. The desirability of economic growth must be weighed against environmental and social costs. Alternatives will have to be found which, while continuing to foster economic growth, do not do so at the ultimate expense of the environment. The nation must acquire new sources of supply to satisfy its energy demands and must develop new and more efficient methods of delivering the necessary raw materials.

ENERGY SOURCES

Fuel wood was the dominant energy source in 1850; by 1910 coal accounted for about 75 percent of total consumption and fuel wood had declined to about 10 percent. In the 50 years between 1910 and 1960, coal in turn lost its leading position to natural gas and oil[1]. Today, over 90 percent of the energy consumed in the U. S. comes from natural gas, coal and petroleum. Although nuclear power is beginning to emerge as a national energy source, rising demands for electric power will require the continued use of fossil fuel burning plants to meet the nation's needs. Fossil fuel plants have an expected operating life of 30 years and will be required even half a century after the change to nuclear power has been initiated[1]. Therefore, while nuclear power appears to be a major energy source in the future, natural gas and petroleum are likely to continue to supply more than 60 percent of our needs for at least the next 25 years.

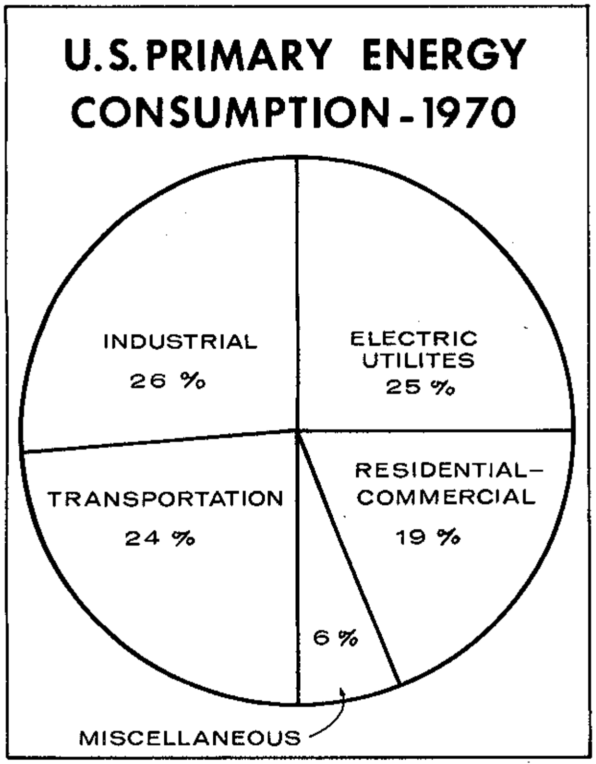
Energy consumption can be divided into four major categories: industrial, residential/commercial, electric utilities, and transportation (Figure 2).

The primary energy sources for the first three categories are coal, petroleum products, natural gas, hydroelectric and nuclear energy. Transportation, however, except for small portions of demand satisfied by electricity, depends almost entirely upon petroleum products. Significant development of new major energy sources in any of the four major categories could markedly reduce dependence on petroleum. However, such development is not considered likely in the near future.

The demand for energy is increasing at a time when domestic production of crude oil is declining. The immediate solution to the problem is to import required petroleum (crude oil or petroleum products) and liquid natural gas (LNG). As shown in Table 1, there is general agreement that petroleum will remain this country's primary energy source through the end of the century. As the nation is coal-rich, and as LNG, having only one-third the density of oil, would not require deep draft harbors to accommodate even the largest carriers contemplated, *petroleum is the major energy source for which new deep draft terminals may be required.*

PRESENT CRUDE OIL IMPORTS

Imported crude, which totaled 7.7 percent of total U. S. crude oil consumption in 1949, rose to 18.5 percent of the consumption by 1972 because of the relatively constant level of domestic oil production.



SOURCE: National Petroleum Council - U. S. Energy Outlook, Nov. 1971

Figure 2

The decline in crude oil discovery and production in the continental U. S. is amply documented. The ratio of proved reserves to domestic production has been steadily declining since 1958 (Figure 3). Such a trend is difficult to reverse. Increased drilling depths, operational costs, and other economic factors have combined to make domestic exploration less attractive to the major oil producers.

The Atlantic coastal area, which comprises the Petroleum Administration for Defense (PAD) District I (Figure 4), is the area most dependent upon imported crude oil. This district accounted for approximately 40 percent of total national petroleum consumption in 1971. Moreover, it is a fuel deficit area, importing almost all of its crude oil by vessel. PAD I received 41 percent of the imports of crude oil into the U. S. in 1971 as shown in Table 2.

The North Atlantic Region portion of PAD I, shown on Figure 4, accounts for about 19 percent of the U. S. energy demand and about 70 percent of the petroleum products consumed in PAD I. In 1971, refineries located in the North Atlantic Region received 1,332,000 barrels of crude oil daily; 1,302,000 barrels were shipped into the region to refineries on the Arthur Kill (26 percent), Delaware River (70 percent), and York River (4 percent), as shown on Figure 5. The remaining 30,000 barrels were shipped to three small asphalt refineries, two located in Baltimore and one in East Providence. In addition, about 450,000 barrels per day were imported through Portland, Maine to serve refineries in the Montreal area.

PROJECTED U. S. CRUDE OIL DEMAND

Studies by Robert R. Nathan Associates, Inc. Chase Manhattan Bank, Shell Oil Company and the National Petroleum Council contain projections of U. S. crude oil demand for 1980 and 2000. In conducting their study, Nathan[2] reviewed these and other studies and projected that U. S. crude oil demand would grow from 11,412,000 barrels/day (bbl/d) in 1970 to 18,700,000 bbl/d in 1980 and to 32,700,000 bbl/d in 2000. Those projections were adopted for use in this study.

PROJECTED U. S. CRUDE OIL PRODUCTION

The National Petroleum Council[3] (NPC) projections to 1985 represent an informed judgment on prospects for domestic oil production under a continuation of existing national policies. Projections to the year 2000 are not available from that source and there is less consensus among available estimates for that year. The National Petroleum Council's production forecast to 1985 assumed that while present U. S. domestic oil exploration and foreign import quota policies would continue, quotas would be relaxed as needed. It concluded that domestic production (including the north slope of Alaska) would level off at about 11,800,000 bbl/d by 1980.

TABLE 1
PROJECTIONS OF U. S. ENERGY SOURCES
(TRILLION BTU'S)

	Dept. Of The Interior [1] (Jan 1972)	National Petroleum Council [2] (Nov 1971)	Shell Oil Co. [3] (Feb 1972)	Oil And Gas Journal [4] (Nov 1971)	Chase Manhattan Bank [5] (Fall 1972)
1970					
PETROLEUM	29,617	28,503	26,000	23,000	30,422
NATURAL GAS	22,546	23,338	22,000	21,000	21,545
COAL	13,792	13,662	12,000	15,000	13,437
HYDROPOWER	2,647	2,677	4,000	4,000	2,579
NUCLEAR	208	240	500	4,000	228
SHALE	–	–	–	–	–
GEOTHERMAL	–	7	–	–	–
TOTAL	68,810	67,827	64,500	67,000	68,211
1985					
PETROLEUM	47,455	40,725	56,000	40,000	62,400
NATURAL GAS	39,422	41,114	24,000	32,000	26,536
COAL	22,260	17,600	22,000	21,500	21,829
HYDROPOWER	3,448	3,320	5,000	4,000	3,733
NUCLEAR	20,811	19,310	16,000	13,000	17,280
SHALE	–	1,478	2,000	–	–
GEOTHERMAL	–	1,395	–	–	–
TOTAL	133,396	124,942	125,000	110,500	131,778
2000					
PETROLEUM	66,216				
NATURAL GAS	50,568				
COAL	26,188				
HYDROPOWER	5,056				
NUCLEAR	43,528				
SHALE	–				
GEOTHERMAL	–				
TOTAL	191,556				

1 US Dept of the Interior, United States Energy, Jan 1972

2 National Petroleum Council's Committee on US Energy Outlook, US Energy Outlook Nov 1971. Volume 2 of 2

3 The National Energy Position—Shell Oil Company, February 1972

4 Oil & Gas Journal—November 1971

5 Outlook for Energy in the U.S. to 1985, June 1972. Energy Economics Divisions Chase Manhattan Bank.

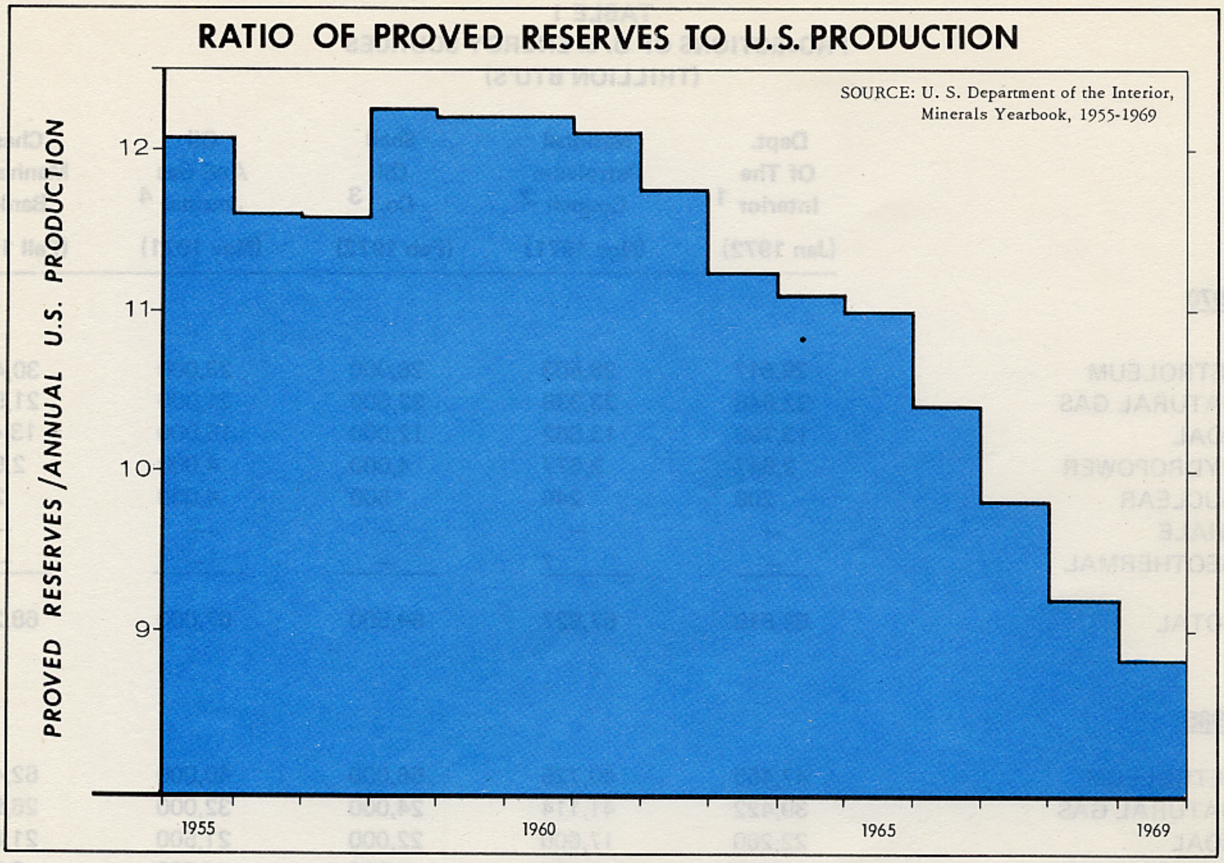


Figure 3

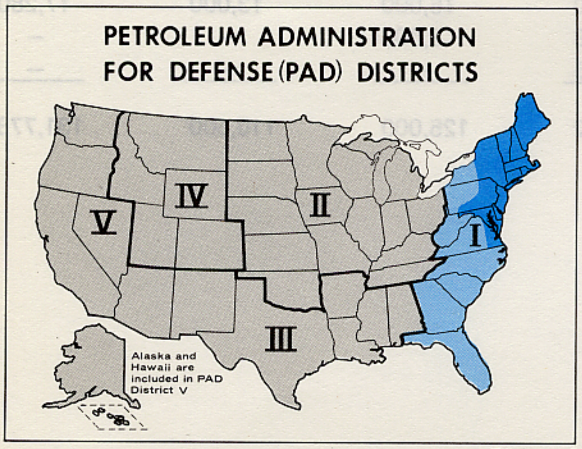


Figure 4

Projections made by Robert R. Nathan Associates, Inc.[2] assume that policies will change after 1980, with the introduction of economic incentives and subsidies to encourage domestic exploration and the production of oil from coal and shale. Consequently, domestic production of petroleum liquids should increase to about 13,000,000 bbl/d by 2000. Recent action by the President substituting a tariff system for import quotas should serve to stimulate domestic production at an earlier date and result in higher levels of production in the future.

PROJECTED U.S. CRUDE OIL IMPORTS

Based on the foregoing projected demand and production rates Nathan determined that the U.S. crude oil deficit, which was 2,162,000 bbl/d in 1972, will grow to 6,900,000 and 19,700,000 bbl/d in 1980 and 2000, respectively. Nathan's projections and those made by Shell Oil Company and the National Petroleum Council are shown on Figure 6.

A major factor in determining the amount of crude oil shipped to the North Atlantic will be the capacity of the refineries in the Region. In 1971, North Atlantic refineries processed 1,332,000 bbl/d of crude oil.

Despite estimates that existing North Atlantic refineries can more than double their capacity at existing locations[4], new refineries will be required if the area is to meet projected demands. Crude oil import projections for the region using a proposed deep water terminal range between 1,000,000 (no refinery expansion) and 6,600,000 bbl/d (Office of Oil & Gas, Department of the Interior projection of the maximum North Atlantic refinery capacity by year 2000) (Figure 7). The high projection assumes no stimulation of U. S. oil and gas production and expansion of East Coast refinery capacity to 50 percent of the area's petroleum requirements. However, in view of regional and State opposition to petroleum production and refinery expans[illegible] new refineries may be limited to areas where refineries now exist. Daily imports and refinery capacity are

TABLE 2
FOREIGN IMPORTS OF CRUDE OIL
U. S. PAD I AND NORTH ATLANTIC 1962-71
(1,000's of Barrells)

Year	District I	North Atlantic*	Total U.S.
1962	244,235	222,446	411,039
1963	248,199	229,397	412,660
1964	252,527	232,026	438,643
1965	258,361	238,995	452,040
1966	259,499	236,529	447,120
1967	216,920	202,952	411,649
1968	263,866	250,080	472,323
1969	269,007	248,840	513,849
1970	211,403	188,053	483,293
1971	252,088	206,968	613,417

* Arthur Kill, Delaware River, and York River.

SOURCE: U.S. Army Corps of Engineers, Philadelphia District

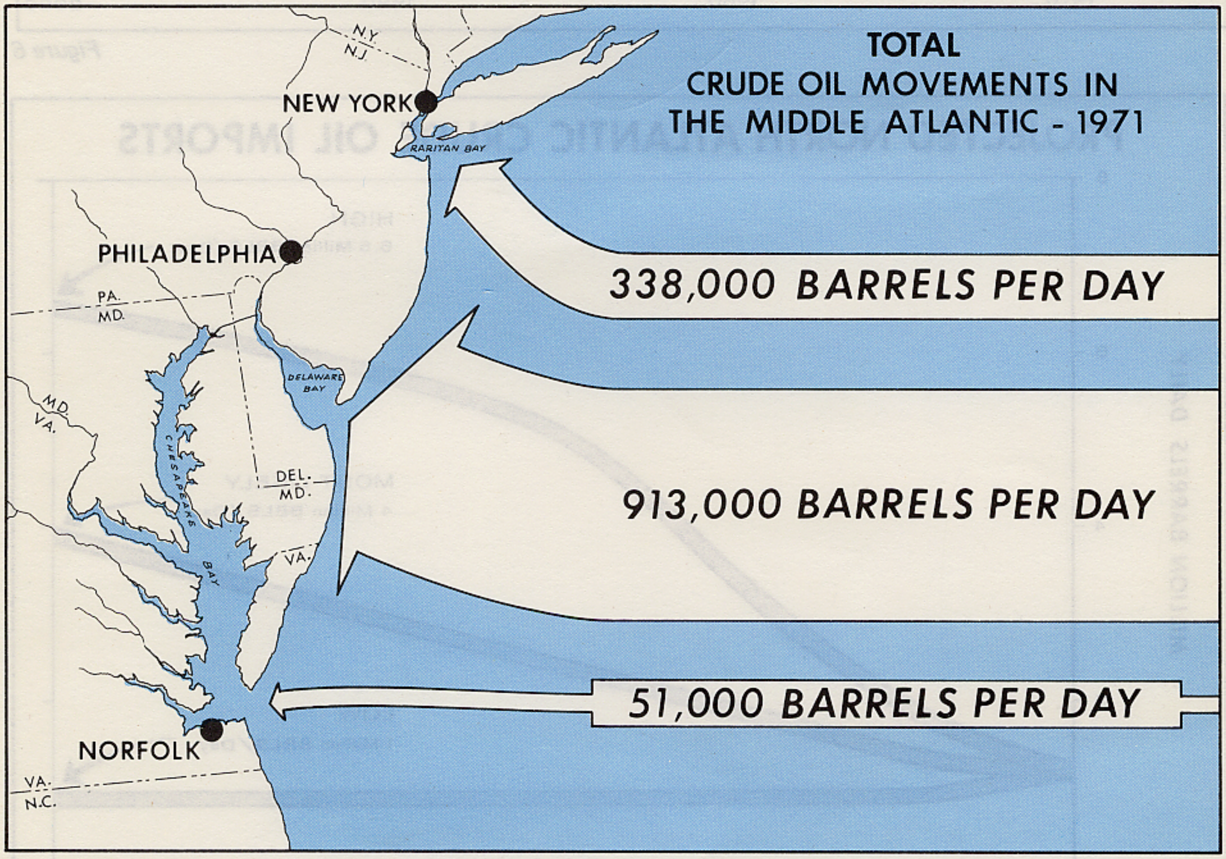


Figure 5

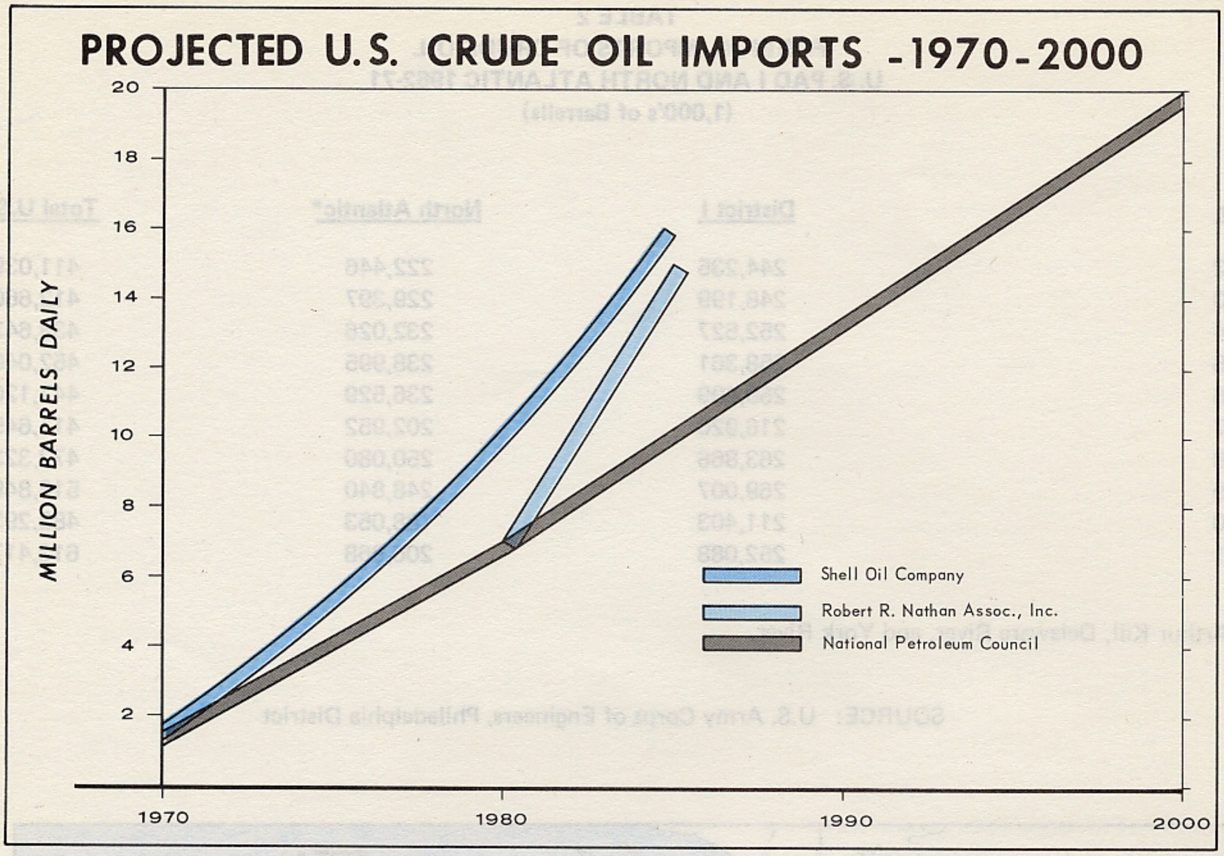


Figure 6

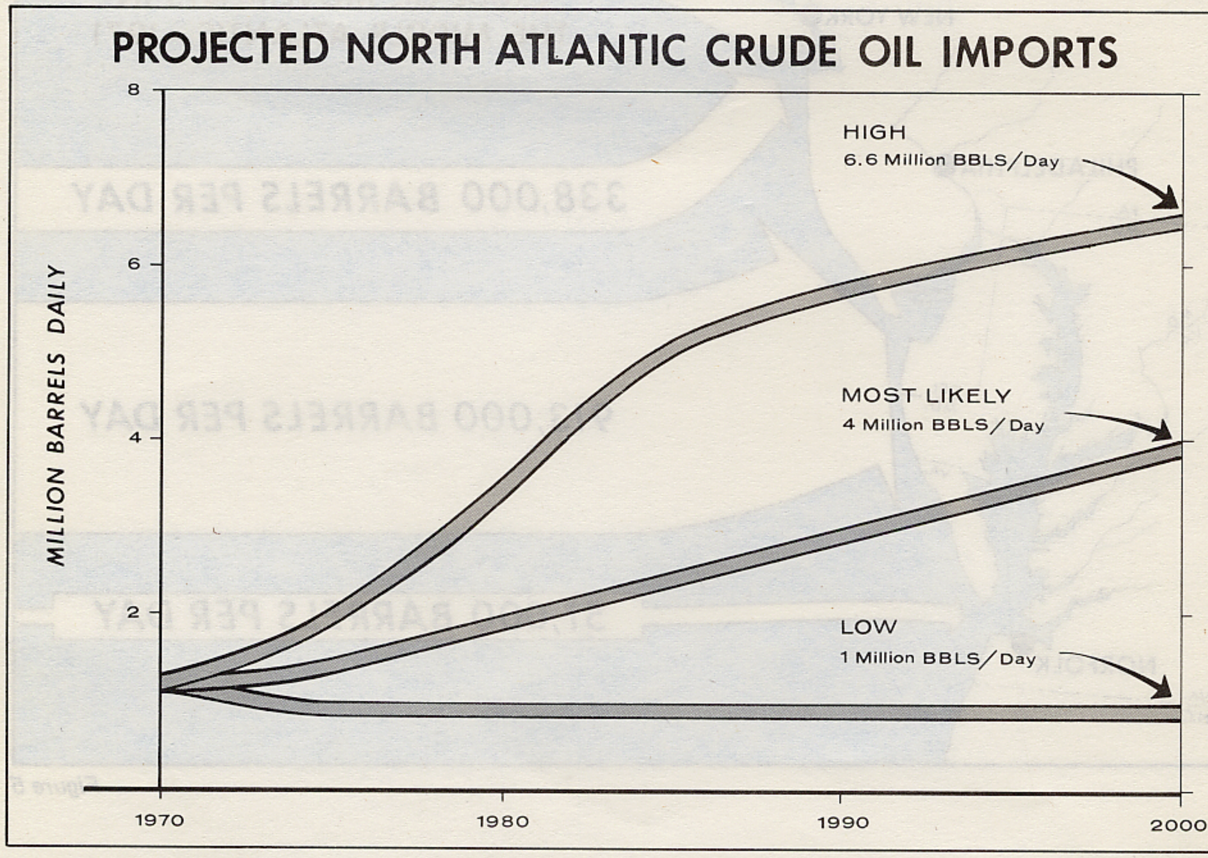


Figure 7

realistically expected to be about 2,000,000 bbl/d in 1980 and 4,000,000 bbl/d by 2000[2]. These projections assume maximum expansion of refinery capacity at existing locations and little or no production of crude oil in PAD 1. Table 3 shows the projected distribution of those imports between North Atlantic refinery centers.

In the past, Venezuela and the U. S. Gulf Coast have been the North Atlantic's major sources of crude oil. Venezuela will be unable to supply the quantities of oil the U. S. will require by 1980[2], partly because of that country's emphasis on its own need to conserve oil for domestic and South American use and because major concession contracts entered into with the Venezuelan Government for exploration and development of that country's petroleum resources will expire in 1983 and 1984. While uncertainty about the terms of service contracts to replace the present concessions could impede Latin America's continuation as our major foreign crude oil source, the determining factor is Venezuela's inability to satisfy the huge projected demand. Even with incentives to increase production along the U. S. Gulf Coast, all of the crude oil produced in that region will be used to meet Gulf Coast demands and those of the mid-continent. Future sources of supply for the North Atlantic Region will inevitably be the Middle East and North Africa, at least until production of crude oil in the North Atlantic can eliminate the deficit which exists in that area.

WORLD PETROLEUM RESERVES

Table 4 displays the present levels of proved and discoverable petroleum reserves in the world. Middle Eastern and African countries have 419 billion barrels of the total proved free world petroleum reserves of 511 billion barrels. By comparison, the U. S. proved reserves including the north slope of Alaska, are 37 billion barrels. However, estimates of reserves which have not yet been found (discoverable oil in place) indicate that the United States has large quantities of crude oil which may be found in the future.

Consequently, the Middle East and Africa will be the dominant sources of supply of crude oil for North Atlantic refineries until such time as additional domestic discoverable reserves are brought into production.

PETROLEUM PRODUCTS

A growing market for refined petroleum products exists in the North Atlantic Region. These products are mainly residual and distillate fuel oil (used in firing electrical generating plants, industrial heating, and many manufacturing processes), gasoline, jet fuel, kerosine, and asphalts.

Residual fuel oil is a low-profit by-product of the refining process. About 60 percent of total U. S. residual fuel oil sales presently occur in states within the North Atlantic Region[5]. Although regional sales of residual fuel oil increased at an annual rate of 1.3 percent from 1950 to 1963, total national demand has remained relatively constant. Residual fuel oil is competitive with other fuels in the region because of the availability of navigation facilities to accept ocean going vessels and the impact of sulfur emission restrictions on coal consumption. Its proportion in domestic refining has dropped from 20 percent in 1950, to approximately 5 percent in 1970. The heavily populated and industrialized New England portion of the North Atlantic Region has no petroleum refining capability and is thus dependent on imports of residual fuel oil and other petroleum products. Imports of residual fuel oil in the New England area totalled some 420,000 bbl/d in 1970[6].

Domestic residual fuel oil production throughout the entire North Atlantic Region was expected to continue to decline.

TABLE 3
EXISTING CRUDE OIL RECEIPTS FOR 1971
AND PROJECTED PERSIAN GULF AND NORTH AFRICAN IMPORTS
(barrels/day)

North Atlantic Refinery Center	1971		1975	1980	2000
	Domestic	Foreign			
Arthur Kill	214,000	124,000	325,000	520,000	1,040,000
Delaware River	438,000	475,000	875,000	1,400,000	2,800,000
York River	100	50,900	50,000	80,000	160,000
Totals	652,100	649,900	1,250,000	2,000,000	4,000,000

SOURCE; U. S. Army Corps of Engineers, Philadelphia District

TABLE 4
WORLD PETROLEUM RESERVES–1970
(in thousands of barrels)

Country	Discoverable oil in place	Proved Reserves
Total Europe	300,000,000	3,708,500
Africa	1,100,000,000	74,757,520
Middle East	900,000,000	344,574,900
Asia-Pacific	300,000,000	14,408,648
Western Hemisphere	1,800,000,000	73,947,890
United States	1,000,000,000	37,012,640
Latin America/Caribbean		26,185,250
	800,000,000	
Canada		10,750,000
TOTAL FREE WORLD	4,400,000,000	511,397,458
COMMUNIST WORLD	1,800,000,000	100,000,000
TOTAL	6,200,000,000	611,397,458

SOURCE: Robert R. Nathan Associates, Inc., U.S. Deepwater Port Study - August 1972

However, the phasing out of the quota system and imposition of tariffs on imported petroleum products may reverse this trend.

The Middle Atlantic states is the principal market area within the North Atlantic Region for petroleum products other than residual fuel oil. That area, which includes New York, New Jersey, Pennsylvania, Delaware, Maryland and Virginia, receives oil products from local refineries and from Gulf Coast refineries via pipeline or coastal vessel. The Philadelphia and New York City metropolitan areas are interconnected by a series of four petroleum product pipelines. Petroleum demand for these areas is also partially satisfied by pipeline shipments from Gulf Coast refineries via the Colonial Pipeline System, which has a current capacity of 732,000 bbl/d.

The New England area, totally lacking crude oil refining capacity, is served almost entirely by waterborne shipments, 75 percent of which originate along the Gulf Coast. In 1970, Gulf Coast refineries supplied this area with approximately 560,000 barrels per day of refined petroleum products other than residual fuel oil. By 1980, it is estimated that daily receipts of these products will approach 740,000 barrels [5]. Six pipelines with a total average annual capacity of 129,000 barrels a day lead from the New England coast to large inland cities.

The past trends of receiving petroleum products other than residual fuel at selected North Atlantic harbors is shown in Figure 8. Representative New England harbors have had a continuous increase in waterborne receipts since 1950. The Colonial Pipeline, which became operational in the early 1960's, caused a decrease in receipts at New York and other mid-Atlantic ports as shown in that figure. The pipeline is now approaching full capacity. Consequently, the volume of product being moved into the region by vessel from domestic sources has been increasing since 1968.

The demand for petroleum products within the North Atlantic Region is projected to increase from 4.8 million bbl/d in 1970 to 6.8 million bbl/d by 1980 and to 9.9 million bbl/d by 2000 [2]. With projected refinery capacity of 2 million bbl/d in 1980, and 4 million bbl/d in 2000, the deficit in products in the North Atlantic Region will expand from the 1970 level of 3.5 million bbl/d to 4.8 and 5.9 million bbl/d in 1980 and 2000, respectively. Petroleum products for the North Atlantic Region are expected to come from two sources, the Caribbean and the Gulf Coast. Caribbean and domestic sources will supply residual fuel oil. Other products (such as distillate fuel oil, gasoline and jet fuels) will most likely be transshipped from the Gulf Coast, either by new pipelines or by coastal vessels. Future refining capacity location will determine ports of origin for these products but it is unlikely that current shipping distances will be shortened. Current and future volumes and trade routes for these products indicate that economic advantages could be realized by using larger bulk carriers than those presently in use and suggest the need for ad-

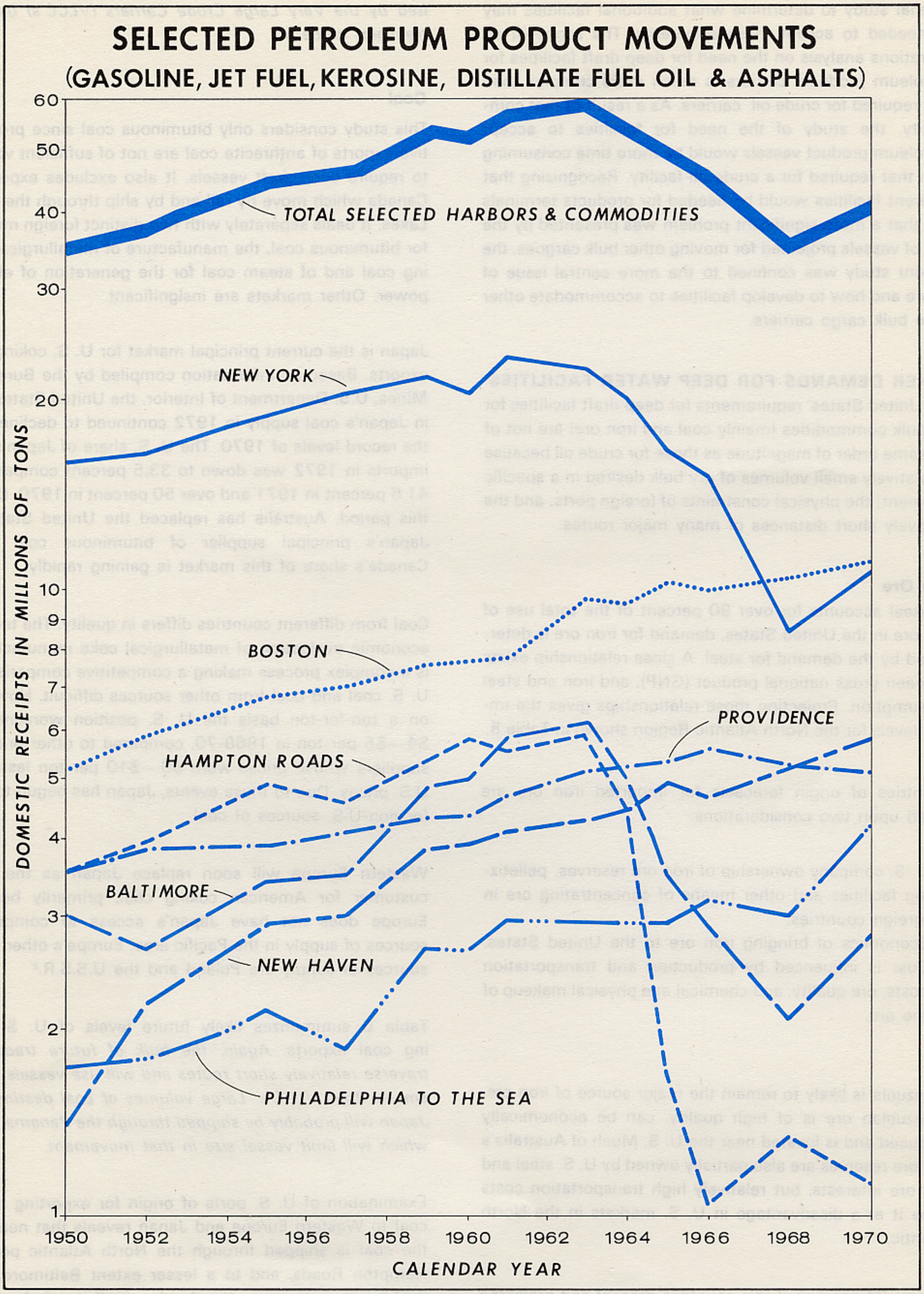

SELECTED PETROLEUM PRODUCT MOVEMENTS
(GASOLINE, JET FUEL, KEROSINE, DISTILLATE FUEL OIL & ASPHALTS)
TOTAL SELECTED HARBORS & COMMODITIES
NEW YORK
BOSTON
PROVIDENCE
HAMPTON ROADS
BALTIMORE
NEW HAVEN
PHILADELPHIA TO THE SEA
DOMESTIC RECEIPTS IN MILLIONS OF TONS
CALENDAR YEAR
1950
1952
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Figure 8

ditional study to determine what additional facilities may be needed to accept these shipments. The scope of an operations analysis on the need for deep draft facilities for petroleum products carriers is much more complex than that required for crude oil carriers. As a result of that complexity, the study of the need for facilities to accept petroleum product vessels would be more time consuming than that required for a crude oil facility. Recognizing that different facilities would be needed for products terminals and that a more significant problem was presented by the size of vessels projected for moving other bulk cargoes, the current study was confined to the more central issue of where and how to develop facilities to accommodate other large bulk cargo carriers.

OTHER DEMANDS FOR DEEP WATER FACILITIES

The United States' requirements for deep draft facilities for dry bulk commodities (mainly coal and iron ore) are not of the same order of magnitude as those for crude oil because of relatively small volumes of dry bulk desired in a specific shipment; the physical constraints of foreign ports; and the relatively short distances of many major routes.

Iron Ore

As steel accounts for over 90 percent of the total use of iron ore in the United States, demand for iron ore is determined by the demand for steel. A close relationship exists between gross national product (GNP), and iron and steel consumption. Projecting those relationships gives the import levels for the North Atlantic Region shown in Table 5.

Countries of origin forecasts for imported iron ore are based upon two considerations:

1. U. S. company ownership of iron ore reserves, pelletizing facilities and other means of concentrating ore in foreign countries.
2. Economics of bringing iron ore to the United States. Cost is influenced by production and transportation costs, ore quality, and chemical and physical makeup of the ore.

Venezuela is likely to remain the major source of iron ore. Venezuelan ore is of high quality, can be economically produced and is located near the U. S. Much of Australia's iron ore reserves are also partially owned by U. S. steel and iron ore interests, but relatively high transportation costs place it at a disadvantage in U. S. markets in the North Atlantic.

Almost 84 percent of this country's present and projected iron ore imports are from countries relatively near the U. S. and thus not susceptible to the economies of scale exhibited by the Very Large Crude Carriers (VLCC's) used to transport crude oil.

Coal

This study considers only bituminous coal since prospective exports of anthracite coal are not of sufficient volume to require deep draft vessels. It also excludes exports to Canada which move by rail and by ship through the Great Lakes. It deals separately with two distinct foreign markets for bituminous coal, the manufacture of metallurgical coking coal and of steam coal for the generation of electric power. Other markets are insignificant.

Japan is the current principal market for U. S. coking coal exports. Based on information compiled by the Bureau of Mines, U.S. Department of Interior, the United States' role in Japan's coal supply in 1972 continued to decline from the record levels of 1970. The U. S. share of Japan's coal imports in 1972 was down to 33.5 percent compared to 41.6 percent in 1971 and over 50 percent in 1970. During this period, Australia has replaced the United States as Japan's principal supplier of bituminous coal while Canada's share of this market is gaining rapidly.

Coal from different countries differs in quality. The techno-economic evaluation of metallurgical coke manufacturing is a complex process making a competitive comparison of U. S. coal and coal from other sources difficult. However, on a ton-for-ton basis the U. S. position worsened by $4—$5 per ton in 1968-70, compared to other principal suppliers whose prices were $8—$10 per ton less than U.S. prices. Due to those events, Japan has begun to look for non-U.S. sources of coal.

Western Europe will soon replace Japan as the main customer for American coking coal, primarily because Europe does not have Japan's access to competitive sources of supply in the Pacific area. Europe's other major sources of supply are Poland and the U.S.S.R.[2]

Table 6 summarizes likely future levels of U. S. coking coal exports. *Again, the bulk of future trade will traverse relatively short routes and will use vessels much smaller than VLCC's. Large volumes of coal destined for Japan will probably be shipped through the Panama Canal which will limit vessel size in that movement.*

Examination of U. S. ports of origin for exporting coking coal to Western Europe and Japan reveals that nearly all the coal is shipped through the North Atlantic ports of Hampton Roads, and to a lesser extent Baltimore, with Gulf Coast ports accounting for the small remainder. Table 6 details export projections for U. S. coking coal for 1980 and 2000.

TABLE 5
TONNAGE OF IRON ORE IMPORTS TO NORTH ATLANTIC
BY ORIGIN AND DESTINATION
(Millions of Short Tons)

Destination	Origin	1970	1980	1990	2000
North Atlantic Region	Canada	7.0	9.5	11.2	12.2
	Venezuela	9.3	12.4	14.6	16.4
	Liberia	2.0	2.6	3.1	3.4
	Other	3.4	4.4	5.0	5.8
	TOTAL	21.7	28.9	33.9	37.8
Baltimore Md.	Canada	3.7	4.5	5.4	6.4
	Venezuela	3.0	4.2	5.0	6.0
	Liberia	1.3	2.5	2.8	3.2
	Other	1.2	3.6	4.1	4.7
	TOTAL	9.2	14.8	17.3	20.3
Delaware River	Canada	3.3	5.0	5.8	5.8
	Venezuela	6.3	8.2	9.6	10.4
	Liberia	0.7	0.1	0.3	0.2
	Other	2.2	0.8	0.9	1.1
	TOTAL	12.5	14.1	16.6	17.5

SOURCE: U. S. Army Corps of Engineers, Philadelphia and Baltimore Districts

SHIP SIZE

Dry and liquid bulk cargoes are being and will continue to be shipped worldwide in increasingly larger vessels. The Federal Maritime Administration predicts that by 1980, the 200,000—300,000 DWT tanker and combination bulk carrier with drafts in the range of 60—80 feet will become standard workhorses of large scale, world bulk trade movements. Ten years ago, only three vessels in the world fleet had drafts greater than 50 feet. In 1971, there were nearly 500, by 1980 there will be over a thousand.[6]

The trend toward giant bulk carriers is worldwide. Since the Japanese breakthrough in construction of greater than 100,000 DWT supertankers in the early 1960's, world shippers have been increasing their orders for the giant ships at a phenomenal rate.

By the end of 1965, prior to the second closing of the Suez Canal, there were only 19 vessels (all tankers) over 100, 000 DWT in operation. By December 31, 1971, the upward trend in vessel size had produced no fewer than 366 tankers, and 104 pure dry bulk and combination dry/liquid bulk similarly sized vessels (Table 7). Thus, from 1966 to 1971, the number of bulk vessels in operation over 100, 000 DWT increased by a factor of over 20. Figure 9 shows a graphical presentation of the best known ships since 1850.

TABLE 6
ORIGINS OF U. S. EXPORTS OF COKING COAL TO WESTERN EUROPE AND JAPAN: 1980 AND 2000 PROJECTIONS
(Millions of Short Tons)

Import Zone	Exporting Port	1980	2000
Western Europe			
	Mobile/Pascagoula	0.6	0.2
	Baltimore	1.7	0.6
	Hampton Roads	32.1	36.2
	TOTAL	34.4	37.0
Japan			
	Texas-Louisiana Ports	0.6	0.6
	Mobile/Pascagoula	0.6	0.3
	Hampton Roads	12.8	7.2
	TOTAL	14.0	8.1

SOURCE: Robert R. Nathan, Assoc., Inc., U. S. Deepwater Port Study, August 1972

Orders for large bulk carriers are continuing to increase worldwide. By the end of 1970, there were 279 tankers (Table 8) averaging 240,000 DWT and 181 straight dry bulk and combination bulk carriers averaging 150,000 DWT either under construction or on order. Figure 10 shows the growth in the number of vessels over 200,000 DWT since 1966. By 1974, the 100,000 DWT plus operational world fleet of bulk vessels will have grown to 779 ships. Of this total, over 400 will be in excess of 200,000 DWT; 371 tankers and 34 bulk carriers. By 1980, this massive fleet of bulk ships over 100,000 DWT is expected to exceed 1,000 vessels.[6]

The largest vessel type in the world fleet has been the crude oil tanker, which has significantly increased in size since 1963. By 1975, over 60 percent of world crude oil tanker capacity is expected to be in ships of more than 150,000 DWT; by 1980, 70 percent will be in tankers larger than 200,000 DWT.[6] The size of these vessels is most strikingly illustrated by comparison with the standard World War II workhorse, the 16,000 DWT T-2 tanker shown in Table 9.

Until recently, the largest tanker in service was the 372,400 DWT Nisseki Maru, which was delivered to Tokyo Tanker Co. in September 1971. However, the Nisseki Maru did not hold the record long, as a 477,000 DWT tanker was launched in October 1972 in Japan by Globtik Tankers, LTD. This in turn will be superseded by the recent order Shell Group has placed with Chantiers d'Atlantique of France for two 540,000 DWT, 17.5 knot VLCC's.

Recent adoption (January 1, 1972) of Intergovernmental Maritime Consultative Organization's (IMCO) anti-pollution proposals for reducing and standardizing tank size, will further increase VLCC construction costs, which have already virtually doubled in the last 4-5 years.[6] Higher construction costs, coupled with recently increased operating costs, may erode some of the economic advantages of the giant (500,000 plus DWT) VLCC and limit future construction.

In the North Atlantic, increased port costs should cause tanker size to eventually level off and stabilize in the 250,000 to 500,000 DWT range.[7] This projected optimum tanker class is expected to become as common in worldwide trading by 1980 as the T-2 tanker was thirty years ago. Within this class, the new popularly sized range for general crude oil movements has become the 250,000-300,000 DWT ship. There are now more orders for this size vessel than for tankers in the 200,000—250,000

TABLE 7

DEADWEIGHT DISTRIBUTION OF LARGE BULK SHIPS IN OPERATION OVER 100,000 DWT AS OF DECEMBER 31, 1971 (NUMBER OF SHIPS)

Year Built and Type of Ship	Total	DEADWEIGHT TON CLASS & DRAFT RANGE IN FEET			
		100,000 to 149,999 DWT	150,000 to 199,999 DWT	200,000 to 299,999 DWT	300,000 to 349,999 DWT
		50-60′	60-70′	70-80′	80-85′
1959	2	2	—	—	—
1960	1	1	—	—	—
1962	2	2	—	—	—
1963	2	2	—	—	—
1964	3	3	—	—	—
1965	9	9	—	—	—
1966	23	20	2	1	—
1967	28	23	4	1	—
1968	56	28	12	14	2
1969	81	21	15	41	4
1970	112	34	9	69	—
1971	150	55	24	70	1
TOTAL	469	200	66	196	7
Bulk Carriers. . .	58	33	25	—	—
Tanker	365	126	38	194	7
Combined Carriers	46	41	3	2	—
TOTAL	469	200	66	196	7

SOURCE: Fearnley & Egers Chartering Co., LTD. and U.S. Department of Commerce, Federal Maritime Administration

DWT range. While orders for the larger tanker class increased from 56 in June 1969 to 123 in December 1970, orders for the smaller 200,000—250,000 DWT tankers placed over the same period declined steadily from a high of 131 to 106 by the end of 1970. Similarly, the increasing size of combination bulk carriers, such as the ore/bulk/oil and ore/oil vessels is affecting present bulk cargo trade patterns. Presently, the popular size range for combination ore/oil carriers under construction over 100,000 DWT is between 200,000 and 250,000 DWT while the ore/bulk/oil vessels orders are concentrated in two ranges, 100,000 to 125,000 DWT and 150,000 to 200,000 DWT. By 1975, the average size of all combination bulk carriers in service will exceed 150,000 DWT—doubling the existing average size and the 200,000—300,000 DWT combination bulk carrier will become the backbone of worldwide bulk commodity transportation by 1980.[6] This class of vessel, therefore, will set ocean freight rates of major trade patterns.

If the United States, and particularly the North Atlantic Region, is to take full advantage of potential savings in transportation costs, it must provide facilities to handle the appropriate vessels for worldwide tanker and dry bulk routes to the North Atlantic.

Table 10 summarizes projections for those commodities which are expected to move to the North Atlantic in larger ships. As vessel capacity is related to vessel draft (Figure 11), these projected increases in export and import tonnages are creating problems in U.S. harbors. Most existing North Atlantic harbors have been deepened to 40-45 feet, and are generally able to receive ships no larger than 40,000 to 70,000 DWT, although the 62 foot depths

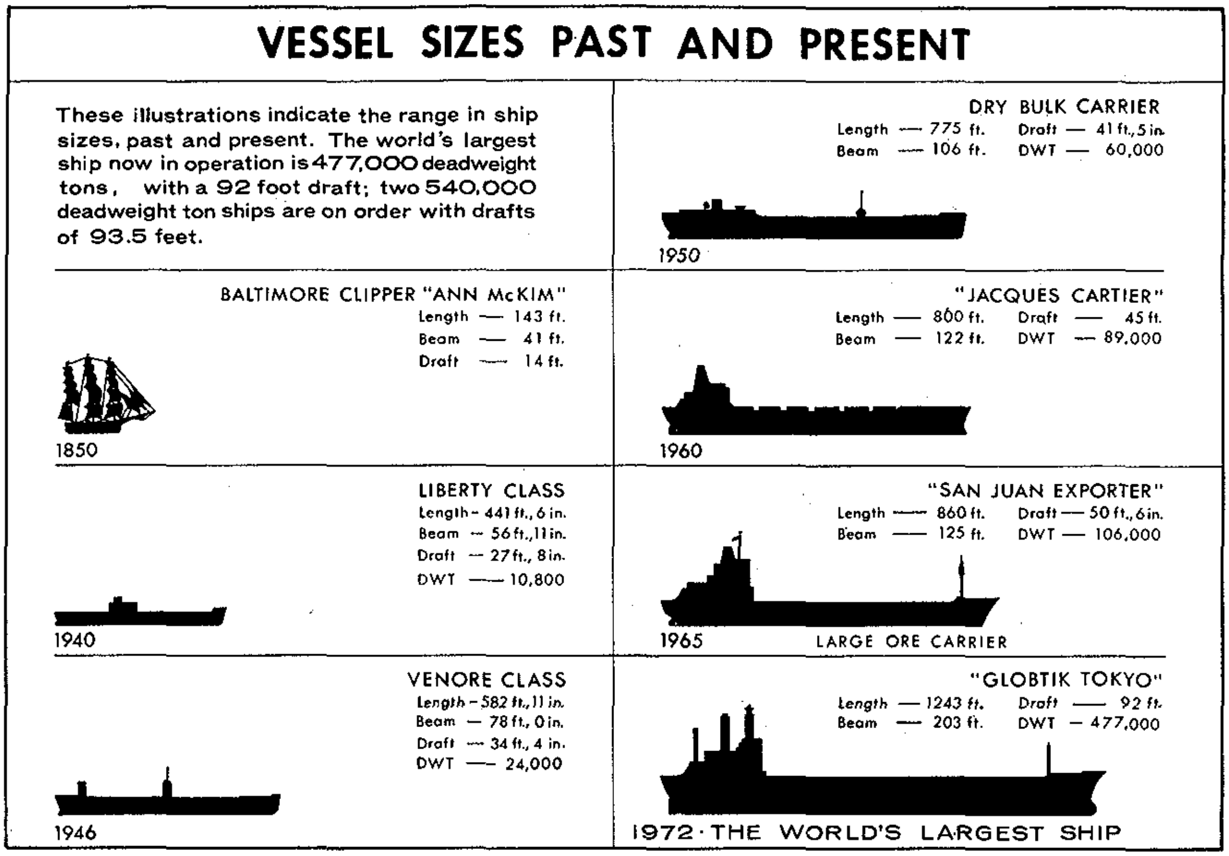
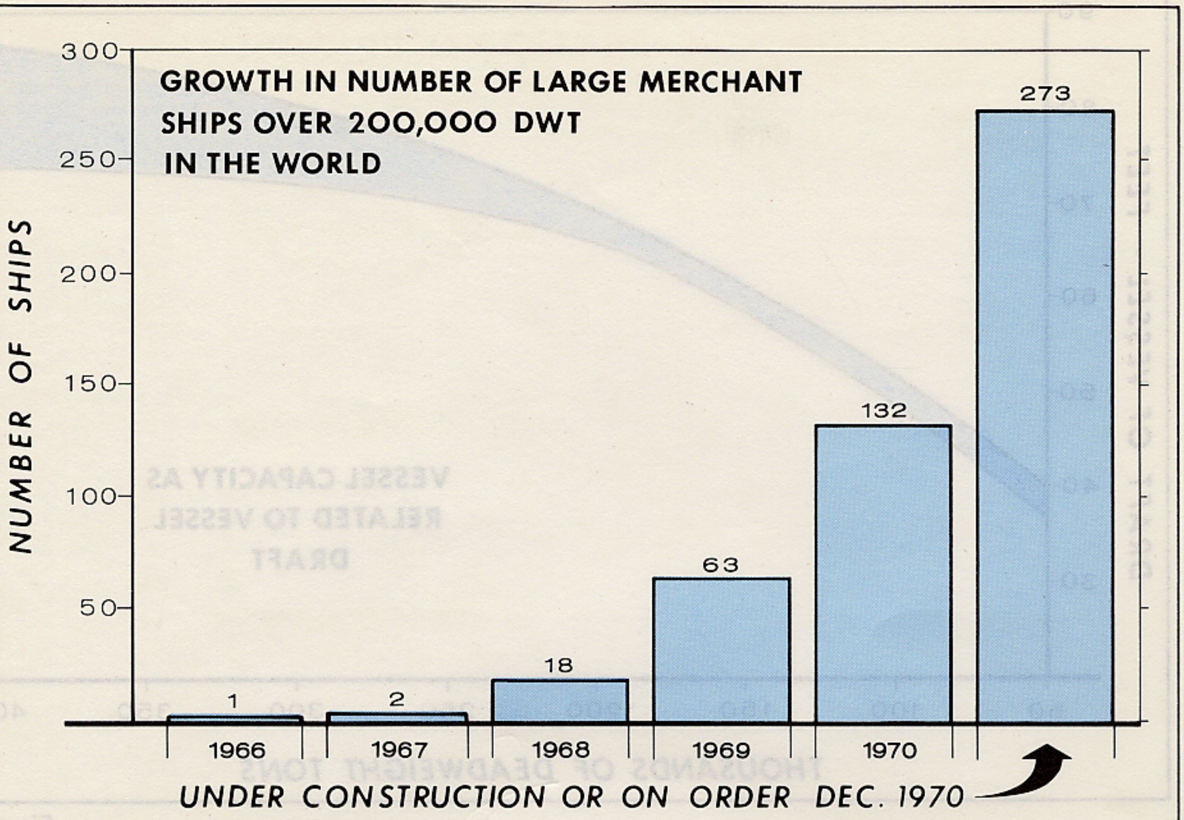


Figure 9

TABLE 8
DEADWEIGHT DISTRIBUTION OF LARGE BULK SHIPS
OVER 100,000 DWT UNDER CONSTRUCTION
OR ON ORDER AS OF DECEMBER 31, 1970
(NUMBER OF SHIPS)

Type of Ship	Total	DEADWEIGHT TON CLASS						
		100,000 to 124,999	125,000 to 149,999	150,000 to 199,999	200,000 to 249,999	250,000 to 299,999	300,000 to 349,999	350,000 and over
Bulk Carrier	44	34	7	3	–	–	–	–
Ore Carrier	4	2	1	1	–	–	–	–
Ore/Oil	62	1	16	11	22	12	–	–
Ore/Bulk/Oil	71	33	5	33	–	–	–	–
Tankers	279	13	20	7	106	123	9	1
TOTAL	460	83	49	55	128	135	9	1

SOURCE: John I. Jacobs and Co., Ltd., *World Tanker Fleet Review,* December 31, 1970. *Fairplay International Shipping Journal,* World Ships on Order, February 25, 1971.



SOURCE: U. S. Dept. of Commerce, Federal Maritime Administration, Economics of Deepwater Terminals - 1972

Figure 10

TABLE 9
COMPARISON OF TANKERS, PAST AND PRESENT

	Shell Group	Globtik Tokyo	Nisseki Maru	Universe Ireland	T-2
Deadweight (tons)	540,000	477,000	372,400	326,600	16,600
Overall length (ft.)	1361.5	1,243	1,243	1,133	524
Beam (ft.)	206.7	203	177	175	68
Draft (ft.)	93.5	92	89	81	30

TABLE 10
PROJECTIONS OF BULK CARGO REQUIRING DEEPER FACILITIES

Commodity	1980	2000
Crude Oil (million barrels/day)	2.0	4.0
(million short tons/year)	112.3	224.6
Iron Ore (million short tons/year)	28.9	37.8
Coal (million short tons/year)	48.4	45.1

available in Delaware Bay are presently used to lighter vessels of up to 125,000 DWT.

Today more than 400 tankers and dry bulk carriers cannot enter or leave any terminal located on the North Atlantic or Gulf Coast fully loaded. By 1974, there will be 779 vessels which will be unable to use those harbors. Most of the demand for these large vessels has been for specialized high volume long distance trade routes such as those from the Persian Gulf to Japan and Western Europe. However, as the United States' dependence upon Middle Eastern oil grows it will become increasingly economical to use larger vessels. *The cost to the shipper of transporting crude oil*

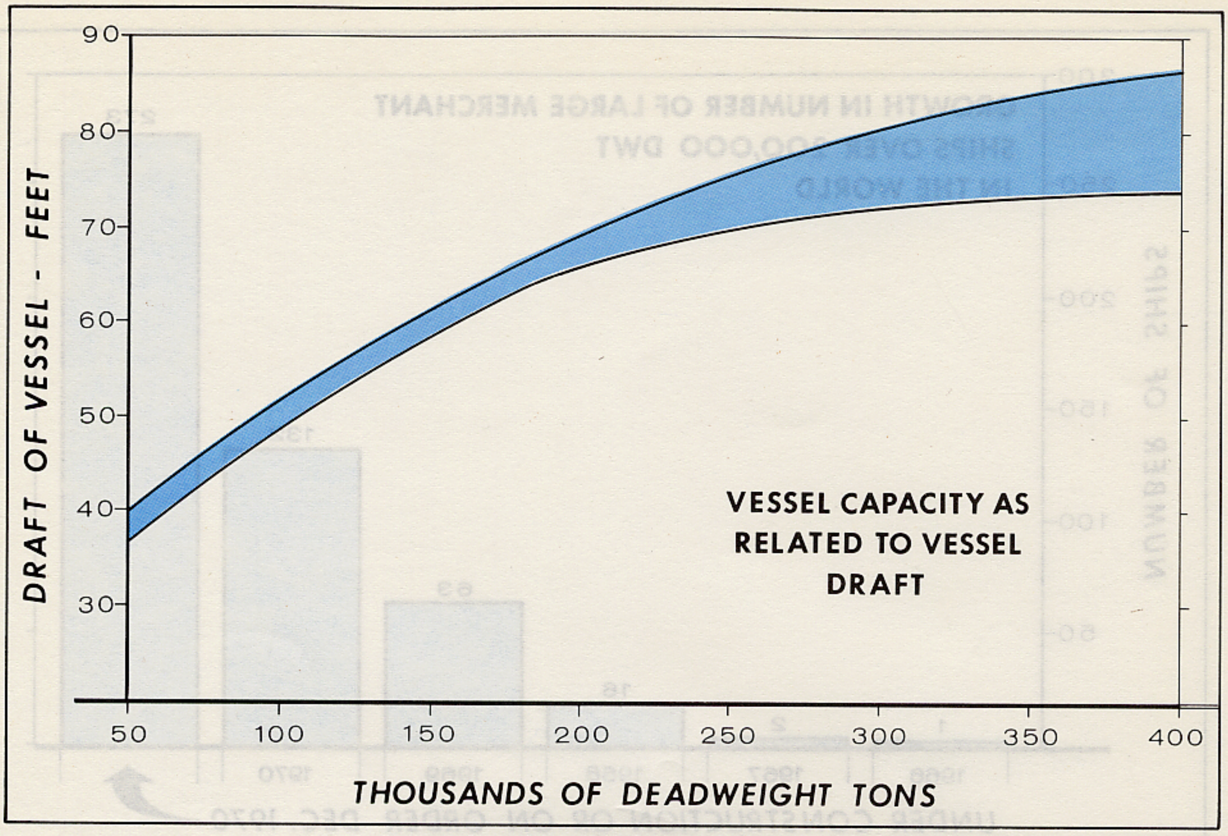


Figure 11

from the Persian Gulf to the North Atlantic using a 326, 000 DWT ship is estimated at $5.34 per ton compared with $7.87 per ton for a 100,000 DWT ship (Figure 12). Although similar savings could be obtained on other routes and for other cargoes, they will not be as significant as those resulting from the use of VLCC's.

TRADE PATTERNS

Significant problems are caused by using new sources to supply our rising need for imported crude oil. While Venezuela will continue to supply a portion of the U. S. crude oil demand, it cannot hope to meet the needs projected for the 1980's. Gulf Coast production, which now supplies about half of the crude oil for North Atlantic refineries, is expected to be devoted entirely to fulfilling the Gulf Coast's growing crude oil needs and those of the Mid-western states, and will be dependent on imports to meet the total needs of those areas.

The Middle East and North Africa, with most of the world's proved oil reserves, are ultimately expected to supply the U. S., as they now supply Western Europe and Japan. Ships which now travel 4,000 miles from the Caribbean to the North Atlantic and return in 12 days to supply North Atlantic refineries will be required to travel 23,000 miles from the Persian Gulf to the North Atlantic and return over a 63 day period. Because of this increased shipping time and the expanding need for imported crude, tanker capacity will have to exhibit comparable growth. This can be achieved by building a large number of small ships, or by building a smaller number of large ships.

For example, movement of the projected North Atlantic 1980 oil imports of 2,000,000 barrels a day entirely from the Middle East would require a fleet of 416-40,000 DWT vessels or a fleet of 67-250,000 DWT vessels.

The investment (1972 dollars) required for the fleet of 40,000 DWT ships required in 1980 would be $4,742,000,000 while only $2,479,000,000 would be needed for the fleet of 250,000 DWT ships.

EXISTING FACILITIES

The economics of large ship transportation—particularly of crude oil—have already produced (in operation, construction, or the planning stage) more than 60 foreign deep water port or buoy facilities capable of accommodating vessels over 175,000 DWT.[8] The U. S. is the only exception among the free world's major industrial powers. Twelve years ago, the U. S. East and Gulf Coast ports were capable of receiving the few 60,000 to 70,000 DWT bulk carriers then in service, while most Japanese and European ports lagged behind, unable to handle vessels larger than 35,000 to 45,000 DWT. By 1971, Japan and Europe both had ports capable of accommodating ships larger than 300,000 DWT.

Today, some of the U.S. neighboring countries have ports capable of servicing tankers and bulk carriers well in excess of 100,000 DWT (e.g., Freeport, Bahamas-300,000 DWT, St. John, Canada-350,000 DWT). Where natural har-

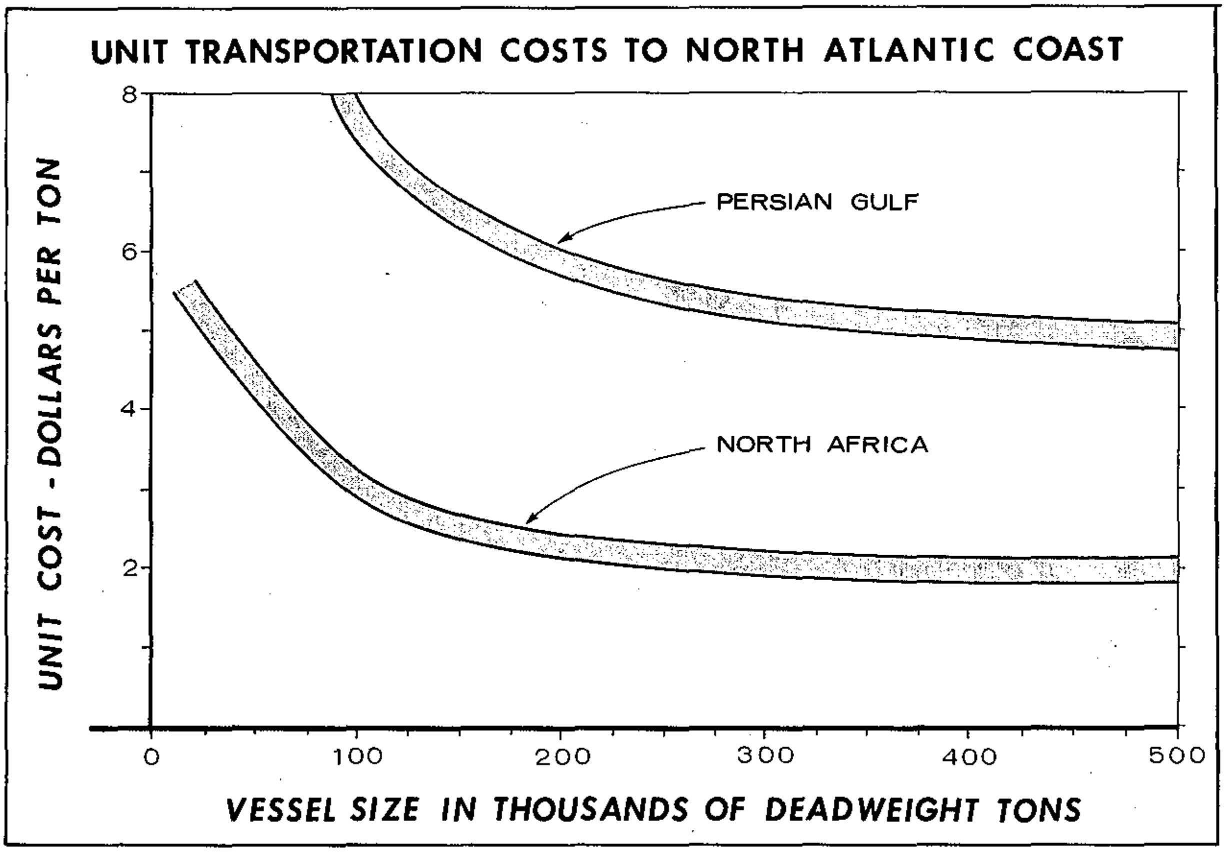


Figure 12

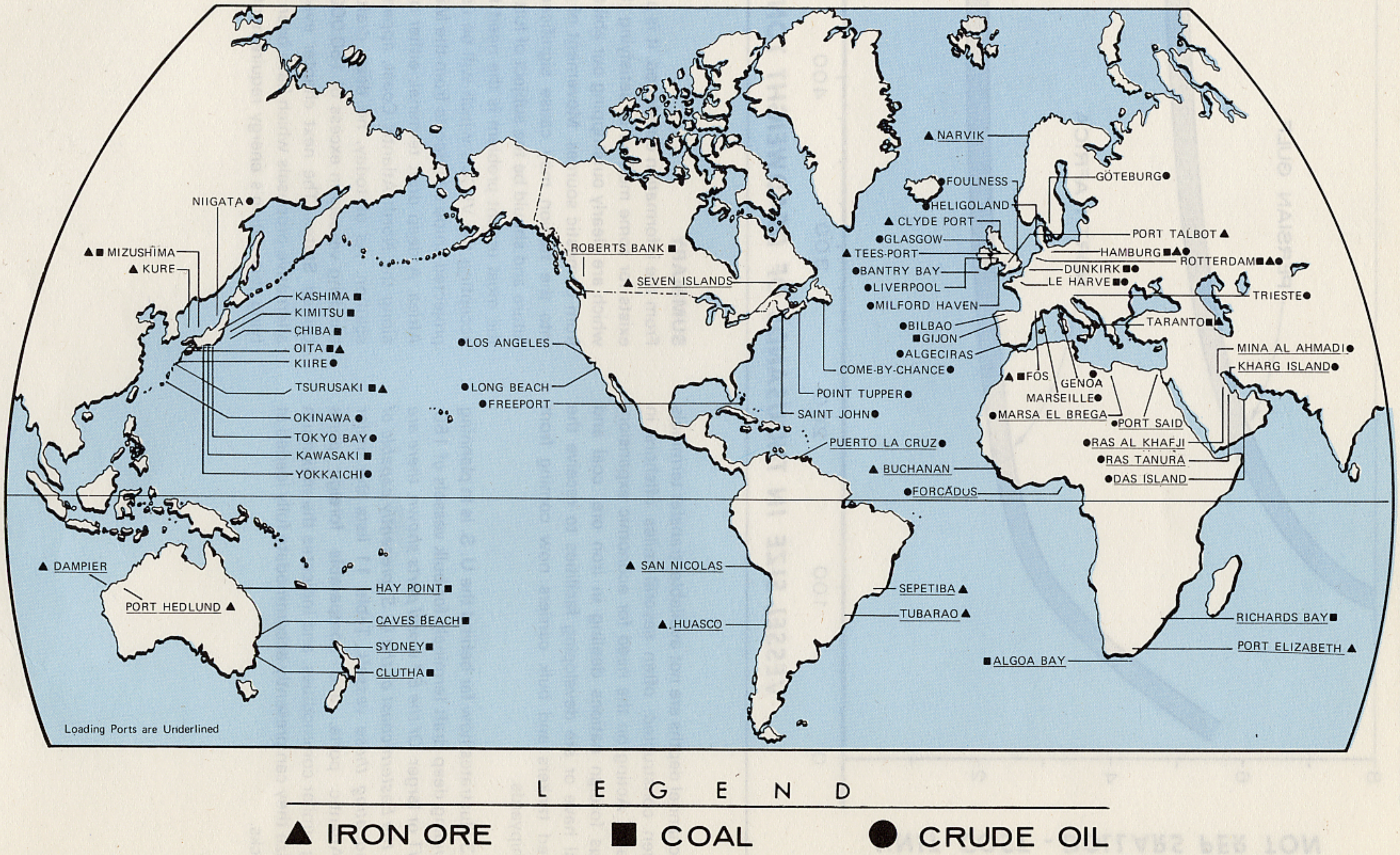
bor and channel depths are not available, transfer terminals have been constructed, often several miles offshore in deep water. Acting on the need for economic expansion, numerous foreign nations dealing in iron ore, coal and crude oil have or are developing facilities to receive the supersized tankers and bulk carriers now coming from world shipyards.

Figure 13 illustrates how far behind the U. S. is in planning and providing deep draft terminals for bulk vessels of 150, 000 DWT or larger. *Of the 67 world ports shown, there are none on the Eastern coast of the U. S. presently capable of accommodating these vessels.* Table 11 lists the major North Atlantic ports, and comparable foreign ports handling similar commodities, and indicates the maximum vessel size they can presently accommodate fully loaded at their docks.

SUMMARY

From the information developed, it is apparent that a need exists for some method of satisfying the energy demands which are clearly outstripping our ability to provide energy from domestic sources. Movement of petroleum products into the Region may cause significant problems in the future and should be the subject of further study. However, the most urgent problem is the need for some method of accepting the VLCC's which will be used to transport the projected crude oil imports from the Middle East and North Africa. A deep draft terminal, either on the Gulf Coast or along the North Atlantic Coast, appears to be a potential solution. As of today, no deep draft facility capable of handling vessels in excess of 150,000 DWT exists in the United States. The next chapter evaluates a number of alternative proposals which have been suggested for satisfying this nation's energy requirements.

REPRESENTATIVE WORLD PORTS CAPABLE OF ACCOMMODATING 150,000 DWT VESSELS



SOURCE: U. S. Dept. of Commerce, Federal Maritime Administration, Division of Ports.

Figure 13

TABLE 11
DEPTH AND MAXIMUM VESSEL SIZE OF SELECTED WORLD PORTS

Port	Approximate Limiting Depth (ft-MLW)	Estimated Maximum Vessel Size (DWT) Oil	Coal	Iron Ore
Baltimore, Md.	42′		53,000	53,000
New York, N. Y.	35	40,000		
Norfolk, Va.	45		80,000	
Philadelphia, Pa.	40	50,000		40,000
Portland, Me.	45	80,000		
Rotterdam (Holland)	64-½	200,000		200,000
Roberts Bank (Canada)	75		250,000	
Oita (Japan)	89		300,000	
Bantry Bay (Ireland)	90	326,000		
St. John (Canada)	85	350,000		
Freeport (Bahamas)	80	300,000		

SOURCE: U.S. Department of Commerce, Federal Maritime Administration, The Economics of Deepwater Terminals, 1972.

GENERAL

This chapter will present general plans for possible solutions to problems created by the need to develop navigation facilities in the North Atlantic Region to accommodate very large bulk carriers. Each alternative plan has relative merits which favor its adoption. Each plan will be examined and analyzed and the most promising will be selected for detailed analysis.

These general plans are divided into those which reduce the need to import crude oil and those which provide facilities to accept projected imports. The first category includes plans implicit in the study authority which would result in deviations from the crude oil protections mentioned in the previous chapter. Those plans include reducing energy demand, substituting other sources of energy for crude oil, and increasing domestic crude oil production. The second category, explicitly stated in the study authority, includes the use of existing facilities for importing oil, the use of restricted draft vessels, changing of trade patterns, dredging of inshore facilities, and provision of offshore terminals. Even if imported crude oil were not required, facilities to handle dry bulk cargoes such as coal and iron ore might still be needed.

PLANS WHICH REDUCE IMPORT NEEDS

Reduce Energy Demand

The United States—with six percent of the world's population—consumes almost a third of the energy used in the world. The demand for additional energy is expected to increase rapidly at a time when U.S. energy resources are being depleted. As a result the United States is becoming more dependent on foreign fuel sources. A recent report completed by the Office of Emergency Preparedness[9] indicates that energy conservation measures could reduce U.S. energy demand by as much as 7.3 million bbl/d of oil by 1980, or about two-thirds of the projected total U.S. petroleum import needs for that year. No in-depth study of that plan's feasibility or consumer acceptance was given in that report.

Another possible method for decreasing energy demand *may be found in the energy pricing mechanism. At present,* large users of energy are encouraged to use more energy by energy cost rates which decrease with increasing consumption. Many foreign countries such as Japan have set rate structures which penalize use instead of encouraging energy consumption.

Assuming these measures are feasible and acceptable, at best they represent only a long term partial solution. These measures would not materially affect the North Atlantic Region's immediate requirements for crude oil, since this Region produces virtually no crude oil and is totally dependent on imports from other areas.

Substitute Other Energy Forms

Although petroleum is the primary fuel under examination in this study, other sources of energy exist which could be used to meet U.S. energy demands. Their use depends on the life expectancy of existing machinery and the time required to solve associated environmental problems and to develop them to a level of economic competitiveness with oil.

Probable intermediate term alternatives to importing oil include substituting natural gas, coal, nuclear energy, oil shale, tar sands, and synthetic fuels from coal. Other alternative sources which do not appear to be feasible short or intermediate term solutions include development of geothermal power, hydroelectric power, solar fusion power, fuel cells, thermoelectric, thermionic generation, tidal, wind and biological energy. A detailed analysis of most of these alternatives may be found in the Environmental Impact Statement for the Trans-Alaskan Pipeline.[10]

While there are many alternative energy sources which could be used to reduce the projected quantities of petroleum needed by the United States and the North Atlantic Region, it is doubtful that any of them or any combination of them will significantly reduce existing imports of crude oil to the North Atlantic, or imports projected for the near future.

Increase Domestic Production

The recent discovery of oil on the North Slope of Alaska was the major breakthrough in U.S. oil exploration efforts. *Domestic crude oil production could be increased by* accelerated exploration, both onshore, and offshore on the outer continental shelf (OCS) of the Gulf of Mexico, the

Atlantic Ocean and the Gulf of Alaska. Under current technological and economic conditions, there are an estimated 246 billion barrels[10] of potentially recoverable crude oil in domestic onshore areas, including Alaska's North Slope. The North Slope, however, is expected to produce only two million barrels of oil a day by the 1980's. Accelerated leasing on the OCS could increase domestic production by about 1,500,000[8] barrels per day by 1985.

However, it is unlikely that existing or projected imports to this Region can be reduced by increasing domestic production until production of crude oil in the North Atlantic is obtained. While leasing in the North Atlantic may be initiated soon, production in that Region cannot be expected until the middle 1980's assuming its environmental impact is not too significant.

PLANS TO ACCOMMODATE LARGE BULK CARRIERS

Use Existing Facilities

One plan considered was to use existing navigation facilities. No initial investment is required although additional navigation facilities in existing harbors might be needed in the future. With shippers forced to use existing depths in North Atlantic harbors, no new port areas would develop. This alternative would not exclude large tankers from North Atlantic waters. Full or partially loaded ships from 100,000 DWT to 500,000 DWT would lighter into barges in deep water at the entrance to New York Harbor and Delaware Bay to serve refineries in those locations.

In the absence of VLCC facilities, shippers could adopt one of several alternatives, including: (1) the use of vessels of moderate tonnage (150,000 DWT) that can enter protected waters and lighter; (2) multiple-port shipping, in which a VLCC is partially unloaded in Canada or the Caribbean and then enters a second shallower port in the North Atlantic for further lightering or direct unloading; and (3) complete transshipment, in which all cargo is unloaded at the foreign deep water port and transshipped to the refineries in smaller vessels or barges. To determine which alternative would be used, transportation costs were calculated for various vessel sizes (Table 12).[11] For multiple-porting, it was assumed that a VLCC would first stop at Nova Scotia and remove enough cargo to allow it to enter the North Atlantic lightering area. All cargo removed at Nova Scotia was assumed to be shipped to the North Atlantic refinery area using 40,000 DWT U.S. flag barges.

When transshipping, all cargo was assumed to be unloaded in Nova Scotia and carried to the North Atlantic refineries in 40,000 DWT barges. The cost of each alternative for each refinery area and vessel class is shown on Table 12.

A review of the above transportation costs indicates that transshipment from Nova Scotia to the North Atlantic is generally the most expensive means of delivery for all classes of tankers while multiple-porting with lightering is more economical than either lightering or direct delivery in smaller ships.

Projections of fleet size distribution through year 2000 were made in conjunction with the Federal Maritime Administration. In the absence of a North Atlantic VLCC facility, it was assumed that maximum ship size would be limited to 500,000 DWT, and that a vessel would partially or completely discharge its cargo at a Nova Scotia deep draft facility. Based on those assumptions a distribution of ship arrivals at each refinery was developed. Estimates of the number of vessels, probable lightering operations and tonnage lightered, were prepared and are shown in Table 13. Those estimates indicate that a significant increase in the number of vessels, number of lightering operations and tonnage lightered will occur in the future. Based on that distribution, it is estimated that the average annual cost of importing the projected quantities of crude oil to the North Atlantic, discounted at 5.5 percent interest, would be $713,500,000.

The increasing number of vessels and lightering operations will increase the probability of future oil spills. A recent study undertaken by the U.S. Coast Guard[12] shows that the probability of spillage from collisions increases logarithmically as traffic increases. In addition, the amount of oil spilled during tanker transfer operations can be approximated by comparing the number of such spills reported to the Coast Guard in 1971 with the amount of oil handled by tankers in 1970. Those data indicate an average spill of seven gallons of oil per transfer operation or 0.5 barrel per million barrels transferred. In confirmation of this, spillage by volume for transfer operations at Milford Haven, Great Britain (considered to be an extremely safe and clean port) is reported to be 0.4 barrel per million barrels of throughput. At Portland, Maine, where 99 percent of all waterborne cargo is crude oil, the 1971 spillage rate was 0.7 barrel per million barrels of throughput. The higher rate at Portland may be partly attributed to the use of smaller vessels than were used at Milford Haven. Smaller vessels require more transfer operations for an equal volume of crude oil, increasing the chances for a spill. As traffic and lightering operations increase, as shown in Table 12, oil spills can be expected to become more frequent and spills may become larger. Woodward-Lundgren[13] concluded that the increased congestion due to lightering operations could significantly increase the likelihood of larger spills which occur while exiting or entering existing ports.

Oil spill probability has been evaluated in preliminary data provided by the Council on Environmental Quality (CEQ) and the study conducted by Woodward-Lundgren and

TABLE 12
SUMMARY OF UNIT COST FOR SHIPMENT WITH EXISTING FACILITIES
($/long ton – July 1972 Price Levels)

Class1/ (000's)DWT	North Africa to North Atlantic Ports									Persian Gulf to North Atlantic Ports								
	Lighter in North Atlantic Region Harbors			Multiple-Port from Nova Scotia with Lightering in North Atlantic			Transship from Nova Scotia			Lighter in North Atlantic Region Harbors			Multiple-port from Nova Scotia with Lightering			Transship from Nova Scotia		
	Del.	YorkR	NY	Del.	YorkR	NY	Del.	YorkR	NY	Del.	YorkR	NY	Del.	YorkR	NY	Del.	YorkR	NY
50-80	4.06	3.99	3.95	–	–	–	–	–	–	9.49	9.38	9.45	–	–	–	–	–	–
80-120	3.55	3.49	3.44	–	–	–	–	–	–	8.15	8.03	8.09	–	–	–	–	–	–
120-160	3.15	*	*	–	3.62	3.51	–	–	–	7.10	*	*	–	7.59	7.52	–	–	–
160-200	*	*	*	3.17	3.59	3.42	4.44	4.51	4.22	*	*	*	6.80	7.21	7.08	8.16	8.23	7.94
200-250	*	*	*	3.06	3.44	3.27	4.26	4.33	4.04	*	*	*	6.43	6.79	6.65	7.70	7.78	7.49
250-300	*	*	*	3.06	3.42	3.24	4.20	4.28	3.99	*	*	*	6.36	6.70	6.56	7.57	7.65	7.36
300-350	*	*	*	–	*	*	4.13	4.20	3.91	*	*	*	–	*	*	7.36	7.43	7.14
350-400	*	*	*	–	*	*	4.07	4.15	3.86	*	*	*	–	*	*	7.22	7.29	7.00
400-450	*	*	*	–	*	*	4.04	4.12	3.83	*	*	*	6.36	*	*	7.14	7.21	6.93
450-500	*	*	*	–	*	*	4.01	4.08	3.79	*	*	*	6.23	*	*	7.05	7.12	6.83

–Not economically feasible
*Not physically feasible
1/Foreign flag vessel

TABLE 13
PROJECTED ANNUAL CRUDE OIL VESSEL AND LIGHTERING OPERATIONS IN NORTH ATLANTIC REGION WITHOUT DEEP DRAFT FACILITIES

Item	New York Harbor			Delaware River			Norfolk Area		
	1975	1980	2000	1975	1980	2000	1975	1980	2000
Number of Vessels:									
VLCC's	86	124	229	229	327	543	14	20	39
Barges 1/	254	745	1,567	511	1,506	3,222	38	107	221
TOTAL	340	869	1,796	740	1,833	3,765	52	127	260
Lightering (crude oil) 2/ number of operations	207	556	1,148	489	1,358	2,582	30	79	162
Tonnage lightered (1,000's long tons)	3,007	16,657	34,411	16,725	54,193	103,265	764	2,357	4,859

1/ Includes only barges carrying crude oil.

2/ Lightering operations are less than number of barges because some barges are transshipment vessels from Nova Scotia and not involved in lightering operations.

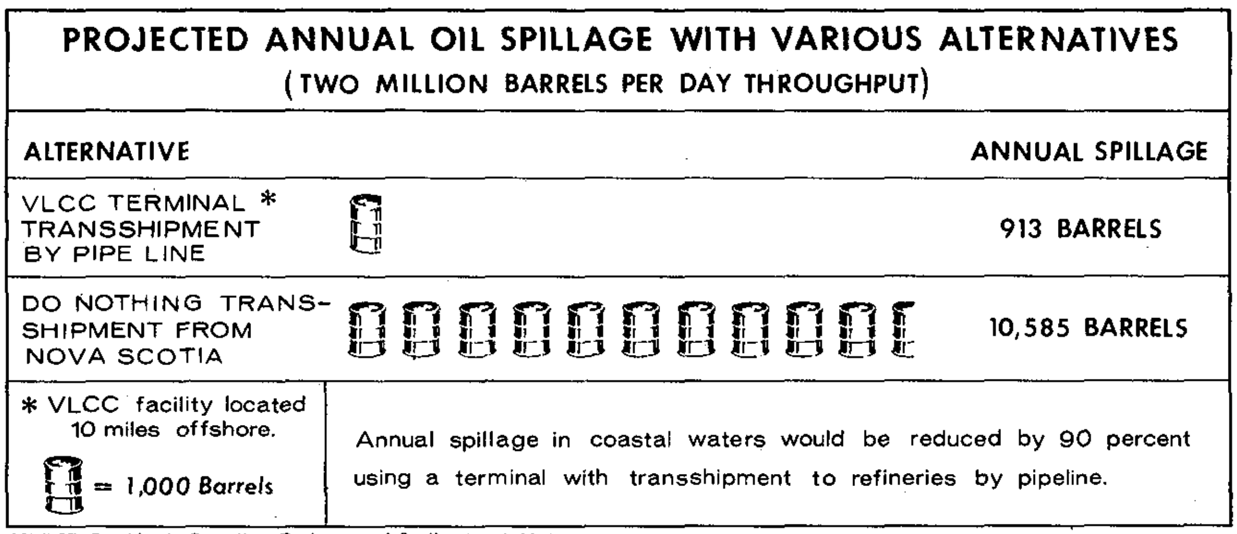
Associates. Without specific improvements to accept VLCC's and at import levels of one million barrels per day (less than the existing North Atlantic refinery capacity), CEQ projected oil spills in the North Atlantic coastal zone to be about 3,500 barrels annually. At two million barrels per day, spillage would be increased to 10,585 barrels per day.[14] The CEQ analysis assumed that all oil would be transshipped from Nova Scotia in 50,000 DWT tankers which would not require lightering. In reality, it is expected that lightering in Delaware Bay, New York Harbor and the York River area will occur and thus increase handling operations and probably oil spills in those areas. As the volume of oil imported to the North Atlantic increases, the amount of oil spilled is expected to increase.

Woodward-Lundgren did not attempt to quantify future oil spills. However, they did analyze spill probabilities without a deep-water terminal and the effects of providing a terminal within a bay and offshore. Their conclusions were that provision of a facility at either location would reduce the probability of oil spill. Within a bay, smaller spills would be reduced most significantly although the probability of larger spills from accidents on entering and exiting the port would also be reduced. It is possible that improved navigational guidance and communication systems would further reduce spills. At an offshore site a comparable reduction of small spills would also be obtainable. In addition, at this location large reductions in the probability of large spills would also occur. With a one million barrel per day terminal located ten miles offshore with transshipment to refineries by pipeline, the CEQ estimates that the amount of oil spilled in coastal waters could be reduced by about 60 percent to 1,455 barrels per year. If this terminal provided for transshipment to refineries by vessel, spillage would increase to 10,950 barrels per year. For a two million barrel per day terminal at the same location with transshipment to refineries by pipeline, oil spillage could be reduced by 90 percent to 913 barrels per day. (Figure 14)[14]

Concern has been expressed about the size of oil spills that could result from using VLCC's. However, failure to provide facilities in the North Atlantic will not eliminate the use of VLCC's in that Region's coastal waters. VLCC's will enter Delaware Bay, New York Harbors, and Chesapeake Bay partially loaded for lightering. VLCC's contain many compartments and it is unlikely that all the oil on the vessel would be spilled even in the event of a major accident. In addition, a major spill from a compartment of a fully loaded VLCC would be no larger than a spill from a compartment of the partially loaded VLCC's which will be used. With increased lightering traffic and harbor congestion, the danger of spills will increase. *Facilities which will accept VLCC's and allow for transshipment to refineries by pipeline will reduce the probability of future oil spills.* Using existing facilities will lead to higher crude oil transportation costs, increased probability of collisions and oil spills, and construction of additional lightering and port facilities at existing harbors to handle the increasing numbers of vessels. In addition, the above mentioned alternatives are not economically feasible for other bulk cargoes such as coal and iron ore. Consequently, deeper channels may be required for those commodities or higher transport costs and increased traffic could result.

Use Restricted Draft Vessels

The draft of very large bulk carriers precludes their use in present U. S. East Coast harbors. However, development of large capacity vessels with drafts of less than 40 feet could eliminate the need for specialized handling facilities and reduce future coastal traffic. Today's vessel construction techniques minimize construction and operating costs. Design modifications are normally made by widening the beam which requires increased hull strength and additional power to overcome additional wave resistance and added weight. Those modifications increase vessel cost. Studies conducted by Nathan[2], the Federal Maritime Administration, the petroleum industry, and consultation with naval



SOURCE: President's Council on Environmental Quality, March 1973

Figure 14

architects indicate that it is feasible to design, construct and operate restricted draft ships. However, Nathan indicates that a ship of 51,500 DWT is the maximum size which could be built with a fully-loaded draft of 35 feet and 78,300 DWT is the maximum size which could be built with a fully loaded draft of 40 feet. Those findings are generally in agreement with the findings of others. Nathan estimated total unit costs per long ton of cargo for restricted draft vs. standard design foreign flag tankers in nine selected ship sizes. Table 14 lists the unit costs of shipping with restricted draft vessels from the Persian Gulf to the North Atlantic. Those costs are based on Nathan's study but escalated to July 1972 price levels.

TABLE 14
RESTRICTED DRAFT VESSEL UNIT TRANSPORTATION COST
PERSIAN GULF TO NORTH ATLANTIC REGION

Draft (feet)		Vessel Capacity (DWT)	Cost/Ton ($)
Restricted	Normal		
40	45	65,000	9.82
45	50	90,000	8.39
50	55	140,000	6.93
55	60	200,000	6.16
58½	65	250,000	5.63
62	71	300,000	5.91
68½	83	400,000	5.64
75	95	500,000	5.54

The cost of using this type of vessel to navigate existing 35 and 40 foot depth channels would be more than that for transshipping through a Canadian port. For example, if a 65,000 DWT vessel with a draft of 40 feet were used, the cost of shipping from the Persian Gulf to the North Atlantic would be $9.82 per ton. If a conventionally designed vessel of 250,000 DWT were to multiple-port from Nova Scotia, the cost would be reduced to about $6.50/ton, as shown in Table 12.

Many naval architects consider extensive draft restriction to be beyond the present state of the art. Small amounts of model basin data are available on broad beam vessels and there is reason to believe that maneuverability, buoyancy and stability will be problems. Worldwide lack of suitable dry docks for emergency repairs also limit the size of such vessels and restricted maneuverability and larger dimensions may require channel modifications to assure safe turning radii. In addition, the threat of an oil spill resulting from a major accident is at least equal to that posed by a ship of conventional design.

A further evaluation was made of the possibility of using a restricted draft 51,500 DWT tanker, with a draft of 35 feet, totransship from a Canadian port. Nathan's figures indicate that operating costs for such a vessel would be 20 percent greater than those of a standard design 51,500 DWT tanker. However, there would be a saving in unit transportation cost when compared to using "normal design" vessels. However, the analysis of the overall system indicates that this alternative is significantly more expensive than the costs projected for the previous plan of using existing facilities. On an average annual basis, discounted at 5-1/2 percent, this plan would cost about $125,573,000 more than using existing facilities.[11]

Change Trade Patterns

Inherent in the need for a deep draft facility in the North Atlantic Region is the assumption that industrial plants needed to process bulk materials are located there. Steel mill location is primarily dependent upon market location and potential savings in transportation costs appear to be too small to justify relocations of steel mills. Therefore, it is doubtful that trade patterns would be altered to service steel mills. However, there is a distinct possibility of changing the trade pattern servicing oil refineries.

Petroleum products needs, for the North Atlantic Region could be served by either of four possible systems.

System 1. Refineries (gasoline and fuel types) and port facilities could be located on the Gulf Coast. This plan would allow crude oil to be imported to and refined on the Gulf Coast. Refined products would then be shipped from the Gulf Coast to the North Atlantic Region for distribution.

System 2. Crude oil could be imported to a deep draft facility located on the Gulf Coast and then transshipped by smaller vessels to the North Atlantic where it would be refined.

System 3. A deep draft facility could be located in the North Atlantic to service refineries in that area.

System 4. Shippers could use existing navigation facilities and import crude oil to North Atlantic refineries using a multiple-port operation from Nova Scotia.

Table 15 shows a comparison of these systems. Clearly, changing trade patterns to use a Gulf Coast deep water port would be more expensive than using a deep water port located in the North Atlantic. Location of new refinery capacity on the Gulf Coast to serve North Atlantic petroleum products needs is more expensive than locating it in the North Atlantic (System 1). Transshipment of crude oil through a Gulf Coast terminal (System 2) would be considerably more expensive than using either North Atlantic

TABLE 15
COMPARISON OF PLANS TO CHANGE TRADE PATTERNS
($/bbl)

	Shipment to North Atlantic Through a Gulf Coast Deep Water Facility			Direct Shipment to North Atlantic	
	Transship Refined Products (System 1)		Transship Crude Oil (System 2)	Using a Deep Water Facility (System 3)	Using Existing Navigation Facilities (System 4)
Operation	Fuels Refinery	Gasoline Refinery			
Ocean Transport	0.76 [1]	0.76 [1]	0.76 [1]	0.73 [1]	0.89 [2]
Unload	0.08 [3]	0.08 [3]	0.06 [4]	0.15 [5]	0.03 [6]
Reduced Refining Cost	(0.17 to 0.25) [7]	(0.23 to 0.35) [7]	0	0	0
Load	–	–	0.06 [9]	–	0
Transship	0.50 [8]	0.50 [10]	0.41 [11]	–	0
TOTAL	1.09 to 1.17	0.99 to 1.11	1.29	0.88	0.92
Additional Cost	0.21 to 0.29	0.11 to 0.23	0.37	0	0.04

(1) Ocean transport cost from Persian Gulf in a 326,000 DWT foreign flag vessel
(2) 326,000 DWT foreign flag vessel using a multiple-port operation thru Nova Scotia
(3) Includes $0.06/bbl charge for deep port facility and $0.02/bbl charge for transshipment to a Gulf Coast refinery
(4) Unloading at a Gulf Coast deep water facility
(5) Cost of deep water terminal and transshipment to refineries
(6) Unloading at North Atlantic refineries
(7) Cost of refining in the Gulf Coast is less than in the east
(8) Cost represents transshipment by pipeline. Residual fuel oil must be moved by vessel and would raise this cost slightly
(9) Includes a $0.03/bbl charge for use of facilities on the Gulf coast and a $0.03/bbl charge for unloading at North Atlantic refineries
(10) Pipeline transshipment
(11) 40,000 DWT U.S. flag barge

deep water facility ($0.37/bbl) or using existing facilities ($0.33/bbl) and is not an economically feasible alternative.

Differences in refining cost and cost of transshipping petroleum products to the North Atlantic are major factors in determining the feasibility of this alternative.

A refining cost and pipeline study[15] was made to evaluate the differences in cost resulting from locating refineries in either of the above two locations to satisfy the North Atlantic Region's demands. That study determined the cost to convert a barrel of crude oil into an identical spectrum of products at each location and to transport those products refined on the Gulf Coast to the North Atlantic.

The refining cost differentials shown on Table 15 are related solely to the cost of converting the crude into products and to refinery storage of these products. Those cost differentials do not include the cost for delivery of the refinery products to the North Atlantic by pipeline or tanker.

Two types of refineries, fuel oil and gasoline, were considered to provide a realistic basis for making the refinery cost comparison. The fuel oil refinery produces only three refined petroleum products for sale, naptha (19%), distillate fuel oil (38%) and residual fuel oil (39%). The gasoline refinery considered produces essentially two major products, lead-free gasoline (55%) and distillate fuel oil (37%). It also produces a relatively small amount of three other products, viz., residual fuel oil, propane LPG, and excess refinery gas.

To determine the cost differential between products produced in a Northeast and a Gulf Coast refinery, use was made of investment and operating cost data, obtained from consultant sources, publications, inhouse estimates, and refiners. Studies were made to determine how the cost differences are affected by varying assumptions as to how much more a North Atlantic U. S. refinery will cost compared to the same refinery on the Gulf Coast, and changes in the levels of investment costs. Cost factors which account for investment and operating cost differences in the base case included:

Construction cost—15% higher in the North Atlantic
Land—$2,000/ac on Gulf Coast, $5,000/ac in North Atlantic
State corporate income taxes—0 in Texas to 6% in the North Atlantic
Labor—4% higher in the North Atlantic
Power—$.001 per kwh higher in the North Atlantic
Fuel—10% greater in the North Atlantic
Future labor cost differentials—same as for present
Environmental controls—will become uniform in the future

Although these differences may change over time, it is expected that the changes will result in making the cost of refining more equal in the two regions. It appears reasonable to assume that the actual facility investment cost difference lies somewhere between 10-15 percent. However, a second analysis was made to deteremine the effect of state taxes and different investment levels than those used for the base case. Based on this study the following conclusions can be made regarding refining cost differences:

1. State income taxes in the North Atlantic have a substantial effect on costs. At a 6 percent level this results in a $.04-.06/barrel range in area cost differential.
2. About 85-90 percent of the area refining cost differences are investment related. Examples of how cost differences are affected by shifts in investment level are shown by:
   a. Keeping constant the percent by which the cost of a North Atlantic refinery facility exceeds that of an identical facility on the Gulf Coast. In this case there is an appreciable effect in the area refining cost differences if the level of investment cost is changed. For example, increasing the investment cost for a gasoline refinery by 20 percent increases refining cost by about $0.04/barrel (i.e. from $0.276 to $0.320/barrel). For a relatively lower cost fuels refinery, a similar shift in investment cost level results in an increase of about $0.03/barrel (i.e. from $0.190 to $0.219/barrel).
   b. Keeping the Gulf Coast refinery facility investment cost constant at base case levels and changing the relative cost of a North Atlantic gasoline refinery over the range of 1.10 to 1.15 times the cost of a similar Gulf Coast refinery. This results in a shift from about - $0.04/barrel ($0.276 to $0.233) to about +$0.02/barrel ($0.276 to $0.297). Similarly, for a fuels refinery the change in cost ranges from about -$0.02/barrel ($0.190 to $0.174) to +$0.03/barrel ($0.190 to $0.220).

Table 16 shows that the cost differential could be expected to range from $0.23 to $0.35 per barrel for a gasoline refinery and $0.17 to $0.25 per barrel for a fuels refinery.

However, relocation of existing North Atlantic refineries to the Gulf Coast should eliminate some of the cost advantage. The cost of refining is heavily dependent upon the capital investment in the refinery and the costs presented above are for new refineries. However, the large initial investment was made at the existing refineries when price levels were much lower. As a result, these refineries probably produce products at a cost below that of a new refinery on the North Atlantic. Consequently, the cost of that portion of the North Atlantic demand being satisfied

TABLE 16
SUMMARY OF REFINERY ANALYSIS
($/barrel Gulf Coast Advantage)

	Type of Refinery	
Condition	**Fuels**	**Gasoline**
1. Base Case: North Atlantic refinery investment cost 12-13 percent more than Gulf Coast.	0.19	0.28
2. Reduce base case North Atlantic refinery facility cost to 1.1 x Gulf Coast.	0.17	0.23
3. Increase base case North Atlantic U.S. refinery facility cost to 1.5 x Gulf Coast.	0.22	0.30
4. Increase each base case refinery facility cost by 20 percent.	0.22	0.32
5. Reduce North Atlantic U.S. refinery facility cost to 1.1 x Gulf Coast refinery cost, per (4) above.	0.20	0.27
6. Increase North Atlantic refinery facility cost to 1.15 x Gulf Coast refinery cost per (4) above.	0.25	0.35
7. Reduce each base case refinery facility cost by 10 percent.	0.17	0.25

by existing North Atlantic refineries would be increased, possibly significantly, if they were forced to relocate.

Consideration must also be given to local impacts resulting from relocating North Atlantic refineries to the Gulf Coast. While improvement in air and water quality would occur in the North Atlantic, there would also be a significant negative impact on the local ecomomy. In 1971, 14,260 persons were directly employed by refineries in the New York and Delaware River areas. Together, they accounted for $127,168,000 in wages.[16] In addition, approximately 3.6 times that number of people were indirectly employed in the construction, metal, agriculture and service industries resulting from refineries.[17] Consequently, relocation of existing refineries out of those areas could eliminate 66, 000 jobs and reduce local income by about $586,000, 000.

The other major factor affecting the cost of refining on the Gulf Coast is the shipment of those products to the North Atlantic. Placement of refineries on the Gulf Coast would require the use of vessels to transship the residual fuel oil to the North Atlantic. Other products would be transshipped by pipeline.

A portion of the petroleum products for the North Atlantic market is now moved from the Gulf Coast through the Plantation pipeline and Colonial pipeline systems. The Plantation pipeline extends only to terminals serving airports in the vicinity of Washington, D.C. whereas the Colonial pipeline delivers products to a series of terminals located between the northern boundary of North Carolina and Linden, New Jersey. Colonial's latest tariff (I.C.C. No. 16, effective March 19, 1973) for products moved from Beaumont, Texas to terminals in the Philadelphia area, is $0.296 per barrel. Plantation's tariff (I.C.C. No. 40, effective July 1, 1971) for products moved from near Beaumont, Texas to a terminal in the Washington area, is $0.419 per barrel. These tariffs could not be used as the pipeline transportation cost for this study because the pipeline and pump station construction was carried out in the early 1960's or earlier and the investment was considerably less than would be required to make the same installations in 1972 measured by 1972 dollars. Even though sizable increase in capacity have been carried out between the original construction and the end of 1971, these increases cost less than if they had been carried out in 1972 and paid for with 1972 dollars. In addition, the loan interest rates and total interest being paid by the lines are considerably lower than if the necessary loans for constructing the present system had been negotiated in 1972.

Therefore, preliminary pipeline designs were made as a basis for determining pipeline transportation costs for two cases. One case provided for the construction of 50 percent of the required additional refining capacity in the North Atlantic, and 50 percent on the Gulf Coast, with transportation of the corresponding 50 percent of gasolines and distillate fuels by pipelines. The corresponding 50 percent of residual fuel oil produced was assumed to be moved by tanker from the Gulf Coast to the North Atlantic. The second case provided for construction of all the required additional refining capacity on the Gulf Coast, and transporting all the gasolines and distillate fuels to the North Atlantic by pipeline. The corresponding amounts of residual fuel oil was assumed to be transported by tanker. In both cases, the forecast quantities of "other" products, which include materials such as asphalt, coke, lubricating oil, petro-chemical feedstocks, liquefied petroleum gas, etc. were omitted from consideration.

The first case (50 percent of new refining capacity on the Gulf Coast) requires initial construction of a single 38-inch line for carrying both the low flash gasolines and naphtha jet fuels, and the high flash distillate fuels, together with receiving tank farms and 14 pump stations equipped with sufficient horsepower for three years. In later years additional horsepower at these stations and 14 intermediate stations, together with additional tankage, were assumed to be added when needed. In the year 1987, when the line was forecasted to operate at capacity, a second 36-inch line would be required, served by 14 pumping stations. Thereafter that line was assumed used for the gasolines, with the original 38-inch line dedicated to handling the distillate fuels. Later, additional horsepower and intermediate stations on the 36-inch line were assumed to be installed with more tankage to handle forecast movements through the year 2000.

The second case (100 percent of new refining capacity on the Gulf Coast) indicated the need for a 36-inch line for gasoline and a 38-inch line for distillate fuel oil, to be constructed initially with seven pump stations on the former and 14 on the latter, plus tankage. In later years, additional horsepower and pump stations were assumed, plus more tankage as needed, until each line was equipped with 28 pump stations. In 1985, when both lines were forecasted to be operating at capacity, a second 36-inch gasoline and a second 38-inch distillate fuel oil line were assumed to be constructed, to be served by 14 pumping stations, with later additions of horsepower and 14 more pumping stations on these lines, plus tankage.

In determining the revenue per barrel required for both cases, it was assumed that the shareholders' equity would be recovered completely by the end of the 1975-2000 study period, and that the shareholders would receive at least 15 percent return on the invested equity throughout the study period.

Table 17 provides information on the required pipeline tariff per barrel for gasoline and distillate fuel oil, from the pick-up area on the Gulf Coast to Philadelphia, corresponding to an average haul of 1,320 miles. The table also provides ultimate gross investment required to handle the year 2000 requirements, and lists the major installations required for the two cases. Based on this study it was assumed that the cost of transshipping products to the North Atlantic would be about $0.50 per barrel.

As shown in Table 15, use of a deep water port and refineries in Texas to meet the North Atlantic product demands would be more expensive than meeting North Atlantic demands with a port and refineries in the North Atlantic. Moving the Gulf Coast refinery center 200 miles to the east in Louisiana could reduce pipeline transshipment cost by $0.07 per barrel. However, the State corporate income tax (4 percent vs. 0 percent in Texas) would reduce the refining cost differentials between the Gulf and East Coasts, and offset part of the savings obtainable by use of a shorter pipeline to the North Atlantic. Consequently, it appears that use of a deep water terminal and refineries on the Gulf Coast would be more expensive than the use of a terminal and refineries in the North Atlantic. Although the additional cost for gasoline refineries may range between $0.11 and $0.23 per barrel, the additional cost of placing fuel oil refineries on the Gulf Coast is even greater being $0.21 to $0.29 per barrel.

Dredge Inshore Facilities

New or existing harbors and channels could be dredged to depths that would permit direct unloading of deep draft vessels. At present, the maximum authorized depth for any Atlantic Coast port is 50 feet, with all channels presently maintained at 45 feet or less. In the Delaware River and New York Harbor areas, solid bedrock precludes further dredging to refineries without enormous financial outlays. There is also the threat of salt water intrusion into fresh water supplies at periods of low flow and possible aquifer contamination. Dredging the entrance to Norfolk harbor is restricted to a depth of 55 feet by the Chesapeake Bay Bridge tunnel. There are also substantial economic and environmental costs involved in dredging and establishing adequate spoil disposal areas for the tremendous quantity of dredged material.

A preliminary study [18] indicates that deepening the Delaware to 50 feet between Philadelphia and the sea is economically feasible. However, it would still not permit the handling of very large carriers and would require an initial capital outlay of over a billion dollars. Study of the New York-New Jersey navigation channels (serving the Arthur Kill refineries) indicates that deepening beyond the present 35 feet may not be justified because of economics. Consequently, channel deepening would not be a feasible alternative for those arteries now feeding the major refinery centers of the North Atlantic. However, moderate deepening to the coal and iron ore docks in the Norfolk and Baltimore areas and the refinery at the York River may be feasible. Minor deepening for movement of petroleum products may also be feasible in many ports in the study area.

TABLE 17
SUMMARY OF
PIPELINE TRANSPORTATION COSTS,
TOTAL INVESTMENT COSTS, AND MAJOR INSTALLATIONS

	Case I	Case II
Transportation Cost per Bbl:		
Weighted Average for 1975-2000	0.439	0.420
Range in Cost	0.570 (1975-83 incl.)	0.50 (1975-93 incl.)
	0.485 (1984) decreasing to 0.411 (1986)	0.345 (1994) decreasing to 0.251 (2000)
	0.535 (1987-92 incl.)	
	0.444 (1993) decreasing to 0.258 (2000)	
Average Annual Cost per Bbl:		
Discounted @ 8%	0.52	0.48
Gross Investment (12/31/2000)	$884,814,000	$1,743,769,000
Major Installations (12/31/2000)		
36-inch Line	1400 miles (1 line)	2800 miles (2 lines)
38-inch Line	1400 miles (1 line)	2800 miles (2 lines)
Pump Stations	28	28
Total Tankage	10,900,000 bbls.	21,800,000 bbls.
Tank Farms	4	4
Delivery Terminals	2	2
Mainline Pump	575,000 HP	1,146,000 HP
Booster Pump	12,000 HP	24,000 HP
Warehouse-Maint. Centers	4	4
Maximum Pumping Rate	1,953,000 BPD	3,907,000 BPD

Provide Offshore Facilities

Another general plan would be to provide deep water facilities offshore. Offshore terminals have been developed in many parts of the world for loading and unloading crude oil and other bulk materials. Pipeline transshipment to shore is generally more economical than dredging close to shore, and reduces harbor congestion. Five systems in regular use are the conventional buoy mooring, the single point buoy mooring, the single anchor leg mooring, the sea island, and the marginal pier. The system selected depends on engineering considerations at a particular site. Where offshore storage is desirable, construction of an artificial island may be required. These systems were considered for the various sites proposed in this study. The criteria for these types of facilities are discussed separately below. In addition, there are many variations of these including floating breakwaters which could provide for integral storage within the breakwater structure itself, and inclosed harbors and terminal complexes providing for airports, treatment plants, atomic generating plants, etc. The entire spectrum of alternative facilities could not be considered in a study of this scope. However, facilities of that type may be feasible and desirable at some locations and should be considered when plans are being developed for construction.

Conventional Buoy Mooring (CBM)

This mooring system (Figure 15) uses a number of buoys to maintain the tanker in a given position and orientation. Many of these facilities have been in operation for years in many parts of the world. However, because tankers are restricted to one orientation, this system is limited to sites where prevailing winds are longitudinal to the berth or, at least, to locations where strong winds are not expected broadside to the berth.

This facility can become untenable in beam or quartering winds greater than 25-35 miles per hour. Limiting current conditions are normally one knot for beam or quartering currents and two knots or more for head currents. In addition, 100,000 DWT appears to be the limiting size for multi-CBM moorings. Consequently, this type of facility has not been considered further.

Single Point Mooring Buoy (SPM or Monobuoy)

This mooring system (Figure 16) consists of a flat cylindrical buoy with its vertical axis held in position by a multi-leg system of anchors and chains. The buoy has a central piping manifold topped by a single or multiple-product swivel, connected by under-buoy hoses to a submarine pipeline. A turntable on top carries pipes from the central swivel to the side of the buoy where they connect by floating hoses to the tanker manifold. The tanker is usually moored to two nylon hawsers running from the buoy turntable to the bow of the ship. This permits the tanker to berth into prevailing winds and to move with changes in

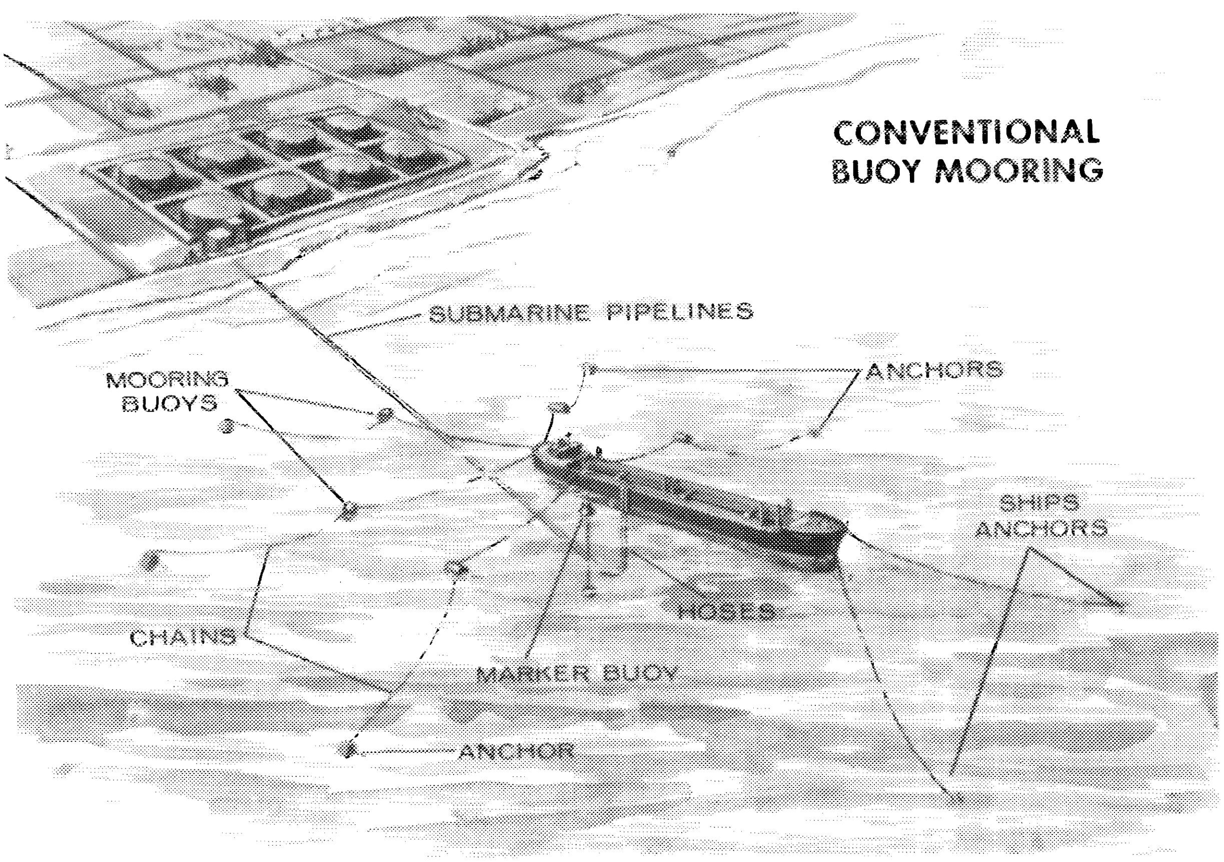


Figure 15

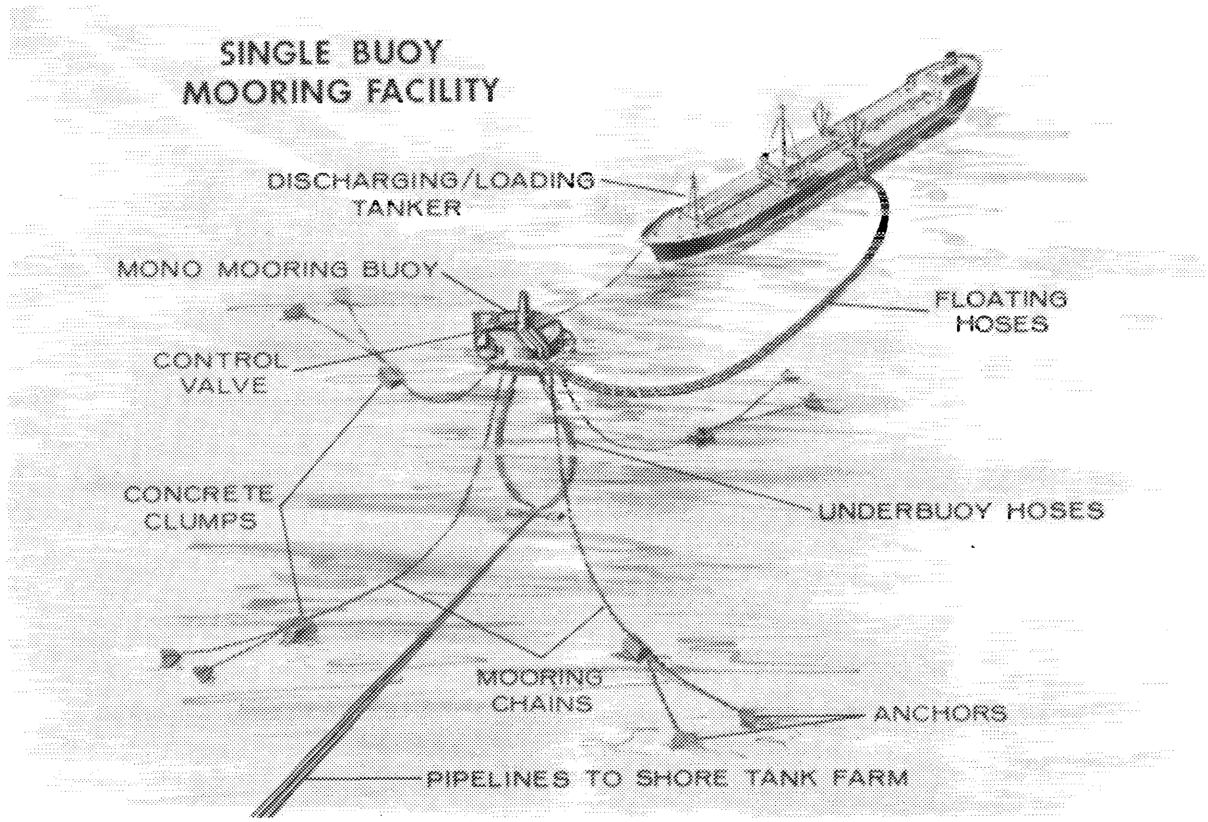


Figure 16

wind and/or current direction while at berth. Combined with the natural resilience of the buoy, this rotational freedom minimizes forces on the mooring hawsers. At present, mooring operations usually require a launch. When launch operations are required, berthing is generally halted by six to eight foot seas. However, monobuoy operations are relatively new. There is a consensus in the industry that, as experience in the use of monobuoys grows, technology will improve to the point where down time, because of weather, will be minimized. If so, the monobuoys will suffer little disadvantage because of adverse weather.

Despite some drawbacks, SPM's are suitable for operation at offshore locations including areas where sea and weather conditions may be severe. They may be designed to operate with waves of 15 to 20 feet in combination with high winds and currents. Berthing operations have limitations similar to CBM's and require 4,000 foot clear swing radius around the buoys.

One experienced problem with SPM's is a tendency of tankers to creep towards the buoy during calm weather and slack tide. This can lead to possible fouling of the buoy mooring chains or submarine hoses by the tankers' bulbous bows. Floating hoses are also susceptible to vessel damage, particularly at night, and to wave damage in heavy seas. Turntable sticking and subsequent wrapping of hoses around the buoy can also cause damage. However, many of these problems have been overcome by the Single Anchor Leg Mooring System.

Single Anchor Leg Moorings (SALM)

The single anchor leg mooring (Figure 17) is a modification of the SPM system. The hose and swivel mechanism however, is located on the sea bed. The buoy floats on the water and is anchored to the bottom by a single chain. Should the bow of the vessel strike the SALM while berthing or drift while berthed, the buoy would be pushed aside and submerged without affecting the hose and swivel mechanism. This system has been installed at two locations in depths of 85 and 140 feet, and can be designed for mooring tankers exceeding 500,000 DWT. Mooring and berthing limitations with this system are similar to the SPM.

Single Point Mooring Pier

This facility (Figure 18) consists of a pylon or tower fixed to the sea floor and a long swivel-mounted semi-submersible floating arm, with a floating tower at its end. The tanker moors at the bow, permitting it to feather into the wind, seas and current, to assume a line of least resistance. The oil moves from the vessel's manifold through a short hose to the floating structure and into the submarine pipeline. This facility is relatively expensive to install, costing two to

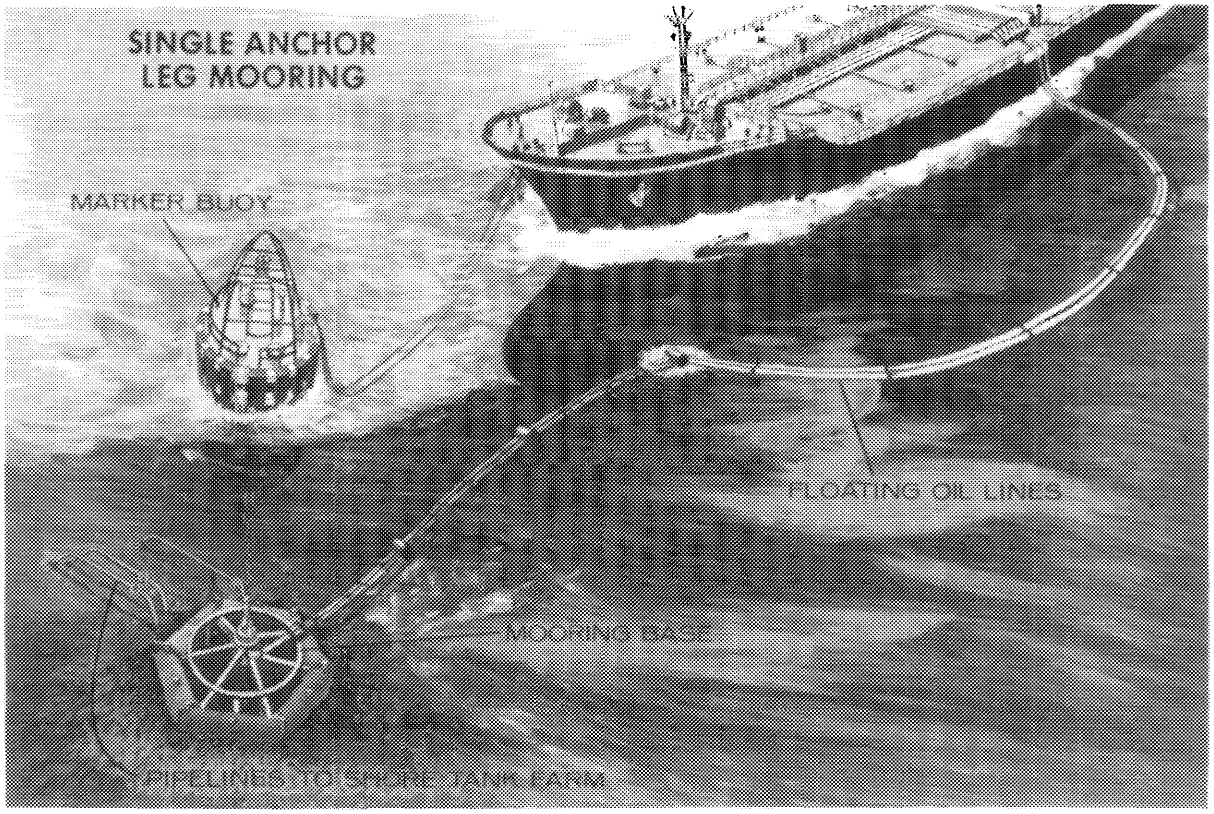


Figure 17

SINGLE POINT MOORING PIER

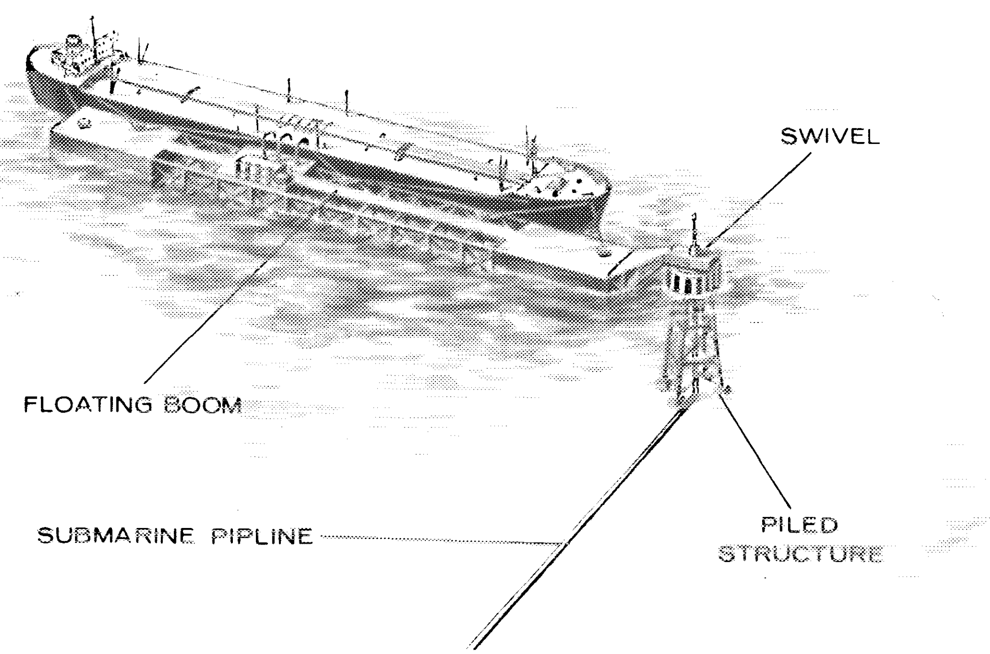


Figure 18

five times as much as a monobuoy. The floating arm may be vulnerable to sea conditions. However, it has a much higher capacity than a monobuoy, as its hoses are shorter and flex only when connected to the tanker manifold. In addition, single pile moorings endeavor to eliminate the monobuoy's major disadvantages (i.e., hose vulnerability and system maintenance) by replacing flexible elements with a rigid truss structure.

Marginal Piers

Marginal piers, like sea islands, are fixed structures (Figure 19). This type of docking facility is usually placed close to an existing shore or artificial island. Cargo is carried ashore either by a trestle-supported pipeline or by conveyor from the mooring facility. Where conveyors are used it is not necessary to slurry solid materials for handling.

Since the ship is moored at a fixed berth, tugs are required for safe berthing. Waves which prevent tugs from completely controlling the operation (waves of more than three feet) will stop berthing at the facility.

Construction of a breakwater to shelter the docking area permits the facilities to be used in much higher seas. The cost of a breakwater must be weighed against the cost of shut-down during adverse sea conditions.

Sea Island

A sea island (Figure 20) is a fixed structure that keeps the ship restrained in position and orientation. Fixed structures are usually used where prevailing winds are parallel to the berth or where strong broadside winds are expected infrequently. This system permits installation of several all metal loading arms allowing high oil transfer rates. Ships may dock at both sides of the sea island concurrently, and can easily be fueled or bunkered. Surveillance of the oil transfer can easily be conducted by trained personnel. For other mooring systems, these personnel would have to operate either from aboard the tanker or from special launches, an inconvenience if the facility is some distance from shore. The oil is transferred to shore via a submarine pipeline.

Fixed berths require tugs to berth tankers safely and require more shelter from waves than do SPM's or CBM's. Therefore, wave conditions that preclude tugs from maintaining complete control of the operation (waves more than three feet high) will stop berthing. Similarly wave height and direction will affect the vessel when moored. A tanker can remain moored in higher waves from the bow and stern than it can from the quarter or beam. Beam and quartering currents, along with or apart from beam and quartering winds, will also have an affect on a berthing tanker and a moored tanker.

MARGINAL PIERS

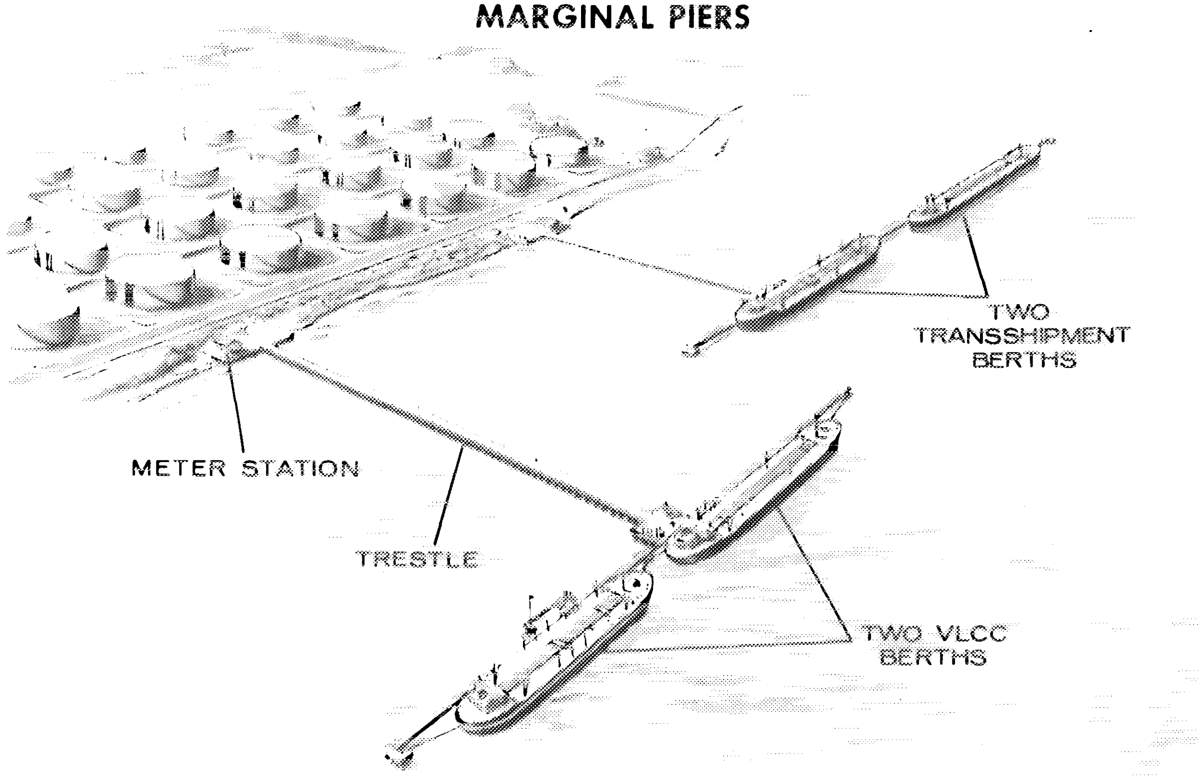


Figure 19

ARTIFICIAL ISLAND WITH SEA ISLAND BERTH

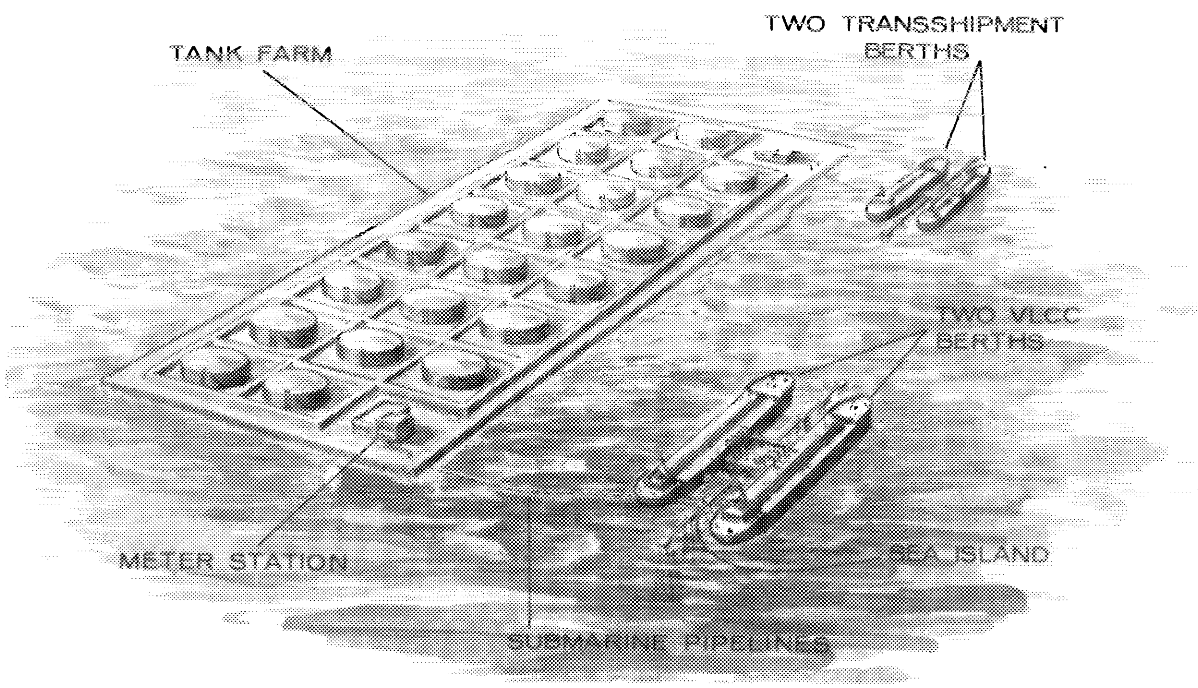


Figure 20

Artificial Island

This is probably the most expensive type of deep water port facility (Figure 20). However, its versatility is practically unlimited. An island would probably be built by placing a rock fill dike around its perimeter; hydraulic fill would then be pumped in and compacted to form the island. Simultaneously, a stone revetment would be built around the outside perimeter of the dike. The revetment would be protected with precast concrete armor units massive enough to remain stable under severe sea conditions. The island size would be determined by the types of material shipped through the facility. A marginal pier or sea island to handle the actual berthing would be attached to the island. The island could be used for the unloading, storage, and transshipment of both liquid and solid commodities. Limitations of the artificial island are similar to those of the marginal pier.

SUMMARY

There are alternative plans to importing large amounts of oil into the U. S. in the future. However, it is doubtful that they would be employed to an extent that will materially effect the projected imports of crude oil to the North Atlantic Region in the near future, barring legislation to control demand.

A deep draft facility and oil refineries could be developed on the Gulf Coast to satisfy a part of the North Atlantic Region's energy demand. However, it would not be economically feasible to use a Gulf Coast terminal to import crude oil for existing North Atlantic refineries. Instead, shippers would choose to use ports in Canada or the Caribbean to meet those needs.

Consequently, it will be necessary to import most, if not all, of the crude oil into the North Atlantic Region by vessel in the near future and possibly until the turn of the century. The use of foreign terminals will increase harbor congestion and lightering operations and the frequency of oil spills. Providing facilities to accept VLCC's in the North Atlantic Region would reduce the chance of oil spills resulting from congestion and lightering, and at the same time would provide some savings in oil transportation costs. Therefore, providing facilities to accept VLCC's on the North Atlantic appears to be preferable to the use of foreign ports.

GENERAL CRITERIA

This chapter describes the criteria established to select locations for development of facilities for accommodating deep draft ships in the North Atlantic and to ensure protection of the environment. The criteria were used to screen all alternative plans to eliminate unacceptable alternatives at an early stage of the study. These criteria include engineering, economic, socio-economic, and environmental parameters.

Within the framework of this study's authority and its injunction to determine the most "efficient, economic, and logical method," the most "efficient" and "economic" method of handling very large bulk carriers has been defined to mean the method which results in the greatest net savings or the largest net benefit. The most "logical" method has been interpreted as being that method which best meets the engineering and economic criteria, while minimizing adverse socio-economic and environmental effects.

ENGINEERING CRITERIA

Engineering criteria were established to serve as a basis for estimates of construction cost estimates and to ensure a workable facility. These criteria relate to atmospheric conditions; waves, winds, and currents; water depths; approach channels and maneuvering areas; berthing facilities; pipelines and pumps; storage facilities; and operating areas. They are summarized below.

Fog and Ice

Dense fog and heavy icing occur in much of the North Atlantic. Generally, areas where these conditions occur frequently should be avoided, as they cause significant amounts of down time and may lead to vessel damage and cargo spills resulting from collisions with other vessels or ice.

Wave, Wind and Currents

Wave, wind, and currents influence the type of berth that will be provided. Normally, wave heights of three feet prevent mooring at a fixed berth, while wave heights of six to eight feet generally halt mooring at today's SPM. Similarly, wave height and direction affect a moored vessel. Ten foot waves from astern and three to four foot waves from abeam are considered limiting for fixed berths; while at an SPM, a ship can remain berthed in waves up to twenty feet. In areas where wave conditions exceed those heights, a breakwater may be required. However, it appears possible that difficulties in mooring at SPM's in heavy seas may soon be overcome. Current mooring procedures are restricted by the need of an assistance launch. A system now being used in the North Sea would allow mooring at an SPM site without launches. It is possible that this technology could be developed for an unloading terminal in the North Atlantic.

Beam and quartering currents exceeding one knot, along with or apart from beam and quartering winds, also affect tankers approaching a fixed berth and mooring of tankers. If currents are severe, but are due to tidal action, berthing can take place during slack water.

Channels and Maneuvering Areas

Channels and maneuvering areas must have adequate dimensions to assure safe navigation. Required dimensions are generally evaluated in relation to vessel dimensions and estimated wave forces to which a vessel will be exposed. Depending on their location, channels generally should have a width of 3 to 5 times the beam of the design vessel* and a depth of 1.1 to 1.2 times its draft. Turning basins require similar depths, and a radius of 1.5 to 2 times the length of the vessel. Maneuvering areas for monobuoys require depths of 1.15 times the draft of the vessel and a radius around the buoy of 4,000 feet [2].

Vessel Berths

Variable loading times, sailing conditions, and weather conditions at loading ports are factors which prevent precise scheduling of arrivals of ocean going vessels at terminal facilities. Unless carefully regulated, arrival times of ships on long voyages are randomly distributed. Selection of the number of berths for each of the deep draft facilities studied was based on a ship queuing analysis developed for this study.[11] Increasing the number of berths tends to reduce total annual vessel waiting time. The optimum number of berths to be installed at each facility site was determined by converting the reduction in waiting time to annual savings in vessel operating costs and comparing it with the cost of additional berths.

*Maximum size vessel to be served by each deep draft facility.

Pipes and Pumps

The number and size of pipelines linking VLCC berths to intermediate storage areas is determined mainly by the viscosity of the oil, tanker unloading rate and the length of the pipelines.

Crude oil characteristics, as used in this study, are as follows:

Specific gravity	= 0.8654
Viscosity	= 80 SSU at 60° F.
Design Flow Temperature	= 60° F.
Pour Point	= 40° F.

The unloading capacities of pipelines and pumps were assumed to be 90,000 barrels per hour. Submarine pipeline sizes were limited to 48 inches, currently the largest diameter submarine pipeline capable of being installed by lay-barges. It was assumed that individual pipelines would serve each berth to segregate the different grades of crude oil.

Required pump horsepower is dependent on the pressure differential between a ship's manifold and the oil level in the storage tank. Horsepower requirements are expressed by the formula:

WHERE: $$H = \frac{PB}{2{,}450 \times E}$$

H = Brake horsepower
P = *Total differential pressure, psi.*
B = Barrels per hour
E = Pump efficiency

Pipeline and pump horsepower requirements between the intermediate tank farm and refineries were determined from a throughput optimization program. Pipeline lengths were determined from the assumed pipeline routes developed for each respective alternative plan. Design throughput was calculated to be 20 percent higher than the annual throughput requirements for each alternative to provide sufficient pipeline flexibility in case of seasonality in flow. Pipeline sizes from tank farm to refinery were limited to 56 inches and average wall thickness was assumed to be 1.0 inch.

Storage and Land Requirements

Intermediate storage and land requirements are mainly dependent on the ultimate capacity of the terminal and the estimates of the early and late vessel arrival times expected to occur as a result of uncertainties such as weather during the vessel trip or at the terminal. For this study, the following criteria were used to evaluate alternatives:

Intermediate Storage Requirements

Protected sites—10 days of facility throughput
Monobuoys—12 days of facility throughput

Land Requirements

Onshore—1 acre per 80,000 bbl/d throughput
Artificial Islands—1 acre per 100,000 bbl/d throughput

All of the alternatives studied can meet the above established engineering criteria, some at higher costs than others.

ECONOMIC CRITERIA

The best designed and most sturdily constructed port facility in the world would be of little value unless it provided economic advantages to the user. Any deep draft facility must reduce ultimate shipping costs of its users below those of its competitors if it is to attract customers. Economic criteria used in this study require that any alternative under consideration reduce total transportation costs from shipping port to receiving port below comparable costs incurred without a deep draft facility.

To determine the effects of the alternatives on transportation costs, the cost of shipping was calculated using vessel operating costs developed by the U.S. Army Corps of Engineers, Office of the Chief of Engineers (July 1972 price levels). In developing those costs, foreign flag vessels were assumed for trade routes between U.S. and foreign ports, while U.S. flag vessels were assumed for transshipment between deep water terminals and refineries. Vessel transportation costs were developed for the 1975 to 2025 period using projected fleet size distribution for various years and project depths. Costs of the terminal and transshipment facilities were estimated at July 1972 price levels, including replacement, operation, and maintenance costs. Vessel transportation and facility costs were converted to an average annual value using an interest rate of 5.5 percent over a 50 year project life. An analysis of the effects of taxes and varying interest rates required for private financing was made for the more economically efficient alternatives.

Average annual benefits for each alternative were computed as the cost of vessel transportation for the particular commodity without a deep draft facility less the cost of vessel transportation with a facility. The most efficient and economic method of handling very large bulk carriers is the method which results in the average annual benefit exceeding the average annual cost by the greatest amount. This difference called "net benefit" is an indication of the effect the method will have on total transportation cost. The method having the greatest net benefit reduces total transportation costs to a minimum.

SOCIO-ECONOMIC CRITERIA

In addition to engineering and economic considerations, care must be taken to avoid significant adverse impacts on the daily life of the people who live in or pass thorugh the area affected by a deep draft facility. Particular attention must be given to meeting, as closely as possible, the following criteria.

1. Man-made and natural resources, leisure opportunites, aesthetic values of the community, community cohesion, public facilities and services should be preserved.
2. Income, employment, tax base, and property values should not be adversely affected. Since one purpose of placing a facility in any community is to assist the economic development (if desired) of that community, any project which seriously impairs the area's economy is not preferred.
3. People, businesses, and farms should not be displaced. Sites preferred for deep draft facilities should not require the relocation of existing farms or businesses, or the displacement of community residents.
4. Desirable community and regional growth should not be disrupted. A proposed facility should not interfere with legitimate community plans for expansion, such as proposed airports or hospitals.
5. Existing laws: No facility should be recommended where such a facility would violate the existing laws of the State for which it is proposed.

Alternatives which would be most desirable provide for minimizing adverse socio-economic impact within the area which would be affected by development of a deep draft facility.

ENVIRONMENTAL CRITERIA

The effects of a deep water port upon the environment depend on many factors including the effects of oil on the environment of the area in which it is located, the safeguards provided to prevent, contain and clean up a spill and control landside impacts, the amount of dredging required and the effects of alterations to the bottom hydrography. Adverse environmental impacts of constructing, operating, and maintaining a crude oil unloading facility must and can be minimized. The criteria set forth in this section have been chosen so as to minimize such impacts and, wherever possible, to bring about improvements in environmental quality.

Effect of Oil In the Environment

It is widely believed that any area subjected to a large oil spill will never completely recover. However, experience with spills which have already occurred throughout the world has been markedly varied. There are nine variables which singly and in combination contribute to determining the impact of an oil spill.[19] These include: (1) the type of oil spilled; (2) the amount of oil spilled; (3) the physiography of the spill area; (4) weather conditions at the time of the spill; (5) the biota of the area; (6) the season of the spill; (7) previous exposure of the area to oil; (8) exposure to other pollutants; and (9) the treatment of the spill. It appears that the type of oil spilled is the most significant item in determining the environmental effect of the spill. In general, light petroleum products (e.g., No. 2 fuel oil) appear to be more toxic than crude oil.

Heavier oils have a smothering effect in the intertidal zone. They also result in greater sea-bird mortality than lighter oils. Studies of the effects of crude oil[20] have shown that the blackest and thickest crude oils are least toxic, while the translucent, brown oils are most toxic. Although the effects of oil in the environment are not accurately predictable, it is known to be toxic in large quantities to most plants and animals. Biological data on the exact tolerance of organisms to crude oil are not available. However, there is some evidence that tolerance may be developed by exposure to oil.[19] Table 18 summarizes the documented effects of past oil spills. Since crude oil in sufficient quantities is toxic, steps should be taken to reduce the concentrations present in the environment and to inhibit the spread of whatever oil is spilled.

Environmental Safeguards

Dangers to the environment can be significantly reduced by several possible safeguards which could be implemented at a deep water terminal. Oil spills represent a major environmental issue in the overall question of deep water port development. Techniques for marine oil pollution control may be categorized as prevention, containment, and clean-up. Prevention techniques involve the use of double-bottomed tankers; positive traffic control systems; pressure-released cutoff valves; site location for prevention of vessel groundings and collisions; and mode of transshipment (i.e., pipelines vs barges) to reduce both vessel casualties and spills during transfer operations.

Studies conducted for the Council on Environmental Quality indicate that the single most cost-effective way to reduce total oil spilled is to use pipelines instead of vessels to transship oil from a deep draft terminal to the shore. Encased burial of pipelines and pressure-released cutoff valves are supplementary means of increasing the overall effectiveness of transshipment by pipeline. Use of double-bottomed supertankers to reduce spills from groundings and offshore siting of a terminal are also cost-effective However, siting a terminal at a far offshore location is inconsistent with employing double-bottomed tankers, since spills from groundings would be less likely offshore. Mandatory radar guided traffic control systems are a reliable cost-effective means of reducing the probability of vessel collisions and groundings and, consequently, total oil spillage. Traffic separation routes, a strictly advisory control measure, can also effectively reduce vessel accident rates near harbor entranceways.

Containment and clean-up techniques are used to control spills and prevent them from spreading beyond the immediate spill area. These techniques include aprons (fixed barriers placed around vessels), booms (floating devices to contain spills), skimmers (devices to remove contained oil), as well as other devices to aid in the containment and clean-up of the oil. These devices are generally employed at the berth although they have been used at sea primarily

TABLE 18

COMPARISON OF CIRCUMSTANCES AND DOCUMENTED DAMAGE OF OIL SPILLS

Locality	Date	Oil Type	Detergent	Acute Damage
Baja Calif. U.S.A.	March 29, 1957	Diesel, total 9,380 cu m (1/3 lost on stranding)	0	Very high mortality of marine life recorded 1 month after spill. Six years later, recovery almost complete. Rocky cover 1/2 mile entrance, three-fourths of cove blocked.
West Falmouth, Mass. U.S.A.	Sept. 16, 1969	No. 2 diesel oil 650 to 700 cu m	0	Ninety-five to 100 percent mortality of marine life in intertidal and subtidal areas to 10 ft. June, 1970, intertidal marsh grass still dead and no sign of recovery in intertidal areas.
Isle of Scilley Off Cornwall, England	March 18, 1967	Kuwait crude 96,000 cu m	2-1/2 million gal at sea and about 140 miles English beaches	Damage greatly increased where detergent was used. Some areas fully recovered but others not 3 years later. Bird mortality recorded.
Santa Barbara Channel, U.S.A.	Jan. 28, 1969	Santa Barbara crude oil	43,010 gal over 13 months at sea	Marine life mortality patchy in intertidal area and confined to areas covered with thick oil. Recovery of algae and sea-grasses and resettlement of barnacles commence 1969. Oil smothering rather than toxic. Bird mortality recorded. (Allan Hancock Foundation Report)
Nova Scotia, Canada	Feb. 4, 1970	Bunker C 12,000 cu m	minimal	Smothering of some intertidal species; some bird mortality.
San Francisco, Calif., U.S.A.	Jan. 18, 1971	Bunker C about 2,222 cu m	0	Marine life mortality patchy in intertidal area and confined to areas covered with thick oil. Oil smothering rather than toxic. Bird mortality at least double that estimated for Santa Barbara.

Source: Journal of Petroleum Technology, Factors Causing Environmental Changes After an Oil Spill, Dale Straughan—March 1972

for large spills. Containment devices ere feasible at fixed berths, but not at SPM facilities, where ships swing freely with wind and current. With the exception of the newest boom developed for U.S. Coast Guard, no presently available boom is effective in containing oil in other than relatively calm seas and very low surface currents. The new boom is designed to contain oil in waves up to four feet high and 1-1/2 knot surface current conditions. Consequently, existing systems are not very effective in the open ocean. However, this is an area of ongoing research and better containment devices are likely to be developed. The largest single problem in open ocean containment and recovery is rapid deployment of equipment within a few hours of the spill. The farther from shore an ocean terminal is located, the better the chance of preventing a spill from reaching shore.

Standard equipment at unloading operations include drip pans, located around unloading arm or hose connections, and around all manifolds. Additionally, the entire deck of the tanker is enclosed by a low wall which provides backup to contain a spill. Newly designed, quick disconnect couplings are used for temporary connections. Once connections are made and pumping is started, electronic monitoring devices now under design will be able to indicate system malfunctions and facilitate early shut-down. However, if oil reaches shore, there are available techniques to clean up the shoreline using absorbents like straw (still considered the most effective method), some light equipment and concentrated manpower. In general, effective clean-ups are costly.

An additional backup would be provided by industry cooperatives, formed to marshal the equipment and trained personnel of a particular geographic area in the event they are needed. There are existing cooperatives at most major ports in the North Atlantic. Under the Water Quality Improvement Act of 1970, every terminal is required to have a contingency plan for handling spills. This plan must be approved by the United States Coast Guard and includes provisions for handling even the largest,most improbable spills.

The tanker and terminal operators are underwritten by the financial liability for pollution cleanup which the oil companies now assume. Two voluntary agreements ensure coverage of oil pollution losses resulting from tanker operations. One such agreement is the Tanker Owners Voluntary Agreement Concerning Liability for Oil Pollution, (TOVALOP). This agreement covers most tankers serving the United States; under it, cleanup costs are insured (based on tanker tonnage) for up to ten million dollars. Backing up this agreement is the Contract Regarding an Interim Supplement to Tanker Liability for oil pollution, known as CRISTAL. Under CRISTAL, participating oil companies have provided additional coverage up to $30 million for the removal of pollutants. In both agreements, control and cleanup action are started immediately, before responsibility for the accident is assigned.

For U.S. waters, the Water Quality Improvement Act of 1970 legally assigns liability up to fourteen million dollars to the owner or operator of the vessels involved. Additionally, the Act assigns liability for pollution from terminals up to eight million dollars.

The national scale of the problem has long been recognized by the Federal Government. Besides assigning financial liability to tanker and terminal operators, the Water Quality Improvement Act of 1970 requires that regional and national contingency plans be established for response to possible oil pollution. The Act sets up a revolving fund, not to exceed 35 million dollars, to finance clean-up. The President has delegated control of clean-up operations to the United States Coast Guard, which now contracts them out, but is developing clean-up capabilities of its own.

In addition, the U.S. Coast Guard has recently issued regulations governing the design, construction and operation of vessels operating in the navigable waters and continguous zone of the United States and governing the design, construction and operation of onshore and offshore facilities engaged in the transfer of oil to and from vessels. Those regulations require the use of the most up-to-date technology to reduce the probability of damage to the environment from accidental oil spills.

Onshore safeguards should include adequate land-use planning and controls to assure environmentally dangerous development does not occur. Landscaping tank farms with trees and plantings to blend in with the countryside and floating roof tanks to minimize release of hydrocarbon vapors into the atmosphere should be required.

Dredging

Dredging, blasting, filling and disposal of spoils, together with periodic maintenance dredging, can also be expected to occur at many deep draft terminal sites. Offshore dredging will not tend to produce long-term effects on the biota. This is not the case with the dredging of estuarine areas where species are more depth sensitive and some, like oysters, require a bed of shells for their existence. Wetland loss is a significant problem which could be caused by poorly planned spoil disposal. The alternative to controlled (land) area spoiling is disposal in deep water. Yet, this option is also encountering difficulties. Beyond escalation in costs, spoiling in deep water is becoming an ecological concern. Care must be taken in offshore disposal to avoid productive bottom areas, increasing water turbidity to damaging levels, and above all to prevent the buildup of toxic substances which might cause prolonged or degradation of marine or estuarine habitats.

Because of these problems, ports requiring the least dredging are preferred. However, a deep water terminal will require significantly less dredging than would be required if existing channels were to be deepened to meet the demands of larger vessels. Consequently, from this aspect an offshore terminal would be preferable to further channel deepening.

Water Transport Alterations

Water transport effects, that is, the changes in direction and character of flow, are largely dependent upon the extent and nature of bottom hydrography alteration, local meteorological and wave conditions, and the physical configuration of the constructed works. At offshore sites, the facility size and distance offshore will influence the effects on littoral drift and wave patterns. At inshore sites, deep channel construction impacts will vary from site to site and the environmental consequences cannot be listed in any universal priority.

Major alterations to the bottom hydrography of an area can cause changes in current velocity and affect areas of scouring and sedimentation. Changes in direction of currents will affect settling areas of larvae and pollution dispersal or dilution. These factors can produce a shift in areas suitable for different groups of biota seeking a preferred range of parameters (temperature, salinity, etc.). Consequently, major changes in bottom hydrography should be avoided.

Offshore vs. Inshore

Estuaries and coastal wetlands, the most biologically productive areas of the marine ecosystem, are also the most sensitive to damage from construction and oil spill effects. At inshore sites such damage may be unavoidable. At offshore locations, however, construction effects are minimized and the probability that spilled oil will enter sensitive estuarine areas is reduced. In addition, the weathering of oil that could take place en route to an estuarine area would tend to remove the most immediately toxic and lethal fractions of the oil. The consensus of researchers[21] is that far offshore locations are less vulnerable to environmental damage than areas close to shore and will minimize the potential for environmental damage. However, it must be noted that most of the coastline of the North Atlantic Region is extensively developed for recreation, and major oil spills could foul the beaches and present a significant economic and social problem.

The foregoing criteria indicate that any facilities recommended should provide for features which will reduce oil spills to a minimum and provide for containment and rapid removal of spills which do occur. In addition, facilities located in areas away from estuaries and requiring as little dredging as possible would be preferred.

GENERAL

Previous chapters have discussed, in general terms, possible solutions to the North Atlantic Region's deep draft port problem, and have established certain criteria as a basis for evaluating them. Having tentatively concluded that the most economically feasible general plan of action for solving the problem lies in providing a deep draft unloading facility for VLCC's somewhere along the North Atlantic Coast, the next step must be an examination of the coastline to determine the most suitable locations for such a facility.

The coastline under consideration in this study extends from Eastport, Maine to Norfolk, Virginia. For descriptive purposes, it will be divided into the six areas shown in Figure 21. Potential sites for deep port facilities are shown on that figure and numbered 1 through 19. A very large volume of petroleum and petroleum products passes through these reaches (Table 19).

Of primary significance to this study is the irregularity of the depth contour lines and the comparatively few locations where 60 to 90-foot depths are found within five miles of the shoreline.[2] These occur along the New England coast in Maine (near the Canadian border at Eastport, Machias, Bangor, Searsport and Belfast); at Portsmouth and Boston; at Narragansett Bay (Providence); and off the northern coast of New Jersey near Long Branch. Other favorable locations at 60-foot depths are off the coasts of Long Island, Delaware Bay, and Virginia.

NORTHEASTERN MAINE

The coastal zone (Figure 22) in this sub-region is characterized by a rough, rocky shoreline with deep, narrow inlets and coastal islands. There is a large tidal range accompanied by strong coastal currents and high flushing rates in bays and estuaries. The area is notable for its natural ruggedness, high water quality, and an absence

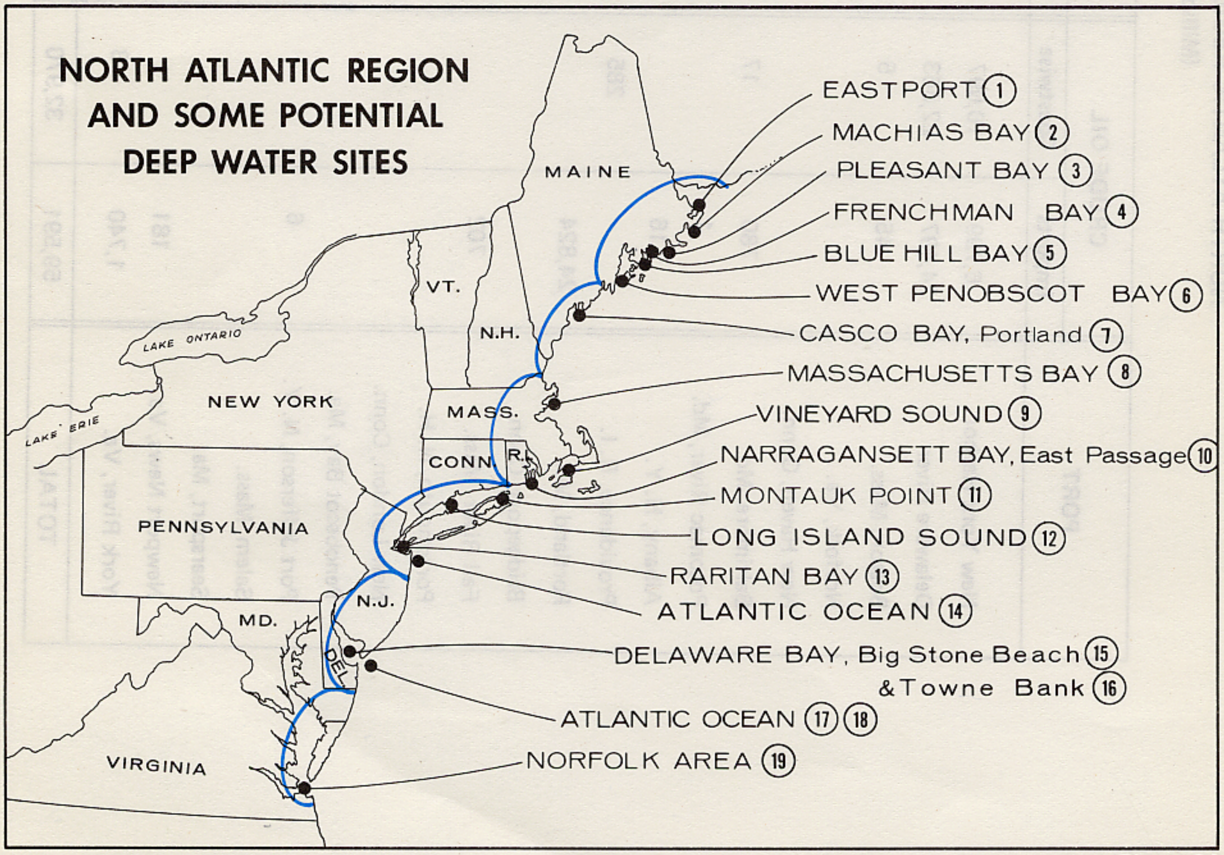
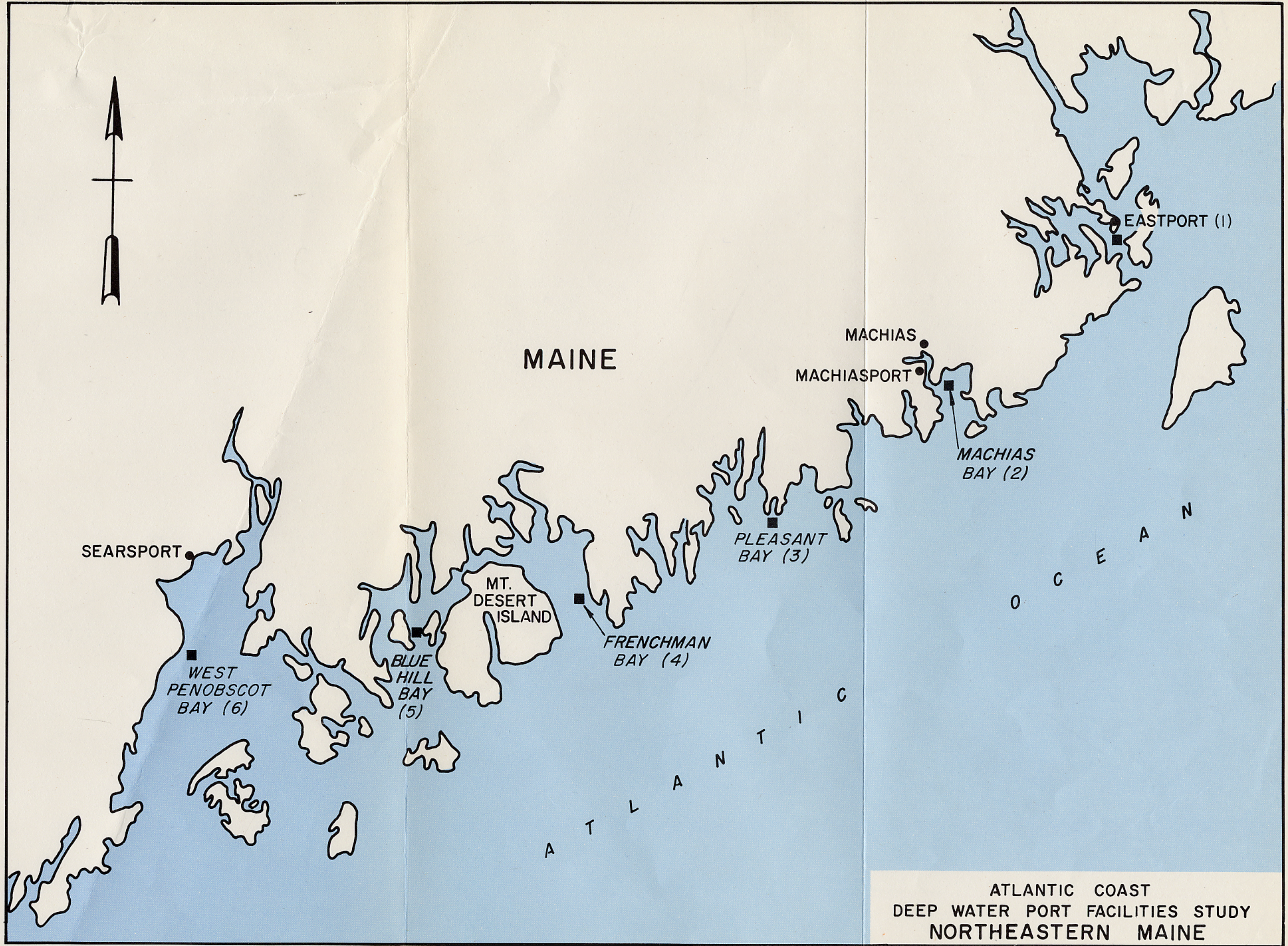


Figure 21

TABLE 19
NORTH ATLANTIC REGION WATERBORNE RECEIPTS – 1971
(Millions of Short Tons)

PORT	CRUDE OIL		RESIDUAL FUEL OIL		OTHER PETROLEUM PRODUCTS		TOTAL
	Imports	Coastwise	Imports	Coastwise	Imports	Coastwise	
New York Harbor	6,799	10,097	23,117	6,439	6,394	14,568	67,414
Delaware River	24,497	22,563	7,200	3,091	199	6,062	63,612
Boston, Mass.	45	5	4,969	1,356	445	12,947	19,767
Norfolk, Va.			5,204	409	130	1,691	7,434
New Haven, Conn.			2,690	215	243	5,802	8,950
Baltimore, Md.	780	17	2,467	1,773	236	2,734	8,007
Potomac River, Md.	1		2,416			417	2,834
Albany, N. Y.	16		1,853	89	86	2,573	4,617
Providence, R. I.		285	1,486	171	24	5,255	7,221
Portland, Ma.	24,824		1,423	182	18	3,754	30,201
Bridgeport, Conn.			1,319	325		1,195	2,839
Fall River, Mass.	702		1,276	161		1,509	3,648
Portsmouth, N. H.			905	4	109	842	1,860
New London, Conn.			947	937		218	2,102
Penobscot Bay, Ma.			497	23			520
Port Jefferson, N. Y.	6		509	601	353	2,475	3,944
Salem, Mass.			803	33	2	207	1,045
Searsport, Ma.			559	15	10	165	749
Newport News, Va.	181		438	23		1,071	1,713
York River, Va.	1,740	3	26	109		290	2,168
TOTAL	59,591	32,970	60,104	15,956	8,249	63,775	240,645

Source: Waterborne Commerce of the United States - Department of the Army - Corps of Engineers



ATLANTIC COAST
DEEP WATER PORT FACILITIES STUDY
NORTHEASTERN MAINE

Figure 22

of major urban areas and population centers. It is the least populated region in the North Atlantic Coastal Zone and is economically dependent on commerical and sport fishing. Commercially important marine resources include crustaceans, shellfish, finfish, and seaweed. In 1969, the total value of the shellfish and finfish harvest was $21.4 million.

The unspoiled coastal zone is intensively used for recreation and provides an attractive center for sightseeing, boating, camping, hiking, picnicking, beachcombing, and fishing. A number of relatively small beaches are suitable for swimming and sunbathing, but cold water limits swimming to the warmest of the summer months. Coastal waters are used primarily for commercial fishing.

Searsport is the most important harbor in the region and receives substantial quantities of petroleum products by vessel (Table 19). It is located at the head of Penobscot Bay, which has an average depth greater than sixty feet. About a mile separates the harbor facilities from deep bay waters, and the 35-foot access channel experiences an average daily tide range of 10 feet.

Six potential deep water sites were examined in this area:

(1) Eastport

Eastport is in the far northeastern corner of the State of Maine and may be reached by U.S. Route 1 and a number of secondary roads. Eastport Harbor has for some time been considered a possible location for a deep water port. It has a reasonably deep well-protected harbor in an economically undeveloped area. A natural access channel, with a depth averaging over 120 feet, is provided by Head Harbour Passage and Friar Roads. However, its approaches are winding; its currents extremely difficult to judge and the area has the highest number of fog days along the coast. Highly sophisticated navigational controls would have to be installed if traffic in this harbor were ever to become heavy. In addition, some dredging is required to provide adequate channel width for large vessels.

(2) Machias Bay

Machiasport Harbor is at the southern end of the Machias Peninsula, 10 miles south of the Town of Machias, county seat and largest town in Washington County. Starboard Island, one-half mile from shore on the east side of the peninsula, and Stone Island lies slightly less than one mile east of Starboard Island in the harbor area. Off Stone Island Ledge, there is a near-shore anchorage more than 100 feet deep with a four mile wide turning basin. The port area is reached by Route 192, the end of which is a dirt road to Starboard Island open only at low tide. The deep water off Stone Island could be utilized for crude oil berths and a site off Starboard Island could be developed for transshipment berths. Waves in the area are less than four feet more than ninety percent of the time. Topography of the peninsula and islands is irregular. Hills 120 and 205 feet high slope steeply shoreward on either side of the creek at Starboard Village. The amount of flat land that could be used for tank storage in the harbor area is limited. In addition, summer fog could reduce port availability to only seventy-eight percent of the year.

(3) Pleasant Bay

Located off Addison Peninsula in a relatively isolated part of the eastern coast, this area is sparsely populated and distant from major highways and railroad networks. Depths of 120 feet exist in the bay off Big Nash Island. Suitable level ground for a storage area exists on Moose Neck approximately two miles from Big Nash Island. The island's unprotected exposure to heavy seas could impair its utilization as a deep water site.

(4) Frenchman Bay

This area is located east of Mt. Desert Island. Depths greater than 200 feet exist in the bay west of Ironbound Island. The Island itself is about one mile square and has relatively flat topography suitable for use as a storage area. Because it is near Acadia National Park and other resort communities located on Mt. Desert Island, this site could entail many serious environmental and sociological problems.

(5) Blue Hill Bay

This area is located west of Mt. Desert Island on the Blue Hill-Brooklin Peninsula. Depths of 100 feet exist within a mile of the rocky, steep shore. Southern Bay in Brooklin Township near North Brooklin Village, contains a gently sloping shoreline and relatively flat land at an elevation of about 100 feet for development of a storage area. Of the Northeastern Maine sites considered here, this is the least developed for recreational purposes. Blue Hill Harbor is serviced by a narrow black top road from Blue Hill, and is 20 miles from U.S. Route 1 and 30 miles from a railhead at Bucksport. The area's sparse population is concentrated near the seashore. Bay currents are regular, not too strong, and protection from severe wave action is excellent; moreover the location is accessible from the open ocean without navigational difficulties. This site's major drawback is its inaccessibility to major land transportation networks.

(6) West Penobscot Bay

This area is located south of Searsport at Great Spruce Head, with water nearby deeper than 120 feet. The terrain is relatively flat with good highway access from U.S. Route 1. Its waters are well protected and waves less than four feet high are anticipated over 95 percent of the time. Natural access channels from the open sea exceed 120 feet depths and pose no navigational difficulties. However, as with other areas in this sub-region, this site lacks easy accessibility and is far from major market centers.

SOUTHERN MAINE AND COASTAL NEW HAMPSHIRE

The coastline (Figure 23) extends southwest from the mouth of the Androscoggin River in Maine to the New Hampshire and Massachusetts border. Casco Bay, northeast of Portland, has deep rock embayments similar to the rockbound shoreline of "Down East" Maine; south of Portland, beach and marsh are predominant. The area has experienced substantial growth over the past two decades, with a population equal to approximately one-third of Maine's 1970 census of 993,663. The Portland Standard Metropolitan Statistical Area is the state's largest population center with a 1970 population of 141,-625. New Hampshire's coastal Rockingham County ranks second in population of the ten counties of the State with a 1970 population of 138,959. Portsmouth is the largest coastal city in New Hampshire with a population of 25,-717.

The coastal resources of the sub-region are used extensively for recreation. Its southern reach has fine sand beaches and the many islands, harbors and bays of the north are extremely attractive to residents of the large urban areas of southern New England—primarily the Boston area.

The two major harbors in the region are at Portland, Maine and Portsmouth, New Hampshire. Portland at the southwestern end of Casco Bay, is the commercial and industrial center of Maine. Both an inner and an outer harbor have been developed. The inner harbor, located along the Fore River, has been improved to 35 feet.The outer harbor is protected by islands in the Bay with a 45 foot deep, 1,000 foot wide channel, providing access from the deep Bay waters. As shown in Table 19, this area is presently the second largest crude oil receiving port in the North Atlantic. All of the crude oil presently received is shipped by pipeline to the Montreal area for refining. The sub-region's other major harbor is Portsmouth, located two miles from the Atlantic Ocean on the Piscatagua River. The river channel has been improved to a depth of 35 feet, with an average width of 400 feet (one-way traffic) for a distance of six miles. In the mouth of the river, natural anchorage depths of 68 feet are available. However, bridges at Portsmouth restrict the channel width to 200 feet with 135 feet of vertical clearance. Depths of over 100 feet are found offshore.

The only deep water site considered in this region is at Portland in Casco Bay.

(7) Casco Bay

This site is served by a variety of good roads, Interstate 95 and U. S. Route 1 being the most important. Depths of 100 feet exist in the vicinity of East Brown Cow Island. This area is only slightly protected and waves less than four feet high are anticipated only 70 percent of the time. The island has an area of approximately four acres and is located two miles off Cape Small, which is relatively flat and suitable for a storage area.

SOUTHEASTERN NEW ENGLAND

The approximately 1500 mile-long coastline (Figure 24) of Massachusetts and Rhode Island has great topographical diversity. From The Rhode Island-Connecticut border to Buzzard's Bay the coast is a mixture of barrier beaches, deep indentations, low rocky headlands, marshes and ponds. North of Cape Cod, cliffs and bluffs mingle with sections of dune. Beyond the island-spotted 47-square miles of Boston Harbor, the shoreline becomes rockier until, beyond Cape Ann, it again features barrier beaches fronting vast tidal marshes. The Cape Cod shoreline is almost entirely sandy beach, relatively narrow in the south, but with extensive dune formations along the outer sections of the lower Cape.

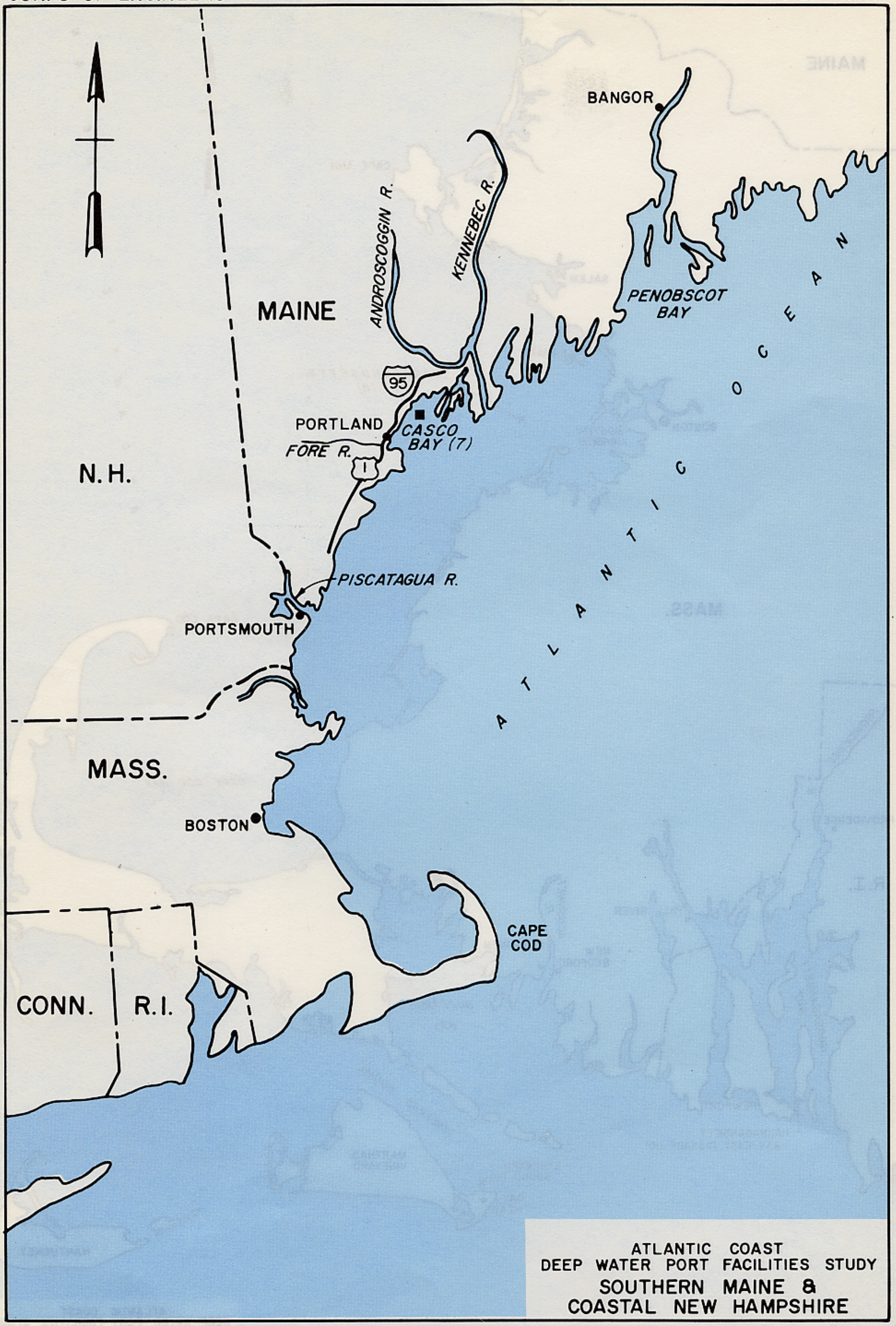
The region north of Cape Cod is dominated by Boston, the northern end of the Boston-Washington megalopolis. Many of the region's coastal towns serve as "bedroom communities" for Boston. There is much industrial activity, especially along the north shore.

The Cape Cod Peninsula is both a public and private recreational area. Economically, it is almost completely dependent upon tourism and its supporting activities, e.g. the construction industry.

South of Cape Cod the coast is more densely populated and has considerable industrial activity. Major population centers of this physcially diversified region are New Bedford, Fall River, Providence and Newport. Its principal industries include marine transport, waste disposal, conservation, commercial fishing, and recreation which is by far the largest.

The sub-region's five major ports are Boston, Providence, Fall River, Salem and New Bedford. The port of Boston consists of an outer harbor formed and protected by islands and peninsulas, and an inner harbor at the confluence of several rivers. Its access channel is 1,200-1,500 feet wide, with depths ranging from 35 to 40 feet. It passes from the Atlantic Ocean through the outer harbor to the inner harbor as far as the mouths of each of the rivers. The main channel cannot be deepened below 43 feet, allowing seven feet of cover, without relocating inner harbor vehicular tunnels.

The Port of Providence has been developed along a 2.5-mile section of the Providence River about 10 miles north of Narragansett Bay. Its 10-mile long access channel is 40 feet deep and 600 feet wide. There are no major developmental restrictions in the main channel to Providence; however, just above Providence, bridges restrict horizontal clearance to 50 feet and vertical clearance to only 9 feet.



ATLANTIC COAST
DEEP WATER PORT FACILITIES STUDY
SOUTHERN MAINE &
COASTAL NEW HAMPSHIRE

Figure 23

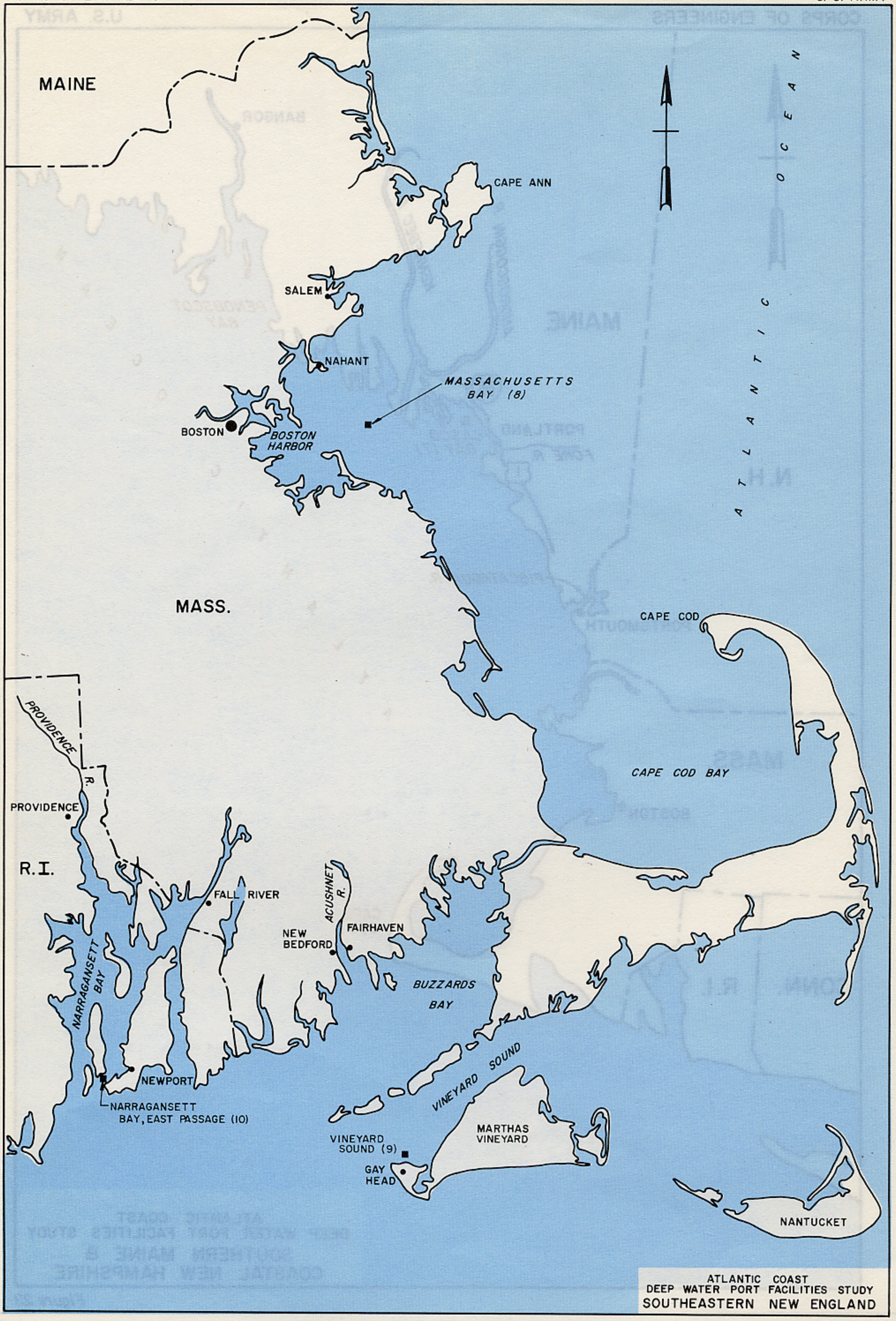

MAINE
CAPE ANN
SALEM
NAHANT
MASSACHUSETTS BAY (8)
BOSTON
BOSTON HARBOR
ATLANTIC OCEAN
MASS.
CAPE COD
CAPE COD BAY
PROVIDENCE R.
PROVIDENCE
R.I.
FALL RIVER
ACUSHNET R.
NEW BEDFORD
FAIRHAVEN
NARRAGANSETT BAY
BUZZARDS BAY
NEWPORT
NARRAGANSETT BAY, EAST PASSAGE (10)
VINEYARD SOUND
MARTHAS VINEYARD
VINEYARD SOUND (9)
GAY HEAD
NANTUCKET
ATLANTIC COAST
DEEP WATER PORT FACILITIES STUDY
SOUTHEASTERN NEW ENGLAND

Figure 24

Fall River on the Northeast side of Narragansett Bay is about 18 miles from Providence and has an existing channel 35 feet deep and from 400 to 1,100 feet wide. Depths of 40 feet are authorized for the access channel to Tiverton and to the mouth of the Taunton River. While there are 22 bridges in the vicinity of Fall River, only two impose potential restrictions upon navigation development. Both cross the Taunton River and restrict horizontal clearance to 98 feet. Salem is just north of Boston, and its 1.5-mile long access channel is 32 feet deep and from 300 to 400 feet wide. Channels ranging in depth from 5 to 10 feet are maintained to various wharves and yacht clubs in the port area. There are no known restrictions on harbor development.

The cities of New Bedford and Fairhaven provide a port at the mouth of the Acushnet River. Its 5-mile long access channel is 30 feet deep and 350 feet wide. Deep draft harbor development may be limited by a hurricane barrier seaward of the harbor, which limits the horizontal clearance to 150 feet and the depth to 35 feet. Three sites in this sub-region were considered as potential deep port sites, two off Massachusetts and one off Rhode Island.

(8) Massachusetts Bay

This site is about three miles offshore at Nahant and has depths in excess of 100 feet, sufficient maneuvering room and is also clear of hazards to navigation. In addition, its proximity to Boston with the present high level of petroleum products that it receives, make this port a prime site for a petroleum facility. Open acreage near Belle Isle Inlet could be used for a tank farm.

(9) Vineyard Sound

This site is off the southeastern coast of Massachusetts. Existing depths of over 100 feet approximately are located 2-1/2 miles west of Gay Head, which is relatively flat and suitable for a storage area. Vineyard Sound is part of the State's North Shore Ocean Sanctuary and building structures on the sea-bed is prohibited. Shifting shoals may make development of this site extremely difficult.

(10) Narragansett Bay

This site is east of Conanicut Island at the mouth of the East Passage of Narragansett Bay. Depths greater than 100 feet exist at the site; however, the access channel leading to the open sea has a limiting depth of 83 feet. Conanicut Island is relatively flat and suitable for a storage area. Its waters are relatively protected and waves less than four feet high are anticipated 90 percent of the time. The area is used heavily by vessels calling at the Port of Providence and by the U. S. Navy.

SOUTHEASTERN NEW YORK, NORTHERN NEW JERSEY, AND LONG ISLAND

This sub-region (Figure 25) can be divided into two distinct areas, Long Island and its vicinity, and the port of New York, including the Raritan Bay-Sandy Hook area. Five sites have been considered for potential deep draft facilities, two off Long Island and three in the New York Harbor area.

Long Island is approximately 20 miles wide and 100 miles long with an exposed Atlantic-oriented southern flank and a semi-protected sound-oriented northern flank. The western half of the north shore is very irregular, with numerous deep bays and promontories. Eastward, the coast is regular with few indentations. North shore beaches are generally narrow and rocky. The 108-mile south shore consists of long 1/4 to 1/2 mile wide, sandy barrier beaches facing a strong Atlantic surf. Behind these beaches are long, shallow, quiet backbays. Long Island Sound's many ports include Port Jefferson and New Haven Harbor, third busiest port in New England. As shown in Table 19, many of them receive large volumes of petroleum products.

The coastal zone is used for commercial and sport fishing and for outdoor recreation. In 1968, the dockside value of the commercial catch was $14.3 million, three-quarters of which was in shellfish. The long oceanfront beaches and coastal waters are ideal for recreation. Water quality in the Sound can be considered average.

(11) Montauk Point, Long Island

At Montauk natural depths of 60 to 90 feet exist three quarters of a mile offshore, with a 65-foot channel leading from 120 foot deep Sound waters to the potential site. The terrain ashore is relatively flat and suitable for a storage area.

(12) Long Island Sound

The potential site in Long Island Sound off Port Jefferson has natural depths greater than 120 feet; however, many shoals would have to be removed to permit access to 120 foot depths in the Atlantic. A berthing facility is under construction in 68 feet of water at Northville, 15 miles east of Port Jefferson. It could be expanded to handle VLCC's; however, a substantial investment would be required if it were to service the crude oil needs of the region.

The Port of New York includes New York City and adjacent parts of New Jersey. It is the largest port complex in the United States, handling three times the tonnage of all West Coast ports combined. Within the study area it handles twice the tonnage of the Delaware River ports, the next largest port system. A 45-foot deep, 2,000-foot wide channel extends from the ocean through Lower New York Bay and into the Upper Bay and Hudson River. Land use in New York Harbor and along the Lower Hudson River is predominantly commercial and industrial, while the New York City ocean front is primarily residential and recreational. The Raritan—Sandy Hook Bay area has high bluffs and marshlands fronted by narrow beaches intersected by numerous tidal creeks. Lands on the north side of the Bay are highly industrialized with existing petroleum facilities.

Water quality in the Bay, influenced by the combined flows of the Raritan, Passaic, and Hackensack Rivers, is generally poor because of wastes discharged into the rivers. Industrial discharges contribute approximately 75 percent of the pollution; attributable to textile, paper, chemical, and petroleum industries. The remainder comes from navigation and runoff of agricultural fertilizer and animal wastes. The Raritan River's high erosion and sedimentation rate, combined with sewage sludge, rocks, mud, dredge spoil, and dumping of industrial wastes at sea in the New York bight area, compounds the problem.

Perth Amboy and southeast Staten Island are heavily industrialized, and additional development might not affect other areas in this sub-region. The newly-authorized Gateway National Recreation Area encompasses many coastal sections of this area. Bay beaches, however, are not of the quality of those along the New Jersey shore. Wetlands are relatively small and due to pollution are not important nursery grounds.

The Atlantic side of Sandy Hook is heavily developed for recreational use. Public and private beaches there exceed 3,000 acres, and are capable of accommodating 4.5 million people daily. They serve the New York metropolitan area, and represent one of New Jersey's biggest industries, recreation.

The major facilities of the Port of New York are, for descriptive purposes, categorized by waterways.

The East River connects Long Island Sound with Upper New York Bay. It is a 16-mile long channel, 35-feet deep, and 1,000 feet wide, passing through the heart of New York City with spur channels designed for barge traffic going into adjacent creeks and rivers, i.e., the Harlem River. For the 2.5 mile section from Upper New York Bay to the Brooklyn Naval Yard on the East River, the channel has a depth of 40 feet. Many rapid transit tunnels and aqueducts cross the East River, limiting channel depth to about 40 feet below mean low water. Pipelines and cables cross the river on or near the existing river bottom and bridges provide at least 700 feet of horizontal and 127 feet of vertical clearance.

Upper New York Bay including Buttermilk, Red Hook and Bay Ridge Channels, is generally deeper than 40 feet because of extensive channel and anchorage development. Gowanus Creek, an offshoot of the Bay Ridge Channels decreases in depth in stages from 30 to 9 feet. The subregion includes the Hudson River below the George Washington Bridge with a 40-foot deep channel for the full width of the river, from Upper New York Bay to 59th Street. A 2000 foot wide section of this project has been deepened to 45-48 feet. A number of rapid transit tunnels and aqueducts cross the river, but none is shallower than 52 feet below mean low water.

There are approximately 200 wharves and piers along the 31 miles of Kill Van Kull and Arthur Kill that constitute the New York and New Jersey channels. About 90 percent of them are specifically designed for the receipt and/or shipment of petroleum products. Traffic entering the New York/New Jersey channels is encouraged to enter Kill Van Kull and exit via Arthur Kill. This procedure has prevented serious congestion. Traffic is dominated by tankers whose dimensions are such that the 35-foot deep channel can scarcely accommodate them. Approximately 1400 vessels with drafts greater than 30 feet use the channel annually. In 1955, no vessels needed the tide to negotiate the channel. By 1965 almost 20 percent needed the tide to aid their passage and by 1968 almost 33 percent required the tide. Vessels entering Newark Bay generally use Kill Van Kull as an entrance channel.

Cargo entering Newark Bay are mostly containerized general cargo. Such cargo is more sensitive to improvement in shore transshipment facilities than to additional waterway improvement. A railroad bridge restricts horizontal clearance to 200 feet at the Bay entrance.

Facilities along the navigable portions of the Hackensack and Passaic Rivers at the upper end of New York Bay are equipped to handle sand, gravel, or petroleum. Many of them are devoted to marine salvage. Bridges cross both rivers, limiting horizontal clearance to less than 100 feet. Fuels dominate commerce along the Raritan River because of petroleum-oriented facilities near its mouth, and inland electric power plants. The New York-New Jersey area is a major North Atlantic refining center, a logical and commercially attractive location for the development of VLCC handling facilities.

Two sites in the New York Harbor area are suitable for development as deep port facilities.

(13) Raritan Bay
Existing access channels have a controlling depth of 35 feet, and would require extensive dredging to handle VLCC's.

(14) Atlantic Ocean
This site is in the naturally deep channel in the Atlantic Ocean with a pipeline coming ashore near Long Branch, New Jersey. It appears suitable for development of a monobuoy system. Water depths at this site exceed 100 feet and waves are anticipated to be less than four feet high, 55 percent of the time and less than eight feet, 90 percent of the time.

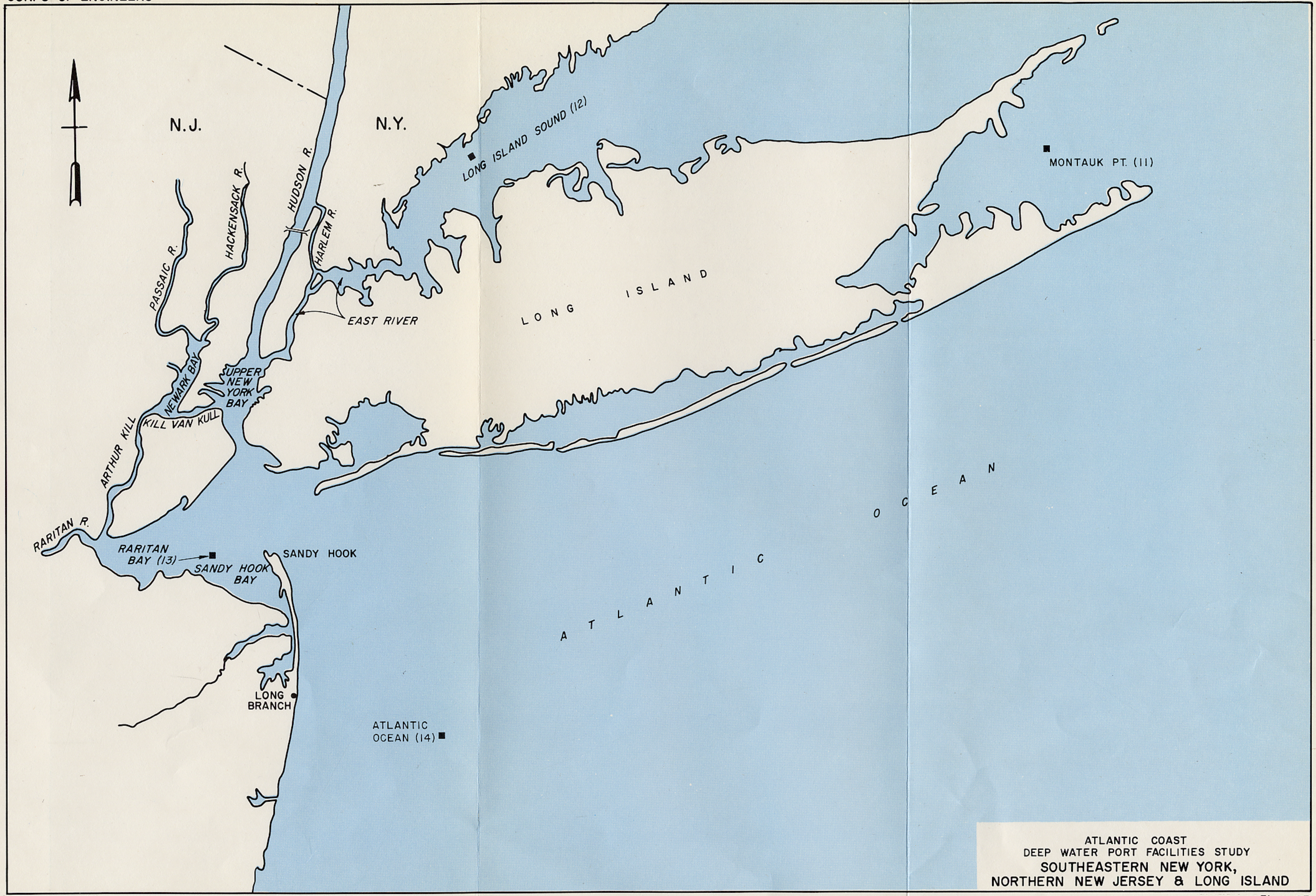

N.J.
N.Y.
HUDSON R.
HACKENSACK R.
PASSAIC R.
HARLEM R.
EAST RIVER
LONG ISLAND SOUND (12)
LONG ISLAND
MONTAUK PT. (11)
UPPER NEW YORK BAY
NEWARK BAY
KILL VAN KULL
ARTHUR KILL
RARITAN R.
RARITAN BAY (13)
SANDY HOOK BAY
SANDY HOOK
LONG BRANCH
ATLANTIC OCEAN (14)
ATLANTIC OCEAN
ATLANTIC COAST
DEEP WATER PORT FACILITIES STUDY
SOUTHEASTERN NEW YORK,
NORTHERN NEW JERSEY & LONG ISLAND

Figure 25

DELAWARE RIVER AND BAY AREA

The coastline in this sub-region (Figure 26) consists of the shores of Delaware Bay and the Delaware River to Trenton, as well as portions of the Atlantic Coast in New Jersey and Delaware. Above Penns Grove on the Delaware River, the waterfront is largely industrial and commercial on both banks. The 85 miles of shoreline from Penns Grove to Cape May on the New Jersey side of Delaware Bay consist of 50 miles of wetlands and 35 miles of narrow, sandy beach and marshland. The 82 miles of Delaware shoreline from Wilmington to Cape Henlopen are almost entirely marsh in the north and narrow, sandy beach fronting marshes in the south. Most of the shoreline has been conserved as wetland. There is little bathing in the bay and shoreline fishing is generally poor. However, bay fishing from boats has improved in recent years and is now considered to be good.

Marine transportation is important to the sub-region. All major Delaware River ports are located above the head of Delaware Bay, between Wilmington, Delaware and Trenton, New Jersey. These ports depend upon navigation for the movement of iron ore, petroleum, other bulk commodities and general cargo. In 1971, iron ore, crude petroleum and residual fuel oil accounted for more than half the tonnage moved by water at the Delaware River Ports. Collectively, in 1971, the Delaware River Ports handled a total volume of almost 124 million short tons of cargo, a tonnage second only to that of the Port of New York.

Most land around Delaware Bay is wetland—tidal flats, salt marsh and salt meadow—often extending inland for several miles. Much of this area has been acquired by State or Federal conservation agencies or by private conservation groups. The Bombay Hook National Wildlife Refuge contains 12,000 acres of prime wetland habitat for migrating waterfowl, and Prime Hook National Wildlife Refuge will contain 5,000 more acres when land acquisition is completed.

The 90 mile long, approximately 800 foot wide, 40 foot deep waterway to Philadelphia provides access to 14 principal port areas, including a portion of the Ports of Philadelphia. About one half of the commerce reported along this stretch of river is delivered to Philadelphia. Major facilities in the reach below Philadelphia serve crude petroleum, petroleum products, chemicals and ship repair yards.

The Schuylkill River empties into the Delaware at Philadelphia. It has been extensively developed throughout its last six miles for commercial navigation. The present Federal project has a depth of 33 feet.

There are 10 ports with 21 piers and wharves along the 30 miles of the Delaware from Philadelphia to Trenton. Three wharves with depths of 42 feet, used for handling iron ore, iron products and fuel oil, abut the main 40 foot channel. Two wharves with adjacent depths of about 27 feet are designed for petroleum and coal handling and are supported by petroleum and coal storage. The remaining facilities whose adjacent depths are less than 21 feet, are generally used for handling petroleum products and are supported by petroleum storage. If the present 300 to 400 foot channel widths are maintained, traffic control may have to be initiated, as the channel is too narrow for two-way traffic. Bridges over the channel below Trenton restrict horizontal clearance to 240 feet. A bridge at the channel terminus at Trenton restricts horizontal clearance to only 60 feet and vertical clearance to 20 feet.

Delaware Bay is the entrance to the largest refining complex on the North Atlantic coast. Seventy percent of the refining capacity of the North Atlantic Region is centered here. Because of its proximity to refineries, Delaware Bay is a desirable site for a VLCC port. It, in fact, partially serves in that role now, with tankers larger than 100,000 DWT lightering into barges within the Bay's waters. A natural channel ranging from 120 to 62 feet deep extends from the Atlantic along the Delaware side of the Bay. Two sites along this channel could be developed as deep draft terminals. In addition, deep water at a site along the New Jersey side of the Bay may be suitable for port development.

(15) Big Stone Beach, Delaware Bay

This site within the Bay has natural depths of 65 to 70 feet. The Delaware shoreline is relatively flat and suitable for a storage area. Sea and visibility conditions are similar to those of the Atlantic Ocean sites off the mouth of Delaware Bay.

(16) Towne Bank, Delaware Bay

This site is four miles west of Towne Bank, and has existing depths of 40 feet with waves less than four feet anticipated 95 percent of the time. Port closure because of poor visibility is anticipated less than 4 percent of the time. Surrounding land is relatively flat and undeveloped, making it suitable for a storage area.

Like the northern New Jersey beaches, the southern New Jersey and Delaware beaches are heavily developed for recreational use. In fact, the beaches in Cape May County could be considered among the best in the country. Two sites were considered in the Atlantic Ocean in this area.

(17-18) Atlantic Ocean

These sites are located off the mouth of Delaware Bay, with depths of 100 feet at locations 8 and 25 miles offshore (sites 17 and 18, respectively). Waves less than four feet high are anticipated 50 percent of the time; less than 8 feet, 90 percent of the time. Port closure due to poor visibility is anticipated less than 5 percent of the time.

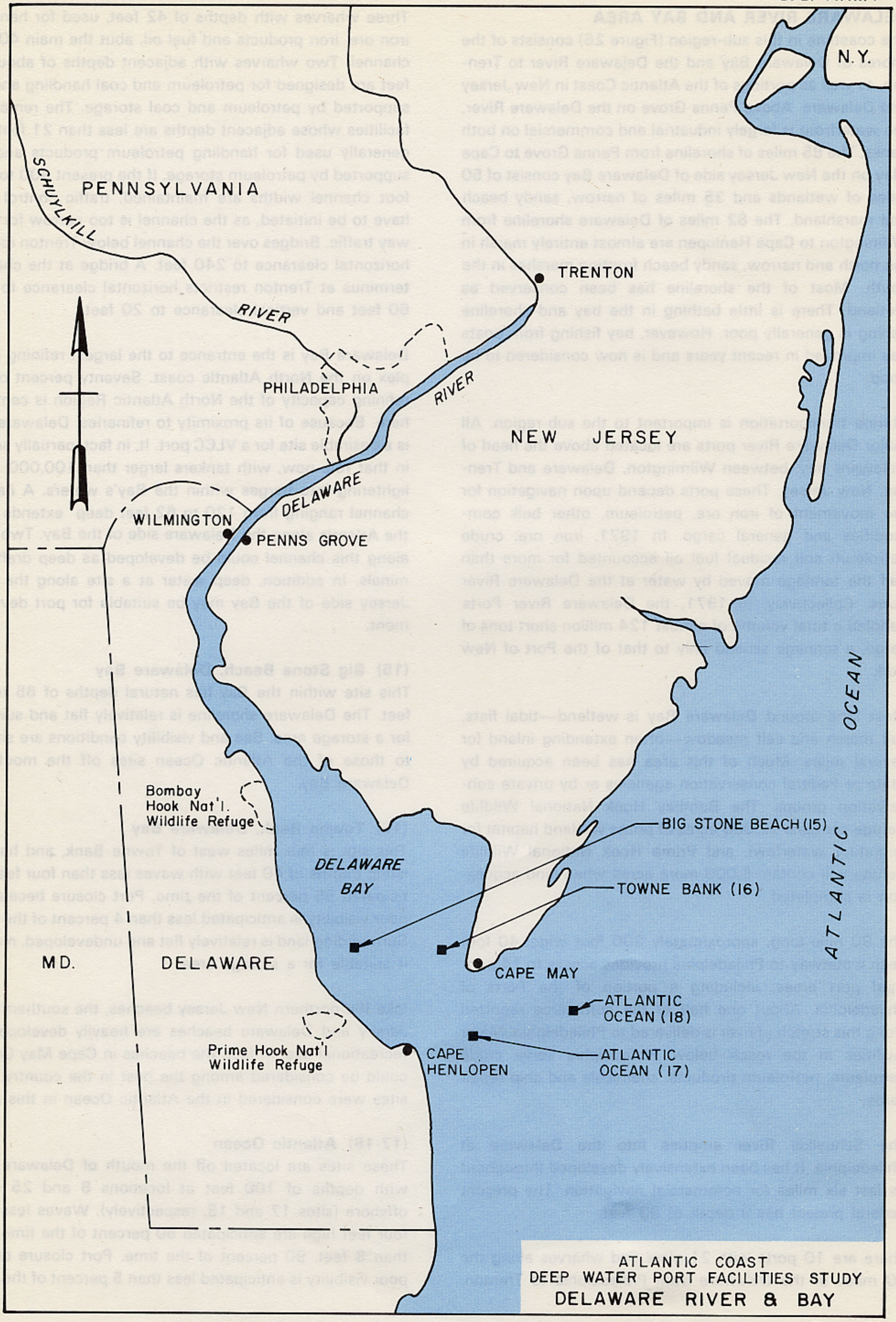

N.Y.
PENNSYLVANIA
SCHUYLKILL
RIVER
TRENTON
PHILADELPHIA
RIVER
NEW JERSEY
DELAWARE
WILMINGTON
PENNS GROVE
ATLANTIC
OCEAN
Bombay
Hook Nat'l.
Wildlife Refuge
BIG STONE BEACH (15)
DELAWARE
BAY
TOWNE BANK (16)
MD.
DELAWARE
CAPE MAY
ATLANTIC
OCEAN (18)
Prime Hook Nat'l
Wildlife Refuge
CAPE
HENLOPEN
ATLANTIC
OCEAN (17)
ATLANTIC COAST
DEEP WATER PORT FACILITIES STUDY
DELAWARE RIVER & BAY

Figure 26

Eight miles east of and adjacent to the deep channel is a large area with 40 foot depths which could be developed as an island transshipment port.

CHESAPEAKE BAY

Chesapeake Bay (Figure 27) is the largest and the most important estuary on the Atlantic coast. It receives water from a basin draining 65,476 square miles and has a shoreline 2,800 miles long, two-thirds of which is located in Maryland. The Bay itself is about 200 miles long, varies in width from about 4 to 35 miles and, with its tributaries, has a water surface area of about 4,400 square miles. Its average depth to head of the tide is about 21 feet; its greatest depth is 174 feet off Kent Island. A Federally-maintained 42-foot deep channel extends from the vicinity of Hayston Road through the Bay, north to Baltimore Harbor. This channel is presently authorized for a depth of 50 feet.

About 280 of the 1,900 miles of Maryland shoreline are on the Bay proper, with the remainder lying along its tributaries. The eastern shoreline consists almost entirely of wetlands, with banks, bluffs and more wetlands on the western shore. Less than 1 percent (15 miles) of the shoreline can be considered as beach.

The approximately 900 miles of Virginia shoreline include a few small scattered beaches, primarily near Hampton Roads and on the southernmost 25 miles of the Delmarva Peninsula. Most of the shoreline is brackish and marshy.

On the western side of Chesapeake Bay, population density is greater along the coast than in the hinterlands. The demography of the coastal zone itself is uneven. The western shore accommodates two of the largest urban centers in the nation; Baltimore/Washington and Hampton Roads. In marked contrast, the eastern shore is expected to continue to remain relatively unpopulated.

In commercial fisheries, Virginia and Maryland rank ninth and tenth among the nation's 24 oceanfront states, with an annual catch of $18 and $17 million, respectively. Almost all of this catch comes from Chesapeake Bay, not from the Atlantic Ocean. In fact, the Bay provides 1/4 of the entire North Atlantic catch. In this region, only Massachusetts (fourth) and Maine (eighth) rank above Virginia and Maryland.

The Port of Baltimore, at the head of the Bay, serves the Bethlehem Steel Mill at Sparrows Point with iron ore; the heavily traveled Curtis Bay region with iron ore imports and coal exports and many other heavy industries surrounding the harbor waters.

The York River estuary is 35 miles long, with a Federal project providing a 22 foot deep channel 400 feet wide to Yorktown. The head of the estuary is at the confluence of the Pamunkey and Mattaponi Rivers. These rivers have been improved for shallow-draft navigation. The York River is the smallest of the three refining centers in the North Atlantic Region. American Oil Company has one 50,000 barrel/day refinery there.

The Norfolk area includes that portion of Hampton Roads lying to the south of the James Estuary. Hampton Roads is served by Federally maintained 45-foot deep channels which lead to the ports of Norfolk, Newport News, and Portsmouth, Virginia. The port includes portions of the estuary and several rivers which pass through the town. U. S. Navy facilities are adjacent to the 45-foot deep access channel from Chesapeake Bay. The principal coal and grain facilities of Norfolk are located just south of the Elizabeth River. These facilities have adjacent channels ranging from 36 to 47 feet deep and are supported by coal, grain, and petroleum storage. Craney Island, directly across the 45-foot deep access channel, has facilities for handling containerized cargo. Adjacent to and north of Craney Island, a land fill disposal area for dredge spoil was completed in 1958. It will be filled to capacity by 1979. Improved channels extend several miles up branches of the Elizabeth River. A 40-foot channel extends from the entrance channel to the Norfolk Naval Shipyard. A further channel extension 35-feet deep, ends at a turning basin which is the northern terminus of the Atlantic Intra-coastal Waterway. Other branches of the Elizabeth River serve general cargo handling facilities, shipyards, yachting clubs, recreational boating and commercial fishing fleets, with authorized channels ranging from 18 to 35 feet deep.

A five mile long, 45 foot deep, 800 foot wide Federally-maintained channel extends from Hampton Roads to deep water in the James River. Newport News, along the northern shore of the James River, has coal handling and general cargo facilities and the yards of the Newport News Shipbuilding and Drydock Company. These installations are served by a road and railroad network.

From Newport News, an improved Federal channel extends 90 miles through the James Estuary and River to a turning basin just south of Richmond, with a minimum depth of 25 feet and a minimum width of 200 feet. The authorized project calls for a 35 foot deep channel, 300 feet wide to Richmond Terminal and an 18 foot deep 200 foot wide channel in Richmond. Creeks and rivers for fishing and recreational craft are scattered along the river and have depths between 4 and 8 feet. Dams across the rivers and creeks often prevent further navigation of already shallow streams. Most commercial facilities are found just south of Richmond.

Only one potential deep water site was considered in this region.

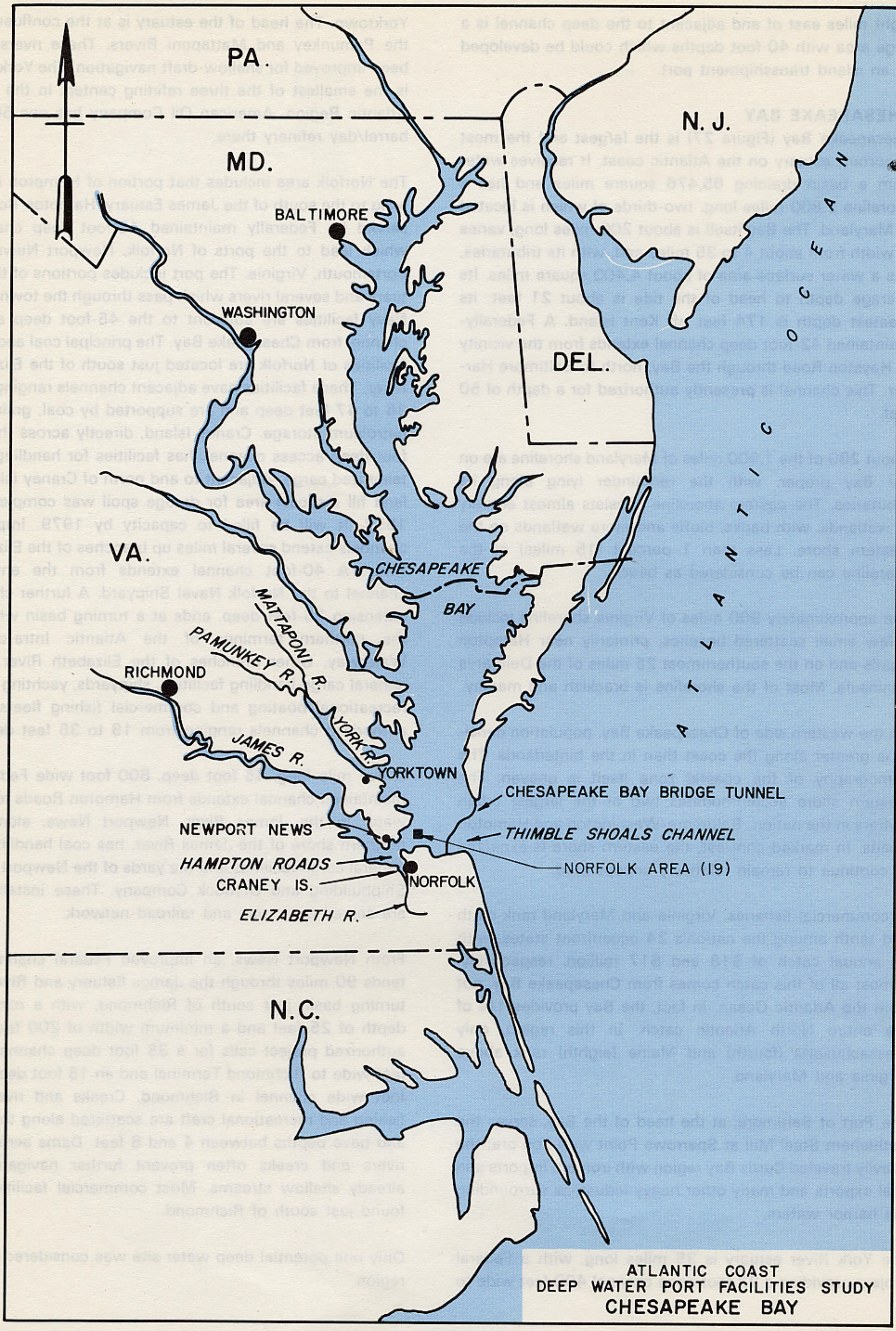

PA.
N.J.
MD.
BALTIMORE
WASHINGTON
DEL.
ATLANTIC OCEAN
VA.
CHESAPEAKE
BAY
MATTAPONI R.
PAMUNKEY R.
RICHMOND
YORK R.
JAMES R.
YORKTOWN
CHESAPEAKE BAY BRIDGE TUNNEL
NEWPORT NEWS
THIMBLE SHOALS CHANNEL
HAMPTON ROADS
NORFOLK AREA (19)
CRANEY IS.
NORFOLK
ELIZABETH R.
N.C.
ATLANTIC COAST
DEEP WATER PORT FACILITIES STUDY
CHESAPEAKE BAY

Figure 27

(19) Norfolk Area

The site selected is located alongside Thimble Shoals Channel approximately three miles northeast of Norfolk, in a relatively well protected area with waves less than four feet high anticipated ninety percent of the time. The major drawbacks of the site are the extensive dredging that would be required and the need to relocate the Chesapeake Bay Bridge Tunnel. Sites oceanward of the Tunnel would require construction of a breakwater and extensive dredging. In addition, this area is extensively developed and suitable storage areas could not be located. Therefore, an alternative at that location was not examined.

GENERAL

In this chapter, criteria established in Chapter IV are applied to the specific locations listed in Chapter V to determine which of the alternative proposals under consideration are the most viable. By this means, the possible courses of action are reduced to manageable proportions as a first step in arriving at the most efficient, economic and logical solutions.

Several of the North Atlantic sites previously described are more attractive than others by reason of location. Close proximity to refineries, steel plants and coal docks is most important. Some sites have been chosen because of stated preferences on the part of industry. Others have been included to give a broad and varied geographic representation of the North Atlantic Region. The sites selected were first analyzed to determine their economic feasibility in the year 1980. Those alternatives which appeared feasible in 1980 were then analyzed to determine their economic feasibility over a 50-year project life.

PRELIMINARY ECONOMIC ANALYSIS

Based on the assumptions shown on Table 20 for 1980 nineteen sites were considered in the preliminary economic analysis [11]. Each was evaluated to determine areas where deep water facilities would be justified in 1980. Fifty-three alternatives at the 19 sites which appeared to merit examination were analyzed. Those alternatives are listed on Table 21 together with a summary of their costs, benefits and net benefits. The "net benefit" column indicates the effect that an alternative would have on transportation costs; the larger the net benefits, the greater will be the reduction in transportation costs. Of those alternatives, 38 were for crude oil unloading facilities at depths of 80 and 100 feet; 13 were for coal handling facilities at depths of 72 feet; one was for an iron ore facility at a depth of 72 feet; and one was a combination liquid and dry bulk handling facility at a depth of 80 feet. First cost estimates for the various deep water port alternatives were based on data obtained from the Robert R. Nathan Associates Report, "U.S. Deepwater Port Study" escalated to July 1972 price levels [2]. First costs were converted to annual costs by using an interest rate of 5.5 percent and repayment periods based on the assumed service life of each component (i.e., 50 years for berths, 25 years for pipelines and 15 years for pumps). To these capital costs were added annual operation and maintenance costs. Transportation costs for each alternative were based on projected 1980 throughput tonnages and an estimated average vessel size serving the particular trade route involved in each case. In making analyses for coal and iron ore, only those volumes of the commodity shipped over long distances and subject to movement in large vessels were considered.

In the absence of existing deep port facilities in the North Atlantic Region (base case), it was assumed that vessels carrying crude oil would multiple-port from Nova Scotia. It was also assumed that coal and iron ore vessels would use existing channels to Baltimore, Hampton Roads and the Delaware River. Annual benefits in each case are the savings in vessel transportation costs resulting from the development of a particular alternative over assumed base conditions. The net benefit is the difference between annual benefits and annual costs. Table 22 shows a typical cost breakdown of a deep draft facility developed in the preliminary analysis and a summary of the benefit calculations for that facility.

Of all the sites studied, only those in or off Raritan and Delaware (13 to 16 and 18) Bays appear economically feasible for a crude oil facility to service existing refinery areas. The annual cost of facilities in Maine is lower than at those sites. However, the additional transshipping costs involved more than offset this advantage because of refinery distribution in the North Atlantic, where 96 percent of the region's capacity is located in the vicinity of Raritan and Delaware Bays.

In analyzing the dry bulk alternatives, average size vessels moving coal and iron ore were 250,000 DWT and 172,000 DWT, respectively. Although some dry bulk facilities appear feasible, there are now only a few ore/bulk/oil ships or bulk carriers in the existing fleet, under construction or on order over 175,000 DWT. As a result the benefits attributed to the deep water facilities are overstated to the extent that vessels of the assumed capacities may not be employed in these trades. However, to determine the economic desirability of those facilities they must be compared to channel deepening.

TABLE 20
SUMMARY OF ASSUMPTIONS FOR PRELIMINARY ANALYSIS

CRUDE OIL			
Terminal Depth		80 and 100 Feet	
Avg. Ship Size	– Middle East	255,000 D.W.T. (80 Feet)	268,000 D.W.T. (100 feet)
	– Africa	177,000 D.W.T. (80 Feet)	177,000 D.W.T. (100 feet)
Transshipment Barge	– New York		30,000 D.W.T.
	– Philadelphia		40,000 D.W.T.
	– Norfolk		40,000 D.W.T.
Throughput (Year 1980)			
Middle East	– New York		14,200,000 Long Tons
	– Delaware River		38,300,000 Long Tons
	– Norfolk		2,200,000 Long Tons
Africa	– New York		11,200,000 Long Tons
	– Delaware River		30,200,000 Long Tons
	– Norfolk		1,700,000 Long Tons
TOTAL			97,800,000 Long Tons
Base Case – Avg. Ship Size	–Middle East		235,000 D.W.T.
	–Africa		177,000 D.W.T.
COAL			
Terminal Depth			72 Feet
Avg. Ship Size	– Japan		250,000 D.W.T.
	– Europe		250,000 D.W.T.
Transshipment Barge			40,000 D.W.T.
Throughput (Year 1980)			
	– Japan		11,500,000 Long Tons
	– Europe		6,500,000 Long Tons
TOTAL			18,000,000 Long Tons
Base Case – Avg. Ship Size	–Japan*		117,000 D.W.T.
	–Europe		47,000 D.W.T.
IRON ORE			
Terminal Depth			72 Feet
Avg. Ship Size (Delaware River & Baltimore)			172,000 D.W.T.
Transshipment Barge	– Delaware River		40,000 D.W.T.
	– Baltimore		30,000 D.W.T.
Throughput (Year 1980)			
Brazil	– Delaware River		1,600,000 Long Tons
	– Baltimore		400,000 Long Tons
Liberia	– Delaware River		100,000 Long Tons
	– Baltimore		2,200,000 Long Tons
TOTAL			4,300,000 Long Tons
Base Case – Avg. Ship Size	–Delaware River		35,000 D.W.T.
	–Baltimore		60,000 D.W.T.

*Vessels are light-loaded leaving Hampton Roads and are topped off in South America with iron ore before proceeding to Japan.

TABLE 21
SUMMARY OF PRELIMINARY ECONOMIC ANALYSIS FOR 1980
($1,000,000's – JULY 1972 PRICE LEVELS)

(4) ALTERNATIVE		TYPE OF REGIONAL FACILITY [5]	PROJECT DEPTH – 80 FEET				PROJECT DEPTH – 100 FEET			
No.	Location		FIRST COST	ANNUAL COST	ANNUAL BENEFIT	NET BENEFIT	FIRST COST	ANNUAL COST	ANNUAL BENEFIT	NET BENEFIT
1.	Eastport	Oil [1]	268.0	28.8	-53.0	-81.8	485.5	46.0	-53.0	-99.0
2.	Machias Bay	Oil [1]	224.4	25.1	-49.0	-74.1	270.8	28.5	-47.0	-75.5
		Coal [2]	306.0	54.0	32.4	-21.6				
3.	Pleasant Bay	Oil [1]	228.0	26.0	-43.0	-69.0	273.0	29.5	-41.0	-70.5
		Coal [1]	141.9	27.5	33.2	5.7				
4.	Frenchman Bay	Oil [1]	218.5	24.5	-43.0	-67.7	263.0	27.6	-41.0	-68.6
		Coal [1]	141.9	27.5	33.2	5.7				
5.	Blue Hill Bay	Oil [1]	218.5	24.7	-43.0	-67.7	263.0	27.6	-41.0	-68.6
		Coal [1]	142.0	27.5	33.2	5.7				
6.	West Penobscot Bay	Oil [1]	224.4	25.1	-32.0	-57.1	270.8	28.5	-30.0	-58.5
		Coal [1]	141.9	27.5	35.2	7.7				
7.	Casco Bay	Oil [1]	220.2	24.8	-31.0	-55.8	266.5	28.2	-29.0	-57.2
8.	Massachusetts Bay	Oil [1]	249.9	27.8	-16.0	-43.8	299.6	31.4	-14.0	-45.4
9.	Vineyard Sound	Oil [1]	224.4	25.1	-2.0	-27.1	270.8	28.5	0.0	-28.5
		Coal [1]	141.9	27.5	39.2	11.7				
10.	Narragansett Bay	Oil [1]	236.8	26.2	-2.0	-28.2	431.9	42.0	0.0	-42.0
		Coal [1]	141.9	27.5	39.2	11.7				
11.	Montauk Point	Oil [1]	242.8	26.7	15.0	-11.7	396.7	38.8	17.0	-21.8
		Coal [1]	142.5	27.6	41.6	14.0				
12.	Long Island Sound	Oil [1]	242.5	26.7	10.0	-16.7	387.4	38.3	12.0	-26.3
13.	Raritan Bay	Oil [1] (Pipeline to Refineries)	756.8	69.5	73.0	3.5	1,226.9	107.3	75.0	-32.3
		Coal [2]	283.2	52.6	43.2	-9.4				
14.	Atlantic Ocean	Oil [3] (Pipeline to Refineries)	452.8	51.0	74.0	23.0	463.0	52.8	77.0	24.2
15.	Delaware Bay at Big Stone Beach	Oil [1] (Pipeline to Refineries)	553.8	52.2	72.0	19.8	747.5	67.5	74.0	6.5
		Coal [2]	208.3	38.2	45.2	7.0				
		Iron Ore [2]	135.0	21.2	12.3	-8.9				
		Combination [2] (Oil Pipeline to Refineries)	803.8	84.6	129.5	44.9				
		Oil		(51.0)	(72.0)	(21.0)				
		Coal		(27.1)	(45.2)	(18.1)				
		Iron Ore		(6.5)	(12.3)	(5.8)				
16.	Delaware Bay at Towne Bank	Oil [1] (Pipeline to Refineries)	690.1	70.6	72.0	1.4	879.9	85.6	74.0	-11.6
		Coal [2]	188.1	34.9	45.2	10.3				
17.	Atlantic Ocean	Oil [2] (Pipeline to Refineries)	1,006.0	82.4	73.0	-9.4	1,087.8	88.6	76.0	-12.6
		Coal [2]	445.8	60.4	45.5	-14.9				
18.	Atlantic Ocean	Oil [3] (Pipeline to Refineries)	621.5	73.9	73.0	-0.9	626.5	75.5	76.0	0.5
19.	Norfolk	Oil [1]	727.2**	61.1	16.0	-45.1	919.7	76.4	18.0	-58.4
		Coal [2]	469.3**	55.3	50.4	-4.9				

1 – Sea Island (Storage Onshore)
2 – Artficial Island (Storage on Island)
3 – Monobuoy
4 – Refers to site location given in Chapter V
5 – Unless otherwise noted, all transshipment is by Barge
** Include Cost of Relocating Chesapeake Bay Bridge Tunnel

TABLE 22
ESTIMATE OF COSTS AND BENEFITS FOR 1980
(15) BIG STONE BEACH, DELAWARE BAY
REGIONAL SEA ISLAND FACILITY, 80 FOOT PROJECT DEPTH
TRANSSHIPMENT TO REFINERIES BY PIPELINE
($1,000'S – JULY 1972 PRICE LEVELS)

Item	Service Life (Years)	First Cost	Annual Cost	Annual Maintenance Cost	Annual Operating Cost
Dredging	50	79,960	4,545	1,924	––
VLCC Berths (4)	50	32,566	1,923	490	––
Storage Tanks	25	104,000	7,761	1,562	––
Miscellaneous Elect. & Mechanical	25	26,200	1,953	262	––
Environmental Safeguards	25	20,000	1,491	300	––
Pipeline (storage) 48" Ø	25	21,080	1,572	42	––
Pumps (storage) 6,100 HP.	15	1,340	134	34	––
Transshipment Berth (1)	50	1,500	89	23	––
Pipeline (feeder) 48" Ø	25	4,225	315	8	––
Pumps (feeder) 3,860 HP.	15	848	84	21	––
Pipeline (refineries) 56" Ø	25	200,000	14,910	400	––
Pumps (refineries) 18,900 HP.	15	4,148	413	104	––
Engineering & Design (7%)	50	34,500	2,038	––	––
Supervision & Administration (5%)	50	26,370	1,557	––	––
Pumping Energy	––	––	––	––	2,208
Labor & Administration	––	––	––	––	6,000

Total First Cost of Facility - $553,800

Total Annual Cost of Facility - $52,200

Calculation of Annual Benefits

Annual Transportation Cost (Base Case) - $502,000

Annual Transportation Cost (Alternative) - -$430,000

Annual Benefits - *$72,000*

Calculation of Net Benefit

Annual Benefits	72,000
Annual Facility Cost	–52,200
Net Benefit	19,800

There are two major North Atlantic ports, Baltimore and Philadelphia, receiving iron ore from five principal countries of supply; Canada, Venezuela, Peru, Brazil, and Liberia.[22] Because the short distances from Canada and Venezuela make the use of very large bulk carriers uneconomical, and trade from Peru would probably use the Panama Canal (which is limited to drafts of less than 41 feet), only iron ore imported from Brazil and Liberia is likely to move through a deep water port facility. For purposes of analyzing the channel to Baltimore, costs given in the Baltimore Harbor and Channels Report (June 1969)[23] were updated to July 1972 price levels. Benefits of deepening the channels to 50 feet were recalculated using the fleet size distributions given in that report. Tables 23 and 24 compare deepening the channel to Baltimore and a transshipment terminal at Big Stone Beach (this appears to be the most economic location for a dry bulk terminal) to serve both Baltimore and the Delaware River trades, in terms of annual costs and benefits in 1980. The tables show that the most economic means of accommodating future bulk iron ore carriers is to deepen the channel to Baltimore, even when compared to the overstated economic justification given for the transshipment terminal.

Coal is exported from the North Atlantic to Japan and Europe through the existing 45-foot channel at Hampton Roads. It is estimated that it would cost approximately $63,535,000 to deepen that channel to 55 feet. The average annual cost of dredging including maintenance is estimated to be $5,340,000. Table 25 compares the cost of deepening the Hampton Roads Channel with that of using a transshipment terminal at Big Stone Beach in Delaware Bay. It is significant that in the transshipment alternative only the coal destined for Japan realizes any transportation savings. Coal exported to Europe costs more when shipped through a deep water facility than through the present 45-foot channel. This, together with the projected decline of coal exports to Japan, makes deepening the existing channel to Hampton Roads the most attractive alternative.

An additional alternative would be development of a combination transshipment terminal. Table 21 shows the economic feasibility of such an alternative at Big Stone Beach. Comparison of this alternative with deepening Hampton Roads and Baltimore channels (Table 26) indicates that deepening is still more economically desirable, although some savings result from using common facilities at a combination terminal.

This analysis does not consider rehandling petroleum products such as residual fuel oil. The large volumes of residual fuel oil imported to meet the region's needs may eventually require improved means for handling petroleum products and other bulk commodities such as liquefied natural gas (LNG). Now, however, the desirability of a products terminal in the North Atlantic Region is of secondary importance when compared to the central issue—where and how large carrier handling facilities for the other bulk cargoes may be developed.

The above analysis makes it possible to rank alternatives in terms of economic efficiency. Since deepwater facilities are not considered desirable for transshipping iron ore and coal, Table 27 ranks each of the 19 sites initially considered for crude oil terminals.

TABLE 23
SUMMARY OF ECONOMIC ANALYSIS FOR IRON ORE MOVEMENTS IN 1980

Alternative	Trade Route	1980 Tonnage (Millions of Long Tons)	Average Vessel Size (DWT)	Unit Transportation Cost ($/L.T.) Ocean Voyage	Unit Transportation Cost ($/L.T.) Trans-shipping	Deep Water Terminal Transfer Charge* ($/L.T.)	Total Annual Cost (Millions $)	Cost Difference (Base Case minus Transshipment Terminal) (Millions $)
Base Case								
Baltimore 42′ Channel	Liberia-Baltimore	2.2	60,000	5.13	--	--	11.29	--
Delaware River 40′ Channel	Liberia-Delaware River	0.1	35,000	5.84	--	--	0.58	--
	Brazil-Baltimore	0.4	60,000	5.54	--	--	2.22	--
	Brazil-Delaware River	1.6	35,000	6.27	--	--	10.03	--

TABLE 23
SUMMARY OF ECONOMIC ANALYSIS FOR IRON ORE MOVEMENTS IN 1980 (cont.)

Alternative	Trade Route	*1980 Tonnage* (Millions of Long Tons)	*Average* Vessel Size (DWT)	Unit Transportation Cost ($/L.T.)		Deep Water Terminal *Transfer* Charge* ($/L.T.)	Total *Annual* Cost (Millions $)	Cost Difference (Base Case minus *Transshipment* Terminal) (Millions $)
				Ocean Voyage	Trans-shipping			
Transshipment terminal at Big Stone Beach w/72 foot Channel	Liberia-Baltimore	2.2	172,000	2.30	0.39[1]	4.93	16.76	-5.47
	Liberia-Delaware River	0.1	172,000	2.30	0.33[2]	4.93	0.76	-0.18
	Brazil-Baltimore	0.4	172,000	2.48	0.39	4.93	3.12	-0.90
	Brazil-Delaware River	1.6	172,000	2.48	0.33	4.93	12.38	-2.35

* - Annual cost of Deep Water Facility $21,200,000: ∴ $\frac{\$21{,}200{,}000}{4{,}300{,}000 \text{ tons}}$ = $4.93/L.T.

1 - 30,000 D.W.T. Barge
2 - 40,000 D.W.T. Barge

TABLE 24
SUMMARY OF ANNUAL SAVINGS FOR IRON ORE MOVEMENTS IN 1980
($1,000,000'S – JULY 1972 PRICE LEVELS)

ALTERNATIVE	ANNUAL COST	ANNUAL BENEFITS	NET BENEFIT
Transshipment Terminal at Big Stone Beach	21.20	12.3	-8.9
Deepen Baltimore Channel	9.73	13.29*	3.56

* Includes iron ore, coal, and petroleum products benefits

TABLE 25
SUMMARY OF ECONOMIC ANALYSIS FOR COAL MOVEMENTS IN 1980

Alternative	Trade Route	1980 Tonnage (Millions of Long tons)	Average Vessel Size (DWT)	Unit Transportation Cost ($/L.T.)		Deep Water Terminal Transfer Charge ($/L.T.)	Total Annual Cost (Millions $)	Incremental Annual Savings (Millions $)
				Ocean Voyage	Trans-shipping			
Existing Project-45′ Channel	Hampton Rds.-Japan	11.5	117,000[2]	10.25	—	—	117.88	—
	Hampton Rds.-Europe	28.5	47,000	4.48	—	—	127.68	—
Transshipping via Deep Water Facility in Del. Bay-72′ Channel	Hampton Rds.-Japan	11.5	250,000	6.91	0.54	2.12[4]	110.06	7.82
	Hampton Rds.-Europe	6.5[1]	250,000	1.95	0.54	2.12[4]	29.95	-0.83
		22.0	250,000	4.48	—	—	98.56	
Deepen Hampton Roads to 55′ Channel	Hampton Rds.-Japan	11.5	120,000	8.97	—	0.13[3]	104.65	13.23
	Hampton Rds.-Europe	28.5	110,000	2.70	—	0.13[3]	80.66	47.02

1 For purposes of analysis, 6.5 million long tons of the 28.5 million long tons of coal destined for Europe were assumed to move through a deep water facility. Actually, European coal may not utilize a deep water facility since the cost of transshipping and rehandling would make that alternative more costly than using the present 45-foot channel.

2 Includes vessels which are light-loaded leaving Hampton Roads and are topped off in South America with iron ore before proceeding to Japan.

3 Dredging cost $\frac{\$5,340,000}{40,000,000\ \text{LT}} = \$0.13/\text{LT}$

4 Transfer charge $\frac{\$38,200,000}{18,000,000\ \text{LT}} = \$2.12/\text{LT}$

TABLE 26
COMPARISON OF CHANNEL DEEPENING TO COMBINATION DRY BULK TRANSSHIPMENT TERMINAL IN 1980
($1,000,000'S–JULY 1972 PRICE LEVELS)

ALTERNATIVE	NET-BENEFIT
Combination Transshipment Terminal @ Big Stone Beach (Iron & Coal)	23.9
Deepening of channels to Baltimore & Hampton Roads	63.8

TABLE 27
RANKING OF SITES BY ECONOMIC EFFICIENCY IN 1980

No.	Location	Rank
(1)	Eastport	*
(2)	Machias Bay	*
(3)	Pleasant Bay	*
(4)	Frenchman Bay	*
(5)	Blue Hill Bay	*
(6)	West Penobscot Bay	*
(7)	Casco Bay	*
(8)	Massachusetts Bay	*
(9)	Vineyard Sound	*
(10)	Narragansett Bay, East Passage	*
(11)	Montauk Point	*
(12)	Long Island Sound	*
(13)	Raritan Bay	3
(14)	Atlantic Ocean	1
(15)	Delaware Bay at Big Stone Beach	2
(16)	Delaware Bay at Towne Bank	4
(17)	Atlantic Ocean	*
(18)	Atlantic Ocean	5
(19)	Norfolk Area	*

* Not economically feasible

FINAL ANALYSIS OF ECONOMIC EFFICIENCY

As described in the previous section, alternatives located in Raritan Bay (13), the Atlantic Ocean (14), & (18), Delaware Bay (15), (16), appear feasible in 1980 and could be the most efficient solution. These five alternatives together with alternative (17) in the Atlantic Ocean were refined to include an analysis of cost and benefits over the 50-year life of the project to determine which would provide the most efficient and economic method of handling VLCC's. Alternative (17) in the Atlantic Ocean was refined because it may have proved feasible when analyzed over a 50-year period. At each of the six locations, various types of facilities (sea islands, artificial islands; etc.) were considered as a further refinement to the analysis. In addition, facilities to serve the refineries of the region or a local area were also considered. To determine which alternative would provide the most efficient and economic solution, criteria established in Chapter IV were applied to the alternatives shown on plates 1 to 6.

Estimates of First Costs

At the six sites, twenty plans were evaluated at either two or three alternative depths. A detailed construction cost estimate and schedule, including replacement items, was prepared for each plan. Estimates included a twenty percent allowance for contingencies, and were based on estimates made by Nathan[2] escalated to July 1972 price levels. Construction was assumed to be accomplished in three stages to satisfy the 1980, 1990, and 2000 throughput projections, respectively. In addition, costs were included in each alternative to allow for items such as navigation guidance systems, containment devices, and automatic shut-off valves. As a sample of the estimates which were made, the estimated cost of the Atlantic Ocean regional alternative (14), located in 100 feet of water, is shown on Table 28.

Estimates of Annual Costs

The average annual facility cost was determined by converting the construction cost to an annual value using an interest rate of 5.5 percent over a fifty year project life. Costs for operation and maintenance were added and discounted at 5.5 percent interest. Table 29 shows the estimated average annual cost for the Atlantic Ocean regional facility (14).

Estimates of Benefits

Benefits expected to accrue from each alternative are equivalent to the reduction in transportation costs resulting from the development and operation of a port. In the absence of a deep draft facility, shippers were assumed to use a combination of practices including multiple-porting from Nova Scotia and lightering in existing coastal areas. To determine the shipping costs, a ship size distribution estimate, for various port depths from 65 feet to 100 feet covering the period 1975-2025, was made in cooperation with the Federal Maritime Administration. Transportation costs were determined for each alternative practice, using foreign flag vessel costs.[11] The most economical procedure for each vessel was selected and used in calculating the cost of transporting crude oil without a deep draft facility. Those fleet size distributions are shown on Table 30. Without a deep port, the average annual cost of transporting crude oil to the North Atlantic discounted at 5.5 percent, was estimated to be $713,500,000. The cost of transporting crude oil through the proposed deep draft alternatives was estimated in a similar manner. The estimated fleet size distribution for a facility in 100 feet of water is shown on Table 31. The cost of transporting crude oil, exclusive of terminal unloading charges, to the Atlantic

TABLE 28
ESTIMATE OF FIRST AND ULTIMATE INVESTMENT COSTS
ATLANTIC OCEAN REGIONAL FACILITY (14)
(JULY 1972 PRICE LEVELS)

FACILITY COMPONENT	STAGE 1 FIRST COST	ULTIMATE INVESTMENT COST
PLATFORM	$ 10,000,000	$ 10,000,000
SINGLE POINT MOORING	22,740,000	34,110,000
REAL ESTATE	6,000,000	6,000,000
STORAGE FACILITY	125,000,000	250,000,000
PIPE TO STORAGE	47,600,000	71,400,000
PUMP TO STORAGE	7,968,000	11,952,000
FEEDER BERTH	1,500,000	1,500,000
MISC. (MECH. AND ELEC.)	26,200,000	52,400,000
PIPE TO REFINERY	141,000,000	141,000,000
PUMP TO REFINERY	6,277,000	42,655,000
PIPE TO FEEDER BERTH	5,930,000	5,930,000
PUMP TO FEEDER BERTH	1,434,000	1,434,000
ENVIR. AND NAVIG. CONTROLS	20,000,000	30,000,000
SUB-TOTAL	421,649,000	658,381,000
ENGR. AND DESIGN	29,515,000	46,087,000
SUPER. AND ADMINISTRATION	22,558,000	35,223,000
INTEREST DURING CONSTRUCTION	38,500,000	58,418,000
TOTAL COST	$512,220,000	$798,109,000

(COSTS INCLUDE 20% CONTINGENCIES)

TABLE 29
ESTIMATE OF AVERAGE ANNUAL CHARGES
ATLANTIC OCEAN REGIONAL FACILITY (14)
(5-1/2% - 50 YEARS)

Initial Investment	$ 512,220,000
Present Worth of Future Investments	96,727,000
Interest and Amortization	35,965,000
Operation and Maintenance	21,935,000
TOTAL AVERAGE ANNUAL COST	$ 57,900,000

TABLE 30
PROJECTED FLEET SIZE DISTRIBUTION
BASE CASE[1]
(PERCENT OF TONNAGE CARRIED)

VESSEL CLASS	1975						1980					
	NORTH AFRICA			PERSIAN GULF			NORTH AFRICA			PERSIAN GULF		
D.W.T. (000's)	PHILA.	NORFOLK	N.Y.	PHILA.	NORFOLK	N.Y.	PHILA.	NORFOLK	N.Y.	PHILA.	NORFOLK	N.Y.
50-80	5	5	5	-	-	-	-	-	-	-	-	-
80-120	15	45	40	5	5	5	5	40	20	-	-	-
120-160	50	-	-	15	15	15	45	-	-	-	-	-
160-200	-	-	(30)	(25)	(25)	(25)	-	-	(55)	-	-	-
200-250	(30)	(50)	(25)	(50)	(50)	(50)	(50)	(60)	(25)	(25)	(25)	(25)
250-300				(5)	(5)	(5)				(75)	(75)	(75)
300-350												
350-400												
400-450												
450-500												

VESSEL CLASS	1990						2000					
	NORTH AFRICA			PERSIAN GULF			NORTH AFRICA			PERSIAN GULF		
D.W.T. (000's)	PHILA.	NORFOLK	N.Y.	PHILA.	NORFOLK	N.Y.	PHILA.	NORFOLK	N.Y.	PHILA.	NORFOLK	N.Y.
50-80	-	-	-	-	-	-	-	-	-	-	-	-
80-120	5	40	15	-	-	-	-	40	10	-	-	-
120-160	40	-	-	-	-	-	40	-	-	-	-	-
160-200	-	-	(55)	-	-	-	-	-	(55)	-	-	-
200-250	(55)	60	(30)	-	-	-	(60)	(60)	(35)	-	-	-
250-300				(65)	(100)	(100)				(50)	(100)	(100)
300-350				-						-		
350-400				-						-		
400-450				-						-		
450-500				(35)						(50)		

( ) indicates multiple-port operation from Nova Scotia

[1] Projected fleet size distribution if deep port facilities are not provided in the North Atlantic.

TABLE 31
PROJECTED FLEET SIZE DISTRIBUTION
REGIONAL DEEPWATER FACILITY - 100 FEET [1]
(PERCENT OF TONNAGE CARRIED)

VESSEL CLASS D.W.T. (000'S)	1975		1980		1990		2000	
	North Africa	Persian Gulf	North Africa	Persian Gulf	North Africa	Persian Gulf	North Africa	Persian Gulf
50-80	5	-	-	-	-	-	-	-
80-120	15	5	5	-	5	-	-	-
120-160	45	15	25	-	20	-	15	-
160-200	10	25	45	-	45	-	50	-
200-250	25	50	25	25	30	-	35	-
250-300		5		65		25		20
300-350				10		30		20
350-400						15		15
400-450						20		25
450-500						10		20

1 Projected fleet size distribution which will use a terminal located in 100 feet of water.

Ocean regional facility (14) was estimated at $575,200, 000.

At single point mooring sites, vessel time in port was increased by approximately one day to allow for increased weather-induced down time. Although new technology may soon minimize that down time, it was included to provide a conservative estimate of the benefits. In addition, costs of waiting for an unoccupied berth were subtracted from the benefits to allow a true comparison of all alternatives. Table 32 shows the calculation of benefits for the Atlantic Ocean regional facility (14).

Comparison of Economic Benefits and Costs

Average annual benefits and costs were calculated for different depth facilities for each alternative so that each might be optimized for depth as shown in Figure 28. Table 33 shows a comparison of the benefits and costs for each alternative at the optimized depth. Both benefits and costs have been discounted at 5.5 percent interest over the 50 year life of each alternative. As Figure 33 shows, each alternative was also examined to determine if the use of restricted draft vessels would be more economical than providing additional dredging or other facilities in slightly deeper waters. Using the fleet size distribution projected for a facility in 100 feet of water, an analysis was prepared of the additional cost of enabling a restricted draft fleet of the same vessel tonnage distribution to traverse the 65 to 95 foot channels. As shown on Figure 28, the use of smaller conventionally designed ships provides greater net benefits than the use of restricted draft vessels of large capacity. This result applies at all sites considered, in-

TABLE 32
ESTIMATE OF AVERAGE ANNUAL BENEFITS
ATLANTIC OCEAN REGIONAL FACILITY (14)—100' DEPTH
(5-1/2% — 50 YEARS)

Average Annual Transportation Cost Without Terminal	$ 713,500,000
Average Annual Transportation Cost With Terminal	–575,200,000
Average Annual Waiting Cost	– 700,000
Average Annual Benefits	$ 137,600,000

TABLE 33
SUMMARY OF OPTIMIZED PROJECTS
(5-1/2% – 50 YEAR LIFE)

ALTERNATIVE		OPTIMIZED	AVERAGE ANNUAL		
No.	LOCATION	DEPTH (ft. below MLW)	BENEFIT ($000)	COST ($000)	NET BENEFIT ($000)
(13)	Raritan Bay				
	Sea Island:				
(a)	Local	73	36,100	35,000	1,100
(b)	Regional	80	121,700	79,600	42,100
	Artificial Island:				
(c)	Local	72	34,900	34,500	400
(d)	Regional	80	121,700	91,000	30,700
(14)	Atlantic Ocean				
	Monobuoy:				
(a)	Local	100	47,200	19,000	28,200
(b)	Regional	100	137,600	57,900	79,700
(15)	Delaware Bay at Big Stone Beach				
	Artifical Island:				
(a)	Local	80	81,700	43,500	38,200
(b)	Regional	80	121,900	59,000	62,900
	Sea Island:				
(c)	Local	80	81,700	40,900	40,800
(d)	Regional	80	121,900	56,100	65,800
(16)	Delaware Bay at Towne Bank				
	Artificial Island:				
(a)	Local	80	81,700	48,800	32,900
(b)	Regional	80	121,900	62,000	59,900
	Sea Island				
(c)	Local	80	81,700	51,400	30,300
(d)	Regional	80	121,900	74,200	47,700
(17)	Atlantic Ocean				
	Artificial Island:				
(a)	Local	100	93,800	80,800	13,000
(b)	Regional	100	138,300	89,200	49,100
(18)	Monobuoy:				
	Big Stone Beach Storage				
(a)	Local	100	92,300	51,500	40,800
(b)	Regional	100	137,300	72,900	64,400
	Greenwich Twp. Storage				
(c)	Local	100	92,300	56,100	36,200
(d)	Regional	100	137,300	82,400	54,900

dicating that small increases in vessel operating costs become more significant over long distance routes than increased terminal costs. Table 34 ranks selected alternative systems by economic efficiency. The Atlantic Ocean regional facility (14b) is the most efficient and economic of the alternatives, although there is little difference among most of them.

Sensitivity of Results

The sensitivity of the most economic alternatives to major variables involved in the decision was tested at a number of throughput levels and ship size projections. It was found that site selection was sensitive to the size of vessel projected to use the terminal. When vessels were limited to 300,000 DWT, the most economic alternative was found to be the development of a regional sea island located in Delaware Bay at Big Stone Beach, Delaware (15d). At high levels (6.6 million barrels per day) of throughput, the selection of the site was found to be insensitive. However, at lower levels (1 million barrels per day), the site selection is sensitive. Without expansion of North Atlantic refineries, an estimated low figure of one million barrels of oil per day would be handled at such a terminal. With that projection, the largest refinery would import about 105,000 barrels per day from the Middle East,[7] and one can assume that a smaller distribution of ships, up to 300,000 DWT would serve the refineries (as shown on Figure 29). At this level of throughput, a regional facility at Big Stone Beach (15d) would be the most economically feasible site.

In evaluating the monobuoy proposals, it was estimated that the average vessel would spend an additional day in port because of weather conditions. If this increased waiting time were increased to 2.5 days the Big Stone Beach Regional Sea Island (15d) would become the most efficient and economic alternative.

In addition, it was assumed that future North Atlantic refining capacity would be located in areas where refineries presently exist. Should new refineries be located in the Boston area or in Maine, additional deep draft facilities might be needed at those locations. However, terminals located in those areas could not economically serve the existing North Atlantic refinery complexes and would not affect the location of the facility located to serve the needs of existing refineries.

It was also assumed that vessel transshipment from foreign countries would be in foreign flag vessels while transshipment from a U.S. terminal would be in a U.S. flag vessel. If legislation were enacted which required importation to the country by U.S. flag vessel, or if coastal movements in foreign flag vessel were allowed, many of the sites in the North Atlantic Region which were declared uneconomic in this study would become economic. However, it is unlikely that they would be more economic than the Atlantic Ocean facility (14b).

SUMMARY

This chapter has shown that facilities to transship iron ore and coal are not economically desirable at this time; deepening existing channels provides a more efficient system. It has also shown that for economic reasons facilities to accept VLCC's should be located along the reach of shore between New York Harbor and the Delaware Bay area. The most efficient and economic method would be to provide a regional monobuoy facility located in the Atlantic Ocean 13 miles off the New Jersey coast (14b) with a pipeline coming ashore at Long Branch. However, at low levels of imports the most efficient and economic method of accepting VLCC's would be to provide a Regional Sea Island at Big Stone Beach (15d). An analysis of the environmental and socio-economic feasibility of each of the economically feasible alternatives must now be undertaken to determine the most logical sites for facilities to handle VLCC's.

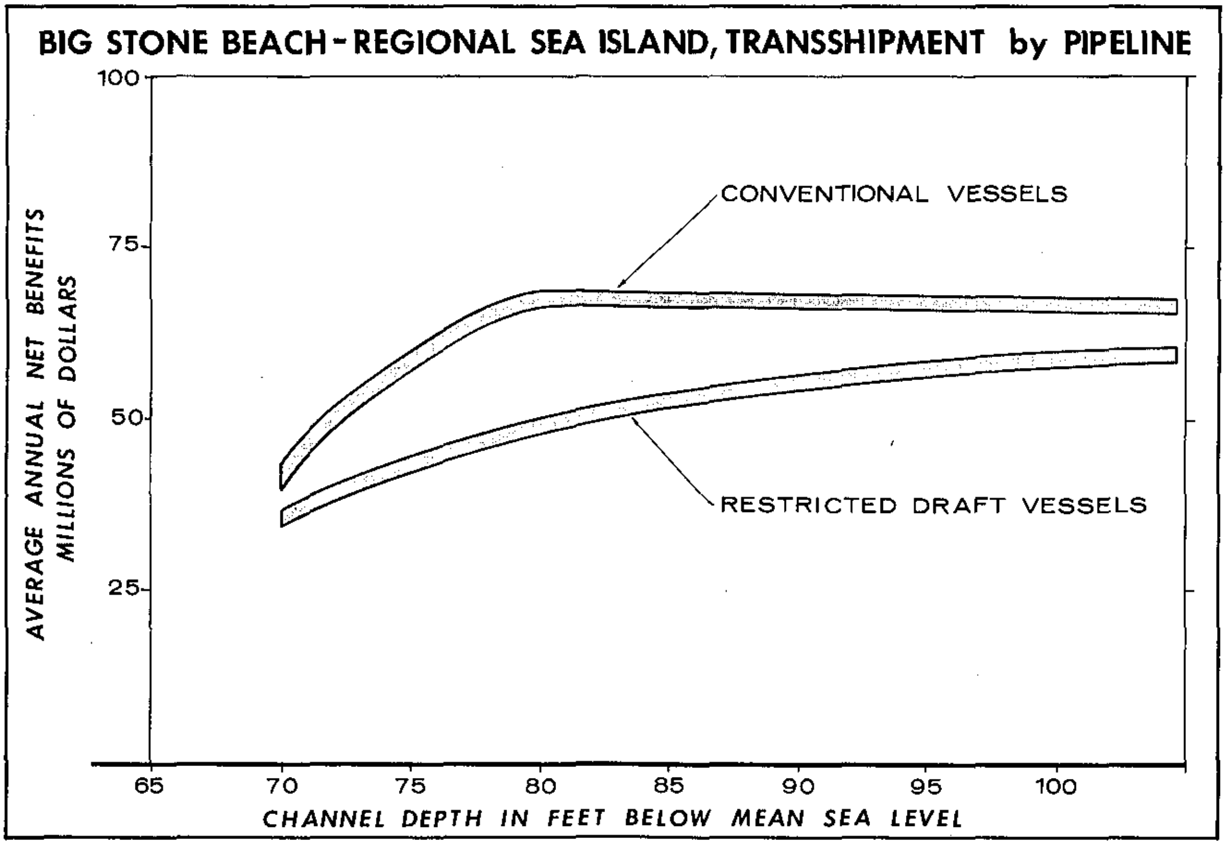


Figure 28

TABLE 34
SUMMARY OF SELECTED ECONOMICALLY OPTIMUM SYSTEMS
(5-1/2% INTEREST - 50 YEAR LIFE)

RANK	SYSTEM	AVERAGE ANNUAL NET BENEFITS
1	Atlantic Ocean - Regional Monobuoy (14b)	$79,700,000
2	Atlantic Ocean Local Monobuoy (14a) and Big Stone Beach Local Sea Island (15c).	$69,000,000
3	Atlantic Ocean Local Monobuoy (14a) and Atlantic Ocean Local Monobuoy with Storage at Big Stone Beach (18a)	$69,000,000
4	Atlantic Ocean Local Monobuoy (14a) and Big Stone Beach Local Artificial Island (15a)	$66,400,000
5	Big Stone Beach Regional Sea Island (15d)	$65,800,000
6	Atlantic Ocean Local Monobuoy (14a) and Atlantic Ocean Local Monobuoy with Storage at Greenwich Township (18c)	$64,400,000
7	Big Stone Beach Regional Artificial Island (15b)	$62,900,000
8	Atlantic Ocean Local Monobuoy (14a) and Towne Bank Local Artificial Island (16a)	$61,100,000
9	Towne Bank Regional Artificial Island (16b)	$59,900,000

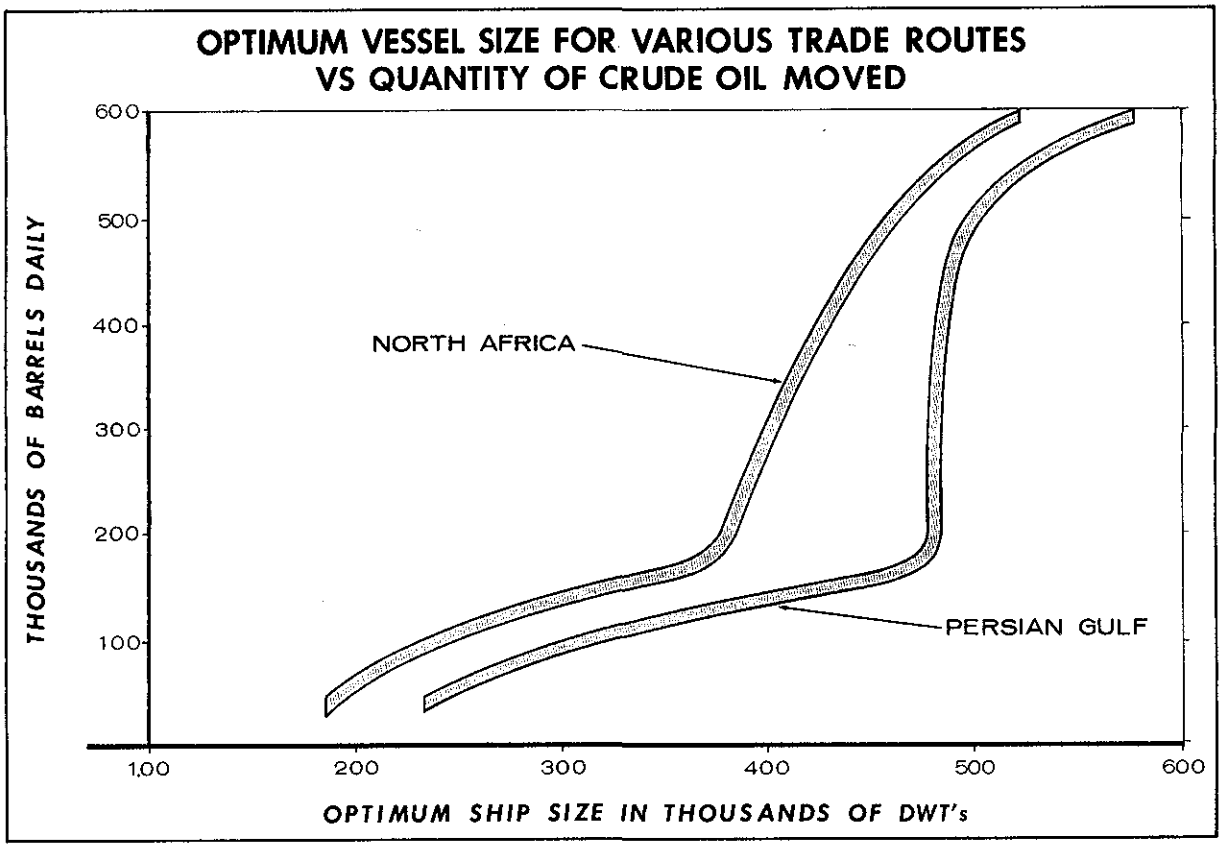


Figure 29

GENERAL

The previous Chapter has shown that 20 alternative deep port facilities in the New York and Delaware Bay area are engineeringly and economically feasible. These alternatives must also be evaluated against the environmental and socio-economic criteria established in Chapter IV to determine which is the most logical method of accommodating VLCC's in the North Atlantic. The following sections of this Chapter will present a general discussion of the environmental and socio-economic implications of developing facilities at each location and a comparison of each facility with the established criteria.

ENVIRONMENTAL EFFECTS

Dangers of Using Existing Facilities

The ecological vulnerability of each proposed deep water terminal site must be considered in the selection process. However, the danger of oil spill appears far graver without a deep water facility with a pipeline to refineries than with such a facility. The major Bay areas, particularly Delaware Bay, are functioning as deep water ports today. Through September 1972, an average of over 100,000 barrels per day was lightered from large tankers inside Delaware Bay, at the rate of 1.6 lightering operations per day.

Increased shipping in coastal and estuarine waters is likely to cause this figure to rise sharply and increase the danger of contamination and pollution along the North Atlantic coastline. As shipping increases, the incidence of oil spillage due to rehandling operations (i.e., lightering) as well as vessel collisions can be expected to increase in like manner. Accidents can be expected to occur, commonly at bay and harbor entrances (notably New York Harbor and Lower Delaware Bay), where traffic is heaviest and damage from oil spills could be most acute. The provision of deep water port and facilities to accommodate VLCC's would serve to substantially reduce the probability of spillage and alleviate a serious problem. The basic and important advantage underlying deep port development can be further heightened by proper site selection and through efforts to minimize adverse environmental effects associated with construction and operation.

Generally, the expected environmental impacts can be divided into two categories: (1) the effects of building and operating a terminal; and (2) the effects of new industrial growth. Studies show that a deep water unloading terminal with a pipeline to refineries will reduce future oil spills in coastal waters. The criteria for selecting environmentally acceptable sites, which were presented in Chapter IV, indicate that an offshore site requiring the least possible dredging with a minimum effect on bottom hydrography would be the preferred alternative. A site selected in this way would assure that the effects of facility construction and operation, together with any possible spills, would be minimized.

Environmental Sensitivity

In Raritan Bay, past environmental deterioration has taken its toll, but recovery is possible through pollution abatement efforts. Recovery is important because the Bay has great potential for commercial fishing and recreational uses, a potential recognized by the authorization of the Gateway National Recreation Area. Major spills which can occur even with a terminal would affect beaches and wetlands of the area, and because of circulation and tidal flow, would also affect the heavily used close-by New York beaches and 6,500 acres of wetlands and wildlife refuge in Jamaica Bay.

Natural movement of sand (littoral drift) along the shore may cause a problem at this site. Littoral currents presently transport about 500,000 cubic yards of sand annually from Sandy Hook into the entrance of Sandy Hook Bay, and frequent dredging is necessary to maintain the present channel. To maintain the proposed channel depth of 80 feet, additional dredging would have to be undertaken along with significant changes to the bottom hydrography. Use of this area would require disposal of approximately 300 million cubic yards of spoil. Although much of Raritan/Sandy Hook Bay area is already closed to clamming because of pollution, a terminal would threaten the only remaining unpolluted clam beds. The estimated annual commercial market value of those beds is $3.0 million. Furthermore, some intrusion of saltwater into aquifers might occur, affecting ground water.

An oil spill in Delaware Bay at flood tide coupled with a southwesterly wind (predominant in summer months) will cause the oil spill to circulate around the Bay in a counterclockwise direction and eventually reach the shoreline.

After testing various tide and wind combinations, the Council on Environmental Quality has stated that it is clear that except for abnormally strong winds (less than 1 percent probability on an annual base) any major oil spill will be confined in the Bay for a long period before escaping the Bay[21]. The impact on the Bay's marshes, shellfish, and other biological communities would be more significant than at Raritan.

Chronic oil spills and consequent deterioration of water quality in Delaware Bay over a long time would critically affect biological productivity, particularly among such commercial species as oysters. Oil could accumulate in the shallow water near Maurice River cove, an area of extensive oyster beds. Oil concentrations along the shoreline and in semi-restricted areas would be at levels lethal to plankton, the major food source for oysters, and could prove a limiting factor in terms of spawning, migrating, and foraging habits of finfish as well. High levels of natural turbidity would tend to increase the settling of oil particles, incorporating oil in the sediment over a long term and potentially damaging all bottom dwelling organisms.

In Delaware Bay, 60-100 million cubic yards of dredging would be required. In addition to the destruction of shellfish habitats, increased salinity could lead to an influx of shellfish predators further impacting the commercially important shellfish beds. Construction of an artificial island could create a channel constriction, increasing tidal current velocities and causing bottom scouring, erosion, and turbidity to the detriment of bottom dwelling organisms and phytoplankton photosynthesis.

Low-level spills occurring offshore could prove as potentially serious in Delaware Bay as those occurring inshore. If some of the Bay's turbidity plume, which extends into the ocean, inter-mixed with offshore currents containing low level concentrations of oil, the oil would settle. Oil particles thus deposited and incorporated in sediment would then be transported into the Bay and onto nearby beaches by bottom currents. Thus facilities located at site (17) in the Atlantic Ocean could cause damage in Delaware Bay.

In general, because of dilution factors and a widespread biotic population, offshore areas and particularly *far offshore* areas have greater assimilative capacities and are relatively less vulnerable than shoreline or estuarine areas to damage from chronic low-level spills. At offshore sites, spills are more likely to be dispersed by wind and wave and to weather by evaporation, dissolution, emulsification, and oxidation. Thus, spills would pose a significantly smaller problem with less likelihood of build-up than similar spills in enclosed estuaries. Furthermore, estuaries, because of their importance as major spawning and nursery areas, are more biologically vulnerable to oil pollution than the open sea. The persistency of oil in the marine environment and the probable slower rates of microbial degradation in the deep oceans could cause long term effects from oil spilled offshore and every effort should be made to prevent them. However, the offshore area appears to be less sensitive to spills than estuarine areas.

At the far offshore Atlantic Ocean sites (14) and (18), no dredging would be required except for installation of pipelines. While less is known about living resources at those sites than in Raritan and Delaware Bays, little damage from dredging is expected in comparison to estuarine sites.

Prevailing winds off northern New Jersey are mostly from the north and northwest and would tend to drive an oil spill directly offshore. Non-tidal drift would provide a southerly vector, so that if the wind direction were constant, the spill would tend to veer to the south, but stay away from shore. However, winds are not always from the same direction, nor are they constant. Consequently, there is no guarantee that a spill would miss the shoreline, even during periods of prevailing offshore winds. In addition, eddies may form along the coast during the peak of the southerly transport of water, and there is a tendency for a northward and westward drift which would make it difficult to predict where a spill will end up. The fate of a medium or large spill will depend upon weather and current conditions at the time of and in the period after the spill.

Off southern New Jersey, the predominant winter wind directions are from the west and northwest. The chance of contaminating the Delaware Bay area with oil spills in the winter is rather small, since it takes 10 to 12 hours of persistent east or southeasterly winds at twenty miles per hour to drive the oil from the site eight miles off the coast (17) to the mouth of the Delaware Bay. The chance of such a combination is rare in this season. Obviously, the SPM site twenty-five miles out (18) is even less vulnerable. The most probable direction of oil movement in these months will be toward the southeast or south. However, the chance of contaminating the beaches south of Indian River Inlet cannot be overlooked, as there is a fair chance that the wind will blow persistently from the northeast for a period long enough to push oil to the south end of Delaware. The most serious winter threat is caused by the strong shoreward bottom drift that would carry sinking oil to the Delaware shore. In the summer, the prevailing southwesterly wind would produce a predominant east to east-northeast oil movement. Thus, the threat of oil pollution would be greater to the New Jersey and New York beaches in the summer.

Potentially, the most important biological resource in the Atlantic Ocean off Delaware Bay would appear to be surf and mahogany clams. The maximum development of these species is from Atlantic City, New Jersey, to Ocean City, Maryland, with the center of the fishery moving south. Approximately 40,000,000 pounds were harvested in 1971.

A large oil spill from any of the offshore locations could move over these beds at any time of the year. Oil interacting with suspended materials in the water would tend to increase in density and suspended materials in the water would tend to increase in density and sink. Though dilution factors would reduce toxicity levels, depending on the amount of oil which reaches the beds (a function of turbidity wind/wave turbulence, oil composition etc.) the effect on the dense surf clam and mahogany clam could be extremely serious. The problem is further compounded in that recovery rates would be extremely slow. It requires 5-6 years for a surf clam to attain commercial size. Turnover time for the main estuarine species, the oyster, is shorter, about 3-5 years in these latitudes. In view of the impact on bottom dwelling species in general, and surf clams in particular, spills at the artificial island location (17) would be more serious than those occuring at the SPM site (18).

It appears that the most environmentally desirable sites would be those located in the Atlantic Ocean. At those locations there would be little or no dredging required, oil spills would be reduced to a minimum, and the environmental effects of any spills which might occur would be less than at other locations.

LANDSIDE IMPACTS

Foreign experience has shown that unless carefully regulated, development of deep port facilities are likely to generate expansion of refinery and petrochemical complexes[24]. In this region the impacts of such development could be severe[25]. *However, such expansion is not inevitable.* Development of deep port facilities in the North Atlantic need not entail industrial development in the immediate vicinity of the facilities. Determination as to whether or not industrial expansion is desirable and where such expansion might take place are issues that can and should be resolved through proper land use planning at the State or local level. The analysis of transportation savings from development of a deep water facility indicates that other more significant factors will cause refineries to locate in the North Atlantic. Changes in the major source of crude oil from the U.S. Gulf Coast and the Caribbean to the Middle East and North Africa will increase pressure to develop refineries near the North Atlantic market, since the closer to market the refineries locate, the greater the resulting economies. *Pressure to develop refineries in the New York to Philadelphia corridor will increase even without a deep draft terminal.* If a deep port is developed in the New York or Delaware River areas, there may be some shifts in pressure from one locality to another, depending upon the precise location of the terminal. However, significant pressures for industrialization will be felt in southern New Jersey, where undeveloped land is relatively abundant compared to the northern counties of the State. In addition, there may be pressures to develop associated petrochemical industries in southern New Jersey. *The extent to which any of this growth will occur depends upon local zoning restrictions.*

However, the general attitude of local interests makes it clear that new refineries would not be welcomed in the New York or Delaware River areas. Few, if any, areas are willing to accept new refineries. Still, refinery and petrochemical expansion may occur in the future, but only in those areas where it is allowed. Consequently, *it is expected that the development of a terminal will not result in the development of any new refineries that would not be built without the facility.*

SOCIO-ECONOMIC EFFECTS

Each area was analyzed in terms of the effects development of a deep water terminal would have on several social and economic parameters, including effects on man-made and natural resources, population, displacement of residences or farms, aesthetic values, transportation, leisure opportunity, community cohesion and growth, tax revenues, property values, public facilities and services, regional growth, income, employment, industrial and business activities[26]. In general, each alternative appears to have a positive economic effect on the community for which it was considered. However, of the areas considered, those *economic effects appear to be of most benefit in the Delaware Bay region* where unemployment is relatively high and income is low.

Social parameters generally tend to be negative. The most significant effects are in the areas of leisure opportunity, and desirable community cohesion and growth. All of the proposed sites are located in or near high valued recreational areas. The thought of oil in the bays and beaches surrounding these sites is frightening to those who derive their livelihood from recreation. These effects can, to an extent, be minimized at the Atlantic Ocean sites (14), (17) and (18). In addition, development of offshore sites would tend to minimize aesthetic effects resulting from the development of inshore facilities. Additional social impacts might result from intermediate storage sites and pipeline routes. Two areas in northern New Jersey were selected for analysis as potential storage sites. The first site, on the grounds of the EARL Naval Depot near Leonardo, is in a highly impacted area, close to a site planned for development as a county airport, and would not conform to the county plan for that area. The other site is on the grounds of the EARL Depot in the New Shrewsbury area. This site appears to be more acceptable and less in conflict with the plans for the region. Moreover, it is already a government facility, and would necessitate no displacement of private families, farms, or businesses, and probably would not affect surrounding property values. In the Delaware Bay area, storage in Cape May County would appear to be the most socially unacceptable alternative due to massive community opposition, and the recreational/residential nature of the entire county.

Consequently, storage areas were considered at Big Stone Beach, Delaware and Greenwich Township, New Jersey. Generally, it is felt that the Greenwich Township property would be the more acceptable as the Big Stone Beach site would be in direct conflict with Delaware's 1971 Coastal Zone Act. The Greenwich Township site is proposed for development of an industrial park and has been offered by the Township for use as a storage facility. In public meetings held in Middletown, Cape May, New Jersey and at Rehoboth Beach, Delaware, in December of 1972, tremendous and unified local opposition to development of any of these facilities was manifested. Moreover, both Cape May and Greenwich Township are officially designated as national historical areas, with noteworthy examples of 19th Century architecture. However, it is not expected that the area would be damaged by the development of any petroleum-related storage facilities in the area selected.

COMPARISON OF ALTERNATIVES

This section presents a description of the various feasible alternatives and tests them against the criteria established in Chapter IV. All of the alternatives considered in this Chapter will reduce the probability of oil spills in the North Atlantic Region compared to that expected without a facility. Some alternatives will have more effect on spill probabilities than others.

Alternative 13a - Raritan Bay - Local Sea Island.

Description. This alternative requires the dredging of a channel 73 feet deep to the berthing area. Berths would be open pile construction with buried pipelines to an onshore storage area located at the EARL Naval Supply Depot near New Shrewsbury. Distribution to the Arthur Kill refineries would be by pipeline.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1. *First cost.*	$408,885,000
2. *Average annual cost.*	$35,000,000
3. *Average annual benefit.*	$36,100,000
4. *Average annual net benefit.*	$1,100,000

Environmental criteria.

1. *Dredging.* Extensive dredging is required.
2. *Water transport alterations.* Some resulting from channel dredging.
3. *Offshore vs. inshore.* Inshore, extensive biological damage from spills in Raritan or Sandy Hook Bays.

Socio-economic criteria.

1. *Man-made and natural resources.* Could affect Gateway National Recreation Area and coastal recreational beaches.
2. *Leisure opportunity.* Could have a small negative effect on beach use resulting from oil spills.
3. *Aesthetic values.* Berths will be visible from shore; tank farm will be visible inland.
4. *Community cohesion.* Negative effect.
5. *Public facilities and services.* Little or no effect.
6. *Income and employment.* Little or no effect.
7. *Tax base.* Will increase local tax base.
8. *Property values.* Should have no effect.
9. *Displacement.* None.
10. *Desirable community growth.* Undesirable.
11. *Desirable regional growth.* Undesirable.
12. *Existing laws.* None violated.

Alternative 13b - Raritan Bay - Regional Sea Island.

Description. This alternative requires dredging a 80 foot deep channel to the berthing area. Berths would be open pile construction with buried pipelines to an onshore storage area located at the EARL Naval Supply Depot near New Shrewsbury. Distribution to the refineries along the Arthur Kill and Delaware River would be by pipeline. The York River refinery would be served by a tug-barge system.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1. *First cost.*	$756,626,000
2. *Average annual cost.*	$79,600,000
3. *Average annual benefit.*	$121,700,000
4. *Average annual net benefit.*	$42,100,000

Environmental criteria.

1. *Dredging.* Requires more dredging than other alternatives.
2. *Water transport alterations.* Some resulting from channel dredging.
3. *Offshore vs. inshore.* Inshore, extensive biological damage possible from spills in Raritan or Sandy Hook Bays.

Socio-economic criteria.

1. *Man-made and natural resources.* Could affect Gateway National Recreation Area and coastal recreational beaches.
2. *Leisure opportunity.* Could have a small negative effect on beach use resulting from oil spills.
3. *Aesthetic values.* Berths will be visible from shore; tank farm will be visible inland.
4. *Community cohesion.* Negative effect.
5. *Public facilities and services.* Little or no effect.
6. *Income and employment.* Little or no effect.
7. *Tax base.* Will increase local tax base.
8. *Property values.* Should have no effect.
9. *Displacement.* None.
10. *Desirable community growth.* Undesirable.
11. *Desirable regional growth.* Undesirable.
12. *Existing laws.* None violated.

Alternative 13c - Raritan Bay - Local Artificial Island.

Description. This alternative requires dredging of a channel 72 feet deep to the berthing area. Berths would be open pile construction with buried pipelines to storage on an artificial island with an ultimate area of 100 acres. Distribution to the refineries along the Arthur Kill would be by pipeline.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1. *First cost.*	$374,731,000
2. *Average annual cost.*	$34,500,000
3. *Average annual benefit.*	$34,900,000
4. *Average annual net benefit.*	$400,000

Environmental criteria.

1. *Dredging.* Extensive dredging required.
2. *Water transport alterations.* Some resulting from both dredging and island construction.
3. *Offshore vs. inshore.* Inshore, extensive biological damage from spills in Raritan or Sandy Hook Bays possible.

Socio-economic criteria.

1. *Man-made and natural resources.* Could affect Gateway National Recreation Area and coastal recreational beaches.
2. *Leisure opportunity.* Could have a small negative effect on beach use resulting from oil spills.
3. *Aesthetic values.* Island and berths will be visible from shore.
4. *Community cohesion.* Negative effect.
5. *Public facilities and services.* Little or no effect.
6. *Income and employment.* Little or no effect.
7. *Tax base.* Will increase tax base.
8. *Property values.* Should have no effect.
9. *Displacement.* None.

10. *Desirable community growth.* Undesirable.
11. *Desirable regional growth.* Undesirable.
12. *Existing laws.* None violated.

Alternative 13d - Raritan Bay - Regional Artificial Island.

Description. This alternative requires dredging of a channel 80 feet deep to the berthing area. Berths would be open pile construction with buried pipeline to storage on an artificial island with an ultimate area of 400 acres. Distribution to the refineries along the Arthur Kill and Delaware River would be by pipeline. The refinery on the York River would be served by a tug-barge system.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1. *First cost.*	$724,246,000
2. *Average annual cost.*	$91,000,000
3. *Average annual benefit.*	$121,700,000
4. *Average annual net benefit.*	$30,700,000

Environmental criteria.
1. *Dredging.* Requires more dredging than other alternatives.
2. *Water transport alterations.* Some resulting from both channel dredging and island.
3. *Offshore vs. inshore.* Inshore, extensive biological damage from spills in Raritan or Sandy Hook Bays possible.

Socio-economic criteria.
1. *Man-made and natural resources.* Could affect Gateway National Recreation Area and coastal recreational beaches.
2. *Leisure opportunity.* Could have a small negative effect on beach use resulting from oil spills.
3. *Aesthetic values.* Berths and island would be visible from shore.
4. *Community cohesion.* Negative effect.
5. *Public facilities and services.* Little or no effect.
6. *Income and employment.* Little or no effect.
7. *Tax base.* Will increase tax base.
8. *Property values.* Should have no effect.
9. *Displacement.* None.
10. *Desirable community growth.* Undesirable.
11. *Desirable regional growth.* Undesirable.
12. *Existing laws.* None violated.

Alternative 14a - Atlantic Ocean - Local Monobuoy.

Description. This alternative consists of a series of SPM's located in the Atlantic Ocean about 13 miles off the New Jersey coast. The buoys would be connected by buried pipelines coming ashore near Long Branch to a tank farm located on the EARL Naval Supply Depot near New Shrewsbury. Distribution to the Arthur Kill refineries would be by pipeline.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1. *First cost.*	$161,991,000
2. *Average annual cost.*	$19,000,000
3. *Average annual benefit.*	$47,200,000
4. *Average annual net benefit.*	$28,200,000

Environmental criteria.
1. *Dredging.* None required.

2. *Water transport alterations.* None.
3. *Offshore vs. inshore.* Thirteen miles offshore.

Socio-economic criteria.

1. *Man-made and natural resources.* Could affect coastal recreational beaches.
2. *Leisure opportunity.* Little or no effect.
3. *Aesthetic values.* SPM's would not be visible from shore. However, the storage facility would be visible inland.
4. *Community cohesion.* Negative effect.
5. *Public facilities and services.* Little or no effect.
6. *Income and employment.* Little or no effect.
7. *Tax base.* Will increase tax base.
8. *Property values.* Should have no effect.
9. *Displacement.* None.
10. *Desirable community growth.* Undesirable.
11. *Desirable regional growth.* Undesirable.
12. *Existing laws.* None violated.

Alternative 14b - Atlantic Ocean - Regional Monobuoy.

Description. This alternative consists of a series of SPM's located in the Atlantic Ocean about 13 miles off New Jersey. The buoys would be connected by buried pipeline coming ashore at Long Branch to a tank farm located on the EARL Naval Supply Depot near New Shrewsbury. Distribution to the Arthur Kill and Delaware River refineries would be by pipeline. Distribution to the York River refinery would be by tug-barge from a feeder berth located in Raritan Bay.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1. *First cost.*	$512,220,000
2. *Average annual cost.*	$57,900,000
3. *Average annual benefit.*	$137,600,000
4. *Average annual net benefit.*	$79,700,000

Environmental criteria.

1. *Dredging.* None.
2. *Water transport alterations.* None.
3. *Offshore vs. inshore.* Thirteen miles offshore.

Socio-economic criteria.

1. *Man-made and natural resources.* Could affect coast recreational beaches and Gateway National Recreation Area.
2. *Leisure opportunity.* Little or no effect.
3. *Aesthetics.* SPM's would not be visible from shore. However, storage tanks and the feeder berth would be visible inland.
4. *Community cohesion.* Negative.
5. *Public facilities and services.* Little or no effect.
6. *Income and employment.* Little or no effect.
7. *Tax base.* Will increase tax base.
8. *Property values.* Should have no effect.
9. *Displacement.* None.
10. *Desirable community growth.* Undesirable.
11. *Desirable regional growth.* Undesirable.
12. *Existing laws.* None violated.

Alternative 15a - Delaware Bay at Big Stone Beach - Local Artificial Island.

Description. This alternative requires dredging of a channel 80 feet deep to the berthing area. Berths would be open pile construction with buried pipelines to storage on an artificial island with an ultimate area of 300 acres. Distribution to the refineries along the Delaware River would be by pipeline. The refinery on the York River would be supplied by a tug-barge system.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1. *First cost.*	$354,968,000
2. *Average annual cost.*	$43,500,000
3. *Average annual benefit.*	$81,700,000
4. *Average annual net benefit.*	$38,200,000

Environmental criteria.

1. *Dredging.* The area has natural depths of 65 to 70 feet. Minor dredging to the optimum depth of 80 feet will be required.
2. *Water transport alterations.* Some resulting from channel dredging and island construction.
3. *Offshore vs. inshore.* Inshore, extensive biological damage possible from spills in Delaware Bay.

Socio-economic criteria.

1. *Man-made and natural resources.* Could affect the coastal recreational beaches.
2. *Leisure opportunity.* Could have a small negative effect on beach use resulting from oil spills.
3. *Aesthetic values.* Island and berths will be visible from shore.
4. *Community cohesion.* Negative effect.
5. *Public facilities and services.* Little or no effect.
6. *Income and employment.* Small positive effect because of the depressed economic situation in the area.
7. *Tax base.* Will increase tax base.
8. *Property values.* Little or no effect.
9. *Displacement.* None.
10. *Desirable community growth.* Undesirable.
11. *Desirable regional growth.* May be more desirable than the northern New Jersey area.
12. *Existing laws.* The project would be in conflict with the Delaware Coastal Zone Act of 1971.

Alternative 15b - Delaware Bay at Big Stone Beach - Regional Artificial Island.

Description. This alternative requires dredging of a channel 80 feet deep to the berthing area. Berths would be open pile construction with buried pipelines to storage on an artificial island with an ultimate area of 400 acres. Distribution to the Arthur Kill and Delaware River refineries would be by pipeline. The refinery on the York River would be supplied by a tug-barge system.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1. *First cost.*	$552,111,000
2. *Average annual cost.*	$59,000,000
3. *Average annual benefit.*	$121,900,000
4. *Average annual net benefit.*	$62,900,000

Environmental criteria.

1. *Dredging.* The area has natural depths of 65 to 70 feet. Minor dredging to the optimum depth of 80 feet will be required.
2. *Water transport alterations.* Some resulting from channel dredging and the island.
3. *Offshore vs. inshore.* Inshore, extensive biological damage possible from spills in Delaware Bay.

Socio-economic criteria.

1. *Man-made and natural resources.* Could affect the coastal recreational beaches.
2. *Leisure opportunity.* Could have a small negative effect on beach use resulting from oil spills.

3. *Aesthetic values.* Island and berths will be visible from shore.
4. *Community cohesion.* Negative effect.
5. *Public facilities and services.* Little or no effect.
6. *Income and employment.* Small positive effect because of the depressed economic situation in the area.
7. *Tax base.* Will increase tax base.
8. *Property values.* Little or no effect.
9. *Displacement.* None.
10. *Desirable community growth.* Undesirable.
11. *Desirable regional growth.* May be more desirable than in northern New Jersey area.
12. *Existing laws.* The project would be in conflict with the Delaware Coastal Zone Act of 1971.

Alternative 15c - Delaware Bay at Big Stone Beach - Local Sea Island.

Description. This alternative requires the dredging of a channel 80 feet deep to the berthing area. Berths would be open pile construction with buried pipelines to an onshore storage area located at Big Stone Beach. Distribution to the Delaware River refineries would be by pipeline, while the York River refinery will be supplied by a tug-barge system.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1. *First cost.*	$326,179,000
2. *Average annual cost.*	$40,900,000
3. *Average annual benefit.*	$81,700,000
4. *Average annual net benefit.*	$40,800,000

Environmental criteria.

1. *Dredging.* The area has natural depths of 65 to 70 feet. Minor dredging to the optimum depth of 80 feet will be required.
2. *Water transport alterations.* Minor resulting from channel dredging.
3. *Offshore vs. inshore.* Inshore, extensive biological change possible from spills in Delaware Bay.

Socio-economic criteria.

1. *Man-made and natural resources.* Could affect the coastal recreational beaches.
2. *Leisure opportunity.* Small effect on beach use resulting from oil spills.
3. *Aesthetic values.* Berths will be visible from shore; tank farm will be visible inland.
4. *Community cohesion.* Negative effect.
5. *Public facilities and services.* Little or no effect.
6. *Income and employment.* Possible positive effect because of the depressed economic situation in the area.
7. *Tax base.* Will increase the tax base.
8. *Property value.* Little or no effect.
9. *Displacement.* None.
10. *Desirable community growth.* Undesirable.
11. *Desirable regional growth.* May be more desirable than in northern New Jersey.
12. *Existing laws.* The project would be in conflict with the Delaware Coastal Zone Act of 1971

Alternative 15d - Delaware Bay at Big Stone Beach - Regional Sea Island.

Description. This alternative requires the dredging of a channel 80 feet deep to the berthing area. Berths would be open pile construction with buried pipelines to an onshore storage area located at Big Stone Beach. Distribution to the Arthur Kill and Delaware River refineries would be by pipeline, while the York River refinery will be supplied by a tug-barge system.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1. *First cost.*	$519,371,000
2. *Average annual cost.*	$56,100,000
3. *Average annual benefit.*	$121,900,000
4. *Average annual net benefit.*	$65,800,000

Environmental criteria.

1. *Dredging.* The area has natural depths of 65 to 70 feet. Minor dreding to the optimum of 80 feet will be required.
2. *Water transport alternations.* Minor resulting from channel dredging.
3. *Offshore vs. inshore.* Inshore, extensive biological damage possible from spills in Delaware Bay.

Socio-economic criteria

1. *Man-made and natural resources.* Could affect the coastal recreational beaches.
2. *Leisure opportunity.* Small negative effect on beach use resulting from oil spills.
3. *Aesthetic values.* Berths and tank farm will be visible from shore.
4. *Community cohesion.* Negative effect.
5. *Public facilities and services.* Little or no effect.
6. *Income and employment.* Possible positive effect because of the depressed economic situation in the area.
7. *Tax base.* Will increase the tax base.
8. *Property values.* Little or no effect.
9. *Displacement.* None.
10. *Desirable community growth.* Undesirable.
11. *Desirable regional growth.* May be more desirable than in northern New Jersey.
12. *Existing laws.* The project would be in conflict with the Delaware Coastal Zone Act of 1971.

Alternative 16a - Delaware Bay at Towne Bank - Local Artificial Island.

Description. This alternative requires dredging of a channel 80 feet deep to the berthing area. Berths would be open pile construction with buried pipelines to storage on an artificial island with an ultimate area of 300 acres. Distribution to the refineries along the Delaware River would be by pipeline. The refinery on the York River would be supplied by a tug-barge system.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1. *First cost.*	$423,771,000
2. *Average annual cost.*	$48,800,000
3. *Average annual benefit.*	$81,700,000
4. *Average annual net benefit.*	$32,900,000

Environmental criteria.

1. *Dredging.* Large amounts of dredging would be required with possible effects on aquifers serving Delaware and New Jersey.
2. *Water transport alterations.* Some resulting from both channel dredging and the island.
3. *Offshore vs. inshore.* Inshore, extensive biological damage possible from spills in Delaware Bay.

Socio-economic criteria.

1. *Man-made and natural resources.* Could affect the coastal recreational beaches.
2. *Leisure opportunity.* Small negative effect on beach use resulting from oil spills.
3. *Aesthetic values.* Island and berths will be visible from shore.
4. *Community cohesion.* Negative effect.
5. *Public facilities and services.* Little or no effect.
6. *Income and employment.* Possible positive effect because of the depressed economic conditions in the area.
7. *Tax base.* Will increase the tax base.
8. *Property values.* Little or no effect.

9. *Displacement.* None.
10. *Desirable community growth.* Undesirable.
11. *Desirable regional growth.* May be more desirable than in northern New Jersey.
12. *Existing laws.* None violated.

Alternative 16b - Delaware Bay at Towne Bank - Regional Artificial Island.

Description. This alternative requires dredging of a channel 80 feet deep to the berthing area. Berths would be open pile construction with buried pipelines to storage on an artificial island with an ultimate area of 400 acres. Distribution to the Arthur Kill and Delaware River refineries would be by pipeline. The refinery on the York River would be supplied by a tug-barge system.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1.	*First cost.*	$627,671,000
2.	*Average annual cost.*	$62,000,000
3.	*Average annual benefit.*	$121,900,000
4.	*Average annual net benefit.*	$59,900,000

Environmental criteria.

1. *Dredging.* Large amounts of dredging would be required with possible effects on aquifers serving Delaware and New Jersey.
2. *Water transport alterations.* Some resulting from channel dredging.
3. *Offshore vs. inshore.* Inshore, extensive biological damage possible from spills in Delaware Bay.

Socio-economic criteria.

1. *Man-made and natural resources.* Could affect the coastal recreational beaches.
2. *Leisure opportunity.* Small negative effect on beach use resulting from oil spills.
3. *Aesthetic values.* Island and berths will be visible from shore.
4. *Community cohesion.* Negative effect.
5. *Public facilities and services.* Little or no effect.
6. *Income and employment.* Possible positive effect because of the need to expand the economic base.
7. *Tax base.* Will increase the tax base.
8. *Property values.* Little or no effect.
9. *Displacement.* None.
10. *Desirable community growth.* Undesirable.
11. *Desirable regional growth.* May be more desirable than in northern New Jersey.
12. *Existing laws.* None violated.

Alternative 16c - Delaware Bay at Towne Bank - Local Sea Island.

Description. This alternative requires the dredging of a channel 80 feet deep to the berthing area. Berths would be open pile construction with buried pipelines, coming ashore in Cumberland County to an onshore storage area located in Greenwich Township, Cumberland County, New Jersey. Distribution to the Delaware River refineries would be by pipeline, while the York River refinery will be supplied by a tug-barge system.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1.	*First cost.*	$432,699,000
2.	*Average annual cost.*	$51,400,000
3.	*Average annual benefit.*	$81,700,000
4.	*Average annual net benefit.*	$30,300,000

Environmental criteria.

1. *Dredging.* Large amounts of dredging would be required possibly affecting the aquifers serving Delaware and Jersey.
2. *Water transport alterations.* Some resulting from channel dredging.
3. *Offshore vs. inshore.* Inshore, extensive biological damage possible from spills in Delaware Bay.

Socio-economic criteria.

1. *Man-made and natural resources.* Could affect the coastal recreational beaches.
2. *Leisure opportunity.* Small negative effect on beach use resulting from oil spills.
3. *Aesthetic values.* Berths will be visible from shore; tank farm will be visible inland.
4. *Community cohesion.* Negative effect.
5. *Public facilites and services.* Little or no effect.
6. *Income and employment.* Possible positive effect because of the depressed economy of the area.
7. *Tax base.* Will increase the tax base.
8. *Property values.* Little or no effect.
9. *Displacement.* None.
10. *Desirable community growth.* Undesirable
11. *Desirable regional growth.* May be among the most desirable.
12. *Existing laws.* None violated.

Alternative 16d - Delaware Bay at Towne Bank - Regional Sea Island.

Description. This alternative requires the dredging of a channel 80 feet deep to the berthing area. Berths would be open pile construction with buried pipelines, coming ashore in Cumberland County, New Jersey. Distribution to the Arthur Kill and Delaware River refineries would be by pipeline, while the York River refinery will be supplied by a tug-barge system.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1. *First cost.*	$626,922,000
2. *Average annual cost.*	$74,200,000
3. *Average annual benefit.*	$121,900,000
4. *Average annual net benefit.*	$47,700,000

Environmental criteria.

1. *Dredging.* Large amounts of dredging would be required with possible effects on aquifer serving Delaware and New Jersey.
2. *Water transport alterations.* Some resulting from channel dredging.
3. *Offshore vs. inshore.* Inshore, extensive biological damage possible from spills in Delaware Bay.

Socio-economic criteria.

1. *Man-made and natural resources.* Could affect the coastal recreational beaches.
2. *Leisure opportunity.* Small negative effect on beach use resulting from oil spills.
3. *Aesthetic values.* Berths will be visible from shore; tank farm will be visible inland.
4. *Community cohesion.* Negative effect.
5. *Public facilites and services.* Little or no effect.
6. *Income and employment.* Possible positive effect because of the need to expand the economic base.
7. *Tax base.* Will increase the tax base.
8. *Property values.* Little or no effect.
9. *Displacement.* None.
10. *Desirable community growth.* Undesirable
11. *Desirable regional growth.* May be among the most desirable.
12. *Existing laws.* None violated.

Alternative 17a - Atlantic Ocean - Local Artificial Island.

Description. This alternative requires dredging of a channel 100 feet deep to the berthing area. Berths would be open pile construction with buried pipelines to storage on an artificial island with an ultimate area of 300 acres. A breakwater would be constructed to provide protection from sea conditions. Distribution to the refineries along the Delaware River would be by pipeline. The refinery on the York River would be supplied by a tug-barge system.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1. *First cost.*	$701,538,000
2. *Average annual cost.*	$80,800,000
3. *Average annual benefit.*	$93,800,000
4. *Average annual net benefit.*	$13,000,000

Environmental criteria.

1. *Dredging.* The existing depths are such that only minor dredging would required.
2. *Water transport alterations.* Some resulting from both channel dredging, the island, and the breakwater.
3. *Offshore vs. inshore.* Eight miles offshore.

Socio-economic criteria.

1. *Man-made and natural resources.* Could affect the coastal recreation beaches.
2. *Leisure opportunity.* Minor effect on beach use resulting from oil spills.
3. *Aesthetic values.* The facility would not be visible from shore.
4. *Community cohesion.* Negative effect.
5. *Public facilites and services.* Little or no effect.
6. *Income and employment.* Little or no effect.
7. *Tax base.* Minimal effect.
8. *Property values.* No effect.
9. *Displacement.* None.
10. *Desirable community growth.* Should have no effect.
11. *Desirable regional growth.* Should have no effect.
12. *Existing laws.* None violated.

Alternative 17b - Atlantic Ocean - Regional Artificial Island.

Description. This alternative requires dredging of a channel 100 feet deep to the berthing area. Berths would be open pile construction with buried pipelines to storage on an artificial island with an ultimate area of 400 acres. A breakwater would be constructed to provide protection from sea conditions. Distribution to the Arthur Kill and the Delaware River refineries would be by pipeline. The refinery on the York River would be supplied by a tug-barge system.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1. *First cost.*	$1,022,408,000
2. *Average annual cost.*	$ 89,200,000
3. *Average annual benefit.*	$138,300,000
4. *Average annual net benefit.*	$49,100,000

Environmental criteria.

1. *Dredging.* The existing depths are such that only minor dredging would required.
2. *Water transport alterations.* Some resulting from channel dredging and construction of the island and breakwater.
3. *Offshore vs. inshore.* Eight miles offshore.

Socio-economic criteria.

1. *Man-made and natural resources.*Could affect the coastal recreation beaches.

2. *Leisure opportunity.* Small effect on beach use resulting from oil spills.
3. *Aesthetic values.* The facility would not be visible from shore.
4. *Community cohesion.* Negative effect.
5. *Public facilites and services.* Little or no effect.
6. *Income and employment.* Little or no effect.
7. *Tax base.* No effect.
8. *Property values.* No effect.
9. *Displacement.* None.
10. *Desirable community growth.* Should have no effect.
11. *Desirable regional growth.* Should have no effect.
12. *Existing laws.* None violated.

Alternative 18a - Atlantic Ocean - Local Monobuoy with Storage at Big Stone Beach.

Description. This alternative consists of a series of SPM's located in the Atlantic Ocean about 25 miles off Delaware Bay. The buoys would be connected by buried pipelines to a tank farm located at Big Stone Beach. Distribution to the Delaware River refineries would be by pipeline. The York River refinery would be serviced by a tug-barge from a feeder berth located at Big Stone Beach.

Engineering criteria. All engineering can be met.

Economic criteria.

1. *First cost.*	$356,123,000
2. *Average annual cost.*	$51,500,000
3. *Average annual benefit.*	$92,300,000
4. *Average annual net benefit.*	$40,800,000

Environmental criteria.

1. *Dredging.* None requied.
2. *Water transport alterations.* None.
3. Offshore vs. inshore. Twenty-five miles offshore.

Socio-economic criteria.

1. *Man-made and natural resources.* Could affect coastal recreational beaches.
2. *Leisure opportunity.* Least effect of all sites considered.
3. *Aesthetic values.* SPM's would not be visible from shore. However, the storage facility and feeder berth would be visible inland.
4. *Community cohesion.* Negative effect.
5. *Public facilites and services.* Little or no effect.
6. *Income and employment.* Possible positive effect because of the depressed economy.
7. *Tax base.* Will increase local tax base.
8. *Property values.* Little or no effect.
9. *Displacement.* None.
10. *Desirable community growth.* Undesirable.
11. *Desirable regional growth.* May be more desirable than in northern New Jersey.
12. *Existing laws.* The project would conflict with the Delaware Coastal Zone Act of 1971.

Alternative 18b - Atlantic Ocean - Regional Monobuoy with Storage at Big Stone Beach.

Description. This alternative consists of a series of SPM's located in the Atlantic Ocean about 25 miles off Delaware Bay. The buoys would be connected by buried pipelines to a tank farm located at Big Stone Beach. Distribution to the Arthur Kill and Delaware River refineries would be by pipeline. The York River refinery would be serviced by tug-barge from a feeder berth located at Big Stone Beach.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1. *First cost.* $585,539,000
2. *Average annual cost.* $72,900,000
3. *Average annual benefit.* $137,300,000
4. *Average annual net benefit.* $64,400,000

Environmental criteria.

1. *Dredging.* None requied.
2. *Water transport alterations.* None.
3. *Offshore vs. inshore.* Twenty-five miles offshore.

Socio-economic criteria.

1. *Man-made and natural resource.* Could affect recreational beaches.
2. *Leisure opportunity.* Least effect of all sites considered.
3. *Aesthetic values.* SPM's would not be visible from shore. However, the storage facility and feeder berth would be visible inland.
4. *Community cohesion.* Negative effect.
5. *Public facilites and services.* Little or no effect.
6. *Income and employment.* Possible positive effect because of the depressed economy.
7. *Tax base.* Will increase tax base.
8. *Property values.* Little or no effect.
9. *Displacement.* None.
10. *Desirable community growth.* Undesirable.
11. *Desirable regional growth.* May be more desirable than in northern New Jersey.
12. *Existing laws.* The project would conflict with the Delaware Coastal Zone Act of 1971.

Alternative 18c - Atlantic Ocean - Local Monobuoy with Storage at Greenwich Township.

Description. This alternative consists of a series of SPM's located in the Atlantic Ocean about 25 miles off Delaware Bay. The buoys would be connected by buried pipelines coming ashore in Cumberland County, New Jersey to a tank farm located at Greenwich Township, Cumberland County. Distribution to the Delware River refineries would be by pipeline. The York River refinery would be serviced by tug-barge from a feeder berth located on the Delaware River.

Engineering criteria. All engineering critiera can be met.

Economic criteria.

1. *First cost.* $412,159,000
2. *Average annual cost.* $56,100,000
3. *Average annual benefit.* $92,300,000
4. *Average annual net benefit.* $36,200,000

Environmental criteria.

1. *Dredging.* None required.
2. *Water transport alterations.* None.
3. *Offshore vs. inshore.* Twenty-five miles offshore.

Socio-economic criteria.

1. *Man-made and natural resources.* Could affect coastal recreational beaches.
2. *Leisure opportunity.* Least effects of all sites considered.
3. *Aesthetic values.* SPM's would not be visible from shore. However, the storage facility and feeder berth would be visible inland.
4. *Community cohesion.* Negative effect.
5. *Public facilites and services.* Little or no effect.
6. *Income and employment.* Possible positive effect because of the depressed economy of the area.
7. *Tax base.* Will increase the tax base.
8. *Property values.* Little or no effect.

9. *Displacement.* None.
10. *Desirable community growth.* Undesirable.
11. *Desirable regional growth.* May be most desirable.
12. *Existing laws.* None violated.

Alternative 18d - Atlantic Ocean - Regional Monobuoy with Storage at Greenwich Township.

Description. This alternative consists of a series of SPM's located in the Atlantic Ocean about 25 miles off Delaware Bay. The buoys would be connected by buried pipelines coming ashore in Cumberland County to a tank farm located at Greenwich Township, New Jersey. Distribution to the Arthur Kill and Delaware River refineries would be by pipeline. The York River refinery would be serviced by tug-barge from a feeder berth located on the Delaware River.

Engineering criteria. All engineering criteria can be met.

Economic criteria.

1. *First cost.*	$650,662,000
2. *Average annual cost.*	$82,400,000
3. *Average annual benefit.*	$137,300,000
4. *Average annual net benefit.*	$54,900,000

Environmental criteria.

1. *Dredging.* None requied.
2. *Water transport alterations.* None.
3. *Offshore vs. inshore.* Twenty-five miles offshore.

Socio-economic criteria.

1. *Man-made and natural resources.* Could affect coastal recreational beaches.
2. *Leisure opportunity.* Least effect of all sites considered.
3. *Aesthetic values.* SPM's would not be visible from shore. However, the storage facility and feeder berth would be visible inland.
4. *Community cohesion.* Negative effect.
5. *Public facilites and services.* Little or no effect.
6. *Income and employment.* Possible positive effect because of the need to expand the economic base.
7. *Tax base.* Will increase the tax base.
8. *Property values.* Little or no effect.
9. *Displacement.* None.
10. *Desirable community growth.* Undesirable.
11. *Desirable regional growth.* May be most desirable.
12. *Existing laws.* None violated.

SUMMARY

There are several economically attractive sites for developing facilities to handle VLCC's. Each of those alternatives have been evaluated against the criteria that was established for the selection of the most logical alternative. Clearly, no one alternative can meet all of the established criteria. However, because of economics, if any alternative can be made environmentally acceptable and logical in the future it must be located along the length of shore between the New York harbor area and the Delaware Bay area. At the present time, it appears that the alternatives located in the Atlantic Ocean (14), (17) and (18) will most closely meet the established criteria and can be considered the most logical sites for development of offshore unloading terminals. In those areas oil spills should be reduced to a minimum and the effects of spills on the natural environment and coastal beaches enhanced most significantly.

FINANCIAL ANALYSIS

Construction of a facility to accommodate very large bulk carriers will require the outlay of large sums of money. Because of the magnitude of these expenditures, funds to construct these facilities will be borrowed and must be repayed to investors with interest. The costs charged for the use of the deep water facility must reflect all related interest and taxes paid by the operator. To determine the user charge, an analysis of the most economic sites was undertaken for several borrowing arrangements to determine the cost which operators would be required to charge for use of the terminal.

The financial analysis developed for this study represented a computerized analysis of annual cash flow data prepared for each alternative deep draft facility.[11] Initially, estimates of first costs at July 1972 price levels were prepared for the various components of each deep draft facility. Principle components of such facilities included, in order of decending cost; breakwaters, channels and maneuvering areas, storage facilities, pipelines to storage and refineries, miscellaneous features (building, electrical, mechanical, etc.), artificial islands, VLCC berths, monobuoys, feeder berths and environmental safeguards. Construction schedules were then prepared for each alternative, predicated on providing a sufficient lead time to meet crude oil imports projected for three target years-1980, 1990 and 2000. Those schedules, developed for alternative facilities required to handle both low and most likely projections of crude oil imports, were translated into computer format to facilitate cash flow analysis. Annual operation, maintenance and replacement costs were also estimated for each facility component. Annual costs and first costs of each facility component were analyzed in accordance with the following financial criteria, using government, revenue, and mortage bonding.

Government Financing:
- Bonding periods—15 and 25 years
- Interest rates—5.5, 7.0 and 10 percent

Private Financing:
- Bonding Periods—15 and 25 years
- Interest rates—8, 10, and 12 percent
- Debt to Equity ratio—80
- Federal and State taxes—55 percent
- Property taxes—4 percent at 80 percent valuation
- Profit—7 percent

Cash flow input, included the bonded costs of construction, annual operation and maintenance costs, and pumping energy costs. When privately financed the cost of Federal, state and local property taxes were also added to the input. The cash flow program analyzed this input, calculated the total annual cost for each year of project life and provided a cumulative total present worth value of the annual costs. The total present worth was then used to determine a fixed annual throughput charge over the life of the project which would provide for total payment of all costs of constructing, operating and maintaining each deep port alternative. The results of this analysis are shown in Table 34 for both government and private financing at selected discount rates for the projected low and most likely levels of crude oil imports to the North Atlantic Region.

Table 35 shows that, for the most likely level of crude oil imports, all listed alternatives could be financed by government with user costs ranging from $0.07 to $0.16 per barrel. However, for the same level of imports, private financing costs for these alternatives ranges from $0.11 to $0.21 per barrel. For low level projections of crude oil imports, government financing would result in throughput costs ranging from $0.11 to $0.20 per barrel. Private financing costs for the low level projection would range from $0.16 to $0.25 per barrel. Decisions regarding the use of such a facility must be based on the logistics problems of each private company. However, with respect to crude oil transportation cost, it is estimated that the cost for using a North Atlantic Region deep draft facility with subsequent transshipment to refineries should be less than $0.13 per barrel for a facility located in 80 feet of water and less than $0.14 per barrel for a facility located in 100 feet of water. These estimates represent the cost of direct shipment to refineries without use of a U.S. deep water terminal in the North Atlantic less the cost of direct shipment to a U.S. deep water terminal, discounted at a private discount rate of 10 percent. Although some shippers may be willing to pay more for a U.S. facility which might provide other tangible savings and would be safe from excessive taxes and political instability, any cost significantly more than that amount would probably cause shippers to

TABLE 35
SUMMARY OF UNIT THROUGHPUT CHARGES-
SELECTED DEEP DRAFT FACILITIES OF NORTH ATLANTIC REGION [1]
(Most Likely and Low Projections
of Crude Oil Imports, Years 1970-2000)
($/bbl)

ALTERNATIVE		METHOD OF FINANCING AND INTEREST RATE (%)					
		Government			Private		
No.	Location	5.5	7.0	10.0	8	10	12
(13 b)	Raritan Bay:						
	Regional— Sea Island	0.10	0.11	0.14	0.16	0.18	0.20
(14 a)	Atlantic Ocean:						
	Regional— Monobuoy	0.09 (0.16)	0.10 (0.17)	0.13 (0.20)	0.14 (0.22)	0.16 (0.24)	0.18 (0.25
(14 b)	Atlantic Ocean:						
	Regional— Monobuoy	0.07[2] (0.11)[3]	0.08 (0.12)	0.10 (0.14)	0.11 (0.16)	0.12 (0.17)	0.13 (0.18)
(15 a)	Delaware Bay at Big Stone Beach:						
	Local— Artificial Is.	0.07	0.08	0.11	0.12	0.13	0.14
(15 c)	Delaware Bay at Big Stone Beach:						
	Local— Sea Island	0.07 (0.11)	0.08 (0.13)	0.09 (0.15)	0.11 (0.17)	0.12 (0.18)	0.13 (0.20)
(15 d)	Delaware Bay at Big Stone Beach:						
	Regional— Sea Island	0.07 (0.11)	0.08 (0.12)	0.10 (0.15)	0.12 (0.17)	0.13 (0.18)	0.14 (0.20)
(17 b)	Atlantic Ocean:						
	Regional— Artificial Is.	0.10	0.11	0.16	0.17	0.19	0.21
(18 a)	Atlantic Ocean:						
	Local— Monobuoy	0.08 (0.14)	0.09 (0.15)	0.11 (0.18)	0.13 (0.19)	0.14 (0.21)	0.15 (0.22)

1 Unit throughput charges not affected by change in bonding period between range of 10-25 years investigated for this study.

2 0.07 — Unit throughput charge for most likely projection of crude oil imports (4 million barrels per day in year 2000).

3 (0.11) — Parentheses indicate unit throughput charge for low projection of crude oil imports (1 million barrels per day in year 2000).

use foreign deep water terminals and will cause increased oil spills as discussed in Chapter III.

Federal assumption of dredging costs for some alternatives might make them more financially attractive. For instance, assumption by the Federal Government of initial and maintenance dredging costs at the Big Stone Beach alternatives in Delaware Bay (15) would reduce facility throughput costs by about $0.02 per barrel.

INSTITUTIONAL AND LEGAL PROBLEMS

General

The construction and operation of a deep water port delivery system for petroleum and other bulk commodities poses a number of problems which may best be categorized as of a legal and institutional nature. Such problems are common to deep water ports in all U.S. coastal areas. Solutions must therefore be sought at the national level which will be applicable to deep water ports in any costal area. Considerable attention has been devoted to these problems by the Executive Branch in Washington, and some of them are provided for in the President's recommendations to Congress for legislation to amend the Outer Continental Shelf Lands Act and to authorize the Secretary of the Interior to regulate the construction and operation of deep water port facilities. Congress will be conducting hearings on the recommended legislation in the course of which additional information will be developed on legal and institutional issues related to deep water ports.

In accordance with the terms of the authorizing resolution, some consideration was given to institutional and legal issues in this study. However, for the reasons stated above, it was not considered appropriate to attempt to reach conclusions on the basis of a regional analysis beyond a definition of the public interest in deep water port development, some aspects of private and governmental roles, management and control, regulation and legal considerations. Research by private contractors is nearing completion which further examines in greater detail the institutional problems and implications of deep water ports on a national basis.

Public Interest

Previous chapters have shown the need for a deep draft facility in the North Atlantic Region. Traditionally, Federal interest in navigational facilities has been restricted to channel dredging and construction of breakwaters. However, the Government's interest in the development of deep draft facilities exceeds its traditional role. The number of economically feasible sites where such facilities may be developed is limited. Widespread concern that adequate and equitable deep draft facilities must be built to serve the nation's crude oil import needs has brought the Federal government into the investment decision process. Public interest in the development of those facilities requires the following conditions:

1. The most efficient use be made of required planning and construction time regarding all aspects of deep water port construction and operation, so that the facility will become available when needed;
2. Optimum economic efficiency within acceptable standards of environmental protection, so that potential economic benefits to the U.S. will be maximized;
3. Economic equity, so that no sector, region or group, will be unfairly advantaged or disadvantaged in economic terms beyond the requirements of optimum economic efficiency;
4. Environmental protection, so that change in and damage to the ecology and to human values are reduced to a minimum;
5. Environmental equity, so that no sector, region, or group shall be unfairly advantaged or disadvantaged by unavoidable change in or damage to the ecology and environment beyond the requirements of optimum economic efficiency, and the requirements of a balanced regional and national approach to land use and natural resource conservation.

Were deep water port development blocked or prolonged by local or regional opposition, as they have been in some cases, U.S. oil companies would probably rely on transshipment facilities in the Caribbean and Canada. It is highly possible that associated refineries and petrochemical plants would be exported to those locations and also to our detriment in terms of possible employment losses, balance of payment deficit and national security. The Federal government must act in behalf of the nation as a whole to protect our national interest.

Private and Governmental Roles

Problems emerge when either a private or a public organization is assigned complete responsibility for the deep water terminal. While allowing private interests to plan and develop deep draft facilites at will might optimize the prospects for an expeditious and economically efficient port, it would not be commensurate with economic equity. Deep water ports, as potential sources of substantial economic savings, may offer attractive investment opportunities and therefore stimulate intensive competition among private capital interests unrelated to the petroleum industry. Development of those industries at the port at the expense of both the country and another region in which a port does not exist could result. In addition, deep water terminals must be built in coastal waters that still must remain compatible with other uses; hence, the presence of a terminal could present serious environmental and social problems.

Public development of a deep water terminal on a national or local level could assure environmental protection and development on a national level could assure both environmental and economic equity. However, it is questionable whether the criteria optimizing time use and economic efficiency could be met because of funding and political decisions involved.

At state and local levels, attitudes toward deep water terminals and related landside impacts range from flat rejection on environmental grounds (North Atlantic Region), to competitive and aggressive campaigning for their economic benefits (Gulf Coast), frustrating the concept of environmental and economic equity. Clearly, planning for these facilities must be done jointly by the Federal government, local governments and industry. To effectuate this, an agency or group within the Federal establishment must be given the appropriate decision making and coordinating authority. That body should have a broad understanding of the term "public interest" as that term is defined differently by various agencies of government. *There is a need for an organizational mechanism to ensure that the decision-making process allows goals to be defined and weighed as objectively as possible.*

Management and Control

Beyond the Federal interest in planning these facilities, is an additional interest in their proper management and control. The two basic methods of exercising that management and control are by direct Federal ownership, or by such indirect means as sitings, operational standards, and regulations. In the past, ownership of most facilities similar to a deep water port, i.e. docking facilities and tank farms, has been private. The private sector has ample capital resources upon which to draw, and would prefer to own, build and operate deep water facilities in the North Atlantic Region. The case for public ownership of a terminal is based upon the likelihood of one or two companies acquiring a monopoly in what is now a largely competitive terminal operation. However, public ownership does not appear necessary to attain public goals, provided that the need for public control is accommodated by appropriate regulatory mechanisms.

From an operational viewpoint considerable technical skills and experience are essential elements in the actual operation of a deep water port facility. The private sector has virtually all of the necessary skills and public agencies do not. Consequently, private operation would probably be required even if the facility were under public ownership. The fundamental problems connected with allowing private operation of the facility are in the area of meeting the public goals for economic regulation and environmental protection.

Regulation

The scope of the regulations to be established will be determined by the need to provide for economic and environmental equity in any deep water port facility. Consequently, as a common carrier, a deep water port could encompass the following basic operational standards:

1. *Access to all qualified users, owners or otherwise.*
2. *Fair and nondiscriminatory financial conditions for all users.*
3. *First come, first served (taking into account advance scheduling arrangements) docking arrangements.*

While those standards are not new in the regulation of a common carrier the deep water port concept may require the government to reconsider their method of application. In the past the price which a user paid was proportional to the services rendered. However, pipeline or vessel transshipment to refinery distances often vary considerably, and under present pricing concepts the refineries farthest from the terminal pay most of its use. Consequently, were terminal prices to be based on present incremental cost concepts, the competitive relationships of the various refineries could be significantly affected. To ensure that the benefits of a terminal are shared equitably by all areas served, the pricing mechanism could be modified to assure all users an equitable cost from facility to refinery.

Environmental controls must be applied to minimize the adverse environmental impact of system operations, including accidents, and to indicate the means for rapidly and effectively coping with them when and if they arise. Controls should include:

1. *Provision of new traffic lanes or fairways for exclusive use of VLCC's, to minimize possibilities of collision.*
2. *Strict limits on operating speeds of VLCC's in designated coastal waters and on permissible distances between vessels in motion.*
3. *Required use of the most advanced navigational aids and communications systems.*
4. *Training and testing of key personnel who actually operate terminal facilities, especially those involving cargo-transfer, piloting, etc.*

In addition, operational policies and standards must be developed and implemented. To insure compliance periodic inspection will be necessary. Finally, the effectiveness of environmental protection efforts will be dependent upon the enforcement procedures implemented. Those should include penalties of a severity sufficient to discourage noncompliance, regardless of whether the facility is privately or publicly operated.

Federal Legislation

Legal aspects of a deep water terminal increase in complexity as the location of such a facility proceeds from territorial waters (up to 3 miles), to a contiguous zone of limited jurisdiction (3 to 12 miles) within the high seas and finally to the high seas (beyond the 12-mile limit).

Article 1 of the *1958 Geneva Convention on the Territorial Sea and the Contiguous Zone* states:

"The sovereignty of a State extends to a belt adjacent to its coasts, described as the territorial sea.[27]". Except for a foreign vessel's right of innocent passage, a coastal nation may legislatively control activities in its territorial sea to the same degree and extent as it controls activities in its land areas. The United States recognizes a three nautical mile limit as the extent of its territorial waters. The United States has viewed any extension of the territorial sea beyond this limit as an encroachment of the high seas. In addition, the Submerged Lands Act[28] fixes at three miles the boundaries of the Atlantic and Pacific littoral States. Sovereignty within this belt is shared between the Federal government and the adjacent coastal states except where an entire area of law has been pre-empted by the Federal government or where Federal law or policy conflicts with that of the state. There would be a few difficulties from an international law point of view should a deep water terminal be located within territorial waters.

The United States has exercised control over certain domestic matters within a limited zone of the high seas contiguous to the territorial sea since the early 19th century. Provision for the exercise of limited controls in this zone is contained in Article 24 (1) of the 1958 Convention which permits a coastal state to establish a contiguous zone and exercise controls necessary to prevent infringement of its customs, fiscal, immigration or sanitary regulations within its territory or territorial sea. In accordance with the 12-mile contiguous zone limitations imposed by Article 24 (2) for the 1958 convention, the United States recognizes a 9-mile contiguous zone adjacent to its 3-mile territorial sea.

The United States could exercise greater jurisdiction over a deep water terminal in the contiguous zone than it could over a facility on the high seas but less than it would possess over its own territorial waters. The importation of oil and the control of oil pollution are clearly within the contiguous zone jurisdiction of the United States. However, jurisdiction to regulate customs, fiscal, immigration or sanitary conditions, does not provide the authority to regulate all activities which could occur at a deep water oil terminal, e.g. civil or criminal liability. Should serious consideration be given to developing a facility within the contiguous zone, it would be advisable to evaluate the specific impact of the United States recent proposal on establishing a 12-mile territorial sea limit.[29] This proposed agreement will be considered at the United Nations Law of the Sea Conference scheduled for 1973.

Environmental considerations appear to favor offshore rather than estuarine sites for a deep water oil terminal. The following portions of this legal review focus on the applicability of existing international and domestic law as it relates to the development of a deep water oil terminal on the high seas. Because of limited Federal interest in developing such a facility, this review is restricted to an analysis of private construction and operation of a deep water oil terminal. The facility in question would be either an offshore island, a sea island or a monobuoy. Transportation of oil between the facility and shore points would be via pipeline or small feeder vessels.

As a matter of international law, the construction and operation of deep water oil terminals on the high seas may be considered a "reasonable use" of the high seas. Although sovereignty over the high seas cannot be asserted, physical uses consistent with the activities of other high sea users are permitted. A facility must not unduly interfere with international navigation lanes, submarine pipelines, marine research, foreign fishing or navigation. In the modern concept of navigation, deepwater oil terminals would be an acceptable adaptation of high seas usage. Also, as construction will be restricted to the continental shelf of the United States, such a facility would not interfere with continental shelf resource rights of other nations.

While the "reasonable use" theory does not provide a means by which the United States could extend its jurisdiction to individuals or ships within the deep water terminal or its nearby waters, it is believed that Federal jurisdiction over the terminal operator would be similar to an assertion of jurisdiction over persons on U.S. flag vessels. Since a terminal and a ship on the high seas are both places where people can live and work and a terminal would have a more intense connection with the United States than would a flag ship, the assertion of jurisdiction over persons at the terminal would require only limited modification of existing international law.

Extensive jurisdictional problems arise when considering the question of jurisdiction over ships docked either at a terminal or in nearby waters. No complications arise concerning jurisdictional rights over U.S. vessels. However, no convention or treaty exists which would permit the exercise of jurisdiction over foreign vessels in these areas.

As a matter of domestic law, Congress has ample legislative power under the Commerce Clause as well as the maritime power to authorize construction and regulate operation of deep water oil terminals on the high seas. Vessels and crews using the terminals or anchoring in nearby waters would be subject to Federal jurisdiction. Although the above persons and vessels may not be U.S. citizens or domestically owned, their involvement with this country's export-import operations would be sufficient to provide the necessary jurisdictional base. Such jurisdiction would also apply to ships which do not intend to use the facility but may otherwise interfere with safe operations.

An analysis of existing legislation was undertaken to determine the regulatory powers of various Federal agencies which could permit them to license the construction and operation of a deep water terminal on the high seas within the confines of the continental shelf. Review of the provisions of the *Outer Continental Shelf Lands Act*[30] shows that the Federal Government has assumed jurisdiction, control, and power of disposition over the lands of the outer Continental Shelf. In addition the Corps of Engineers has the authority to regulate offshore deep port developments. That review also indicated the existence of apparent overlapping authority between the Department of the Interior, the Department of Transportation, the Coast Guard and the U.S. Army Corps of Engineers for licensing such a facility on the continental shelf. However, there is no basis for determining the number of permits to be issued or which applicant should be issued a permit if two or more apply at the same location. It therefore becomes necesary to clarify existing statutory authorities as recognized in the President's recent Energy Message[8] and designates a single Federal agency with the necessary licensing authority and to provide it guidelines under which to operate.

The necessity to establish proper licensing requirements for those wishing to construct or operate a facility on the high seas is obvious. The owner or operator of such facility should be either a United States citizen or, if it is a foreign corporation or other business entity, it should be organized under the laws of the United States, or one of its states or possessions, to insure that the owner or operator is subject to suit in State or Federal courts in the event of improper operations. Neither adequate laws nor licensing requirements exist requiring the facility owner or operator to post a bond or other form of warranty to insure financial responsibility in the event of damage arising from operation of the facility.

The U.S. Coast Guard has statutory authority to enforce safety and shipping regulations within the navigable waters of the United States (12 miles). The Department of the Interior has its own authority, over the leasing of lands from seaward to the 3-mile limit where the authority of the individual states comes into play. The Department of Transportation has certain rights over the construction and operation of pipelines. The Army Corps of Engineers also has authority within the navigable waters of the United States to permit the erection of structures, to remove unauthorized obstructions to navigation and to regulate certain other activities to insure safety[32]. Although the authority to prevent obstructions extends to the outer continental shelf[33] and might apply to waters encompassing a deep water terminal, such authority relates only to obstructions. Consequently, legislation would be required to extend both the Corps' and Coast Guard's authority to deep water terminal waters. Further, some minor modification of existing international conventions would be required to insure that the Coast Guard has the necessary regulatory authority within terminal waters.

The National Environmental Policy Act of 1969[34] would require the preparation of an environmental impact statement for a proposed deep water oil terminal, whether proposed by Federal or private interests, due to significant Federal regulatory involvement. To insure applicability to deep water terminals, existing international conventions and statutory provisions which pertain to environmental matters associated with deep water terminal operations, e.g., the control of solid or liquid waste discharges by ships or the disposal of other pollutants, would need to be modified in this regard.

Current regulations are ambiguous in their application to storing commodities at the terminal or transshipping them from the terminal to shore points via pipeline or feeder vessels. New Federal regulations are required to maintain minimum safety and environmental standards for storage and transshipment outside the territorial waters of the United States. Present regulatory authority in these areas of activity is delegated to the Department of Transportation and the U.S. Coast Guard and pertains only to the navigable waters of the United States.

The Bureau of the Customs administers the laws dealing with the control of imports and also enforces the coastwise laws, which require that ships operating between ports in this country be United States vessels. These laws in their present form will need to be amended to apply to deep water terminals. Customs operations could be expedited either on shore or at the terminal depending on the extent of the facilities available at a deep water terminal. If they are to be undertaken at the terminal, it would become necessary to designate the terminal a port of entry[29]. New legislation relevent to these operations should contain criteria for distinguishing between the different types of deep water terminal facility.

The construction and operation of a deep water terminal would require a large number of people to live and work beyond the territorial limits of the United States. The state and Federal civil and criminal codes would not be applicable to this facility unless so extended by new Federal legislation. The *Longshoremen's and Harbor Worker's Compensation Act*, important to workers involved in the construction of a terminal, currently applies only to injuries sustained during employment upon the navigable waters of the United States. Under present state laws, local officials whose jurisdictions are necessarily limited, regulate building and health codes. Consequently, applicable codes would have to be developed and an administrative agency delegated to enforcement responsibility for the development, operation and maintenance of deep water terminal.

Conflicts between state and Federal jurisdictions whether the facility is offshore or onshore are not unique to a deep water terminal. Measures necessary to alleviate these conflicts are either available or capable of being established.

State Legislation

New Jersey. No statutes presently exist which either affirmatively prohibit or authorize such a facility. However, it has been proposed by the New Jersey legislature that a coastal development bill be enacted. Such a statute could ban a bulk transfer facility of the type under consideration within State waters and industrial growth in certain portions of the State. This statute, nevertheless, would not directly affect a facility off the New Jersey coast seaward of the three-mile limit.

New Jersey, while it cannot impose its jurisdiction upon a deep water port facility located beyond the three-mile limit, can impose some reasonable measure of regulation upon facility structures (i.e., pipeline, tank farm(s), and pumping stations) within the three mile limit. The statutes which provide the basis for such regulation are:

1. Title 13 N.J.S.A. Sec. ID-1 *et seq.* established the New Jersey Department of Environmental Protection (DOEP).
   a. DOEP is empowered to enforce all of New Jersey's antipollution laws and regulations within New Jersey's territorial limits (13 N.J.S.A. Sec. ID-9(n)).
   b. DOEP has established a permit procedure whereby the approval of DOEP must be obtained as a condition precedent to the initiation of any activity which has a potentially adverse environmental effect (13 N.J.S.A. Sec. ID-9(N)).
   c. The Natural Resources Council of DOEP is the leasing agent for riparian lands in New Jersey. However, the concurrence of the Commissioner of DOEP and the Governor must also be obtained before such a lease can have legal effect (13 N.J.S.A. Sec. IB-13).
   d. The laying of pipelines under the tidal waters of the State without the consent or permission of the Governor and the Commissioner of DOEP is prohibited (12 N.J.S.A. Sec. 3-26).
2. *The Coastal Wetlands Act of 1970* (13 N.J.S.A. Sec. 9A-1 *et seq.*) empowers DOEP to regulate the dredging, filling, or altering of the estuarine zone of New Jersey. Any activity which is statutorily defined as regulated is prescribed prior to the issuance of a permit.
3. *The New Jersey Water Quality Improvement Act of 1971* (58 N.J.S.A. Sec. 10-23. *et seq.*) empowers New Jersey, through DOEP, to impose or levy upon a person who discharges petroleum products or hazardous substances into the waters of New Jersey the costs of removal, and, if warranted, fines and penalties.

Delaware. In 1971 Delaware enacted the *Coastal Zone Act* (7 Del. C. Sec. 7001 *et seq.*). This statute specifically bans all heavy industry and offshore bulk transfer facilities in the coastal zone limits of Delaware. The aforementioned limits include the waters of Delaware Bay within the territorial boundaries of Delaware and the waters of the Atlantic Ocean seaward to the three-mile limit. In addition, a permit procedure was established whereby all uses of the coastal zone must be authorized by the State Coastal Zone Industrial Control Board. If the facility is located within the three-mile territorial sea limit, the *Coastal Zone Act* would be applicable. Any deep water port facility would, therefore, be prohibited within either the coastal waters of Delaware or Delaware Bay. If the facility is located beyond the three-mile limit, the *Coastal Zone Act* is not applicable since that line is the exterior limit of Delaware's territorial jurisdiction. However, while the facility itself would not be subject to the statute's restrictions, its appurtenances, i.e., pipeline, tank farm (s) and pumping stations, arguably could be.

Delaware can impose some reasonable measure of regulation upon the appurtenances of a deep water port facility even though the facility itself is located beyond the three-mile limit. The statutes which provide the bases for such regulation are:

1. Title 29 Del. C. Sec. 8001 *et seq.* established the Delaware Department of Natural Resources and Environmental Control (DONREC) to oversee the administration and enforcement of Delaware's conservation regulations then in force or to be enacted in the future.
2. DONREC is empowered to promulgate and enforce rules and regulations including a permit procedure as a means of controlling the pollution of the waters of the State (7 Del. C. Sec. 6001 *et seq.*)
3. DONREC is also empowered under 7 Del. C. Sec. 6001 *et seq.* to promulgate and enforce rules and regulations including a permit procedure as a means of controlling air pollution in Delaware.
4. DONREC with the concurrence of the Governor has exclusive jurisdiction to convey or lease any of Delaware's subaqueous lands (7 Del. C. Sec. 6451).
5. The *Coastal Zone Act* (7 Del. C. Sec. 7001 *et seq.*) empowers the State Coastal Zone Industrial Control Board to regulate industrial development in a statutorily defined "coastal zone" through a permit procedure. While the appurtenances of the facility under discussion would not be prohibited, it is highly probable that the permit procedure would be applicable.

With regard to the alternate sites in Delaware Bay and Raritan Bay adequate legislation exists whereby complete supervisory authority could be exercised by either the Delaware River and Bay Authority (32 N.J.S.A. Sec. 11E-1 *et seq.*) or the New York-New Jersey Port Authority (32 N.J.S.A. Sec. 1-1 *et seq.*) Both agencies are empowered to purchase, construct, lease, and operate any type of marine terminal facility within their jurisdictional boundaries. But because both agencies are creatures of Congressionally approved interstate compacts, the concurrent approval of the States is required for the initiation of any project. (Art. IV *Delaware-New Jersey Compact,* Pub. L. 87-678, 20 Sept. 1962; Art. III, VI, VII; *Compact of April 30, 1921, Pub. Resolution No. 17, 67th Congress,* S.J. *Res. 88,* 42 Stat. 174). Moreover, the Governors of the respective States have an absolute veto power over any proposed project (Id., Art VI; Art XVI).

SUMMARY

There are alternative deep draft facilities which appear financially feasible and within the legal rights of the United States to develop. In addition, there is significant public interest in the planning, development, and operation of deep water ports. A need also exists for a mechanism to ensure that all goals in the decision-making process will be defined and weighed as objectively as possible, especially in the planning phases of deep port development. However, the attainment of public goals in the management and control of a deep draft terminal does not require public ownership. Rather, the public interest would appear to be served best by allowing private ownership and operation under a permit system, with appropriate economic and environmental control sanctions placed upon the operation of the facility. In addition, there is no precedent for Federal development of port facilities of this nature.

Several Federal agencies have overlapping authorities to permit and regulate this type of facility. In addition, some existing statutory authorities need clarification. The need for action to resolve many of the institutional and jurisdictional problems has been recognized in the President's recent Energy Message.

The States have authority to issue permits for construction within territorial waters. In this area, both the Federal Government and the States would exercise joint control over a deep water terminal. In addition, the control which the States must exercise can be used to limit pipeline throughputs and undesired landside impacts resulting from industrialization. In addition, *State land use zoning bills such as those enacted in Delaware and proposed in New Jersey can also limit any undesirable industrial growth.*

GENERAL

Petroleum products refined in, or transferred through, the North Atlantic ports are distributed to major tributary areas in the northeastern and mid-western United States, including New England, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, and parts of Ohio. In the event of a national emergency, it will become necessary to somehow satisfy the region's heat, electricity, and transportation requirements. Oil now supplies 60 percent of all energy consumed along the East Coast. While some energy source substitution could be made in the electrical utility, industrial, commercial, and residential energy sectors, oil will continue to satisfy almost the total transportation requirement.

Were a major VLCC unloading facility out of operation, an alternative method of supply would have to be rapidly implemented or alternative means of unloading deep draft vessels would be required. Because of the wide dispersion and size of North Atlantic storage terminals, their continued availability is a reasonable assumption. Similarly, it is unlikely that all refineries in the region (Table 36) would be inoperable. These refineries provide almost 1.4 million barrels of product daily. In addition, petroleum storage for over 200 million barrels is available at widely dispersed locations (Table 37).

The regional facility under consideration would chiefly handle crude petroleum imported in VLCC's. Petroleum products will in all likelihood continue to be landed in smaller vessels at various ports along the North Atlantic Coast, and many of them might be utilized in an emergency.

TABLE 36
NORTH ATLANTIC REGION
PETROLEUM REFINING CAPACITY
(January 1, 1972)

Location	Capacity (Bbls/Day)
New York Harbor Area	
Linden, N. J. (Exxon)	272,000
Port Reading, N. J. (Amerada-Hess)	70,000
Perth Amboy, N. J. (Chevron)	80,000
Delaware River	
Westville, N. J. (Texaco)	91,000
Paulsboro, N. J. (Mobil)	90,800
Philadelphia, Pa. (Atlantic-Richfield)	160,000
Philadelphia, Pa. (Gulf)	168,500
Marcus Hook, Pa. (B P)	104,800
Marcus Hook, Pa. (Sun)	158,000
Delaware City, Del. (Getty)	140,000
Norfolk Area	
York River, Va. (American)	51,000
TOTAL	1,386,100

TABLE 37
NORTH ATLANTIC PORTS
PETROLEUM STORAGE CAPACITY[1]

Port	Number of tanks	Capacity (bbls)
Searsport, Maine	8	642,000
Portland, Maine	14	137,000
Portsmouth, New Hampshire	NA	NA
Salem, Mass.	NA	NA
Boston, Mass.	365	15,131,000
Fall River, Mass.	100	3,362,000
Providence, R. I.	442	8,616,000
New London, Conn.	38	1,050,000
New Haven, Conn.	182	6,362,000
Bridgeport, Conn.	58	1,871,000
New York, N. Y. & N. J.	3,428+	93,775,000
Albany, N. Y.	249	11,031,000
Port Jefferson, L.I. , N.Y.	53	850,000
Delaware Bay	1,809	61,508,000
Baltimore, Md.	493	14,910,000
Potomac River, Md.	NA	NA
York River, Va.	NA	680,000
Hampton Roads, Va. (Norfolk and Newport News)	363	9,610,000
TOTAL	7,602+	229,535,000+

[1]Does not include numerous private facilities outside the indicated port limits.

EMERGENCY DEMAND

National defense fuel requirements would be less than normal requirements. Assuming fuel rationing and curtailment of non-essential activities, petroleum product requirements for defense are estimated at 25 percent of our present East Coast demand of 11 million barrels per day. Of this, about seven million barrels per day are consumed either directly or indirectly as energy fuel. Since the North Atlantic Region consumes about five million barrels of oil per day, the required petroleum products needed for an emergency would be about 1.25 million barrels per day.

Alternative Petroleum Supply Sources

1. *Pipelines.* North Atlantic coastal ports are served by a number of clean petroleum products pipelines (Figure 30). While these lines are unsuitable for delivering crude or residual fuel oil during an emergency, they do offer alternatives to assure a continued flow of products to the region in the event that deep draft facilities were disabled for any length of time.

a. *Colonial Pipeline:* Originating in the Houston/Galveston refining territory, the largest pipeline in the United States passes through major refining centers in Louisiana, gathering products for delivery throughout the eastern United States. By connections to other pipelines, petroleum can be gathered from many major Texas and Louisiana refineries. Important delivery points include Norfolk, York River, Baltimore, Marcus Hook, Paulsboro, Philadelphia, Trenton, and New York Harbor. A connection with the Buckeye pipeline extends service to Long Island. Presently, the Colonial line can deliver 732,000 barrels per day to the northeastern United States through its 32 inch pipe, with an ultimate capacity of 930,000, barrels per day.

b. *Plantation Pipeline:* The second largest products line from the Gulf coast generally parallels the route of the Colonial line. Although this line ends at Washington, D.C., it also serves a major section of the North Atlantic Coast and has a capacity of over 400,000 barrels per day.

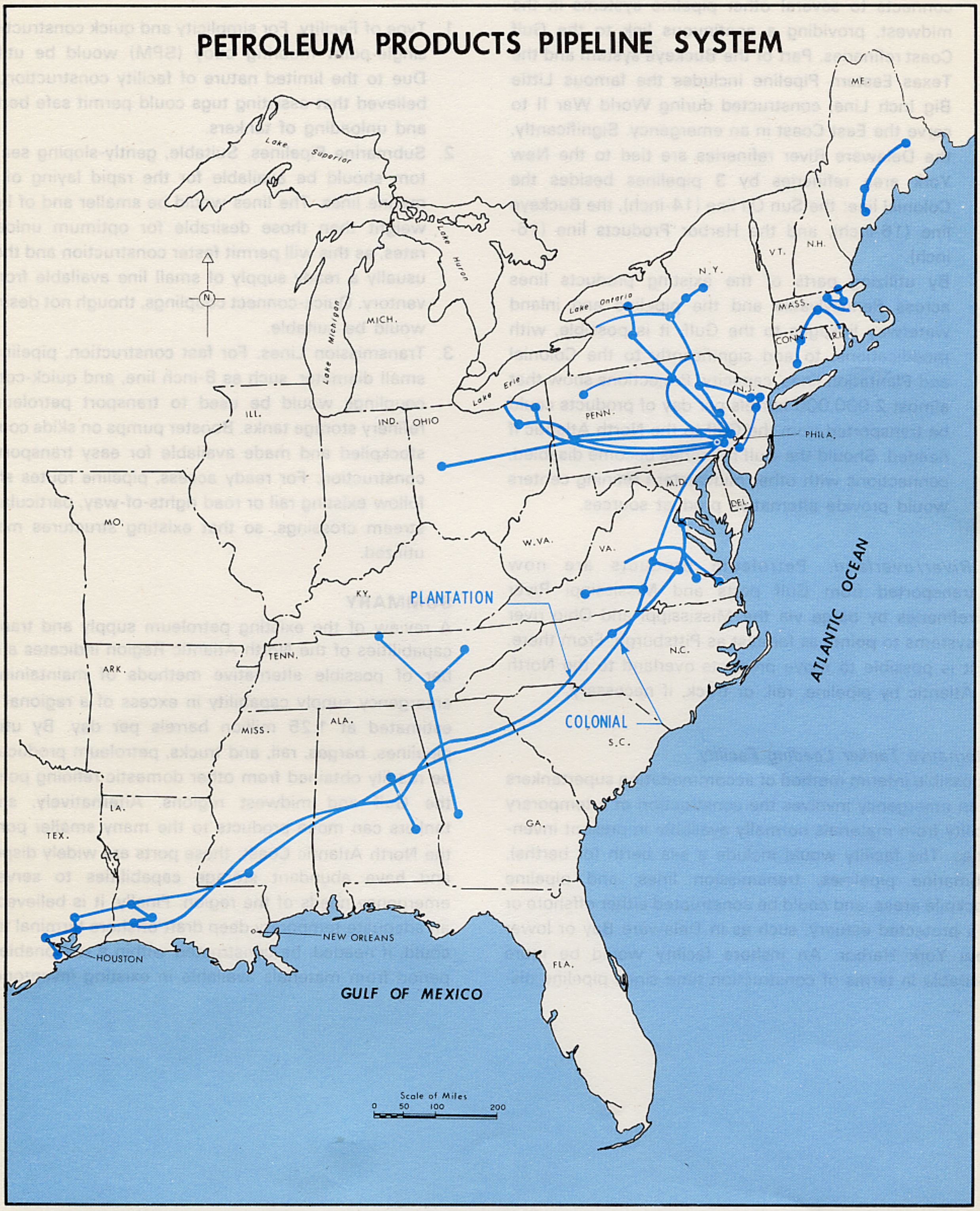

PETROLEUM PRODUCTS PIPELINE SYSTEM
Lake Superior
Lake Huron
Lake Michigan
Lake Ontario
Lake Erie
ME.
VT.
N.H.
MASS.
CONN.
N.Y.
N.J.
PENN.
PHILA.
M.D.
DEL.
MICH.
ILL.
IND.
OHIO
MO.
W.VA.
VA.
KY.
TENN.
N.C.
S.C.
ARK.
MISS.
ALA.
GA.
LA.
TEX.
FLA.
HOUSTON
NEW ORLEANS
PLANTATION
COLONIAL
GULF OF MEXICO
ATLANTIC OCEAN
Scale of Miles
0 50 100 200

Figure 30

c. *Other Lines:* At least six product pipelines cross Pennsylvania to serve the western part of the State, Ohio, and points west from the refining centers on the Delaware River. Two lines continue to the New York area refineries. The major Buckeye Pipeline connects to several other pipeline systems in the midwest, providing a continuous link to the Gulf Coast refineries. Part of the Buckeye system and the Texas Eastern Pipeline includes the famous Little Big Inch Line, constructed during World War II to serve the East Coast in an emergency. Significantly, the Delaware River refineries are tied to the New York area refineries by 3 pipelines besides the Colonial line: the Sun Oil line (14-inch), the Buckeye line (16-inch), and the Harbor Products line (16-inch).

   By utilizing parts of the existing products lines across Pennsylvania and the pipeline and inland waterway linkages to the Gulf, it is possible, with modifications, to add significantly to the Colonial and Plantation lines' capacity. Projections show that almost 2,000,000 barrels per day of products could be transported from the Gulf to the North Atlantic if needed. Should the Gulf refineries become disabled, connections with other midwestern refining centers would provide alternative product sources.

2. *River/overland:* Petroleum products are now transported from Gulf ports and Mississippi River refineries by barge via the Mississippi and Ohio river systems to points as far east as Pittsburgh. From there, it is possible to move products overland to the North Atlantic by pipeline, rail, or truck, if necessary.

Alternative Tanker Loading Facility.

A possible interim method of accommodating supertankers in an emergency involves the construction of a temporary facility from materials normally available in present inventories. The facility would include a sea berth (or berths), submarine pipelines, transmission lines, and pipeline stockpile areas, and could be constructed either offshore or in a protected estuary, such as in Delaware Bay or lower New York Harbor. An inshore facility would be more desirable in terms of construction time since pipeline distance would be shorter and construction operating conditions easier to control. However, the restricted depths in Delaware Bay and New York Harbor could require lightering operations. The limiting depths are 62 feet in the former case and 45 feet at mean low water in the latter.

1. Type of Facility. For simplicity and quick construction, a single-point mooring buoy (SPM) would be utilized. Due to the limited nature of facility construction, it is believed that assisting tugs could permit safe berthing and unloading of tankers.
2. Submarine Pipelines. Suitable, gently-sloping sea bottom should be available for the rapid laying of submarine lines. The lines would be smaller and of lighter weight than those desirable for optimum unloading rates, as this will permit faster construction and there is usually a ready supply of small line available from inventory. Quick-connect couplings, though not desirable, would be suitable.
3. Transmission Lines. For fast construction, pipelines of small diameter, such as 8-inch line, and quick-connect couplings would be used to transport petroleum to refinery storage tanks. Booster pumps on skids could be stockpiled and made available for easy transport and construction. For ready access, pipeline routes should follow existing rail or road rights-of-way, particularly at stream crossings, so that existing structures may be utilized.

SUMMARY

A review of the existing petroleum supply and transport capabilities of the North Atlantic Region indicates a number of possible alternative methods of maintaining an emergency supply capability in excess of a regional need estimated at 1.25 million barrels per day. By utilizing pipelines, barges, rail, and trucks, petroleum products can be readily obtained from other domestic refining points in the Gulf and midwest regions. Alternatively, smaller tankers can move products to the many smaller ports on the North Atlantic Coast; these ports are widely dispersed and have abundant storage capabilities to serve the emergency needs of the region. Finally, it is believed that an adequate temporary deep draft offshore terminal facility could, if needed, be constructed within a reasonable time period from materials available in existing inventories.

GENERAL

At the outset of the study, public meetings were held in Portland, Maine; Boston, Massachusetts; New York, New York; Bridgeton, New Jersey; Philadelphia, Pennsylvania; Dover, Delaware; Baltimore, Maryland; and Norfolk, Virginia. Although there were some expressions of need and desire for deep draft vessels, most of the speakers at those meetings were opposed to development of deep draft facilities near their own communities.

At the Portland meeting, there was a generally negative reaction to locating deep draft facilities in Maine. Although the Governor of Maine was represented there, the State refrained from taking an official position, since a state directed Task Force study on development of the Maine coast was still in progress.* Deep draft facilities at Eastport and Portland were recommended for development by their respective city governments. Significant opposition was expressed at the Boston meeting to developing facilities in the Vineyard Sound and Narragansett Bay areas. Proponents for facilities in Massachusetts Bay did make statements. At the New York meeting, there was opposition to developing facilities in Long Island Sound and in the Raritan Bay and Sandy Hook, New Jersey areas. However, Congressional interest in developing a port in the New York area was indicated. At the Bridgeton, Philadelphia and Dover meetings, both proponents and opponents of deep draft port were represented. Several proposals were offered, including one by a representative of the Delaware Bay Transportation Company, a consortium of 14 oil companies, to develop facilities in Delaware Bay at Big Stone Beach, Delaware. The Governor of Delaware indicated his personal desire to transfer the lightering operations currently being carried on in Delaware Bay to an offshore facility on the continental shelf. However, he indicated that his State's decision would have to be delayed until the completion of a report by his State's Delaware Bay Oil Transport Committee which was studying the problem.** At Baltimore, opposition emerged against the development of either petroleum or iron ore rehandling facilities in Chesapeake Bay. It appeared that industry representatives believed that deepening existing channels to Baltimore was the most economic solution to their iron ore supply problems. In Norfolk, the Vice-Chairman of the Governor's Council on the Environment indicated that, while an offshore facility for VLCC's would have a significant negative environmental impact, it would be less harmful than intensive inshore dredging.

In December and January 1972-1973, two additional series of public meetings were held near the tenative deep water port sites at Erma (Cape May County) and Middletown (Monmouth County), New Jersey, and at Rehoboth Beach, Delaware, to inform local residents of the progress made on the study and to gauge public opinion. Reactions obtained were extremely vocal and almost uniformly negative. At the first meeting, at Erma (Cape May County), Congressional, State, and local representatives joined in presenting a petition bearing 40,000 signatures against locating a deep water facility in their area. Many local officials opposed construction of a facility because of the impact that oil spills might have on the resort industry. It was stated that the psychological effects resulting from news coverage of spills which did not reach the shore could significantly impair the local economy. In addition, some feared the heavy industrialization which has occurred at other oil import terminals. Such industrialization, they claimed, would not be compatible with the resort elements of their economy. Questions were also raised regarding the advisability of undertaking port development to import oil, which might not be needed after the turn of the century, at the expense of the seashore resources which will be needed long after that time.

Presentations favoring a facility were made by a representative of the Delaware Bay Transportation Company, who recommended a deep water terminal in lower Delaware Bay at Big Stone Beach, and by a representative of Intercontinental Pipeline Company, Inc., who proposed an SPM pipeline-connected facility in the Atlantic Ocean, thirty-five miles off Cape May, New Jersey. A representative of the

*The study, now completed, concludes that both refineries and terminals should be limited to Casco Bay for the present, with Machias Bay a possibility later.

**Since that time the committee has completed its study. The committee recognized the growing problem resulting from lightering and oil traffic in Delaware Bay and recommended that a port be developed in the Bay if no alternative could be found.

Atlantic City Electric Company supported a monobuoy proposal, while spokesmen for the Delaware Valley Council and the Joint Executive Committee for the Improvement and Development of the Philadelphia Port Area favored other facilities at Big Stone Beach. The Mayor of Greenwich Township, New Jersey, offered property in his community as the site for a possible tank farm. Almost all of the other speakers were in opposition.

The meetings at Middletown and Rehoboth Beach were virtual recapitulations of the Erma meeting, with strong local opposition to any facility. At Middletown, several Congressmen and New Jersey legislators indicated that they would introduce legislation in their respective legislatures to ban all deep port development within their State's territorial waters. The popular mood conveyed a distaste for any facility, necessary or not, and a desire to locate it elsewhere. A spokesman for Intercontinental Pipeline Company, Inc. also spoke at this meeting indicating his company's willingness to construct a facility off the northern New Jersey coast, if desirable.

At Rehoboth Beach, the Governor of Delaware voiced his opposition to any facility, as did the State's Congressional representatives, and all State and local officials present. A spokesman for the Delaware Bay Transportation Company spoke in favor of its proposal for a facility off Big Stone Beach, Delaware. These meetings were heavily attended, with 300, 400, and 700 people at Erma, Middletown, and Rehoboth, respectively. There were 29 speakers at Erma, 45 at Middletown, and 39 at Rehoboth Beach.

The purpose of the final set of meetings was to solicit views from local interests on the conditions which should be made a part of any permit that might be issued for building or operating a deep water terminal. Although these meetings were less heavily attended than those of the previous series, opposition was just as vocal. Speakers did not address the conditions which should be attached to permits. Instead, they indicated that they would rather not have the facility. Many speakers, including one representing the Governor of New Jersey, indicated a fear that potential landside impacts could not be controlled and that the environmental and social costs associated with development of a terminal exceeded its potential benefits. As a result, the Governor opposed any of the deep port facilities considered in waters along the New Jersey coast. At Rehoboth Beach, a representative of the Governor of Delaware indicated that proposals in that State would be prohibited by its Coastal Zone Act. Suggestions for conditions to be placed on any permits issued included (1) total liability for oil spills on the part of the ship owner, and (2) jail sentences for shipping and oil company executives whose companies are responsible for oil spills or other environmental degradation.

SUMMARY

Several proposals have been advanced by private industry for developing facilities to accept VLCC's in the North Atlantic Region. However, those people who live in the vicinity of any site considered by industry or this study have, through their elected representatives and appointed officials, expressed almost unanimous opposition to every proposal for deep port facilities that has been advanced. That opposition stems mostly from (1) fears of large oil spills at sea, and (2) induced industrialization of the hinterland—which, historically, local government has not been able to control.

GENERAL

There is a need to import crude oil into the North Atlantic Region by vessel. At present, all of the crude oil refined in the North Atlantic Region is moved by sea-going vessel. Since no crude oil is produced in that region, movement of crude oil to the North Atlantic refineries will continue in the future. Alternatives to such movement (e.g., increasing domestic production of crude oil, reducing energy demands and substituting other types of energy for petroleum) may be feasible in the long term; however, they will not alleviate present needs for crude oil imports nor those which will exist in the near future.

The projected quantities of crude oil will come mostly from the Middle East and North Africa. In the past, most of the crude oil refined in the North Atlantic Region was produced along the U.S. Gulf Coast and in Venezuela. However, the reserves of these two areas can no longer keep pace with demands. As a result, it appears likely that Gulf Coast production will be used to satisfy Gulf Coast and mid-west demands, while Venezuelan crude oil will be consumed in South America. The only major substitute sources of crude oil remaining are expected to be in the Middle East and North Africa.

The shift in sources of crude oil will lead to the use of very large crude oil carriers (VLCC's) to service North Atlantic Region refineries. If facilities to accommodate vessels in the 250,000 to 500,000 DWT range are not available in the North Atlantic, those vessels will unload all or a portion of their crude oil cargo at foreign ports, such as those that are now available in Nova Scotia or the Bahamas.

Partially loaded tankers will continue to the North Atlantic for further lightering in the Delaware Bay and New York harbor area. The portion of the cargo removed will be shipped to the North Atlantic refineries in smaller vessels capable of entering North Atlantic harbors. These transshipments through foreign ports will increase the number of vessels using North Atlantic ports and the number of lightering and cargo handling operations. As a result, the probability of vessel collisions and oil spillage in the coastal waters of the North Atlantic, particularly in Delaware Bay and New York harbor areas, will grow. Also, the increased distances travelled and the extra cargo handling costs will raise transportation costs.

Provision of facilities to accept VLCC's in the United States would be preferable to allowing current trends to continue unchecked. Studies conducted by the Council on Environmental Quality and others indicate that the probability and quantity of oil spills would be substantially reduced by providing facilities to accept VLCC's, and serving the refinery complexes by pipeline. In addition, those facilities would enable reductions in the cost of transporting crude oil to the North Atlantic.

Facilities to accept VLCC's serving the refinery complexes of the North Atlantic should be located in the North Atlantic. Two alternatives to developing deep draft facilities in the North Atlantic Region were considered: (1) development of a fleet of large shallow draft vessels; and (2) development of a deep draft facility on the Gulf Coast. The shallow draft vessel alternative has finite limits imposed by structural considerations and also poses potential safety problems. A fleet of these specially designed vessels would be more costly in both capital and operating costs than either conventional VLCC's transshipping from foreign terminals or a deep draft facility in the North Atlantic Region. Consequently, their use in lieu of deep draft facilities in the North Atlantic is not economically feasible. The second alternative considered development of Gulf Coast port facilities and, as a further variation, development of port facilities and new refinery capacity along the Gulf Coast to serve the needs of the North Atlantic Region. A Gulf Coast terminal for transshipment of crude oil to North Atlantic refineries is not a feasible alternative as it is considerably more costly than employing either foreign deep draft terminals or a terminal in the North Atlantic. The variation of this alternative provides for shipment of petroleum products from Gulf Coast refineries to the North Atlantic by pipeline. However, that system would increase the cost of petroleum products in the North Atlantic Region by $0.11 to $0.29 per barrel. Also, such a system would not alleviate the needs to ship crude oil to the existing refineries located in the North Atlantic. Those refineries will continue to import crude oil in larger ships. Consequently, this latter proposal is not considered a feasible alternative to using either a foreign deep draft terminal or a terminal in the North Atlantic.

Economic considerations indicate that facilities to accommodate VLCC's serving existing North Atlantic refineries *should be located along the reach of shore between New York harbor and the Delaware Bay area.* Although there are many locations in the North Atlantic where deep draft facilities could be constructed, only those in that reach of shore will result in a savings in transportation cost which will exceed the cost of such facilities.

Maximum reduction in the effects of oil spills can be attained by construction of facilities offshore. At present, tanker movement along the North Atlantic Coast and lightering operations in the New York harbor and Delaware Bay areas present a significant threat to the coastal environment of the area. This is especially true of Delaware Bay where tankers in excess of 100,000 DWT are lightering with increasing frequency. Although wave activity and other natural forces are more severe at offshore sites, the probability of major oil spills is less there than at inshore sites. Most major spills occur in coastal waters and at harbor entrances as a result of collision and groundings. At offshore sites traffic density and groundings would be reduced to a minimum. In addition, offshore areas appear to be less sensitive biologically to oil than such estuaries as Delaware Bay. Any spills that do occur offshore might be carried out to sea instead of onto beaches.

Development of facilities to accept VLCC's in the North Atlantic Region is not desired by affected States at this time. Fear of large oil spills affecting the recreational beaches of New Jersey and Delaware and of new large industrial complexes which would affect those recreational areas has caused tremendous local opposition to such facilities. Until such fears can be allayed, the construction and operation of any deep port facility does not appear logical. In addition, it does not appear that the States would grant the necessary permits to bring the required pipelines to shore.

There is no precedent for Federal development of port facilities of this type. In addition, private interests have indicated their willingness to develop those facilities and have sufficient funds for their construction and operation. The public interest in these facilities can be protected by applying the appropriate economic and environmental sanctions to the Federal permits and licenses required for construction and operation of the facilities. However, if a decision is reached to develop a facility in the North Atlantic, that facility should be examined to determine if there is a special reason for Federal participation in its development or operation.

The Federal government has the authority to issue permits for construction of offshore facilities in its territorial waters or on the high seas. Authority to permit and regulate offshore facilities is available to the Corps of Engineers under the Outer Continental Shelf Lands Act. However, there is a need to clarify and extend some statutory authority. Such action is now pending before The Congress.

Movement of petroleum products into the North Atlantic Region by vessel could lead to significant problems in the future. With the expected restrictions which are likely to be imposed on developing refineries in the Region, large volumes of petroleum products may be moved into the Region from refineries on the Gulf Coast and in the Caribbean in the future. Although the vessels will not be as large as those expected to import crude oil, they will increase in size and number as the volume of products imports increases. The problems associated with those increased movements may be most significant in the New England area which has no refineries, and many small harbors which may require enlargement. Additional study should be undertaken to determine if any regionalization of facilities to accept those movements is feasible.

The major purposes of this study are identified in Chapter 1. With respect to those purposes I conclude:

1. The most efficient and economic method of accepting very large bulk cargo carriers in the North Atlantic Region, assuming the most likely projection of crude oil imports, would be to provide a regional monobuoy unloading facility in the Atlantic Ocean approximately 13 miles off the New Jersey coast in the vicinity of Site 14b. (See Plate 2) That facility would have a pipeline which would come ashore at Long Branch and would provide for transshipment to the northern New Jersey and Delaware River refineries by pipeline. If the low level of projection is assumed, the most efficient and economic site would be located in Delaware Bay off Big Stone Beach in the vicinity of Site 15d. (See Plate 5) The York River refinery would be served by a tug-barge system in either case. Because of the cost of rehandling and the smaller ships used to transport coal and iron ore, it is more efficient and economic to deepen the existing projects of Hampton Roads and Baltimore than to develop transshipment facilities for those commodities. Because of the strong opposition by affected States to all proposed sites at the present time, there is no publicly acceptable method of accommodating VLCC's in the North Atlantic Region.
2. If constructed, deep draft facilities should be financed, built, maintained and operated by non-Federal interests. The public interest and equitable distribution of benefits between areas served by regional facilities can be ensured by conditions applied to construction and operating licenses.
3. Measures needed to ensure protection and enhancement of affected localities fall into two categories.
   a. *Sea and beach areas.* Development of facilities to

accept VLCC's will reduce the probability of oil spills substantially below that which would be experienced without such facilities. The frequency and severity of oil spills can be further reduced by safety and operating conditions applied to any construction and operating permit.

b. *Landside areas.* However, major landside impacts could result from such facilities, if they are not carefully controlled. Creating a point source for the importation of large quantities of crude oil could induce heavy concentrations of industrial facilities in areas having high environmental value, such as wetlands and recreational areas. Local interests have the ability to regulate the extent and nature of such growth through conditions applied to State permits and through local land use control. Nevertheless, historically, local governments have not demonstrated an ability to withstand pressures to use their lands for purposes of economic growth and development.

In summary, while I find that there is a need for a deep draft port facility in the North Atlantic Region; that it is economically, engineeringly and environmentally feasible; that private interests are able and willing to construct and operate it; and that, if undertaken, the public interest could be protected through conditions attached to the permits or licenses under which the facility is built and operated; I also find that there is no suitable site in this Region that is not strongly opposed by the local inhabitants and their elected representatives and officials. Accordingly, I am unable to recommend Federal participation in any such project at this time.

CARROLL D. STRIDER
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1. **Aquifer** - A water bearing stratum of permeable rock, sand or gravel - used as a source of water supply in many locations.

2. **Anthracite** - "Hard coal;" coal containing less than 10 percent volatile matter; mined mainly in eastern Pennsylvania.

   -Hard, black, lustrous, nonagglomerating coal having 92 percent or more, and less than 98 percent, of fixed carbon (dry, mineral-matter-free) and 8 percent or less, and more than 2 percent of volatile matter (dry, mineral-matter-free). (Am. Soc. of Testing Materials, D388-38).

3. **Barrel** - A liquid volume measure equal to 42 American gallons.

4. **Bituminous coal** - "Soft coal;" coal containing between 15 and 50 percent volatile matter.

   -Coal of rank between lignite and anthracite; coal which is high in carbonaceous matter, having between 15 and 50 percent volatile matter. (USBM, Dictionary of mining, mineral, and related terms).

5. **Common-carrier** - A carrier offering its services to all comers for interstate transportation by railroad, motor carrier, ship, aircraft or pipeline.

6. **Btu** - British thermal unit; the amount of heat needed to raise the temperature of one pound of water 1°F. at or near 39.2°F.; a measure of energy.

7. **Coal gasification** - The conversion of coal to a gas suitable for use as a fuel.

8. **Deadweight ton** - The cargo carrying capacity of a ship in long tons.

9. **Distillate fuel oil** - Refined product of crude oil used mostly for heating.

10. **Dredge spoil** - Material dredged from an area which must be disposed of at some location.

11. **Fossil Fuel** - Any naturally occurring fuel of an organic nature, such as coal, crude oil, and natural gas.

12. **Fuel oil** - Relatively heavy refined oil used as fuel for producing heat or power.

13. **Gross National Product (GNP)** - The total market value of goods and services produced by the Nation before the deduction of depreciation charges and other allowances for capital consumption; a widely used measure of economic activity.

14. **Lighter** - Transfer of portion of cargo from a large deep draft vessel to a smaller vessel to allow the former to enter a shallow draft port.

15. **Liquefied natural gas (LNG)** - Natural gas that has been changed into a liquid by cooling to about -260°F., at which point it occupies about 1/600 of its gaseous volume at normal atmospheric pressure.

16. **Local facility** - A terminal to serve the refineries of a portion of a region.

17. **Long ton** - 2,240 pounds, approximately 7.3 barrels of crude oil.

18. **Metallurgical quality coal** - Coal with strong or moderately strong coking properties that contains no more than 8.0 percent ash and 1.25 percent sulfur, as mined or after conventional cleaning. (Sheridan, E.T., and DeCarlo, J.A., USBM).

19. **Natural gas liquids** - Hydrocarbon products recovered in a natural gas processing plant; e.g., LPG and natural gasoline.

20. **Oil shale** - A sedimentary rock containing solid organic matter (kerogen) that yields substantial amounts of oil when heated to high temperatures.

21. **Petroleum** - A naturally occurring material (gaseous, liquid, or solid) composed mainly of chemical compounds of carbon and hydrogen.

22. **Proved reserves** - Discovered or reasonably assured sources of crude oil which can be obtained with existing technology.

23. **Queuing analysis** - A study of the time a vessel spends waiting in line for a vacant berth.

24. **Regional facility** - A terminal to serve the refineries of an entire region.

25. **Reserves** - The amount of a mineral expected to be recovered by present day techniques and under present economic conditions.

26. **Residual fuel oil** - Topped crude petroleum or viscous residuum obtained in refinery operation. (Am. Petroleum Inst. Glossary).

27. **Short ton** - A unit of weight that equals 20 short hundred-weights or 2,000 avoirdupois pounds. Used chiefly in the United States, in Canada and in the Republic of South Africa. (USBM, Dictionary of mining, mineral, and related terms).

28. **Steam coal** - Coal that is suitable for generating steam as distinguished from that used for metallurgical processes.

29. **Tar sand** - Any sedimentary rock that contains bitumen or other heavy petroleum material that cannot be recovered by conventional petroleum recovery methods.

30. **Thermionic conversion** - The conversion of heat into electricity by boiling electrons from a hot metal surface and condensing them on a cooler surface.

31. **Throughput** - The quantity of cargo being transferred through a facility.

32. **Transship** - Transfer of cargo for further transportation from one conveyance to another.

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J. Radley - Landscape Architect
R. Steelman - Counsel
F. Thoumsin - Biologist
C. Warner - Draftsman
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Woodward-Lundgren and Associates, Oakland, Calif.

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S. Jellinek - President's Council on Environmental Quality
Lt. Cmdr. Porricelli - U.S. Coast Guard
Dr. Maurer - University of Delaware, College of Marine Sciences
Dr. Pierce - National Marine Fishery Laboratory Sandy Hook
Dr. Gross - State University of New York at Stoney Brook
Dean Gaither - University of Delaware, College of Marine Sciences
American Petroleum Institute
American Institute of Merchant Shipping
American Association of Port Authorities
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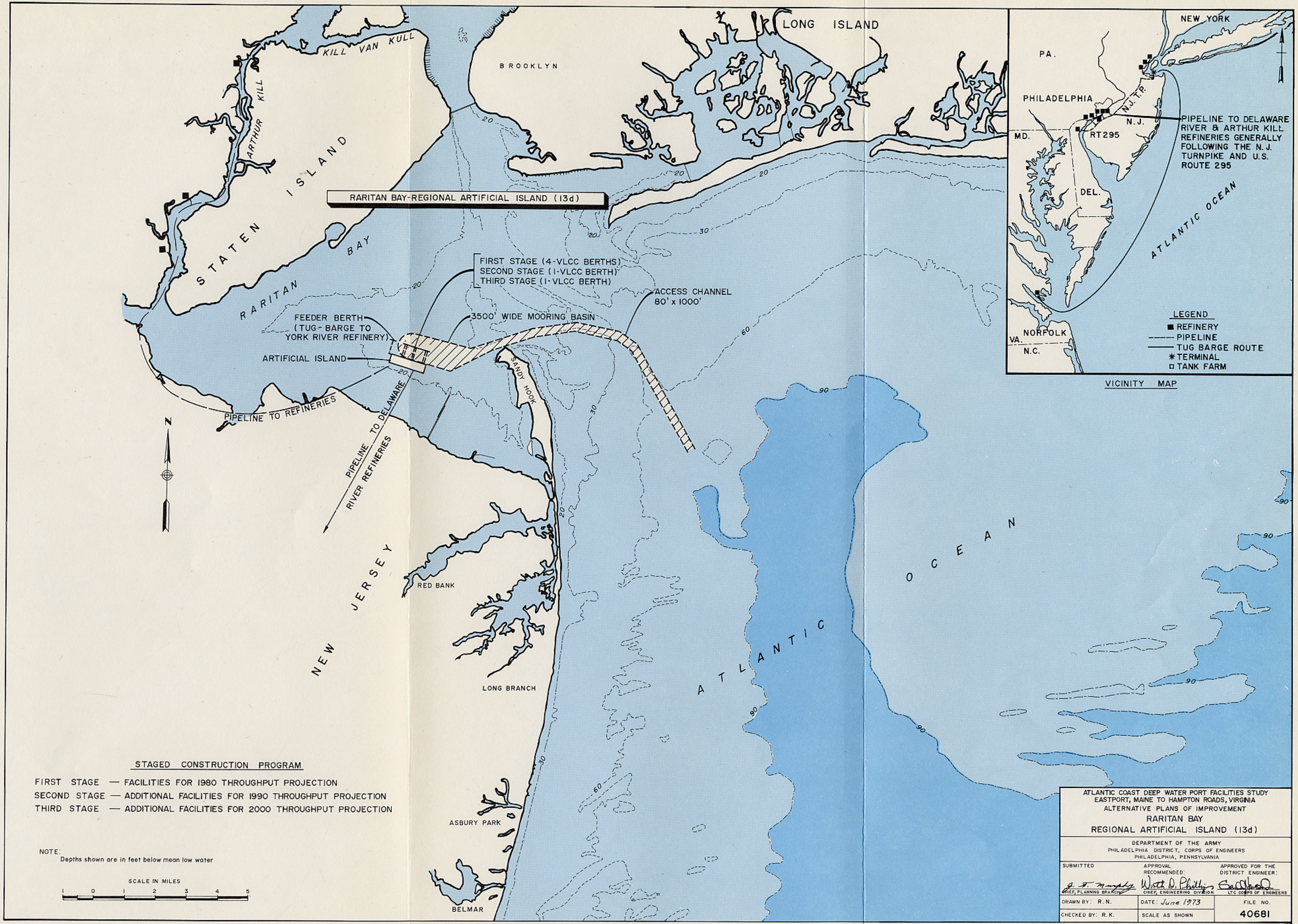
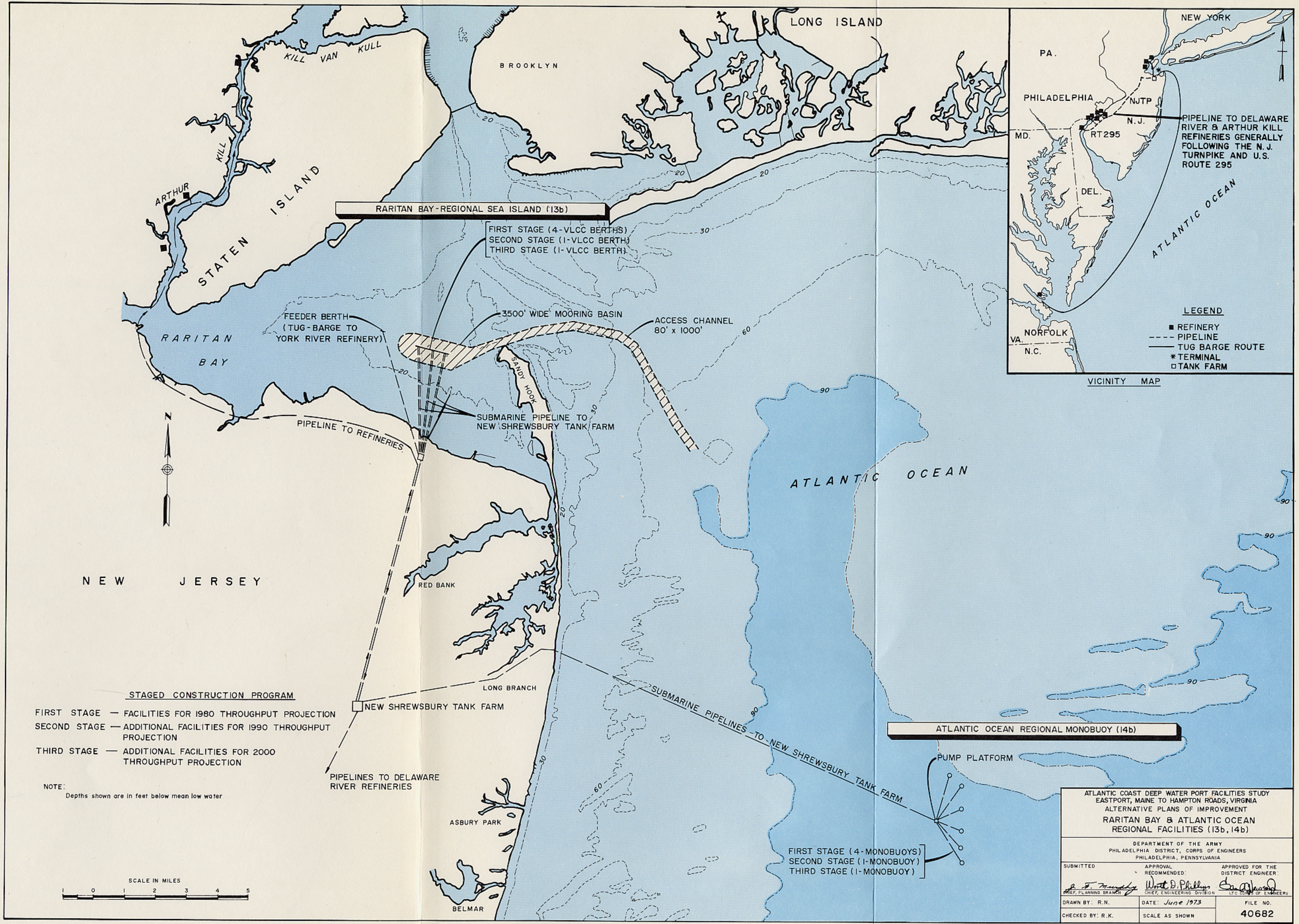

LONG ISLAND
KILL VAN KULL
BROOKLYN
ARTHUR KILL
STATEN ISLAND
RARITAN BAY
RARITAN BAY-REGIONAL ARTIFICIAL ISLAND (13d)
FIRST STAGE (4-VLCC BERTHS)
SECOND STAGE (1-VLCC BERTH)
THIRD STAGE (1-VLCC BERTH)
ACCESS CHANNEL
80' x 1000'
FEEDER BERTH (TUG-BARGE TO YORK RIVER REFINERY)
3500' WIDE MOORING BASIN
ARTIFICIAL ISLAND
PIPELINE TO REFINERIES
PIPELINE TO DELAWARE RIVER REFINERIES
SANDY HOOK
NEW JERSEY
RED BANK
LONG BRANCH
ASBURY PARK
BELMAR
ATLANTIC OCEAN
N
NEW YORK
PA.
PHILADELPHIA
N.J.T.P.
N.J.
RT 295
MD.
DEL.
VA.
N.C.
NORFOLK
ATLANTIC OCEAN
PIPELINE TO DELAWARE RIVER & ARTHUR KILL REFINERIES GENERALLY FOLLOWING THE N. J. TURNPIKE AND U.S. ROUTE 295
LEGEND
REFINERY
PIPELINE
TUG BARGE ROUTE
TERMINAL
TANK FARM
VICINITY MAP
STAGED CONSTRUCTION PROGRAM
FIRST STAGE — FACILITIES FOR 1980 THROUGHPUT PROJECTION
SECOND STAGE — ADDITIONAL FACILITIES FOR 1990 THROUGHPUT PROJECTION
THIRD STAGE — ADDITIONAL FACILITIES FOR 2000 THROUGHPUT PROJECTION
NOTE:
Depths shown are in feet below mean low water
SCALE IN MILES
ATLANTIC COAST DEEP WATER PORT FACILITIES STUDY
EASTPORT, MAINE TO HAMPTON ROADS, VIRGINIA
ALTERNATIVE PLANS OF IMPROVEMENT
RARITAN BAY
REGIONAL ARTIFICIAL ISLAND (13d)
DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
SUBMITTED
CHIEF, PLANNING BRANCH
APPROVAL RECOMMENDED:
CHIEF, ENGINEERING DIVISION
APPROVED FOR THE DISTRICT ENGINEER:
LTC CORPS OF ENGINEERS
DRAWN BY: R.N.
DATE: June 1973
FILE NO. 40681
CHECKED BY: R.K.
SCALE AS SHOWN

PLATE I



LONG ISLAND
BROOKLYN
KILL VAN KULL
ARTHUR KILL
STATEN ISLAND
RARITAN BAY-REGIONAL SEA ISLAND (13b)
FIRST STAGE (4-VLCC BERTHS)
SECOND STAGE (1-VLCC BERTH)
THIRD STAGE (1-VLCC BERTH)
FEEDER BERTH (TUG-BARGE TO YORK RIVER REFINERY)
3500' WIDE MOORING BASIN
ACCESS CHANNEL 80' x 1000'
RARITAN BAY
SANDY HOOK
SUBMARINE PIPELINE TO NEW SHREWSBURY TANK FARM
PIPELINE TO REFINERIES
ATLANTIC OCEAN
NEW JERSEY
RED BANK
LONG BRANCH
NEW SHREWSBURY TANK FARM
SUBMARINE PIPELINES TO NEW SHREWSBURY TANK FARM
PIPELINES TO DELAWARE RIVER REFINERIES
ASBURY PARK
BELMAR
ATLANTIC OCEAN REGIONAL MONOBUOY (14b)
PUMP PLATFORM
FIRST STAGE (4-MONOBUOYS)
SECOND STAGE (1-MONOBUOY)
THIRD STAGE (1-MONOBUOY)
STAGED CONSTRUCTION PROGRAM
FIRST STAGE — FACILITIES FOR 1980 THROUGHPUT PROJECTION
SECOND STAGE — ADDITIONAL FACILITIES FOR 1990 THROUGHPUT PROJECTION
THIRD STAGE — ADDITIONAL FACILITIES FOR 2000 THROUGHPUT PROJECTION
NOTE: Depths shown are in feet below mean low water
SCALE IN MILES
1 0 1 2 3 4 5
N
20
30
60
90
NEW YORK
PA.
PHILADELPHIA
NJTP
N.J.
RT295
MD.
DEL.
PIPELINE TO DELAWARE RIVER & ARTHUR KILL REFINERIES GENERALLY FOLLOWING THE N.J. TURNPIKE AND U.S. ROUTE 295
ATLANTIC OCEAN
NORFOLK
VA.
N.C.
LEGEND
■ REFINERY
- - - - PIPELINE
—— TUG BARGE ROUTE
* TERMINAL
□ TANK FARM
VICINITY MAP
ATLANTIC COAST DEEP WATER PORT FACILITIES STUDY
EASTPORT, MAINE TO HAMPTON ROADS, VIRGINIA
ALTERNATIVE PLANS OF IMPROVEMENT
RARITAN BAY & ATLANTIC OCEAN REGIONAL FACILITIES (13b, 14b)
DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
SUBMITTED
APPROVAL RECOMMENDED:
APPROVED FOR THE DISTRICT ENGINEER:
CHIEF, PLANNING BRANCH
CHIEF, ENGINEERING DIVISION
LTC CORPS OF ENGINEERS
DRAWN BY: R.N.
DATE: June 1973
FILE NO. 40682
CHECKED BY: R.K.
SCALE AS SHOWN

PLATE 2

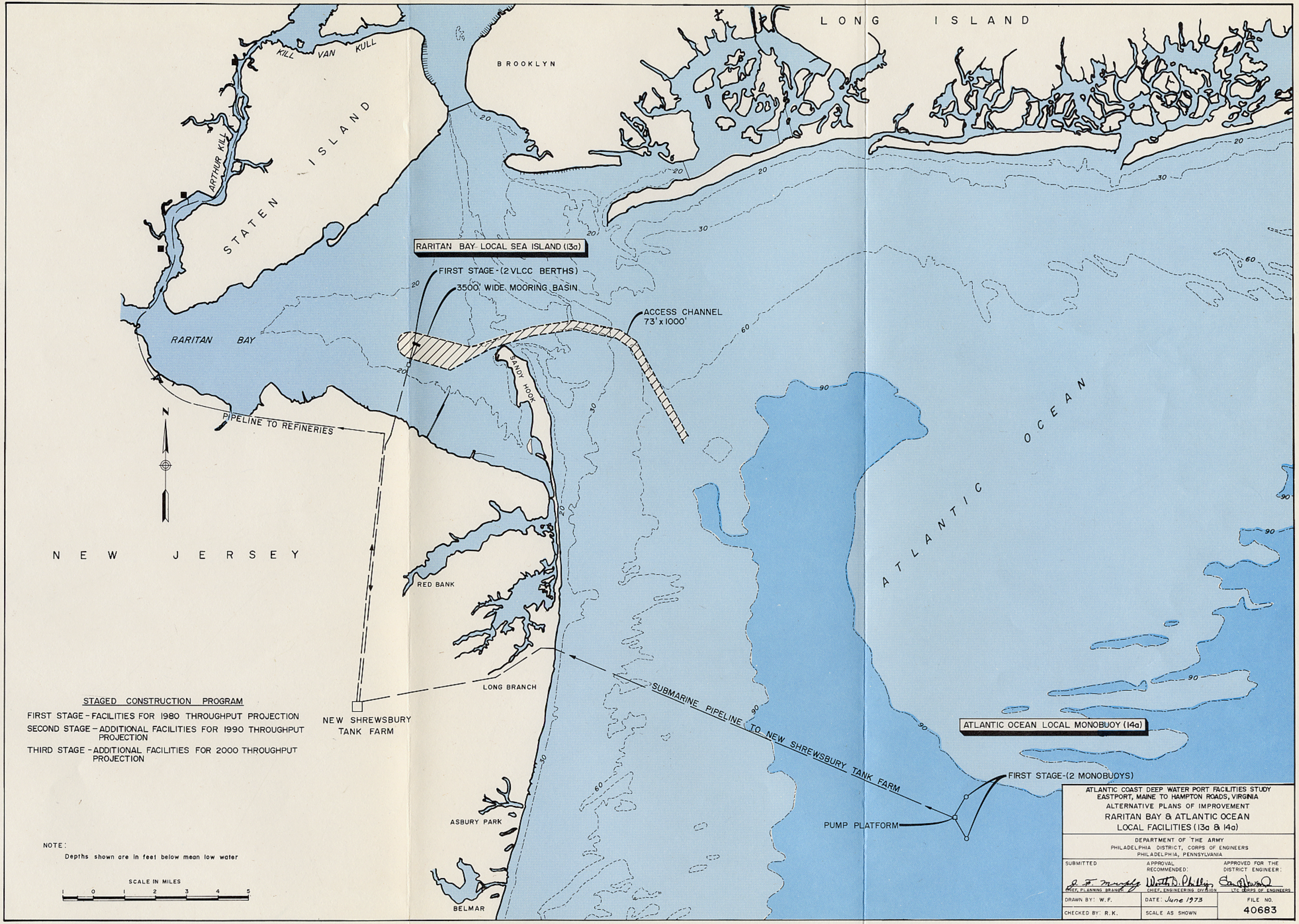

LONG ISLAND
BROOKLYN
KILL VAN KULL
ARTHUR KILL
STATEN ISLAND
RARITAN BAY LOCAL SEA ISLAND (13a)
FIRST STAGE-(2 VLCC BERTHS)
3500' WIDE MOORING BASIN
ACCESS CHANNEL
73' x 1000'
RARITAN BAY
SANDY HOOK
PIPELINE TO REFINERIES
N
NEW JERSEY
ATLANTIC OCEAN
RED BANK
LONG BRANCH
NEW SHREWSBURY
TANK FARM
SUBMARINE PIPELINE TO NEW SHREWSBURY TANK FARM
ATLANTIC OCEAN LOCAL MONOBUOY (14a)
FIRST STAGE-(2 MONOBUOYS)
PUMP PLATFORM
ASBURY PARK
BELMAR
STAGED CONSTRUCTION PROGRAM
FIRST STAGE - FACILITIES FOR 1980 THROUGHPUT PROJECTION
SECOND STAGE - ADDITIONAL FACILITIES FOR 1990 THROUGHPUT PROJECTION
THIRD STAGE - ADDITIONAL FACILITIES FOR 2000 THROUGHPUT PROJECTION
NOTE:
Depths shown are in feet below mean low water
SCALE IN MILES
1 0 1 2 3 4 5
ATLANTIC COAST DEEP WATER PORT FACILITIES STUDY
EASTPORT, MAINE TO HAMPTON ROADS, VIRGINIA
ALTERNATIVE PLANS OF IMPROVEMENT
RARITAN BAY & ATLANTIC OCEAN
LOCAL FACILITIES (13a & 14a)
DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
SUBMITTED
APPROVAL RECOMMENDED:
APPROVED FOR THE DISTRICT ENGINEER:
J. F. Murphy
CHIEF, PLANNING BRANCH
Worth D. Phillips
CHIEF, ENGINEERING DIVISION
LTC CORPS OF ENGINEERS
DRAWN BY: W.F.
DATE: June 1973
FILE NO.
40683
CHECKED BY: R.K.
SCALE AS SHOWN

PLATE 3

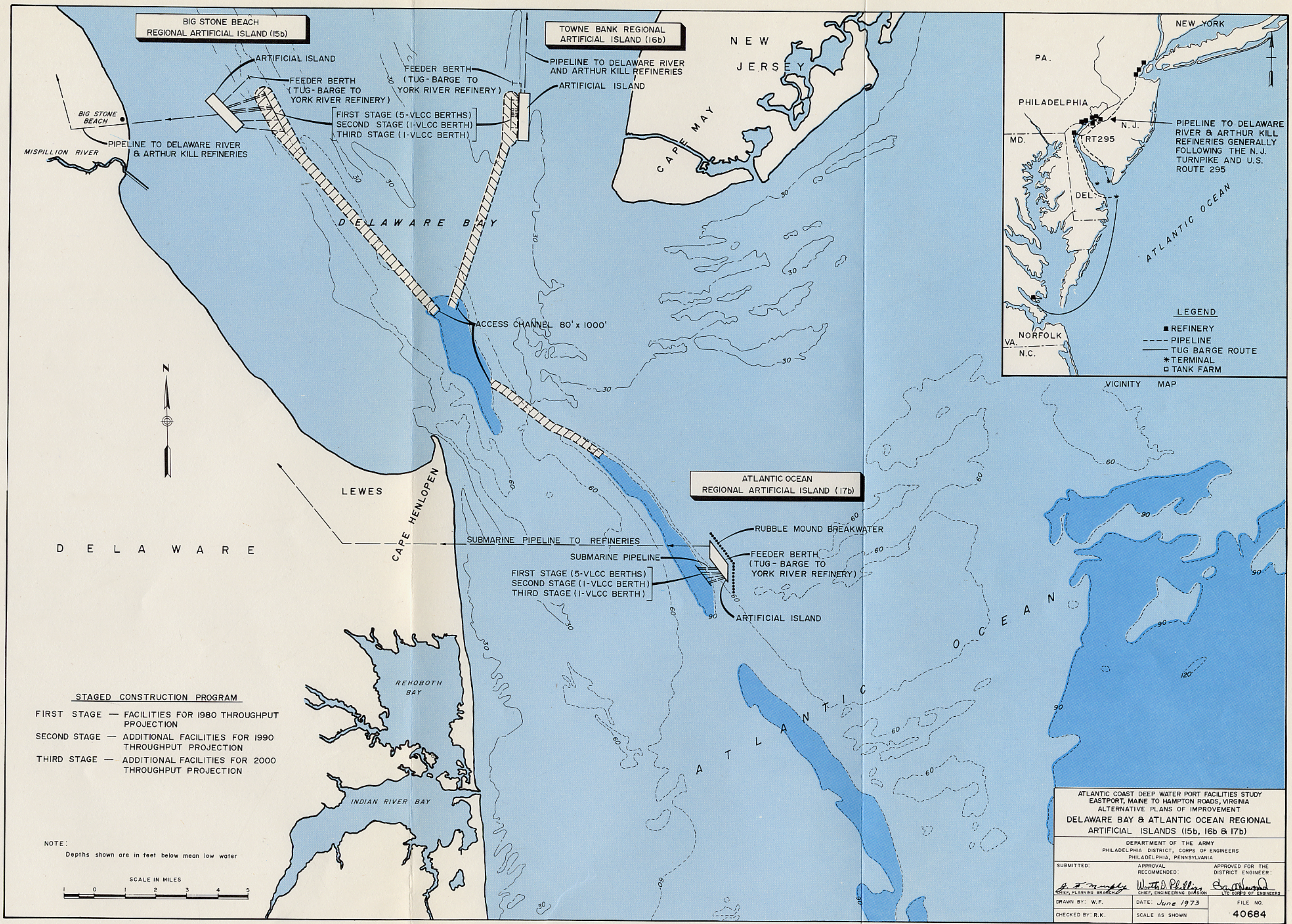
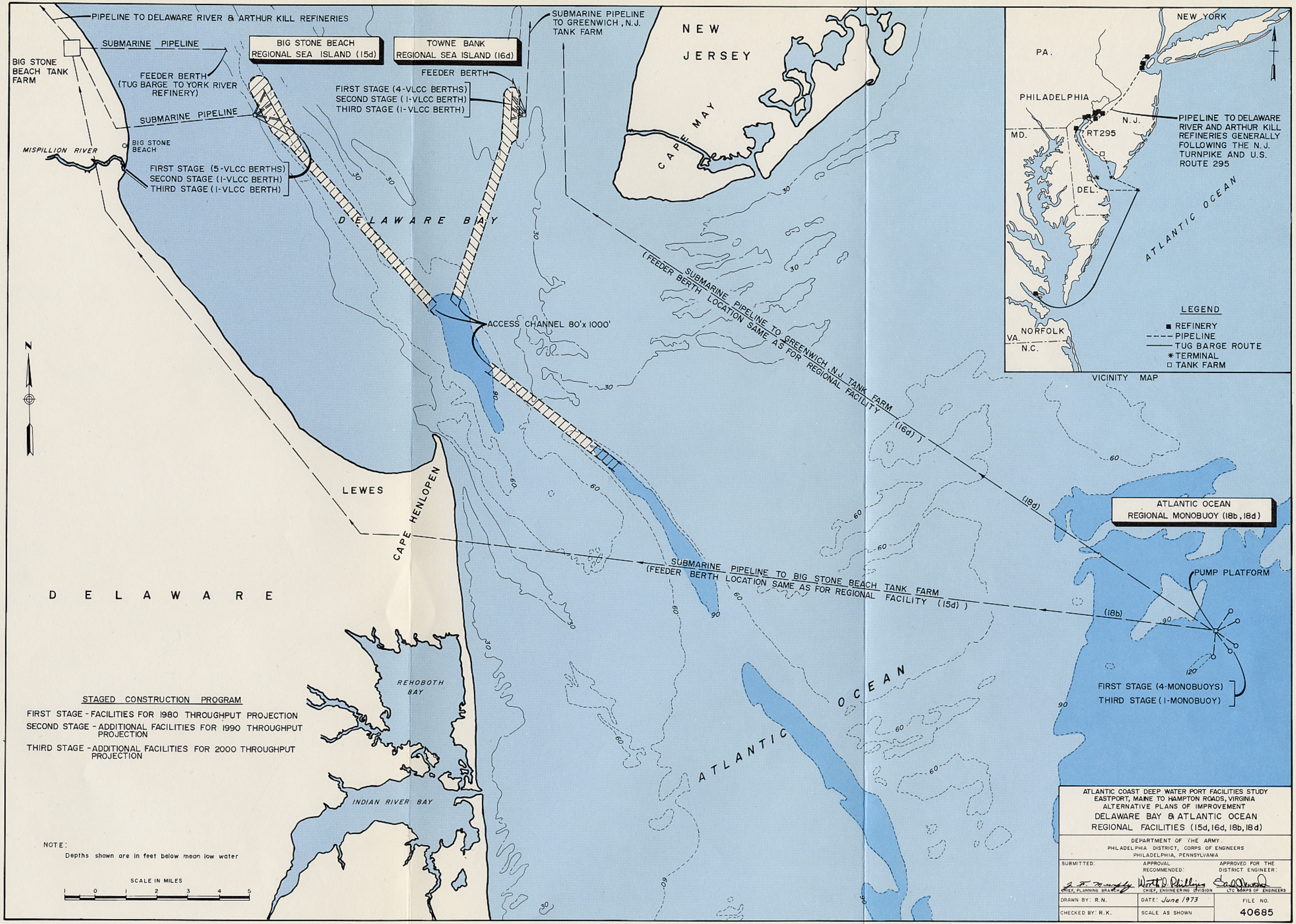

BIG STONE BEACH
REGIONAL ARTIFICIAL ISLAND (15b)
ARTIFICIAL ISLAND
FEEDER BERTH
(TUG-BARGE TO
YORK RIVER REFINERY)
BIG STONE BEACH
PIPELINE TO DELAWARE RIVER
& ARTHUR KILL REFINERIES
MISPILLION RIVER
FIRST STAGE (5-VLCC BERTHS)
SECOND STAGE (1-VLCC BERTH)
THIRD STAGE (1-VLCC BERTH)
FEEDER BERTH
(TUG-BARGE TO
YORK RIVER REFINERY)
TOWNE BANK REGIONAL
ARTIFICIAL ISLAND (16b)
PIPELINE TO DELAWARE RIVER
AND ARTHUR KILL REFINERIES
ARTIFICIAL ISLAND
NEW
JERSEY
CAPE MAY
DELAWARE BAY
ACCESS CHANNEL 80' x 1000'
N
LEWES
CAPE HENLOPEN
DELAWARE
SUBMARINE PIPELINE TO REFINERIES
ATLANTIC OCEAN
REGIONAL ARTIFICIAL ISLAND (17b)
RUBBLE MOUND BREAKWATER
SUBMARINE PIPELINE
FEEDER BERTH
(TUG-BARGE TO
YORK RIVER REFINERY)
FIRST STAGE (5-VLCC BERTHS)
SECOND STAGE (1-VLCC BERTH)
THIRD STAGE (1-VLCC BERTH)
ARTIFICIAL ISLAND
ATLANTIC OCEAN
REHOBOTH BAY
INDIAN RIVER BAY
NEW YORK
PA.
PHILADELPHIA
N.J.
MD.
RT295
DEL.
PIPELINE TO DELAWARE
RIVER & ARTHUR KILL
REFINERIES GENERALLY
FOLLOWING THE N.J.
TURNPIKE AND U.S.
ROUTE 295
ATLANTIC OCEAN
NORFOLK
VA.
N.C.
LEGEND
REFINERY
PIPELINE
TUG BARGE ROUTE
TERMINAL
TANK FARM
VICINITY MAP
STAGED CONSTRUCTION PROGRAM
FIRST STAGE — FACILITIES FOR 1980 THROUGHPUT PROJECTION
SECOND STAGE — ADDITIONAL FACILITIES FOR 1990 THROUGHPUT PROJECTION
THIRD STAGE — ADDITIONAL FACILITIES FOR 2000 THROUGHPUT PROJECTION
NOTE:
Depths shown are in feet below mean low water
SCALE IN MILES
1 0 1 2 3 4 5
ATLANTIC COAST DEEP WATER PORT FACILITIES STUDY
EASTPORT, MAINE TO HAMPTON ROADS, VIRGINIA
ALTERNATIVE PLANS OF IMPROVEMENT
DELAWARE BAY & ATLANTIC OCEAN REGIONAL
ARTIFICIAL ISLANDS (15b, 16b & 17b)
DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
SUBMITTED:
CHIEF, PLANNING BRANCH
APPROVAL RECOMMENDED:
CHIEF, ENGINEERING DIVISION
APPROVED FOR THE DISTRICT ENGINEER:
LTC CORPS OF ENGINEERS
DRAWN BY: W.F.
CHECKED BY: R.K.
DATE: June 1973
SCALE AS SHOWN
FILE NO.
40684

PLATE 4



PIPELINE TO DELAWARE RIVER & ARTHUR KILL REFINERIES
SUBMARINE PIPELINE
BIG STONE BEACH TANK FARM
BIG STONE BEACH REGIONAL SEA ISLAND (15d)
TOWNE BANK REGIONAL SEA ISLAND (16d)
SUBMARINE PIPELINE TO GREENWICH, N.J. TANK FARM
NEW JERSEY
FEEDER BERTH (TUG BARGE TO YORK RIVER REFINERY)
FEEDER BERTH
FIRST STAGE (4-VLCC BERTHS)
SECOND STAGE (1-VLCC BERTH)
THIRD STAGE (1-VLCC BERTH)
SUBMARINE PIPELINE
MISPILLION RIVER
BIG STONE BEACH
FIRST STAGE (5-VLCC BERTHS)
SECOND STAGE (1-VLCC BERTH)
THIRD STAGE (1-VLCC BERTH)
CAPE MAY
DELAWARE BAY
SUBMARINE PIPELINE TO GREENWICH N.J TANK FARM (FEEDER BERTH LOCATION SAME AS FOR REGIONAL FACILITY (16d))
ACCESS CHANNEL 80'x 1000'
N
LEWES
CAPE HENLOPEN
(18d)
ATLANTIC OCEAN REGIONAL MONOBUOY (18b, 18d)
PUMP PLATFORM
SUBMARINE PIPELINE TO BIG STONE BEACH TANK FARM (FEEDER BERTH LOCATION SAME AS FOR REGIONAL FACILITY (15d))
(18b)
DELAWARE
FIRST STAGE (4-MONOBUOYS)
THIRD STAGE (1-MONOBUOY)
ATLANTIC OCEAN
REHOBOTH BAY
INDIAN RIVER BAY
STAGED CONSTRUCTION PROGRAM
FIRST STAGE - FACILITIES FOR 1980 THROUGHPUT PROJECTION
SECOND STAGE - ADDITIONAL FACILITIES FOR 1990 THROUGHPUT PROJECTION
THIRD STAGE - ADDITIONAL FACILITIES FOR 2000 THROUGHPUT PROJECTION
NOTE:
Depths shown are in feet below mean low water
SCALE IN MILES
1 0 1 2 3 4 5
NEW YORK
PA.
PHILADELPHIA
N.J.
MD.
RT295
DEL.
PIPELINE TO DELAWARE RIVER AND ARTHUR KILL REFINERIES GENERALLY FOLLOWING THE N.J. TURNPIKE AND U.S. ROUTE 295
ATLANTIC OCEAN
NORFOLK
VA.
N.C.
LEGEND
REFINERY
PIPELINE
TUG BARGE ROUTE
TERMINAL
TANK FARM
VICINITY MAP
ATLANTIC COAST DEEP WATER PORT FACILITIES STUDY
EASTPORT, MAINE TO HAMPTON ROADS, VIRGINIA
ALTERNATIVE PLANS OF IMPROVEMENT
DELAWARE BAY & ATLANTIC OCEAN
REGIONAL FACILITIES (15d, 16d, 18b, 18d)
DEPARTMENT OF THE ARMY.
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
SUBMITTED:
APPROVAL RECOMMENDED:
APPROVED FOR THE DISTRICT ENGINEER:
CHIEF, PLANNING BRANCH
CHIEF, ENGINEERING DIVISION
LTC CORPS OF ENGINEERS
DRAWN BY: R.N.
DATE: June 1973
CHECKED BY: R.K.
SCALE AS SHOWN
FILE NO.
40685

PLATE 5

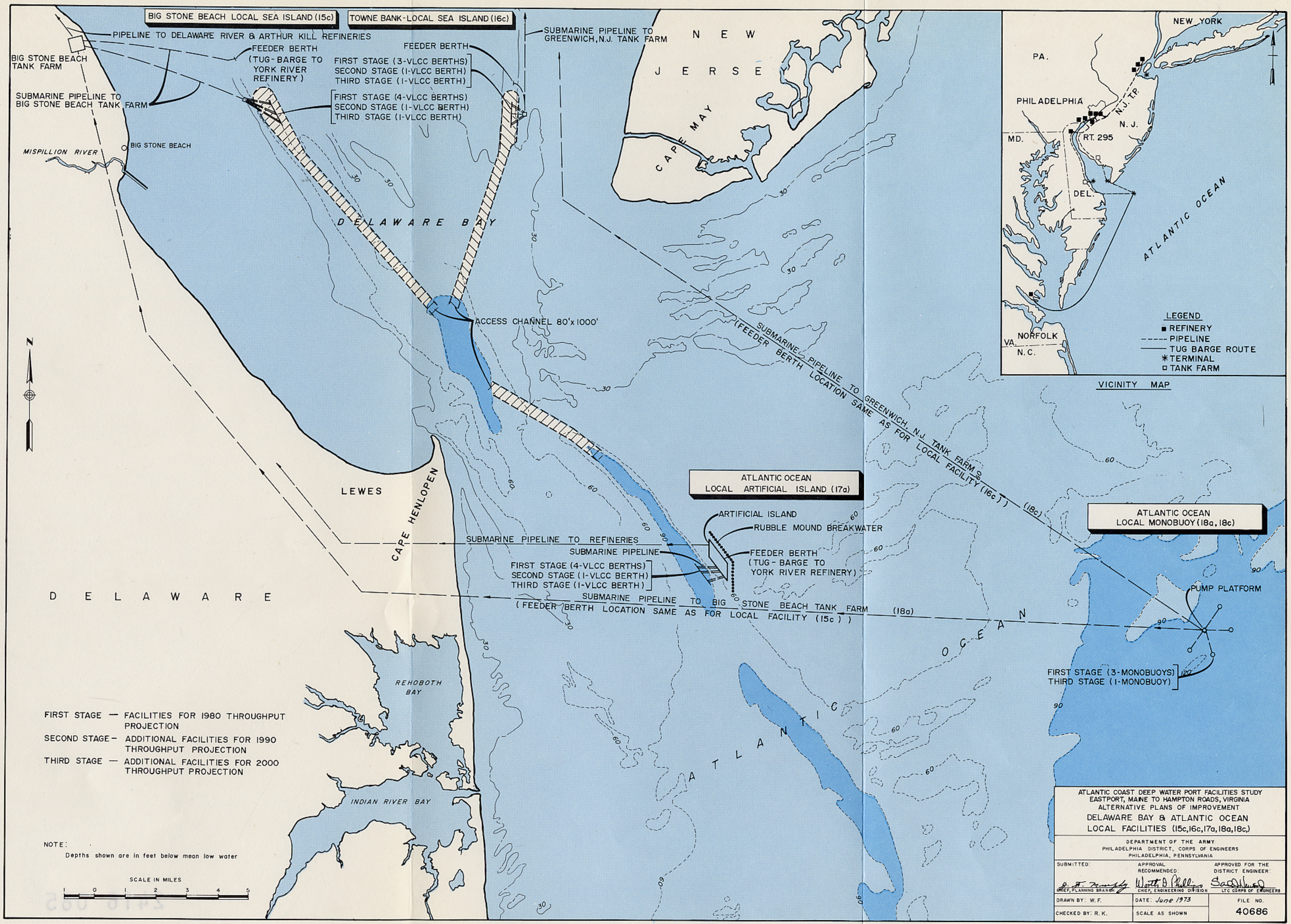

BIG STONE BEACH LOCAL SEA ISLAND (15c)
TOWNE BANK-LOCAL SEA ISLAND (16c)
PIPELINE TO DELAWARE RIVER & ARTHUR KILL REFINERIES
BIG STONE BEACH TANK FARM
FEEDER BERTH (TUG-BARGE TO YORK RIVER REFINERY)
FEEDER BERTH
FIRST STAGE (3-VLCC BERTHS)
SECOND STAGE (1-VLCC BERTH)
THIRD STAGE (1-VLCC BERTH)
SUBMARINE PIPELINE TO GREENWICH, N.J. TANK FARM
SUBMARINE PIPELINE TO BIG STONE BEACH TANK FARM
FIRST STAGE (4-VLCC BERTHS)
SECOND STAGE (1-VLCC BERTH)
THIRD STAGE (1-VLCC BERTH)
MISPILLION RIVER
BIG STONE BEACH
NEW JERSEY
CAPE MAY
DELAWARE BAY
ACCESS CHANNEL 80'x1000'
SUBMARINE PIPELINE TO GREENWICH, N.J. TANK FARM & (FEEDER BERTH LOCATION SAME AS FOR LOCAL FACILITY (16c))
(18c)
ATLANTIC OCEAN LOCAL ARTIFICIAL ISLAND (17a)
ATLANTIC OCEAN LOCAL MONOBUOY (18a, 18c)
LEWES
CAPE HENLOPEN
ARTIFICIAL ISLAND
RUBBLE MOUND BREAKWATER
SUBMARINE PIPELINE TO REFINERIES
SUBMARINE PIPELINE
FEEDER BERTH (TUG-BARGE TO YORK RIVER REFINERY)
FIRST STAGE (4-VLCC BERTHS)
SECOND STAGE (1-VLCC BERTH)
THIRD STAGE (1-VLCC BERTH)
SUBMARINE PIPELINE TO BIG STONE BEACH TANK FARM
(FEEDER BERTH LOCATION SAME AS FOR LOCAL FACILITY (15c))
(18a)
PUMP PLATFORM
FIRST STAGE (3-MONOBUOYS)
THIRD STAGE (1-MONOBUOY)
DELAWARE
ATLANTIC OCEAN
REHOBOTH BAY
INDIAN RIVER BAY
FIRST STAGE — FACILITIES FOR 1980 THROUGHPUT PROJECTION
SECOND STAGE — ADDITIONAL FACILITIES FOR 1990 THROUGHPUT PROJECTION
THIRD STAGE — ADDITIONAL FACILITIES FOR 2000 THROUGHPUT PROJECTION
NOTE:
Depths shown are in feet below mean low water
SCALE IN MILES
1 0 1 2 3 4 5
NEW YORK
PA.
PHILADELPHIA
N.J. TP.
N.J.
MD.
RT. 295
DEL.
ATLANTIC OCEAN
NORFOLK
VA.
N.C.
LEGEND
REFINERY
PIPELINE
TUG BARGE ROUTE
TERMINAL
TANK FARM
VICINITY MAP
ATLANTIC COAST DEEP WATER PORT FACILITIES STUDY
EASTPORT, MAINE TO HAMPTON ROADS, VIRGINIA
ALTERNATIVE PLANS OF IMPROVEMENT
DELAWARE BAY & ATLANTIC OCEAN
LOCAL FACILITIES (15c, 16c, 17a, 18a, 18c,)
DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
SUBMITTED:
CHIEF, PLANNING BRANCH
APPROVAL RECOMMENDED:
Worth D. Phillips
CHIEF, ENGINEERING DIVISION
APPROVED FOR THE DISTRICT ENGINEER:
LTC CORPS OF ENGINEERS
DRAWN BY: W.F.
DATE: June 1973
FILE NO.
40686
CHECKED BY: R.K.
SCALE AS SHOWN

PLATE 6