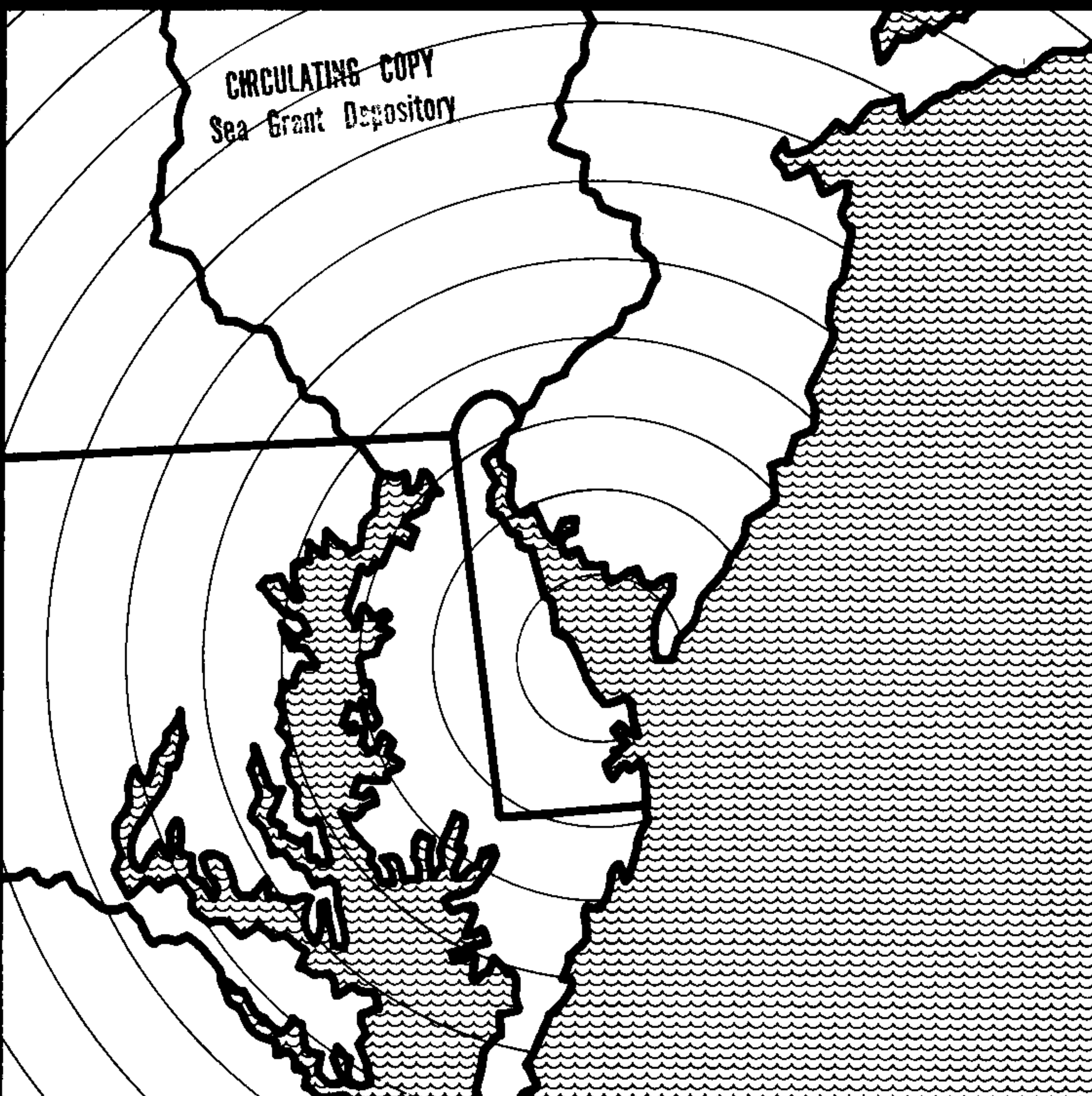
A Comprehensive Marine Transportation System for the Delaware Valley Region

A Case Study Prepared by Students in CMS 680 (Concepts in Applied Ocean Science)

May, 1977



A Special Report for the Delaware Sea Grant Program College of Marine Studies, University of Delaware

A CASE STUDY OF A COMPREHENSIVE MARINE TRANSPORTATION SYSTEM FOR THE DELAWARE VALLEY REGION

Prepared by the Students in

CMS 680
Concepts in Applied Ocean Science
As a term project

J. J. Murray
E. A. Tupin
C. M. Golt
N. D. Dey
R. L. Tremaine
A. S. Wilson
D. E. Moss
B. R. Petrosky
R. S. Prezant
M. S. Redmond
H. T. Rowland
W. R. Johnson
H. K. Dean
R. L. Burnett

University of Delaware

College of Marine Studies

May 25, 1977

DEL-SG-12-77

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

Figures

Tables

PREFACE

This study was conducted as a semester-long class project by the students in Concepts of Ocean Engineering, CMS 680, offered yearly as a core course by the College of Marine Studies (CMS), University of Delaware. The students had no engineering background, but represented the breadth of disciplines offered at the College, including biology, chemistry, physical oceanography, and marine affairs. Also included were students from other colleges in the University. The scope of this course is outlined in Appendix I.

This report was designed as a prototype for interdisciplinary studies to be conducted by the CMS combined core course system to be initiated in September 1977. As such, the subject was chosen to appeal to a broad range of students as well as to be of interest to the community served by the University. In practice, this work has served to acquaint the students with project organization, research, report preparation and presentation of the type produced by engineers and consulting firms. The organization of student task groups and the study schedule is given in Appendix II.

It is recognized that this report gives only superficial coverage to many important topics. However, time was a severe constraint in completing the report in a 15-week semester.

In addition to this written report the class made an oral presentation to an "expert panel" on May 18, 1977. Some of the comments made by the panel were incorporated in the text. Panel members' names and their written comments are included as Appendix III.

Signed:

J. J. Murray
E. A. Tupin
C. M. Golt
N. D. Dey
R. L. Tremaine
A. S. Wilson
D. E. Moss
B. R. Petrosky
R. S. Prezant
M. S. Redmond
H. T. Rowland
W. R. Johnson
H. K. Dean
R. L. Burnett

Newark, Delaware
May 25, 1977

ACKNOWLEDGMENTS

We wish to acknowledge the contribution of W. S. Gaither, Dean of the College of Marine Studies and instructor of CMS 680, for the original concept of the port-island system (Ref. 56a), the many introductions he was able to make, and the numerous suggestions he was able to offer during the semester.

We would also like to thank the following people who freely contributed their time and expertise, without which this project would have sunk soon after launching:

R. B. Biggs (CMS)
D. Billington (Princeton University)
J. Babiarz (Port of Wilmington)
C. Burtch (Dravo Corporation)
W. Cook (Bethlehem Steel Corporation)

E. Craig (Department of Business and Economics)
B. Cranston (Columbia LNG Coporation)
F. Daiber (CMS)
J. Drinane (Frederic R. Harris, Inc.)
D. Dougherty (Kidden-Peabody, Inc.)
J. R. Galloway (Delaware Bay Transportation Company)
J. Gaffigan (Delaware Bay Port Authority)
M. H. Greaser (American Dredging Company)
E. Harlow (Frederic R. Harris, Inc.)
W. Harrison (Getty Oil Corporation)
F. C. Hess (Gulf Oil Corporation)
S. Hudson (J. E. Brenneman Corporation)
R. Jordan (University of Delaware)
R. Kalisch (American Gas Association)
L. Kazmerczak (Sun Oil)
J. Kinniard (Sun Oil)
Mr. Kreh (U.S. Army Corps of Engineers)
Mr. Kuhn (Kuhn Construction Company)
J. P. Lewis (Transco Terminal Company)
W. Lord (Dravo Corporation)
J. Malone (Port Corporation of Philadelphia)
G. Mangone (CMS)
T. Manley (Dravo Corporation)
A. J. McNerney (Sun Oil Company)
T. Metz (Bunge Corporation)
J. O'Brien (Kent County Planning Office)
J. O'Sullivan (Kidden-Peabody, Inc.)
M. Pleass (University of Delaware)
J. Richter (Delaware Transportation Authority)
Mr. Riggins (Delmarva Power)
L. G. Rogers (Columbia Gas)
J. P. Royston (Conrail)
M. Tang (Dyckerhoff and Widmann)
J. Wallace (Delaware Transportation Authority)
M. Willis (Sun Shipbuilding Company)
E. Wright (Dravo Corporation)

We finally wish to acknowledge the following CMS staff people who were able to provide invaluable production assistance:

L. Butler
M. Ottolini
J. Palmer
J. Pezley

SUMMARY

This report presents a marine transportation system especially applicable to Delaware Bay. The central component

is a man-made island that serves as a deepwater port. Other components of the system include an air-sea cargo center near Dover Air Force Base, a trestle corridor connecting the cargo center to the island, a restricted access rail and highway corridor to up-state connections, a deepwater channel to the ocean, and provision for submarine pipeline access from outer continental shelf oil and gas fields, if these materialize.

This case study, as a class project, is intended to evaluate the benefits as well as the detriments of this project including 1) engineering aspects, 2) financial requirements, 3) environmental consequences, 4) social and economic effects, and 5) management and safety factors. The estimated total cost of the proposed project is between $770 million and $2.3 billion, and it would require approximately seven years to construct.

The objectives of the system are first to provide the deepwater docking facilities required by modern, large economical ships; second to stimulate economic growth within Delaware and the surrounding region; third to increase the safety of marine transportation; fourth to develop a commercial center adjacent to Dover Air Force Base as an alternative to military use; and fifth to demonstrate Delaware's commitment to the future regional needs for transportation and energy within the existing environmental preservation standards.

I. INTRODUCTION

This report describes a comprehensive deepwater port marine transportation system for Delaware Bay, which in turn would serve the middle Atlantic states.

The objectives of this system are first, to provide new sources of revenue for the state by stimulating economic growth within the state and by providing a needed service for the entire Delaware Valley; second, to increase the safety of marine transportation in the Delaware River and Bay by reducing the traffic in the ship channel to Philadelphia and providing a special port and channel for large ships in the lower bay; and third, to develop a complementary commercial center adjacent to the Dover Air Force Base so that the facility could be put to productive commercial use if the federal government should elect to deactivate the base.

Delaware has been strongly influenced by shipping since it was first settled in the early 1600s. The nature of this influence has changed with the evolution of ships, of markets, and of commodities produced. Early sailing ships were of shallow draft and called at many river towns in Delaware to take on agricultural products. Farther up river, where streams tumbled out of the Piedmont and offered water power, colonial manufacturing began and population centers grew. Traffic also passed by Delaware on its way to the upriver cities, Wilmington, Philadelphia, and Trenton. With passing decades and centuries, ships became larger and ports with shallow water access were abandoned. This trend has continued with the inevitable result that ports served by 40-foot deep channels are now passing into obsolescence in favor of new ports which will permit ships of deeper drafts to enter. In a matter of 20 years, bulk carriers for coal, ore, and petroleum have been increased in size to realize lower shipping costs, and the drafts of such ships have increased from 35 to 40 feet to the present 60 to 90 feet.

Petroleum has been important in the Delaware Valley since the middle of the nineteenth century. Refineries in the Philadelphia area started in the days of sailing ships but increased at a quickening pace through the close of World War II. During this period of growth, waste discharges from industrial and domestic sources steadily degraded the quality of water in the estuary.

Recently, because of an increasing number of tanker mishaps, a reevaluation of the status quo revealed the following facts:

First, approximately 70% of all the oil that is delivered to the east coast of the United States moves by water up the Delaware Bay and River; and

Second, about 25% of this oil is transferred several miles off the coast or in the mouth of the Bay from large, deep-draft tankers to barges or to smaller tankers so as to reduce the draft of the vessels to allow navigation up the Bay and River to unloading docks; and

Third, such lightering operations are hazardous and provide a potential threat of a catastrophic spill that could seriously contaminate our waters and beaches; and

Fourth, the volume of oil transported up the Bay is destined to increase markedly in the future even with no new refineries in Delaware; and

Fifth, the U.S. Department of Commerce is vitally concerned with providing an adequate supply of oil to the eastern United States, and has been studying bulk transfer terminals in the Delaware Bay and is now launching a study of the practicality and feasibility of an offshore terminal on the continental shelf; and

Finally, the trend in ocean shipping is to ever larger tankers of deeper draft.

Clearly, oil and gas imports cannot be eliminated from Delaware Bay. Equally clear is the fact that Delaware Bay has been impacted by the up-river activities and discharges of not only the industrial concerns but also domestic sources. The problem all Delawareans face is the prevention of further deterioration of the Bay, and planning for its eventual revival. This has been accomplished in other places and can be done here.

The system presented and analyzed is not meant to be the ultimate answer to the Delaware Valley's marine transportation needs. However, through the evaluation of this system, it is hoped to impress upon planners the magnitude of such a project and also to stimulate creative solutions to our current problems.

II. THE NEEDS AND CONCEPT OF A MARINE TRANSPORT SYSTEM

1. NEEDS TO BE MET BY A COMPREHENSIVE MARINE TRANSPORTATION PLAN (Ref. 56a)

The State of Delaware has three important resources that are not currently used to their full economic and ecological potential for the state and the region. Two are natural and one is man-made. The two natural resources are, first a central location in the New York-Norfolk population belt which includes over 35 million people and second, a natural, sheltered, deep-water channel and terminal location in the lower Bay near the sea. The man-made resource is the Dover Air Force Base, designed and operated specifically for the largest air cargo planes in the world. Precedents exist for the government to share the use of such facilities with commercial operations.

Because of the presence of these resources, it is appropriate that the State of Delaware take the initiative in this marine transportation plan even though the completed system will be of considerable benefit to the entire Delaware Valley and the financing and operating responsibilities may be shared with other legal entities (such as the Delaware River and Bay Authority and turnpike or transportation authorities).

The needs to be met by this proposed system are important to the State of Delaware, the Delaware Valley, and a wider east coast hinterland. Specifically, the proposed comprehensive marine transportation system will:

1. Provide a down-bay, deep-water port and thus reduce ship traffic in the river and consequently reduce the probability of collisions and spills.
2. Reduce ocean shipping costs for bulk commodities arriving for use by Delaware Valley industry.
3. Provide a site in the lower Bay on a man-made offshore port island for crude oil unloading, liquefied natural gas (LNG) delivery and regasification, coal and other dry bulk cargo transshipment containers, and possible power plant siting.
4. Provide a restricted transportation corridor between the industrial-port island in the lower Bay and an industrial park site immediately adjacent to the Dover Air Force Base.
5. Provide a long-range alternative use plan for the Dover Air Base as an air-sea cargo and industrial center should the federal government deactivate the facility in the future.
6. Provide a limited access transportation corridor from the Dover air-sea cargo center up the state to join the principal New York to Washington transportation routes for highway, rail, pipelines, and electric power transmission.
7. Provide a submarine pipeline access corridor from offshore oil and gas fields (if these materialize) to the down-bay island and thence to refineries or natural gas distribution pipelines.

8. Prevent aesthetic degradation of the lower Bay by locating the man-made, industrial-port island farther offshore than the existing lighering area.
9. Provide continued protection against refineries in the coastal zone by allowing only controlled pipeline access to existing up-river refineries.
10. Stimulate economic growth for the State of Delaware by constructing and operating the parts of the system located in Delaware.

2. THE CONCEPT OF A COMPREHENSIVE MARINE TRANSPORTATION SYSTEM FOR DELAWARE (Ref. 56a)

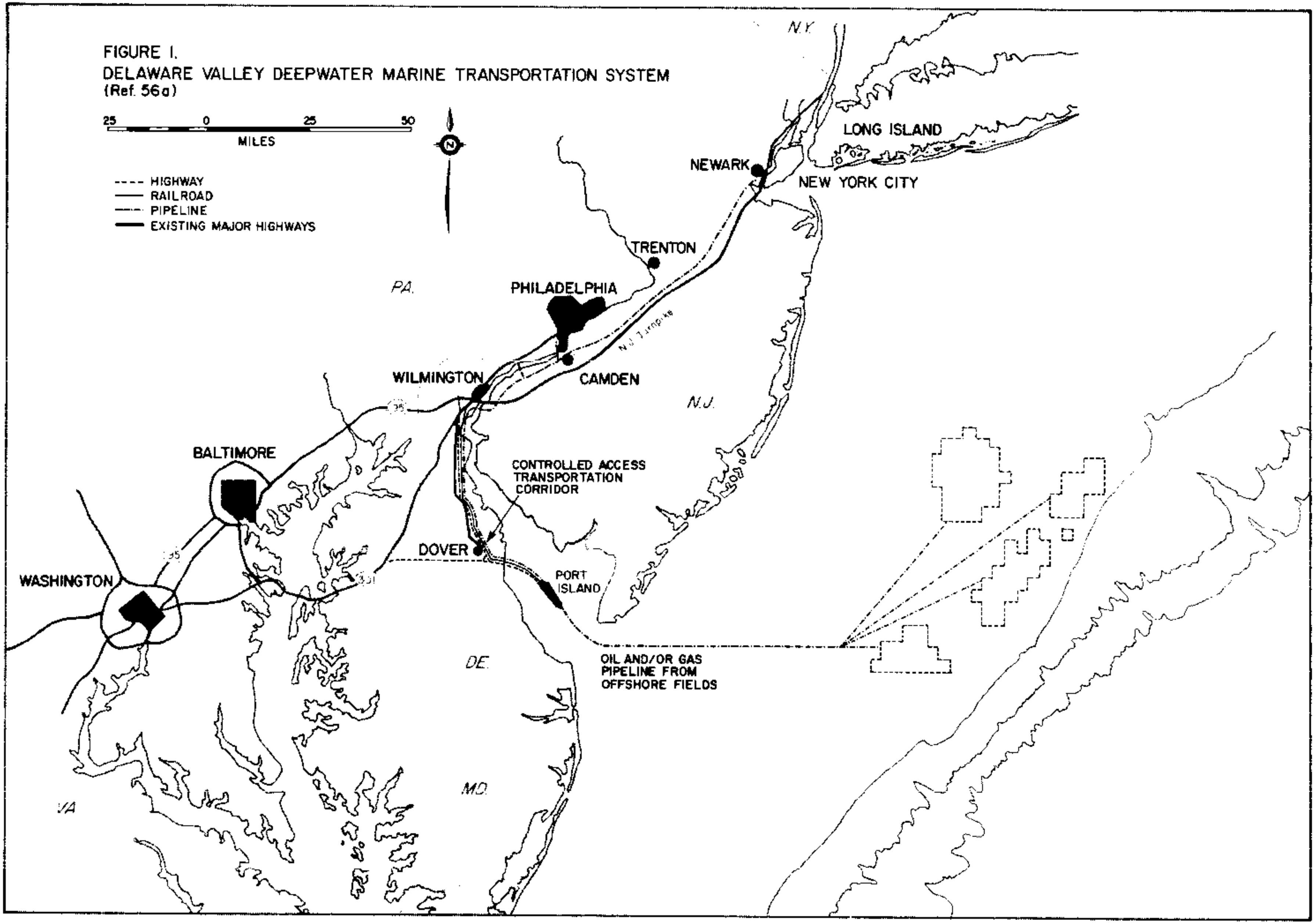
The scope for the total system is shown in Figure 1. The principal elements of this basic system include:

2.1 Lower Bay Port Island

Desirable features of a deepwater port site include a short, safe channel from the open ocean, shelter from ocean storms, shallow water immediately adjacent to deep water, and a location close to consumers and producers. The deepwater channel in the lower Delaware Bay possesses all of these features. While several possible port configurations could be considered, this concept proposes the construction of a man-made island using Lower Middle Shoal as its core. This location is shown on Figure 2.

The island would be designed for maximum future flexibility since oil imports may decline and other uses may increase. A typical cross section through the island is

FIGURE I.
DELAWARE VALLEY DEEPWATER MARINE TRANSPORTATION SYSTEM
(Ref. 56a)



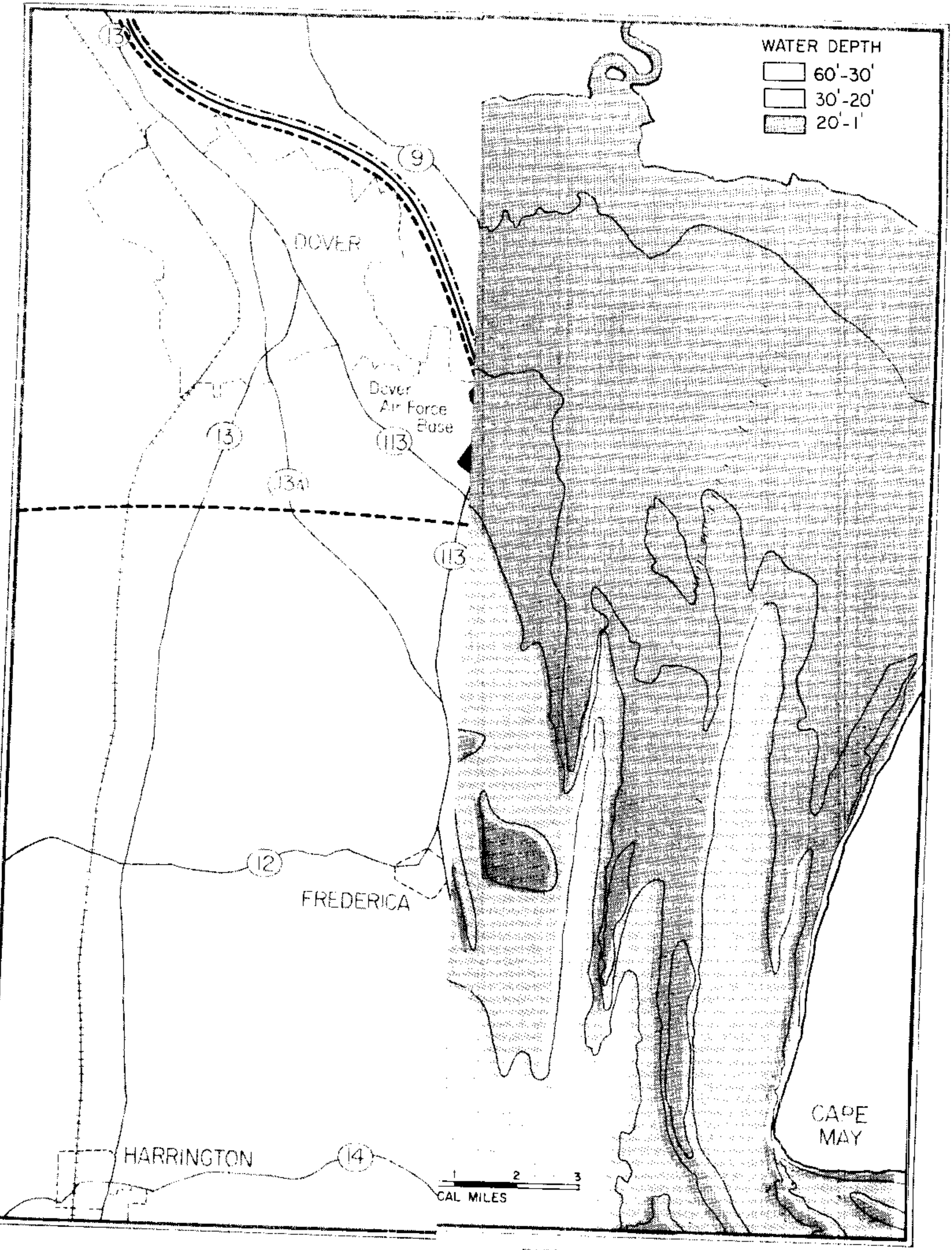


FIGURE 2. LOWER BAY ISLAND PORT AND ACCESS CORRIDOR
(Ref. 56a)

shown in Figure 3. On the side of the existing ship channel, a continuous vertical wharf would be provided both to contain island fill and to provide docking space for all ships and barges which will use the ship channel to Philadelphia. The surface of the island would be fill material capable of bearing heavy loads of storage tanks, dry bulk material such as a coal or iron ore and facilities such as power plants and LNG storage and regasification facilities.

On the deep water side of the island, a dike or wall would contain the fill in a water depth of 40 feet or less. The exact depth would be dictated by economic considerations and would vary along the length of the island due to natural bottom variations. The deepwater ship berths would extend beyond the edge of the island and would be located at the edge of the deepwater channel in water depths of 72 to 80 feet (MLW). These would serve special types of bulk carriers such as crude oil tankers, ore or coal ships, or LNG carriers. Each berth would be built so that it could be removed in the future if it were no longer needed and the deepwater berth could be put to some other use.

2.2 Deepwater Access Channel

A natural deepwater channel now exists from the proposed port island site on Lower Middle Shoal to the open sea. It is approximately 12 miles long from Cape Henlopen to the proposed Phase I island berths. Its depth varies from 120 feet at the deepest point to approximately 62 feet (MLW) at

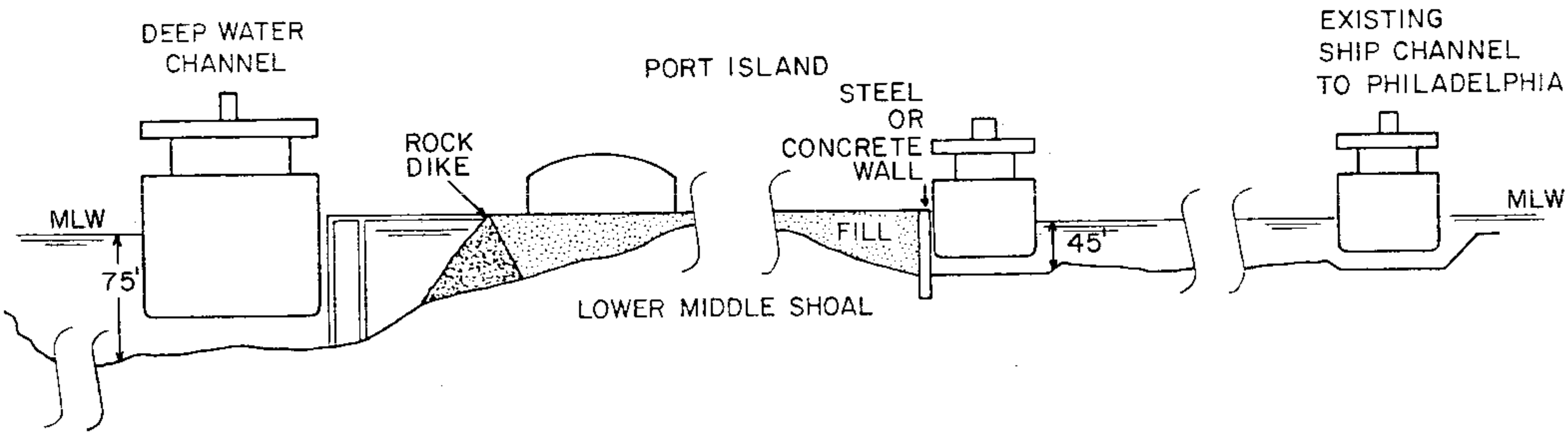


Figure 3. SECTION THROUGH ISLAND ON LOWER MIDDLE SHOAL
(Ref. 56a)

the shallowest. By dredging a few high areas, the channel can be deepened to operating depths of 70 or 80 feet.

This deepwater channel is short, straight, and wide, being approximately one mile wide at its narrowest point. It is also separate from the existing ship channel to Philadelphia and could be readily monitored by a Coast Guard-operated ship traffic control system.

2.3 Submarine Pipeline Corridor to the Continental Shelf

Commercial quantities of oil and/or gas may be found on the continental shelf in the Baltimore Canyon Trough formation 60 to 100 miles offshore to the east. A submarine pipeline corridor should be part of the original port island concept. This corridor would be available between the two ship channels for one or more crude oil or natural gas pipelines. This could be attractive to New Jersey and Delaware as well as the producing companies, since it would avoid the need to bring pipelines across beaches and through the states.

2.4 Restricted Island to Shore Corridor

All-weather access to the port island would be provided by a restricted access transportation corridor. This corridor would connect the island to the Dover air-sea cargo center by means of a trestle over open water and tidal marshes. On higher fast land, the corridor roadbeds would be laid on the ground surface in the conventional way. An aesthetically pleasing trestle design can be employed and sound deflecting berms and evergreen screens can be used on shore.

The corridor would be approximately the same width as an interstate highway right-of-way. It would have no access or egress points between the port island and the Dover air-sea cargo center. A cross section of the corridor is shown in Figures 4a and b. The four basic transportation modes provided would be two or more rail tracks for high speed passenger service plus freight, a dual highway plus service lanes providing the equivalent of three lanes in each direction, a pipe rack and a power transmission line.

2.5 Dover Air-Sea Cargo Center

This area would be located on property immediately adjacent to the east boundary of the Dover Air Base. It would be planned to accommodate services for the port island, certain industrial activities, storage and marshalling areas which cannot be readily accommodated on the island and parking space for island employees who will travel to and from work by commuter train. In Phase I of port-island development, the Dover center would serve primarily as a terminal point for workers on the island and for the freight marshalling. In the later stages of island development, as containership and air cargo activity begins, the Center would expand to accommodate selected industrial activities and to provide ground support for commercial air freight service.

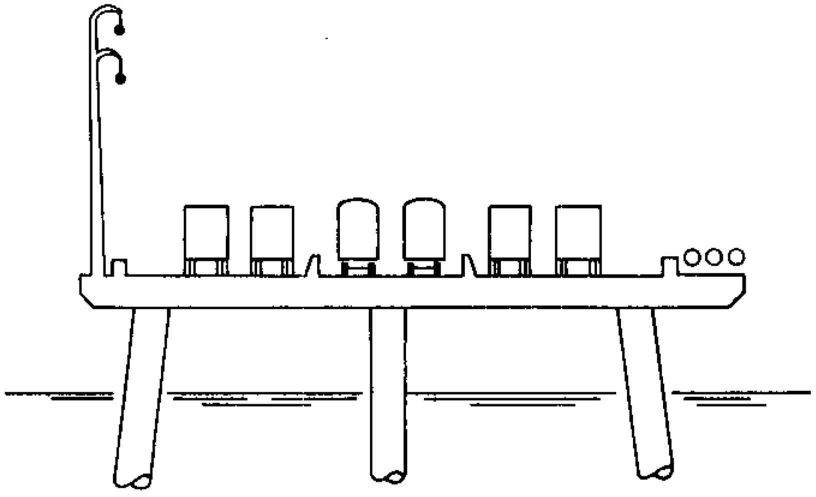


FIGURE 4a. PORT ISLAND TO SHORE TRESTLE
(Ref. 56a)

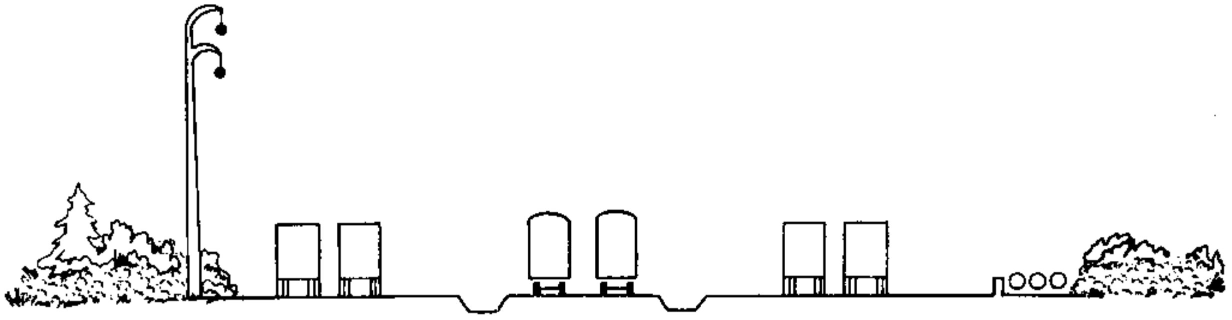


FIGURE 4b. ON SHORE RESTRICTED ACCESS CORRIDOR
(Ref. 56a)

2.6 Restricted Access Up-State Transportation Corridor

From the Dover air-sea cargo center, a restricted corridor will be needed to accommodate rail, highway and pipeline facilities. Factors to consider in route selection include minimum new land taken for construction, ease of constructing a high level access bridge over the C & D Canal, and the optimum location to join the highway, rail and pipeline routes in the Newark-Wilmington area.

2.7 Optional Features

The centralized nature of this project might also make two other features attractive. The first would be the continuation of the oil and gas pipelines through Philadelphia and into the northern New Jersey area to feed the refineries there. The other feature would be a transportation corridor heading west to connect with the Chesapeake Bay bridge, thus opening the Washington-Baltimore markets.

III. BULK COMMODITY THROUGHPUT ESTIMATES FOR DEEPWATER TERMINAL

More than 90% of all world trade moves via marine transportation (Ref. 126). Waterborne trade is vitally important to the Delaware Valley because the basic materials for a vigorous economy must be transported up the river. Most of the essential fuels and basic raw materials only come to the Delaware Valley by marine transportation.

1. CRUDE PETROLEUM

Crude oil imports for the Delaware Valley refineries have traditionally played a major role in the economic strength of the entire region. All crude oil comes to the Delaware Valley by waterborne transportation. Crude oil imports alone account for 33% to 40% of all commodity traffic that moves on the River and Bay (Ref. 41). In 1975, oceanborne imports and exports of petroleum products and crude oil represented 70.6% of all tonnage imported and exported. Also in 1975, the movement of petroleum within the Delaware River waterways from one point to another accounted for 83.3% of all such internal port traffic. See Figure 5.

In a vigorous economy, even with very slow population growth, there is demand for an inexpensive, versatile, readily available fuel. Therefore, it will be necessary to bear the costs of purchasing foreign oil for some time because of the decline in domestic production since 1970 and the long lead time necessary to change technologies (Ref. 133). There has been some expansion in Delaware Valley petroleum refinery capacity (see Table 1). There have been a number of plans to build new refinery capacity to handle anticipated growth in demand for petroleum throughout the mid-Atlantic region. By 1980, growth in demand by one-fourth over 1975 levels, by 1985 growth by two-thirds over 1975 (Ref. 55, 127). These plans have not been implemented.

FIGURE 5.

Traffic Tonnage on the Delaware River - Trenton, New Jersey to the Sea

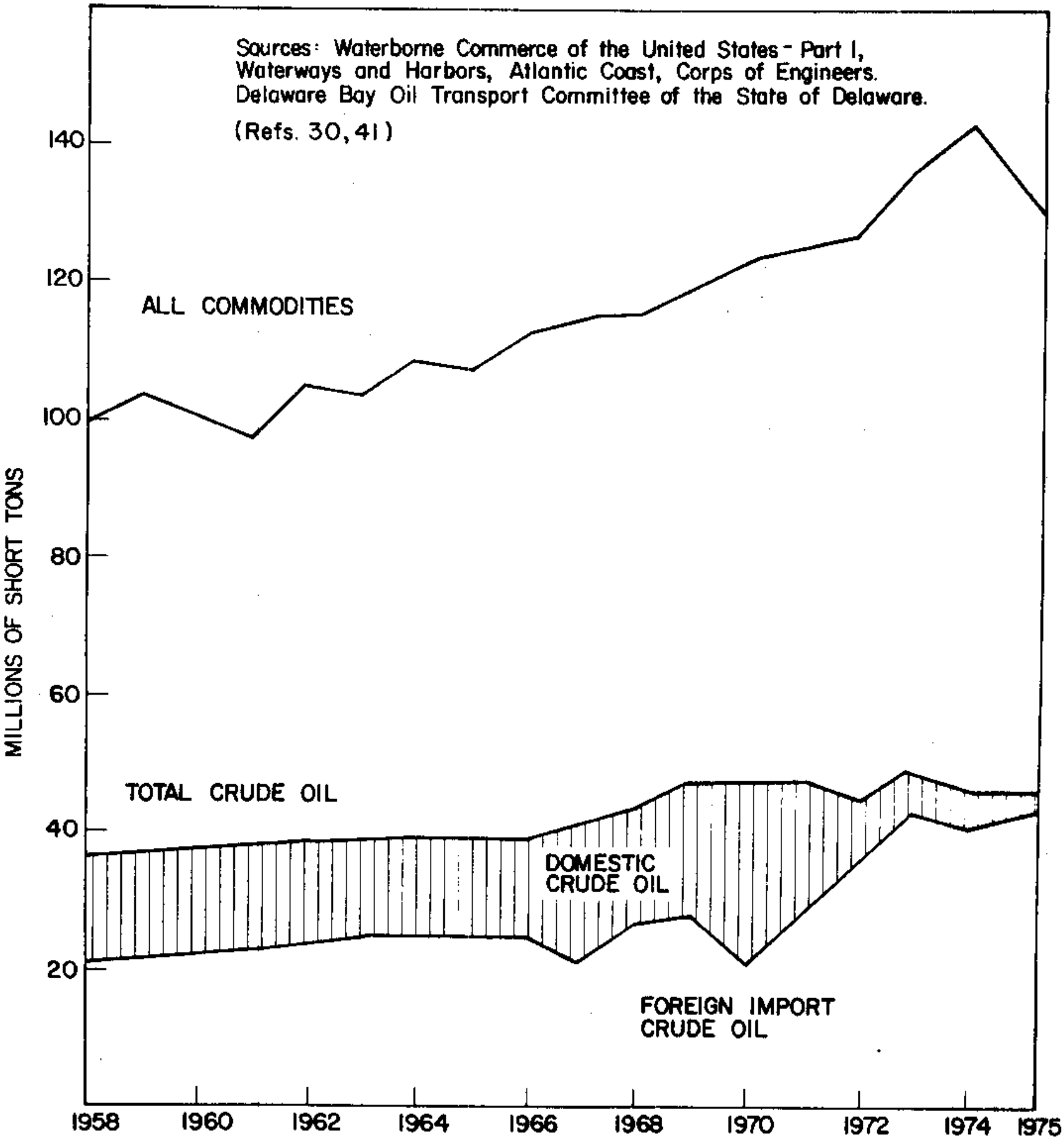


TABLE 1

Delaware Valley Petroleum Refineries

	Throughput Capacity (barrels per day)
1972	913,100
1974	944,500
1976	993,330

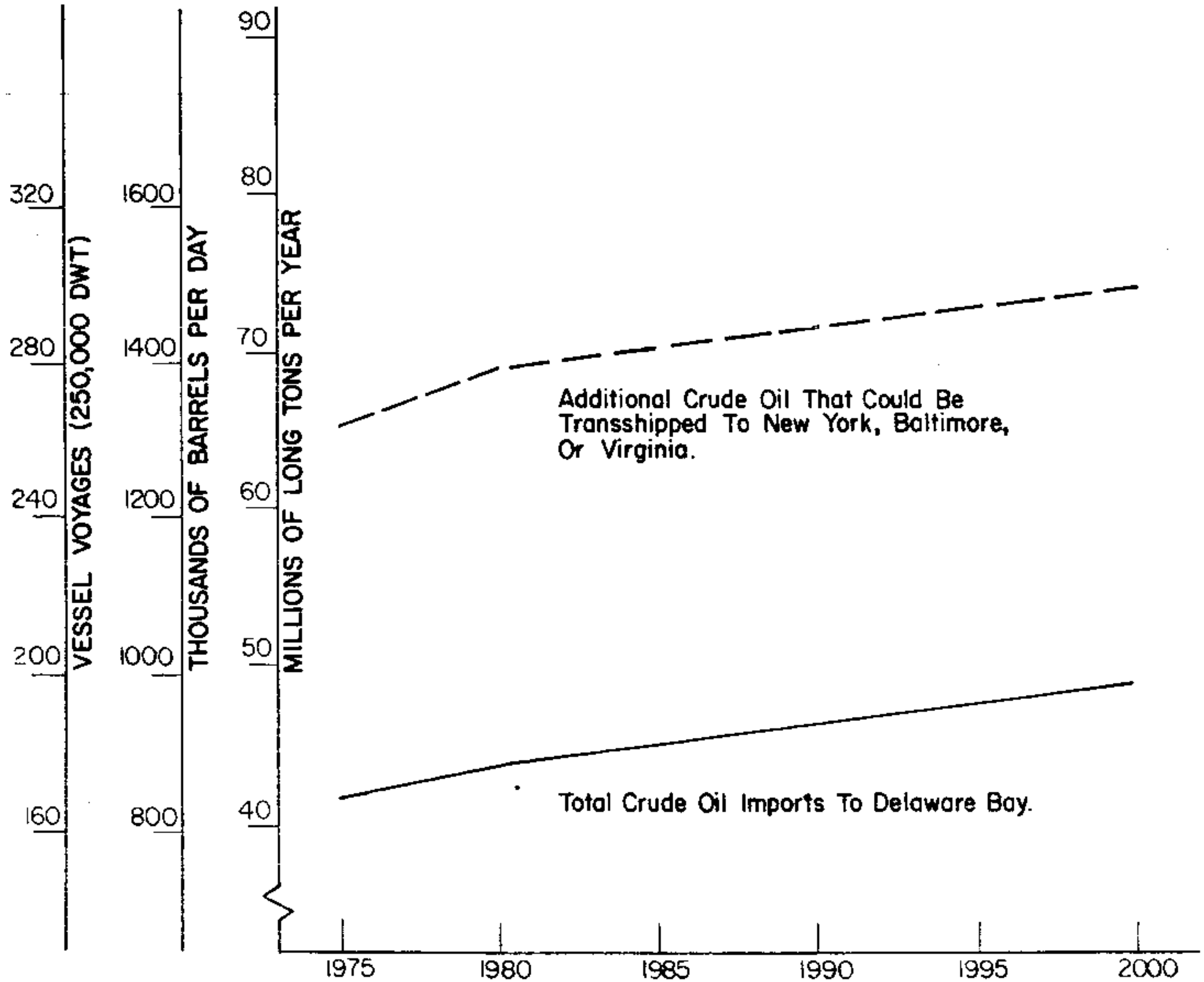
The strict enforcement of the Environmental Protection Agency's air quality standards make refinery expansion very unlikely at this time (Refs. 58, 65, 72, 92, 127). Increased demands will probably be met by shipment of finished products in smaller sized tankers.

However, with replacement of old equipment and with marginal increases in refinery capability, total regional capacities should expand, but at a very gradual rate. (850 thousand barrels/day of crude oil were shipped into the Delaware Valley during 1975.) Figure 6 shows a growth rate for imported oil from all sources of less than 1% per year for the entire Delaware Valley, reaching 1 million barrels/day by the year 2000.

Because of rapidly rising costs of vessel construction and deepwater terminal construction, the large economies of long distance bulk transportation are not as significant as several years ago (Refs. 59, 121). Some oil companies feel that the use of a deepwater terminal would make the crude oil they get from West Africa or closer even more costly (Refs. 58, 72, 92). At today's prices, the costs of lightering

FIGURE 6.
(Refs. 41, 58)

Estimates of Crude Oil Imports to the Year 2000 for the Delaware Valley, New York Area, Baltimore, and Yorktown Refineries.



in lower Delaware Bay are competitive with a deepwater terminal (Refs. 72, 92, 127). Most oil imported to the Delaware Valley is not brought from long haul distances of over 6000 miles (Refs. 58, 65, 72), therefore, the cost savings inherent in larger vessel usage is of marginal benefit.

If it is found that in order to insure environmental safety there should be as few operational transfers of oil as possible, then a centrally located deepwater terminal to handle the great volume of foreign imports might be required. As Figure 6 shows, another 23 to 25 million long tons of crude oil could be delivered to a deepwater port for transshipment to other mid-Atlantic states via pipeline or ship. Other east coast refineries face the same air quality standards as those in the Delaware Valley with, consequently, no growth.

One pressing need for the Delaware River is to be able to prevent oil tanker collisions and groundings in the upper portions of the river. A deepwater terminal in the lower Bay would accomplish this by drawing a great proportion of the normal ship traffic out of the Philadelphia channel. This change would improve navigability of the River and reduce turnaround time for both tankers and other vessels because of less time spent waiting to proceed to berth. If all crude oil had to be brought to a deepwater terminal the channels up-river to Philadelphia would be less crowded, hence less dangerous. Since 1959, the largest tankers entering the Bay have had to lighter off cargo in order to permit transit up the ship channel. Lightering creates two potential problems. First, the need for many more operational transfers of crude oil with an associated chance of spillage. In 1975, 425 tankers lightered to 1055 barges in Delaware Bay (Ref. 127). Second, traffic flow is greatly increased as two tugs and at least two barges are required for every lightered tanker. However, there have been no accidental spills from lightering since its inception in 1959. The termination of lightering would eliminate two potential sources of accidental and operational spillage (Ref. 127).

TABLE 2

Total Number of Vessel Voyages Per Year
Between Trenton and the Sea (Ref. 41)

	Oceangoing	Internal	Vessels Drawing More Than 36 Ft.
1970	7251	66081	1032
1973	7497	70674	1273
1975	6144	53650	1106

As of January 1976 the world's oceangoing fleet contained 5311 tank ships of all types. This classification of vessels has continued to grow despite the uncertainties of crude oil tanker chartering. The majority of all tank ships continue to be under 60,000 deadweight tons (DWT), i.e., draw less than 40 to 45 feet. The 125,000 DWT and over size classes represent only 14% of the number of all tank ships. The 60,000 DWT and over classes, i.e., the size of ships that must lighter or wait for high tides in order to use the Philadelphia ship channel, comprise 26% of the number of all tank ships. 38% of all tankers draw more water than 36 feet. This large group must either lighter off cargo in Delaware Bay or wait for the appropriate tides (Ref. 131). Yet, over 50% of world tanker tonnage is in the 100,000 DWT and over size range (127,134). In other words, 50% of tanker capacity cannot use the Philadelphia ship channel without lightering. The capacity share of the very large classes of tankers is expected to grow (Refs. 2, 134).

TABLE 3

Existing Channel Limitations
(Refs. 41, 134)

	Controlling Depth	Max. Draft (ft.) of Vessels 1970	1973	1975	Maximum Tanker Size (DWT) Accommodated
Portland, ME	45 ft.	51	47	46	80,000
Boston	40	42	41	41	50,000
New York	45	44	46	57	55,000-(lightering
Delaware Bay	40	46	47	47	55,000-(doubles)
Baltimore	42	40	42	42	55,000
Hampton Roads	45	47	47	47	50,000

The economies of crude oil transport are intimately tied to the environmental constraints on expanding refinery capacities as well as the distance from the source of crude. This relationship warrants further study in order to develop a comprehensive plan for the best marine transportation system in Delaware Bay.

2. OTHER PETROLEUM

Residual and distillate fuel oils comprise a large share of the petroleum traffic in the Delaware Valley. These classes of petroleum are almost exclusively used as heavy fuel oils for industry and utilities. Fuel oils move in smaller tankers to a great variety of destinations for final unloading. Residual and distillate oils would not be candidates for terminal use at this time.

Refined, or finished, petroleum products that are exported from the Delaware Valley by water move in smaller vessels directly from refineries to points of final distribution.

3. IRON ORE

Iron ore, essential in the manufacture of steel, comes to the Delaware Valley and to Baltimore by water. Dry bulk cargoes can realize the same kind of cost savings as petroleum through the economies of bulk transportation. It is less expensive per ton to ship large volumes of bulk items, like iron ore, over long distances.

However, dry bulk moves in smaller size lots than oil because of smaller volume raw material demands and a more dispersive distribution system. The use of deep-draft, very large bulk carriers for dry cargo is more restricted because of these factors. 14% of the total number of world fleet dry bulk and combination bulk carriers are in the 60,000 DWT and over classes. Only 28% of the total number of this world bulk fleet have drafts over 36 feet (Ref. 131). Nonetheless, a deep-draft port serving the entire mid-Atlantic region would provide a significant opportunity for utilization of very large dry bulk lot movements. This is especially true where the distance of transport is 6000 miles or more (Chile, Peru, Australia).

Figure 7 represents the high and low range of values for possible imports to both the Delaware Valley and Baltimore that could be handled at a specialized bulk terminal. The 1975 actual figure for the Delaware Valley is indicated. The range is 13 to 17 million long tons for 1980, 19 to 29 million for 1985, and 21.5 to 33 million for the year 2000.

4. COAL

Coal is a commodity of increasing importance in the United States and abroad. The U.S. produces much of the high quality metallurgical coal of the world. To remain competitive in an international market, U.S. coal must move via the least expensive mode of transportation.

However, the volume that is exported more than 6000 miles is a limited share of the total. Exports to Japan account for most of the long haul volume. Because of the nature of the dry bulk trades, high density commodities, diffuse distribution, smaller volume size lots, the use of very large, deep-draft bulk carriers is not foreseen to be as widespread as very large liquid tankers (Ref. 59).

FIGURE 7.
(Refs. CMS 680, 30, 59, 121, 129)

Estimates of Iron Ore Imports to the Year 2000 for the Delaware Valley and Sparrows Point, Maryland.

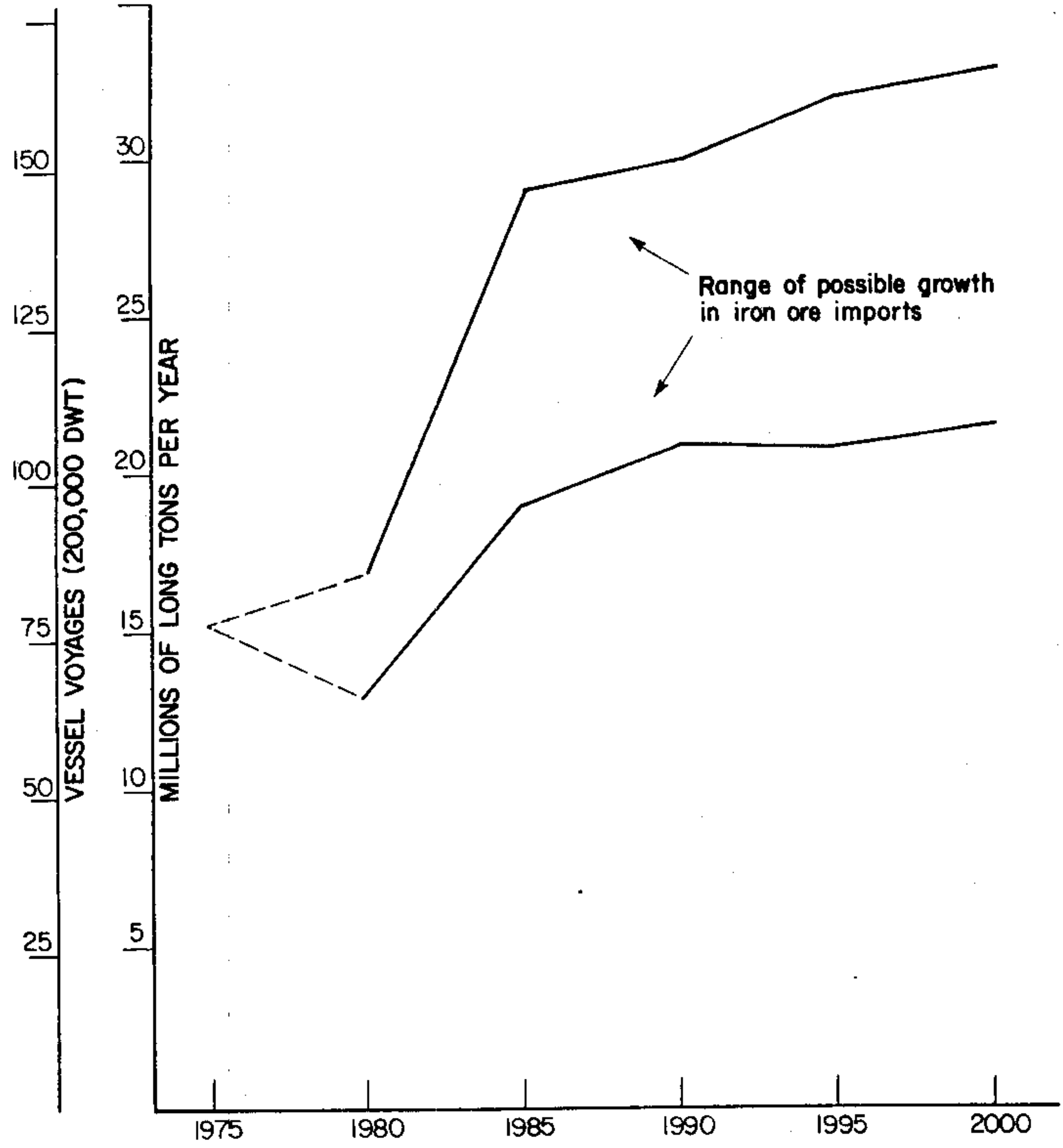


Figure 8 represents the range of possible volumes that could be attracted to a deepwater port. The actual value for 1975 Delaware Valley exports is indicated. The maximum range expected over the 1980-2000 period is 4 to 6-1/2 million long tons.

Present inland freight rates favor coal shipment via rail to Hampton Roads, Virginia. Some previous studies suggested that 20, 30, or even 50 million long tons could be transshipped from Hampton Roads to Delaware Bay via barge for deepwater terminal access (Refs. 38, 142). The number of deep-draft vessels required for long distance movements will not warrant the transshipment of such volumes. However, a ship or barge with both oil and bulk ore capabilities would be highly valuable to transship oil to Virginia and coal back to lower Delaware Bay.

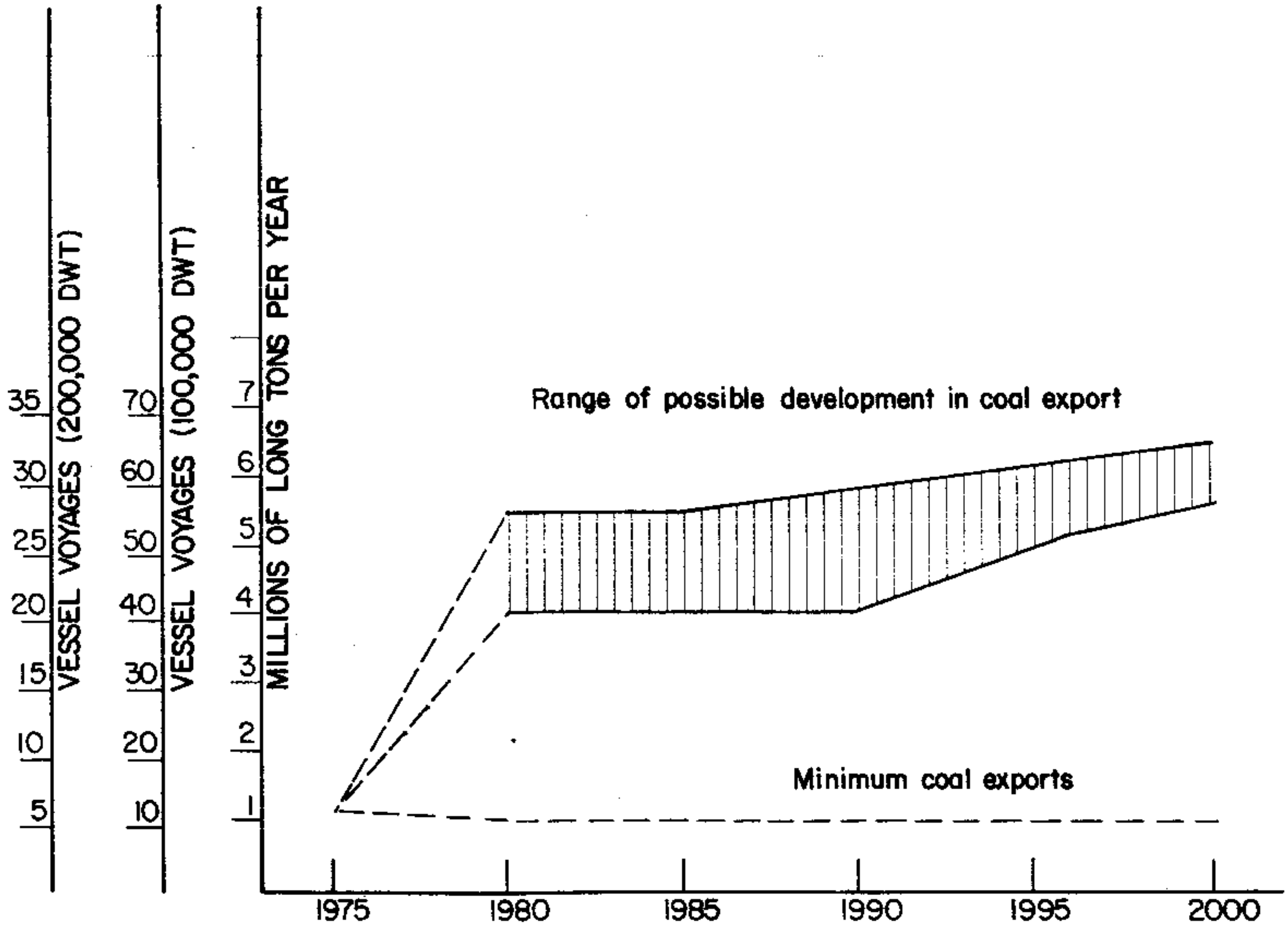
5. GRAIN

This is a large commodity grouping including corn, wheat, sorghum, and soybeans. Interstate freight rates facilitate the movement of grain to the Gulf coast for shipment. Grain is a low density commodity grouping and does not require deep-draft port facilities. Additionally, grain moves in more conventional lot sizes to a variety of distributional terminals.

The development of an industrial-port island terminal would enhance the possibilities of large volume shipments of grains to Africa or Asia. A facility to handle very large

FIGURE 8.
(Refs. CMS 680, 59)

Estimates of Coal Exports to the Year 2000 from the Delaware Valley.



lots could increase the Delaware Valley's present 2-1/4 million tons of export to nearly 4 million tons. See Figure 9.

6. LIQUEFIED NATURAL GAS

Natural gas is a fuel in great demand. Diminished domestic production has led to foreign imports of LNG (Ref. 133). Because of the extremely volatile nature of LNG, its importation is closely regulated by the Coast Guard. At present all importation projects must be approved by the Federal Power Commission. A total of 400 billion cubic feet per year of LNG has been approved for importation to the east coast. (This includes the El Paso-Columbia LNG terminal at Cove Point, Maryland.) See Figure 10. Another 700 billion cubic feet, pending approval by the FPC, is scheduled for other east coast and New Brunswick, Canada terminal locations. There is an associated long lag time from approval date to initial delivery.

LNG shipments do not require deep-draft capabilities at the port site. Special handling is necessary because of the extreme cold temperatures needed to maintain its liquid form during transoceanic shipment. A facility for regasification on an industrial-port island removes both the LNG carriers and the plant from congested urban port areas. One previous project planned for the Delaware Valley included 106 vessel voyages up the river per year (Ref. 51).

Imports of liquefied petroleum gas (LPG) and synthetic natural gas (SNG) are possible alternatives to LNG. LPG and

FIGURE 9.
(Refs. CMS 680, 59, 121)

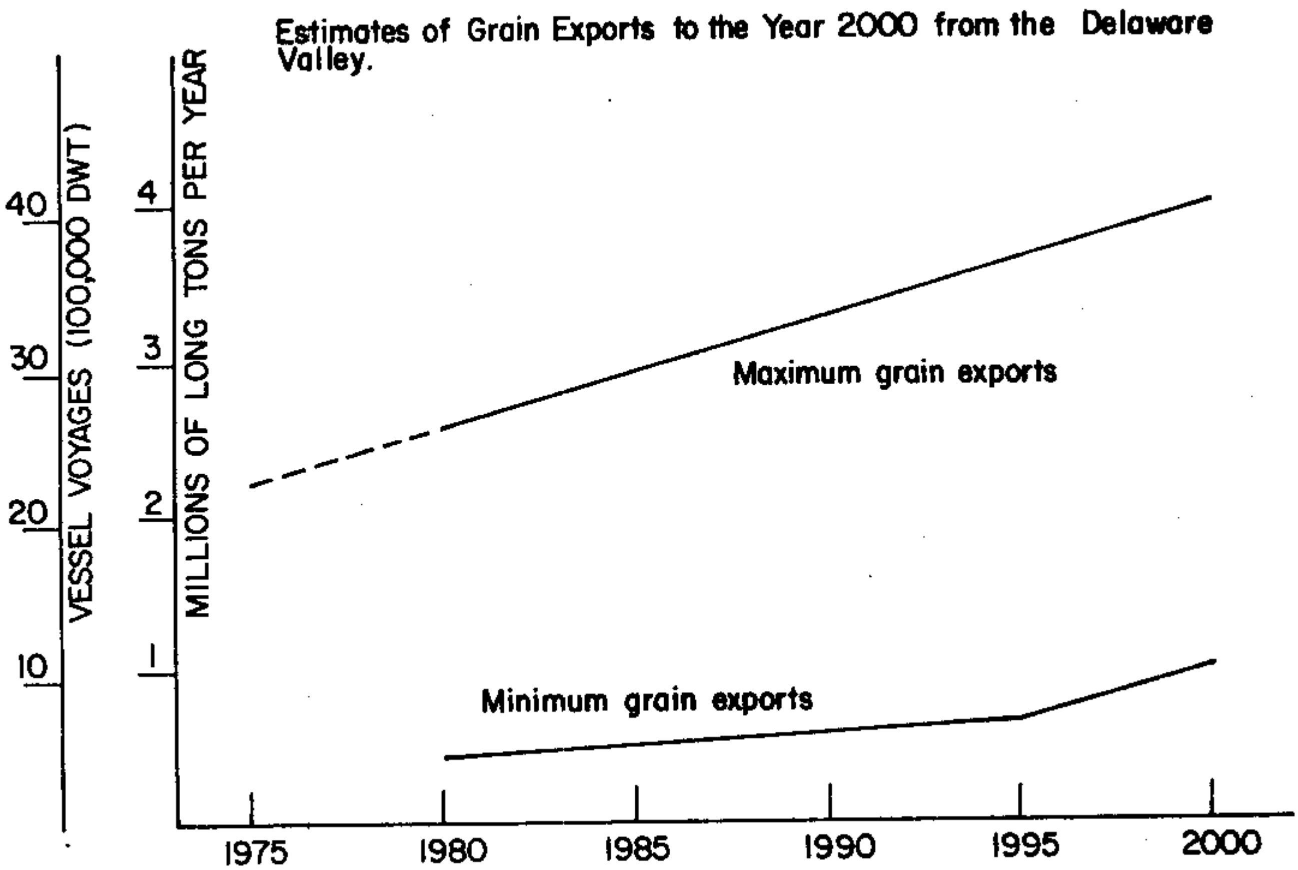
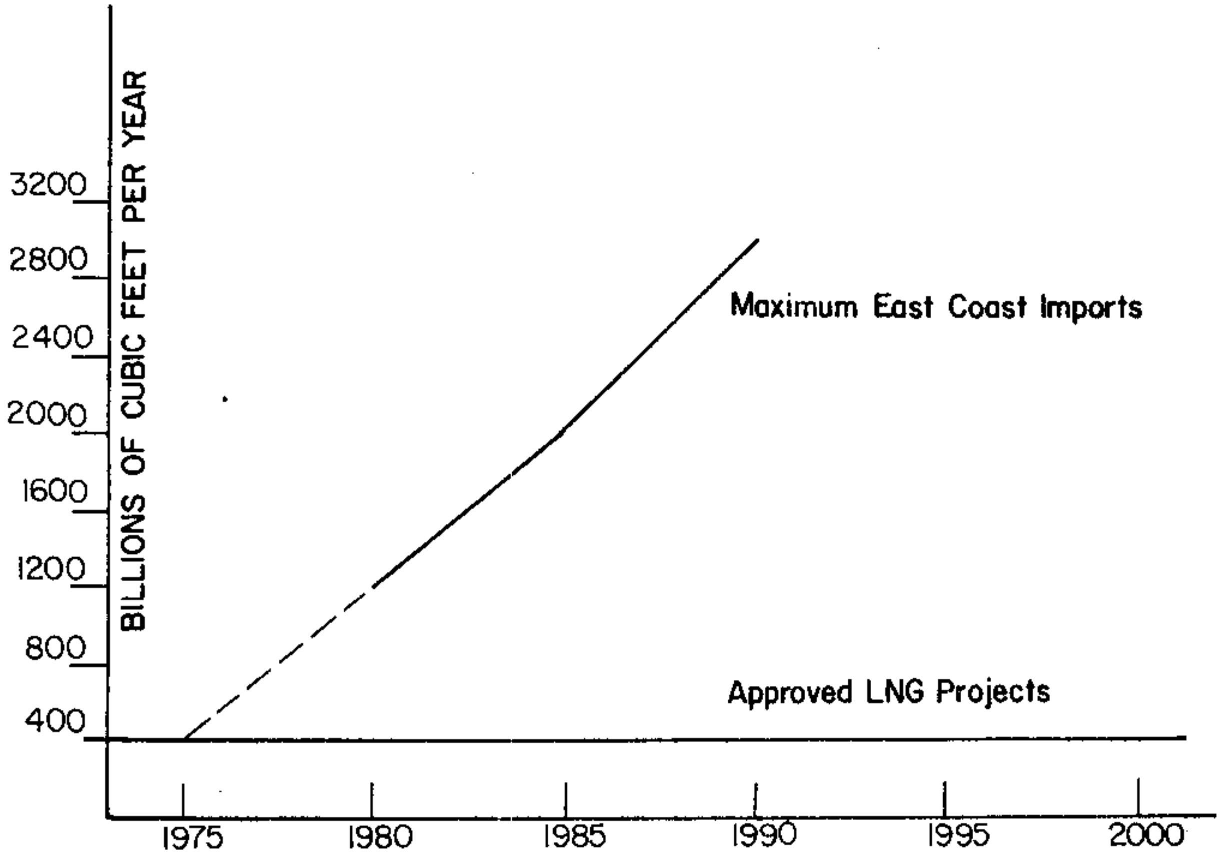


FIGURE 10.
(Refs. 3, 54, 55, 71, 100, 105)

Estimates of Liquified Natural Gas Imports to the Year 1990 for the Entire United States East Coast.



SNG do not require the extreme temperatures and pressures that are needed for ocean transportation of LNG. It will be some time before the technology of SNG is commercially feasible.

7. CONTAINERS

Containerized shipments are possible candidates for a deepwater port in Delaware Bay. Lots of as few as 200-300 containers can be profitable enough for smaller vessels to alter course for a Delaware port. Larger ships require thousands of containers for terminal or port pickup operations (Ref. 59). Table 4 gives the most recent figures for the port of Philadelphia.

TABLE 4

Containerized Cargo
(Ref. 130)

	1972	1973	1974
Containers	23,000	36,000	44,000
Long Tons	348,300	519,000	613,000

The determining factors for containerized cargo are the inland freight rates versus transshipment costs and the International Longshoremen's Association labor contract. The first determines the economic feasibility of a shipper's use of the port. Containerized cargo should follow the path of least cost to the port of first shipment. The second factor determines the efficiency of port operations. There would be a standard labor contract with the ILA as at all other upper east coast ports, but the history of ILA and containerized cargoes is not good.

IV. ISLAND SPACE ALLOCATION

	Projected Annual Throughput In Year 2000	Allocated Space
Import oil	50 million tons minimum	200 acres
Import iron ore	33 million tons minimum	140 acres
Export coal	6.5 million tons minimum	100 acres
Export grain	4.0 million tons minimum	100 acres
LNG	400 billion cubic feet	100 acres
Import containers	4066 thousand long tons	40 acres
Waste-water treatment		80 acres

Figure 11 shows one possible configuration for port island space allocation. If warranted by demand, the 200 acre vacancy at the island's north end could accommodate variation in space requirements for the above commodities. In the absence of such shift, the vacant area may house new services (e.g. nuclear power station), or serve as a construction link to future island increments. One proposed increment scheme is indicated by dotted lines in the figure.

V. MARINE DESIGN CRITERIA

The major design criteria concerning construction of an artificial island in the Delaware Bay are: wind, waves,

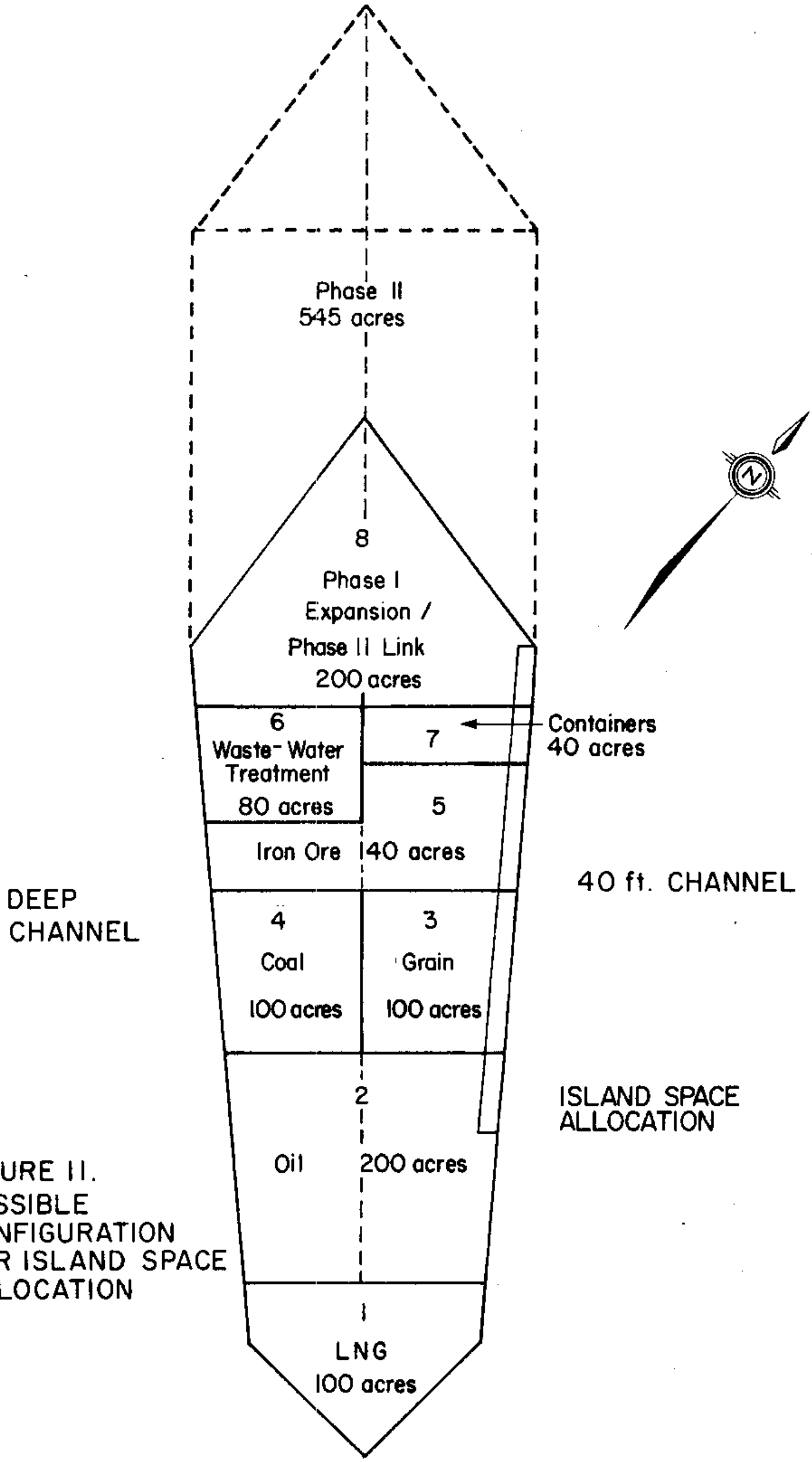


FIGURE 11.
POSSIBLE
CONFIGURATION
FOR ISLAND SPACE
ALLOCATION

currents, precipitation, ice, earthquakes, sediments, and storm conditions. All wind, wave and storm data were measured at 38° 55.9' N, 75° 10.3' W, just southwest of the proposed island location.

The wind speeds and direction affecting wave heights and direction are shown in a cumulative monthly percentage in Table 5. All speeds marked as 0 indicate less than .5% occurrence or less than 43.2 hours per year.

Waves are an important factor when considering construction of the island. The trestle, mooring piers, and retaining wall are somewhat dependent on the normal expected wave heights. When measuring wave heights, the highest 33% of waves observed passing a stationary location during an approximate 20-minute observation period were considered significant. Wave height is measured as vertical distance from crest to adjacent trough. The highest wave expected to occur in 1000 waves would be 186% of this significant wave height. The direction given for the waves is the direction from which the waves approach the site. These heights are shown in Table 6. It should be remembered that these are long term observations and therefore seasonal fluctuations are to be expected.

The normal tidal currents between the Fourteen Foot Bank Light and Mispillion River range up to 2.5 knots. At the light, these currents occur at 340° intercept during flood tide and a 175° intercept during ebb tide. At the Mispillion River mouth, the intercepts are 025° at flood and

WIND SPEED (M.P.H.)

WIND DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	>35	Total
N	16	61	49	30	23	9	5	1	194
NE	12	52	39	17	13	5	1	0	139
E	7	43	24	12	4	0	0	0	90
SE	3	37	21	11	1	0	0	0	73
S	18	72	45	24	15	8	2	0	184
SW	18	69	50	23	14	7	1	0	182
W	14	57	40	22	14	7	5	3	163
NW	10	50	41	31	23	10	6	4	175
Total	98	441	310	170	107	46	20	8	1200

Table 5: CUMULATIVE MONTHLY WIND IN LOWER DELAWARE BAY (Ref. 60)

ORIGINATING DIRECTION	0-1.9	2-3.9	4-5.9	6-7.9	8-9.9	10-15	>15	Total
N	156	24	13	1	0	0	0	194
NE	114	25	0	0	0	0	0	139
E	74	16	0	0	0	0	0	90
SE	52	20	1	0	0	0	0	73
S	149	35	0	0	0	0	0	184
SW	160	22	0	0	0	0	0	182
W	148	15	0	0	0	0	0	163
NW	101	64	10	0	0	0	0	175
Total	954	221	24	1	0	0	0	1200

Table 6: CUMULATIVE MONTHLY SIGNIFICANT WAVE HEIGHT IN LOWER DELAWARE BAY (Ref. 60)

190° at ebb. The current rotation in the Delaware Bay flows southward along the Delaware shore, reinforcing the ebb tide, and northward along the New Jersey shore, reinforcing the flood tide. The normal yearly tidal range in the Fourteen Foot Bank Light area is 7.7 feet, rising to 6.4 feet above MLW.

The Delaware Bay area averages 45 inches of rain per year. The maximum rain which will fall in a 24 hour period is 5 to 7 inches, usually in the late summer or early fall.

The Bay does have ice floes which can become rather thick. However, ice is not foreseen as a design problem because of the collision safety factor which will be designed into all pilings and bulkheads.

Earthquake frequency and magnitude are relatively unknown for the Delaware area. A Mercalli intensity VII+ earthquake was recorded in the Wilmington area in 1871. Reports from a Mercalli intensity VI earthquake that occurred in the same area in 1973 registered I on the same scale in the Delaware Bay. No sizable earthquakes or tremors have been instrumentally recorded in the lower Delaware Bay. Research in this area is ongoing.

The Lower Middle Shoal has risen and lengthened since 1848. It is composed primarily of 1.76 phi mean diameter sand with a slight amount of silt and gravel (Ref. 139). The major portion of the Delaware Bay floor is composed of sand, gravel, and silt which are suitable for solid fill. There are no known freshwater aquifers that would be affected by dredging the required channel. More coring will be required.

The maximum storm conditions which can be expected in the Lower Middle Shoal area are (Ref. 60):

25-year storm	
Maximum astronomical tide	6.4 ft.
Storm tide	8.2 ft.
Maximum wave height	19.7 ft.
Period of maximum wave	7.1 sec.
Sustained wind speed	60 m.p.h.
Maximum instantaneous gust	90 m.p.h.
50-year storm	
Maximum astronomical tide	6.4 ft.
Storm tide	10.3 ft.
Maximum wave height	31.6 ft.
Period of maximum wave	9.1 sec.
Sustained wind speed	85 m.p.h.
Maximum instantaneous gusts	129 m.p.h.
10-year storm	
Maximum astronomical tide	6.4 ft.
Storm tide	12.5 ft.
Maximum wave height	36.8 ft.
Period of maximum wave	10 sec.
Sustained wind speed	110 m.p.h.
Maximum instantaneous gusts	165 m.p.h.

Further considerations should be drag pressure and inertial pressure. Also it should be noted that the berthed ships will require a minimum of 10% of their draft for bottom clearance.

It is important that the life of the system's components be considered during design. Designs must incorporate protective measures against the maximum conditions expected. Therefore, it is recommended that the 100-year storm conditions be considered as the maximum.

VI. DESIGN AND CONSTRUCTION OF PHYSICAL FACILITIES

1. ISLAND CONSTRUCTION AND DREDGING

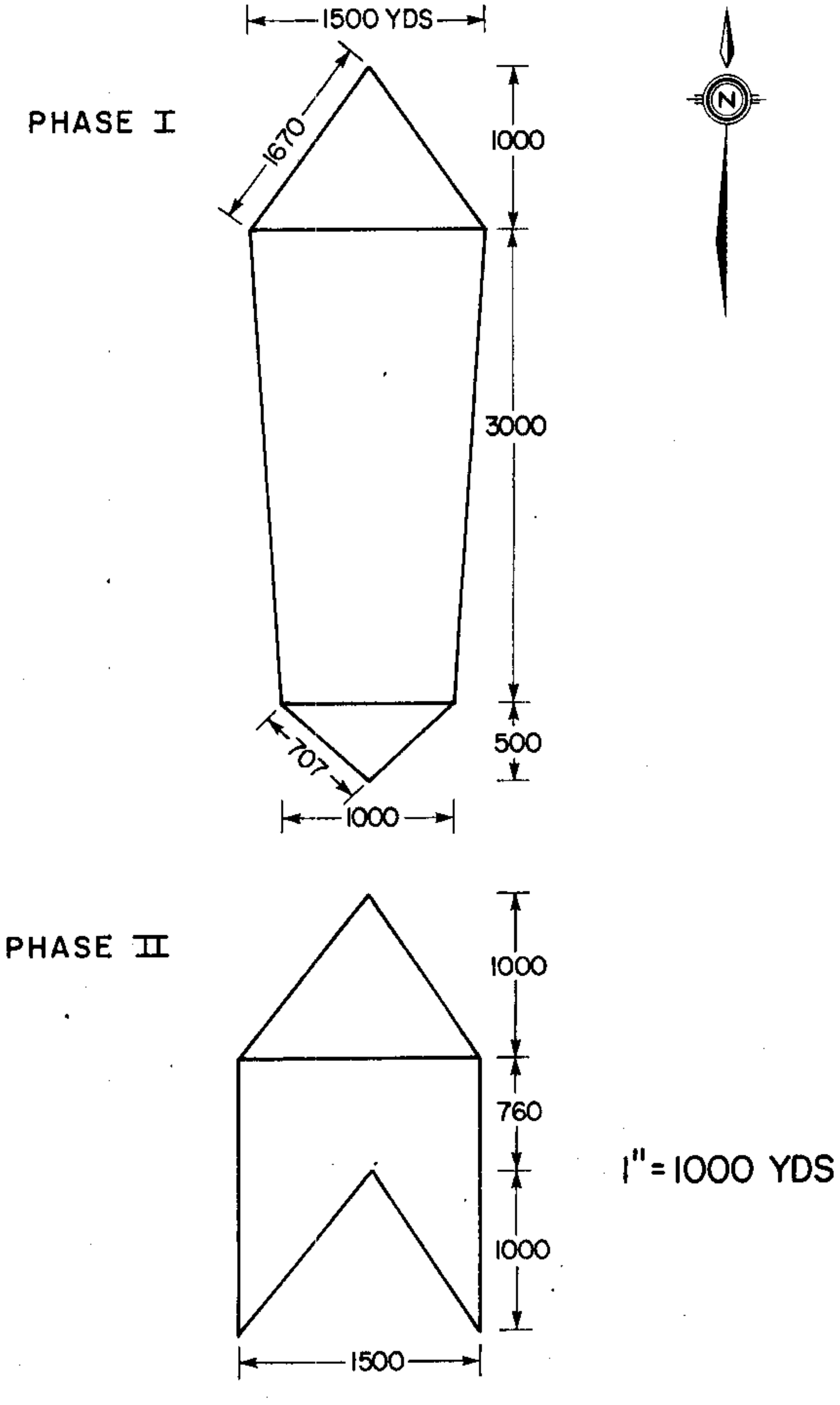
The port island would be constructed using Lower Middle Shoal as its core. Preliminary geologic evaluations show the shoal to be a stable formation composed basically of sand and gravel, and it is thus an ideal core for a load-bearing structure. Borings must be taken to confirm this, however, since seams of mud were found in Joe Flogger Shoal nearby (Ref. 139). The island would be constructed so that the 100-year storm surge coupled with maximum astronomical tide would not inundate any part of the island. This requires an elevation of 19 feet above mean low water. The island would also be constructed with approximately a 0.1% grade from its edge to its center, resulting in a central height of 21.25 feet above mean low water. This would allow drainage of the island.

The original section of the island would be in the approximate configuration and dimensions shown in Figure 12. This represents a surface area of 4.68 million square yards or 1.5 square miles. The exact island configuration and orientation would be dictated by model studies. It should conform to the shape of the shoal to reduce the amount of fill and the effect on present circulation and current patterns in the Bay.

1.1 Perimeter

The first step in constructing the port island would be to build the perimeter which will contain the dredged fill

FIGURE 12. ISLAND DIMENSIONS



material. The northern, southern and western sides would be rock dikes. See Figure 13. These dikes can withstand great forces and should be less expensive than other possible types of construction. The eastern side of the island would be constructed of sheet pile cells or concrete caissons. This side would present a shear face which would serve as a wharf when suitably fendered.

The rock dikes consist of a layer of core material topped by layers of filter and armor rock (Ref. 13). The armor rock for the southern perimeter would be large, weighing approximately 40 tons. On the western side, the rock size would gradually grade to 10 tons approximately 1000 yards along the west side. This size would continue around the rest of the dike. This construction would be used because the southern perimeter would be subjected to the greatest wave and storm forces. The armor layer would be about six feet thick and would cost about $30 per cubic yard delivered. The filter rock layer would be about two feet thick and would be composed of rock ranging from 100 to 1000 pounds. Quarry run rock, usually 10 to 20 pounds in size, would be the core material and make up the largest part of the dikes. The cost of filter and core material is approximately $18 per cubic yard. The slope of both the inner and outer walls would be about 1 on 2.5. Only the exterior faces of the dike would require the filter and armor layers. Using this information and the average depth to which the dike must extend, an approximate total cost of

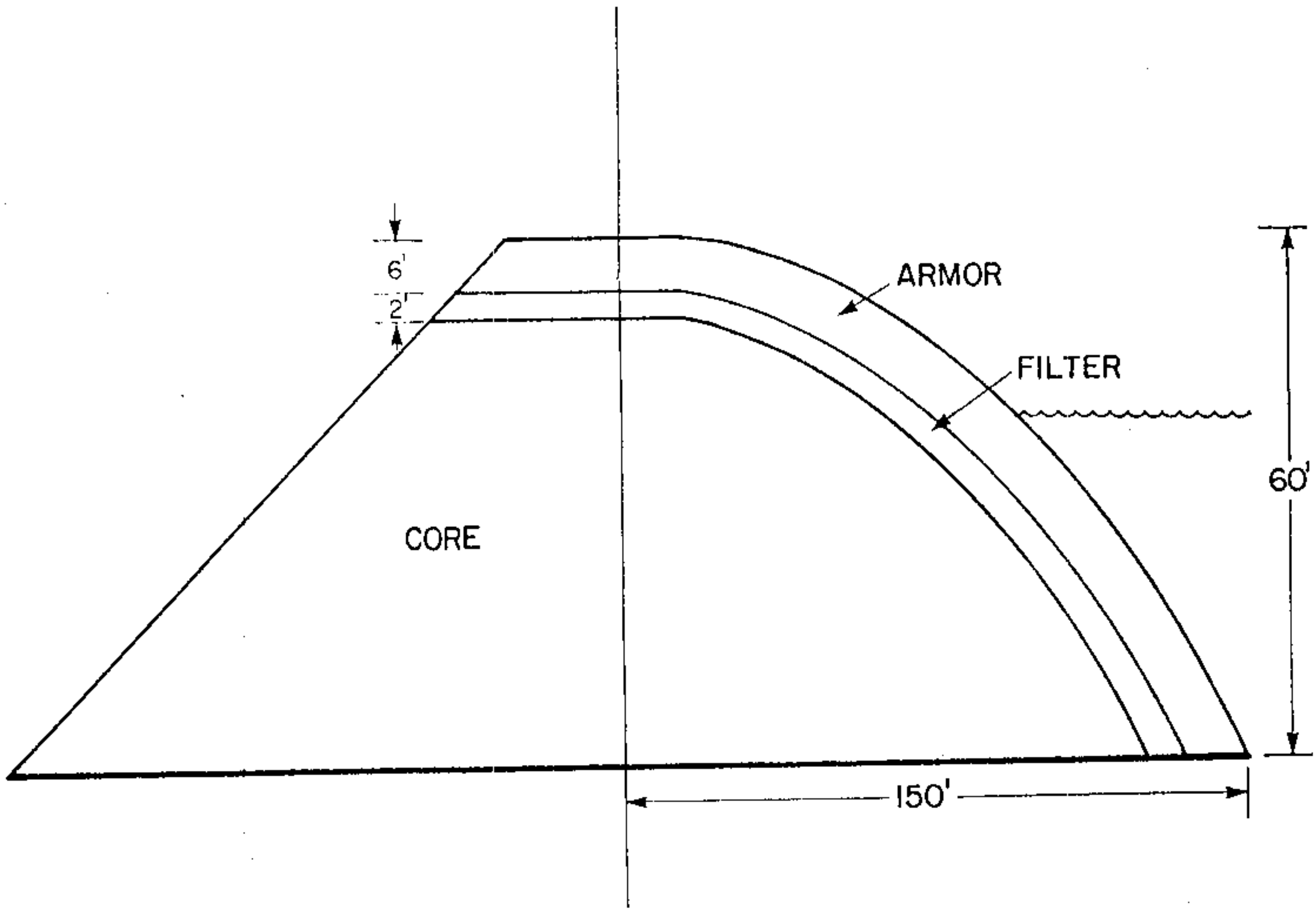


FIGURE 13. ROCK DIKE

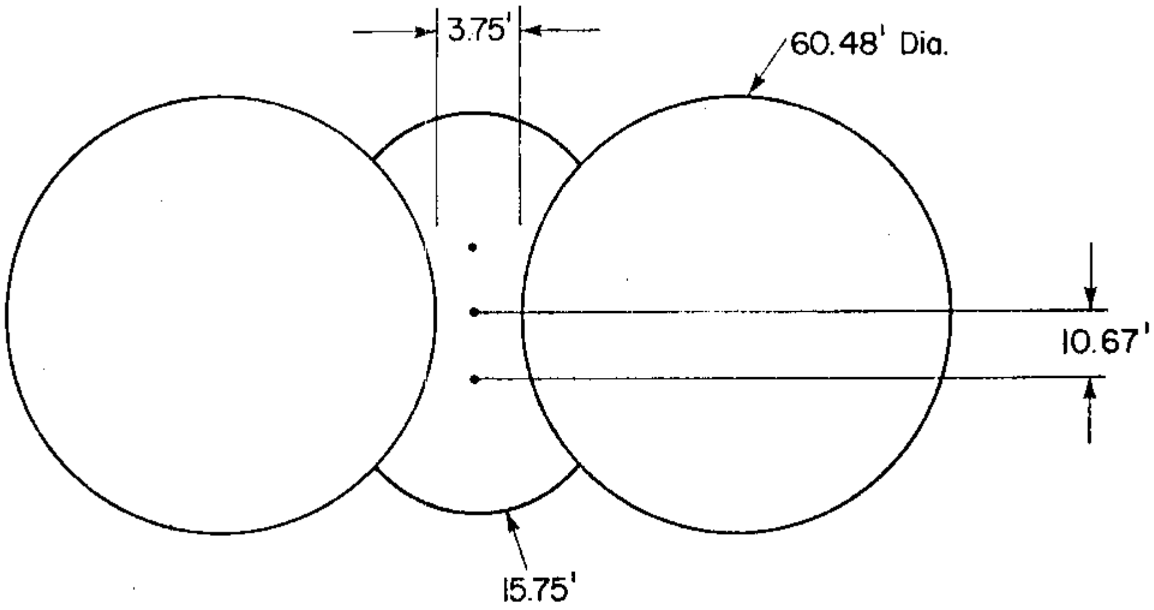
$145 million is obtained. It would take an estimated four years to complete the entire rock dike perimeter.

The eastern perimeter would be constructed of either sheet piles or concrete caissons. See Figure 14. Either type of construction could serve to produce a sheer wall 65 feet high. Once in place, both would require toe protection to combat the sheer wall effect.

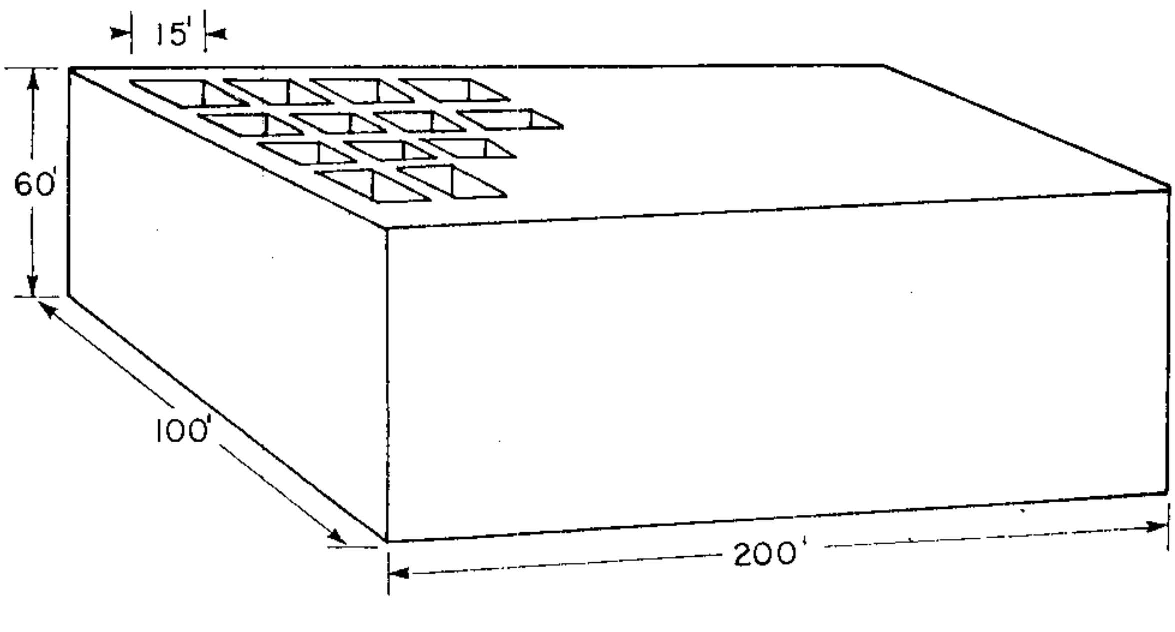
Sheet pile cells can be obtained at an approximate in-place cost of $10 per square foot (Ref. 50). Cells approximately 60 feet in diameter and 75 feet high would be required along about 9000 feet of the island. These would cost between $75 and $100 million (Refs. 50, 76). The cells would be driven into the bottom and filled with the same fill material being used for the island. Using two pile drivers, cell installation could more than keep pace with the placement of the rock.

Concrete caissons as an alternative to sheet pile cells have the major advantages of not requiring any cathodic protection and of providing longer service life. They could be of similar design to those proposed for use in the Atlantic Generating Station (Ref. 113). Essentially, the caissons are large concrete boxes closed at the bottom and open at the top. They would be precast, floated to the site, sunk into place, and filled with rock and dredged fill. They would be held in place by their weight. Each caisson would be 65 feet high, about 100 feet wide and 200 to 250 feet long. The spaces between caissons would be sealed with a

FIGURE 14.



A. STEEL SHEET PILE CELL CONSTRUCTION



B. CONCRETE CAISSON

key consisting of vertical bulkheads with intervening spaces filled with granular material. These serve to accommodate differential movements that might occur. Additionally, to install the caissons, the bottom would have to be dredged deeper than the desired bottom of the caisson and crushed stone placed for bedding and leveling. The area would then have to be backfilled after the caisson was in place. The approximate cost for installing concrete caissons along the entire 9000 foot eastern perimeter would be approximately $200 million.

Since the island's original section would contain more space than necessary for the anticipated needs of the primary tenants (oil and LNG), it would be advisable to subdivide the section to allow construction and operation of oil and LNG facilities before the whole 960 acres is filled. This could be accomplished by building the southern half of the perimeter, both rock dike and sheet pile cell (or concrete caisson) first. A temporary sheet pile barrier could then be erected across the width of the island about 2000 yards from the southern tip, creating a subsection. This would take approximately two years. Filling would begin as soon as this subsection perimeter was completed. After enough fill was placed at the northern edge of the subsection to ensure stability of the temporary barrier, filling would proceed from south to north. Filling should be completed in about three years. Work on the remaining part of the perimeter would continue while the southern subsection was being filled. The northern part of the remaining perimeter would be completed first and work would proceed southward toward the previously completed subsection. Once completed, the northern rock dike would serve as an effective breakwater for the subsection.

Subsection construction would require extension of the trestle an additional mile southward at a cost between $15 and $25 million. Trestle extension would entail relatively little construction time and would be concurrent with the dredging operation so the trestle should be finished before the island.

1.2 Dredging

The approximate amount of fill material required for the island can be estimated by using the average depth of the area to be filled, the maximum astronomical tide and the projected height of the island above the astronomical high tide. The initial section of the island would require about 53.7 million cubic yards of material, about 23 million of which would be required to complete the southern subsection. Material obtained from dredging the associated channels would be used as the fill for constructing the port island. This material is primarily sand and gravel with some silt. This type of granular material is excellent fill and of optimum density when pumped out of the dredge pipe (Ref. 62).

Two channels from the current ship channel and another immediately adjacent to the eastern side of the island would be dredged to a depth of 45 feet and a width of 100 yards. This would provide about 11 million cubic yards of fill material. The deepwater channel providing access to the western side of the port island is to a large extent a natural channel. However, to have a channel 300 yards wide and 75 feet deep with a turning basin 1000 yards in diameter, about 21 million cubic yards of material would have to be removed. In addition, to provide access to this deepwater channel, dredging also would be required in the ocean and at the bay mouth. The ocean area is about 3.4 miles long and would require removal of about 13.5 million cubic yards of material. The bay mouth area is about 1.7 miles long and would require removal of 8.7 million cubic yards of material. This would provide an access channel 300 yards wide and suitable for vessels of 75-foot draft (Ref. 12). The material obtained by dredging these channels would be sufficient to fill the first section of the port island.

Several large hydraulic dredges using booster stations and a maximum pipe length of about fourteen miles would be used to accomplish the dredging. Work would continue year-round except for the months of June and July. This would lessen, as much as practical, the impact on spawning fish populations. One large (27-inch) cutter suction dredge could excavate about 200,000 cubic yards of granular material each month at a cost of $1.50 to $3.00 per cubic yard (Ref. 50, 75). Four large dredges would complete the total first section dredging in about seven years, while the fill for the southern subsection could be dredged in about three years. The total cost would range from \$81 to \$161 million. Because of the magnitude of the dredging project, development of an advanced dredge representing the technological state of the art might be justified.

Additional sections of island would be constructed as demand warrants. These sections could be of any required length with maximum projected island length of about 5-1/2 statute miles. A proposed configuration of additional sections of island is shown in Figure 15. A maximum of three such sections could be constructed, each with a surface area of 2.64 million square yards or 0.85 square miles. Data for these three additions is:

Section	Fill Required $\times 10^6$ cu. yds.	Cost \$ $\times 10^6$
I	33	49.5 to 99.0
II	30.4	45.6 to 91.2
III	29	43.5 to 87.0

Each section would require about four years (each of ten months) of simultaneous dredging by four large dredges. The additional fill material could be obtained by widening or deepening any of the associated channels. For example, section II could be completed by widening the deep water channel from 300 to 900 yards. There also exists the possibility of obtaining some fill material from the Delaware District Corps of Engineers. This is not considered

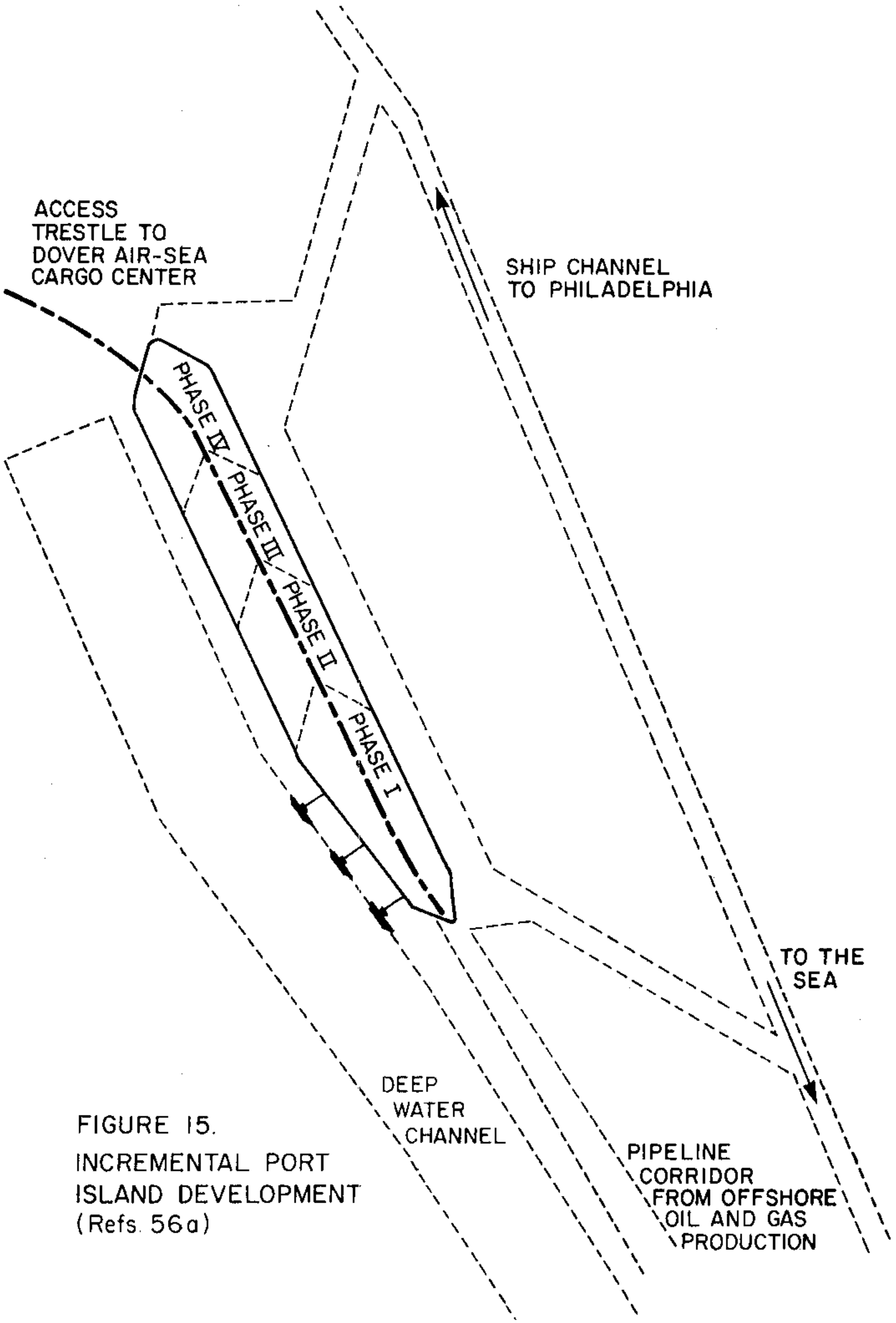


FIGURE 15.
INCREMENTAL PORT ISLAND DEVELOPMENT
(Refs. 56a)

economical at this time because the material presently being removed from the Delaware River and Bay is generally poor fill material and is dredged at locations which make transport to the lower Bay economically prohibitive. Some maintenance dredging may be required after projected channels are completed. Model studies would be required to evaluate this possibility. Overall, the island would require about 10 years construction time and cost between $220 million and $345 million depending on type of construction chosen. This would provide about 960 acres of usable space and 9000 feet of wharf.

2. TRESTLE DESIGN AND CONSTRUCTION

The trestle connection between the port island and the mainland would be designed for two railroad lines, four through lanes of road traffic, two 48-inch pipelines, utilities, and service lanes. The railroads will be capable of withstanding Cooper E-72 (72,000 lb./axle) loading or higher (Ref. 5). The roads would be designed for H20-S16 AASHO (80,000 lb.) truck loads (Ref. 104). Each railroad line would require a minimum clearance of 16 feet horizontally and 23 feet above the rails vertically (Ref. 5). The road lanes should be 12 feet wide with vertical clearance of 14 feet 6 inches (Ref. 40). Each pipe should have at least an area 6 feet by 7 feet high.

2.1 <u>Alternate I</u>

2.1.1 <u>Design</u>. Alternate I would provide the requirements of the system in two separate trestles which could be built nearly simultaneously or could be built in stages as needed. The construction planning resulted from conversation with a major East Coast design firm (Ref. 141). Each trestle would be 60-feet wide and contain one rail line and 2-1/2 road lanes, with 14 feet for pipelines (Fig. 16). The second trestle would contain the same 2-1/2 lanes of road and one rail line, with the possibility of either additional pipelines or an additional roadway, or a narrower trestle.

Each trestle would be founded on five pile bents of 36-inch diameter solid concrete piles driven 40 or 50 feet below the mud line. Bents would be spaced about 70 feet apart. Rectangular precast concrete girders about 5 feet high would support the road and highway portions of the trestle. A similar length and height of steel girder would go under each rail of the railroad to support the greater load over the long span. Concrete deck slabs would be used to form the roadway and as a base for the pipe cradle. Ties and rails for the railroad would be placed directly on the girders for the railroad.

2.1.2 Construction Method. The trestle would be constructed using traditional construction methods, requiring access for heavy barge cranes to all points along the trestle. This could most easily be accomplished by dredging a 12-foot deep channel through the shallow water areas and through the marsh. This has been done successfully on other construction projects. Standard pile drivers would place the pilings,

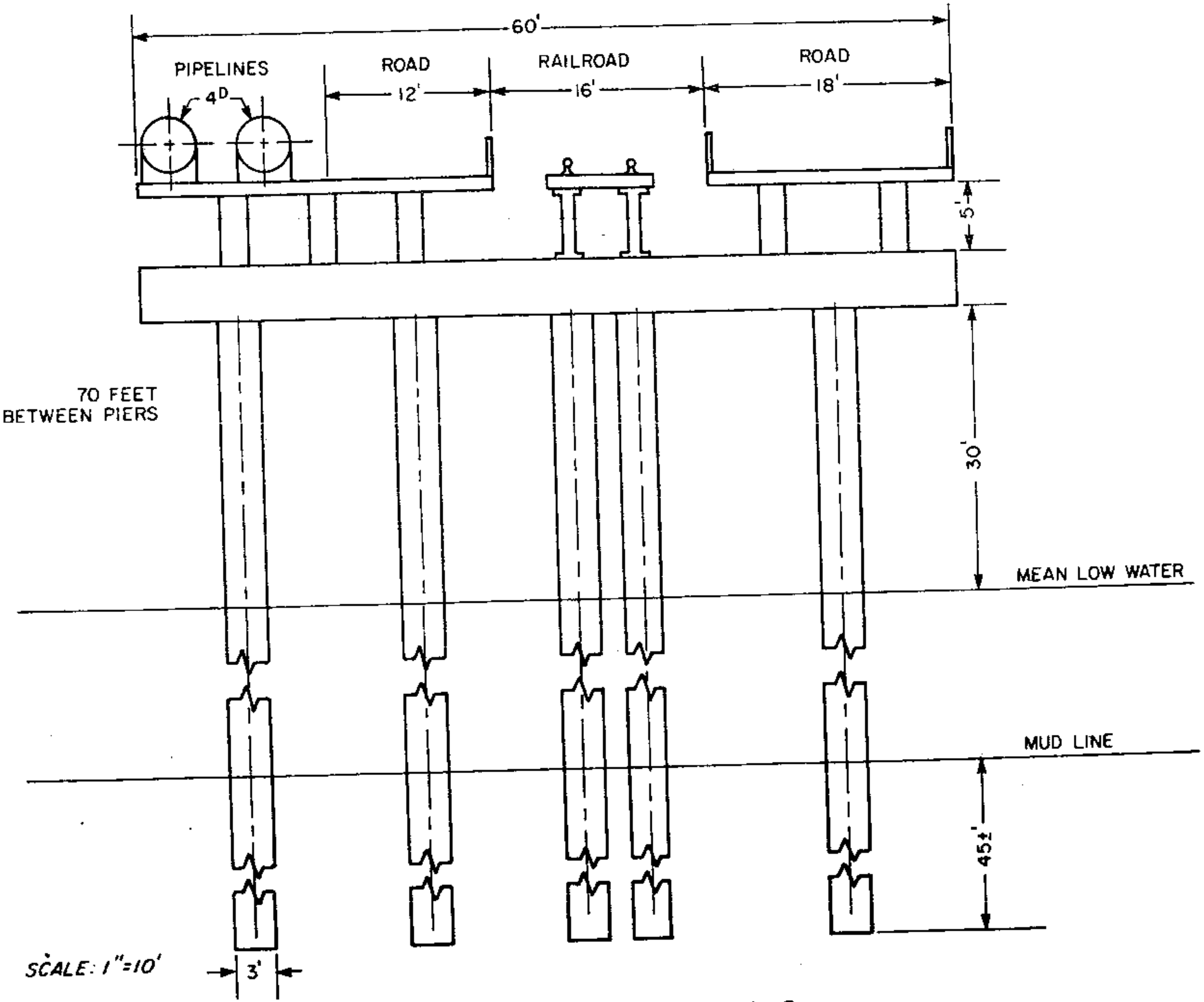


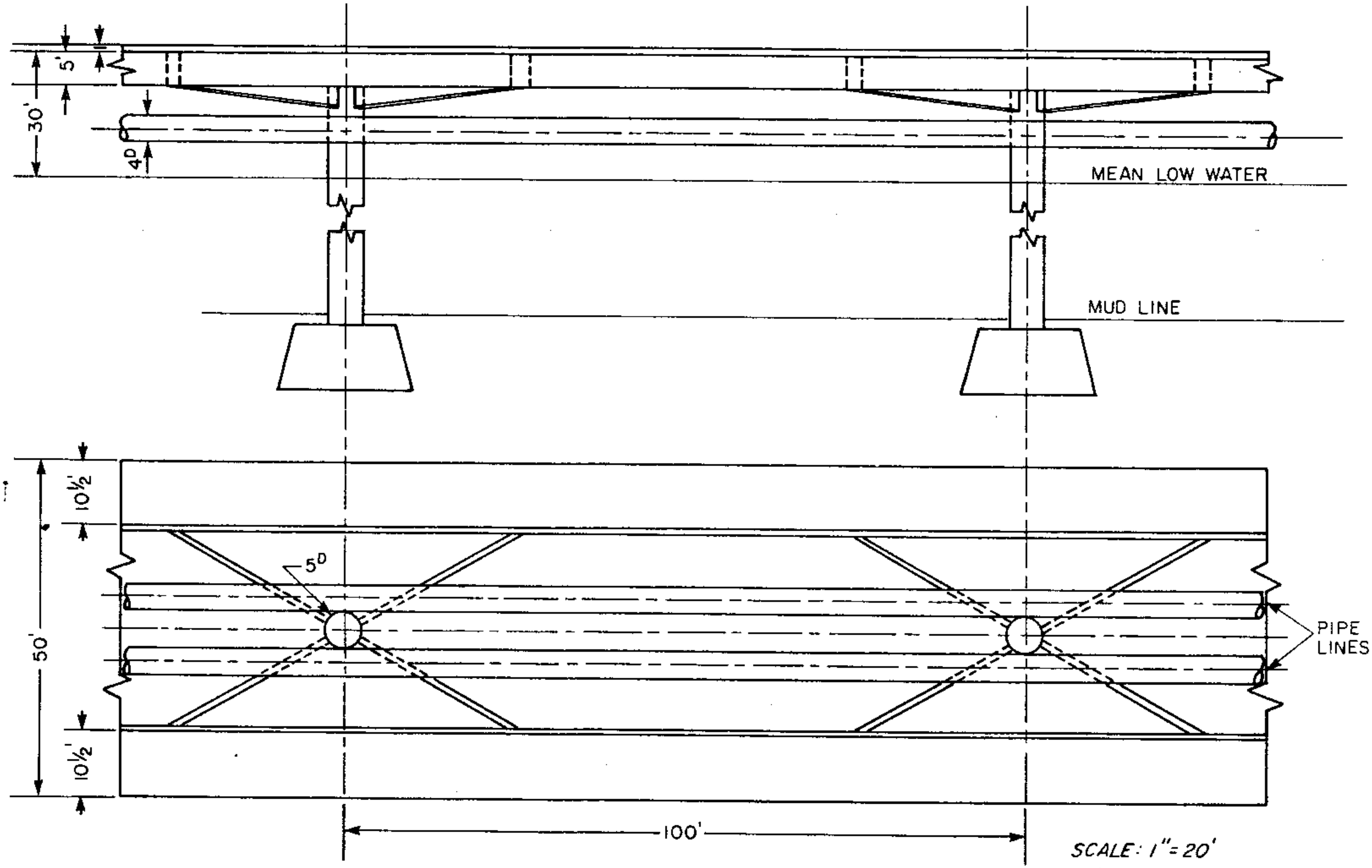
FIGURE 16. TRESTLE DESIGN I

caps would be poured, beams placed, then roadway and rails constructed. Depending upon the amount of equipment and manpower available, the structure could be completed in about two or three years.

2.1.3 Cost. Estimated costs for a trestle 15-1/2 miles long, and 60 feet wide (excluding rails, ties, and pipe) is $140 million plus or minus 15%. If the second identical trestle were built immediately, it would be somewhat cheaper as equipment would be mobilized and the work force would be familiar with the construction methods. Total construction costs for two trestles should range from $238 to $322 million. This is a cost of approximately $24 to $33 per square foot of surface.

2.2 Alternate II

2.2.1 Design. Alternate II also separates the trestle project into two structures. The following information is from a conversation with a New York design firm (Ref. 117). The separation in this case is done on the basis of load type. One trestle would be about 50 feet wide and contain the roadway and pipeline (Fig. 17). The other would contain only the railroad and would be narrower. Both trestles would be identical as to support column size, span length, and girder size. The trestle would be supported on 5-foot diameter, solid concrete columns resting on spread foundations. Each span would run 100 feet between supports. The span itself would be of a plate girder type. Two double "tee"



HIGHWAY & PIPELINE TRESTLE   RAIL TRESTLE 45 FEET WIDE

FIGURE 17. TRESTLE DESIGN II

girders with long cantilever arms would be used for each span. The girders would be 5 or 5-1/2 feet high, with 4-foot high webs. The cantilevered slabs would be 10-1/2 feet to the side from the end of the girder, and taper parabolically from 16 inches thick at the girder to 9 inches thick at the outer edge. The sections between the supports would likewise taper from 16 inches at the piers to 9 inches at the center of the span (Ref. 122).

The pipelines could either be suspended under the road bridge, between the girders and the piers or could be placed on a slightly widened railroad trestle. Underneath, they would be out of the elements except for splash from directly below. A catwalk erected at the level of the base of the girder would have only 5 feet of headroom, so it might have to be suspended somewhat below that level for ease of operation.

2.2.2 Construction Method. A temporary steel cofferdam would be sunk onto the bay floor, pumped dry and the softer bottom material removed. The spread footing would then be poured into forms built into the bottom of the cofferdam. The prewelded reinforcing bar cages would then be set into place and the column would be poured to the desired height. One such support would be needed every 100 feet. Piling would probably be needed. Concurrent construction using multiple cofferdams would allow rapid completion of the footings. Across the marshes, a pathway approximately 50 feet wide would be necessary to provide the logistical support for construction of the footings. Some dredging might be required in the very shallowest parts of the Bay (under 6 feet deep at MLW).

The remainder of the trestle would be built from above using a steel truss approximately 175 feet long with a movable scaffold carrier. Ground support would be necessary only to provide material delivery to the scaffold carrier. The truss would span the distance from one pier to the next, the scaffold carrier would be positioned, precast sections and reinforcing bars would be put into place and the cast-in-place concrete would be poured into forms in the scaffold carrier. The carrier would then be lowered to serve as a work platform for finishing before being shifted to the next position. The scaffold carrier would be able to produce 25 feet of span at one positioning, requiring four positionings to complete a span. At this time, the truss would be moved forward to the next pier and the process repeated. Initially, it wpi;d take about 1 month to complete a span, but as the workers gained familiarity with the technique, each span should require about 7 or 8 working days for completion. It is possible to justify construction of one such truss and scaffold carrier for each 4000 feet of bridge, but other considerations would probably limit the number used on this project to 4 per trestle. Construction could be completed in 2 or 3 years at this rate.

2.2.3 Cost. Cost for this method of construction varies greatly according to local labor costs. A low of $22 square foot to a high of $35 or $40 could be expected. The road trestle would be about 4.9 million square feet and cost between $107 and $200 million. The second trestle for the railroad would be somewhat narrower, 44 feet, and contain only about 3.6 million square feet. At similar cost, this trestle would cost between $80 and $144 million. Total for this method ranges between $187 and $344.

2.3 Alternate III

2.3.1 Design. Alternate III includes everything in the required design in one structure 120 feet wide, supported on four pile bents of 60 inch hollow concrete caissons, with spacing of 30 feet between bents. The construction design was suggested by a leading New York engineering firm (Ref. 50). Ten 7-foot high precast concrete girders, one under each rail and one under each road lane would support the load between the supports. Ties and rails would be placed directly on the center girders for the railroad. Precast roadway sections would be placed on the outer ones for the highway lanes and pipe cradles (Fig. 42).

2.3.2 Construction Method. This would be constructed using standard construction methods and would require dredging the shallow areas and marsh to allow heavy pile drivers and lifting cranes access to the structure. One pile driver could be expected to complete one bent per week, including time for repositioning and pouring the pile cap. With four pile drivers working, this would entail about 12 years. Placement of the girders, roadway sections and ties and rails could be expected to keep pace with the rate of pile driving.

2.3.3 Cost. Total cost for this massive trestle design, 81,000 feet long, are estimated at $1.394 billion.

2.4 Comparisons

Design I would have the highest continuous maintenance because the steel girders would need repainting about every two years. Designs II and III would not have nearly as high a requirement for maintenance since they do not have areas of exposed steel.

Alternate designs I and II must be considered equal in cost at this time, whereas alternate III is much higher. The cost factor would probably rule out further consideration of this design.

From an ecological standpoint, design II is the best, since it would involve least disruption of the bottom and marshes. The division proposed in design I would be preferable for the gradual development of the total system, since it would provide all three modes of transportation at a relatively rapid pace, yet provide for the possibility of greater capabilities as the traffic warranted. Alternate II does not provide both modes on one structure. If feasible, the best solution might be to use the construction methods of alternate II and the load division suggested for design I. Such a design would give the most practical, economical, and environmentally sound design.

3. AIR-SEA CARGO CENTER

The design of the proposed port includes a restricted access transportation corridor connecting the offshore island to an area east of Dover Air Force Base (DAFB). This proposal includes plans to take advantage of the DAFB facility, which in its present operation handles the largest air cargo planes in the world. An area of land adjacent to the east boundary of DAFB (the exact location to be designated at a later time) would be used to accommodate services for the port island. In the initial stages of development, this area would serve as a center for construction activities with equipment storage areas, employee parking, etc. With the beginning of port operations, this area would serve as a site for the storage and marshalling of goods which cannot be accommodated on the island, and as a support area for island operations. In the later stages of port development as possible containership and air freight service begins, this cargo center would expand to include selected industrial activities and provide ground support for commercial air freight service.

There are precedents for the sharing of government facilities with commercial operations. The Kent County Planning Office has had past experience in negotiating just such a shared use with DAFB and is quite knowledgeable of shared-use procedures. Shared use of facilities such as DAFB are not to be negotiated with the Base Commander or even the Wing Commander. Such negotiations must be carried out directly with the Department of Defense in Washington, D.C. (Ref. 102). The Base and Wing Commanders would be involved in such negotiations but only as interested parties. They would have no direct say in the final decision.

Kent County had obtained a shared-use permit with DAFB for a county airport. The initial phase of this project was to involve the use of runways and a taxi apron at DAFB for commercial freight transport, an air taxi service, and some private landings. The permit for shared use had several restrictions placed upon the usage of the facilities which eventually contributed to the defeat of a referendum for construction of this airport (Ref. 102). Kent County had purchased a 100-acre farm adjacent to DAFB to handle the ground support needed for such an airport and construction was about to begin when this referendum was defeated. Many of the building permits necessary for construction will expire this summer (1977) and this airport will not be constructed in the near future.

Air freight facilities would be needed when such an offshore port is in operation and perhaps the county airport design could be meshed with that of the cargo center. There is also the possibility that the farm purchased by Kent County could be incorporated into the plans of the air-sea cargo center which would serve the offshore island.

It has been proposed that a free trade port be established at this air-sea transportation center. A free port of trade offers storage facilities which may be used to simplify procedures and reduce import costs. In addition these goods can be exhibited while held in the free zone. Buyers can inspect the products and decide whether to make purchases before importation. Since this port facility would be so far away from major cities, there exists the possibility of establishing a subzone used only for exhibition of goods. Such subzones have been established in the past and their feasibility in this instance should be explored. Other advantages may be gained by using this free trade zone in manipulation and manufacture of goods prior to the imposition of import duties and taxes. There are in fact only two free ports of trade currently in operation on the east coast of the United States: New York and Charleston, South Carolina (two more are proposed for the ports of Boston and Fall River). In the case of New York's free port, there have been problems in attracting customers despite the above mentioned advantages. The problem is that the markets for goods are situated in Manhattan and the free port is in Brooklyn. It is cheaper to go directly to Manhattan thus avoiding the additional costs of ground transportation of the goods (Ref. 11).

Because of the distance of the proposed port facilities from any major marketplace, it is probable that establishment of a free port zone would attract little additional traffic to this port.

In summary, an air-sea cargo center is proposed for the area east of DAFB to be used for ground support throughout both construction and operation of the port. This would entail obtaining a shared-use permit for the air base facility. Previous negotiations have been carried out for a similar use by Kent County and although the proposed share use never materialized a precedent was set for some amount of shared use of DAFB. This is no guarantee that the Department of Defense would agree to the shared usage proposed by this project however. The establishment of a free port of trade at this air-sea cargo center would probably attract little additional traffic to this port.

4. RIGHT-OF-WAY

Connection of the proposed deepwater terminal with existing major transportation arteries would require the acquisition of new rights-of-way and upgrading the capabilities of current transportation routes. It would be desirable to limit the amount of right-of-way required to the minimum necessary to safely and effectively accomplish the connections and to combine uses of the land as much as is feasible. The connection points to be reached are: 1) the air-sea cargo center; 2) the Penn-Central Railroad peninsula main line near Dover; 3) Delaware Valley oil refineries; 4) the existing natural gas distribution center near Philadelphia; and 5) I-95 between state route 896 and state route 273 south of Newark.

The access corridor would remain on the trestle from the northern end of the phase Ia island until it had crossed the marshland about one mile south of Kitts Hummock. About 3000 feet of marsh would have to be traversed. Locating the crossing south of Kitts Hummock would avoid the nearshore "unexploded ordnance" area and wildlife refuge north of Kitts Hummock. Various configurations of the trestle are shown in Figures 42, 16, and 17; the design and construction of the trestle is explained in section VI-2.

Once on the fast land of St. Jones Neck, the limited access corridor would assume the configuration shown in Fig. 18. Two alternate routes are available for bypassing Dover. Alternate I would run nearly due west, pass south of Dover and then turn north on the west side of Dover and continue to the various upstate connections. Alternate II would turn north immediately and pass by Dover on the east side, between the Dover Air Force Base and Delaware Route 9, and then turn west between Dover and Delaware Route 42 to the western third of the state before turning north again to the upstate connections (Fig. 18).

4.1 Alternate I

Alternate I is farther from the wildlife refuges and marshlands found on the east side of Dover than Alternate II. The number of highway miles needed to be constructed (53) is greater than the 51 miles estimated for Alternate II. See Figure 18.

The first interchange on Alternate I going from south to north would be for a two-mile long access spur north to the air-sea cargo center east of Dover Air Force Base. This

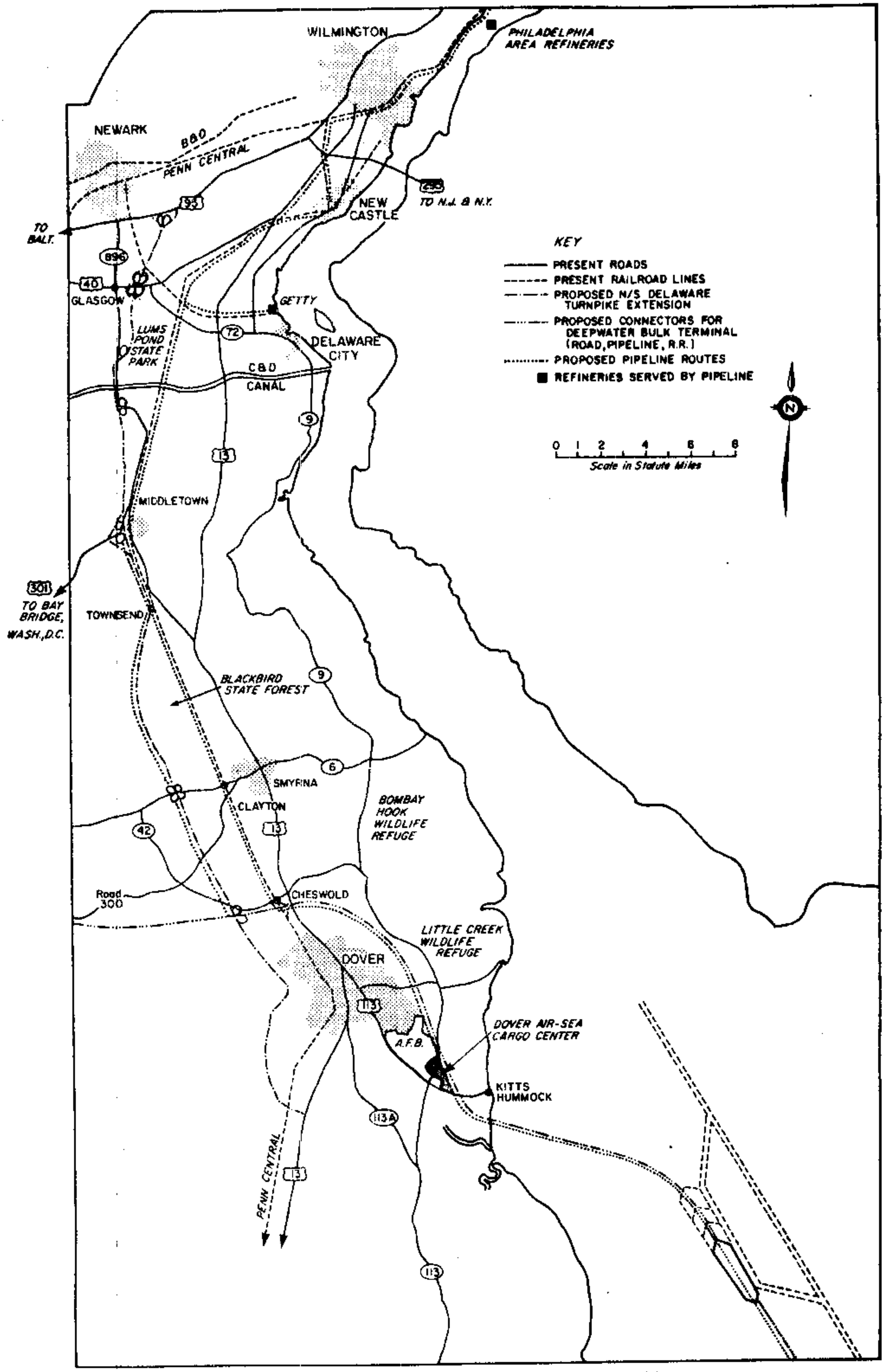


FIGURE 18. LIMITED ACCESS CORRIDOR

interchange would involve both the railroad and highway portions but not the pipelines. From this point, the corridor highways would be available to general public vehicular traffic as interstate highways are. The corridor from the spur to the cargo center to the island would be restricted to those vehicles with business on the island. Private automobiles would generally be prohibited.

The corridor would proceed west to an interchange with U.S. 113 just south of Dover Air Force Base. The corridor would cross four secondary roads and the St. Jones River before reaching the third interchange at U.S. 13. Continuing west, the corridor would cross U.S 13A. At the crossing of the Penn-Central Railroad tracks west of U.S. 13A, the railroad would leave the corridor and follow the current rail routing through Dover to the multi-track Conrail main lines. The highway and pipeline portions of the corridor would then turn nearly due north and go along the west side of Dover, as proposed for the north-south extension of the Delaware Turnpike (Ref. 40). There would be an interchange at Hazlettville Road west of Dover. The corridor would then run between Kenton and Cheswold, cross S.R. 42 with a structure appropriate for the "scenic route" designation of that road, pass west of Smyrna and Clayton and interchange with Delaware 6. The highway and pipeline would then angle toward the rail line and might make use of the rail right-of-way from just north of Townsend to south of Middletown. When the highway and rail separated at this point, the pipeline would follow the rail alignment, which is currently much farther east. The highway would interchange with U.S. 301 as it passes Middletown. Next it would proceed north over Summit Bridge (existing), probably replacing or containing U.S. 301N and Delaware 896 as through routes. From Summit Bridge, the route would turn slightly east, interchanging with U.S. 40 between Delaware 896 and Delaware 72. The highway corridor would then cross Delaware 72 and interchange with I-95 between route 72 and Delaware 273.

4.2 Alternate II

Alternate II turns north and runs toward the eastern edge of Dover Air Force Base, crossing the road to Kitts Hummock and then crossing, replacing, or requiring eastward relocation of Delaware route 9 in the vicinity of Postles Corner. The air-sea cargo center would be immediately west of this corridor and an interchange would be built for rail and highway access to the center. The whole corridor would go northwest, west of Little Creek, then turn west, south of Delaware route 42 to a highway interchange with U.S. 13 south of Bishops Corner. The rail portion of the corridor would then join the peninsula rail line just south of Cheswold. The highway would continue west until it reached the proposed turnpike extension alignment just south of route 42, where it would turn north and follow the same routing as outlined for Alternate I.

Additional interchanges at Delaware route 8 and at Dover Downs might be built if traffic studies could justify them. This alternate passes very close to the wildlife refuges and would probably replace route 9, which has been designated as the boundary of the primary coastal zone, along the east side of Dover Air Force Base. Several miles of interstate highway, railroad and pipelines would then be on the edge of this area and border on the wildlife refuges.

4.3 Railroads

The general alignment for the railroad is the current peninsula railroad system. This would need to be improved to serve the projected requirements of the port island. Primarily the improvements would consist of eliminating large numbers of grade crossings and double tracking other areas. Traffic volume would probably make it advisable to replace the current lift bridge over the Chesapeake and Delaware Canal with a high-level, fixed span. This would preclude canal and rail traffic from interfering with each other and lessen the probability of bridge closure due to accident.

4.4 Pipeline

The pipeline routing has been covered with the highway and railroad up to north of the Chesapeake and Delaware Canal. Where the railroad branches south of Red Lion, the pipeline would probably follow the eastern branch toward New Castle. A spur pipeline would follow the rail spur to the refinery at Delaware City. The main pipeline could either follow the railroad through New Castle and Wilmington or find a separate right-of-way around New Castle to the shore of the Delaware River, and then north to Marcus Hook and Philadelphia. At some point, the pipeline could be extended across the Delaware River to serve the Paulsboro refinery, and then run up New Jersey to serve the Bayonne-Elizabeth area refineries.

4.5 Summary

The access corridor would require 50 to 55 linear miles of new right-of-way for highway, approximately 350 feet wide to accommodate sound-deflecting berms and railroad at some places. An additional 150 miles of pipeline right-of-way, possibly along existing railroad right-of-way, would be required to reach upper New Jersey. Construction of 50 to 55 miles of highway, 200 miles of pipeline, and 10 to 16 miles of new railroad would be needed to fulfill the needs of the access corridor.

5. LNG FACILITIES

Although design criteria would be determined by the lessee, a typical (Ref. 51) Liquid Natural Gas terminal includes facilities for unloading, storage, processing and distribution of LNG (Fig. 19) (Ref. 51). A two-berth marine terminal would moor LNG tankers clear of the shipping channel. Storage facilities might consist of three 600,000-barrel LNG storage tanks (with each tank containing three

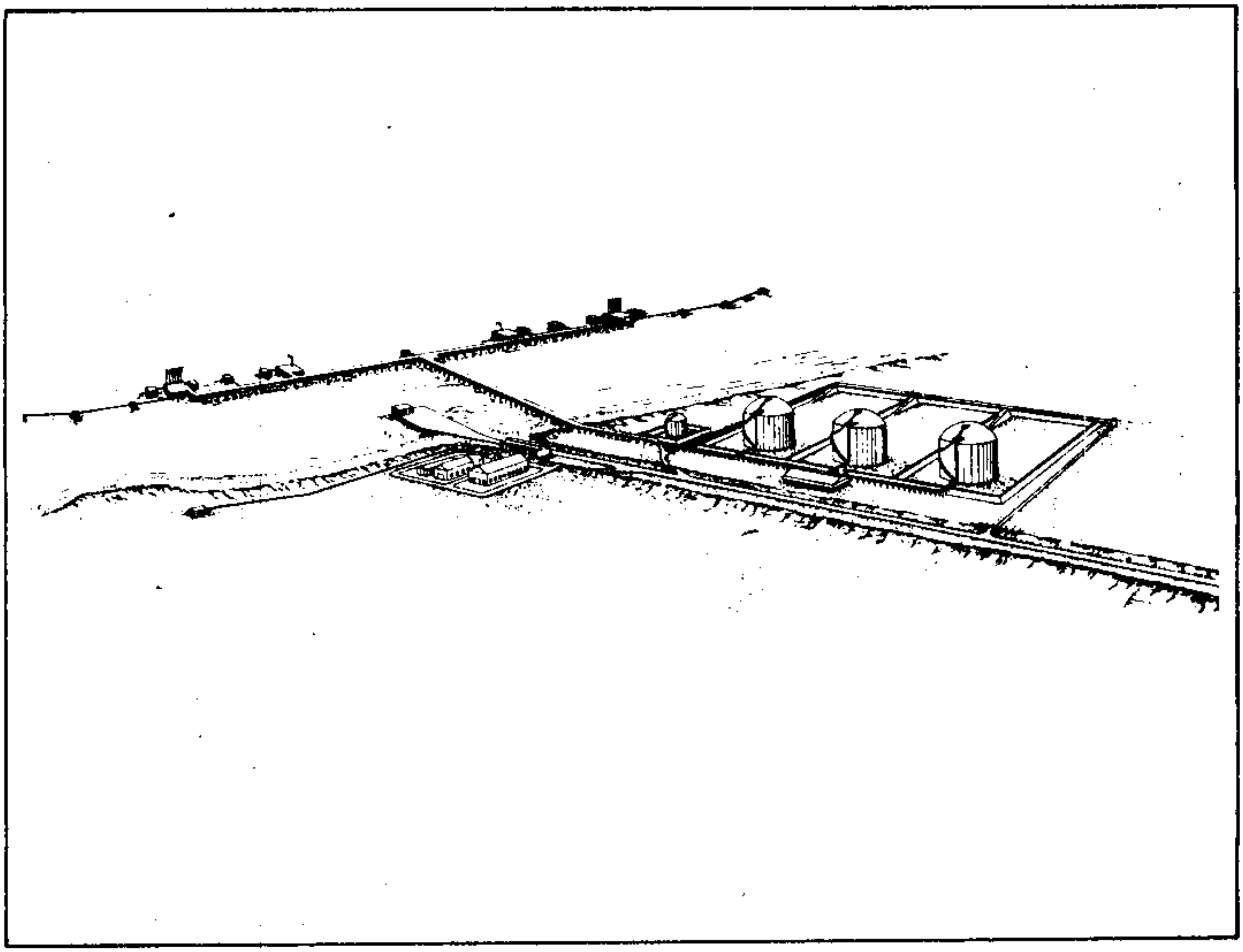


FIGURE 19. PLANT PERSPECTIVE VIEW LNG TERMINAL
(Ref. 49)

in-tank pumps) and one 46,000 barrel Bunker-C fuel-oil storage tank for servicing LNG tankers. A utility area would provide for water treatment and power generation. A process area would house the recondenser, a suction drum, second stage send-out pumps, and vaporization units.

LNG unloading would take place from moored tankers through four 16-inch unloading arms. A vapor return system, maintaining positive pressure in the tanker's cargo tanks, would be implemented through the use of another 16-inch return arm. The necessary valving and piping would be incorporated to allow a tanker to deliver LNJ to one or all of the storage tanks. Bunker-C fuel-oil transfer would occur through an 8-inch loading arm. LNG unloading would take approximately 10 hours at a rate of 52,500 gallons per minute, and the average tanker berthing time would be approximately 24 hours. LNG berths could be constructed in a similar manner to crude oil berths as illustrated in Figures 21 and 22.

The three 600,000-barrel storage tanks (Fig. 20) (Ref. 49) are each comprised of an inner tank which is subjected to cryogenic temperatures and hydrostatic pressures of the LNG in storage and a vapor tight outer tank for containing internal gas pressure as well as for retaining the insulation which surrounds the inner tank. The plate material of the inner tank would be 9% nickel steel surrounded by a 3-foot layer of loose fill, expanded perlite, and resilient fiberglass blanket insulation. Around this insulation would be a

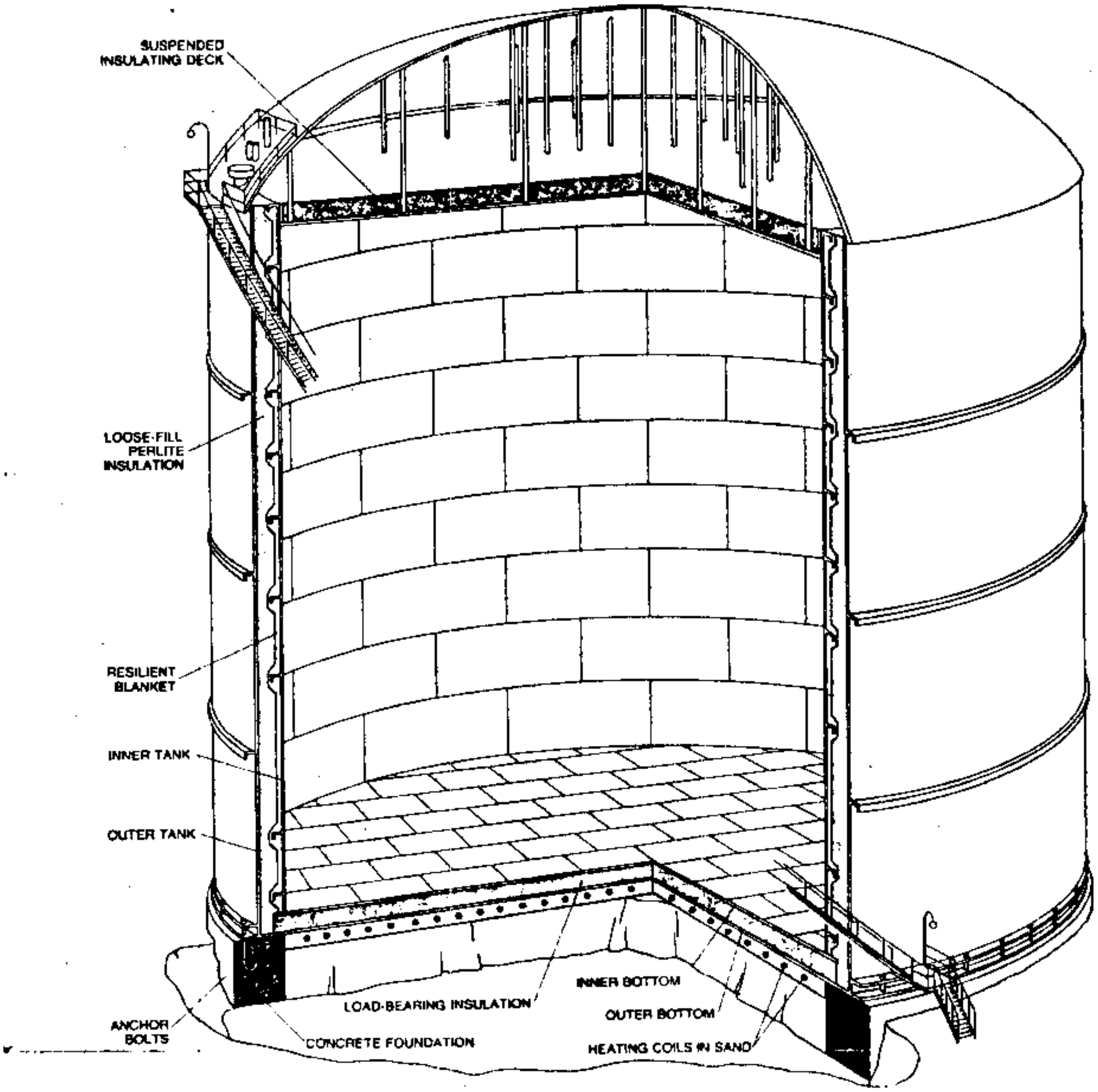


FIGURE 20. TYPICAL LNG STORAGE TANK
(Ref. 49)

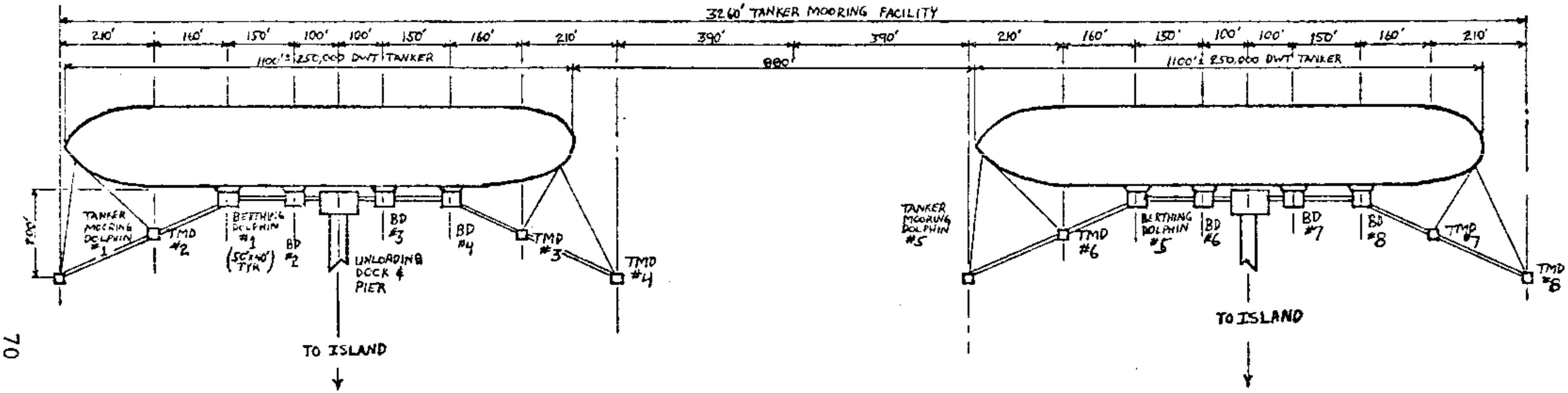


FIGURE 21. TANKER MOORING FACILITY
(Ref. 46)

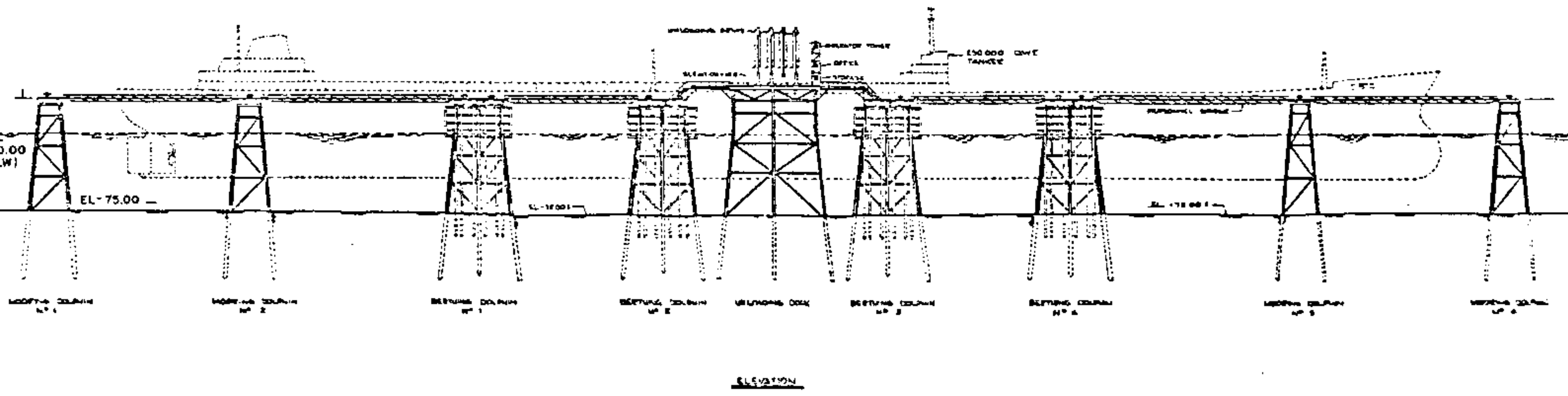


FIGURE 22. CRUDE OIL OFFLOADING PIER
(Ref. 46)

mild steel outer tank consisting of a vertical cylindrical shell, flat bottom, self-supporting roof, with a diameter of 192 feet, and a shell height of approximately 138 feet. The inner tank would be 186 feet in diameter with a shell height of approxiately 129 feet, 7 inches. Insulation for the top of the inner tank would be provided by an aluminum alloy, lap welded, suspended deck, supported from the roof of the outer tank by a series of rods or bars. The inner tank bottom would be 3/16-inch lap welded construction and a 3/8-inch thick annular ring would be used at the intersection of the bottom and the shell. Between the inner 9% nickel steel and outer carbon steel tank bottoms would be 20 inches of Foamglas blocks utilized for load bearing insulation. The tanks would be constructed according to specifications for a 0.04 seismic factor which exceeds the basic 0.025 factor corresponding to zone 1 of the Environmental Science Services Administration Seismic Risk Map.

Each LNG storage tank would be surrounded by an individual dike capable of containing more than 100% of each tank's contents should a spill occur. The 12-foot high dikes' interior core would be of material not subject to dissolution and compactible to 90 pounds per cubic foot density. The exterior surface, two feet thick normal to the dike face would be sand and gravel, graded to reduce vaporization rates.

Regasification equipment provides for stored LNG to be pumped from the tank by in-tank LNG pumps to the recondenser where compressed boil-off gases would be injected back into the LNG send-out stream. The LNG would pass through a suction drum and then to second stage send-out pumps where it would be pumped to pipeline pressure (up to 800 psig) and sent to the vaporizers, from which it enters the pipeline system.

Other facilities and buildings which would be located at the terminal are: water and wastewater treatment systems; an administration building; the plant workshop, warehouse, and fire station; and the control house.

VII. ENVIRONMENTAL ANALYSIS

1. DELAWARE BAY NOW

Lower Delaware Bay is still a relatively healthy and viable system (Ref. 87). Delaware has a shoreline of close to 260 miles with no region of land more than eight miles from some tidal waters. In a study completed in 1967, (Ref. 1) found that most fish recovered from this estuary between August and January were juveniles or larvae. This is indicative of the prime spawning and nursery grounds which compose the Delaware River estuary. Some 138 species of fish have been collected from these waters and among these more than 60 are known to spawn locally (Ref. 124). Many of the fish found in the Bay are migrants who, with the approach of summer, enter the lower Bay. A separate list (Table 7) of some of the economically valuable species associated in a developmental capacity is included on the following pages with zoogeographic maps of their local occurrence and activities (Figs. 23, 24a-241).

The commercial fisheries industry for Delaware recovered only about 12.6 million pounds of seafood in 1972 worth about $2.5 million. The best haul by the fisheries was the blue crab, accounting for about 2.6 million pounds. This latter figure was the highest among the middle Atlantic states in 1972. Oyster harvesting has been on a steady rise since 1967. In actual economic value, the sportfisheries in Delaware Bay far exceed the commercial effort. Sportfishing in the lower Bay is among the best in the mid-Atlantic region with about 140,000 man-days spent fishing in 1972 (Ref. 124). Especially popular among the fishermen are the weakfish which tend to follow the natural deep water channel into the Bay (Ref. 124). Sportfishing associated with the Bay produces an annual expenditure of about $4 million (Ref. 124).

Recovery of the shellfish industry (oysters, hard clams) is certainly a desired economic parameter for Delaware Bay. Maurer (1974) and Keck (1972) have shown that there is a good potential for a commercial bed of hard clams around Old Bare and Joe Flogger Shoals (Ref. 88). The largest specimens of hard clams are typically found in the lower Bay where spawning occurs from June through September.

Potential loss of fisheries must be evaluated not only on present value, but also upon potential future value. With the current improvements being made in the water quality

TABLE 7

SOME IMPORTANT SPORT AND COMMERCIAL FISHERIES IN DELAWARE BAY

Weakfish (*Cynoscion regalis*); spawn in lower bay from May to September with peaks in mid-June and mid-July, principally on eastern side in 3-5 fathoms but also offshore, they have pelagic eggs, adults enter bay in late spring and are abundant over the warm half of the year, a very important sport and commercial fish.

Summer flounder (*Paralichthys dentatus*); larvae drift into the bay in the winter and early spring from offshore spawning, adults important over warm half of year until early fall, taken by trawl.

Winter flounder (*Pseudopleuronectes americanus*); spawn offshore in winter, larvae drift into bay in late winter, lower bay is important nursery, many adults winter in shallows of bay with a fall migration into deeper waters.

Striped bass (*Morone saxatilis*); pelagic eggs, anadromous species (spawn in fresh or brackish waters), larvae in bay in April and May, adults abundant in lower bay in winter but is a very ubiquitous species, important sport fish.

Bluefish (*Pomatomus saltatrix*); often abundant in lower bay over summer, also nearby coastal waters, juveniles abundant near Lewes in July and August (often along with anchovy and herring post-larvae), some adults taken in May, winter in deeper waters (migrant).

White perch (*Morone americanus*); present over most of bay all year, adults abundant in fall, ripe specimens recovered in mid-November, juveniles present in summer near Lewes, often found in tidal creeks in summer.

Scup (*Stenotomus chrysops*); larvae in bay in June, pelagic eggs.

American eel (*Anguilla rostrata*); adults and elvers abundant from May to October but present all year, an important potential commercial fisheries, elvers very abundant in lower bay tributaries in February and March.

Other important species include croakers, trout, other flatfish, herring, menhaden and shad.

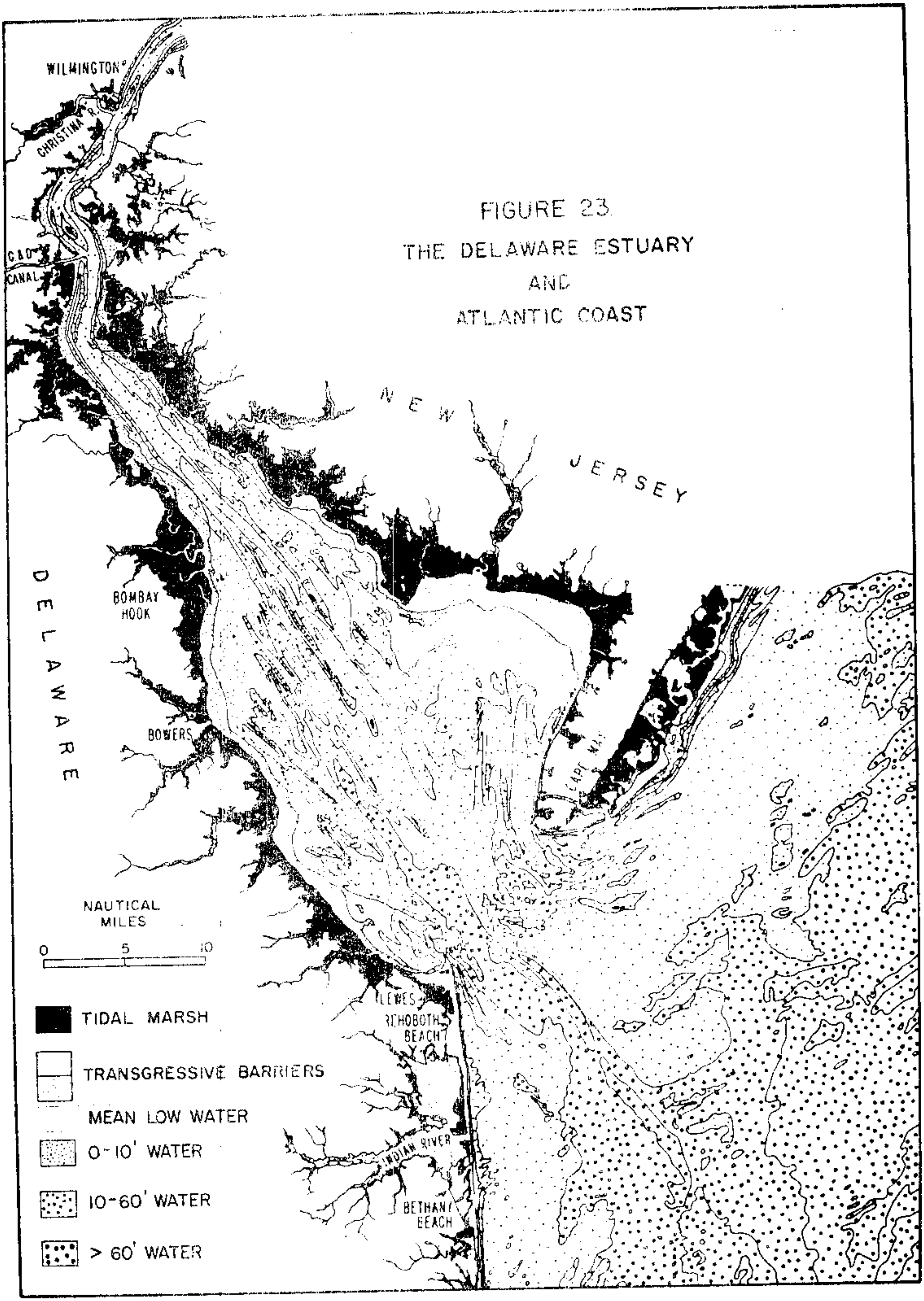
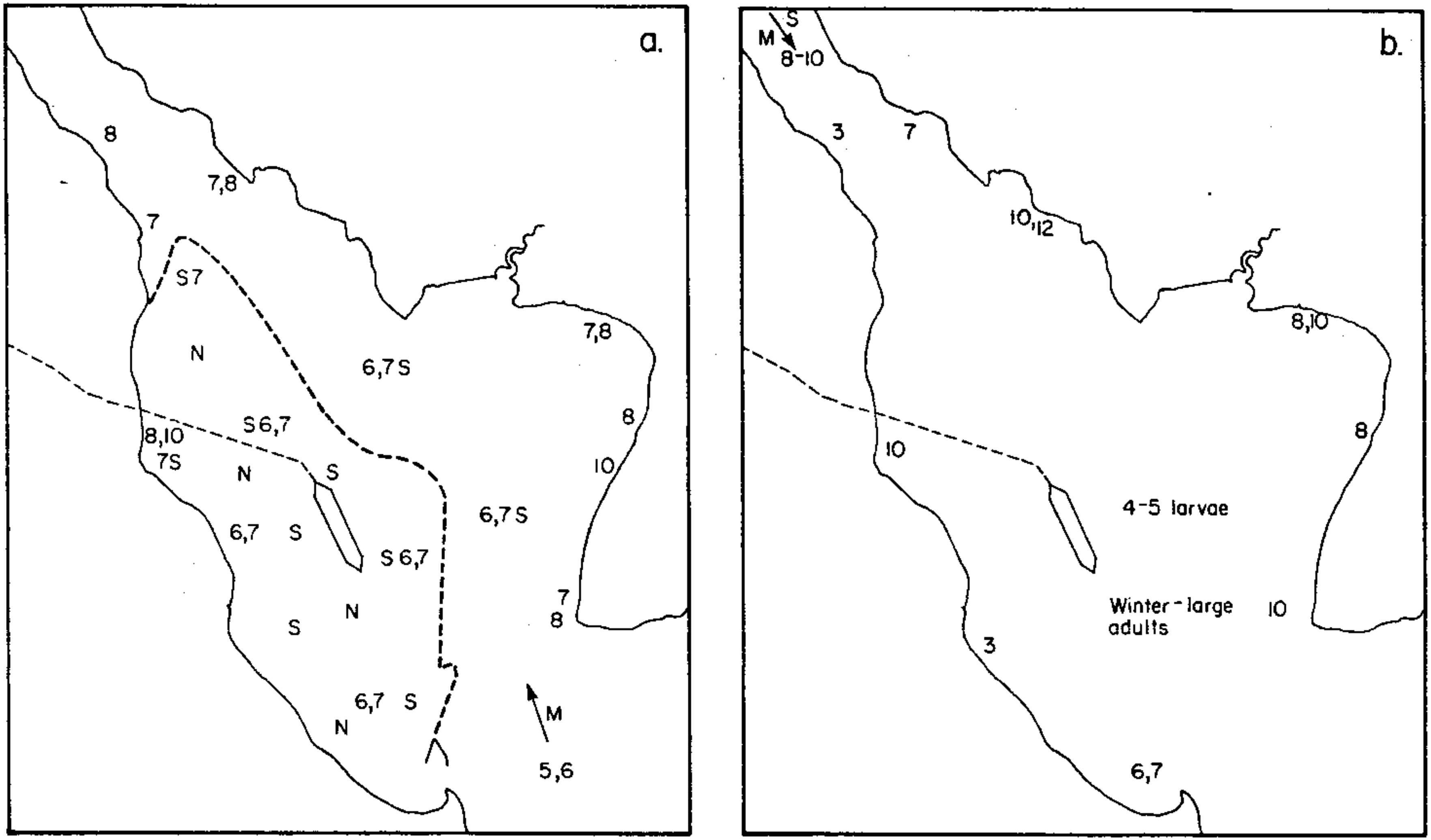


FIGURE 23
THE DELAWARE ESTUARY
AND
ATLANTIC COAST
WILMINGTON
CHRISTINA R.
C.&D.
CANAL
NEW JERSEY
DELAWARE
BOMBAY
HOOK
BOWERS
CAPE MAY
LEWES
REHOBOTH
BEACH
INDIAN RIVER
BETHANY
BEACH
NAUTICAL
MILES
0
5
10
TIDAL MARSH
TRANSGRESSIVE BARRIERS
MEAN LOW WATER
0-10' WATER
10-60' WATER
> 60' WATER

FIGURE 24



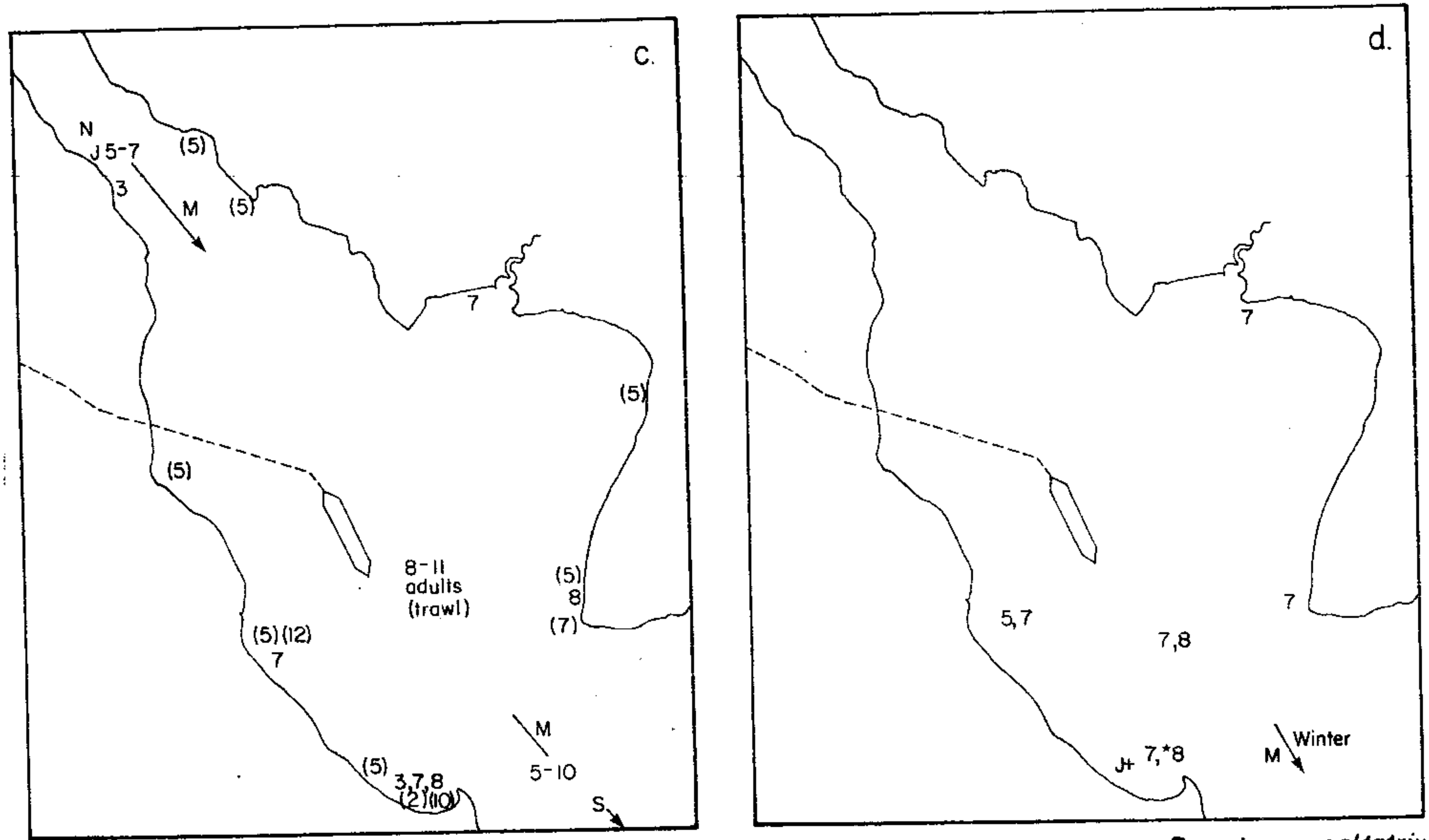
Cynoscion regalis
Weakfish

Morone saxatilis
Striped bass

N = nursery grounds
S = spawning grounds
M = migration

1-12 = months when abundant
J = juvenile
* = very abundant

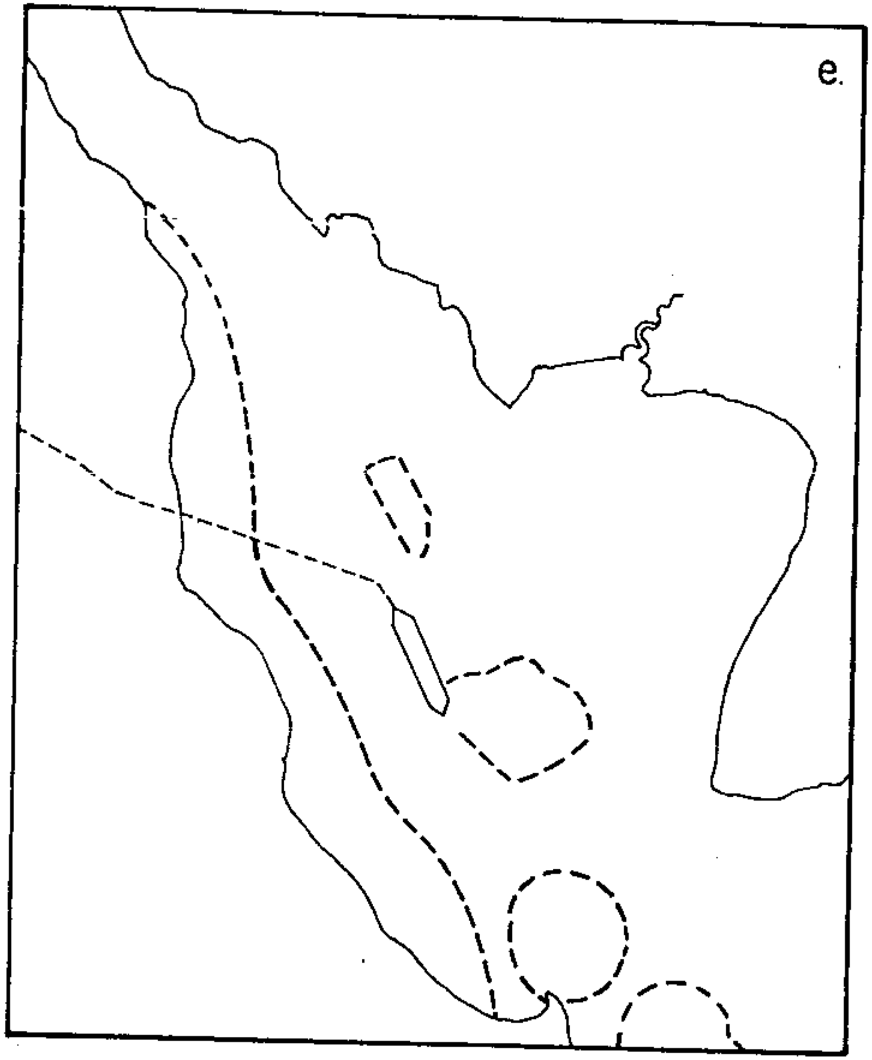
FIGURE 24



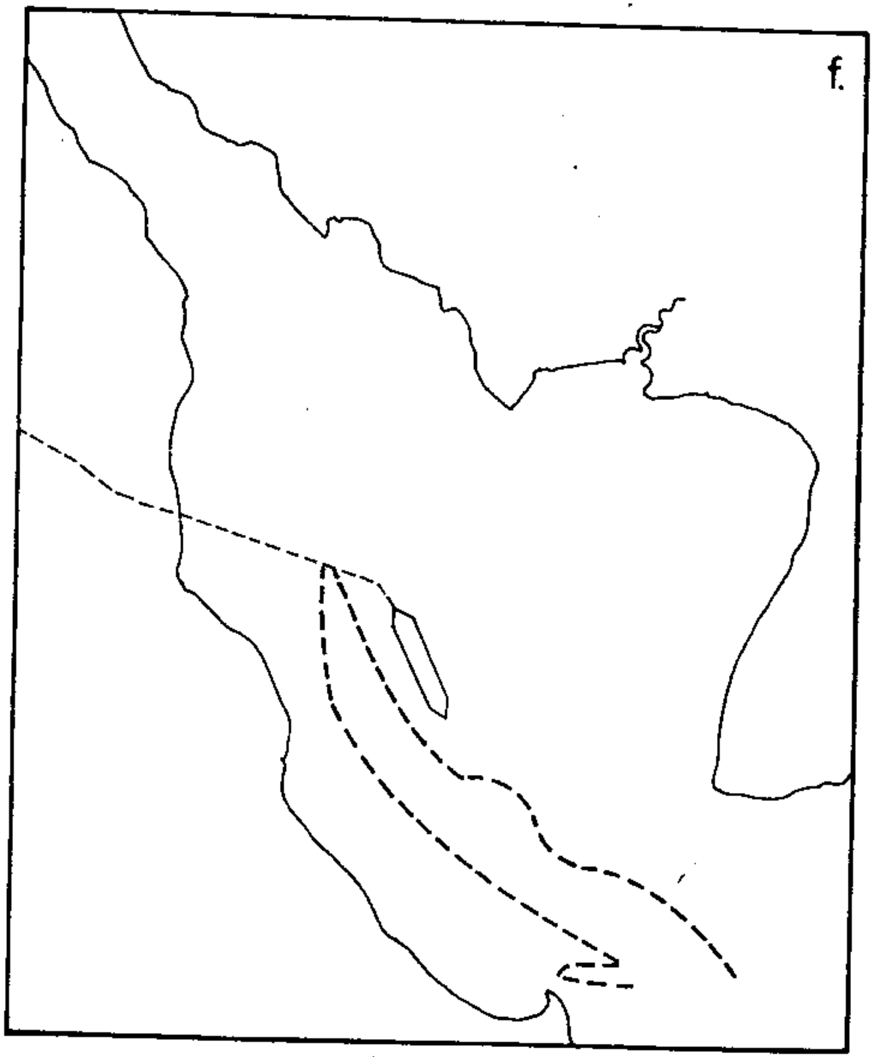
Brevoortia tyrannus
Atlantic Menhaden

Pomatomus saltatrix
Bluefish

FIGURE 24



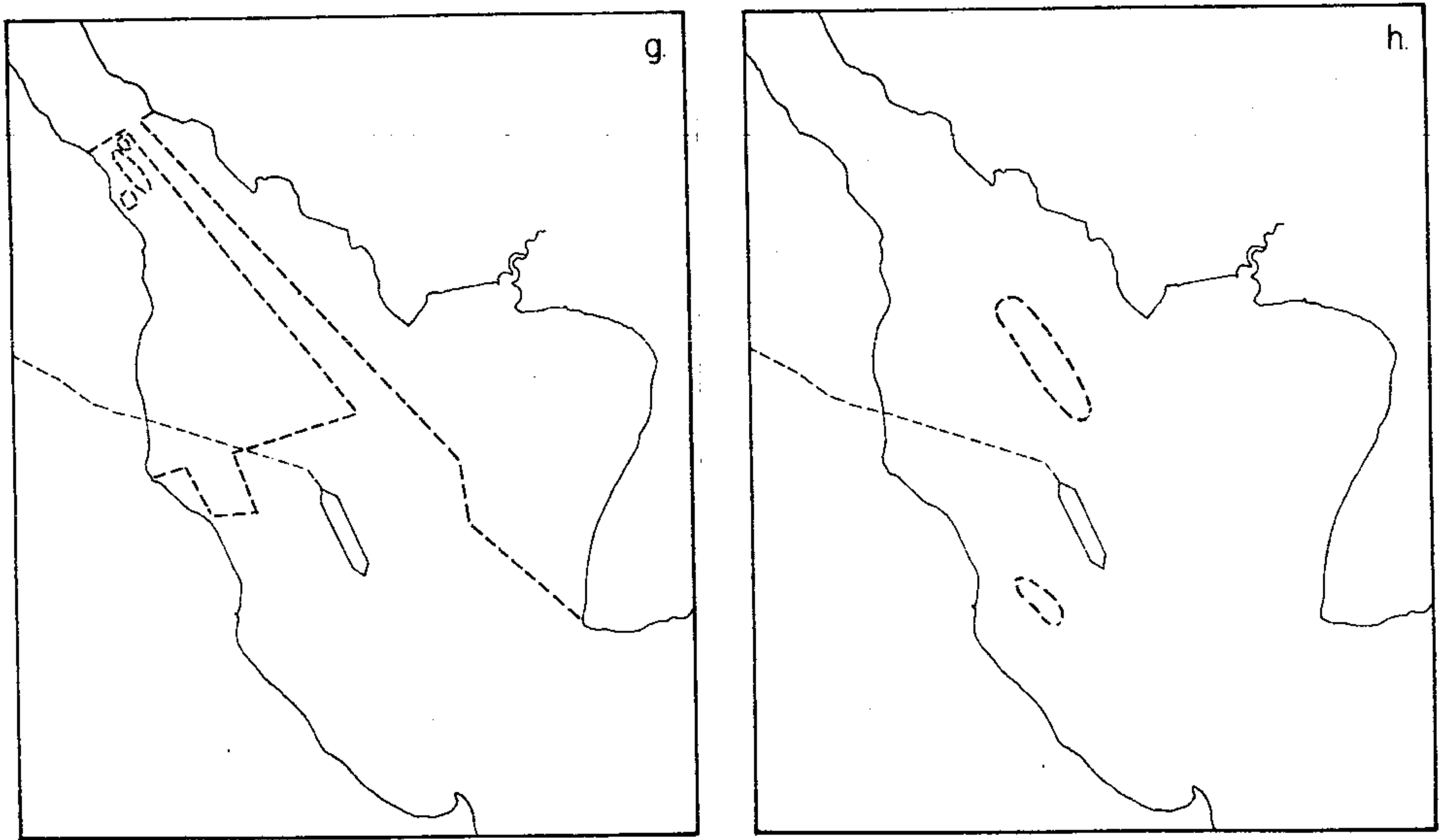
Callinectes sapidus
Crabs



Homarus americanus
Lobsters

Winter time in deep water channel.

FIGURE 24



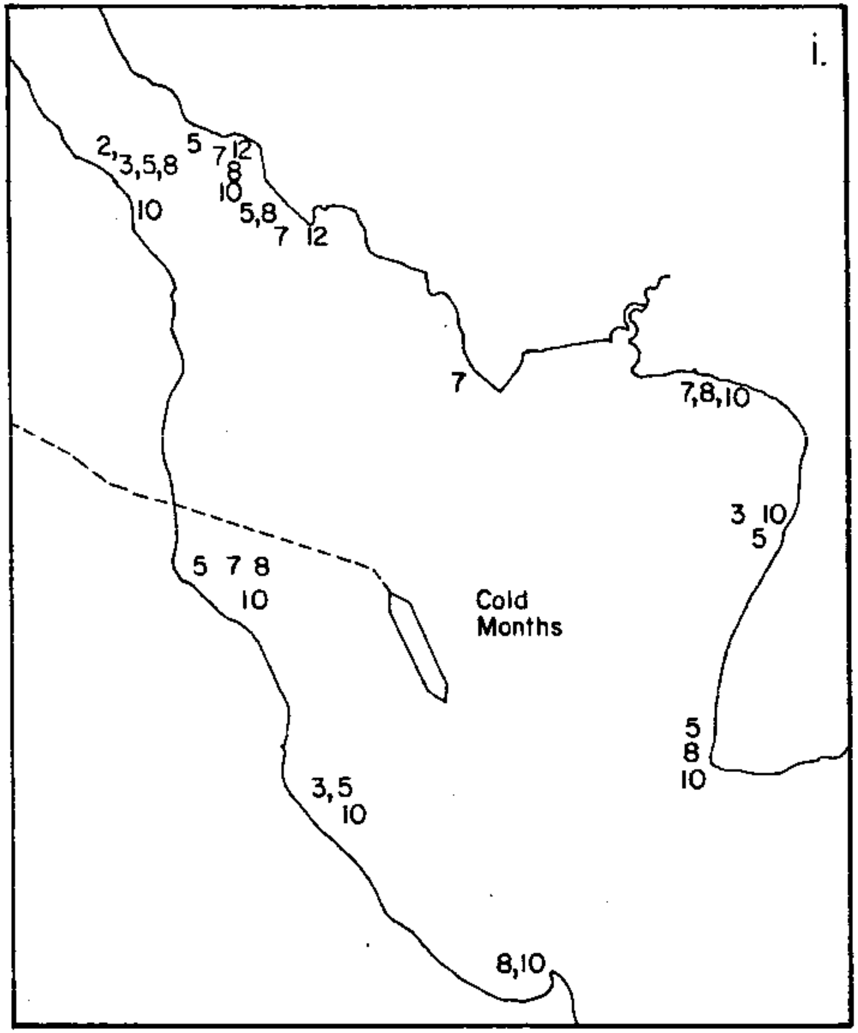
Crassostrea virginica
Oysters

Spawn 6-10

Mercenaria mercenaria
Clams

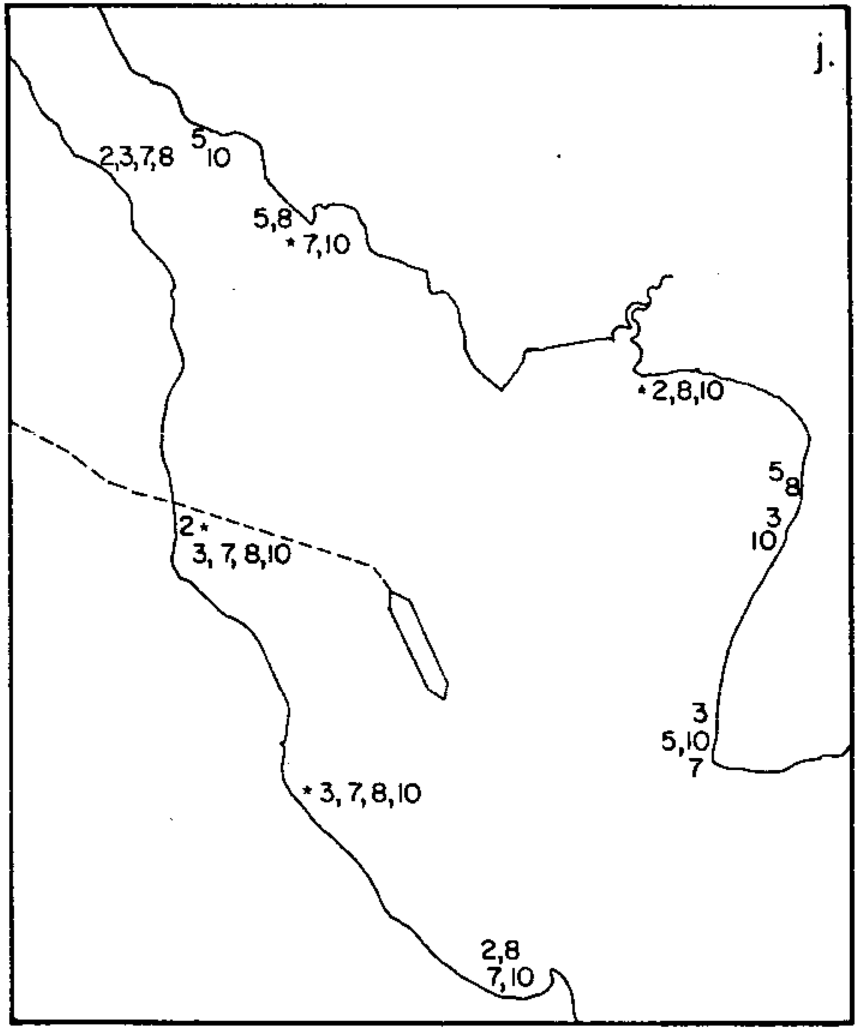
Spawn 6-10

FIGURE 24



Morone americanus
White perch

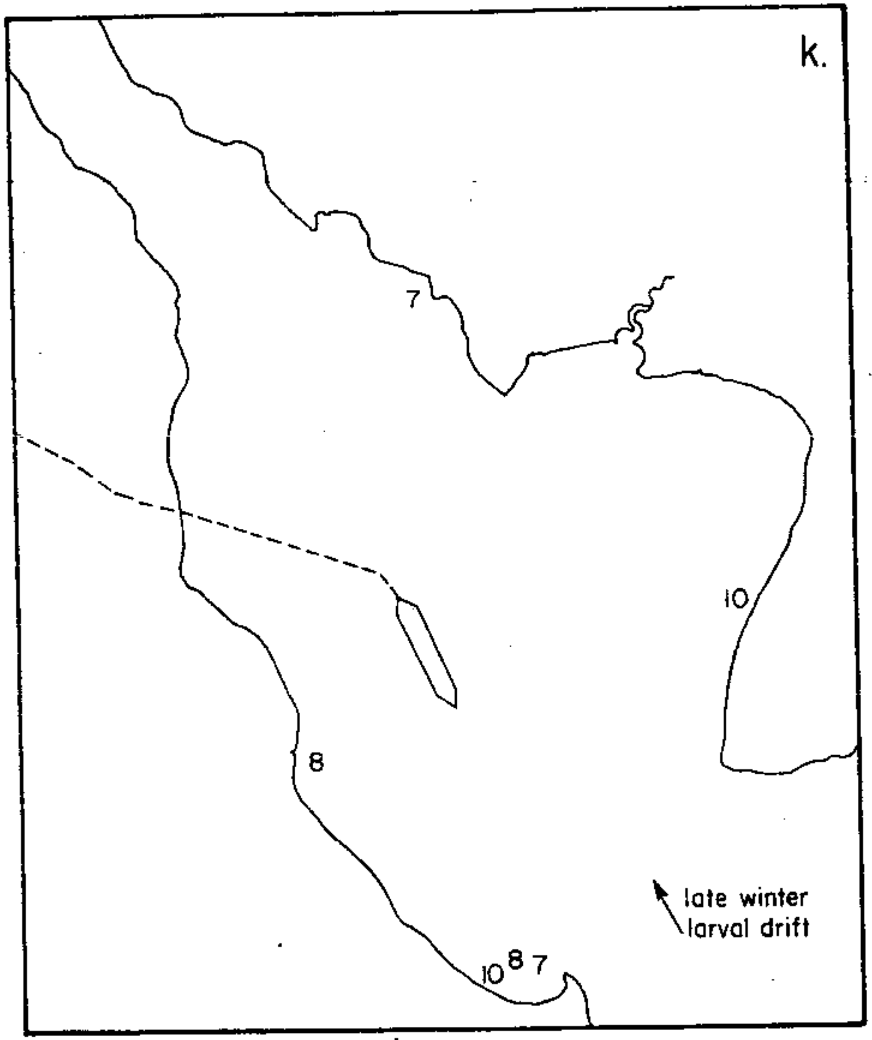
Greatest abundance 5-10



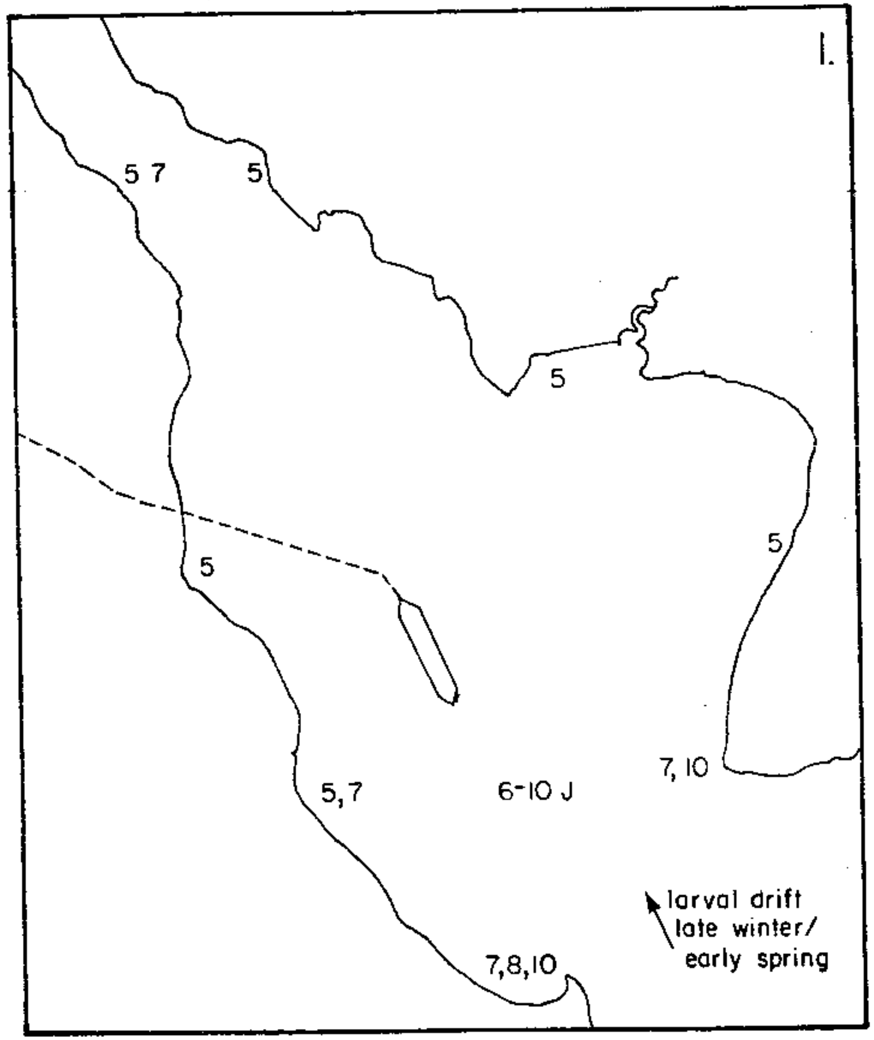
Anguilla rostrata
American eel

In bay → cold months
Tidal streams → summer

FIGURE 24.



Pseudopleuronectes americanus
Winter flounder



Paralichthys dentatus
Summer flounder

of the Bay under federal directives, improvement in fisheries is expected to continue. Improvements noted in recent years included greater harvests of oysters, increasing the size of weakfish and bluefish, and the return of croakers after years of absence.

There is a rich invertebrate population in the lower Bay which is reviewed by Maurer and Watling (1973) and Maurer and Wang (Ref. 87). Many of these invertebrates (and especially zooplankton for many fish larvae) serve as prime food sources for many of the important fisheries species. Prominent algal populations either in bloom or low level concentrations serve as the initial step on a most intricate and delicate food web.

2. POTENTIAL ENVIRONMENTAL IMPACT ON LOWER DELAWARE BAY IN RESPONSE TO PROPOSED MARINE TRANSPORT SYSTEM--CONSTRUCTION, MAINTENANCE AND OPERATION

It is desirable to examine each component of an entire system as separate entities in order to ascertain individual environmental effects before attempting an overall impact statement. This line of action allows modifications within the system in the event of potential environmental detriments and also allows room for suggestions relating to environmental enhancement possibilities.

Immediate and long-term impacts of both a positive and negative nature must be examined. Among these impacts, concern must be centered on direct effects (i.e. immediate physical changes in environment causing direct harm or benefit to organisms) and indirect effects (physiological or behavior effectors other than direct influences). Some of the direct effects which must be dealt with include dredging, turbidity and turbulence while some of the indirect effects include pollutants (chemical, thermal, etc.).

2.1 Port Island

During construction of the proposed port island, care must be taken to contain dredge spoil in order to prevent problems with turbidity, sedimentation and heavy metal contamination, if present.

Turbidity effects depend not only on concentration of particles in a given volume of water, but also on the size of those particles (Ref. 137). Turbid waters may result in two different types of environmental impact. First, increased suspended material can decrease the euphotic zone and thus hinder phytoplankton photosynthesis. This results in decreased primary productivity. Second, settling of particles can silt over harder substrates, bury organisms and eggs, and clog feeding structures of filter feeding animals. With regard to systems such as Delaware Bay, Watling (Ref. 137) notes that estuarine organisms are less vulnerable to turbid waters than are oceanic species. Limits, however, do occur in estuarine species and Davis (1960) found that, under laboratory conditions, less than one third of the oyster eggs he used in turbidity tanks survived in concentrations of 0.5 grams of silt per liter.

After completion, the island itself may offer subtle changes in bay circulation and produce new areas of shoaling and erosion. This, however, will be only incidental and a relatively long-term process. The actual activities on the island may offer more detrimental effects. There is always the possibility of oil spill. However, in the anchorage area now in use, there have been no major oil spills caused by the almost continuous lightering activities. It is, however, likely that long-term, low-level oil spills are more detrimental to the environment than a single spill of, for example, 20,000 metric tons (Ref. 89). Concern over oil spills must not only center around quantity but must also include type of oil, distance from shore, duration of spill in time (Ref. 87) and weather conditions. Models of oil spill distribution may be found in several sources (Refs. 87, 89). The toxicity of oil components is reported by Blumer (1971). The latter author reports that the oil derivative hydrocarbons are lethal to marine organisms either by direct contact or within dilute concentrations. Struhsaker and Benville (Ref. 74) find benzene to be one of the most toxic petroleum components.

With the possibility of power plants on the island, there is a threat of thermal pollution. Thermal pollution is a very real problem in many of the nation's rivers and bays. Biological reactions which are enzymatic in nature are highly temperature dependent. This means that changes in temperature can alter biochemical/physiological reactions within organisms. The potential effects of long-term temperature increases in northern hemisphere fishes is summarized by deSylva (Ref. 45). Some of these effects include: thermal shock and death, changes in spawning habits and nursery grounds, alterations in feeding habits, prolonged growth period, community changes, increased eutrophism causing high turbidity via plankton blooms, increased parasite infestation, migratory thermal barriers, high respiratory rates and high egg mortality.

Thermal pollution may also change some of the physical properties of water as well. Thus with a high concentration of thermal effluents there may be ensuing changes in salinity, density, solubility of dissolved gases, pH and solubility of other potential pollutants (Ref. 137).

The island offers a prime area for the handling of LNG. With the diminishment of U.S. gas supplies, it seems evident that importation of LNG will increase. The positive aspects of such activities are numerous and include the clean burning of the gases, availability of adequate handling technology and, of course, the gas shortage itself. The main argument against bulk LNG importation is its highly explosive nature when handled improperly. The inherent danger here is not in the technology of containing or working with LNG but in the threat of collision in crowded shipping lanes (Ref. 49). The lower Bay port should alleviate this problem for the upper Bay ports, but care should be maximized to prevent collisions within the deep water channel port.

2.2 Deepwater Channel and Access Channel

With the possibility that the channel may reach depths of greater than 80 feet, substantial initial and maintenance dredging will have to take place. The immediate effect of dredging is the destruction of the sedentary benthic organisms in the path of the dredge. Here the term sedentary is used to signify all animals that are unable to avoid such disturbances. These latter organisms include crabs, tubeworms, sea stars, oysters, clams, whelks and other gastropods, sponges, tunicates, and of great importance, demersal eggs and fish larvae. Secondarily, the destruction of benthic communities may have an impact upon bottom-feeding fish (Ref. 27).

Aside from the primary impact caused by dredging, the degree of damage will vary with community type present, frequency and volume of dredging, sediment type, bottom contours, current patterns and season (Ref. 87). The type of community present before dredging will indicate its viability in recolonization. It is well documented that the initial dredging is often not as deleterious as is periodic maintenance dredging which would, if carried out annually, interfere with previous inhabitants' recolonization attempts (Ref. 87). Dredging may also result in sediment changes via exposure of lower substrates or shifting of substrates. In either case, new communities may become established in place of previous biota.

According to the Task Force Report (Ref. 123), dredging to a depth of this magnitude could cause "incalculable environmental harm."

The arrangement of channels and currents will influence the dispersion and settling of particles in turbid waters and the turbulence caused by supertankers may resuspend bottom sediments.

2.3 Pipeline Corrider from the Shelf

Dredging involved in laying a pipeline will create problems of habitat loss via displacement and burial. The dredging incorporates a sediment dispersal which creates high turbidity in its path. The effects of such a pipeline should be short term and care must be taken to avoid pipeline-laying at times of the year when propagation is high.

2.4 Controlled Access Trestle

The construction of such a trestle and the heavy equipment involved with it may lead to short-term, local derogatory impacts. Again special note should be made to avoid crucial spawning periods during the trestles construction.

Since the trestle is to cross marshland it must be carefully planned with regard to time and components. The marsh is the most active portion of the estuary and one of the most productive ecosystems on earth. Aside from the unique floral productivity, which surpasses that of any farmland, many animals are limited to the marsh where they may spawn, nest and/or over-winter. Some of these creatures include voles, mice, many fish species, Canadian geese and snow geese. The relationships developed among marsh biota are extremely complex and interdependent.

The trestle pilings and the port island itself may also serve to increase the range of habitats available for many organisms. As with many structures placed in the ocean, these new units will offer new attachment sites for a multitude of invertebrates. These concentrated areas may serve as a new feeding ground and attract many fish to the area. This type of phenomena has been noted around piers, breakwaters and offshore oil rigs. Whether this concentration represents a real increase in the number of organisms is speculative as such structures may act as a positive attractant from other areas.

2.5 Corridor to Dover

Construction of a new corridor to Dover could lead to increased destruction of valuable wetlands and farmlands. The area over which the corridor is to traverse is already burdened by Wildcat Sanitary Landfill, Dover Air Force Base, St. Jones Sanitary Landfill and Kent County Regional Sewage Treatment Plant (Ref. 138).

2.6 Dover Air-Sea Cargo Center

Such a center would undoubtedly bring with it a high density of traffic and an increased concentration of industry. Lower Delaware is now relatively free from much industrial usage and maintains a fairly intense agrarian and recreational community. Such a facility will likely allow much economic growth in the Dover region. Highly concentrated pockets of industry often breed highly concentrated pockets of pollution. Carefully planned zoning must be the rule to accrue the most benefits that are possible.

2.7 Upstate Corridor, Bay Bridge Throughway, Pipelines to Delaware Valley and New York/New Jersey Refineries

As with all such projects, there is the potential for disturbances to existing neighborhoods, increased community noise levels and new sources of air pollution via high density traffic.

2.8 Summary Statements

Potential environmental impacts have been discussed which include pollution, habitat gain and loss, turbidity problems and the ramifications of all of these. Special care must be taken to prevent the disruption of spawning and nursery grounds in the Bay and the surrounding marshes.

Added expenses may be predicted in the pollution/sewage control of the high density community increases that are likely to follow such a project.

VIII. COMMUNITY EFFECTS

It is difficult to predict the effects of any proposed project with great precision (Ref. 14). It is especially true in the present case where a number of details have not been fully worked out and where the entire concept is new.

Therefore, the following estimates are based on extrapolations from other related cases and are of uncertain accuracy.

There would be four major areas of work force impact on the local and upstate area. These are: temporary construction employment; permanent operating employment; indirect, induced, and related employment; and loss of employment in certain competitive areas.

1. CONSTRUCTION EMPLOYMENT

Direct construction employment for a "conventional" deepwater port was predicted to last for five years with a peak of 1000 jobs about year three (Ref. 13). In the present case, construction would be extended because of the lengthier construction process; perhaps eight years for the island and causeway plus two more for installation of island facilities. Additional employment of 500 between years two and five has been allowed for the transportation corridor.

2. OPERATING EMPLOYMENT

Permanent operating employees would be in several categories. The first would be petroleum offloading and general operation and maintenance of the island. While precise job categories might differ, it is assumed that the figure of 200 (Ref. 13) cited for the offshore terminal may be reasonably applied.

Additional docking space and a separate crew would be required for LNG transfer, but since general operation of the island has been accounted for, no more than about 50 additional workers should be required. Regasification would probably share management personnel with offloading so a maximum of about 30 additional employees should be adequate (based 28-48 for natural gas processing) (Ref. 14). When general cargo (dry bulk, containers, etc.) is added to the picture another set of workers must be considered. The Port of Wilmington directly employs 236 (Ref. 26). While the volume of the proposed port might be larger, it would have state-of-the-art equipment and minimum labor, so that this estimate is probably not unreasonable.

3. INDIRECT AND INDUCED EMPLOYMENT

Indirect (supply and related) and induced (general services to increased population) employment were estimated at about 75% and 65% of direct employment respectively for OCS oil development in southern New Jersey (Ref. 80). Indirect employment for the Port of Wilmington is 67% (Ref. 26).

4. LOSSES IN EMPLOYMENT

A new port facility would tend to compete (to an unknown extent) with existing port employment along the Delaware River. Those potentially affected would include the Port of Wilmington, the Port of Philadelphia, private (mostly oil) facilities and the present lightering activities.

5. SUMMARY OF EMPLOYMENT PROJECTIONS

Temporary direct construction employment of 1500 is predicted from about year two through year five and then declining to about 1000 in years six through eight. Starting about year 10, an operational work force of 200 would begin unloading oil, increasing to about 280 with LNG and eventually to around 500 with general cargo (about year 12?). Maximum direct employment should occur early at about 1500 and level off after construction at about 500 (Fig. 25). This represents more work force flux than might be immediately apparent in that the operating personnel, in general, would probably not come from the ranks of the construction workers.

Estimates of the percentage of workers coming from outside the region (for southern New Jersey) ranged from 40+% for OCS development to "virtually all" for refinery and petrochemical development (Ref. 80). For the present proposal, something closer to the lower figure is probably appropriate. Since the existence of a large project tends to attract job-seekers to an area, the same factor might reasonably be applied to indirect and induced employment. Taking the above employment estimates and assuming 50% of the work force as immigrants from other areas, total employment would be predicted as follows in Table 8.

It should be noted that certain construction activities (such as major fabrication, quarrying stone, etc.) would take place outside the immediate region and thus the resultant benefits and problems would also occur elsewhere.

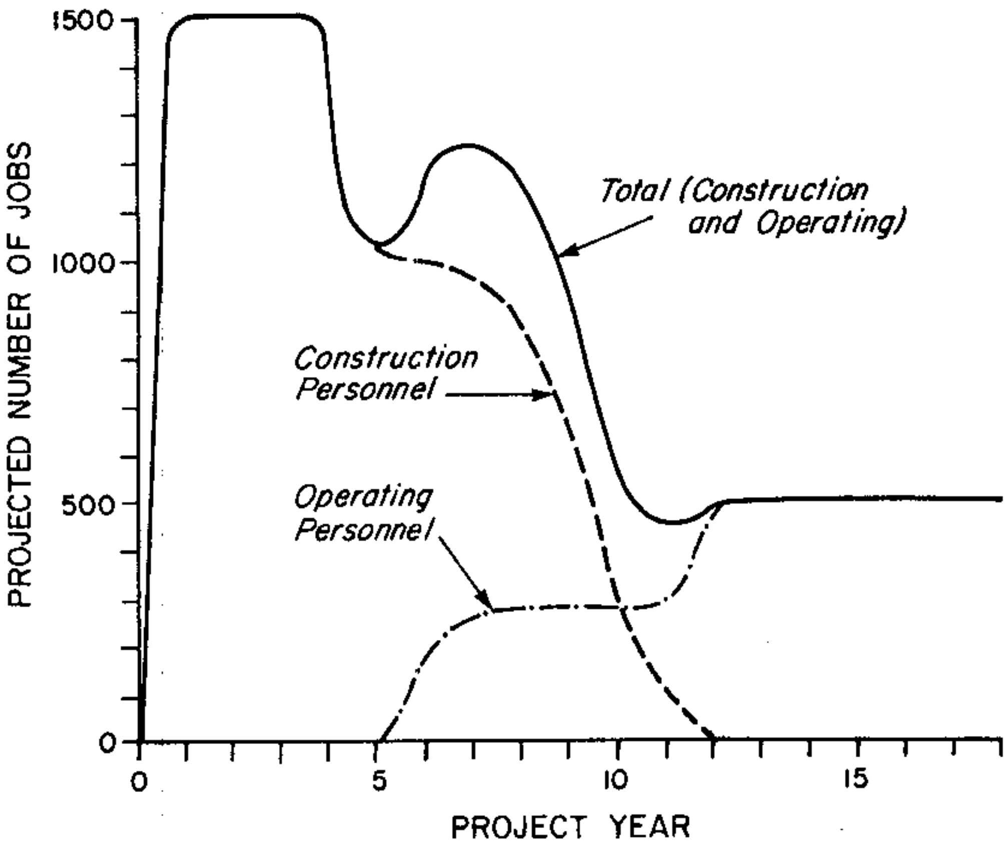


FIGURE 25. PROJECTED POTENTIAL EMPLOYMENT DURING CONSTRUCTION AND OPERATION OF DEEPWATER PORT ISLAND

TABLE 8. Predicted employment related to a deepwater port island in lower Delaware Bay for various phases of development.

	year 3-5	year 6-8	year 12-on
	construction		operation
Direct Employment	1500	1000	500
Indirect (Direct x .75)	1125	750	375
Induced (Direct x .65)	975	650	325
Total	3600	2400	1200
New Residents (Total x .5)	1800	1200	600

6. DIRECT SERVICE NEEDS OF THE FACILITY

Direct services to the island proper should be minimal. The island would supply its own water, sewage treatment, fire protection, oil spill protection, and security. Electricity might be provided from shore and a small amount of solid waste would probably be produced. The industrial neighborhood would need sewer, water and electricity, but these needs would not be great in that the tenants would not include heavy industries. The turnpike portion of the transportation corridor would be patrolled by the state police. Construction of the transportation corridor should be accomplished early in the project because existing transport facilities in the area are deemed inadequate for "any new large scale development" (Ref. 106).

7. SERVICE NEEDS OF INDUCED POPULATION

Development of the port island would probably result in a temporary population increase of about 4% (1.3 dependents/

employee) (Ref. 13) in addition to the present rate of growth (about 2.5% annually for Kent County) (Ref. 103). Increases in population do not improve the revenue picture for local governments in that increased revenues are balanced by increased expenditures for services. Revenue benefits accrue from taxing real property or output (throughput) (Ref. 13). An additional problem arises when the greatest demand for services occurs before the major revenue flow begins as is the case with deepwater ports (Ref. 13). This can be overcome by the allotment of "front-end-money" to the affected local governments as part of the development costs (Ref. 14).

8. REVENUES

State and local government revenue benefits depend essentially on taxing property and/or production. It is assumed that the proposed port would be subject to the usual taxes, although there is some question as to jurisdiction over offshore components for tax purposes. For a "conventional" offshore terminal with only onshore components subject to taxation, income to Delaware governments was predicted at an overall rate of $2979/capita on direct operating employees and their dependents (Ref. 13). Applying that rate to employment estimates above (500 x 2.3 x $2979) yields about $3.4 million annually in revenues.

9. BENEFITS TO THE REGION

Certain other benefits would accrue to the region in addition to the employment and revenues described above. Transportation facilites would be improved. With the rest of the mid-Atlantic region, Delaware would have access to the port for shipping and receiving goods although no major change in local energy prices was predicted as a result of either a deepwater port or OCS oil and gas development (Ref. 106). Recreational use of the causeway for sportfishing presents a possibility, as does commercial shellfish culture.

10. OTHER SOCIAL IMPACTS AND CONCERNS

In addition to the issues already addressed, certain other concerns of local residents have been expressed: pollution from the port or associated industries; weakening of the Coastal Zone Act and changes in land use regulation; urbanization and attendant problems such as altered lifestyles (Ref. 14), increased crime (Ref. 47), and aesthetic degradation; control over port operations and dilution of Delaware's control in a bi- (or multi-) state commission; aesthetic impact of the causeway and transportation corridor which would be highly visible (and audible) on the bay, in the marshes and in rural areas; and additional loss of valuable farmland (Ref. 103) and an increased threat to the rural, undeveloped character of lower Delaware which is unique in this region of the nation.

IX. SAFETY, SECURITY OF SYSTEM COMPONENTS, HAZARD ANALYSIS

The commander of the port has responsibility for and superintendence over the inspections, enforcement and administration of Coast Guard regulations. The officer in charge of marine inspections and his staff, regulate and inspect lifesaving appliances, firefighting equipment, emergency equipment, and emergency drills.

Proper and safe operation of the proposed marine transportation system in lower Delaware Bay would necessitate an extensive set of safety components. Of primary importance for quelling fires aboard the port island, aboard incoming ships, and on the Bay surface would be a 24-hour firefighting force on the island and another force on call in the Dover area. It would be advisable to have at least one fireboat at the port island and others in the island vicinity. There would also be a need for an island-based security force to limit access to those with authorization. This force should be trained with respect to operations, fires, toxic spills, and personal injuries.

1. OIL POLLUTION ASPECTS OF THE PORT ISLAND

Because the proposed port island would be handling large quantities of oil, this would constitute one of the greatest hazards to the environment and man. Oil spills are characterized by accidental events of major proportions, by natural events such as storms, and by chronic small spills (Ref. 61). To attempt to minimize the amount of oil spilled into Delaware waters, it would be necessary to comply with the Coast Guard statutes dealing with oil pollution and prevention equipment, and personnel requirements.

Compliance with Coast Guard law requires the implementation of 1) a malfunction detector system capable of: a) detecting and locating all leaks and malfunctions, b) being monitored at the cargo transfer supervisor's place of duty, 2) oil transfer system malfunction alarm, and 3) discharge containment and removal material capable of removing at least 10,000 U.S. gallons for unloading ports.

The implementation of a total oil spill recovery system must accompany the increased transfer of oil from very large crude carriers coming into the Delaware Bay en route to the proposed port island. This system would be characterized by 1) sweeping and/or containment equipment, 2) oil-water separation equipment, 3) skimming equipment, and 4) a recovered oil storage unit on the port island. Formation of an oil spill contingency plan in coordination with such a system should prove effective in cleaning up spills that occur in the Delaware Bay due to groundings, collisions, and human errors, and spills that occur at the port island mooring berths.

Oil slicks that occur in open Delaware waters can be contained and collected by a variety of methods. Oil spill booms can be used as barriers across the path of an oil spill. Booms can delay the passage of a slick until the depth of the oil pool against the arc of the boom approaches two-thirds of the draft of the boom. Booms can also be used to gather pools of surface oil so that collection can be facilitated. Limited areas of slicks or small slicks can be pulled and diverted away from sensitive environmental areas. Finally, booms can be used to contain the spread of a slick from the source.

Recovery of floating oil can be accomplished by a variety of methods. One method uses a rotational disk skimmer. This type of skimmer uses rotational disks 7 feet x 12 feet long and is capable of collecting 50,000 gallons per hour (gph). The disk skimmer can pick up oil slicks that are spread as thin as 1.5 mm, but increased thickness of slicks increases efficiency of collection. With this method, all types of oil can be collected in seas up to 5 feet and wind speeds of 2 knots and no oil-water separation is necessary if the water content is less than 10%. Disk skimmers can collect approximately 1190 barrels per hour (bph). This means that a 250 foot x 44 foot x 6 inch tank barge having a capacity of 25,000 barrels is capable of working for 21 hours, while a 320 foot x 56 foot x 9 inch barge with a capacity of 56,000 barrels is capable of working for 47 hours.

Another type of collection method uses a hydraulic skimmer system containing floating chambers which concentrate and collect surface oils. This system uses deck-mounted pumps and tanks which can be easily and quickly transported to oil spill sites. Collection by this system is 97%

efficient and can remove 6800 bph in winds up to 2 knots, but is only 24% effective in winds of 4 knots. Short, choppy wave conditions up to 30 inches have little or no effect on collection efficiency. This type of skimmer can be used in conjunction with a spray boom which provides a continuous spray impingement pattern on the water surface to sweep floating oil toward the collection point.

An experimental method for spill cleanup and retardation of spreading rate is that of "gelling" crude oils to reduce marine pollution. Certain chemicals such as isocyanate and amines cause gelling or "solidification" of hydrocarbons. Effectiveness of this method in terms of pollution reduction is a function of 1) the time lapse to initiate gelling; 2) rupture size, and 3) rupture location in relation to the water line. Gelled crude oil will not form a slick but rather coagulate into lumps. Chemical gelling agent storage and dispersal equipment can be designed for shipboard installation or in appropriate size and weight containers to permit helicopter or surface transport to the spill area. The chemical-physical properties of a gelled oil must meet the following: 1) the specific gravity must be less than that of seawater, 2) the gel-oil must be both water and oil insoluble, 3) the gel action must be quick, 4) the gel must have low toxicity, and be noncorrosive.

Aside from these measures to collect and contain surface spills, the use of sorbent materials such as polyurethane is effective but quite time consuming and inadequate for large spills. Overall, great difficulty is met when oil cleanup and containment on the open surface waters is attempted in adverse environmental conditions (waves greater than 2 feet and winds greater than 4 knots).

It is easier to contain and collect spills that will occur at the fixed berths of the port island. The idea of using a flexible boom to encircle a berthed tanker has been modified in several ways in developing more efficient containment methods. One method suggested in the "Olympic Refineries Inc., New Hampshire Marine Oil Terminal Project" report called for encircling booms used in combination with loading platforms "designed to be water tight with curbed reinforced concrete decks." Secondary curbed retention areas would be positively sloped to drain oily water into below deck waste water sump tanks. Oil residues between the curbed areas could be cleaned by use of steam and oil dispersants and then transferred into ballast water lines.

Transfer of petroleum products from the VLCCs should be carried out using "counter balanced steel pipe marine loading units fitted with swivel joint pipe fittings." This type of loading is better than hose units because of 1) easier uncoupling and coupling with the pipe fittings, 2) less wear, damage and subsequent leakage, 3) easier drainage after operations, and 4) less storage space required.

Air barriers which are similar to encirclement devices can be used at single point moorings to contain potential spills. This method is economically favorable because of 1) moderate installation costs, 2) minimum manpower needed to activate and monitor use, 3) easy access of supply and workboats to the tankers, and 4) nonsusceptibility to ice accumulation.

Rapid and continuous oil-water separation can be achieved using a vortex separation process (Ref. 4). The efficiency and simplicity of the vortex separation process makes it favorably suited for incorporation into a total oil recovery system comprising sweeping, skimming, separation, and storage. Although this method suffers from being unable to separate true emulsions, one can employ a highly portable skimmer-vortex separator for rapid recovery in restricted areas such as mooring berths, or employ larger shipboard systems for use on open waters.

Spills can be minimized at the berthing sites if efficient oil transfer operations are developed and practiced by experienced personnel. Because a high percentage of berth spills occur during coupling and uncoupling activities, large tankers should decrease the amount of spillage because the greater quantities of oil will require less transfer coupling than similar amounts carried in several small ships. The important factor of oil pollution cleanup is the protection of the surrounding ecosystem. As technologic advances are made in the field of pollution control, system update should occur concurrently.

2. VESSEL TRAFFIC CONTROL AND NAVIGATIONAL AIDS REQUIREMENTS

The safety of marine transportation in the Delaware Bay and River is decreased due to high density traffic in the ship channel to Philadelphia. One of the objectives of the Comprehensive Marine Transportation Concept for Delaware is "to provide a down bay deep-water port and thus reduce ship traffic in the Delaware River and consequently reduce the probability of ship collisions and oil spills" (Ref. 56a).

The Coast Guard has identified the Delaware Bay area as one of 16 ports and waterways in need of vessel traffic systems (VTS) (Ref. 19). An estimate of the effectiveness of VTS by the Coast Guard showed that major reductions in vessel collisions and groundings could be achieved with the use of a basic VTS. Delaware Bay is considered an area where implementation of a basic VTS costing from $3.5 million to $7 million should be more cost effective in reducing vessel casualties. Coast Guard experience and available studies indicate that a basic system with regulations, a traffic separation scheme (TSS), and a vessel movement reporting system can be expected to 1) prevent vessel casualties caused by collision by 60-65%, 2) cost $3.5-$9 million to develop in Delaware Bay, and 3) take two to four years to become operational.

In the case of the Delaware River and Bay, the captain of the port holds control over all vessels entering, moving through, and leaving the area. Because of the enormous variety of ships and ship cargoes entering the Delaware Bay area, it is necessary for the captain to look at each individual ship and cargo in order to set requirements with respect to speed, mooring, movement, etc. (Ref. 111). The movement by ship of liquid cargo in bulk which is inflammable or combustible, or oil in any form requires special considerations and handling. The handling requirements for so-called dangerous cargoes are outlined in the Proceedings of the National Symposium on Marine Transportation Management, April 29 - May 1, 1975, (Ref. 112) as 1) daylight only movements within harbors (ports and congested waterways), 2) restriction of other vessel movement, 3) escort vessels and early arrival reporting, and 4) voluntary vessel traffic control systems.

The Coast Guard has complete control over the requirements for private aids to navigation (Ref. 21). In building spoil banks, artificial islands, dredged channels, offshore structures, etc., it will be necessary to consult with the captain of the port on marking requirements, obstruction lights and fog signals needed, and markings and lighting on all traffic channels and attendant vessels. Applications for permits to establish and maintain private navigational aids shall be reviewed by the captain of the port and approved by the Commandant of the Coast Guard. Based on the final plans for the Comprehensive Marine Transportation System in Delaware Bay, the Coast Guard will assess all necessary private aids that must be implemented during project construction and after completion.

The Symposium suggested the installation of radar transponders on light ships and approach light towers would lighten the burden of navigation for ship pilots within congested waterways. Also, the use of surveillance radar could provide coverage over principal anchorages. The members of the Symposium agreed that the most essential element in an effective VTS is reliable communications. The Coast Guard has extensive safety measures dealing with vessel movement in and near congested waterways. These measures, along with the requirements for vessel traffic supervisors, radio listening watches, and communications devices are documented in the Federal Register, Vol. 42, #2, 1/31/77 and the Code of Federal Regulations, §-33.

Safe operations of ship movement and cargo handling and transshipment in the lower Delaware Bay will definitely necessitate the building and coordination of the component of a basic VTS and all required private navigational aids associated with an offshore port island, a dredged channel, a marine corridor, and a marine pipeline. At this point, the funds available to the Coast Guard for developing vessel traffic control systems are quite limited. Implementation of a VTS is of paramount importance to the success of an efficient, comprehensive transportation center in the lower Delaware Bay and to increase safety and prevent destruction of the environment, property and human life.

3. LNG TRANSPORT AND STORAGE

Previous accidents and fatalities associated with liquefied natural gas (LNG) base load terminal mishaps in Cleveland and Staten Island, N.Y. have caused public views toward large scale importation of LNG to be very negative. The major question dealing with importation of LNG for U.S. needs as put forth by Drake and Reid (Ref. 49) is "...whether the safety provisions that can be devised would be sufficient to allow the large scale importation of LNG to proceed with acceptable risks to the public." Sufficient safeguards must be provided in order to prevent accidents due to 1) LNG carriage by tankers, 2) pipeline transfer to storage facilities, and 3) storage mishaps.

Tankers designed to carry LNG can accommodate up to 165,000 cubic meters of this cargo. The LNG containment tanks on board have double walls and insulations greater than a meter thick. Accidents such as groundings and collisions will be unlikely to cause LNG leakage if impact safety factors have been applied according to prior analysis of minimum impact and angle of impact necessary to release LNG. Pipeline transfers of LNG from ship to storage facility can be as fast as 50,000 gallons per minute. Practical materials such as high content nickel-steels, aluminum alloys, and prestressed concretes should be used for the transfer pipeline and island storage units in order to adequately contain the -162°C LNG.

Typical LNG containment tanks have an inner diameter of 55 meters, an outer diameter of 58 meters, a height of 55 meters and are designed to contain up to 90,000 cubic meters or 550,000 barrels of LNG. Surrounding impoundment dikes can be low, 2-10 meters high and encompass a large area around the storage tank, or more preferably the impoundment dike can be much higher and closer to the storage tank. The latter type of dike would be able to contain any LNG leakage in a smaller area around the tank. Federal regulations require adequate buffer zoning around the storage tanks in order to prevent accidents such as the Cleveland mishap in which 128 persons died because of LNG leakage and subsequent combustion.

Several hazards are associated with LNG leakage from storage facilities. Leakage of LNG can cause asphyxiation to persons in the immediate area due to the exclusion of oxygen. Also, frostbite can be a resulting occurrence to persons exposed to the extreme cold (-162°C) of LNG. While LNG is contained there is less chance of ignition and subsequent fire than when it is exposed to the open air. LNG burns much like gasoline but the combustion wave of LNG must travel at least 30 meters in order to become a self-detonating wave.

The leakage of LNG forming a thin layer on a water surface can result in a flameless vapor explosion. This occurs only when the LNG contains significant amounts of ethane and propane. The pressure wave from this explosion

(100 pounds/square inch) is attenuated rapidly with distance, and subsequent damage can be minimal.

A rollover is a pressure increase that results from the mixing of LNG of different densities and temperatures. This can cause great increases of pressure within a storage tank. Modern tanks are designed to allow loading of new shipments of LNG into partly filled tanks without the threat of a rollover occurring. Pressure increases can be alleviated by venting off some of the contained LNG but this is potentially dangerous due to increased chance of combustion and explosion.

The Natural Gas Pipeline Safety Act of 1974 lists the standards set by the Secretary of Transportation on design, installation, testing, construction, extension, operation replacement, and maintenance of LNG pipeline facilities. The above ground pipeline suggested for use with the transportation corridor must comply with all of the requirements set forth in this act if LNG is to be transshipped to shore.

Overall evaluation of the benefits to be gained by the United States in using LNG as an additional energy source requires adequate consideration of the present hazards associated with LNG carriage by tankers, transfer to shore, and storage in offshore or land based containers. The safety standard proposed by Drake and Reid (1977) for LNG storage facilities requires that the public would not be endangered even if the largest pipe connection to the storage tanks or to the tankers should fail at the maximum rate of flow of LNG. When substantial experience in the handling of LNG is gained and adequate research on LNG safety procedures has been carried out, the hazards of LNG transfer and storage will be similar to those of other fuels.

X. CONSTRUCTION SCHEDULE

The major elements of the project are the island, the island-to-shore trestle, and the upstate limited access corridor. Construction time for these items would determine the overall construction schedule (Fig. 26) for the project.

1. THE ISLAND

The first step in construction of the island would be placement of the perimeter to contain the dredged fill material. Construction of the perimeter would start from the south end and proceed northward along both sides. At the same time, the divider would be erected across the island. The perimeter should be finished to the divider in about two years. An additional two years should be required to finish the perimeter around the complete phase I area.

When the perimeter has reached the divider, and an enclosed area is available for placement of spoil, dredging could begin. The first area to be dredged would be the deep water side. Four large dredges should be able to dredge this area in about 2-1/2 years. Simultaneously, additional dredges would be at work on the shallow areas

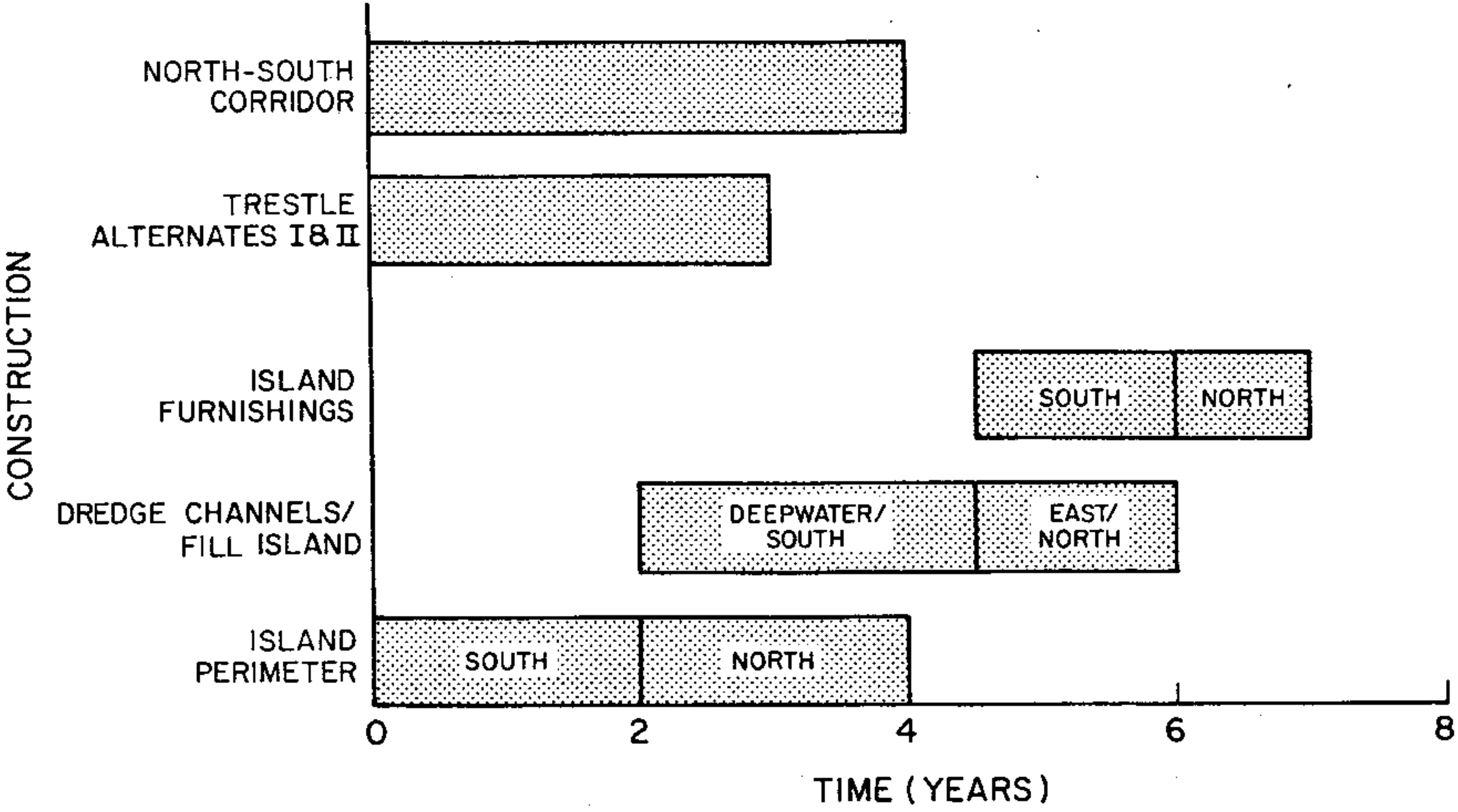


FIGURE 26. CONSTRUCTION TIMETABLE

around the bay mouth and contributing additional fill. The lower section of the island should be filled at about year 4-1/2 from the beginning of the actual construction. An additional 1-1/2 to 2 years of dredging would be required to construct the ship channels on the east side of the island and simultaneously fill the northern portion of phase I. Initial dredging should be substantially complete at year 6-1/2 to 7.

As soon as the southern section is complete, construction of island furnishings could begin. This probably would be an ongoing process, but an initial complement of structures should be finished in about 1-1/2 to 2 years. At this time, 6 to 7 years after beginning construction, the island would be ready to receive its first cargo.

2. TRESTLE

Construction of the trestle depends upon the alternate selected, but alternates I and II would require about 3 to 4 years to construct (Refs. 122, 141). Since this construction would proceed concurrently with island construction, the trestle should be finished before the southern section was completely filled. Alternate III would require a much longer time for construction, about 12 years. If this were selected, the trestle construction time would control the opening of the island for business.

3. NORTH-SOUTH CORRIDOR

The major portion of the upstate corridor will be construction of an interstate highway type road from Dover to Newark. This construction should require about 4 years or less. The other major project in the corridor is the replacement of the railroad lift bridge over the Chesapeake and Delaware Canal. Even with the necessity of maintaining the current rail service, construction time should not exceed three years. Other improvements to the existing rail line could be done as the traffic warrants. The connectors from the air-sea cargo center to the existing rail lines should require about 2 years. Since these projects could all be ongoing while the island was under construction, they should be ready when the island was ready to open for business.

XI. CONSTRUCTION COST ESTIMATES

Construction cost estimates are shown in Table 9. In some cases these figures represent "best guess" estimates. Other figures are high-low spreads, given when such numbers are available.

The minimum cost for the phase I, southern section of the island, with minimum trestle access is $660 million, based on low estimates for all quantities. Total cost for the whole phase I island with full access, would range from $785 million to $1287 million. If trestle design III were considered, the top figure would rise to $2.3 billion. On this basis, trestle design III is probably not justifiable. Other total costs would probably give more realistic prices.

TABLE 9 -- Construction Cost Estimates

		Cost (millions of dollars) low/single	high
ISLAND			
I.	Rock perimeter	145	
II.	Wharf area		
	A. Sheet pile cells	100	
	B. Concrete caissons		200
III.	Divider (sheet pile)	11.5	
IV.	Dredging		
	A. Deep water channel	31.5	63
	B. Bay mouth/ocean	33	66
	C. East side channels	16.5	33
V.	Furnishings south end		
	A. Sewage plant	40	
	B. Utilities	10	
	C. Roads	3	
	D. Administration/service center	4	
	E. Railroad	2	
VI.	Furnishings north		
	A. WharfFenders & hardware, cap	10	
	B. Warehouses	2.5	
TRESTLE			
I.	Alternate I	251	342
	Single trestle	125.5	171
II.	Alternate II	211	379
	A. Road portion	115	209
	B. Railroad portion	96	170
III.	Trestle III	1394	

ONSHORE			Cost (millions of dollars) low/single	high
I.	Air-sea cargo center land		1	2.5
II.	Access corridor, alternate I		151	283.5
	A. Road	106-238.5		
	B. Rail	45		
III.	Access corridor, alternate II		149.5	274.5
	A. Road	100-225		
	B. Railroad	49.5		
TOTALS	(Disregarding Trestle III)		770.5	1255
	(Including Trestle III)		770.5	2270

XII. RATES AND CHARGES

The proposal to construct a deepwater port on Lower Middle Shoal off the coast of Delaware is primarily intended for petroleum products and perhaps LNG shipments. There is little question of the need of a deepwater port capable of handling the large supertankers (250,000-300,000 DWT) now commonly used for carrying petroleum products. The deep draft of these vessels has necessitated lightering into barges off the coast of Delaware since 1959. The isolation of the proposed site from surrounding populations makes it an ideal port for the safe handling of LNG.

The purpose of this section of the report is to analyze both the rate structure of major dry bulk products and the additional costs of ground transportation of these products once the proposed port has been constructed. There will, of necessity, be additional costs of ground transportation due to the distance of the proposed port to the major origin-destination points (New York, Philadelphia, Baltimore, etc.). Once these rate structures have been analyzed, the feasibility of dry bulk shippers using this port and the rates for such use may then be analyzed.

Virtually all the existing major origin-destination points for goods and materials are closer to another major port than the proposed deepwater port. The shippers using the deepwater port would have to transport their goods and materials greater distances by ground transportation, resulting in added costs. If these added costs are not matched by savings gained from the use of the deepwater port, then it would be foolish to expect shippers to come to this facility. Such savings could come about through such means as economies of scale realized by the use of larger draft vessels, reduced turnaround time, and more efficient loading and unloading facilities. For example, turnaround time for large ships in Philadelphia given good weather conditions is 2 to 3 days. The estimated costs of demurrage for a 25,000-40,000 DWT ship is estimated at $5,000 to $10,000 per day, so eliminating turnaround time alone would save on the order of $15,000 to $30,000.

In evaluating rail and motor carrier transportation costs, Roach (Ref. 117) estimated that it would be approximately $1.20/ton more expensive to ship grain by rail from Chicago to the site of the deepwater port than to ship it to Philadelphia. It would be approximately $1.60/ton more expensive than shipping the grain to Baltimore. Coal from Louisville would be about $1.80/ton more expensive to ship by rail to the proposed port than to Baltimore, $1.00/ton more expensive to Philadelphia, and only $.60/ton more expensive than to Norfolk. It is this magnitude of additional shipping costs which must be more than offset by sea transportation savings gained by use of this proposed port.

In Roach's study dealing with the shipping of general commodities, the rates for shorter distances (under 100 miles) favor the use of trucks, but for longer distances rail is the cheaper method of transportation. In addition, if shipments are larger than a single truckload it is more economical to ship by rail. The cheapest mode of rail transportation is by "unit train" rates. If the commodity to be transported is of large quantity and is shipped at a reasonably steady, rate unit train rates might be negotiated. In such a case, the shipper agrees to anywhere from 5-45 repeated trips of not less than 10 cars each. An entire set of equipment is used to serve a single shipper resulting in reduced costs to both the railroad and the shipper. Unit trains generally consist of 75-100 cars with a total carrying capacity of up to 10,000 tons. Bulk commodities such as iron ore and steel (and perhaps grain) are shipped in such volumes as to allow for the use of unit train rates. Brill (Ref. 17) cites a possible savings of $1.60/ton for a shipment using 5 consecutive shipment unit train rates as compared to a 10-car shipment at the normal rate.

Trailer on flat car (TOFC) eliminates much of the terminal freight handling costs and is also able to use the less expensive rail transportation. This method offers higher quality service benefits; however, the costs of TOFC operations are rather high due to the costs of ownership of the trailer. The use of the deepwater port for containerized cargo is questionable at the present time. The largest container ships in use have a maximum draft of 45 feet with the average draft in the 15-20 foot range. These ships probably will not increase in draft since the center of gravity for such low density cargo must be kept low enough to remain stable. The main advantage of utilization of this port by containerized cargo would be the reduction in ship time due to its accessibility.

Perhaps the least expensive mode of nonoceanic transportation is by barge. The major bulk coastal shipment is coal shipped from major ports to customers such as power plants. Lee (Ref. 77) estimates a rate of 1/2 cent per ton mile for barge transportation in Delaware Bay. The use of barge transportation is obviously restricted to shipment of goods to coastal and up-river ports, many of which could be served by the smaller bulk carriers.

Fuller's research (Ref. 56) indicates that for iron ore imports, use of large (150,000-300,000 DWT) bulk vessels could result in savings of approximately \$.30 to \$1.00/ton in comparison to 60,000 DWT vessels (depending on ship size and port of origin). For coal exports, the estimated savings were from \$.20 to \$1.00/ton. These savings and price reductions gained by using unit train rates, plus savings due to location, available space, and the latest technology could offset ground transportation costs to the port. Utilization by iron ore and soft coal shippers would depend on the volumes of material moving through the proposed port.

The export of grain (wheat, corn, and soybeans) should continue to increase slowly but the role of the Atlantic ports in the handling of this material is questionable. The bulk of these products are grown in the midwest and it is generally cheaper to ship these via barge down the Mississippi

River to ports on the Gulf of Mexico than to ship by rail to the Atlantic ports. In addition, there is little demand for large draft grain ships with the maximum in the near future being perhaps 50,000 DWT. It seems that it would not be economical to export grain from the proposed deepwater port due to the high ground transportation costs. There are few deep-draft ports in existence, yet those that do exist are generally convenient to the United States' largest grain customers. If a demand for larger shipments were to arise, the deepwater port could conceivably become competitive with other ports for grain shipments.

A determination of the charges for use of this deepwater port can only be obtained after a more detailed financial assessment has been made. A basic rate of $1.05/gross ton was obtained for the unloading of iron ore from a standard bulk carrier to railroad car in the ports of Philadelphia and Baltimore (Ref. 118); however, information of this sort is generally unavailable. In any event, the rates of both land-based ports and superports in the Gulf of Mexico would not be applicable due to such factors as a wider range of services provided by the proposed port and quite different environmental conditions. The determination of charges for use of this deepwater port can only be made after a detailed financial study of the revenues necessary for port operation and the acceptability of such rates by potential users has been ascertained.

In summary, the added costs of ground transportation must be offset by savings in oceanic transportation due to the use of the deepwater port. Savings would result from the accessibility of the proposed port to shippers. Less time would be taken in traveling up the Delaware ship channel, in unloading and loading at the docks, and in turning around. In the case of iron ore and soft coal, the additional savings due to the use of deep-draft vessels and unit train rates could make it profitable for utilization of the port for these products. Grain shipments are generally handled by the Gulf ports and at least for the near future, it appears that medium sized (50,000 DWT) vessels will be used for transport. Grain shippers cannot be expected to use the proposed deepwater port unless there is an increase in demand for larger shipments. The user fees for the facilities provided by the proposed port complex cannot be determined without a more detailed financial evaluation of operating costs and present port rates.

XIII. FINANCING

To retain public control over the port system, an intergovernmental agency (Delaware, New Jersey, and possibly federal representatives), which would issue revenue bonds to be paid through private usage and leasing payments, would be preferable to a private financing method. Exceptions might include pipelines financed by a consortium of oil companies, since pipelines would involve common carrier regulations, and improvements of present onshore rail lines.

The Delaware River and Bay Authority could be the financing agency, since it already has a proven bond record, and the necessity for setting up a new agency would be eliminated. It has been suggested that financing the port project would harm the present Authority bond rating, but this may be avoided by the legally mandatory separation of the two financing projects.

A possible cost and financing breakdown is provided in Table 10. Only trestle alternative number three is considered, since this would involve the maximum costs which might be encountered. For the same reason, maximum cost estimates for the other components of the system are used. It should be emphasized that this is only one of many possible breakdowns, and that the figures are only rough estimates.

The financing schedule provided gives estimates for the portion of the project to be financed by revenue bonds. The remainder is assumed to be financed by corporate users and governmental funds. Possible sources for federal funds are highway funds, Economic Administration grants, and federal loans.

Several bond issues, probably about six, would be required to finance such a large amount. In addition, to make the project attractive to investors, it would be necessary to serve leases and levy charges to meet debt service by a factor of 1.5 times the annual debt service (Ref. 44).

TABLE 10 -- Financing Breakdown

Element of System	Type of Financing
Total island	Financed and controlled by a separate authority, with space and facilities leased to large users and small users paying charges (estimated at 30% authority revenue bonds, 70% corporate and government financing).
Trestle	Separate authority revenue bonds, with users paying regular rates.
Oil pipelines	Consortium of oil companies
Onshore road system (Dover to Newark)	Federal and state of Delaware (80% federal, 20% state--Ref. 131)
Onshore railroad system:	
1. Rail line from trestle to current track north of Dover	As trestle
2. Improvements in present system, new bridge over Chesapeake and Delaware Canal	Conrail

Project Costs (Revenue bond portion, millions of dollars):

Island (30%)	177
Trestle	1394
Rail line	13.6
Total	1584.6

Additional costs such as debt service reserve, capitalized interest, and financing costs would bring the total amount of revenue bonds needed to approximately $1.8 billion (possibly higher).

Debt srvice requirements for $1.8 billion are as follows:

Number of Years	Amount (billions of dollars)	Rate	Approximate Annual Debt Service Requirement (millions of dollars)
20	1.8	6-1/2	160
25	1.8	6-3/4	150
30	1.8	6-7/8	140
35	1.8	7	140
40	1.8	7-1/8	140

(Based on figures obtained from Kidder-Peabody and Co., Inc., Ref. 44)

XIV. INSTITUTIONAL ARRANGEMENTS

A marine transportation system with a port in the Delaware Bay would facilitate the import and export of raw materials and finished products, which would improve the economic condition of the Delaware Valley area. The institution established to operate the facility must consider the needs of the entire area. Three ports are already operating on the Delaware Bay at Wilmington, Philadelphia, and Camden which handle general, bulk and containerized cargo. The refineries operate their own docking facilities.

An institution must be established which would plan, construct, and operate all components of the port, pipeline and air-sea cargo center system. The agency should be independent of direct state control so that state tax money is not involved in the operation. The port agency should plan and construct the island and lease space on the island to the oil companies, gas companies, etc. for the construction of the facilities for their particular needs. Revenue would also come from charges for the use of the pipeline, highway and rail facilities. The charges for the use of the port should make the agency self-supporting for operations, maintenance, debt service and retirement.

To raise the necessary funds for construction, the agency should be able to issue bonds and securities which are negotiable, lawful investments and qualified for deposit. The purchase of these bonds would be made more attractive if they were declared to be tax exempt by the state.

The Delaware River and Bay Authority already possesses the structure necessary to implement these plans and has an interest in the operation of the port. The Delaware River and Bay Authority is a bi-state agency operating in the interests of Delaware and New Jersey for the operation of transportation projects. Concurrent legislation would be required by both the New Jersey and Delaware legislatures in order to allow the DRBA to operate the port. If it were not possible to obtain the necessary legislation, another agency could be established by the State of Delaware for the port construction and operation.

The concerns of nearby ports over competition from a port in the lower Delaware Bay must also be met. A port in the lower Delaware Bay might lead to further industrial development in southern Delaware to the detriment of the City of Wilmington. The port-related industries in Wilmington justify the existence of the port. The application of the Coastal Zone Act would limit the industrial development in the area of the proposed Delaware Bay port facility. The limitation of petroleum imports to the island port would make more space available in the shipping channel for a greater number of shipments to upriver ports.

According to the 1972 Port Development Plan (Ref. 26), the Port of Wilmington has recently experienced a period of rapid growth. The Port is owned by the City of Wilmington which requires that any annual operating surplus be returned to the City. This has a seriously limiting effect on the port development. It is possible that the Port of Wilmington would benefit if it were to be operated in conjunction with the island port. It would then be necessary to compensate the City of Wilmington for the loss of revenue that the port provides.

XV. LEGAL AND LEGISLATIVE ASPECTS

Increasing commercial interest in using the oceans, bays and rivers has resulted in recent legal changes. There will be more changes in the future. There are state statutes, interstate compacts and federal laws which affect the use of land in the Delaware Bay for a deepwater port facility.

The State of Delaware has constitutional jurisdiction over the land up to three miles from shore according to the Submerged Lands Act of 1953. The United States government has jurisdiction over all land to the outer continental shelf according to the Outer Continental Shelf Lands Act of 1953 (Ref. 6).

1. STATE OF DELAWARE

The 1933 decision of the Supreme Court (Ref. 83) gave the State of Delaware the title to and the right to exercise sovereignty over those submerged lands within the Delaware Bay that lie within its boundaries. The state boundaries in the Delaware Bay go up to the low water mark on the New Jersey shore within the 12-mile radius of the town of New Castle. Below this circle, the boundary is the middle of the main channel of navigation. The state may convey, lease, or permit to others the use of any part of these lands. By statute, the Governor and the Secretary of the Department of Natural Resources and Environmental Control have the power to permit the use of the submerged land. The entire proposed deepwater port facility is within the boundaries of the State of Delaware.

The Coastal Zone Act of 1971 (Ref. 32) banned construction of new heavy industry and offshore bulk transfer facilities in the coastal zone. The proposed port facility would be prohibited unless an amendment of the Coastal Zone Act was passed by the state legislature. The State Planning Office administers permit applications for new uses of the coastal zone and would be involved in the port facility planning. When making a decision concerning the coastal zone, the state planner must take into account: (a) the environmental impact, (b) the economic effect, (c) the aesthetic effect, (d) the effect on neighboring land uses, and (e) county and municipal plans for the development and/or conservation of the coastal zone falling within their jurisdictions. Appeals of State Planning Office decisions may be made to the State Coastal Zone Industrial Control Board.

Another state agency involved in the construction of the port facility is the Department of Natural Resources and Environmental Control. The department would be consulted before the Corps of Engineers permit is approved. At each point where the oil pipeline would cross a stream in the state a permit would be required from the department (Ref. 83).

2. KENT COUNTY

Kent County Planning Office would have to approve a change of zoning where the pipeline comes ashore and the air-sea cargo center to a General Industrial District. A pipeline through Kent County might be considered a "Potentially Hazardous Use" which would require the Board of Adjustment to ban the construction unless it could be shown that the public health and safety could be properly protected. Kent County Zoning Ordinance would claim to regulate the submerged land in the Delaware Bay to the state line. There is some doubt about the validity of this claim (Ref. 83), but a court test would delay construction of the port. In order to eliminate county or local obstructions to the construction of the port the state legislature could pass a statute which would limit their power to adopt zoning ordinances against the port.

3. NEW CASTLE COUNTY

A pipeline from the proposed port to the Pennsylvania refineries must pass through New Castle County. The Zoning Code of New Castle County does not mention pipelines (Ref. 83). Therefore the zoning authorities of New Castle County probably would not attempt to regulate the pipeline.

4. INTERSTATE AGREEMENTS

The Delaware River Basin Commission was established by New York, Pennsylvania, Delaware and New Jersey along with the federal government to "develop and effectuate plans, policies and projects relating to the water resources of the basin." The Commission must review and approve all projects which will have a "substantial" effect on the water resources of the Delaware River Basin (Ref. 83). The Commission has authority over any construction in the Bay which would affect the water quality of the Bay. The effect on water pollution and soil erosion from construction on the marshland would be two key factors affecting the approval of construction by the Delaware River Basin Commission.

The Delaware River and Bay Authority was created to carry out those activities which could not be accomplished by one state alone such as bridge, tunnel or ferry crossings of the Delaware Bay. The Authority has tried to establish its sole jurisdiction over the construction and operation of a port in the Delaware Bay. This jurisdiction has not been clearly established (Ref. 36). For the Authority to begin a port project, concurrent legislation would have to be approved by both the Delaware and New Jersey legislatures. The Delaware River and Bay Authority may not prohibit or regulate the construction of a port in the Delaware Bay by another organization (Ref. 83).

5. FEDERAL GOVERNMENT

The federal government is involved whenever any new construction is linked with the areas of commerce, navigation, national defense or international affairs. There are thirty federal government agencies involved with port policy in the United States, and in many cases their jurisdiction overlaps or their interests conflict (Ref. 85).

According to the Rivers and Harbors Act of 1899, the Corps of Engineers must approve a permit before construction is begun which would affect the navigable capacity of any of the waters of the United States. An environmental impact statement must be filed by the Corps of Engineers with the President's Council on Environmental Quality before the construction permit is approved. A certificate must be filed with the Secretary of Commerce stating that the proposed construction complies with the State Coastal Zone Management Plan when the Plan is adopted in order for the Corps of Engineers permit to be granted (Ref. 85). The Secretary of Commerce may overrule the Coastal Zone Management Plan only in the interests of national security. The Delaware state planner must approve of the construction before the Corps permit is granted (Ref. 83). The Secretary of Commerce may overrule the objections of the state planner if he determines that the construction is in the best interest of the country. The U.S. Fish and Wildlife Service must also be consulted before the Corps of Engineers permit may be approved (Ref. 85). The approval of the permit application by the Corps of

Engineers is based on the following factors: "conservation, economics, aesthetics, general environmental concerns, historic values, fish and wildlife values, flood damage prevention, land use classifications, navigation, recreation, water supply, water quality and the needs and welfare of the people" (Ref. 83).

The Coast Guard established regulations for the operation of deepwater oil terminals after the Federal Water Pollution Control Act was passed. A letter of intent must be filed with the Coast Guard 60 days before operations are to begin at an oil terminal. The Coast Guard also requires an operations manual which describes the equipment and the procedures, duties and responsibilities of personnel during oil transfer operations (Ref. 85). The Coast Guard may inspect the terminal at any time and suspend operations if there is a threat of an oil emission into navigable waters.

The Federal Water Pollution Control Act Amendments of 1972 forbid harmful oil discharges into United States waters (Ref. 85). The Environmental Protection Agency is given the authority to enforce water quality standards in interstate waters by use of a compliance order or a lawsuit.

The Office of Pipeline Safety in the Department of Transportation has the responsibility for ensuring the reliability of pipeline systems. The Transportation of Explosives Act and the Department of Transportation Act of 1966 gave the agency this jurisdiction. Regulations for the safe transport of liquefied natural gas are also administered by the Department of Transportation under the authority of the Natural Gas Pipeline Safety Act of 1968 (Ref. 85).

The Federal Power Commission would have regulatory power over the siting of a liquefied natural gas plant on the proposed port island (Ref. 85). The Federal Power Commission also issues certificates for the construction and operation of interstate pipeline facilities.

Application would be made to the Secretary of the Treasury for designation as a customs "port" or "port of entry." The Bureau of Customs "is charged with assessing and collecting duties and taxes on imported merchandise, with the control of carriers and merchandise imported into or exported from the United States, and with enforcement against smuggling and fraud" (Ref. 85).

The agency which is given jurisdiction over the development of the Delaware Bay port facility would have to comply with all of the preceding regulations and many others for the construction of the port to proceed. The process for obtaining approval for such a project could take several years. An environmental impact statement for a major project may take 12-18 months to complete. It would appear that the legal barriers to the port construction are not insurmountable. Citizen and legislative approval of the project would be necessary.

6. COASTAL ZONE MANAGEMENT ACT AMENDMENTS

One source of aid could come from the Coastal Zone Management Act Amendments of 1976, Public Law 94-370. In particular, Section 7, the Coastal Energy Impact Program provides financial assistance to meet the needs of coastal states and local governments resulting from specified activities involving energy development. This financial assistance consists of grants for study and planning, loans to provide new or improved public facilities and services required as a result of energy development, and bond guarantees.

Grants are available for the planning needed to meet the impacts resulting from deepwater ports, LNG facilities, coal transportation, and power plants.

Energy facilities covered by loans, grants and bond guarantees are designed to provide front-end money for public facilities and services, such as schools and hospitals, required due to coastal energy development and coastal energy transportation.

Grants are available for financing the prevention and/or repair of unavoidable damage caused by energy activities to valuable coastal environmental and recreational resources such as beaches, wetlands, and fresh water supplies.

XVI. REFERENCES

1. Abbe, G. R. An Evaluation of the Distribution of Fish Populations of the Delaware River Estuary. Master's thesis, University of Delaware, 1967.

2. American Association of Port Authorities, Committee on Ship Channels and Harbors. Merchant Vessel Size in U.S. Offshore Trades by the Year 2000. June 1969.

3. American Gas Association. "Update on Status of LNG Projects." Gas Supply Review. Vol. 5, #5. February 1977.

4. American Process Equipment Corporation. Vortex Separation Process for Oil Spill Recovery Systems. EPA 2.10-15080-EUU, Oct. 1970.

5. American Railroad Engineering Association (AREA). Engineering Div. Manual. Vol. I. Chicago, Ill., March 9, 1972.

6. An Evaluation of Multi-Purpose Offshore Industrial Port Islands. Final Technical Report to NSF-RANN. College of Marine Studies, University of Delaware, May 1975.

7. Association of American Railroads, Economic and Finance Department. Yearbook of Railroad Facts. 1976.

8. Atlantic Resources Systems Division-Marine Systems. Recovery of Floating Oil by Rotational Disk Type Skimmer. EPA 2.10-15080-EUU, Oct. 1970.

9. Battelle Memorial Institute, Pacific Northwest Laboratory. Concept Development of a Hydraulic Skimmer for Recovery of Floating Oil. EPA 2.10-15080-FWP, April 1971.

10. Bechtel Engineering. Delaware Bay Oil Transport Committee, Final Progress Review. Sept. 29, 1972.

11. Benn Brothers, Ltd. Ports of the World. 27th ed., London, 1974.

12. Biggs, R. B. Letter to Robert J. Berndt, Senator, State of Delaware. Mimeographed, Oct. 3, 1975.

13. Bish, R. L. Fiscal Effects on State and Local Government from Offshore Oil/Gas and Port Development. In Coastal Effects of Offshore Energy Systems, Vol. II; working papers. OTA, 1976.

14. BLM, USDI. Final Environmental Statement, OCS Sale No. 40. Vol. II of IV, 1976.

15. Blyth Eastman Dillon & Co. et al. Official Statement, City of Valdez, Alaska (Arco Pipe Line Company Project), 1977.

16. Bragaw, Louis K., Henry S. Moreus, Gary C. Raffaele, and James R. Townley. The Challenge of Deepwater Terminals. Lexington, Mass. 1975.

17. Brill, Judith T. Select Bulk Commodity Shipping with Implications for a Deepwater Port. Advanced Study Project in Transportation, Wharton Graduate Division, University of Pennsylvania, 1976.

18. Campbell, Fred. Conrail, personal communication with H. Rowland, March 16, 1977.

19. Can Greater Benefits Be Achieved By Developing Basic Vessel Systems? Report to Congress by the Comptroller General of the U.S. in Government Documents Red. 75-319-(GAO), Jan. 1975.

20. Clark, Allen F., Jr. Impact of Increasing Vessel Sizes on the Ports along the Delaware. American Association of Port Authorities, Jan. 1970.

21. Code of Federal Regulations. Sec. 33, Parts 140-156 and 161; Sec. 46, Parts 94, 95, 105.

22. Coffell, Gerry. Regional Engineer's Office, Conrail, personal communication with H. Rowland, March 8, 1977.

23. Cook, William. Bethlehem Steel Corp., personal communication, April 28, 1977.

24. Craig, Eleanor. Department of Business and Economics, University of Delaware, personal communication with M. Redmond, March 9, 1977.

25. Cranston, Bart. Columbia LNG Corporation, personal communication with A. Wilson, March 16, 1977.

26. Cresap, McCormick & Paget, Inc. Port of Wilmington Development Plan, Vol. 1, Marketing and Financial Report. Wilmington: Port of Wilmington, Delaware, Board of Harbor Commissioners, May 1972.

27. Daiber, F. C. and R. W. Smith. An Analysis of the Weakfish Population in Delaware Bay, 1970-1971. Annual Dingel-Johnson Report to Division of Fish and Wildlife, Department of Natural Resources and Environment, Cont. Delaware Project, F-13-R-13, 1971.

28. Daiber, Franklin. University of Delaware, personal communication.

29. Dean, Robert, University of Delaware, personal communication with R. Tremaine, April 12, 1977.

30. Delaware Bay Oil Transport Committee of the State of Delaware. _Energy, Oil, and the State of Delaware._ Vol. 1 and 2, Jan. 15, 1973.

31. Delaware Bay Transportation Company. _A Proposed Deepwater Tanker Terminal and Onshore Pipeline Distribution System._ May 1972.

32. Delaware. _Delaware Coastal Zone Act._ Del. Code Ann. Tit. 7, 7001 et. seq., 1974.

33. Delaware River and Bay Authority. Minutes of meeting between Delaware and New Jersey representatives leading to the preparation of a compact between New Jersey and Delaware. November 24, 1958-October 29, 1959.

34. Delaware River and Bay Authority. The joint report of Delaware and New Jersey conferees relating to the legislation which resulted in the formation of the Delaware River and Bay Authority. October 29, 1959.

35. Delaware River and Bay Authority. Memorandum responding to report dated Sept. 1975 issued by Center for the Study of Marine Policy at University of Delaware entitled "Legal Considerations for the Construction and Operation of a Deepwater Oil Terminal in the Delaware Bay. December 1975.

36. Delaware River and Bay Authority. A memorandum concerning the duties, responsibilities, jurisdiction and authority of the DRBA relating to transportation or terminal facilities within those areas of both states which borders or are adjacent to the Delaware River or Bay between Delaware and New Jersey. March 1975.

37. Delaware River and Bay Authority. Rebuttal to the University of Delaware report entitled "Legal Considerations for the Construction and Operation of a Deepwater Oil Terminal in the Delaware Bay. March 1976.

38. Delaware River Port Authority, World Trade Division. "A Deepwater Port Analysis: Delaware River and Bay." May 1972.

39. Delaware State Highway Department. Proposed Interstate Spur to Dover. Dec. 1976.

40. DeLeuw, Cather & Co., Engineers and Planners. Recommended Location of the North-South Extension of the Delaware Turnpike. For the Delaware Department of Highways and Transportation, Division of Highways, March 18, 1974.

41. Department of the Army Corps of Engineers. Waterborne Commerce of the United States, Part I: Waterways and Harbors Atlantic Coast. 1968-1975.

42. Department of the Army Corps of Engineers. Feasibility Report: Delaware River Philadelphia to the Sea Offshore Terminal. Nov. 1969.

43. "Department of Transportation, Coast Guard--Deepwater Ports. Regulations on Licensing, Procedures and Design Construction Equipment and Operations Requirement, and Proposal and Site Evaluation." Federal Register, Nov. 10, 1975.

44. de Sylva, D. P., F. A. Kalber, Jr., and C. N. Shaster, Jr. Fishes in the Shore Zone and Other Areas of the Delaware River Estuary. University of Delaware Marine Labs Info. Series, Pub. #5, 1962.

45. de Sylva, D. P. "Theoretical Considerations of the Effects of Heated Effluents on Marine Fishes." In Biological Aspects of Thermal Pollution. Oregon: Vanderbilt Univ. Press, 1969.

46. Divcon Engineers, Inc. Cost Study and Design of Marine Terminal Facilities for Delaware Bay Transportation Company. June 1968.

47. Division of State Police, Delaware Dept. of Public Safety. Delaware Uniform Crime Report. 1976.

48. Dougherty, David, and James O'Sullivan. Kidder-Peabody & Co., Inc., Philadelphia, Pa., Personal communications with M. Redmond, March-April 1977.

49. Drake, Elisabeth and Robert C. Reid. "The Importation of Liquefied Natural Gas." Scientific American. April 1977, p. 22-29.

50. Drinane, Joseph and Richard Woo. Frederic Harris Co., personal communications with J. Murray and E. Tupin, March 31, 1977.

51. El Paso Eastern Company, Transco Energy Company, Transco Terminal Company and Transconinental Gas Pipe Line Corporation. Final Environmental Impact Statement for the Construction and Operation of an LNG Import Terminal at Raccoon Island, Gloucester County, New Jersey. June 1976.

52. Engineering News Record. McGraw-Hill, May 27, 1976.

53. Engineering News Record. McGraw-Hill, April 1977.

54. Exxon Oil Company. Exxon Company, USA's Energy Outlook 1976-1990. Dec. 1975.

55. Federal Energy Administration. National Energy Outlook. February 1976.

56. Fuller, Steven W. "Market Study for a U.S. Deepwater Bulk Port: Ocean Bulk Flows and Costs." Advanced Study Project in Transportation, Wharton Graduate School, University of Pennsylvania, 1975.

56a. Gaither, W. S. A Comprehensive Marine Transportation System for Delaware, Luncheon talk to Wilmington Rotary Club. Hotel Du Pont, Wilmington, Delaware, March 3, 1977.

57. Galloway, J. R., President, Delaware Bay Transportation Co., Philadelphia, Pa., personal communication with M. Redmond, March 1977.

58. Galloway, J. R., Delaware Bay Transportation Co., Gulf Oil Company, personal communication with A. Wilson, April 21, 1977.

59. Gladstone Associates. Potentials for a Delaware Deepwater Port. Oct. 1970.

60. Glenn, A. H., and Associates. In Reference 31.

61. Goodman, Joel M. "Sea Grant Looks at OCS Development." Marine Advisory Services, University of Delaware Sea Grant Program, Feb. 1975.

62. Greaser, M. H. American Dredging Co., Philadelphia, Pa., personal communication with J. Murray, April 1975.

63. Harrison, Walter. Getty Oil Corporation, personal communication, March 1977.

64. Harrison, Walter. Industry and Community Relations Manager, Getty Oil, Delaware City, Delaware, personal communication with C. Galt, March 21, 1977.

65. Harrison, Walter. Getty Oil, personal communication with A. Wilson, April 19, 1977.

66. Hess, Frank C. Gulf Oil Corporation, personal communication with H. Rowland, February 25, 1977.

67. Hudson Engineers. Six Mile Superport. 1973.

68. Hudson, Sam. J. E. Brenneman Co., personal communication with H. Rowland, March 11, 1977.

69. International Petroleum Encyclopedia, 1976. The Petroleum Publishing Company, Tulsa, Oklahoma, 1976.

70. Jordan, R. University of Delaware, personal communication.

71. Kalisch, Robert. American Gas Association, personal communication with A. Wilson, March 31, 1977.

72. Kazmerczak, Leon. Sun Oil, personal communication with A. Wilson, March 25, 1977.

73. Keck, R. T., L. Watling and D. Maurer. Survey of Delaware's Hard Clam Resources, 1971-1972. Annual Report to National Marine Fisheries Service, 1972.

74. Korn, S., T. W. Struhsaker, and P. Benulle, Jr. Effects of Benzene on Growth, Fat Content, and Caloric Content of Striped Bass, Morone saxatilis. Fish. Bulletin, 74(3)(1974): 694-699. 1976.

75. Kreh, . U.S. Army Corps of Engineers, Delaware District, Philadelphia, Pa., personal communications with J. Murray, April 1975.

76. Kuhn Construction Co. Personal communication with E. Tupin, April 28-29, 1977.

77. Lee, Susan E. Investigations of Cost Characteristics for Barges on the Delaware River and Bay. Advanced Study Project in Transportation, Wharton Graduate Division, University of Pennsylvania, 1976.

78. Levino Shipping. Philadelphia, Pa., personal communication with H. Rowland, March 18, 1977.

79. Lewis, James P. LNG Project Manager, Transco Terminal Co., personal communication with H. Rowland, March 25, 1977.

80. Little, A. D., Inc. Potential Onshore Effects of Deepwater Oil Terminal-Related Industrial Development. Vol. II, Part 1, Mid-Atlantic Region, Part 3, Maine. 1973.

81. Maine Port Authority. Testing and Evaluation of Oil Spill Recovery Equipment. EPA 2.10-15080-DOZ, Dec. 1970.

82. Malone, John. Port Corporation of Philadelphia, Philadelphia, Pa., personal communication with M. Redmond, March 28, 1977.

83. Mangone, Gerard J. "Legal Considerations for the Construction and Operation of a Deepwater Oil Terminal in the Delaware Bay." Center for the Study of Marine Policy, College of Marine Studies, U. of Delaware, 1975.

84. Mangone, Gerard J. and Jerry Homer. "Sea Grant Looks at Legal Aspects of OCS Development." Marine Advisory Service, U. of Delaware, Oct. 1975.

85. Marcus, H. S., J. E. Short, J. C. Kuypers, P. O. Roberts. Federal Port Policy in the United States, MIT Press, Cambridge, Mass.: MIT Press, 1976.

86. Maurer, D. and L. Watling. "Studies on the Oyster Community of Delaware: The Influence of the Estuarine Environment on the Associated Fauna." Inter. Rev. Ges. Hydrobiology 58(2):161-201, (1973).

87. Maurer, D. and H. Wang. Environmental Vulnerability of the Delaware Bay Area to Supertanker Accommodation, Vol. 2, Biology. NTIS, U. of Delaware, 1973.

88. Maurer, D. Biological Condition of the Deepwater Portion of Lower Delaware Bay. NSF-RANN Program, 1974.

89. Maurer, D. Impacts of a Deepwater Terminal, Vol. I, Environmental Problems Associated with a Deepwater Port in the Delaware Bay Area. NSF-RANN Program, 1974.

90. McGarry, John. Delaware Valley Council, personal communication with H. Rowland, March 1, 1977.

91. McHugh, Noble. Philadelphia Electric Co., personal communication with H. Rowland, April 20, 1977.

92. McNerney, Alfred J. Sun Oil Company, personal communication with A. Wilson, April 12, 1977.

93. Menzel, R. W. "Effects of Man's Activities on Estuarine Fisheries." Underwater Naturalist, 7(2): 19-31.

94. Metz, Theodore. Bunge Corporation, personal communication with H. Rowland, March 3, 1977.

95. Miller, William. Delaware River and Bay Authority, personal communications with M. Redmond, March 1977.

96. Modjeski and Masters. Port of Wilmington Development Plan, Vol. 2 (Engineering Report). Port of Wilmington, Delaware, Board of Harbor Commissioners, 1972.

97. National Ocean Survey. Tidal Current Tables. U.S. Dept. of Commerce, 1976.

98. National Ocean Survey. Tide Tables. U.S. Dept. of Commerce, 1976.

99. National Oceanographic and Atmospheric Administration, NOAA Chart 12304, 1976.

100. National Science Foundation, Research Applied to National Needs Program. An Evaluation of Multipurpose Offshore Industrial-Port Islands, Vol. I, General Island Characteristics. 1975.

101. "Navigation." Federal Register, Vol. 42, #2, Jan. 31, 1977.

102. O'Brien, J. Kent County Planning Office, personal communication, March 10, 1977.

103. O'Brien, J. Kent County Planning Office, personal communication with B. Petrosky, April 11, 1977.

104. Oglesby, Clarkson H. Highway Engineering. New York: John Wiley Sons, 1975.

105. Orlofsky, S. "Gas Supply Update." Columbia Gas System, Pennsylvania Gas Association, May 1976.

106. OTA. Coastal Effects of Offshore Energy Systems: An Assessment of Oil and Gas Systems, Deepwater Ports and Nuclear Power Plants off the Coast of New Jersey and Delaware. 1976.

107. Penjerdel Corp. Oil Port Update, Philadelphia, Pa., May 1975.

108. Pickett, Thomas E. Papers presented by staff members of the Delaware Geological Survey at the Baltimore meeting of the Northeastern Section of the Geological Society of America, March 1974. Delaware Geological Survey, May 1974.

109. Pleass, C. M. University of Delaware, personal communications with R. Tremaine, March 30, 1977.

110. Portridge, John W. Natural Gas The Cornerstone of U.S. Energy Policy, Economic Well-Being. Columbia Gas System, May 1975.

111. "Ports and Waterways Safety Act of 1972." U.S. Code, 33 Sec. 1221, 1222.

112. Proceedings of the National Symposium on Marine Transportation, April 29-May 1, 1975. College of Marine Studies, U. of Delaware, Nov. 1975.

113. Public Service Electric and Gas Company. "Atlantic Generating Station Units 1 and 2, Preliminary Safety Analysis Report." 1975.

114. Richter, Jack. Delaware Transportation Authority, personal communication, March 25, 1977.

115. Riggins, E. Delmarva Power, personal communication, March 3, 1977.

116. Rogers, L. G. Energy Supply Department, Columbia Gas, personal communication with M. Redmond, March 1977.

117. Rouch, Harold K. An Evaluation of Rail and Motor Carrier Transportation Costs in the Region of the Proposed Port. Advanced Study Project in Transportation, Wharton Graduate Division, University of Pennsylvania, 1975.

118. Royston, James P. Director, Ore and Facilities, Consolidated Rail Corporation, Philadelphia, Pa., personal communication with M. Redmond, March 28, 1977.

119. Shaw, William. Environmental Law, People, Pollution and Land Use. St. Paul, Minn.: West Publishing Co., 1976.

120. Smith, J. G. (coordinator). State of Delaware: Intrastate Water Resources Survey 20-1-21-73. W. N. Cann, Inc., 1959.

121. Soros Associates. Offshore Terminal Systems Concepts for the Maritime Administration. Sept. 1972.

122. Tang, Man Chung. Dyckerhoff & Widmann, personal communication with E. Tupin, April 19, 1977.

123. Task Committee on Port Structure Costs of the Committee on Ports and Harbors. Waterways, Harbors and Coastal Engineering Division, Am. Soc. Civil Engineers, 1974.

124. The Coastal Zone of Delaware. Task Force, College of Marine Studies, U. of Delaware, 1970-1971.

125. Thomas, Richard S. Free Ports and Foreign Trade Zones. Cambridge, Md.: Cornell Maritime Press, 1956.

126. Truver, Scott. Marine Policy Reports. Vol. 1, #3, Center for the Study of Marine Policy, U. of Delaware, May 1977.

127. U.S. Congress. Office of Technology Assessment. Coastal Effects of Offshore Energy Systems, Vol. 1, Nov. 1976.

128. U.S. Congress. Senate. Deepwater Port Act of 1974, Joint Report of the Committees on Commerce; Interior and Insular Affairs; and Public Works. Oct. 2, 1974.

129. U.S. Dept. of Commerce. Maritime Administration. The Economics of Deepwater Terminals. Division of Ports, Office of Ports and International Systems, 1972.

130. U.S. Dept. of Commerce. Maritime Administration. Containerized Cargo Statistics. 1973-1974.

131. U.S. Dept. of Commerce. Maritime Administration, Office of Subsidy Administration. A Statistical Analysis of the World's Merchant Fleets. Dec. 31, 1975.

132. U.S. Dept. of the Interior, Bureau of Mines. Mineral Industry Surveys: Petroleum Refineries Annual. Nov. 1974.

133. U.S. Dept. of the Interior. Annual Report of the Secretary. Mining and Mineral Policy. Jan. 1977.

134. U.S. Dept. of Transportation. A Report to Congress: Activities Relating to the Deepwater Port Act of 1974. Fiscal year 1975.

135. U.S. Supreme Court. New Jersey vs. Delaware, 295 U.S. 694 (1934).

136. Wallace, Jack. Delaware Transportation Authority, personal communication with M. Redmond, March 7, 1977.

137. Watling, L., A. Pembroke, and H. Lind. Environmental Assessment in an Evaluation of Multipurpose Industrial-Port Islands. Final Tech. Report to NSF-RANN, 1975.

138. Watton, T. E. and N. R. Palrick (eds.). Delaware River Estuarine Marsh Survey. NSF-RANN Program, 1973.

139. Weil, C. B., Jr. "A Model for the Distribution, Dynamics, and Evolution of Holocene Sediments and Morphologic Features of Delaware Bay." U. of Delaware, 1976.

140. Western Company of North America. Gelling Crude Oils to Reduce Marine Pollution from Tanker Oil Spills. EPA 2.10-15080-DJN, Jan. 1971.

141. Wright, Everald and William Lord. Dravo Corporation, personal communications with E. Tupin, April 1977.

142. Zapata Bulk Systems, Inc. Delaware Transfer Terminal--Current Assessment. Governor's Task Force on Marine and Coastal Affairs. Feb. 1971.

Appendix I

CMS 680 COURSE OUTLINE

Course Outline
CMS 680: Concepts in Applies Ocean Science
Spring 1977, 3 credits
Instructors: W. S. Gaither & Associates
Wednesdays, 7 to 10 p.m.

PURPOSE AND PHILOSOPHY

This is a course for non-engineers, however engineers will benefit if they participate and in addition they will help non-engineering students. It assumes that each student has a grasp of basic physics and mathematics through differential and integral calculus. The instructors are experienced engineers who will use illustrated examples of actual engineering projects as their primary teaching technique. Each lecture will be designed to set the stage for understanding several basic engineering concepts. Problems, selected reading, and a major case study of a comprehensive marine transportation system for the Delaware Valley will be assigned to help fix the concepts discussed in class.

GRADING

Each student's performance will be evaluated on the basis of:

1. Occasional tests
2. Completion of assigned problems
3. Overall quality of case paper and presentation to expert panel on May 18. (See attached rating sheet.)
4. Instructors evaluation of student's total learning experience and level of understanding at end of course.

TEXT AND REFERENCES

1. Gaither, W. S. A Comprehensive Marine Transportation Concept for Delaware. January 24, 1977.
2. Shore Protection Planning and Design published by the Coastal Engineering Research Center of the U.S. Army Corps of Engineers (in 3 Volumes). Ordered by University Bookstore.
3. Gaither, W. S. Systems approach to petroleum port site selection, Journal of Waterways and Harbors Division, ASCE. v. 95, no. WW3, August 1969, pp. 375-412.
4. Lecture notes (to be handed out).
5. Other references cited from time to time.

Schedule-Revision 4
Lecture Topics
CMS 680 Concepts in Applied Ocean Science
Spring 1977

Date (Wednesday)	Topic and Reading	Instructors
February 9	Philosophy and Principles of Engineering - Outline case study (Read refs. 1 and 4)	Gaither
February 16	Marine Construction (Notes)	Gaither
February 23	Marine Construction (Notes)	Gaither
March 2	Dredging & Use of Dredged Material	Kreh
March 9	Materials and Corrosion (Notes)	Dexter
March 16	Submarine Pipelines (Notes)	Lammert
March 23	Ships and Floating Bodies	Gaither
March 30	Tides, Currents, Waves and Wave Forces (Ref. 1 pages to)	Dean
April 6	Spring Recess	
April 13	Coastal Engineering & Modeling (Ref. 1 pages to)	Dean
April 20	Ports, Harbors & Off Shore Islands (Ref. 3 and Notes)	Gaither
April 27	Marine Pollution & Modeling (Notes)	Ditmars
May 4	Submersibles, Diving & Underwater Work	Savage
May 11	Communications in Engineering & Review	Gaither
May 18	Presentation of Case Study to Expert Panel	Gaither & Students
May 23-27 (To be scheduled)	Final Examination (Course evaluation by students)	Gaither

Appendix II

CASE STUDY ORGANIZATION AND SCHEDULE

PROJECT MANAGEMENT

Project Manager Murray

Asst. Project Manager Johnson

1. Team coordination and scheduling
2. Budget and cost control
3. Report planning and scheduling
4. Oral presentation planning and scheduling

WSG/jlp/3-10-77

TEAM 1 ECONOMIC & INSTITUTIONAL

Team Leader Golt

Member Wilson

Member Dean

Member Redmond

Member

1. Define needs of Delaware Valley and hinterland
2. Analyze existing traffic and project throughput requirements on a commodity-by commodity basis on the year 2000
3. Examine rate structure for interstate shipment to port
4. Determine use charges for components of system
5. Examine shared use of federal facility at Dover A.F.B.
6. Examine institutional arrangements to build and operate components of the system
7. Propose methods to raise capital for construction of system
8. Opportunities for free trade zone
9. Relationship of system to Port of Wilmington

WSG/jlp/3-10-77

TEAM 2 SYSTEM COMPONENT DESIGN & CONSTRUCTION

Team Leader Tupin

Member Tremaine

Member Murray

Member Rowland

Member Burnett

1. Establish environmental design criteria (i.e. wind, waves, life of components)
2. Design system components including right-of-way selection
3. Determine island areas required to accommodate quantities of material throughput based on projections until year 2000
4. Establish size of increments of island construction (assume that USCE will supply 2 million/yr. 1980-85, 4 million/yr. 1985-90, 6 million/yr. 1990-2000 and 4 million/yr. after 2000)
5. Determine construction material quantities
6. Estimate construction costs
7. Consider designs which can be converted to other uses in the future
8. Consider designs which will enhance ecosystem productivity
9. Plan for construction dredging and spoil use
10. Schedule for construction and operation

WSG/jlp/3-10-77

TEAM 3 ENVIRONMENTAL AND SOCIAL IMPACT AND BENEFITS

Team Leader Petrosky

Member Dey

Member Prezant

Member Moss

Member

1. Define (on map) distribution of valuable marine species in lower Delaware Bay
2. Define impacts resulting from construction of system components
3. Define ecosystem enhancement opportunities through construction features
4. Define work force impact and benefits to Dover and up state areas
5. Define community service needs to accommodate project
6. Define safety and security of system components - Hazards analysis
7. Define ship traffic control system requirements

WSG/jlp/3-10-77

CMS 680 Case Study

Milestone To Be Completed

March 16	Group 1	Complete items 1, 2, 5, 8 & 9
	Group 2	Complete items 1 & 2
	Group 3	Complete item 1
March 23	Group 1	Complete items 3 & 4
	Group 2	Complete items 3, 4 & 5
	Group 3	Complete items 2 & 3
March 30	Group 1	Complete items 6 & 7, review and revise items 2, 3 & 4
	Group 2	Complete items 6, 7, 8, 9 and 10
	Group 3	Complete items 4, 5, 6 & 7

April 13 — Complete Draft I of all parts of written report. Hand out for individual review and critique. Have preliminary figures prepared to show to class as view-graphs. Revise figures and send to draftsperson. (Lois Butler)

April 20 — Discuss results of critique and resolve differences. Authors prepare Draft II.

April 25 — Draft II to typist, revise figures.

May 4 — Review of total report and plan final revisions. Prepare visual aid sketches and give to Pezley.

May 11 — Mail Draft II report to the expert panel. Full rehearsal of oral presentation before class with all visual aides. Pezley will attend class to revise charts.

May 18 — Oral presentation to Expert Panel. Final revisions to report by authors. Draft III completed by Group Leaders and Project Manager.

WSG/jlp/3-10-77

Appendix III

EXPERT PANEL MEMBERS AND COMMENTS

An oral presentation of the comprehensive marine transportation system was made by the students in CMS 680 to an invited panel of experts on May 18, 1977. Many of their comments were incorporated into the text. Each expert was also invited to make written comments, which are included verbatim in this section (alphabetically by author).

Experts who attended are listed below.

Mr. Donald Alfieri
Port Director
Port of Wilmington
P.O. Box 1191
Wilmington, DE 19899

Dr. Robert B. Biggs
College of Marine Studies
University of Delaware
Newark, DE 19711

Dr. Dale W. Brown
Marine Assessment Division
Environmental Data Service - NOAA
Washington, DC 20235

Provost L. Leon Campbell
Office of the Provost
University of Delaware
Newark, DE 19711

Mr. Vincent D'Anna
Coordinator of Constituent Services
Office of Senator Biden
6021 Federal Building
844 King Street
Wilmington, DE 19801

Mr. David Daugherty
Kidder-Peabody & Company
3 Girard Plaza
Philadelphia, PA 19102

Dr. Charles E. Epifanio
Marine Studies Complex
University of Delaware
Lewes, DE 19958

Mr. John R. Galloway, President
Delaware Bay Transportation Company
Suite 1820
Three Parkway Building
Philadelphia, PA 19102

Mr. Adrian Hooper
IOT Corporation
214 Transportation Center
Six Penn Center Plaza
Philadelphia, PA 19103

Dr. Gerard J. Mangone
College of Marine Studies
University of Delaware
Newark, DE 19711

Mr. Albert S. Matlack
R.D. 1, Box 137
Hockessin, DE 19707

Mr. William J. Miller, Jr.
Director, Delaware River
and Bay Authority
P.O. Box 71
New Castle, DE 19720

Mr. Carl S. Oldach, Director
Division of Economic Development
State of Delaware
630 State College Road
Dover, DE 19901

Mr. James E. O'Sullivan
Vice President
Kidder-Peabody & Company
3 Girard Plaza
Philadelphia, PA 19102

Mr. Gary Patterson
Executive Assistant
Office of Senator Roth
Federal Building
300 South State Street
Dover, DE 19901

Dr. Jonathan Sharp
Marine Studies Complex
University of Delaware
Lewes, DE 19958

President E. A. Trabant
Office of the President
University of Delaware
Newark, DE 19711

Mr. Norman Wilder, Director
Delaware Nature Education Society, Inc.
Brackenville & Barley Mill Road
Greenville, DE 19807

Captain K. G. Wiman
Captain of the Port, Philadelphia
Commanding Officer, U.S.C.G.
Gloucester City, NJ 08030

Mr. William C. Wyer
Executive Assistant
Office of Congressman Evans
5021 Federal Building
844 King Street
Wilmington, DE 19801

EXPERT PANEL COMMENTS

R. B. BIGGS, College of Marine Studies, University of Delaware.

Overall objectives for the construction of an island are well conceived. Calculated throughputs seem reasonable for crude oil, iron ore, coal, grain and containerized cargo though neither the economic or marketing rationale for such throughputs are presented. Rather it seems as though the estimates were made by assuming that a fraction of the existing market could be captured.

Space allocations seem to be assumed. No justification for the areas designated for each use is presented. I regard this as the report's most serious weakness. I can't understand the need for 200 acres of island area for petroleum handling, for example. If twice as much area is required there will need to be some exponential increases in fill required because land will have to be created in deep water.

Island construction and access seem well conceived. I suggest that consideration be given to combining the island access trestle with a suggested lower bay highway crossing being considered for the area.

The environmental analysis of the project is weak. Dredging effects were considered to be the greatest single environmental insult. Although environmental analyses are very difficult, there are reasonable estimates of the effects of turbidity (caused by dredging) on estuarine organisms. Community and hazards analysis seem reasonable though for crude oil, the hazard of a spill as compared with the hazards associated with the existing lightering operation.

Construction schedule and costs as well as financial, institutional and legal aspects seem reasonable but I don't see clearly what's in it for Delaware as a state. We get five hundred jobs, no taxes on bonds, pay 20% of the cost of construction of highways and lose over one mile of Delaware Bay bottom.

An excellent conceptual study that deserves refinement.

VINCE D'ANNA, Office of Senator Biden.

The most serious deficiency I see in the study is the relatively small emphasis placed on the land side impact of constructing such a facility. Such a port would place great pressure to locate other industry normally conducted close to such a port. The decision to build the port is likely a decision to industrialize Kent and possibly Sussex County and more importantly the coastline.

Because of the nature of the study group I expected a much fuller and more detailed discussion of the environmental effects of the port. The probabilities and consequences of a major disaster such as a major spill or explosion should be closely examined.

CHARLES E. EPIFANIO, College of Marine Studies, University of Delaware.

The section of potential ecological effects was shallow. Massive amounts of literature exist--particularly relative to oil pollution--and the students should have been able to come up with a stronger case for possible effects. Their use of cited research to strengthen their case was much too limited.

The discussion of engineering aspects of construction of the island and supporting roads was perfunctory. I realize that the students were not engineers, but I would have expected a more technical approach than the one taken.

ALBERT S. MATLACK, The Society of Natural History of Delaware.

There are a few points which may not have been brought out enough in the discussion.

Straight line extrapolation of past trends does not always lead to the correct prediction of the future. The energy picture is changing. The 44% of oil consumed in the U.S. that is imported will cost $40 billion this year. Once abroad, this money competes for commodities on the world market with U.S. needs. The end result can only be inflation here. To correct the balance of payments deficit the federal government is telling public utilities and other large users to switch to coal. It is also starting to push conservation of energy. Oil transport in Delaware Bay will go down, but we're not sure how soon.

Iron ore companies are shifting toward more domestic production, as a foreign cartel forms and raises uncertainties about foreign sources.

Basic human needs must be considered in the long range view. Food and water must come first, with oil, industry, housing, recreation lower in priorities. The proposed north-south turnpike would follow the state's very best farmland, the Sassafras-Matapeake soils, from Middletown to Dover. It would parallel an underused railroad, where one track can haul as many passengers as a 12-lane highway.

The class did not consider the extent of the commercial fishery on the continental shelf that is dependent on the estuary. The Bay is not as healthy as desired, as shown by the steady decline in the commercial finfishery. The fact that in the summer the Delaware River at the Pennsylvania line can have 0 ppm dissolved oxygen indicates a real problem. Philadelphia and Camden sewage contaminate the nursery grounds of the menhaden, hindering its comeback.

A suitable project for a future class might be to analyze the decline of the finfishery in the Bay to determine the reasons. Then the class could decide on methods to remove the problems. These factors include sewage, industrial wastes, effluents from boats, sediment from farms, urban construction and dredging, "mosquito control," filling of marshes, waterfront lots, killing of plankton, fish eggs and larvae in cooling water, etc. The class could identify the technology and legislation needed to reduce these problems, then turn to the possibilities of farming the estuary more systematically, with improved techniques of mariculture.

The class report brought out the need to reduce overlapping jurisdiction and to streamline the permit system for new projects. A simpler system that provides both an overall view (regional and national) and local input is needed. Much planning could be done better on a regional basis, rather than state by state. Perhaps Dr. Mangone and his classes could consider the problem, if they have not already done so.

Dr. Biggs' report on oil spills does not support Hooper's optimism on their minimal impact. Rather, the report emphasizes how little field data is available, both on baseline studies and after spills. A good project would be to gather baseline data in the Delaware Bay and to set up some controlled mini-spills in the field for continued monitoring.

You hinted at the possibility of future class projects dealing with the alternatives to a port island in the Bay. I hope these can include the cheaper single buoy terminal off the shore of northern New Jersey. A shorter, cheaper pipeline could serve both the north Jersey and Philadelphia refineries. Iron ore and coal could be delivered (or exported) as slurries by the Marconaflow system. The 300-mile long coal pipeline in Arizona can serve as a model.

On a very limited data base, lightering in Delaware Bay (no major spill in 18 years) seems safer than transfer at a fixed platform (Bantry Bay, Ireland, two major spills in six months).

WILLIAM J. MILLER, JR., Delaware River and Bay Authority.

1. There has been no position advanced by the Delaware River and Bay Authority in support of, or opposed to, a deep-water port in the Delaware River Bay. However, the Authority has consistently stated that under the terms of the existing legislation which created the Compact between Delaware and New Jersey such facilities must be the responsibility of the Authority.

2. The exercise provided an opportunity for all participants to become acquainted with the many complexities and details associated with such a project. The realities of legislative approvals; financial arrangements; construction alternates; economic and environmental impact results, and other details seemed enormous.

   When questioned, it was announced that the class had not voted for or against the project but it was obvious that there were mixed feelings within the class. Nevertheless, the class did a commendable job in arranging for and making the presentation.

3. The lack of alternate plans resulted in critical reviews of the submitted plan by the review panel. Had there been an opportunity for consideration of alternates perhaps certain elements in this presentation would have been abandoned in favor of the alternates.

4. Without attempting to quarrel with many of the details contained in the exercise it would seem that additional review would be required in the following areas:

   a. The rail crossing of the Chesapeake and Delaware Canal with an approach grade for satisfactory rail usage would not only be extremely expensive but, without a demonstrated need, would not quickly be built by any agency.

   b. The trestle design for two railroad lanes and four highway lanes for truck traffic, plus the pipe and other utility arrangements, will hardly be considered esthetically attractive simply because it rests on a single pier, but then, what a single pier this would be!

   c. The presentation seemed to indicate that the up-state connection to a Delaware Turnpike extension would be financed with 80-20 Federal funds.

      This extension has been proposed on the basis of toll financing for which Federal funds are not eligible.

5. The primary justification for the port plan revolves around the need to provide facilities for deep-draft oil tankers. Many recent statements in the public press have indicated that the oil supply will dwindle as we approach the year 2000. This factor did not seem to be considered through the exercise. If the oil supply changes, the economic feasibility of such a project would be drastically affected.

6. One comment related to the effects of the project on "the whole Bay," yet there were no contacts made or interest expressed in New Jersey's attitude or position concerning the exercise. In this regard it would seem that the pipeline proposed to take the off-shore drilling could easily be able to be directed to New Jersey rather than to the Bay. In addition to this, the oil pipeline location and depth could have a very material effect on Bay shipping activities.

7. It would seem that this is one exercise which could quite readily be expanded by a consideration of alternates, many alternates. As an exercise it would seem that this would be a logical step to take for the future.

C. S. OLDACH, Division of Economic Development, State of Delaware.

Forecast of increased oil shipments to Delaware Valley. How realistic? For how long?

Can you afford to build such a system which cannot handle the really big ships being built today?

How can you utilize the very large refrigeration content of LNG?

Economics:
Must go further in defining required charges for use of new facilities, $/ton, in order to pay for the investment and then relate this to the shippers' alternative costs since it will not be used if it doesn't save money.

JONATHAN H. SHARP, College of Marine Studies, University of Delaware.

Logical inconsistency -- island designed primarily for immediate use as oil port with potential future use also for other purposes (containers, grains, iron ore). But in analysis of these uses, it is concluded that none are practical for this island port.

Environmental analysis is inadequate. Most statements are based upon unpublished local studies. There is much literature on estuarine ecology and specific pollutant effects that are overlooked.

Logical inconsistency -- despite a statement that no spills have occurred from the lightering activity, part of the premise of the island port is to avoid such spills.

If island is built upon existing shoal, will a new shoal form on the periphery and if so, won't this probably silt in access channels?

If 10 month dredging schedule is planned, what will happen to fish and benthic invertebrates that spawn in months other than June and July?

There is mention of compatibility of island port to Dover Air Force Base for eventual use of air cargo facility. There is no mention of what sort of air cargo is planned or why proximity to the air facility is desirable.

Reference is made that salt marsh ecosystems are more productive than most other ecosystems. Do you have quantitative evidence for this? This statement is made often, but little confirmation has been given from actual measurements.

Could not much of the present congested traffic hazard of shipping be lessened by better navigational aids and better trained personnel on ships?

Why not build a port more to the south requiring less dredging and closer to the shore lessening trestle construction costs. Perhaps closer to Cape May to utilize right-of-way access to Philadelphia and New York?

It appears that presently much of the chemical pollutant input to the Bay comes from the northern end and is dispersed, destroyed, or buried before being carried to the mouth and out (in essence, the lower Bay is relatively clean). With any spillage from the island port, the lower Bay and probably coastal ocean would receive pollution in quantities far greater than at present.

K. G. WIMAN, Captain of the Port, Philadelphia, U.S.C.G.

I have some very basic problems with this study and they probably all can be boiled down to "what incentive has been shown in terms of improved shipping economy that can make this billion dollar proposal viable on an economical basis?" I do not believe you have made your case.

In terms of specific comments--

1. You are providing deep berths in 72 to 80 feet of water but there is no concrete evidence of this depth being needed at present for any ships other than tankers.

2. There is no proven need for such drafts to serve ore, coal, LNG shipment, or containers.

3. If tankers are the only captive deep water users, the unloading of them can most economically be done through single point moorings with an underwater pipeline to shore with a tank farm, pumping station and an upriver pipeline on shore. The tanker cannot be used to justify island or causeway construction, and if not, what shipping economy can?

4. In terms of iron ore, what incentive is shown that will divert Baltimore bound cargo to this terminal, or even encourage unloading of Delaware River ships at this terminal with subsequent reloading on rail cars. I believe the fairless works will still prefer to unload iron ore from handy size ships directly into their plant. You must provide an inherent economy to attract the cargo.

5. Coal exporters are not generally big users of very large ships. What can this terminal do for the coal shipper that Norfolk cannot?

6. LNG ships don't need deep water. What incentive is there for this high cost man-made island?

7. For grain you simply state "development of the port would enhance possibilities of large volume shipments of grains to Africa and Asia." You cannot justify a terminal on speculation as to what might happen. The existing major grain ports on the western rivers system do a good job now. What dollar savings would cause a major shift in the entire national grain transportation system to favor your port?

8. The port does not appear attractive for containers.

9. As far as design specifics, assuming other parts of the study are true--

   A. Why have a 200-acre tank farm on expensive filled land? Shouldn't it be onshore and be served by pipeline from the terminal?

   B. What justification for a 4 to 6 lane causeway--what cargo will move by truck?

   C. Why two rail tracks rather than single line with a passing siding on the shore terminus.

10. In your cost estimate, I expect that an omitted item, the high level railroad bridge over the C&D Canal will cost more than the total amount devoted to all other rail corridor construction. I have considerable doubt that the cost can be simply assessed to Conrail. In order to reach the necessary grade elevation the approaches on either side will involve more than two miles of elevated track, reaching a height of over 135'--a substantial undertaking.

Debt service table is of course in error. The 1.6 hundred thousand will service the proposed debt for perhaps 12 hours rather than the year proposed. How can this port generate the more than 2 million dollars per week in profits needed to pay for itself? The study does not address this vital facet, much less the annual operating and maintenance budget.

Despite my rather negative comments, I find the report of interest, and certainly feel that it is a study worthy of undertaking. I hope only to convey my general concern that there is a definite tanker problem and that there is a solution to be found in a lower bay tanker terminal, but that the tanker problem alone cannot be used as a justification for construction of other facilities that might not be economically constructed on their own merits.

You must look to the high cost elements and seek further to reduce their cost. It is not enough to investigate a number of alternative causeway designs, you must go back to the basics of what service must the causeway provide and to reduce the scope and cost where possible. You are dealing in far too much money to be casual about the number of lanes or number of tracks to be built.

WILLIAM C. WYER, Office of Congressman Evans.

The only real concern that I have, outside of the feasibility of the payback, is the philosophical question of whether a governmental or quasi-governmental agency should be involved in a venture of this magnitude. Because of the sophisticated technical and mind-boggling financial components, I think the approach would be much better if it were handled by the private sector as a joint venture or consortium type of arrangement.

Appendix IV

COMMENTS BY STUDENTS

This project and the resulting report represented a cooperative effort by the students in CMS 680, and does not necessarily reflect personal views of the authors. Accordingly, each was given an opportunity to express those views in this section. The comments are presented alphabetically by author.

HARLAN K. DEAN

I do not believe a strong enough case has been made for the necessity of such a deepwater port for the handling of bulk products other than oil. The unloading of oil alone does not warrant this hihgly expensive island-trestle system. No attempt was made to compare this transportation system to any alternative systems during the preparation of this report. When alternative methods for the unloading of oil off the coast of Delaware are explored I feel they will not only be less expensive but also will cause considerably less disturbance to the environment.

N. DEAN DEY

As I pointed out in the introduction, there is no real alternative to the importation of oil and gas into the mid-Atlantic region. The question which must be answered is what is the best way to land the hydrocarbons, keeping in mind both what is actually possible and what would be best for the bay as a whole. As I see it, there are only three basic alternatives. The first is to continue taking tankers to the refineries in Philadelphia. The second is some type of facility in the bay. The last is an offshore facility. Recent accidents, as well as data from ACOE, suggests that the upriver tanker traffic is presently undesirable, and not maintainable for more than another 10-15 years (due to dredge spoil problems). The offshore option would require either an island, which would probably be economically unfeasible, or a single point mooring system and onshore tank farm, which is unacceptable to most Delawareans. An in-bay facility can take many forms. I do not believe that the design we examined is the best option. Further, I do not feel that it is economically feasible to provide for anything except LNG and oil. Once this point is accepted, the need for a trestle is eliminated, which I feel is unacceptable for aesthetic and environmental reasons.

The idea of using Lower Middle Shoal is good. My suggestion is for a small island to contain a low-profile tank farm for LNG and oil. From the island, pipelines would extend ashore and to the Philadelphia refineries. This simplified system, employing advanced pollution abatement controls, would, I feel, be preferable to the present system, and a realistic alternative to the offshore proposals. Thus, by considering my options Delaware would have a tool for once, to help control its future.

WALTER R. JOHNSON

For this case study, there are still several questions and problems which should be reemphasized.

1) Overland vs. big ship freight transportation costs and the trade-offs between them need to be more closely examined. The oil pipeline may be economically feasible, but the other bulk cargo transport may not be.

2) The environmental analysis conducted here constitutes a collection and distillation of several previous studies, and can only be considered the first step of an environmental impact assessment. Environmental damage would result from the construction and operation of this proposal, and the cost of this damage compared to the benefits gained must be more fully quantified.

3) As mentioned in the preface, this study did not consider alternatives of the basic concept (alternatives for detail of the trestle and right-of-way had to be discussed). Other types of deepwater facilities obviously do need to be considered.

BERNARD R. PETROSKY

I am not in favor of the concept presented in the preceding report. I feel that such a development would have an adverse effect on the quality of life in lower Delaware and that insufficient demand would exist for the services to be provided. Limiting the project to oil/gas and only a pipeline right-of-way onshore would mitigate these objections to some extent. From an environmental point of view I feel an open-ocean site offshore would be much more desirable and could provide greater draft for the largest projected ships. In any event, I would be adamantly opposed to refineries or other heavy industry in lower Delaware.

If any changes are to be made in Delaware's Coastal Zone Act, they should be made cautiously and with great deliberation, since development of the type proposed is essentially irreversible and can tend to be self-propagating. Justification on the basis of potential offshore petroleum production is premature at this point. Delaware's coastline and rural character are resources both unique and in great demand in this region. They will become more so in the future.

BOB PREZANT

As a course project, this has indeed been a valuable learning experience. However, as a working and viable system the actual construction of such a proposed marine transport system is, at this time, far from feasible. The project, as it stands, would have severe detrimental impacts, both environmental and social, upon the lower Delaware Bay and Bay region.

I cannot endorse such a large scale system in Delaware Bay as it would be ecologically unsound.

MICHELE REDMOND

The hazardous conditions resulting from the present lightering operation indicate a need for some sort of deep water anchorage in Delaware Bay. In my opinion, however, present and projected future commodity demands do not justify a project on the scale of the transportation system suggested. In addition, I believe that environmental, social, and financial problems preclude the construction of such an involved system. A better alternative would be a simple mooring system with an inland tank farm, or at most a simple port island minus trestle (particularly if LNG facilities become necessary).

H. ROWLAND

"There may be more beautiful times, but this one is ours" (Sentra).

EDWARD A. TUPIN

I feel that the State of Delaware or some agency of the state should build a deepwater port such as has been proposed in this report as soon as possible. Oil will continue to be imported to feed the existing refineries, so the two ecologically most attractive alternatives (for Delaware) non-importation and importation through other ports are not practical. Continuation of the existing lightering operation is probably inviting a major spill at some time. The lightering operation is occurring in Delaware waters currently, so Delaware ought to take steps to make the importation of oil as safe as it can be made. Additionally a deepwater port would tend to generate secondary employment to enhance the state's economy. For these reasons I feel that the port should be constructed as soon as possible.