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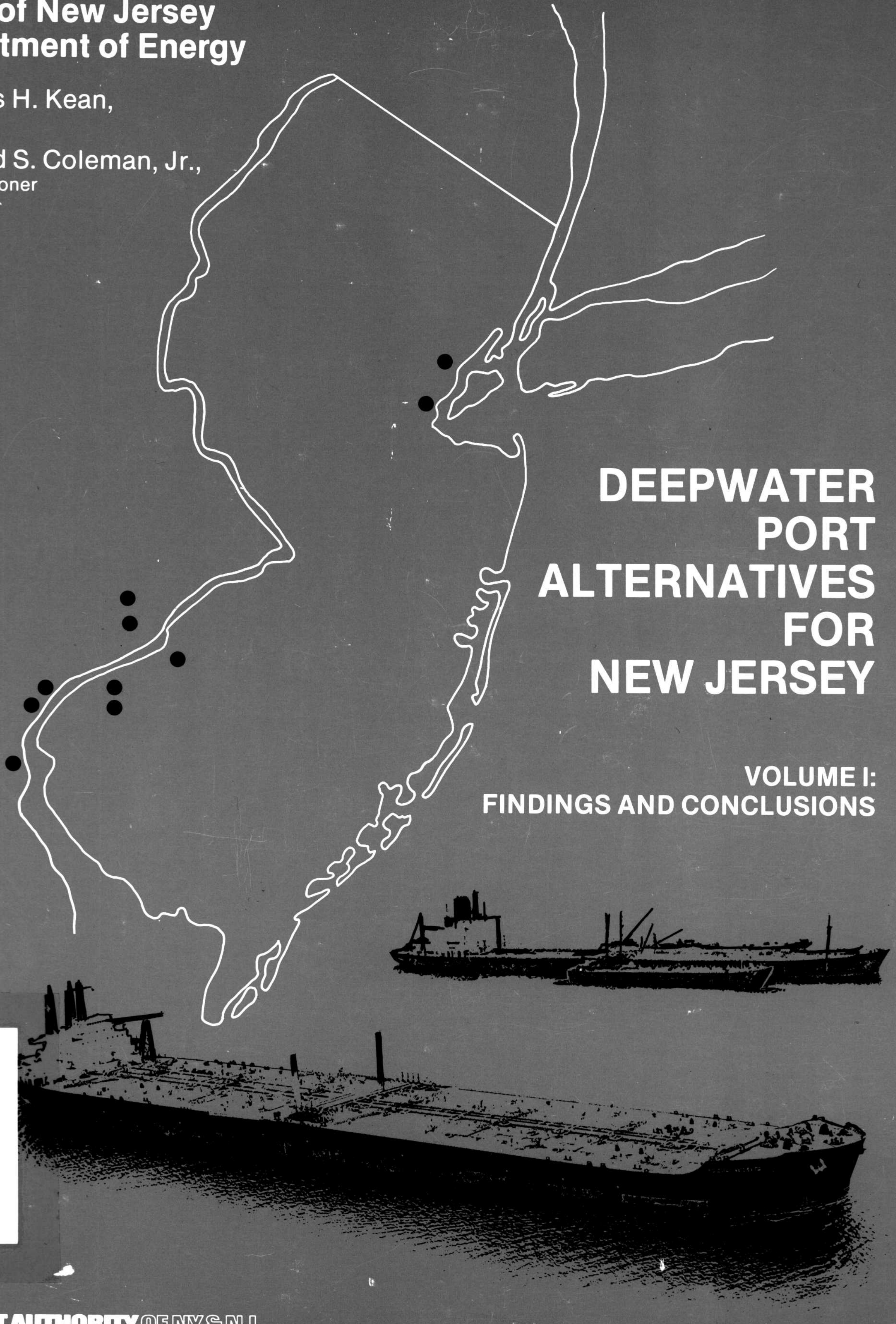

DEEPWATER PORT ALTERNATIVES FOR NEW JERSEY

VOLUME I:
FINDINGS AND CONCLUSIONS

THE PORT AUTHORITY OF NY & NJ

DEEPWATER PORT ALTERNATIVES FOR NEW JERSEY

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Deepwater Port Alternatives for New Jersey

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State of New Jersey
Department of Energy

Leonard S. Coleman, Jr.
Commissioner

Dear Reader:

This study stems from the legislative goals of the New Jersey Department of Energy and the New Jersey Energy Master Plan, which provide that the Department will assume the initiative in energy facility siting when such facilities promote the policy goals of the Master Plan. These goals are:

1. To assure uninterrupted energy supplies to all residential, commercial, utility, and industrial users in New Jersey;

2. To promote economic growth while safeguarding environmental quality;

3. To encourage the lowest possible energy cost consistent with conservation and the efficient use of energy.

The two volume analysis which follows has the specific goal of finding an alternative marine crude oil transportation system which will operate in an environmentally acceptable manner and help maintain the efficiency of operations at the region's refineries.

The economic component of the study was formulated with the goal of finding which type of alternative transportation system could service all or at least some of the region's refineries on a cost effective basis. In August, 1982 Exxon Corporation and Chevron Oil Company announced that the operating capacity of their refineries in the New York area was being evaluated in light of current market conditions.

It is vital that the reader view these announcements within an expansive context. Both companies have stated that the refinery cut backs are not irreversible. Moreover, many energy forecasters predict that oil consumption will rise slowly but predictably through the remainder of the decade even with diligent conservation programs.

The petroleum industry is still undergoing a dramatic transformation caused by a world wide recession and the loosening of the world crude market by the Organization of Petroleum Exporting Countries. Before long term investment decisions can be made by the oil companies a sense of normalcy must return to the market place.

Finally, modern competing refinery systems to service northeastern markets are available to the industry on the Gulf of Mexico. New Jersey and the region have a vital economic interest in maintaining the maximum level of operation at the region's existing refineries.

The Port Authority of New York and New Jersey was the principal consultant in the study. Together our agencies are committed to long term solutions which enhance the economy, protect the environment and contain or lower energy costs for the region.

Sincerely,

Leonard S. Coleman, Jr.

EXECUTIVE SUMMARY

Purpose

The purpose of the Deepwater Port Alternatives for New Jersey study was to evaluate the economic and environmental feasibility of a deepdraft marine crude oil unloading terminal to serve the ten refineries in New Jersey and adjacent states - the two on the Arthur Kill in New York Harbor and the eight located on the Delaware River. The investigation into the feasibility of a deepwater marine terminal was not limited to the concept of a major offshore port. In general terms, a conventional deepwater oil port consists of an offshore mooring facility connected to an onshore storage terminal via pipeline, enabling deepdraft oil tankers to receive or discharge cargo in waters of sufficient depth. This study included the evaluation of any modification to or scaling down from that concept which would allow deepdraft tankers to be accommodated at in-harbor facilities. Offshore and inshore alternatives were subjected to the same economic and environmental feasibility tests.

The present study differs somewhat from several earlier Atlantic Coast deepwater port (DWP) studies. The earlier studies were concerned primarily with demonstrating the technical feasibility of offshore DWPs to handle rapidly increasing volumes of imported crude oil in response to steadily rising demand. This study was adapted to more modest oil import levels and to reductions in demand experienced since 1979. The continued interest in the DWP concept derives from the desirability of reducing the cost of delivering crude oil to the region and mitigating the environmental impacts of present delivery practices in New York Harbor and in the Delaware Bay and River.

Additionally, the impacts of the opening of the Louisiana Offshore Oil Port, the only operational deepwater oil port in the United States, and the deepening of the Suez Canal were considered. Selected environmental issues associated with deepwater ports were identified and analyzed.

Table A
REFINERIES IN THE AREA OF INTEREST
(units in barrels per day)
As of January 1, 1981

Company	Location	Capacity	Estimated Crude Throughput
Chevron	Perth Amboy	168,000	142,800
Exxon	Linden	290,000	246,500
SUBTOTAL FOR NORTHERN NEW JERSEY		458,000	389,300
ARCO	Philadelphia, PA	185,000	157,300
BP	Marcus Hook, PA	164,000	139,400
Getty	Delaware City, DL	140,000	119,000
Gulf	Philadelphia, PA	206,300	175,400
Mobil	Paulsboro, NJ	98,000	83,300
Seaview	Paulsboro, NJ	44,400	37,700
Sun	Marcus Hook, PA	165,000	140,300
Texaco	Westville, NJ	90,000	76,500
SUBTOTAL FOR SOUTHERN NEW JERSEY, EASTERN PENNSYLVANIA, AND DELAWARE		1,092,700	928,900
TOTAL		1,550,700	1,318,200

Market for a New Jersey deepwater port

In order to assess the potential for a regional offshore deepwater port for the Mid-Atlantic Coast it was necessary to evaluate its probable market. Table A identifies the ten refineries in the region of interest, their locations, rated capacities and estimated crude oil throughputs. The estimated total throughput of 1.32 million barrels per day (b/d) represents 85% of the total rated capacity of 1.55 million b/d. The 85% refinery utilization rate is lower than that achieved in the period 1976 through 1979 but higher than the present rate.

It was assumed that a regional deepwater oil port would not capture all the crude oil throughput requirements for each of the ten refineries. Crude oil deliveries that would be likely to bypass any offshore facility include domestic crude oil shipped in small American flag tankers, imported crude oil which requires special handling due to high pour point or other physical characteristics, and small batches of special crudes needed for blending. Based upon these variables as well as an analysis of refinery receipts by major geographic source area, it was estimated that the expected throughput for an offshore DWP would be 800,00 b/d.

Location and feasibility of a deepwater port

In order to serve the two geographically separated groups of refineries, an offshore oil port would have to be located between the entrances to New York Harbor and Delaware Bay. Major considerations for siting are water depths of 90 feet or more and safe maneuvering room for VLCCs. Attention also must be given to, among other things, the appropriateness of the landfall for the submarine pipeline, onshore pipeline rights-of-way, storage tank farm space requirements and the environmental impacts of the project during both the construction and operation phases.

Two sites were selected for evaluation. The northern site is located about 15 miles due east of Asbury Park, New Jersey. At this site the facility would consist of two single point mooring buoys and a pumping/control/quarters platform in about 100 feet of water. Submarine pipelines of 48 inches in diameter would connect each buoy with the platform and then a single 48-inch line would extend 14 miles to shore. Landfall would be in the vicinity of Asbury Park, with the pipeline corridor following highway rights-of-way. A storage tank farm with a capacity of approximately 8 million barrels would be located southwest of the Earle Naval Weapons Station. The northern group of refineries and the southern group would be supplied from this farm via pipeline.

The southern site is located about 20 miles east-southeast of Atlantic City, New Jersey in about 100 feet of water. It has essentially the same offshore and onland components as the northern version. The onland pipeline would cross the state to a tank farm site in the vicinity of the New Jersey Turnpike, southwest of Exit 3. Pipelines to supply the northern group of refineries and the southern group would emanate from there. Pipeline distances are somewhat longer for the southern site.

An offshore DWP would reduce by about two-thirds the number of tankers delivering crude oil to the in-harbor areas. The lightering of crude oil would be reduced even more, thereby greatly reducing the risk of oil spills in inland waterways of New Jersey, New York, Pennsylvania, and Delaware. However, a DWP would introduce the risk of oil spills in new areas of the open ocean with the concurrent though highly improbable risk of a single large catastrophic spill. From the standpoint of environmental protection, the benefits of eliminating a majority of crude oil spills from the inland waterways appear to outweigh the new oil spill risks associated with a DWP.

Rough project costs for the northern and southern facilities were prepared, as were estimated annual operating and maintenance costs. The cost in 1986 dollars of the southern facility was estimated at $1.8 billion and the northern facility at $1.5 billion. Assuming a throughput estimate of about 800,000 b/d, total annualized costs came to about $1.50 and $1.20 per barrel, respectively.

Estimates of marine transportation cost savings were made for the three principal geographic source areas for crude oil for these refineries; the Arabian Gulf, North Africa and West Africa. A comparison between estimated costs for present deliveries of crude and estimates of future delivery costs to a deepwater port using a 260,000 dwt tanker, yielded a 'savings' attributable to the new port facility of about $1.00 per barrel in 1986 dollars for both locations. (These 'savings' are computed based upon break even economics for the facility and do not take into account any profit to the developer.)

Throughout the study, a simple test for economic feasibility of alternative marine crude oil delivery proposals was applied. A direct comparison between the transportation savings realized by use of a given alternative and the cost of implementing that alternative is made. If the cost of implementation equals or exceeds the associated transportation savings, the alternative is judged to be economically infeasible. However, if the estimated implementation cost is less than the projected transportation savings, the alternative is judged to have survived the initial level of evaluation.

The above project cost estimates of $1.50 and $1.20 per barrel for the southern and northern offshore DWP sites respectively exceed the projected savings of roughly $1.00 per barrel from these facilities. Given these estimates, neither offshore location for a DWP appears feasible.

In-harbor alternatives to a deepwater port

The negative findings for an offshore DWP led to investigations of scaled-down alternatives located closer to shore. An in-harbor bulk crude oil handling facility was evaluated for each water body; one to serve the group of refineries along the Delaware River and the other for the New York Harbor refineries.

A facility in the Lower Delaware Bay would reduce by more than half the number of incidents of oil spills at the refinery piers and in the present anchorage area but it would increase the risk of spills in the lower bay area. The lower bay is more environmentally sensitive than further upriver and any benefits to the environment from a new terminal would depend upon a well-developed pollution prevention program.

The site chosen for a terminal to serve the refineries along the Delaware River is at the northern edge of Big Stone Anchorage on the west side of the lower bay. This site would require relatively little dredging, although it would involve long pipeline distances to reach the refineries. At present, it does not appear that the construction costs of such a facility could be justified given the expected throughput.

The total cost of the Delaware Bay facility is estimated to be $700 million or an annualized cost of about $1.00/barrel based on a facility throughput of 560,000 b/d. The transportation savings were estimated at $.70/barrel in 1986 dollars based on per delivery crude oil amounts equivalent to the cargo carried by a 185,000 dwt tanker. As with the offshore port, the costs of the Delaware Bay facility appear to be substantially higher than the 'savings' as defined here. The costs of pipeline construction at the site in lower Delaware Bay could be reduced only by moving the terminal closer to the refineries, that is, up the river, thereby vastly increasing dredging requirements and associated environmental problems.

The geography of New York Harbor differs radically from that of the Delaware Bay. If Ambrose Channel, the 45-foot deep gateway to the Harbor, were dredged to 60 feet, then deeper draft tankers could be accommodated at an in-harbor terminal. Once the tanker is inside the Harbor, the pipeline distances for such a facility are short, thereby reducing its construction, operating and maintenance costs. Preliminary comparative estimates for the New York Harbor facility showed a capital investment of roughly $190 million which came to about $.40/barrel in the opening year (1986) including operating and maintenance charges, based upon the assumption that throughput proportions capturable by the facility return to levels similar to those of the 1976-1979 period or about 240,000 b/d. The transportation savings were estimated to be in the neighborhood of $.80/barrel in 1986 dollars. These estimates indicated that an in-harbor terminal for New York might have economic feasibility.

Table B
ECONOMIC COMPARISON OF DEEPWATER PORT ALTERNATIVES
(1986 dollars)

	project cost (millions of $)	cost/barrel throughput	transportation saving
Offshore-Southern site	$1,800	$1.50	$1.00
Offshore-Northern site	$1,500	1.20	1.00
In-harbor-Delaware Bay	$ 700	1.00	.70
In-harbor-New York	$ 190	.40	.80

A summary comparison of the economics of these DWP alternatives is shown in Table B. All figures in the table are in 1986 dollars. Project costs do not include federal channel dredging and, in the case of both in-harbor sites, they assume the existence of 60-foot depths to the terminal.

Crude oil terminal for New York Harbor

One of the conclusions of this study is that an in-harbor deepwater oil terminal for New York Harbor appears feasible. The naturally deep water of The Narrows favors locating a supertanker terminal inside the Upper Bay. Site selection was limited to the western side of the Upper Bay since both operating refineries are located on the New Jersey bank of the Arthur Kill.

The two sites chosen for further evaluation were the eastern tip of the Port Jersey pier on the Bayonne/ Jersey City border and piers 13 to 15 at Stapleton, Staten Island. Both sites have the advantage of short pipeline runs of eight to ten miles each to a tank farm located either on the western shore of Staten Island, south of the Goethals Bridge or on the New Jersey side of the Arthur Kill just south of Exxon's refinery.

The study recommends that a detailed, site-specific analysis of the Staten Island site be conducted since this provides a more economical location for an in-harbor terminal compared with Port Jersey. Among other reasons for this recommendation, the Staten Island site would require considerably less access dredging connecting the terminal to the federal channel and fewer waterway crossings for the pipeline.

More detailed examinations of the economics of an in-harbor alternative at the Stapleton site provided these results. The estimated transportation cost savings associated with a New York Harbor terminal were calculated to be in the range of $.56 to $1.06 per barrel throughput in 1986 dollars. This compares with a capital amortization, operating and maintenance cost per barrel throughput in the opening year (1986) of $.47. Thus, the minimum difference is approximately $.10 per barrel in favor of the facility, a sufficiently significant amount to warrant serious consideration.

When the scope of the Deepwater Port Alternatives for New Jersey Study was determined in 1979, construction and maintenance costs required for federal channel improvements had no direct bearing on a project's economic viability. By the time the last of the study's analyses were being completed in late 1981, it had become clear that some form of user fee - coupled with fast-tracking - was likely for any federal waterway improvement project. However, as the study goes to press, there is no consensus on two major questions concerning a user fee:

(1) Having defined the extent of a dredging project, what portion of the total construction and maintenance costs will have to be covered by a user fee?

(2) What existing and potential new traffic - other than that destined for the single facility being studied - would pay the user fee designed to cover the local share of these construction and maintenance costs?

Legislation is before both Houses of Congress which might have far-reaching effects on the time frame for authorization of and the funding mechanism for federal channel improvement. More information on this legislation is provided in Chapter Nine and Appendix G of the report.

In summary, a final economic analysis must await the enactment of federal legislation to resolve the financing of future major port improvements. At that time, more precise estimates of user fees may be determined.

Environmental Perspective

The basic environmental test for the alternative deepwater port configurations in this study is that no further degradation of air or water quality should result and if possible the facility should produce some discernible improvement to the environment. The basic environmental evaluations indicate that either an offshore or an in-harbor terminal may improve inshore water quality by:

(1) reducing the number of harbor visits for tank vessels;

(2) reducing the number of tanker to barge lightering connections;

(3) reducing the risk of crude oil spills in the affected water body due to fewer tank vessel and barge transits to refineries' piers.

Similarly, air quality in the designated Harbor and Bay areas may be improved by:

(1) less venting of crude oil vapors due to reduced lightering;

(2) less stack and vapor emissions due to fewer tanker visits to the port;

(3) less stack emissions due to faster vessel turnaround.

As is the case in determining ultimate economic viability, channel deepening issues will have an impact on the environmental viability of any proposed in-harbor facility. Until the location and nature of other potential users of the deepened channel system are identified, their requirements, and thus, the overall extent of the improvements cannot be defined. An assessment of the environmental impacts of the channel deepening program must await such definition. Work done by the Port Authority and others, outside the framework of this study, suggests that dredged materials to be removed to facilitate any of the projects under consideration are more likely to be in demand for beach nourishment than to be a problem in dredge spoil disposal.

A comparison between the environmental advantages of an offshore system and an in-harbor system is overshadowed by the economic differential between the two systems. At current levels of refinery throughput and regional petroleum consumption, an offshore system is not cost effective. The in-harbor alternative is at least marginally cost effective and environmentally acceptable, given present circumstances in the petroleum industry.

In evaluating the Delaware Bay and New York Harbor terminal proposals the study team found that Delaware Bay is a more sensitive water body with better water quality than New York Harbor. The economics of building a crude oil pipeline to the Pennsylvania and New Jersey refineries on the Delaware River, coupled with the sensitivity to oil spills of water fowl and oyster populations, make the Bay an undesirable location for an in-harbor facility. The existing tanker to barge lightering operations at Big Stone Anchorage, Delaware present an identifiable, but manageable, risk of pollution in the Bay.

New York Harbor, by contrast, represents a water body with existent pollution levels. The operation of an in-harbor facility will not present additional stresses on water quality and may result in some improvement. A New York Harbor receiving terminal would help reduce the incidence of oil spills compared to current practices. Although chronic small crude oil spills presently do not create a large-scale problem in the Harbor due to tidal flushings, the new facility would engender at least marginal improvements over current practices. With respect to the catastrophic or worst case spill projection, the spill size would have to be raised from the current planning level of 1.7 million gallons to 2.8 million gallons with the new facility and the introduction of larger tankers. Due to reduced traffic, the probability of this catastrophic event would be much lower were a new facility in place. The facility operator would be reponsible for planning for and providing a rapid and adequate response in the unlikely event of such a catastrophic spill, which would result in a better cleanup capability for any major spill.

INTRODUCTION

Since the advent of deepdraft tankers in the 1960s, the need for deepwater oil ports in the U.S. has been recognized but remains largely unmet. There are no harbors serving oil refinery centers on the East and Gulf Coasts which can accommodate tankers with drafts over 45 feet. This problem of shallow harbors has produced transshipment terminals in the Caribbean at which deepdraft tankers offload crude oil into relatively shallow draft tankers for delivery to refineries. It has also prompted numerous proposals for offshore deepwater oil ports, using the new technology of single point mooring systems.

The single point mooring system for loading or unloading oil tankers was developed in the early 1960s. This concept permits large tankers to stand offshore in sufficiently deep water and take on or discharge crude oil through a pipeline connection to shore. The new offshore mooring system has made it possible to accommodate deepdraft tankers near shallow ports.

The first applications of single point mooring sytems were undertaken by the military and by major oil companies in both oil importing and exporting countries. In 1968, the first single point mooring buoy for deepdraft tankers (up to 264,000 dwt) was installed in Japan, and during the 1970s offshore moorings for deepdraft tankers using the new devices were built in countries throughout the world at a rate of over ten per year.

The Deepwater Port Act of 1974 was passed by Congress to authorize and regulate deepwater ports beyond the territorial limits of the United States as well as to protect federal and state interests in the location, construction and operation of these ports. It was written to regulate two specfic deepwater port development projects on the U.S. Gulf Coast - the Louisiana Offshore Oil Port (LOOP) and SEADOCK, an oil port project for the Texas coast. In this legislation, Congress provided for the protection of the marine and coastal environment by ordering the prevention or mitigation of any adverse impacts which might occur as the result of the development of deepwater ports.

The subject of deepwater oil ports presents a wide range of public policy issues including impact on economic development and numerous environmental considerations arising from facility siting and pipeline routing.

Purpose

This study investigates whether it is feasible from an economic and environmental standpoint to locate an offshore deepwater crude oil terminal or alternative crude oil delivery facility along the New Jersey coast. Such a facility would serve the refineries in the New Jersey, eastern Pennsylvania and Delaware region. The objectives of this study are:

(1) to determine the need for a deepwater port (DWP);
(2) to assess the environmental benefits of a DWP;
(3) to examine possible crude oil delivery alternatives to present operations, including a marine terminal, pipelines, pumping stations and storage facilities;
(4) to examine technology relevant to construction and operation of marine terminals;
(5) to review the relevant regulatory framework.

This review is not limited to the concept of a major offshore port. It includes any modification to or scaling down from that concept to accommodate the larger tankers at in-harbor facilities which would in any way fulfill the study's purpose of making more efficient deliveries of crude oil to the region, and mitigating the environmental impacts of the existing system. A deepwater port within the statutory definition of the federal Deepwater Port Act includes any of several engineering configurations which are located beyond the U.S. territorial sea.

The purpose of this study is different from previous studies, summarized below. They were concerned primarily with demonstrating the technological feasibility of DWPs to accommodate rapidly increasing volumes of crude oil deliveries to meet steady increases in demand. This study is adapted to the more modest oil import levels experienced since 1979 and to continued concern for mitigating the environmental impacts of the current systems of crude deliveries to the New York Harbor and the Delaware Bay/River regions.

Review of past studies relevant to this analysis

There has been a considerable amount of research directed toward the concept of deepwater ports and their siting on the U.S. East Coast by federal and state agencies and private consulting firms during the last 10 years. (See note.) The principal studies which preceded this one are summarized in Appendix A. In reviewing these studies, it became obvious that, despite major changes in supply and demand trends for crude oil in the United States over the last several years, much of their data, conclusions and recommendations remain valid and have contributed to the work of this study.

One major study was conducted by the U.S. Army Corps of Engineers and published in 1973. Noting the lack of facilities to accommodate the more efficient supertankers then coming into service, the study identified several sites along the New Jersey coast as feasible for a DWP serving East Coast refineries. The study also described, as a result of public hearings, local and state level opposition to DWPs which was due mainly to fears of increased oil pollution at sea and secondary economic impacts.

In 1976, another federal study by the Office of Technology Assessment included an assessment of DWPs. The conclusions about whether a DWP would actually be built on the East Coast were essentially negative. This was due to the lack of apparent economic benefits to industry despite certain environmental advantages.

Finally, in 1978 there was a report to Congress by the Comptroller General appealing for a 'definitive study' on the prospects for DWPs in the United States. A subsequent report, prepared by the Department of Transportation, reflected uncertainty about the future. The study evaluated sites along the New Jersey and Delaware coasts and determined that a DWP was technically feasible. However, the volume of crude oil required to justify a large scale project raised serious doubts about the economic feasibility of a DWP for the East Coast.

Basic assumptions

The assumptions of refinery capacity and crude oil imports in the mid-Atlantic region are critical to conclusions about the need for a DWP. The earlier studies tended to make generous assumptions concerning economic growth, increasing oil import levels, and the resulting need for facilities to accommodate very large crude carriers (VLCCs) and ultra large crude carriers (ULCCs) on the U.S. East Coast.

For example, the U.S. Army Corps of Engineers assumed in 1973 that imported crude oil for the East Coast refineries would amount to 2 million barrels per day (b/d) in 1980 and 4 million b/d by 2000. This increase included some expansion of refinery capacity. As late as 1978 the Comptroller General assumed that national crude oil imports in 1985 would be **twice** the U.S. Department of Energy projections of 6 to 7 million b/d by then.

Actually, in the late 1970s there were dramatic improvements in the efficient use and conservation of energy and in the diversification of energy sources. The energy efficiency of the national economy as measured by the ratio of energy use per constant gross national product (GNP) dollar has greatly improved since 1973.

There also have been more modest projections of economic growth resulting from the 1974-1975 recession and the milder recessionary trends during 1979 and 1980. These economic setbacks and the sharp increase in prices caused national oil consumption to decrease from a peak of 18,850,000 barrels per day in 1978 to an average of 15,950,000 barrels per day for the first ten months of 1981 - a decrease of 2,900,000 barrels per day or 15.4%. In addition, from 1977 to 1980, there was a concerted federal policy to reduce oil import

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Note: The term 'deepwater port' is used throughout this study to designate an offshore or inshore mooring and cargo handling facility for tankers with a draft in excess of 45 feet. This mooring may use the single point buoy design or any other berthing arrangement. If such a deepwater port were located outside the territorial limits of the U.S., it would be regulated under the Deepwater Port Act of 1974.

levels substantially by the end of the 1980s. Total imports fell from a peak of 8,565,000 barrels per day in 1977 to 5,430,000 barrels per day for the first nine months of 1981 - a decrease of 36.6%.

These developments have prompted revisions in the assumptions of previous deepwater port studies. The specific assumptions concerning projected crude oil requirements for the refineries in New Jersey, eastern Pennsylvania and Delaware and the potential throughput for a deepwater port serving those refineries are treated in detail in Chapter Four. The more general economic and energy-related assumptions, which form the background for projections of crude requirements, are summarized as follows:

1. The economy of the Northeast and of the State of New Jersey will expand very modestly during the 1980s, at a rate somewhat less than that of the U.S. as a whole.
2. This modest expansion of the regional economy will include a corresponding but increasingly smaller growth in total energy consumption. This growth in energy consumption for the region will approach zero by 1990. This assumption is consistent with the recently declining trend in the energy/GNP ratio and the virtually flat projections of oil requirements for the Northeast during the 1980s.
3. Petroleum consumption in the US will not exceed 17 million b/d in 1990 and total imports will not exceed 7 million b/d and could be as low as 3 million b/d.
4. The Northeast will continue to import a larger proportion of its oil requirements than any other region of the U.S.
5. Petroleum shippers will continue to have the option of transshipping crude oil from VLCC/ULCCs to medium and small sized tankers at various locations in the Caribbean for final delivery to the East Coast. Any new port facilities designed to accommodate VLCCs will have to be economically competitive with these transshipping alternatives.
6. Crude oil, if discovered on the U.S. Atlantic outer continental shelf, will displace imported oil to the region's refineries but is not likely to bring major expansion in refinery capacity to the Northeast.

Conceptual Methodology

The study is premised on two basic factors - economics and environmental compatibility. The economic aspect of this study assumes that any offshore or in-harbor deepwater port must support itself unsubsidized in the market and yield a sufficient return on investment to its owners. The economic methodology evolves out of a standard origin and destination study.

Of equal importance is the environmental compatibility of a deepwater port with its site. The facility must not in any way contribute to, or accelerate, continuing environmental stresses, either in its construction or operational phases. Further, the facility should choose a technology and be operated in a manner which, if possible, contributes to a net positive environmental gain. These points are amplified in Chapter Ten.

This study has benefited from several completed deepwater port studies for the Atlantic Coast as well as the licensing reports and Environmental Impact Statements on actual projects for the U.S. Gulf Coast - the Louisiana Offshore Oil Port (LOOP) and the SEADOCK/Texas Deepwater Port Authority projects. This extensive assemblage on DWPs moved the work program for the study beyond basic data collection and determination of technical feasibility. It also helped to expedite an updated assessment of economic feasibility for a DWP.

By examining in greater detail the economics of potential deepwater facility operations, the study has compared the economics of such operations with current practices, including consideration of such developments as the opening of the Louisiana Offshore Oil Port and the possible further deepening of the Suez Canal.

The study's objectives are broad enough to include ways in which the new transport technologies and associated port facilities could be adapted to the geographic circumstances and energy requirements of East Coast refineries. Toward this end, the study focused on the development of proposals for alternative in-harbor facilities, though it concludes with no specific recommendations for building a facility.

Study outline

Chapter One contains general background on changes in transportation technology represented by VLCCs. The chapter explains how the economies of scale offered by VLCCs have prompted major port development projects throughout the world to accommodate the deeper draft and larger volume deliveries of these tankers.

The description of current practices in Chapter Two highlights the lack of port facilities for VLCCs at the major refinery centers on the U.S. East Coast. This chapter discusses the inefficient and time-consuming method of transshipping in the Carribbean from VLCCs to intermediate size vessels and the subsequent in-harbor lightering process.

Since a principal justification for a DWP depends upon the volume of crude oil delivered to the refineries, Chapter Three is devoted to estimating potential throughput. The throughput estimate is critical to economic calculations in subsequent chapters.

Chapter Four gives a description of the major technological components of deepwater marine facilities. These descriptions are offered in order to acquaint the non-technical reader with terms and concepts used in subsequent chapters as well as to provide some background for later conclusions concerning the mitigation of pollution risks.

Chapter Five presents the engineering, environmental and economic criteria used to select the offshore sites for a DWP. Relying heavily on the work of previous studies, and especially on the first-hand experience of LOOP personnel, facility costs and transportation savings are estimated and compared to determine the economic feasibility of the two alternative sites.

The most promising engineering configurations and most feasible sites for in-harbor alternatives are presented in Chapter Six. Pursuant to the conclusion in Chapter Six that a terminal for New York Harbor is economically feasible, Chapters Seven and Eight present a detailed analysis of marine transportation costs and construction and operational costs for such a facility.

Chapter Nine is a detailed analysis of New Jersey-oriented legal and regulatory issues for an in-harbor terminal, while Chapter Ten is a summary of the consultants' reports which primarily address the air and water pollution impacts of the in-harbor projects described in Chapter Six. Chapter Eleven presents the conclusions and recommendations of the study.

Advisory boards and consultants

Four advisory boards were organized to review and critique the study's findings and conclusions. Vigorous rather than pro forma participation by these groups helped to focus the study on relevant issues and to crosscheck various assumptions and data inputs.

Members of the Technical Advisory Board, consisting of representatives from private industry, reviewed various editions of the draft chapters for technical accuracy and analytical soundness. This board was made up of individuals from the relevant industries such as major oil companies, pipeline companies, and engineering consulting and construction firms. Also, the study team was in frequent contact with experts involved in the planning, construction and operation of the Gulf Coast deepwater port projects.

A briefing was held for and responses were solicited from members of the Public Agency Advisory Board. This board consisted of representatives from the following agencies:

U.S. Army Corps of Engineers
U.S. Coast Guard
U.S. Environmental Protection Agency
U.S. Department of Energy
U.S. Department of Interior (Fish and Wildlife Service)
U.S. Department of Transportation (Office of Deepwater Ports)
U.S. Maritime Administration

State Coastal Zone Management Programs (NY, NJ, PA)
State Energy Offices (NY, NJ)
State Environmental Protection Agencies (NY, NJ)
State Departments of Transportation (NY, NJ)
City of New York (Department of Planning and Department of Ports and Terminals)
South Jersey Port Corporation
Regional planning authorities (New York and Philadelphia area)

The Scientific Advisory Board consisted of a diverse group of specialists who acted as paid consultants to the study team and submitted reports on specific environmental aspects of the study. These consultants were:

Dr. Richard Bartha, Rutgers - The State University of New Jersey
Irving D. Cohen, Enviro Sciences, Inc.
Dr. Kenneth N. Derucher, Stevens Institute of Technology
Dr. Allahverdi Farmanfarmaian, Rutgers - The State University of New Jersey
Dr. Harold H. Haskin, Oyster Culture Department of the Agricultural Experiment Station, Rutgers University
Dr. Richard I. Hires, Stevens Institute of Technology
Dr. George L. Mellor, Princeton University
Dr. Lie-Yauw Oey, Princeton University
Dr. Norbert P. Psuty, Center for Coastal and Environmental Studies, Rutgers University

The findings of these consultants are summarized in Chapter Ten and their full reports are included in a separate volume.

Finally, an Environmental Advisory Board which included representatives of the American Littoral Society and the Natural Resources Defense Council reviewed the study and offered comments on appropriate environmental issues.

Data collection

Much of the data in this study were collected from state and federal agencies. Studies related both directly and indirectly to the subject were consulted. Complementing the Port Authority's extensive internal resources, there were meetings and correspondence with private industry, including the oil companies in the region, and informal contacts with private consultants. Since major components of any deepwater oil port would include onshore pipelines and storage, there also have been consultations with pipeline companies and oil terminal operators. Additionally, a computer program was developed to help analyze marine transportation costs under various scenarios.

Although the inputs for the various analyses performed came from numerous reliable and reputable sources, the findings and conclusions of this study are entirely the reponsibility of the Port Authority of New York and New Jersey and the New Jersey Department of Energy.

CHAPTER ONE
GENERAL BACKGROUND

There is a continuing interest in deepwater port facilities for the Atlantic Coast as a way to mitigate the environmental impacts of crude oil deliveries on shallow ports and to make such deliveries more efficient. The need for such facilities, however, must be viewed in the context of the dramatic changes in world crude oil trade. This chapter presents a broad overview of such changes and a brief description of recent port developments in the United States and abroad which resulted from them. It traces the development of transportation practices over the years and points out what economic and environmental benefits could be gained from an alternative crude oil delivery facility. With this information, the reader should be able to put into perspective the description of existing methods of delivering crude oil to the Delaware Bay and New York Harbor regions presented in Chapter Two.

The international crude oil trade and the supertanker

In the mid-1960s a new breed of tank vessel began to alter ocean traffic flows and change the patterns of port activity. This tanker was the very large crude carrier (VLCC) with a displacement of over 175,000 deadweight tons (dwt) and later, the ultra large crude carrier (ULCC) of over 300,000 dwt. These new classes of tankers were born out of the spectacular increase in world oil consumption which followed World War II and the lower transportation costs achieved by shipping in very large quantities over long distances.

Radical changes in the nature of crude oil tanker operations, especially during the 1970s, derived from huge increases in crude oil consumed by the industrialized nations and the almost coincidental increases in distances over which it had to be imported. As can be seen from Table 1, crude oil imports by the developed countries increased from 1.6 million barrels per day (b/d) in 1950 to 5.7 million b/d in 1960 and 18.0 million b/d in 1970. Growth then tapered off, reaching about 22.5 million b/d by 1980. The oil imports of individual countries, except for the United States, have shown this same pattern of growth during the past 30 years. Japan's imports, for instance, increased from less than 0.1 million b/d in 1950 to approximately 5.0 million b/d in 1980.

Table 1
CRUDE OIL IMPORTS FOR THE DEVELOPED COUNTRIES*
(millions of barrels per day)

Year	Developed Countries*	Japan	U.S.
1950	1.6	0	0.5
1960	5.7	0.5	1.0
1970	18.0	3.4	1.3
1980	22.5	5.0	8.0

*Developed countries include Western Europe, U.S., Canada, Japan, Australia, and New Zealand.

Source: *Yearbook of World Energy Statistics, 1980*, United Nations.

The history of U.S. imports diverges somewhat from that of the other Western industrialized nations. From 1950 to 1970, imports increased very slowly from 0.5 million b/d to only 1.3 million b/d. This pattern of imports is the result of the relative self-sufficiency of the U.S. due to its large domestic production of crude oil through the 1960s. Until 1970, increases in U.S. domestic crude oil liftings roughly equalled the increases in domestic petroleum consumption.

During the 1970s, however, U.S. imports increased sixfold to about 8.0 million b/d. Domestic crude oil production, which had roughly equalled the increases in domestic crude oil consumption, decreased 20% between 1970 and 1980. The sharp increase in consumption, together with the steady decline in domestic production since 1970, led to an exponential increase in U.S. crude oil imports through 1980. Thus, the international transportation of oil, as it affects imports, has become a very significant concern to the U.S. in the past ten years.

With such large increases in the quantities of crude oil being traded worldwide, there were also significant changes in the distances over which these increased quantities were being shipped. As shown in Table 2, in 1950 only 2.8 million b/d of 10.5 million b/d produced worldwide were exported, or about 27%. Conversely, 73% of world oil produced in 1950 was consumed in the country of origin. By 1980, more than 32 million b/d or 53% of some 60 million b/d produced was exported; the other 47% was consumed by the country of origin.

It is also important to note that by 1980 the Middle East and Africa were the sources for 79% of all oil for export, whereas in 1950 these areas supplied 39% of total oil exports. The average distance over which a barrel of crude oil was carried in 1950 has been calculated to be about 900 nautical miles. By 1980, as a consequence of changes in consumption and export patterns, the average barrel of crude oil traded on the international market was shipped approximately 2,700 nautical miles.

The industrialized countries, including the U.S., import oil primarily from the fields of the Middle East, West Africa and North Africa. For the U.S. these areas accounted for 33%, 17% and 15%, respectively of imported crude oil in 1979.

The dramatic shift in proportions of domestic and imported oil in the U.S. over the past 30 years is illustrated in Figure 1. For reasons already mentioned, the most significant changes have occurred since 1970. Although not shown in Figure 1, oil imports in 1970 accounted for 23% of total oil supplies and 14% of crude oil supplies. In 1980, imports accounted for 44% of total supplies and 38% of crude supplies. This represents a doubling of the nation's dependence on all types of imported oil in the past 10 years and an almost three-fold increase in the percentage of foreign crude oil imported.

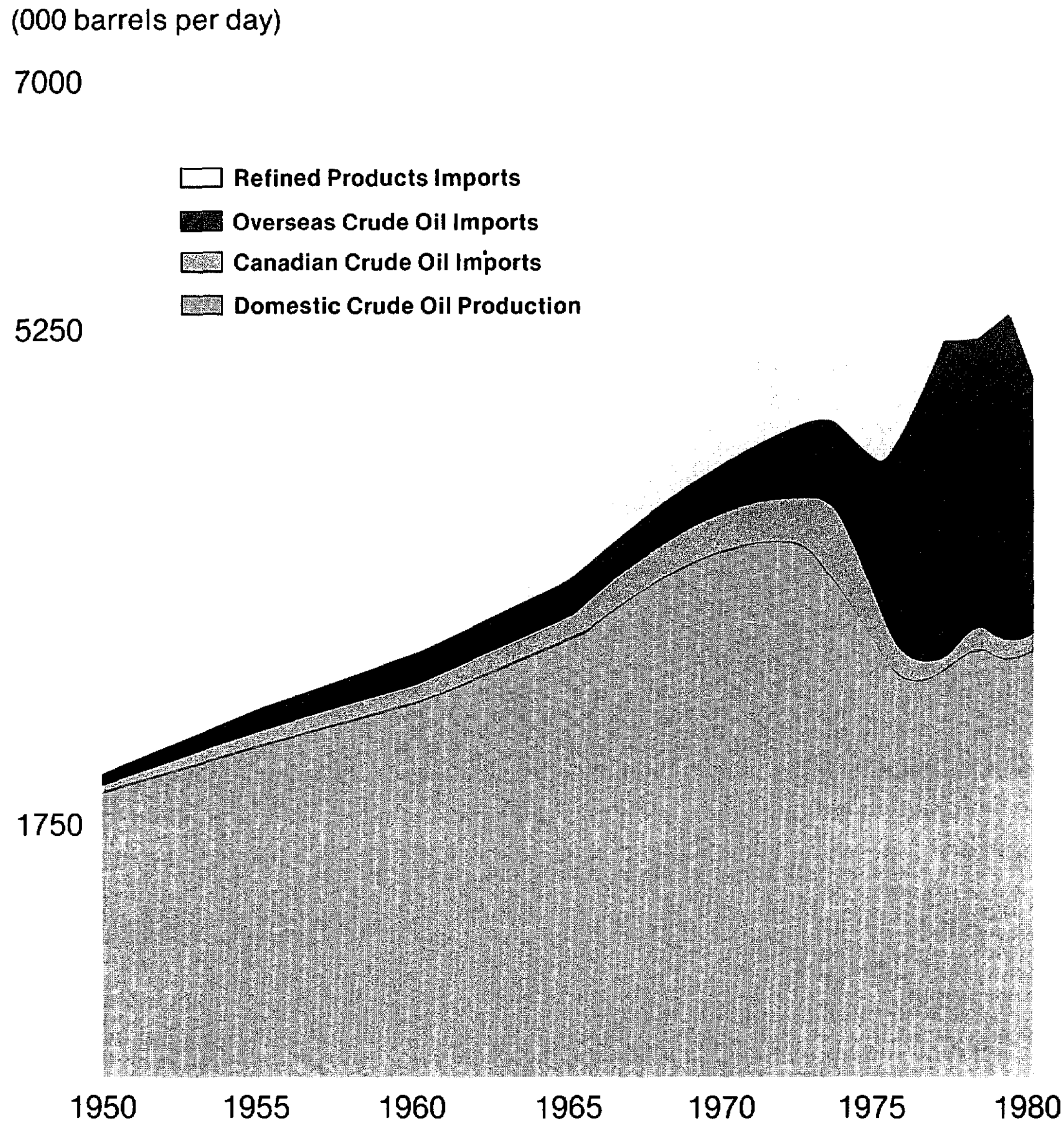
Table 2

WORLD CRUDE OIL MOVEMENTS 1950, 1960, 1970, 1980
(oil production and exports in millions of barrels/day)

Year	Total Production	Total Exports	Exports as % of Total Production	Exports from Mid-East & Africa	Exports from Mid-East & Africa as % Total Exports
1950	10.5	2.8	27%	1.1	39%
1960	21.2	7.7	36%	4.5	58%
1970	45.7	23.4	51%	17.8	76%
1980	60.3	32.2	53%	25.5	79%

Source: Bureau of Mines, U.S. Department of the Interior and Energy Information Administration, U.S. Department of Energy.

Sources of U.S. Oil Supplies, 1950 - 1980



SOURCES: Statistical Review of the World Oil Industry (British Petroleum) and Monthly Energy Review (U.S. Dept. of Energy).

FIGURE 1

Economies of scale for VLCC/ULCC

The burgeoning volumes and increased distances involved in the world crude oil trade brought an equally dramatic response in shipbuilding and shipping technology. Comparative cost analysis demonstrates that large carriers are very economical on long distance routes. In Figure 2 it can be seen that transportion costs for an 11,000-mile voyage decrease sharply with progressively larger tankers up to about 200,000 dwt, after which, costs decline only slightly in relation to increased tanker size. Figure 3 illustrates how tanker costs vary based on voyage distance and size of vessel.

The price of bunker fuel has risen sharply since these cost curves were published in l979. Table 3 shows increases in bunker fuel prices at six-month intervals beginning in December l978. During the two-year period from December 1978 to December l980, bunker fuel prices increased almost 300%. In l978, bunker fuel accounted for about 30% of operating costs for VLCCs. In mid-1981 bunker fuel accounted for between 50% and 70% of operating costs, depending on ship size. Seasonal depressions in the charter market for VLCCs have resulted in some instances where shipowners were not able to recover fuel costs from voyage charters.

Despite this recent escalation of bunker fuel prices, the general trends illustrated by the cost curves in Figures 2 and 3 remain valid, although the relative proportions of transportation, voyage and operating costs have changed. (See note.) For example, Figure 3 shows that a tanker voyage of 24,000 miles, roughly the round-trip distance from the Middle East to the U.S. East Coast, can be accomplished in a 250,000 dwt vessel for less than half the cost per ton of cargo of a 50,000 dwt carrier. A voyage of 9,000 miles, or roughly the round trip between West Africa and New York, shows similar savings for the larger tanker. In comparison with these economies of scale for the larger tankers, smaller tankers are economical only on short-haul routes with low volume trades.

Table 3
BUNKER FUEL PRICES, 1978-1980
Bunker "C" prices in US dollars per metric ton

Date	Mena Al Ahmadi	Rotterdam
December, 1978	$ 80.26	$ 81.80
June, 1978	$138.44	$148.00
December, 1979	$167.65	$179.84
June, 1980	$173.74	$153.42
December, 1980	$233.69	$222.51

Source: "World Tanker Fleet Review," July-December 1980,
John I. Jacobs & Co., Ltd., London.

Note: Tanker costs can be divided into three major categories, namely, voyage costs, operating costs and capital costs. Voyage costs are the variable costs incurred in trading a vessel, namely:
Fuel costs
Port charges
Canal dues and extra expenses (where applicable)

Operating costs are the generally fixed costs associated with trading a vessel, namely:
Manning
Insurance premiums
Repairs and maintenance
Stores, spare parts and lubricating oil
Other expenses, including administration

Capital costs comprise the following:
Purchase price
Financing terms
Return on capital investment
Residual value

World tanker fleet

The economy and convenience of large tankers have been the main incentives to the stunning growth in their numbers over the last two decades. Table 4 shows the composition of the world tanker fleet by ship size for each year since 1957. The first tanker larger than 40,000 dwt was delivered for service in 1952; the first tanker larger than 100,000 dwt in 1961; the first VLCC in 1967 and the first ULCC in 1968. As of 1979, the latter two categories of 'superships' had grown to comprise more than 60% of the total tonnage of the world tanker fleet and 79% of the tanker tonnage owned by the seven major oil companies.

The rapid change in the size composition of the world tanker fleet is further illustrated in Figure 4. The chart reveals that by l978 there was a preponderance of VLCCs as a proportion of total tanker tonnage. A comparison of the physical dimensions of the various tanker size categories is illustrated in Figure 5.

Table 4

WORLD TANKER FLEET 1957-1980

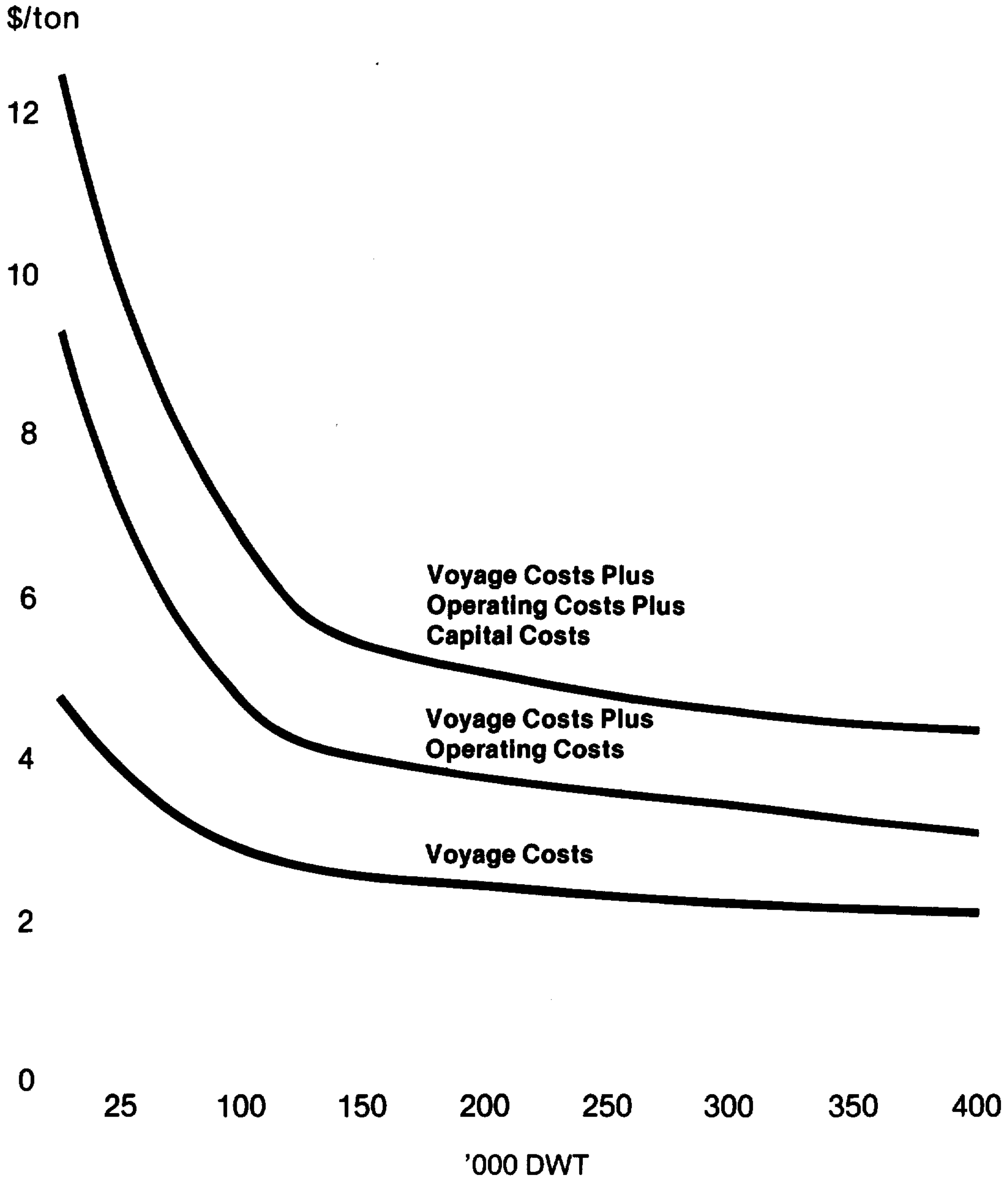
At year end	Number of Vessels in Each Tonnage Class*			
	25-99 dwt	100-149 dwt	150-199 dwt	200 + dwt
1957	427	0	0	0
1958	568	0	0	0
1959	715	0	0	0
1960	826	0	0	0
1961	892	2	0	0
1962	989	4	0	0
1963	1092	4	0	0
1964	1226	6	0	0
1965	1303	15	0	0
1966	1395	34	0	0
1967	1446	59	5	2
1968	1488	82	17	17
1969	1535	96	30	61
1970	1572	110	34	131
1971	1600	125	37	200
1972	1609	136	38	270
1973	1656	152	41	357
1974	1718	193	42	479
1975	1714	241	47	588
1976	1753	265	64	676
1977	1580	279	76	712
1978	1453	269	83	700
1979	1435	304#	45#	699
1980	1482	300	41	658

* Tonnage Classes are in thousands of long tons, dwt.

Size categories for these years are
100,000 to 159,999 dwt and 160,000 to 199,999 dwt

Source: John I. Jacobs & Company Ltd., London.

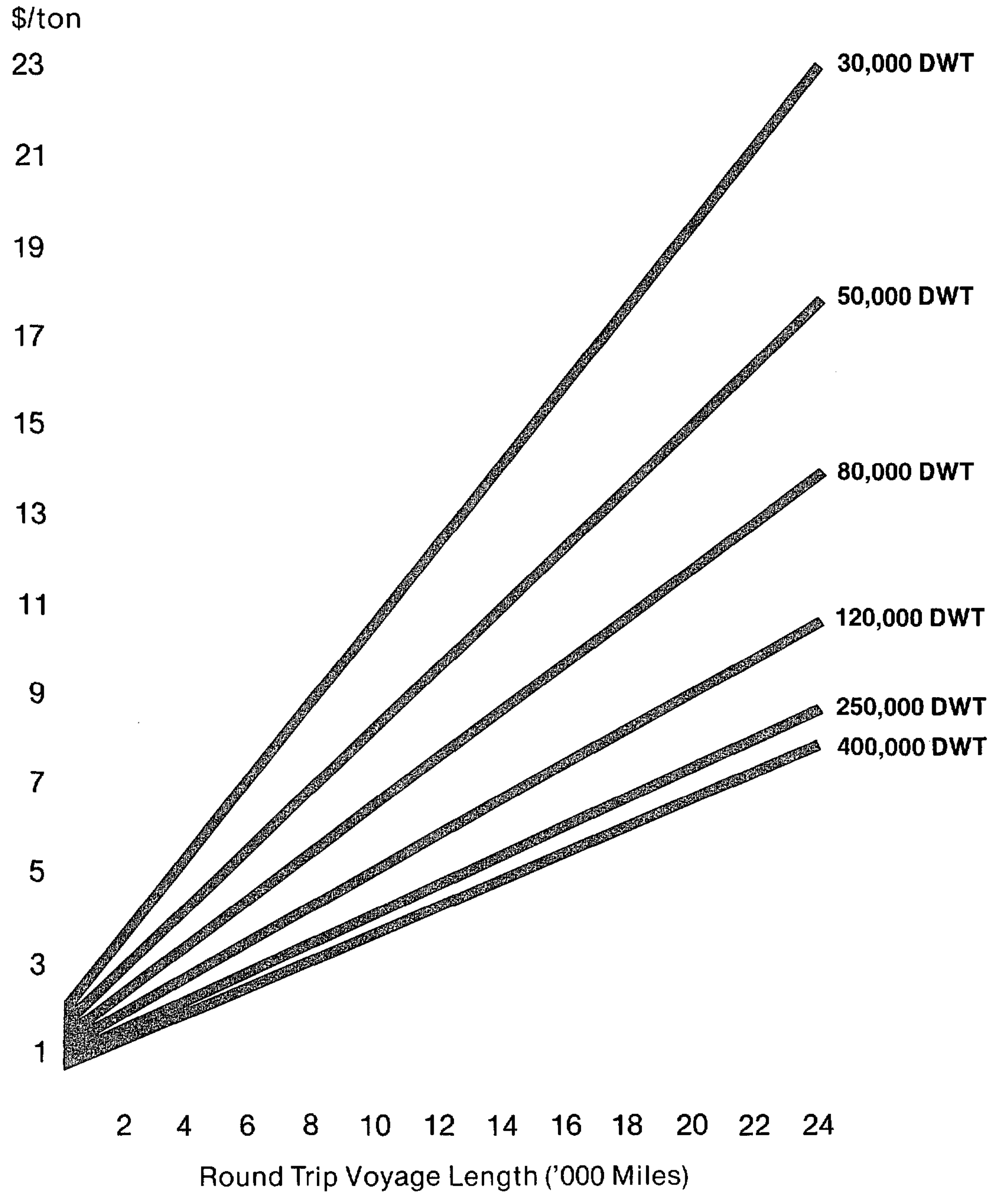
Transportation Costs by DWT on a Round Trip Voyage of 11,000 Miles



SOURCE: H.P. Drewry (Shipping Consultants) Ltd. London

FIGURE 2

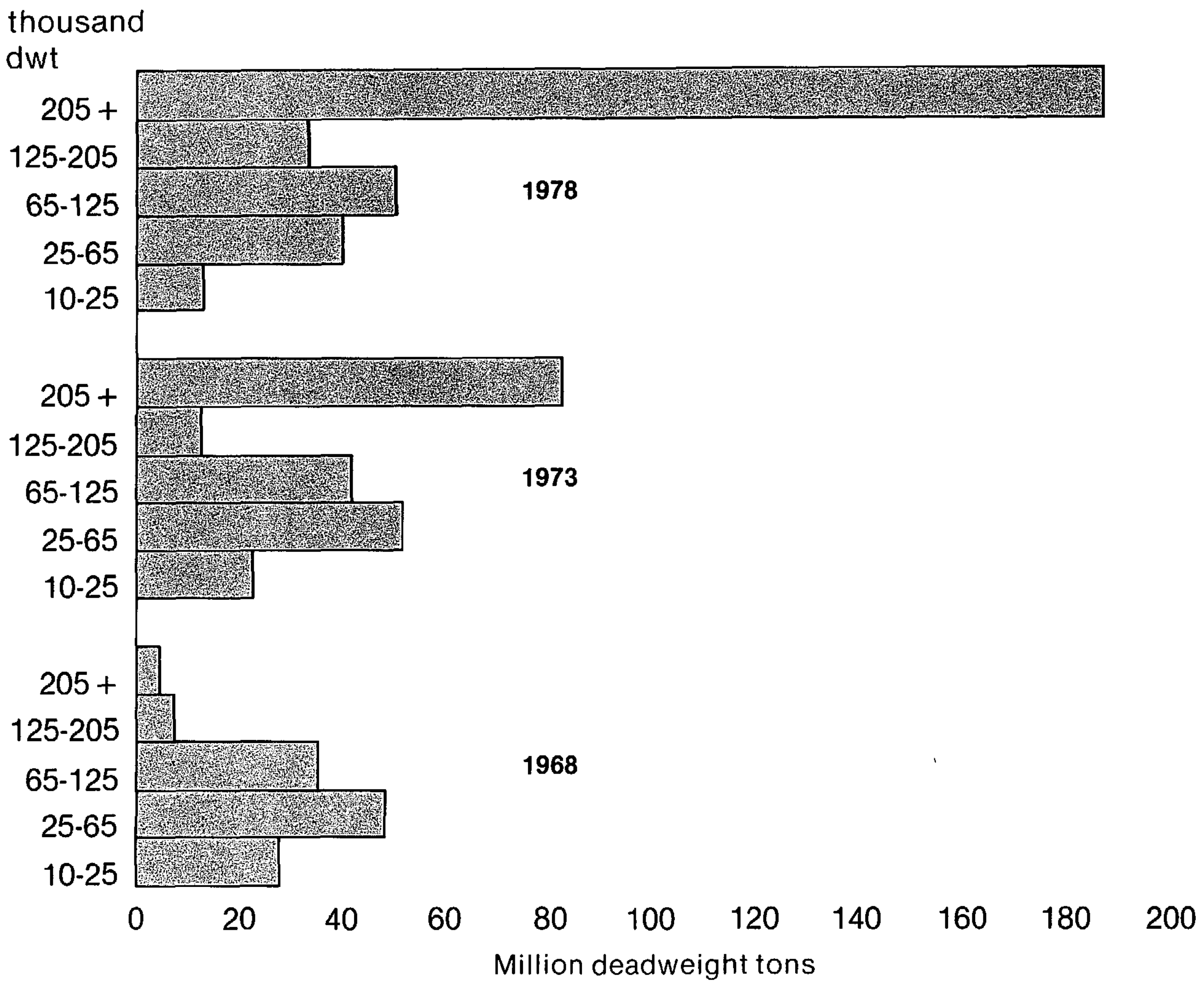
Transportation Costs (Voyage plus Operating plus Capital)



SOURCE: H.P. Drewry (Shipping Consultants) Ltd. London

FIGURE 3

World Tanker Fleet - 1968, 1973, 1978 (by size categories)



SOURCE: John I. Jacobs & Co., Ltd.

FIGURE 4

Comparative Tanker Sizes in Deadweight Tons

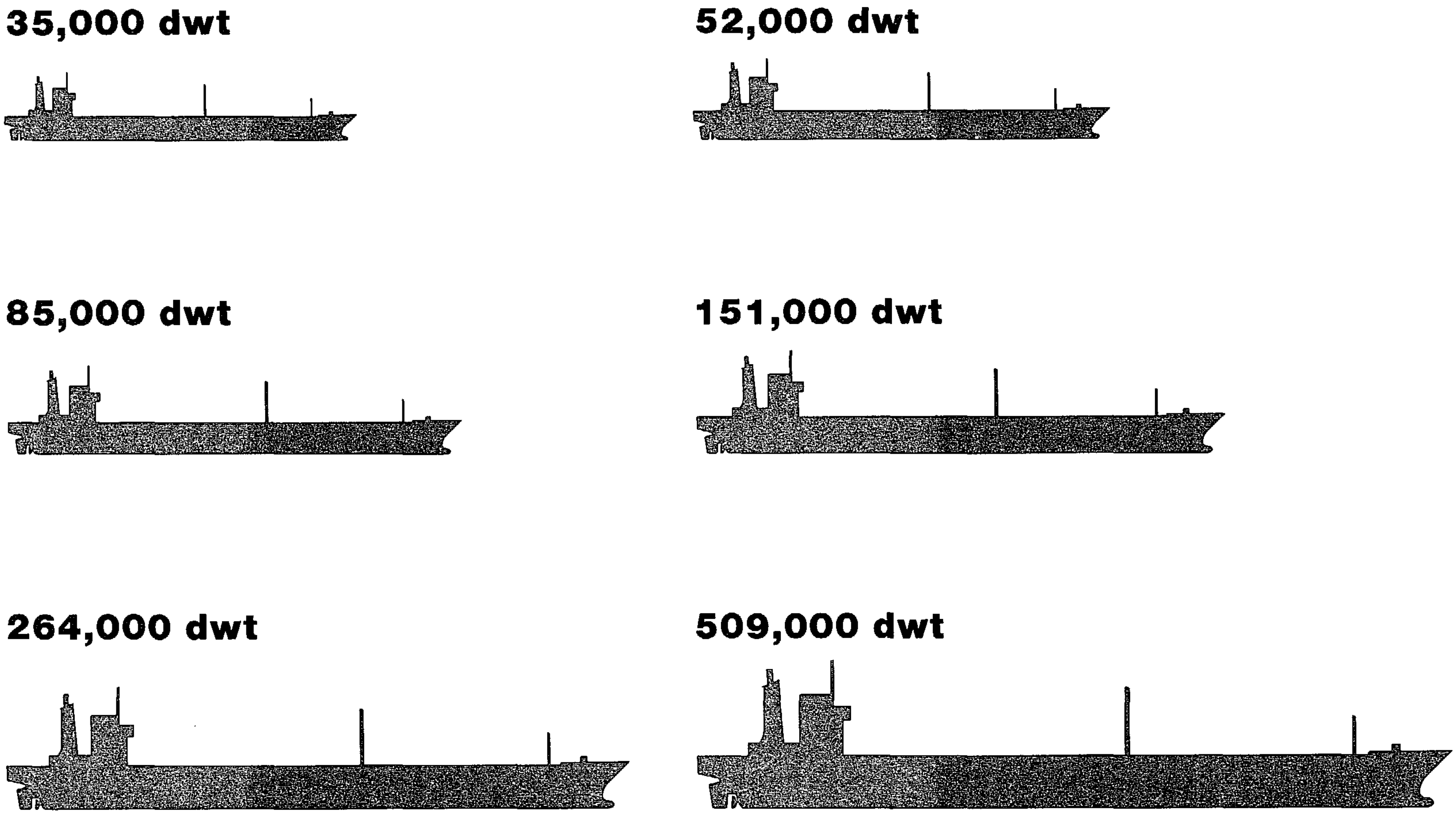


FIGURE 5

With the number of VLCCs in the world tanker fleet, and the continued construction of new tankers in the VLCC category (seven new VLCCs were on order in mid-1981), a sufficient number of large tankers should be available to meet the needs of the bulk oil trade through the end of the century. In fact, according to one estimate, there is currently a 30% surplus of VLCCs in the world tanker fleet. This surplus is the result of overbuilding by shipowners during the mid-1970s.

Because of the heavy spurt of VLCC construction in 1973 and 1974 - and a typical 10-15 year useful life - the present surplus should be retired by the mid-1980s. In the meantime, it is likely that the market for VLCCs will remain somewhat depressed, resulting in transportation cost savings which are higher than normal market conditions traditionally have allowed.

Developments in port facilities

Deepdraft harbors are those able to handle ships which have drafts of more than 50 feet. By the early 1970s it was apparent that the harbor facilities of oil exporting countries would not limit the size of the tankers used. The major crude loading terminals in the Arabian Gulf include artificial sea islands located at Ras Tanura, Saudi Arabia, with a maximum draft of 72 feet, and Kharg Island, Iran, with a maximum draft of 106 feet. Maximum drafts for African ports include 68 feet for Arzew, Algeria; 70 feet on the Mediterranean end of the SUMED pipeline at Sidi Kreir, Egypt; and 131 feet at Cape Lopez, Gabon. Additionally, the East Coast of Mexico has several offshore mooring buoys in water depths of 75 feet or more for loading supertankers.

The harbors of the oil importing countries tend to be shallower than those in the exporting countries. Major investments in port development have been necessary for importing countries to accommodate deepdraft vessels. Shell has installed a single buoy mooring (SBM) terminal off the coast of Anglesey, England, and Elf Aquitaine has a deepwater terminal at Le Havre-Antifer, France. The largest European harbor for receiving crude oil is Europort in Rotterdam which can accommodate tankers with maximum drafts of 68 feet. In the absence of such facilities, oil companies have resorted to offshore lightering, chiefly off the coast of South Devon, England, before delivering crude to refineries in the Netherlands, Belgium, the United Kingdom, France and Germany.

In the United States, points of delivery for crude oil have been focused principally on the refining areas of the Gulf Coast and the Delaware and Hudson Rivers. Most of these centers were established before 1950. At that time the largest tanker needed less than 35 feet of water and the U.S. was a net exporter of crude oil. The natural harbors serving these refinery centers are not able to accommodate deepdraft tankers. There are no established ports on the East or Gulf Coasts able to berth ships with drafts over 45 feet. The only naturally deep harbors serving existing refineries on the East Coast of North America are found in Newfoundland, the deepest being St. John with a maximum draft of 108 feet. Long Island Sound is a minor exception. The Northville Industry facility at Riverhead, N.Y., consists of an offshore berth connected by pipelines to a tank farm ashore and is occasionally used to store crude oil which is sold to East Coast refineries. However, long distances to the nearest refineries and proximity to urban areas preclude economic and environmentally acceptable pipeline delivery systems from Riverhead. Therefore, all oil stored there must be re-shipped over water.

Prior to the spring of 1981, the largest vessels able to berth fully-laden at U.S. refinery piers were about 120,000 dwt on the West Coast and between 60,000 dwt and 70,000 dwt on the Gulf and East Coasts. In most U.S. oil ports, the outer harbors are used for lightering the tankers. Once lightered, tankers can negotiate shallow-draft channels to dock at refinery piers. Even with this costly and time-consuming practice, ship size before lightering is still limited to about 85,000 dwt for most East Coast ports and to about l50,000 dwt for the Delaware Bay area.

Transshipment facilities for U.S. East Coast

The absence of U.S. deepwater harbors, or artificial sea islands with access to major refining centers, has prompted the development of transshipping facilities in the naturally deep harbors of the Caribbean. In these transshipping operations, VLCCs and ULCCs are offloaded either directly into smaller size tankers or into submarine pipelines for temporary storage onshore. These operations permit transportation savings from

VLCCs/ULCCs over most of the distance from the Arabian Gulf and other areas to the U.S. The higher transportation costs of the smaller and medium sized tankers are incurred only on the relatively short distance runs from the Caribbean to the U.S. East and Gulf Coasts.

The locations of the various transshipment ports in the Caribbean are shown in Figure 6. Table 5 gives details on the type of terminal at each site, the maximum tanker size that can be accommodated, depth, and ownership of the terminal. The 'common carrier' terminals are those operated by Burmah Oil at South Riding Point, Bahamas and by Northville Industries at Bonaire, Netherlands Antilles. The transshipment points most commonly used by East Coast importers are those in the Bahamas and the Netherlands Antilles, including the terminals at Aruba and Bonaire.

U.S. deepwater oil ports

The first U.S. deepwater oil port is the Louisiana Offshore Oil Port (LOOP) which received its initial deliveries of crude oil in May, 1981. The LOOP facility was begun in 1972 and now has five oil companies participating in the project, which cost more than $700 million to build. The terminal opened as a common carrier facility in January, 1982 with an initial capacity of 1.4 million barrels of crude oil per day.

Table 5

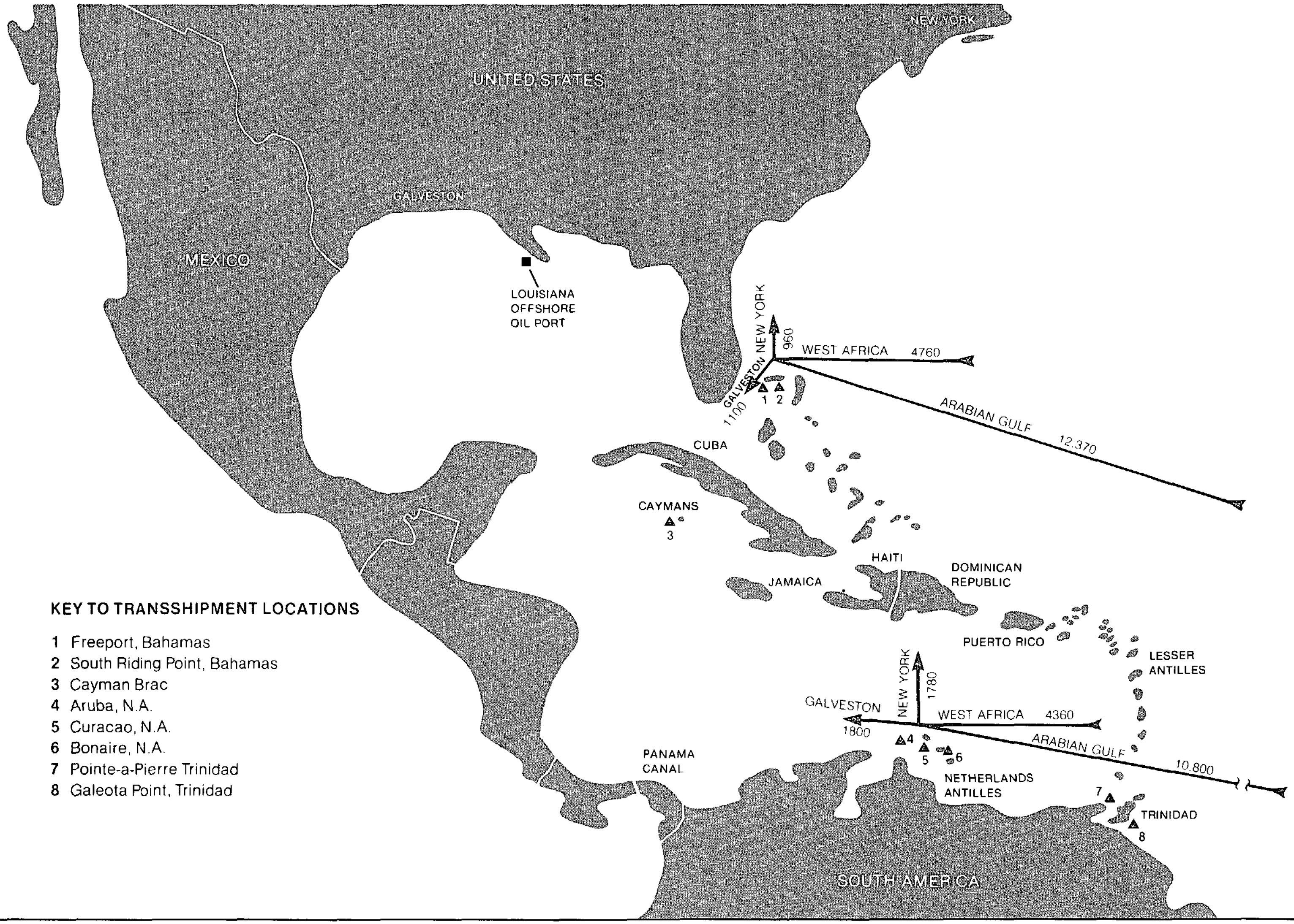
CRUDE OIL TRANSSHIPMENT SITES IN CARIBBEAN AREA

Country	Location*	Max. DWT Full/Partial	Maximum Draft in Feet	Terminal Type	Owner/Operator
Bahamas	1. Freeport	380,000/500,000	85	Port	Chevron
	2. South Riding Pt.	440,000	100	Sea Island	Burmah Oil, Ltd.
Cayman Islands	3. leeward coast of Cayman Brac	none	none	Anchorage Only	Cayman Energy, Ltd.
Netherlands Antilles	4. Aruba	500,000	95	Port	Lago Oil & Transport Co. (Exxon)
	5. Bonaire	500,000	110	Port	Northville Industries
	6. Curacao	530,000	95	Port	Shell
Trinidad	7. Galeota Pt.	250,000	95	Single buoy mooring	NA
	8. Pointe-á-Pierre	260,000	81	Single buoy mooring	Texaco

*See Figure 6 for geographic locations.

Source: Office of Energy, Port Authority of New York and New Jersey

Transshipment Facilities for Crude Oil with Shipping Distances for Principal Transshipment Locations

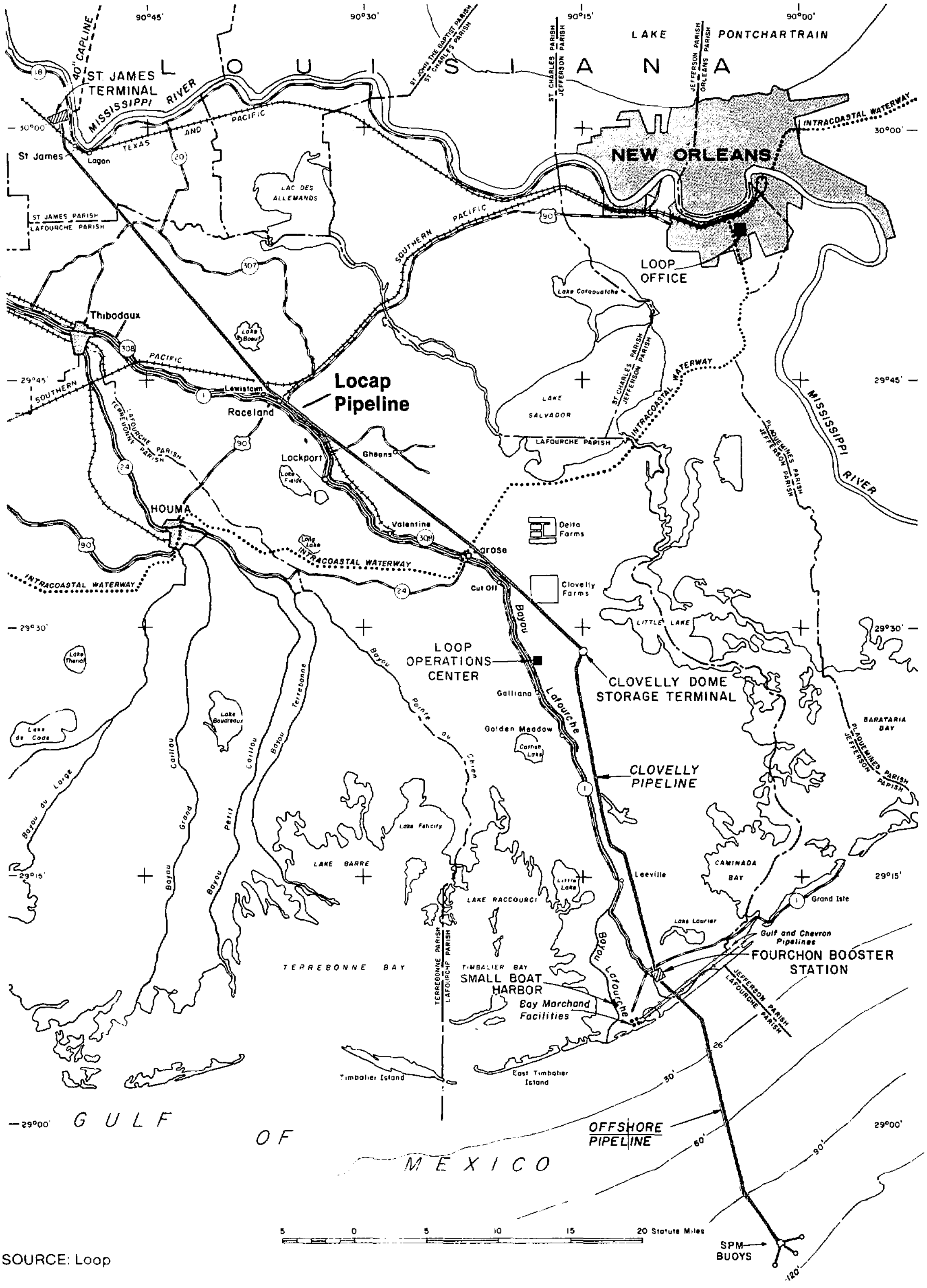


KEY TO TRANSSHIPMENT LOCATIONS

1 Freeport, Bahamas
2 South Riding Point, Bahamas
3 Cayman Brac
4 Aruba, N.A.
5 Curacao, N.A.
6 Bonaire, N.A.
7 Pointe-a-Pierre Trinidad
8 Galeota Point, Trinidad

FIGURE 6

Location of the LOOP Offshore Port Complex



SOURCE: Loop

FIGURE 7

VLCCs arrive and depart LOOP's offshore component via a designated 'fairway.' This offshore component consists of three single-point mooring buoys (SPMs) anchored to the seabed in about 115 feet of water, lying some 19 miles out in the Gulf of Mexico south of New Orleans. The buoys are designed to handle up to 700,000 dwt tankers moored in seas of up to fifteen-foot significant wave height. Each of the buoys is connected to the pumping/control/quarters platform by a 56-inch diameter submarine pipeline about 8,000 feet long. On this structure, where about 35 people work and live, equipment meters, moves and monitors the crude oil on its way to shore via a 48-inch submarine pipeline some 19 miles in length.

The onshore portion of the system includes a booster pumping station located at Fourchon, close to the pipeline's landfall, 28 miles of 48-inch diameter pipeline laid through marshland, and a crude oil storage terminal at the Clovelly Salt Dome. This unique depot eventually will consist of eight cavities leached out of the salt with an overall capacity of 32 million barrels. Figure 7 provides a geographic overview of the system.

The LOOP system is tied into existing and planned pipelines through the LOCAP pipeline which connects the storage terminal with the St. James, Louisiana, terminus of CAPLINE, a crude oil pipeline serving the Midwest. From the St. James location, the oil will be piped either to refineries in Louisiana and Texas or into the CAPLINE system to be transported as far north as Chicago and Buffalo. Because of the availability of these pipeline systems, when fully operational LOOP will be able to provide crude oil to almost 30% of the nation's refinery capacity.

LOOP promises to be efficient and safe. With the completion of oil storage facilities by the end of 1982, it will require only 40 hours to unload a vessel at LOOP compared with up to 12 days under the previous system of lightering. Energy efficient pipelines will replace small tanker and barge operations. Shipping accidents, which have occurred fairly frequently in the lower reaches of the Mississippi, are expected to decrease as the offshore terminal eliminates many small tanker movements in Gulf Coast harbors.

The main opposition to LOOP came from environmentalists who feared that the discharge of brine from pumping out the salt caverns would harm the fish population of the Gulf of Mexico. So far, officials monitoring Gulf Coast waters report that these fears have not been realized.

Meanwhile, construction of a second deepwater port in southern waters is planned for 1982. Four companies — Dow Chemical, Continental Pipeline, Phillips Petroleum, and Seaway Pipeline — have formed the Texas Offshore Port (TOP) Consortium with plans for a monobuoy system 12 miles offshore from Freeport, Texas in about 70 feet of water. The project is expected to be completed in 1983 at an estimated cost of $150 million. It will handle half a million barrels of crude oil daily.

The TOP project has evolved from two earlier deepwater port plans off the coast of Texas. The first was SEADOCK, which was licensed by the Department of Transportation in 1976, but was found to be unsatisfactory to the user companies. The successor to SEADOCK, Texas Deepwater Port Authority, (TDPA) failed to attract sufficient subscribers. These early projects were to be 17 miles further offshore than TOP and would have pumped as much as 2.4 million barrels per day of crude oil. Both the SEADOCK and TDPA proposals would have cost in excess of $1 billion.

Another deepwater port project is the proposed Pelican Island Terminal and channel deepening plan for Galveston, Texas. The project, estimated to cost $400 million, would be the first onshore superport in the U.S. Permits have been granted for widening and deepening the Galveston Ship Channel from 40 to 54 feet which would make it capable of handling partially loaded VLCCs. Onshore construction includes offloading and storage facilities and a pipeline for deliveries to local refineries. There would also be provision onshore for coal and other cargo handling facilities. Dredging operations for Pelican Island are expected to begin in 1982, if a satisfactory method of sharing construction and maintenance costs between the federal government and local users can be worked out.

CHAPTER TWO

CURRENT CRUDE OIL TRANSPORTATION PRACTICES IN THE NORTHEAST REGION

In order to determine the economic and environmental feasibility of any new crude oil receiving facilities for the Northeast region, current operations must be examined. The description and analysis of the current crude oil flow which are presented in this chapter will encompass the following:

1) the identification of the refineries in the region, their capacities and inputs of crude oil;
2) the determination of current quantities of crude oil delivered to Delaware Bay and the New York Harbor area, their points of origin and crude oil transportation routes utilized;
3) a description of the prinicipal aspects of marine deliveries of crude oil in the region today;
4) an evaluation of the recent history of oil spills in the two port areas.

The discussion in this chapter, as in the entire study, focuses on crude oil and does not include refined petroleum products. The principal reason for this is that marine deliveries of product to the region could not easily, or even practically, be consolidated. Marine product deliveries tend to be high frequency, low volume movements made to hundreds of different locations in the New York and Philadelphia areas. A more complete discussion and analysis of these refined petroleum flows are presented in Appendix B.

Refineries to be served and crude oil requirements

Presently, there are ten oil refineries operating in the New Jersey, eastern Pennsylvania and Delaware region. (See note.) These refineries, whose locations are illustrated in Figure 8, receive their crude oil supplies **exclusively** by marine shipment either through the Port of New York or through the Delaware Bay and Delaware River. There are no common carrier pipelines for transporting crude oil in the study region. This situation is different from that of the Gulf Coast and Midwest refineries which are served by extensive crude oil pipeline delivery systems.

The ownership, location and capacity of the ten operating refineries in the study area are listed in Table 6. Additional refineries on the East Coast are listed in Table 7. These additional refineries, however, are too scattered geographically to benefit from the deepwater facility being investigated in this study.

Eight of the ten refineries listed in Table 6 are located on the Delaware River with all but one of these (Getty) being situated within ten miles of Philadelphia. The remaining two refineries, owned by Exxon and Chevron, are located in northern New Jersey.

As of January 1981, the aggregate capacity of the ten refineries in the region was 1.55 million barrels per day (b/d). This amounts to about 91% of the total refinery capacity on the East Coast and 81% of capacity in Petroleum Administration for Defense District I (PAD I). Table 6 shows the crude requirements aggregated for each group of refineries in the northern and southern portion of the region. The two northern refineries have a combined capacity of 458,000 b/d and the eight southern refineries have a combined capacity of 1,092,700 b/d.

The total throughput of these refineries and their average utilization rates in recent years are given in Table 8. The table shows that the peak year for throughput was 1978 in which 1.43 million b/d were received by the refineries. The decline in crude oil input and average refinery utilization rates in 1979 and 1980 reflects the nationwide decline in demand for petroleum products, especially gasoline. The small increases in refinery capacity in 1979 and 1980 reflect the start-up phases of the Seaview Petroleum Company in June, 1979.

Note: The Amerada Hess refinery, located in Woodbridge Township is not included in this total since it was closed in 1974. The announced plans to reopen this refinery at a reduced capacity do not affect the deepwater facilities under study here. The reopened refinery would process desulphurized heavy crude which would be delivered in relatively small tankers.

Sources of crude oil

In addition to refinery capacity and utilization, the source of crude oil is another important consideration in investigating the economic feasibility of a crude oil handling facility. At present, about 90% of the region's crude oil is supplied by foreign sources whose ports are capable of loading VLCCs and ULCCs. Crude oil volumes from domestic sources, shipped to refineries in smaller tankers, have fluctuated as a small percentage of total crude received by regional refineries over the last five years, ranging between 4% and 9% (see Table 9).

Since the economic feasibility of the facility under study depends primarily on 'over-the-water' savings from large volume, long haul crude deliveries, the origins and volume of imported crude deliveries are most important to this study.

The sources of imported crude oil for each company will vary from year to year and month to month. The data presented in Table 10 represents only one year, though it is typical of the sources of supply for these companies' refineries in recent years. Saudi Arabia has been the leading supplier to five of the refineries, accounting for 28% of the region's imported crude for 1979. Nigeria and Algeria, each the leading supplier of two refineries, respectively accounted for 25% and 14% of the total crude imports to the region. Together, these three countries accounted for approximately two-thirds (67%) of the total imported crude oil to the region's refineries in 1979.

Saudi Arabia, Nigeria and Algeria are three principal source countries in the three principal geographic areas which account for most of the long-distance crude deliveries to the United States. These areas are the Arabian Gulf, West Africa and North Africa. Together, these three geographic areas accounted for 84% of all imported oil to the ten refineries in the region in 1979. Other source areas include Venezuela and Mexico, in the Caribbean.

Table 6
OPERATING REFINERIES IN THE AREA OF INTEREST
(units in barrels per day)

as of January 1, 1981

Company	Location	Capacity
Chevron	Perth Amboy, NJ	168,000
Exxon	Linden, NJ	290,000
SUBTOTAL FOR NORTHERN NEW JERSEY		458,000
ARCO	Philadelphia, PA	185,000
BP	Marcus Hook, PA	164,000
Getty	Delaware City, DL	140,000
Gulf	Philadelphia, PA	206,300
Mobil	Paulsboro, NJ	98,000
Seaview	Paulsboro, NJ	44,400
Sun	Marcus Hook, PA	165,000
Texaco	Westville, NJ	90,000
SUBTOTAL FOR SOUTHERN NEW JERSEY, EASTERN PENNSYLVANIA, AND DELAWARE		1,092,700
TOTAL		1,550,700

Source: "Petroleum Refineries in the U.S. & U.S. Territories," *Energy Data Reports*. Energy Information Administration, U.S. Department of Energy, May 22, 1981.

Table 7
OTHER OPERATING REFINERIES ON EAST COAST
(rated capacities in barrels per day)

Ten operating refineries in area of interest	1,550,700
Other refineries in Northeast near Atlantic Coast:	
ATC Petroleum (Newington, NH)	13,400
Cibro Petroleum (Albany, NY)	27,100
Amoco (Baltimore, MD)	15,000
Chevron (Baltimore, MD)	13,500
Other East Coast refineries	82,400
TOTAL East Coast Refinery District	1,702,100
Other Petroleum Administration for Defense District I (PAD I) (WV, West PA, West NY)	206,220
TOTAL PAD I	1,908,320

Source: "Petroleum Refineries in the U.S. & U.S. Territories," *Energy Data Reports*. Energy Information Administration, U.S. Department of Energy, May 22, 1981.

Table 8
CRUDE OIL INPUT AND UTILIZATION RATES FOR REFINERIES IN NEW JERSEY, EASTERN PENNSYLVANIA AND DELAWARE, 1976-1980
(millions of barrels per day)

Year	Crude Oil Input	Total Rated Capacity	Utilization Rate
1976	1.33	1.51	88%
1977	1.40	1.51	93%
1978	1.43	1.51	95%
1979	1.38	1.53	90%
1980	1.19	1.55	77%

Source: "Crude Petroleum, Petroleum Products and Natural Gas Liquids," annual summaries for 1976-1979 and monthly reports for 1980, Energy Information Administration, USDOE; and informal data from Chevron and Exxon collected by Office of Energy, Port Authority of New York and New Jersey, 1981.

Table 9
DOMESTIC CRUDE RECEIPTS FOR THE TEN REFINERIES IN DELAWARE, NEW JERSEY AND EASTERN PENNSYLVANIA, 1976-1980
(millions of barrels per day)

Year	Total	Domestic	Domestic as % of Total
1976	1.33	.05	4%
1977	1.40	.04	3%
1978	1.43	.09	6%
1979	1.38	.07	5%
1980	1.19	.11	9%

Source: "Crude Petroleum, Petroleum Products and Natural Gas Liquids," annual summaries for 1976-1979 and monthly reports for 1980, Energy Information Administration, USDOE; and unofficial data from Chevron and Exxon collected by Office of Energy, Port Authority of New York and New Jersey, 1981.

Table 10
LEADING COUNTRIES OF ORIGIN FOR IMPORTED CRUDE OIL BY REFINERY—1979
(with total imported oil for the year)

1. ARCO: 35,100,000 barrels

Saudi Arabia	33%
Iran	21
Nigeria	19
Other (9)	27

2. BP (Sohio): 37,100,000 barrels

Saudi Arabia	22%
Iran	19
Algeria	19
Other (9)	40

3. Chevron: 40,500,000 barrels

Saudi Arabia	72%
Nigeria	17
Venezuela	8
Other (1)	1

4. Exxon: 78,800,000 barrels

Saudi Arabia	40%
Venezuela	40
Nigeria	6
Other (8)	14

5. Getty: 33,600,000 barrels

Gabon	40%
Saudi Arabia	33
Venezuela	11
Other (3)	16

6. Gulf: 74,500,000 barrels

Nigeria	59%
Libya	21
Algeria	8
Other (7)	2

7. Mobil: 34,700,000 barrels

Saudi Arabia	79%
Nigeria	20
Canada	1
Other	0

8. Seaview: 3,300,000 barrels

Nigeria	66%
Libya	30
Venezuela	4
Other	0

9. Sun: 48,500,000 barrels

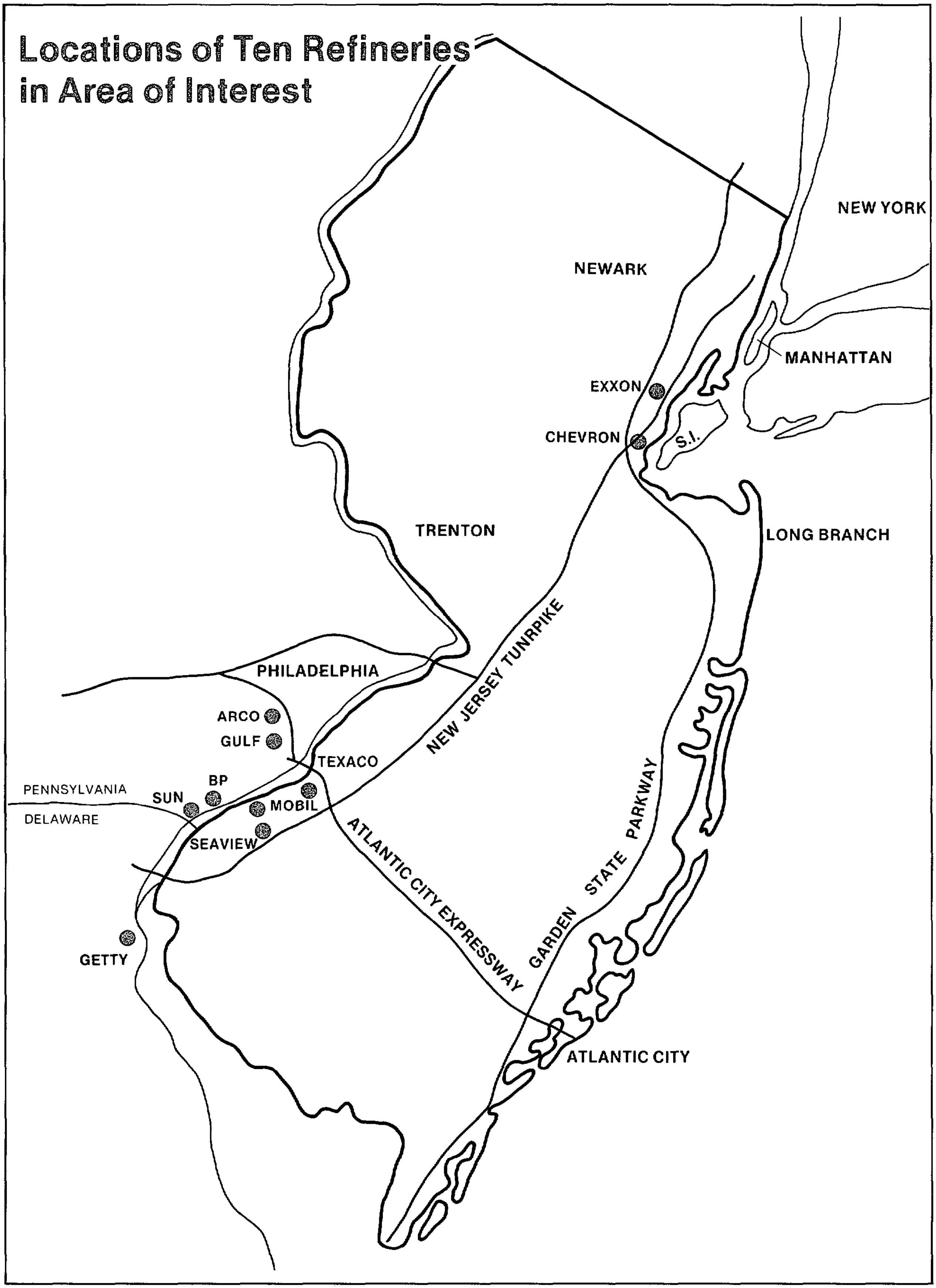
Algeria	42%
Nigeria	29
Libya	16
Other (10)	13

10. Texaco: 30,600,000 barrels

Algeria	53%
Indonesia	37
Libya	4
Other (3)	6

Note: (X) indicates the number of other countries from which crude oil was imported.

Source: "Imported Crude Oil and Petroleum Products," monthly reports for 1979, American Petroleum Institute.



Locations of Ten Refineries in Area of Interest

FIGURE 8

Crude Oil Flows from Principal Source Areas to Delaware River Refineries, 1979

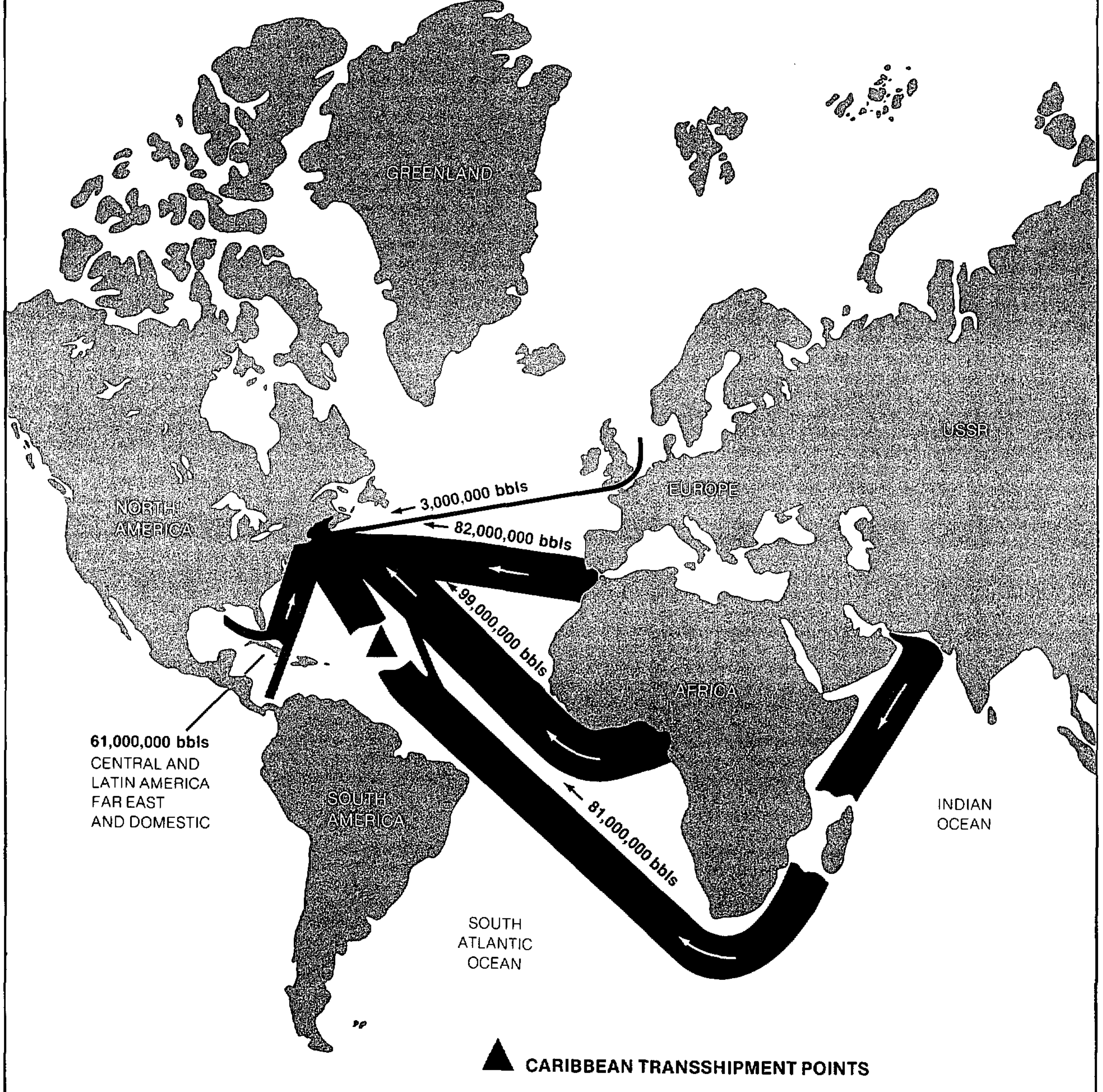


FIGURE 9

Crude Oil Flows from Principal Source Areas to Northern New Jersey Refineries, 1979

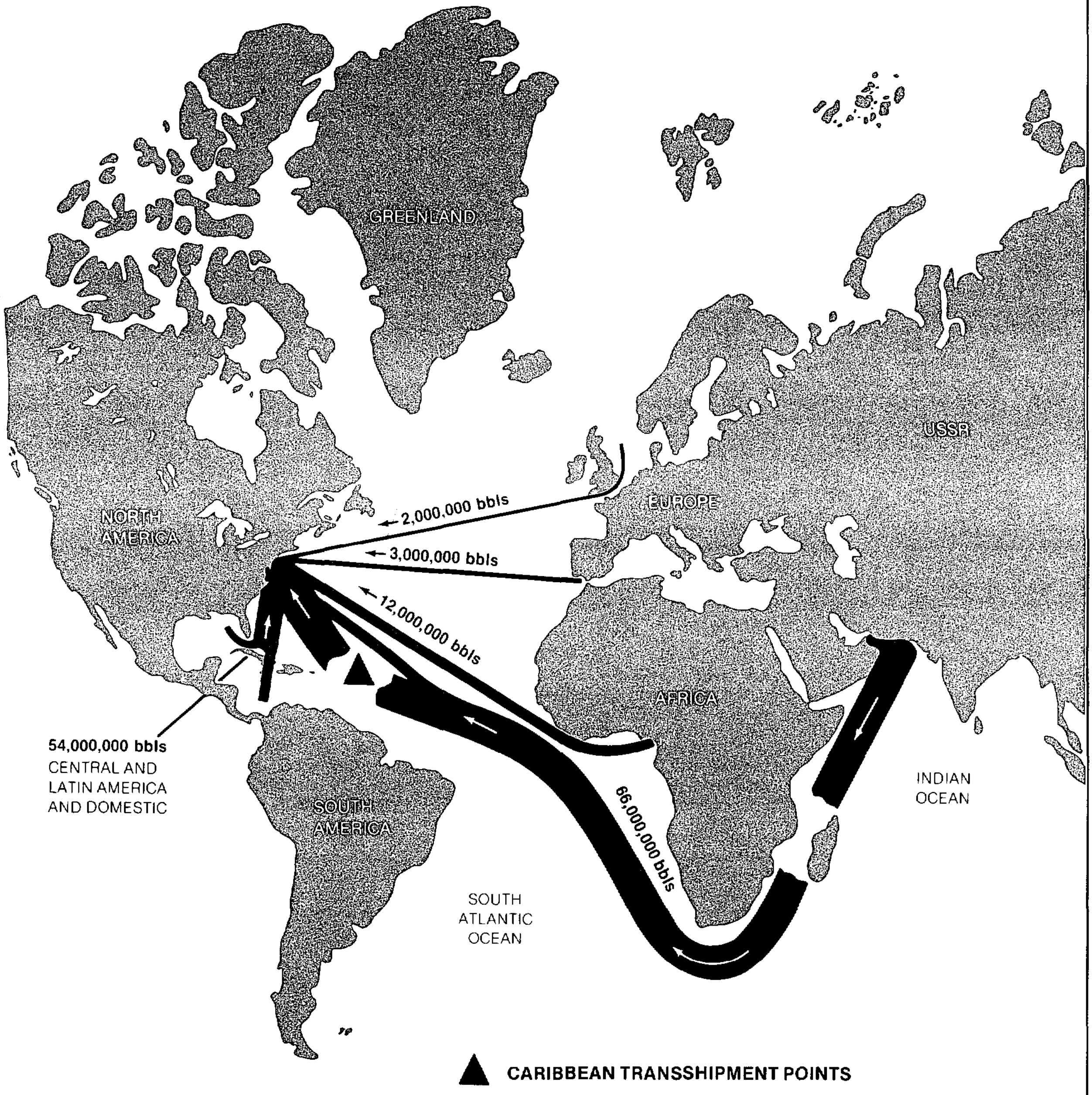


FIGURE 10

The distribution of imported crude oil receipts by geographic area for each refinery is shown in Table 11. The data in this table indicate that only Texaco and Exxon relied heavily on countries outside the Arabian Gulf, West Africa or North Africa. Texaco received 37% of its imported crude from Indonesia whereas Exxon received 40% of its crude from Venezuela. Since 1979, however, Exxon has reduced its deliveries from Venezuela.

Figures 9 and 10 show the relative size and direction of crude flows from the principal source areas to both the Delaware Bay region and New York Harbor. As shown in Figure 9, West Africa has been the dominant supplier of crude to the refineries in the Delaware Bay region with additional crude being supplied by Arabian Gulf and North African countries. The flows in Figure 10 indicate that the Arabian Gulf is the dominant supplier of crude to the northern group of refineries with significant supplies also coming from West Africa and Western Hemisphere sources.

Tanker routes

To traverse the longer distances for crude delivery in an economical manner from the three principal oil exporting regions, oil companies have resorted to chartering or employing their own VLCCs as well as transshipping in the Caribbean. Smaller tankers, generally those of less than 50,000 dwt, are used on shorter distance routes, such as those from the Caribbean area, or on those routes which transit the Panama Canal.

As a general rule, the crude flows depicted in Figures 9 and 10 can be summarized as follows.

- Most of the crude oil from the Arabian Gulf is transshipped in the Caribbean.
- A small portion of the crude oil supplied by Arabian Gulf countries is heavy and high pour point crudes. These crudes are delivered directly to the United States East Coast in smaller tankers.
- A small portion of West African crude oil is transshipped in the Caribbean, with the remainder being shipped directly to the United States.
- Virtually none of the North African crude oil deliveries is transshipped on this side of the Atlantic Ocean since there is no convenient en route protected area for transshipping.

In the near future, with the opening of the new Saudi Arabian port of Yanbu on the Red Sea, there may be some changes to these general crude oil shipping patterns. It may then become economically attractive for some companies to load 150,000 dwt tankers on the Red Sea and reach the Mediterranean Sea via the recently deepened Suez Canal. The economics of such alternate routes depend upon rate schedules as yet undetermined.

Table 11

IMPORTED CRUDE OIL RECEIPTS BY GEOGRAPHIC AREA AND BY COMPANY—1979
(as percent of total imported oil for the year)

Area	Company ARCO	BP	GETTY	GULF	MOBIL	SEAVIEW	SUN	TEXACO	total for Delaware River	CHEVRON	EXXON	total for New York Harbor	total for Region
Arabian Gulf	65%	49%	38%	1%	79%	—	4%	3%	28%	72%	47%	56%	36%
West Africa	19%	20%	40%	64%	20%	66%	29%	3%	34%	17%	7%	10%	27%
North Africa	13%	20%	2%	32%	—	30%	59%	57%	28%	3%	1%	2%	21%
Other	3%	11%	20%	3%	1%	4%	8%	37%	10%	8%	45%	32%	16%
TOTAL									100%			100%	100%

Source: "Imported Crude Oil and Petroleum Products", monthly reports for 1979, American Petroleum Institute.

Overview of the tanker fleet serving the region

Principal determinants of marine petroleum shipping operations in any harbor or port area are the depths of the approach channels as well as the depths of access channels into the refinery piers. These channel depths govern the size of tankers which can be accommodated in crude oil transport operations and the amount of lightering which may be required. If the channels were to be deepened, current crude oil shipping practices could be significantly altered.

In the New York Harbor area, the larger class of tankers delivering crude ranges between 66,000 dwt and 88,000 dwt. On the other hand, the class of tankers delivering crude in the Delaware Bay region ranges from 85,000 dwt to 153,000 dwt. Drafts of these vessels, which typically are less than 10 years old, generally range from 43 to 51 feet (see Table 12). Tankers constructed with recent innovative designs, however, may have shallower drafts than have been common for a given tonnage.

The maximum speed of the tankers listed in Table 12 ranges between 15.0 and 17.5 knots. However, since the late 1970s, there has been a widespread practice of 'slow steaming' to increase fuel efficiency. With slow steaming, the normal transit speed for these vessels is reduced to between 10 and 12 knots.

Crude oil deliveries by tanker to the New York Harbor refineries

The two northern New Jersey refineries, Exxon in Linden and Chevron in Perth Amboy, receive their crude oil supplies via New York Harbor. Presently, the depths of the main approach channel — the Ambrose Channel — and the access channels to these refineries' piers limit the tanker size which can be accommodated (see Figure 11). The main approach channel from the Atlantic Ocean to just south of the Verrazano-Narrows Bridge is twelve miles long and has a depth of 45 feet. The refinery access channels, however, which include the Arthur Kill, the Kill van Kull, Sandy Hook and Raritan Bay, are 35 feet deep. As these depth limitations indicate, relatively small tankers, as opposed to VLCCs, must be utilized for crude oil deliveries to the region. These depth limitations are the determining factor in how crude is delivered to the refineries.

Table 12
DIMENSIONS OF TYPICAL TANKERS SERVING THE REGION

Size (dwt)	Draft (feet)	Length (feet)	Width (feet)
33,950	35.5	660.0	89.4
35,053	34.3	661.0	90.3
51,966	39.4	743.1	102.3
*79,229	40.0	820.0	144.4
79,999	43.2	774.3	133.3
85,071	45.6	805.5	124.8
88,285	46.5	792.3	131.4
100,885	48.0	864.5	128.0
101,307	50.6	895.7	121.8
*149,107	50.0	918.6	176.9
151,568	56.4	942.1	145.9

*These ships are of recent construction and have been designed with a broad beam to permit a shallower draft than has been typical for ships of comparable tonnage.

Source: *The Tanker Register*, London: H. D. Clarkson, Ltd., 1981.

Crude oil discharge operations in New York Harbor

The principal anchorages in New York Harbor are Stapleton, Bay Ridge and Gravesend. Of these anchorages, Stapleton is the deepest, having water depths in places in excess of 60 feet. Thus, most lightering operations in New York Harbor are carried out at Stapleton. If vessels require more than 24 hours at anchorage, they are usually moved to either Bay Ridge or Gravesend.

In New York Harbor the largest tankers used for crude oil deliveries are about 88,000 dwt. However, the more commonly used tankers are less than 85,000 dwt with a draft of about 45 feet. Some tankers must adjust their arrival time at Ambrose to arrive at high tide. Other tankers wait outside Ambrose for an anchorage assignment and for tugs. After taking on a pilot, the tanker proceeds to an anchorage. Generally, this trip takes about two and one-half hours but its duration may vary depending upon visibility, other weather conditions and harbor traffic.

At the anchorage the tanker offloads between 20% and 30% of its cargo into barges in order to reduce its draft to about 35 feet for the trip to the refinery. Typically, 25% of the tanker's cargo is lightered. The time at anchorage ranges between 12 and 48 hours with both arrival and departure set at high tide. The first two hours at anchorage are taken up with government inspections (customs and immigration) and make ready operations before lightering can begin. Lightering itself takes about 12 hours. The balance of the time is determined by the availability of barges, tugs, and space at refinery piers.

After offloading sufficient cargo to reduce the tanker's draft, the vessel proceeds to the refinery pier and is docked. Exxon tankers follow the Kill van Kull to approach their refinery at the north end of the Arthur Kill. This trip normally takes about three and one-half hours including the time to make the ship fast to the pier. Chevron tankers usually exit the inner harbor via a portion of the Ambrose Channel, entering the Sandy Hook and Raritan Bay Channels to approach the Chevron pier located on the south end of the Arthur Kill. This trip normally takes about five and one-half hours including the time to make the ship fast to the pier.

Once docked, the tanker will remain at the pier from 24 to 48 hours. Between 15 and 20 of those hours are spent pumping crude oil off the tanker at maximum ship's pump speed (usually between 30,000 and 50,000 barrels per hour). An additional 4 to 5 hours of pumping time may be needed for the pumps to reach maximum speed at the beginning of discharge and to conclude the offloading operation. The balance of the time at the pier is taken up by preparations for return to sea, which includes ballasting operations. There are also delays caused by weather and shore systems.

The smaller tankers, which make deliveries directly to the refineries' piers, carry slightly less oil than a lightered 85,000 dwt tanker. Since their pumps have slightly less capacity than the 85,000 dwt, pumping time at maximum rate is still approximately 15 to 20 hours. All other time elements are identical.

After leaving the pier, both Exxon's and Chevron's tankers usually return to the Atlantic Ocean via the Raritan Bay and Sandy Hook Channels. Chevron's tankers are turned around in the Arthur Kill Channel and make the trip in about two and one-half hours. Exxon's tankers usually take about four hours to leave port because of the longer trip down the Arthur Kill.

A tanker's total time in port, which includes ship transit and oil transfer operations, normally ranges from two and one-half to five days. The typical time in port for the larger ships is three days. In the case of voyage-chartered vessels, demurrage must be paid by the shipper for loading and unloading time typically in excess of 72 hours. Normally, such vessels will try to offload within 36 hours.

Crude oil deliveries by tanker to the Delaware River refineries

In the Delaware Bay region, there are eight refineries (Getty, Sun, BP, Mobil, Arco, Gulf, Texaco, Seaview) which receive crude oil by tanker. The approach lanes into Delaware Bay permit vessels with drafts of over 55 feet to enter the lower portion of the Bay as far as Big Stone Anchorage (see Figure 12). The Delaware River Channel begins about six miles southeast of Big Stone Anchorage. This channel, with a depth of 40 feet, continues up the Delaware River and provides access to all the refineries in the Philadelphia port region.

Once a tanker arrives at the lower portion of the Delaware Bay, it must travel between 60 and 100 miles up the Delaware River to arrive at one of the eight refinery piers (see Table 13).

Table 13
DISTANCES FROM ENTRANCE OF DELAWARE BAY TO REFINERIES

Refinery	Location	Approximate Distance
Getty Oil	—Delaware City, Delaware	60 miles
Sun	—Marcus Hook, Pennsylvania	80 miles
BP (Sohio)	—Marcus Hook, Pennsylvania	80 miles
Mobil	—Paulsboro, New Jersey	90 miles
Arco	—Philadelphia, Pennsylvania	95 miles
Gulf	—Philadelphia, Pennsylvania	95 miles
Texaco	—Westville, New Jersey	100 miles
Seaview	—Paulsboro, New Jersey	100 miles

Crude oil discharge operations in the Delaware Bay

The principal anchorage for tankers entering Delaware Bay is Big Stone Anchorage, which is located about ten miles northwest of Cape Henlopen, Delaware. The water depth for the largest portion of this anchorage area is in excess of 60 feet. Thus, most of the lightering of crude oil in the region is accomplished at Big Stone.

The largest tankers delivering crude to the Delaware River refineries are in the 150,000 dwt range, with vessel size varying between 85,000 and 150,000 dwt. With the wide variation in vessel size, there is no typical tanker size. Some of the largest tankers will unload their cargo completely at the anchorage. More often, tankers will lighter between 20% and 50% of their cargo before proceeding to the refinery piers.

The times for transit and offloading operations vary widely as well. A pilot boards the incoming tanker at Cape Henlopen for the one to two hour trip to Big Stone Anchorage. The time required for lightering ranges from 12 to 48 hours. Departure for the refinery frequently is delayed because the long transit through the narrow channel of the Delaware River is often subject to unfavorable weather conditions. Transit time up the Delaware River takes between 10 and 15 hours with a stay at the refinery pier of between one and three days. There is considerably more range in dwell times at the piers for these refineries than is the case in New York Harbor. An additional problem which may affect the rate of tanker unloading is a lack of sufficient storage capacity for crude oil at some of the refineries in the region.

The return of the tanker to sea is also subject to weather delays, but can normally be accomplished in 11 to 14 hours. The total operational and transit time for tankers making deliveries on the Delaware ranges between three and six days.

Summary of discharge operations in the region

In summary, the depths of the main approach channels into New York Harbor and the Delaware River limit tanker size well below the VLCC/ULCC category. This limitation dictates that relatively small tankers be used for crude oil delivery to the region, though occasionally a VLCC or ULCC is brought into Delaware Bay in a partially laden condition and completely offloaded by barge at Big Stone Anchorage. In both New York Harbor and Delaware Bay, the access channels into the refinery piers are even shallower than the main entrance channels. The depths of these access channels, therefore, become the controlling depths for marine shipments of crude to the refineries. Even after transshiping in the Caribbean, the shallow access channels in both ports require that substantial amounts of lightering be accomplished before most tankers can proceed to the refinery piers and discharge the balance of their cargoes.

New York Harbor Area and Refinery Locations

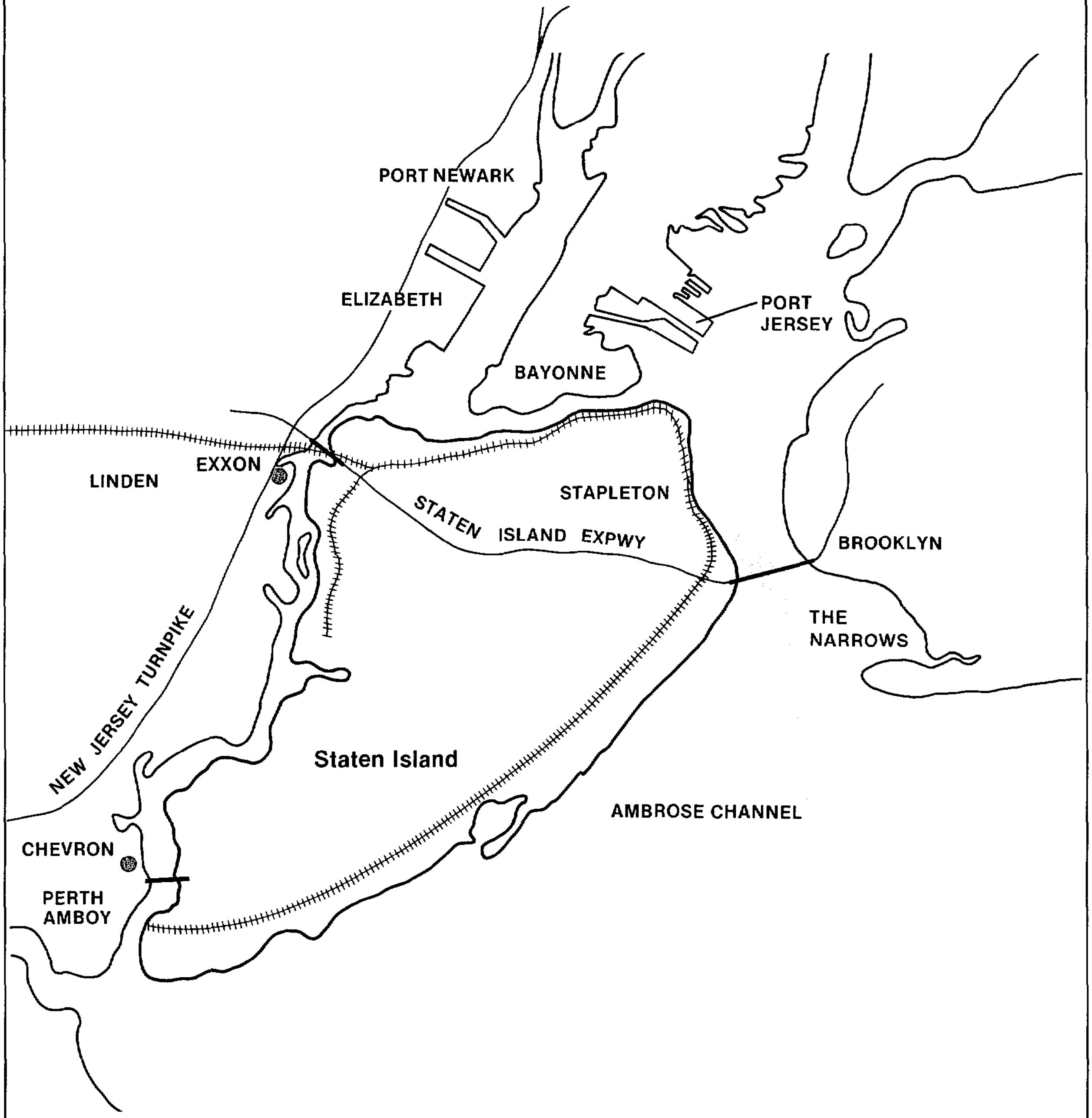


FIGURE 11

Delaware Bay and River Area and Refinery Locations

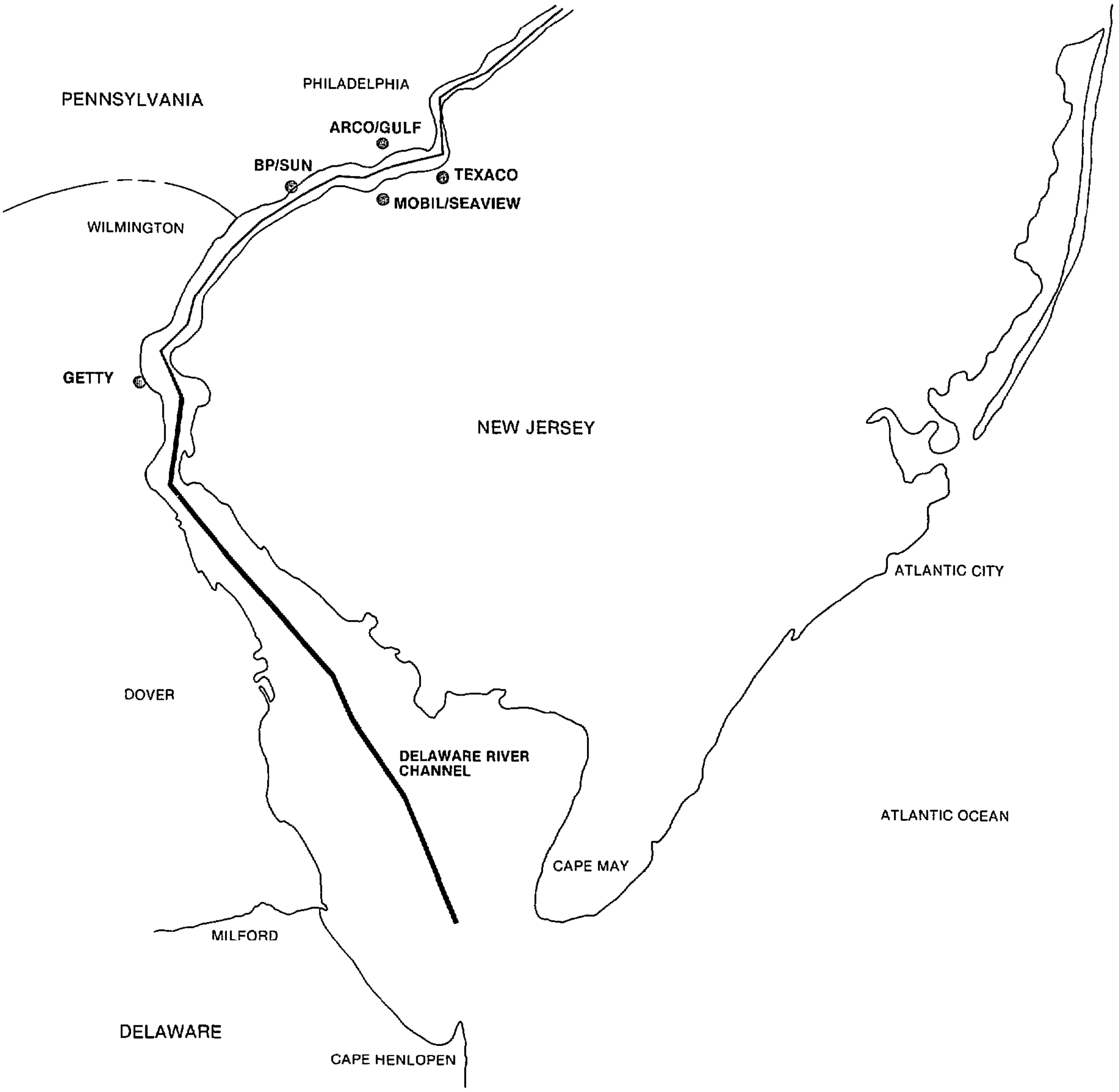


FIGURE 12

Some crude oil, is delivered in small tankers which can proceed to the pier with little or no lightering. This includes a significant portion of domestic deliveries as well as deliveries from other countries such as Venezuela where there are draft limitations at the port of origin or other physical constraints on loading. There is also a small volume of crude, though in some cases a large proportion of the total throughput of individual refineries, which requires special handling due to high viscosity or corrosive characteristics. These types of crudes are also delivered in the smaller size tankers.

The current costs of marine transportation of crude oil to the region will be discussed in Chapter Five.

A recent history of marine crude oil spills

Current marine crude oil delivery to the two refineries served through New York Harbor and the eight refineries served through the Delaware Bay/River has been described above. During such deliveries, crude oil can be and, from time to time, is discharged accidentally into the marine environment. Historical data on oil spills in the two areas of interest were analyzed in order to determine the magnitude of the spill problem associated with current crude oil handling procedures. From such a base of knowledge, projections may be made concerning the effects on the spill problem which may result from proposed changes in delivery methods. A summary of the analysis of seven years of spill data is presented in this section. Additional details may be found in Appendix D.

Petroleum spill data — The reporting of pollution incidents is mandated by the Federal Water Pollution Control Act of 1970. As called for in this law, the United States Coast Guard (USCG) keeps records of petroleum spills as part of its Pollution Incident Reporting System (PIRS). A listing of all petroleum spill incidents was acquired from the USCG for the years 1974 through 1980 covering the areas of interest. As used here, petroleum is a generic term which includes crude oil as well as refined products.

For the purposes of this analysis, the PIRS data on petroleum spills were sorted in a spill-by-spill format for each of two geographically defined regions: one encompassing New York Harbor and the other taking in the Delaware Bay/River to a point north of Philadelphia (see Figures 11 and 12). The information provided on each spill consisted of the incident's index number, date of the incident, location in latitude and longitude, material spilled, quantity spilled (if reported), source of the spill, cause and operation in progress at the time of the incident.

Marine vessel petroleum spills — Table 14 presents a summary of all marine vessel petroleum spills and marine vessel crude oil spills in New York Harbor and in the Delaware Bay/River as found in the USCG PIRS data from 1974 through 1980. For the seven-year period, the total number of marine vessel petroleum spill incidents reported in New York Harbor was 1,314, with 1,120 of these reporting the quantity involved. Of the total number, 64 (5%) involved crude oil, and 57 of these reported quantities. The total amount of petroleum reported spilled from marine vessel sources for that period was 1,189,479 gallons with 298,357 gallons (25%) of that total being crude oil. Four major marine vessel petroleum spill incidents of 100,000 gallons or more occurred during the seven years, one of which was a 277,200 gallon spill of crude oil. This single incident accounted for 93% of the crude oil reported spilled from marine vessels during the seven-year period. The total crude oil spilled from the 56 other marine vessel incidents with quantities reported was 21,157 gallons.

In the Delaware Bay/River there was a total of 541 (477 with quantities recorded) marine vessel petroleum spills reported between 1974 and 1980, inclusive. Crude oil was involved in 92 (17%) with 84 of these reporting quantity spilled. The total amount of petroleum reported spilled by marine vessels was 2,026,284 gallons with 878,502 gallons (43%) reported as crude oil. There were five major incidents involving spills of 100,000 gallons or more, three of which were crude oil spills; one of 500,000 gallons, one of 189,000 gallons and one of 134,000 gallons. These three incidents were responsible for 94% of the marine vessel crude oil spills for the seven years. The other 81 marine vessel crude oil spills with quantities recorded amounted to 55,502 gallons.

Tanker and barge crude oil spills — Concentrating on crude oil spills from tankers and barges, a further sorting of the data revealed that incidents could be categorized broadly as occurring either in an anchorage, where crude oil is transferred from tankers to barges; at a refinery pier, where the barges and tankers offload into storage tanks; or while a tanker or barge is underway. For a relatively small number of incidents, the available information was insufficient to make a determination of whether a given vessel was in an anchorage, at a refinery pier or underway and so a fourth category, 'Operational Mode Unknown', was created.

Table 14
MARINE VESSEL PETROLEUM SPILLS IN NEW YORK HARBOR AND THE DELAWARE BAY/RIVER, 1974–1980

	Incidents (see note)		Quantity (in gallons)	
Region	**Total Number**	**Crude Oil Only**	**Total Spilled**	**Crude Oil Spilled**
New York Harbor	1,314/1,120	64/57	1,189,479[1]	298,357[3]
Delaware Bay/River	541/477	92/84	2,026,284[2]	878,502[4]

Note: X/Y— X represents the number of spills reported.
Y represents the number of spills reported for which a quantity spilled was recorded.

[1] Includes four major incidents with spill quantities of 277,200 (1976), 120,000 (1979), 102,000 (1975) and 100,000 (1977) totalling *599,200* gallons.

[2] Includes five major incidents with spill quantities of 630,000 (1978), 500,000 (1975), 285,000 (1974), 189,000 (1979) and 134,000 (1976), totalling *1,738,000* gallons.

[3] Includes one major crude oil spill of *277,200* gallons in 1976.

[4] Includes three major crude oil spills of 500,000 (1975), 189,000 (1979) and 134,000 (1976) totaling *823,000* gallons.

Source: United States Coast Guard, Pollution Incident Reporting System, computer printout received July, 1981.

Table 15 displays, on an annual basis, the tanker and barge crude oil spills in New York Harbor under the four categories described above for the 1974 through 1980 period. Immediately apparent is the year-to-year variation in numbers of incidents and in quantities spilled under each category. The inflationary effect of the one underway incident in 1976, which resulted in a reported spill of 277,200 gallons, distorts any statistical analysis which includes it. However, it would be equally misleading to ignore it. Rather, it serves as a grim reminder that major crude oil spills can and do occur. This specific incident resulted from a tanker grounding on rocks which punctured its hull. The accident occurred in the narrow Arthur Kill.

Table 16 has the same format as Table 15 but depicts Delaware Bay/River information. Again, the wide range of values from year to year, both in numbers of incidents and quantities reported under each heading, is noteworthy. In 1975 the tanker Corinthos, berthed and discharging its cargo of crude oil at the BP pier at Marcus Hook, was struck by the tanker Edgar M. Queeny, which was underway upriver. Since it was the crude oil from the Corinthos which spilled into the marine environment, the incident was categorized as 'At Pier' rather than 'Underway'. The quantity spilled, 500,000 gallons, distorts the expected size of an operational 'At Pier' spill.

Observations on the Data — Mention must be made concerning apparent discrepancies between certain totals which appear on Table 14 and those which appear on Table 15 or 16. Note that Table 14 reports on marine vessel spills, whereas Table 15 and Table 16 restrict entries to spills from tankers and barges. Consider, for example, the number of crude oil spill incidents in New York Harbor. In Table 14, the total number is 64, with 57 reporting quantities whereas in Table 15 the numbers are 61 and 54, respectively. According to the PIRS printouts, three vessels — a dry cargo ship for 125 gallons, a combatant vessel for 100 gallons and a fishing vessel for 10 gallons — spilled crude oil into New York Harbor between 1974 and 1980, inclusive. Similarly for the Delaware Bay/River, four vessels other than tankers or barges were reported to have spilled crude oil amounting to 1,056 gallons. Thus, the reconciliation between marine vessel crude oil incidents and quantities and tanker and barge crude oil incidents and quantities is accomplished.

The PIRS oil spill data described above show that there is a problem of recurring crude oil spills in both Delaware Bay and New York Harbor apparently resulting from operational handlings of the oil. The largest number of oil spill incidents appears to occur either in an anchorage or at the pier. However, from the limited data available (only seven years' worth), there is no easily discernible pattern of spills. The larger number of

Table 15

SUMMARY OF TANKER AND BARGE CRUDE OIL SPILL INCIDENTS FOR NEW YORK HARBOR* 1974–1980 (quantities in gallons)

Year	Incidents: In Anchorage		At Pier		Underway		Mode Unknown		Total	
	#	Quantity	#	Quantity	#	Quantity	#	Quantity	#	Quantity
1974	1	42	5	6,205	1	5	–	–	7	6,252
1975	4	10,082	3	477	–	–	–	–	7	10,559
1976	2	85	4	410	1	277,200	–	–	7	277,695
1977	8[1]	348	7[3]	131	–	–	–	–	15[4]	479
1978	6[1]	56	7[1]	501	–	–	–	–	13[2]	557
1979	1[1]	unknown	4	2,413	1	15	1	30	7[1]	2,458
1980	4	22	1	100	–	–	–		5	122
Total	26[3]	10,635	31[4]	10,237	3	277,220	1	30	61[5]	298,122

*Data were retrieved from the USCG PIRS for the region bounded by:
North Latitudes—39 degrees, 50 minutes and 40 degrees, 50 minutes.
West Longitudes—73 degrees, 10 minutes and 74 degrees, 20 minutes

[1] For one incident of this reported number, no quantity was recorded.
[2] For two incidents of this reported number, no quantity was recorded.
[3] For three incidents of this reported number, no quantity was recorded.
[4] For four incidents of this reported number, no quantity was recorded.
[5] For seven incidents of this reported number, no quantity was recorded.

Source: U.S. Coast Guard, Pollution Incident Reporting System, computer printout received July, 1981.

Table 16

SUMMARY OF TANKER AND BARGE CRUDE OIL SPILL INCIDENTS FOR DELAWARE BAY/RIVER* 1974–1980 (quantities in gallons)

Year	Incidents: In Anchorage		At Pier		Underway		Mode Unknown		Total	
	#	Quantity	#	Quantity	#	Quantity	#	Quantity	#	Quantity
1974	2	330	10	15,467	1	50	3	1,015	16	16,862
1975	2[1]	2	14	506,869	2	2,010	–	–	18[1]	508,881
1976	1	10	8	704	2[1]	134,000	–	–	11[1]	134,714
1977	7[1]	467	6	346	–	–	–	–	13[1]	813
1978	3[1]	120	5[1]	2,330	–	–	–	–	8[2]	2,450
1979	1	3,400	10[1]	19,995	1	189,000	–	–	12[1]	212,395
1980	3	544	7[2]	787	–	–	–	–	10[2]	1,331
Total	19[3]	4,873	60[4]	546,498	6[1]	325,060	3	1,015	88[5]	877,446

*Data were retrieved from the USCG PIRS for the region bounded by:
North Latitudes—38 degrees, 50 minutes and 40 degrees, 05 minutes.
West Longitudes—74 degrees, 30 minutes and 75 degrees, 40 minutes.

[1] For one incident of this reported number, no quantity was recorded.
[2] For two incidents of this reported number, no quantity was recorded.
[3] For three incidents of this reported number, no quantity was recorded.
[4] For four incidents of this reported number, no quantity was recorded.
[5] For eight incidents of this reported number, no quantity was recorded.

Source: U.S. Coast Guard, Pollution Incident Reporting System, computer printout received July, 1981.

'In Anchorage' and 'At Pier' incidents in Delaware Bay (79) compared with New York (57) may be related to the larger number of deliveries of crude oil to the eight refineries on the Delaware River. But the difference is not proportional to differences in either volumes per delivery or numbers of tankers. These operational spills tend to be relatively small; over 90% of the incidents spilled at most 2100 gallons per occurrence, and over 50% spilled less than 1,000 gallons each.

Four major spills involving vessels underway suggest that in-harbor transit presents a greater risk of large spills than oil handling operations. As noted above, the 1975 spill of 500,000 gallons, listed in the 'At Pier' category, was caused by a vessel underway. Chronic small spills apparently are associated with oil handling operations, whereas larger episodic spills seem to be associated with vessel movement.

CHAPTER THREE

ESTIMATION OF CRUDE OIL THROUGHPUT FOR A DEEPWATER TERMINAL

The need for an offshore deepwater terminal relates both to the volume of marine crude oil shipments to the East Coast refineries and the problem of shallow harbors. As described in Chapter Two, the volume of crude oil deliveries has ranged in recent years between 1.2 and 1.4 million barrels per day. It is necessary to estimate how much of this delivery volume reasonably could be expected to pass through a deepwater crude oil handling facility. This estimate is critical in determining the economic feasibility of such a facility.

The throughput estimates developed in this chapter are hypothetical. They are based on obvious considerations such as the likelihood of delivery by VLCCs and the physical properties of the crude oil types likely to be processed. If an offshore DWP were built, there would be additional considerations peculiar to each participating refinery which would affect actual throughput volume. This chapter attempts to make a reasonable first determination of what that volume would be.

Throughput for a deepwater terminal - general assumptions

The throughput estimates in this chapter are conservative in comparison to previous studies. In the past, assumptions concerning refinery expansion and utilization have yielded larger amounts of throughput for an Atlantic Coast deepwater port. The estimates presented here are compatible with the general background assumptions set out in the Introduction, especially the assumption of little or no growth in petroleum product demand in the Northeast during the 1980s. In particular, the estimates are based on five assumptions about the refinery industry in the region and its sources of crude oil supplies. These assumptions are:

1. **There will be no significant additions to refinery capacity in the region through 1990.**

It is unlikely that any new refinery will be constructed in the region. In the past ten years, at least three new refineries have been proposed for the region and were subsequently defeated on environmental and economic grounds.

There is a likelihood, however, of expanding one or more of the existing refineries. Additional downstream processing may be added in response to changing demands for refined products. For example, one small new refinery of 44,400 barrels per day owned by Seaview Petroleum Corporation opened in June 1979 and since has been expanded to 77,000 barrels per day. On the other hand, ARCO has reduced the throughput capacity of its Philadelphia refinery by shutting down one old crude oil unit and Gulf has announced that it would reduce its production to 65% of present capacity over the next five years. While there may be additional expansions and contractions of capacity in the region during the 1980s, these developments are projected to be modest and are not expected to change the aggregate refinery capacity in the region significantly.

2. **The utilization rate for these refineries will average about 85% during the first decade of Deepwater Terminal operation.**

The recent average refinery utilization rates for the ten refineries are shown in Table 8. The average refinery utilization rate for the years 1976 to 1980 is 89%. This is well above the 85% rate which is assumed for estimation purposes. An 85% utilization rate assumes an eventual return to more 'normal' operating levels than 1981 levels which are under 70% in some cases. The actual rates will depend in large part on consumer demand for petroleum products in the Northeast. However, since the refinery output of this region must be supplemented with pipeline and waterborne deliveries to meet consumer demand, utilization rates for the region's refineries should typically exceed national averages.

3. **Imported crude oil from long distance overseas sources will continue to comprise a high proportion of total crude oil input for these refineries.**

As discussed in Chapter Five, transportation cost savings with the use of VLCCs must be sufficient to justify a deepwater facility. The potential for these savings increases with shipping distance. Therefore, only if there is continued dependence on long distance overseas sources for crude oil can a bulk oil facility be justified economically.

Since the refineries in the Northeast have the least convenient access to domestic supplies of crude, we assume that these refineries will continue to process large quantities of imported oil averaging between 80% and 90% of total refinery requirements for the region. Recent developments such as the deepening of the Suez Canal to 53 feet and the Trans-Arabian pipeline, which is under construction, will enhance the deliverability of Middle Eastern oil to this region.

4. **Domestic deliveries of crude oil to the East Coast refineries will not exceed 10% to 15% of refinery receipts.**

The proportion of receipts of domestic crude to East Coast refineries since 1976 has ranged between 3% and 9% of the total (see Table 9). Most domestic deliveries are made by tankers which have used the Panama Canal. These deliveries should continue to come directly to the refinery sites with little or no lightering and must be excluded from throughput for a bulk oil facility.

5. **If there are commercial finds of crude oil on the Atlantic Outer Continental Shelf (OCS) of the U.S., that crude oil will not be delivered in quantity to local refineries until 1990, at the earliest.**

Any nearby domestic oil production likely would displace foreign oil imports at local refineries and thus reduce VLCC deliveries through any deepwater port. Oil industry estimates call for about a ten year lag between a commercial find and initial production. As of late 1981, no announcement about a commercially exploitable crude oil discovery on the U.S. Atlantic Coast OCS has been made. The importation of Canadian Atlantic Coast OCS oil is a highly remote possibility.

Throughput for a deepwater terminal - other considerations.

Any deepwater port serving the East Coast refineries could be expected to handle only a portion of their aggregate crude oil requirements. In developing throughput estimates, we have assumed the participation of all ten oil companies with refineries in the region of interest. However, there are considerations in addition to those discussed above which would affect the potential volume of throughput for a deepwater terminal. These include the physical characteristics of the crudes used by the refineries as well as limitations at the ports of origin.

a) **High pour point crudes.** One important physical characteristic of crude oil is its ability to flow at certain temperatures as measured by its pour point. Crude oils with high pour points (over 50 degrees Fahrenheit) do not flow readily and thus could not be passed through a ten to twenty mile long submarine pipeline without heating. In this case, such a requirement would be very costly because of the small quantities of oil involved. In 1979 the high pour point crudes comprised about 13% of the total throughput of the ten refineries (see Table 17). During the 1980s the proportion of high pour crudes processed by these refineries is expected to increase slightly. The proportion of these crudes has been estimated at 15% of total imports and this amount has been excluded from the throughput calculations for a deepwater terminal.

Table 17
REFINERY THROUGHPUT OF HIGH POUR POINT CRUDES, 1979

	Total Throughput	High Pour Crudes	High Pour Crudes % of Total
Southern Refineries	896,390	126,400	14%
Northern Refineries	362,900	40,650	11%
Total	1,259,290	167,050	13%

Source: Informal survey of oil refineries by Office of Energy, Port Authority of New York and New Jersey, May 1981.

b) **Specialized deliveries.** Some oil will continue to be delivered in small sized tankers due to the particular requirements of certain refineries. Small quantities of a variety of crude oils are used to achieve the necessary blend at the refinery. These crudes are usually delivered in small volumes on an irregular basis and would not be likely to pass through a deepwater facility.

c) **Limitation at ports of origin.** Additional factors affecting throughput for a deepwater terminal include limitations on tanker accommodations at the port of origin for loading VLCCs. The effect these limitations will have on future deliveries will depend on the continued development of improved port facilities in some of the oil exporting countries.

First estimate of throughput for a deepwater terminal

Two methods were used to estimate potential throughput. The first method involved simple downward adjustments to aggregate refinery receipts to derive an estimate of throughput potential for all ten refineries. These calculations are shown in Table 18.

The variables discussed in the preceding sections must be taken into account in estimating the quantity of crude oil throughput that possibly could be delivered through an alternative crude oil delivery facility. Total projected crude oil receipts of 1,318,000 barrels per day (line 1) are discounted by 15% for domestic deliveries (line 2) and 15% of the remainder for high pour point crudes (line 4), to arrive at 952,000 barrels per day (line 5). The proportion of domestic deliveries is assumed to be slightly higher than at present to take into account increased deliveries from Alaska's North Slope to Exxon. The proportion of high pour crudes is also somewhat higher following recent trends for the oil exporting countries to ship out large quantities of the heavier, higher sulfur crudes. Finally, the total throughput has been discounted by an additional 10% (line 6) since, for the various reasons discussed above, some deliveries will continue to be made in small tankers directly to the refineries.

These calculations yield a throughput of 857,000 barrels per day or about two-thirds of the total crude requirements for the ten refineries (line 7). Even this quantity is optimistic since it represents 90% of the 'market' as defined by the ten refineries. The lack of participation by any one of the larger refineries would reduce throughput by an additional 10% or more.

Table 18
ESTIMATION OF CRUDE OIL THROUGHPUT FOR CRUDE OIL HANDLING FACILITY

	barrels/day
1. Projected crude receipts for ten refineries (estimated at about 85% of capacity—see Table 6)	1,320,000
2. Less domestic deliveries (estimated at 15%)	198,000
3. Estimated foreign deliveries	1,120,000
4. Less high pour point crudes (estimated at 15% of foreign imports)	168,000
5. Potential COHF market from ten refineries	952,000
6. Less 10% for miscellaneous deliveries	95,000
7. Estimated throughput	857,000

Second estimate of crude oil throughput

A more detailed method for estimating throughput involves analyzing the distribution of refinery receipts by major geographic area for each refinery group. The source areas for crude oil imports determine the practicality of using VLCCs as well as the economic benefits to be gained. In general, it is assumed that the large volume, long distance deliveries, especially from the Arabian Gulf, but also including West and North Africa, offer advantages for VLCCs. Deliveries from the Caribbean area are much less likely to employ VLCCs. Also, with source areas identified, some account can be taken of crude oil types and port facilities. The estimates presented in Tables 19 and 20 take these factors into account and are based on data from the years 1977 to 1979.

Table 19 shows estimated throughput from the eight refineries along the Delaware River by geographic area. It is assumed that 80% of deliveries from the Arabian Gulf and 75% of deliveries from West and North Africa would pass through a bulk terminal. Only 10% of the remaining imports and domestic is assumed as throughput. Throughput for these refineries is estimated at 60% of total crude deliveries or 561,000 barrels per day.

Table 20 gives comparable estimates for the two refineries in northern New Jersey. Since there are fewer varieties of crude oil processed by these plants, with a lower proportion of high pour point crudes, it is assumed that 85% of Arabian Gulf deliveries and 80% of African deliveries could pass through a bulk terminal. The large proportion of receipts in the 'other' category (41%) adds greater uncertainty to this assessment. Because of the potential quantities involved, deliveries from the North Sea and Mexico may offer possibilities for using tankers larger than 100,000 dwt. It is assumed that 30% of these deliveries would provide throughput for a bulk terminal. Throughput for these two refineries is estimated to be 62% of total deliveries or about 240,000 barrels per day.

Comparison of throughput estimates

The two methods of estimating throughput are independent calculations which are similar in result. A comparison is shown in Table 21. The second method more easily takes into account changes in assumptions about crude oil supply sources and delivery methods. Those estimates have been carried forward into subsequent chapters. The total of 802,000 barrels per day for the second estimate appears to be conservative and therefore should not distort seriously the determination of environmental and economic feasibility for a deepwater terminal.

Table 19
ESTIMATED CRUDE OIL THROUGHPUT FOR BULK OIL TERMINAL: SOUTHERN REFINERIES
(barrels per day)

Source Area	% of Total	Total Receipts	% From Area Thru Terminal	Throughput for Bulk Terminal
Arabian Gulf	23%	210,000	80%	168,000
West Africa	30%	280,000	75%	210,000
North Africa	23%	215,000	75%	161,000
Other Imports	24%	225,000	10%	22,000
Total	100%	930,000	60%	561,000

Source: "Imported Crude Oil and Petroleum Products," monthly reports for 1979, American Petroleum Institute and estimates by Office of Energy, Port Authority of New York and New Jersey.

Table 20
ESTIMATED CRUDE OIL THROUGHPUT FOR BULK OIL TERMINAL: NORTHERN REFINERIES
(barrels per day)

Source Area	% of Total	Total Receipts	% From Area Thru Terminal	Throughput for Bulk Terminal
Arabian Gulf	49%	190,000	85%	161,000
West Africa	9%	34,000	80%	27,000
North Africa	1%	6,000	80%	5,000
Other Imports	41%	160,000	30%	48,000
Total	100%	390,000	62%	241,000

Source: "Imported Crude Oil and Petroleum Products," monthly reports for 1979, American Petroleum Institute and estimates by Office of Energy, Port Authority of New York and New Jersey.

Table 21
COMPARISON OF THROUGHPUT ESTIMATES
(barrels/day)

	First Method	Second Method
Northern refineries	—	241,000
Southern refineries	—	561,000
Total	857,000	802,000
as % total receipts (1,320,000 bbls/day)	65%	61%

CHAPTER FOUR

TECHNOLOGICAL CONSIDERATIONS RELEVANT TO DEEPWATER OIL TERMINALS

Within the restrictions and conditions imposed by laws and regulations, there is a wide range of options for the configuration and technical components of a marine crude oil handling facility, located either offshore or inshore. This chapter provides information on some of the major technologies available for such a facility. All of the onshore components of a conventional offshore DWP would be required by an inshore terminal. Hence, a discussion of the systems from the tanker unloading point to the crude oil storage point for a DWP will include the systems associated with an alternative facility nearer shore.

Design alternatives for deepwater ports

The design of a deepwater terminal must take into account the operational and environmental concerns specific to the proposed construction site. There have been a number of detailed studies which have examined the variety of mooring configurations designed to accommodate deepdraft vessels. The principal design alternatives are discussed below.

Conventional pier — A conventional pier is a type of platform structure which rests on pilings driven into the sea bottom. Conventional piers have direct access to shore from the loading platform with pipelines suspended above the water on a pier or pipe trestle. The mooring of a supertanker at a conventional pier or sea island requires tugs and sometimes launches. In all cases tankers are moored bow and stern on a fixed heading.

Sea island — A sea island consists of a landfill area with either pier or seawall berthing arrangements. Submarine pipelines commonly are used to transport the oil ashore, though a barge or tanker shuttle service may also be used. As with conventional piers, tankers are moored on a fixed heading using tugs and sometimes launches for line handling.

Conventional buoy moorings — Conventional buoy moorings (CBMs) or multiple buoy moorings have been used widely for oil transfer operations with tankers. Usually the tanker drops its bow anchors and connects bow and stern mooring lines to buoys which are attached to the sea bottom by chains and anchors. The oil cargo is offloaded into barges or another tanker.

Single point moorings — The most popular technique for mooring and offloading crude oil tankers is now the single point mooring (SPM) concept. The SPM is a single buoy unit held in place with chains attached to anchors or to piles in the ocean floor. Compared with the berthing or mooring configurations described above, the SPM unit is more efficient and practical in remote offshore locations and where sea and weather conditions are severe. Mooring forces are minimized since the tanker, attached to the buoy only by its bow line, is free to assume a position of least resistance to wind, wave and current. An offloading tanker can remain moored to or a departing tanker can put to sea from an SPM during severe weather but generally an arriving tanker can make fast to an SPM only when conditions permit mooring launches to operate.

There are two types of SPMs in current use - the catenary anchor leg mooring (CALM) and the single anchor leg mooring (SALM). The CALM type of SPM is a cylindrical steel hull ranging in size from 33 to 50 feet in diameter, which serves as a stationary floating platform (see Figure 13). A turntable or similar device on the buoy supports a rotating mooring arm to which the vessel's bow line is attached. The turntable also supports a rotating cargo manifold to which the tanker-to-buoy floating hose lines are connected.

An undersea hose system connects the underbuoy side of the rotating cargo manifold to the pipeline end manifold which, in turn, is connected by submarine pipelines to shore installations. A CALM for supertankers is normally kept in position with six to eight pretensioned chains attached to piles driven into the sea bottom.

A relatively recent advancement over the CALM is the single anchor leg mooring (SALM) (see Figure 14). The SALM differs in design in that the mooring buoy is anchored to a base on the sea floor by means of a single mooring chain which is attached some 60 feet or more below the ocean surface to a base universal joint at the top of the anchor leg. The cargo hoses are connected to this swivel unit far below the sea surface. The mooring buoy on the SALM is approximately 16 feet in diameter and 25 feet high. The SALM can be installed in a wide range of water depths and is adaptable to many seabed locations.

Appendix C gives a list of 37 single point moorings that have been installed worldwide since 1978. There have been over 160 installations since 1959. This includes over fifteen SALMs with the remainder being mostly CALMs.

Design comparisons

A comparison of DWP design alternatives shows that certain constraints associated with the use of conventional piers, sea islands and conventional buoy moorings are lessened with SPMs. Considering the elements to be a constraint, SPMs allow tankers to remain moored and transfer cargo in heavier weather than with the other types of DWPs. Another major constraint is economics. Sea islands or artificial islands are estimated to cost from five to ten times as much as an SPM installation.

Although conventional buoy moorings cost less to install and are less susceptible to maintenance problems than SPMs, a conventional buoy mooring entails a great number of operational limitations and disadvantages compared with SPMs. In general, SPMs have distinct advantages over other offshore installations in terms of operational criteria and minimal environmental impact during construction.

Between the two types of SPM installations, the SALM requires more shipyard fabrication than the CALM and is somewhat easier to install in water depths in excess of 100 feet. The comparative costs of SALMs and CALMs in deep water are determined by local shipyard costs and the costs of the heavy link chain used for the CALM. In many deepwater installations the costs of CALMs and SALMs are very similar. Recent experience with SALMs gives them an operational advantage over CALMs under conditions of severe weather with less susceptibility to damage by tankers and heavy seas.

Ultimately, each of the various DWP alternatives must be evaluated in relation to the particular geographic circumstances, weather and sea conditions, frequency of tanker movements and volume of crude oil throughput for any proposed site. Conventional piers and sea islands necessarily need to be located fairly close to the coastline and in shallow water. The availability of tugs and launches must also be taken into account. Various studies, including those conducted by the U.S. Army Corps of Engineers and the U.S. Department of Transportation (see Appendix A), have concluded that some type of SPM is preferable for the requirements and conditions of the U.S. Atlantic Coast. Given the water depths and sea conditions off the New Jersey coast, it seems likely that an engineering feasibility study would recommend a SALM installation for this region because of the operational advantages mentioned above.

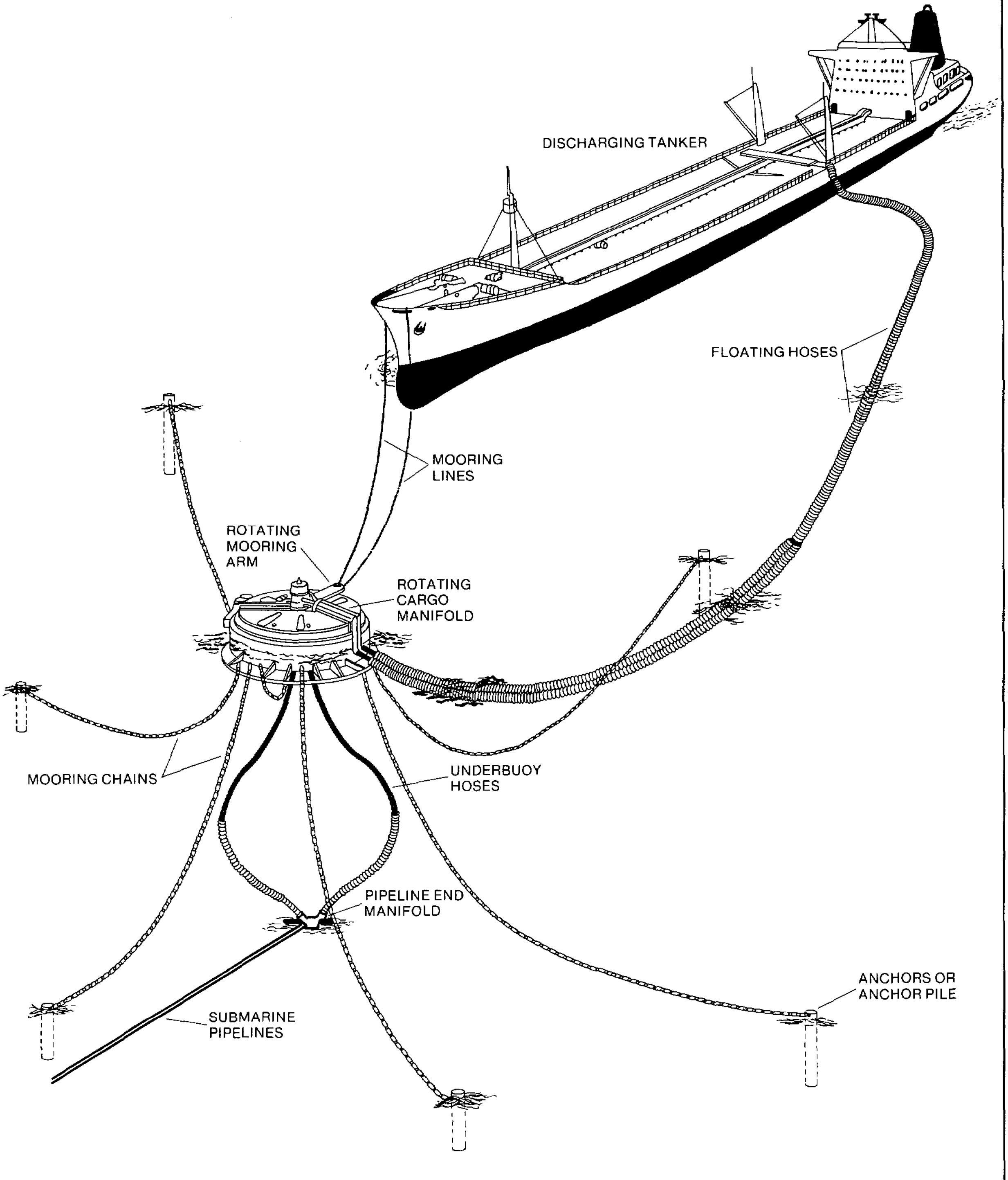
Pipeline regulations and technology

The pipeline system is one of the most important components of any crude oil handling facility. The transportation of petroleum by pipeline is regulated by the federal government, as well as by numerous other agencies at the state and local levels.

The most important pipeline regulations are those of the U.S. Department of Transportation (USDOT), especially the Federal Liquid Pipeline Safety Regulations (Part 195 of Title 49, *Code of Federal Regulations* as revised). These regulations specify the minimum design requirements for new pipeline systems including internal and external design pressures. The regulations also provide construction criteria for inspections, welding and burial requirements, hydrostatic testing standards and general requirements for operation and maintenance. There are also rules governing the reporting of any failure in the pipeline system including any resulting damage to property or persons. These regulations are administered by the Office of Pipeline Safety Regulation of the USDOT.

State-of-the-art technologies for operating and monitoring pipelines have made them a secure and preferred means for transporting oil since they cause less contamination from spills and evaporation than transportation by ship, barge, rail or truck. The New Jersey Coastal Management Program, for example, clearly prefers pipeline deliveries of oil and natural gas from offshore wells, stating that 'pipelines ... are the preferred and more environmentally sound method' of transportation (State of New Jersey, May 1980, p.199).

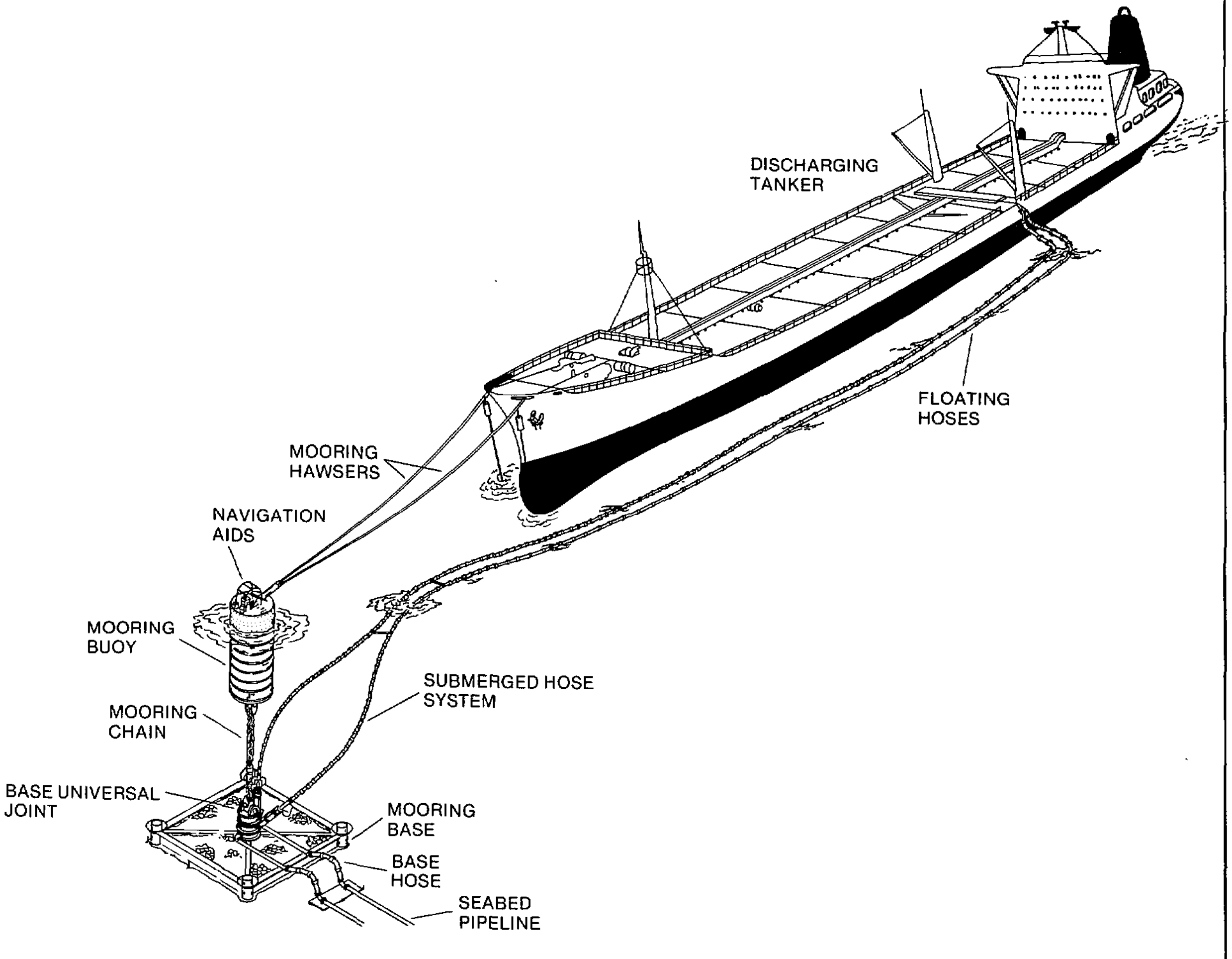
Catenary Anchor Leg Mooring System



SOURCE: IMODCO, The Offshore Marine Terminal Company.

FIGURE 13

Single Anchor Leg Mooring System



SOURCE: IMODCO, The Offshore Marine Terminal Company

FIGURE 14

The planning for a new pipeline system needs to begin at an early stage in the facility design. Proper planning takes into account the terrain and soil conditions of a particular site in order to minimize the adverse environmental impacts of the construction phase. A detailed description of the factors involved in constructing pipelines can be found in 'OCS Natural Gas Pipelines: An Analysis of Routing Issues,' by Rutgers University and the New Jersey Department of Energy (March, 1980). Additional useful information on submarine pipeline construction techniques is contained in 'Report on Design of Single Buoy Mooring Terminals,' prepared for the U.S. Army Corps of Engineers by Dravo Van Houten (November, 1975).

Pipeline installation at the landfall of a submarine pipeline and in waterway crossing areas is a principal concern. The depth at which such a pipeline is buried depends upon the erosion rate at the specified location and the depth of sediment over bedrock along the pipeline route.

In traversing urban areas, the environmental disruptions that may occur from pipeline construction would be incurred mainly by local residents. If highway rights-of-way are used, careful planning and coordination with state and local agencies can prevent unnecessary delays and disruptions in transportation routes. The construction and operation of pipelines in sensitive environments such as wetlands, forest lands or any protected regions may require special construction techniques and mitigating measures.

The operating concerns of an oil pipeline focus on spill prevention through adequate inspection and maintenance. Standards for inspection and maintenance are contained in the federal regulations cited above and are supplemented by state and, in some cases, local laws.

Pumping systems — An understanding of the design of the pipeline pumping and monitoring system is critical to assessing the anti-pollution and safety measures which have been developed to manage such a system. The following sections describe in detail some theory and operational aspects of the pumping and metering system for an oil facility.

Onshore pump station — The pumping pressures available from tanker cargo pumps vary considerably. Newer vessels have discharge pressures in the range of 100 to 150 psi, and often this is adequate to reach a nearby storage tank farm. Where tanker pressures are not adequate, it is necessary to provide an onshore pumping station to boost the pressure to enable the oil to reach the tank farm.

The capacity of the booster pumps should equal the maximum offloading rates of tankers using the facility. A number of pumps should be installed to allow for varying unloading rates and to provide a standby unit during pump maintenance. Centrifugal type pumps are recommended as they are high-speed, high-volume pumps which produce relatively even and smooth flows. Other advantages are their simple construction and comparatively low cost.

Storage tank farm pumping systems — The filling of the storage tanks is usually accomplished by the pressures developed by remote pumps, ordinarily those at the onshore pumping station. A separate pumping system is required at the tank farm for oil transfers between tanks or for distribution to a refinery.

The tank farm pumps are usually a vertical turbine type because they have the capacity to operate with low suction pressures. (The pressure developed by the height of oil in the tanks is quite low.) They may also serve as booster pumps when the pipeline distance to the refinery is long and higher pressures are required. As booster pumps, they provide positive suction pressure to prevent cavitation (vaporization of a fluid) in the mainline pumps, which are normally horizontal type centrifugal pumps. In centrifugal pumps, cavitation causes pitting of internal parts and produces tremendous shocks to the pump casings.

Pump selection — The elements that must be considered for pump selection include head (pressure differential across the pump), capacity, piping and characteristics of the fluid to be pumped.

Two characteristics of the fluid, viscosity and specific gravity, affect its ability to be pumped. Viscosity is resistance to internal flow; high viscosity crude oils require higher pump pressures. With some crude oils, viscosity increases rapidly at lower temperatures with the result that the quantity pumped will be reduced if pumping pressure remains constant as the temperature falls. Required pumping pressure varies directly with the specific gravity of the liquid pumped; the higher the specific gravity the higher the pressure needed to move that liquid.

Pipeline size is an essential factor in pump selection. Reducing the pipeline size causes a rapid increase in pressure requirements, which in turn increases energy and pump construction costs. Compared with 22-inch (inside diameter) pipe, 18-inch pipe requires about 2.5 times as much pressure for the same quantity. At the same pressure, a 22-inch pipe will have about 1.7 times the capacity of the 18-inch pipe.

An economic analysis should be performed to select pump and pipeline sizes to provide the lowest cost per barrel of crude oil pumped.

Pressure controls — With the increase in offloading rates and varying ship pumping configurations, pump station operating requirements have become more exacting. This is especially true of tightline systems and pipelines handling a variety of crude oils. To accomplish the pump station's function efficiently, automatic control devices are an integral part of the installation.

Pressure controllers are provided at each pumping station to maintain pressures within pipe and equipment tolerance and to maintain an identical pumping rate when multiple pumping stations are used in a tightline system (each station pumps directly into the pumps of the next station).

Automatic pressure controllers are used to maintain pressures. The controllers sense the rise or fall of the system pressure and relate it to a reference pressure which is normally an air system. Depending upon system pressure, air pressure opens or closes a diaphragm-operated control valve. Closing the valve increases the pressure drop across the valve, thereby lowering system pressure.

If system pressure continues to rise and approaches the safe working limit of the pipe, a pressure relief valve is used to lower the pressure. This valve, equipped with an internal spring, opens at a pre-set pressure and allows fluid to flow to a tank or back to the suction side of the pump. The effect is increased flow on the discharge side of the pump which, in turn, reduces system pressure.

Metering — The method of measuring crude oil commonly used in the past was tape-gauging of storage tanks and carrier compartments. This practice is often inaccurate because of vessel list and compartment configuration. Although gauging may still be used at some locations, the preferred method involves meters, provers and other instrumentation to provide custody transfer accounting. Metering improves accounting accuracy, reduces carrier turnaround time, allows control of different crudes in pipelines and can also provide a means of leak detection.

Meter types to be readily found in use are either positive displacement meters or turbine meters. The type used is determined in part by characteristics of the oil, flow rates, pressure, fluid temperature and space requirements. It is recommended that multiple meters be mounted in parallel; this configuration will allow closing off one or more meters during reduced flow operations or for meter proving or maintenance.

Meter proving systems — Meter readings are sensitive to changes in flow rate, fluid characteristics and age and wear of the meter assembly; therefore, a means of determining the effect of the changes is required. It is acomplished through the use of meter proving systems, from which a meter factor is derived. The meter factor is the ratio of the actual volume displaced divided by the volume shown on the meter.

Three types of proving systems in common use today are master meter provers, tank provers and pipe provers. The pipe prover system is frequently the system selected for proving meters because it can handle high flow rates, high vapor pressure fluids and can perform the proving function without interruption of flow.

Tanks — Tanks can be classified according to their function in two general categories: production tanks and storage tanks. Production tanks are those used in the producing fields to receive crude oil as it comes from the well. Storage tanks are designed for the storage and handling of a large volume of oil. The tank farm for the crude oil handling facility under consideration in this study contains storage tanks.

The two common construction techniques for storage tanks are riveting and welding. Most large new construction storage tanks have welded tank shells, which prevent leakage at the joints. Specifications for the construction of welded tanks have been established by the American Petroleum Institute.

A satisfactory tank foundation or 'pad' is one which provides a stable, well-drained surface with sufficient load-bearing capacity to support the floor of the tank. This may be flat or it may be 'coned up' or 'coned down'. Another feature of some tank pads is a concrete ring which encloses the entire foundation. This ring compensates for the extra load of the tank shell which rests on the ring when the tank is in place.

The grading of the tank site should insure that the bottom will be kept dry in order to minimize bottom corrosion. Methods of providing a suitable foundation depend on the location and kind of soil at the tank site.

The roof construction of tanks is of special importance for safety reasons and because of air pollution. Various types of special roofing have been developed for cylindrical tanks to reduce the evaporation losses of stored oil to the atmosphere. The special types of roofing are the floating roof, the breather roof, the balloon roof and the lifter roof. The floating roof has gained wide acceptance, since evaporation losses are less than with any other type of roof. Since the floating roof almost certainly would be used in the tanks under study here, other roofs will not be described.

A floating roof actually floats on the surface of the oil and rides up and down the tank shell as the oil level changes. Tanks with floating roofs also have a wind guider installed around the outside of the tank at or near the top. This stiffens the tank shell and helps maintain the tank shape when the floating roof is low in the tank.

In its simplest form, the floating roof is a large flat pan, slightly smaller in diameter than the inside of the tank shell. It is provided with a system of flexible 'shoes' to enclose the space between the edge of the roof and the tank shell. Some newer floating roofs have two separate decks of steel plate over the entire tank area. The space between the upper and lower decks is divided into compartments. With these double-deck types, the oil is never in contact with the underside of a plate whose top surface is directly exposed to the sun. As a consequence, evaporation losses for the double-deck floating roofs are less than for those of any other type.

With a floating roof, the vapor space has been virtually eliminated under the roof, and there is no vapor discharge when pumping into the tank. 'Breathing' from temperature changes is reduced greatly because the actual vapor space is so small. Danger from fire is reduced because the oil surface is almost entirely covered.

The need for mechanical maintenance of the seals is a disadvantage. This can be minimized by constructing all-welded tank shells with butt joints throughout to provide the smoothest possible interior surface. In some climates rapid accumulation of water in time of heavy rainfall or the weight of heavy snowfall may cause the floating roof to sink unless preventive action is taken. In general, floating roofs are most suitable where tanks are filled and emptied frequently and where the risk of fire is a major concern.

CHAPTER FIVE

INVESTIGATION INTO THE ECONOMIC FEASIBILITY OF AN OFFSHORE DEEPWATER PORT AS AN ALTERNATIVE TO CURRENT CRUDE OIL SHIPPING OPERATIONS

As stated previously, a variety of technologies and designs are applicable as alternatives to present modes of crude oil delivery to the New York Harbor and Delaware Bay regions. Each alternative offers certain advantages and disadvantages. However, economics will be the critical factor in the feasibility of a crude oil handling facility. Economics also will dictate which alternative should be more closely scrutinized for its environmental, social and institutional implications.

Economic criterion

With respect to this study, the minimum economic criterion for an alternative crude oil handling facility is whether it produces transportation cost savings over present crude oil delivery methods. Unless transportation cost savings are sufficient to pay for the facility, the facility will not be considered economically feasible. (See note.)

This simple definition of economic feasibility does not take into account the level of savings over and above project costs required by the oil companies as an incentive to participate. There are also considerations which could affect the ultimate economic feasibility of alternatives to current delivery practices but which are incalculable at this time. Examples of such considerations, which could influence the economic viability of a marine facility which depended upon a deepened channel, would include any port user fee or channel user fee levied against deepdraft vessels to recoup the cost of acquiring and maintaining such channel depth. However, if the basic economic criterion applied here is not met, consideration of additional factors is pointless.

In order to determine whether there is a more acceptable crude oil handling practice than exists at present, estimates of future crude oil marine transportation costs and costs of building and operating the various proposed facilities were analyzed. The derivation of these estimates is described below.

Note: These cost savings are defined as the difference in delivery costs per barrel between current practices and delivery via VLCCs to a deepwater crude oil handling facility either offshore or in-harbor. The costs of building and operating a new facility would have to be paid out of the transportation cost savings as defined.

Marine transportation costs

In developing estimates of the costs of delivering crude oil to the region's refineries, a computer program was used with a standard format for calculating voyage, operating, and capital costs on a per barrel delivered basis. (See note.) Cost estimates were generated for the major trade routes using various assumptions concerning ship size, bunker fuel costs and port charges. These estimates were then compared to rates in the international tanker charter market for the present and recent past. These estimates were reviewed and verified as reasonably accurate by several major oil companies currently delivering crude oil to the region. Lightering costs were reviewed and verified by the oil companies currently operating in the New York Harbor and Delaware River areas as well as by various barge companies.

The estimated savings from any new deepwater facility studied here arise primarily from the economy of scale of large tankers as discussed in Chapter One. The cost calculations presented on the following pages are based on varying assumptions about voyage costs and certain fixed assumptions about operating and capital costs.

Note: In order to determine the transportation cost savings, a brief description of the three categories of marine transportation costs is necessary. Voyage costs are the marginal costs of employing a vessel in a particular trade defined as the roundtrip voyage between two designated ports. These costs consist of bunker fuel costs, port charges and applicable canal fees. Operating costs include labor, stores and supplies, repairs and maintenance, insurance and administration. Capital costs include vessel construction, interest on construction costs, return on investment and government subsidies.

A detailed assessment of the true economic costs or fully built-up costs of employing a vessel (capital plus operating plus voyage costs) would include a sensitivity analysis of the assumptions affecting capital and operating costs as well as voyage costs. Such a detailed analysis of capital and operating costs is beyond the scope of this study. Reasonable estimates of these costs as well as assumptions concerning these costs, which have been taken from reports submitted to the U.S. Congress by the Federation of American Controlled Shipping (a trade group representing American owners of foreign flag vessels), have been used in this study. The capital and operating costs are treated as a fixed operating cost per day for a given size tanker. Additionally, it should be noted that all costs presented in this study apply only to foreign flag vessels.

In this study, close attention has been given to voyage costs since these represent the marginal costs of operating a vessel for a given trade. These costs have increased substantially in the past ten years. In analyzing voyage costs, bunker fuel prices were varied between $175 and $300 per ton which reflects the range in bunker prices in the past three years. However, the values presented in the following tables are based upon an assumed bunker fuel price of $200 per ton, a typical value in mid-1981.

Since the escalation of bunker fuel prices beginning in the early 1970's, the relative proportions of capital, operating and voyage costs have changed drastically. In some cases, voyage costs have risen to well over 50% of fully built-up costs. As a result, voyage costs now dominate the total true economic costs of marine transportation.

Estimates of the cost of shipping crude oil have been developed for each of the prinicpal geographic sources of crude oil for the East Coast refineries, namely, the Arabian Gulf, West Africa and North Africa. A detailed explanation of the derivation of shipping cost estimates is contained in Chapter Seven. Estimates have been made for each of the major alternatives for delivery, i.e., delivery to an offshore deepwater port in a 260,000 dwt tanker and delivery to an in-harbor terminal in a 185,000 dwt tanker. These estimates by geographic area and transportation scenario are shown in Table 22 for the offshore DWP and in Chapter Six, Table 26 for the inshore alternatives.

Table 22 shows that the current cost of delivering a barrel of oil to the East Coast from the Arabian Gulf is about $2.50. This includes the cost of transshipping in the Carribbean, losses due to evaporation, lightering and miscellaneous costs at the final destination point. This cost compares with $1.80 per barrel for the same delivery by a 260,000 dwt tanker and $2.00 per barrel by a 185,000 dwt tanker.

Table 22
ESTIMATED MARINE TRANSPORTATION COSTS FOR CRUDE OIL DELIVERIES TO THE U.S. EAST COAST–I
(1981 dollars per barrel)

from	(a) Current operations[1]	(b) DWP w/ 260,000 dwt[2]
ARABIAN GULF[3]	$2.50	$1.80
WEST AFRICA	1.30	.80
NORTH AFRICA	1.10	.60

[1] As described in Chapter Two.

[2] The offshore deepwater port concept with direct deliveries by VLCCs as described in this chapter.

[3] The figures for the Arabian Gulf include transshipment costs in the Caribbean as well as the cost of the smaller tankers making final delivery to the U.S. East Coast.

The savings realized from employing large tankers is derived in Table 23. The table shows the full potential savings in column (a) followed by a weight factor in column (b). The weight factor is that portion of crude oil deliveries from each area which the larger tankers could be expected to deliver (i.e., in contrast to current practices). The percentages in column (b) are derived from Tables 19 and 20 in Chapter Three. Finally, column (c) shows the average savings on each barrel of crude oil delivered to an offshore DWP serving all ten refineries to be $.60 per barrel.

The estimates of marine transportation costs in this section are the result of extensive study. However, they do not reflect any detailed differences in individual companies' operations such as degree of reliance on chartering, differential access to terminals for transshipment, tax considerations, etc. Therefore, the figures have been rounded to the nearest $.10. The cost figures, however, should be sufficiently accurate to help determine the magnitude of transportation cost savings which can be expected from a crude oil handling facility. In essence, if the alternative under consideration does not show even a preliminary savings over costs, it is pointless to consider additional factors such as dredging costs, right-of-way acquisition, and the potential crossing of environmentally sensitive lands.

Construction cost estimates

Construction cost estimates are based on the system configuration required by site location (i.e., buoys, platform, pipeline, pumping stations, tank farm, etc.). The system configuration for each site was determined after consultation with manufacturers, construction firms, operators and users of similar facilities as well as an analysis of system configuration compatibility with some general engineering and environmental siting criteria.

Cost estimates for the offshore port facilities were derived primarily from the actual and proposed costs of LOOP and SEADOCK, two Gulf Coast deepwater port facilities comparable in many respects to those considered in this study. LOOP was essentially completed in 1981 at a cost in excess of $700 million (see descriptions in Chapter One).

The rough project costs for the facilities described here are based upon unit costs such as: cost per mile of pipe; cost per barrel of storage; cost per SPM buoy fully installed, etc. In each case, the total estimate includes all project costs. The unit costs were developed from contacts with engineering and construction firms which design and manufacture the components as well as from estimates found in industry publications for similar projects.

These estimates do not reflect specific site considerations such as variations in water depth, terrain over the pipeline route, and mitigation measures required for environmental reasons or permit stipulations.

Table 23
ESTIMATED MARINE TRANSPORTATION COST SAVINGS WITH OFFSHORE DEEPWATER PORT
(1981 dollars per barrel)

from	(a) estimated savings[1]	(b) % throughput from area[2]	(c) weighted average savings[3]
ARABIAN GULF	$.70	45%	
WEST AFRICA	.50	30%	$.60
NORTH AFRICA	.50	25%	

[1] Calculated as difference between columns (a) and (b) in Table 22.

[2] Derived from proportions presented in Tables 19 and 20.

[3] For estimating purposes it has been assumed that there are no contributions to the weighted average savings from the "other" areas as shown in the tables in Chapter Three.

General siting criteria

Deepwater ports are designed to accommodate VLCCs and ULCCs with draft requirements of up to 100 feet. These ports usually are located some distance offshore in order to accommodate the deep draft requirements of these vessels and consist of either a fixed island pier or some type of floating mooring system. As discussed in Chapter Four, the engineering configuration most appropriate and most economical for the Mid-Atlantic Coast is some type of single point mooring system.

Logically, if a deepwater port were to be constructed in the Mid-Atlantic region to serve the 10 refineries in the New Jersey/Pennsylvania/Delaware region it would be located between the New York Harbor area and the Delaware Bay. One requirement for such a facility is that it be located as close as practical to the shore as well as to the refinery locations. In adhering to this criterion, the costs of pipeline construction and maintenance would be minimized. Additional siting criteria, which would significantly affect construction and maintenance costs of other deepwater port facility components, are listed.

- **Adequate water depth** — For an offshore port, a minimum water depth of 90 feet is desirable in order to easily accommodate the majority of the deep draft vessels likely to use the facility.
- **Safe maneuvering area** — A designated approach, fairway, anchorage and restricted navigation zones around the buoys and pumping platform are required by the U.S. Coast Guard under provisions of the Deepwater Port Act of 1974. The DWP site should also be a reasonable distance from major shipping lanes to minimize risk of collision when tankers are maneuvering.
- **Feasible pipeline landfall** — The facility site should be chosen in such a way that there is a feasible landfall and pipeline route which will minimize pumping distances and yet at the same time minimize environmental damage from construction and operation of various components of the crude oil delivery system.
- **Protection from heavy weather** — There may be few, if any, alternatives among offshore sites which would have reduced exposure to heavy weather conditions. Even so, the severity of wind and sea conditions will affect engineering design criteria and could restrict the number of operating days for the facility.

Design criteria

Based upon the siting criteria mentioned above as well as the knowledge derived from the previous construction of other offshore crude oil handling facilities such as LOOP, a workable design for the facility was determined. This design also took into consideration the requirements of VLCCs, the needs of the refineries to be served as well as this study's previously specified general economic and environmental objectives. The preliminary design of the facility and the siting criteria were used to develop estimates of construction costs.

If constructed, the crude oil handling facility would consist of the following major components: offshore mooring buoys, pipelines, pumping stations and tank storage. These components are described briefly below.

1. **Offshore mooring buoys** — For an Atlantic Coast deepwater port, two single point mooring buoys are required for the approximately 800,000 barrels of crude oil per day to be handled by the facility. Two buoys would be sufficient to handle the expected number of tanker visits immediately upon arrival and to provide a back-up in the event of accident or other causes of operational breakdown. The buoy type would depend upon weather and sea conditions. Recent technical literature and the experience of several major oil companies favor the single anchor leg mooring (SALM) buoy described in Chapter Four.

2. **Pipelines** — The pipeline size is determined by the volume of oil to be handled and the tanker unloading rate. It has been assumed that the pipeline would be 48 inches in diameter and that the larger tanker's rated unloading capacity would be about 100,000 barrels per hour.

3. **Pumping stations** — The number of pumping stations depends upon the length of the pipeline and the type of terrain to be traversed. As a general rule, however, it is assumed that with flat terrain there would be a station every 30 miles.

4. **Storage requirements** — Storage requirements are mainly dependent upon the capacity of the port facility and the number of crude segregations the facility will be expected to accommodate. The U.S. Army Corps of Engineers has recommended that for unprotected offshore sites, there should be enough storage to handle 10 days of expected throughput. In the case of an offshore terminal handling 800,000 barrels per day, eight million barrels of storage would be desirable. Land requirements for this storage would be approximately 100 acres.

Selected sites

The sites in this study have been selected in accordance with the general energy facility siting policies of the New Jersey Departments of Energy and Environmental Protection. For instance, the pipeline routes have been selected after evaluating the state's CZM policy which recommends that, to the maximum extent practicable, pipeline routing should avoid off-shore munitions, chemical and waste disposal areas, heavily used waterways, geological faults, wetlands and significant fish or shellfish habitats. At a minimum, the pipeline corridors must avoid the Pine Barrens Exclusion Area and the developed areas along the coastline in order to minimize damage to the Barrier Islands and other undeveloped and recreational areas. If the crude oil handling facility is determined to be, at least initially, economically feasible, a more detailed evaluation of possible pipeline route alignments will be necessary.

The guidelines for the study stipulated that alternative sites be identified where possible. In the case of the offshore DWP, two sites have been examined. These sites were:

1. a site approximately twenty miles east southeast of Atlantic City; and,
2. a site approximately fifteen miles due east of Asbury Park.

Southern New Jersey DWP site — The southern New Jersey site is located about 20 miles east southeast of Atlantic City (see Figure 15). The platform would be in 90 feet to l00 feet of water on a relatively flat bottom at 39 degrees 8 minutes North, 74 degrees 6 minutes East. The terminal would consist of two buoys with 48-inch pipelines to the pumping and quarters platform and one 48-inch pipeline continuing to landfall twenty miles away.

Once ashore, another fifty miles of pipeline would be required to bring the crude oil to the Philadelphia - Camden area refineries. An additional sixty-five miles of pipeline would be required to carry the oil to the Perth Amboy and Linden area. A tank farm with a capacity of about eight million barrels would be needed at the junction of the north-south pipeline runs. As shown in Table 24, a preliminary cost estimate for such a

Table 24

ECONOMIC SUMMARY OF OFFSHORE DEEPWATER PORT ALTERNATIVES

	Southern Location	**Northern Location**
1. Facility crude throughput[1] (barrels/day)	800,000	800,000
2. Pipeline distance (miles)	135	105
3. Pumping requirements (millions of barrel-miles/day)	76	58
4. Rough project cost (million $)	$1,800	$1,500
5. Variable operation & maintenance costs[2] (millions of $/yr)	120	90
6. Fixed operation & maintenance costs (millions of $/yr)	53	41
7. Approximate cost per barrel throughput[3] ($/barrel)	$1.50	$1.20

[1] See Chapter Three.

[2] Includes primarily energy costs.

[3] Project costs are amortized over 20 years at 14.5% per year. Estimates of operation and maintenance costs for the first year of operation also included. Annual amortization cost plus annual operating and maintenance costs are divided by 292,000,000 barrels (800,000 b/d x 365) to come up with a cost per barrel throughput for the first year of facility life.

facility, without environmental and institutional criteria taken into account, would be about $1.8 billion. The approximate cost per barrel throughput for the southern New Jersey site is $1.50.

Northern New Jersey DWP site — The northern New Jersey site would be located about 15 miles due east of Asbury Park (see Figure 16). The platform is in 100 feet to 110 feet of water on a relatively flat bottom at 40 degrees 14 minutes North, 73 degrees 42 minutes East. The site is located between the inbound Barnegat to Ambrose traffic lane and the outbound Hudson Canyon traffic lane. The buoy and platform configuration would be the same as that for the southern location.

For the northern site, a total of one hundred five miles of pipeline would be needed as well as a tank farm. A preliminary cost estimate, as shown in Table 24, is $1.5 billion. This estimate is about $300 million or 17% lower than the southern facility because of the shorter pipeline runs. The approximate cost per barrel throughput for the northern DWP is $1.20.

Economic analysis of constructing an offshore DWP

A comparison of the transportation cost savings and the cost per barrel of throughput applicable to the two locations of the full service deepwater port offers a test of their economic feasibility. As summarized in Table 25, the transportation cost savings offered by an offshore DWP is $.60 per barrel, in 1981 dollars, regardless of location. This savings has been escalated by 10% per year to arrive at 1986 dollar savings of about $1.00 per barrel. In view of the stabilization of bunker fuel prices in late 1981, this escalation rate is probably too high. Also, the tanker market continues to be depressed so that the cost savings for 1981 may change little in the next several years. Therefore, the 1986 savings represent an optimistic assumption about the economic benefits of an offshore terminal. The facility cost per barrel of throughput, assuming 800,000 barrels per day, is $1.50 for the southern location and $1.20 for the northern one. In both cases the facility costs exceed the potential savings; by $.50 per barrel for the south location and by $.20 per barrel for the north. This demonstrates that the total throughput required to finance an offshore DWP is greater and, depending on the accuracy of the savings estimate, may be substantially greater than East Coast refineries can be expected to provide.

If, in the future, the environmental needs were to become so great that an offshore DWP appeared desirable despite high economic costs, a large public subsidy would be necessary. Based on the estimates developed here, this subsidy would be about $50 million to $80 million per year or a one-time capital grant of about a billion 1981 dollars.

A comparison of these facilities with LOOP is useful in regard to their feasibility. The LOOP project began eight years ago and cost about $700 million, or less than half as much as estimates for either of the DWP facilities discussed here ($1,800 million and $1,500 million). The difference in compared costs is due both to inflation and higher interest rates as well as to greater pipeline and above ground storage costs. Yet, LOOP expects to handle up to 1,400,000 b/d compared with only 800,000 b/d for a New Jersey deepwater port. The managers of LOOP have observed that no comparable facility is feasible for the Mid-Atlantic refineries.

Table 25
COMPARISON OF TRANSPORTATION SAVINGS AND FACILITY COSTS: OFFSHORE DEEPWATER PORT
(Opening Year, 1986)

	Facility cost/barrel throughput	Transportation savings/barrel
DWP—South location	$1.50	$1.00
DWP—North location	$1.20	$1.00

Offshore Deepwater Port Site: Southern New Jersey

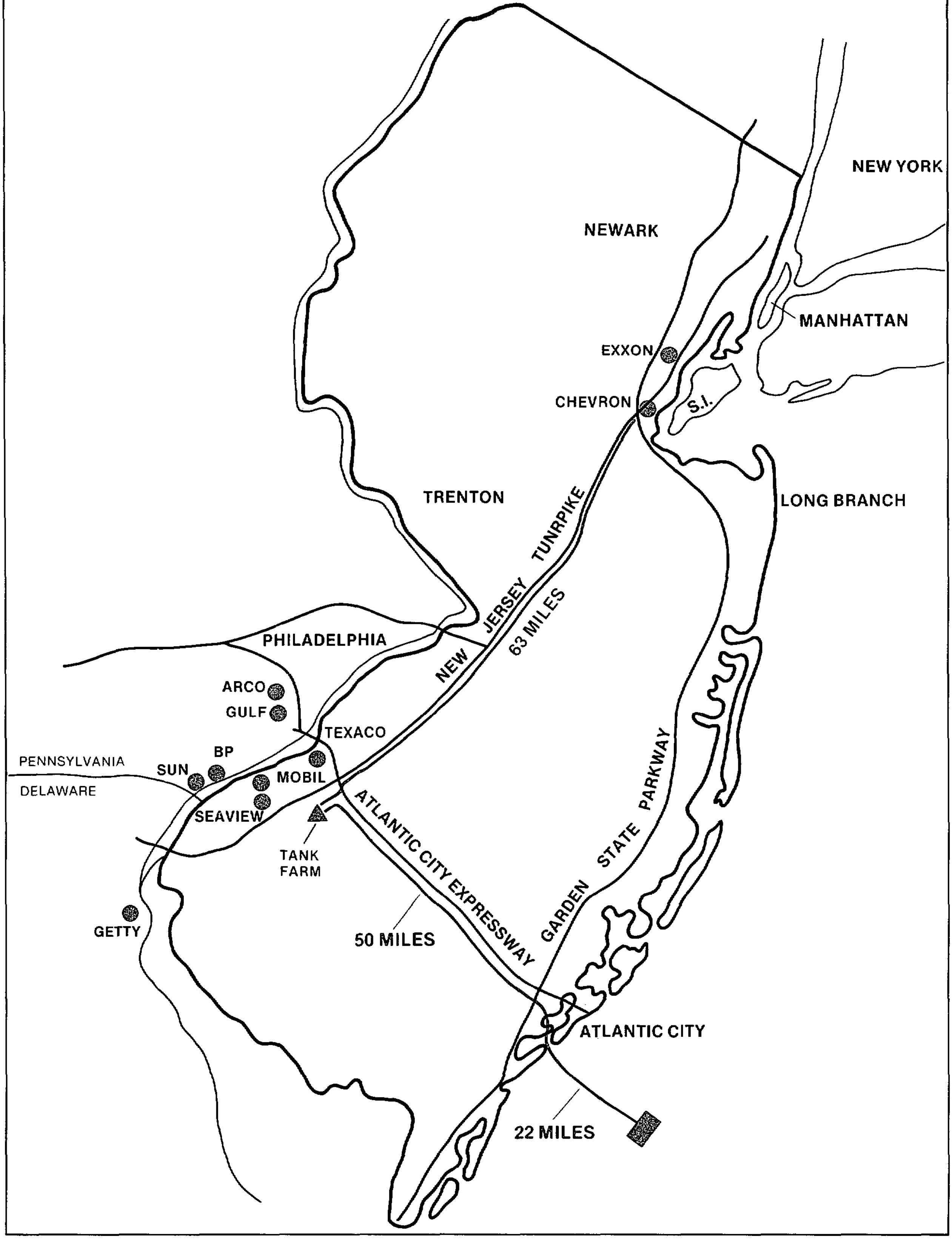
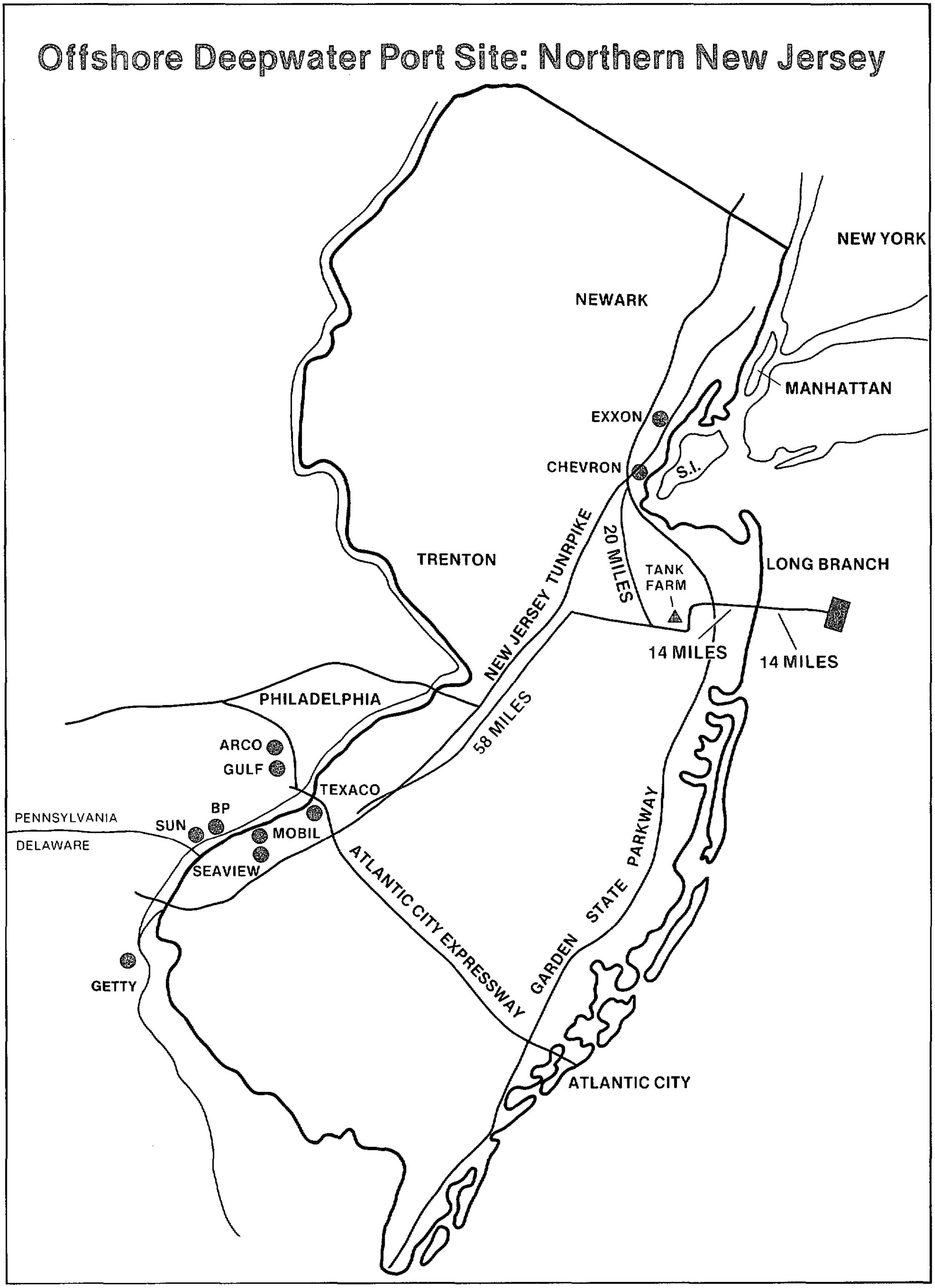


FIGURE 15



Offshore Deepwater Port Site: Northern New Jersey

FIGURE 16

Another difficulty with adapting the concept of an offshore DWP to the needs of the Mid-Atlantic refineries is that the facility cannot be scaled down easily to accommodate lower volumes of throughput. This is due in part to the long submarine pipeline distances required. For the New Jersey coast the buoys must be located fifteen to twenty miles offshore in order to find adequate water depths to accommodate ULCCs. There is also the need to construct long distance land pipelines due to the lack of an existing onshore crude oil pipeline system for the Mid-Atlantic refineries. Additionally, the major components of any facility - offshore platform, pumping stations and tank farm - have a high minimum capital cost.

In summary, an offshore deepwater port serving the Mid-Atlantic refineries does not appear to be economically feasible and is not likely to become feasible in the foreseeable future.

CHAPTER SIX

INVESTIGATION INTO THE ECONOMIC FEASIBILITY OF AN IN-HARBOR CRUDE OIL HANDLING FACILITY FOR DELAWARE BAY AND NEW YORK HARBOR

Upon reviewing the economics of the proposed deepwater port facilities described in the previous chapter as well as engineering and environmental criteria, it was determined that alternatives to an offshore deepwater port should be investigated. The general criteria for feasibility guiding the investigation of one alternative, an in-harbor crude oil handling facility, were similar to those stated for the offshore port. Thus, the general assumptions guiding the investigations of an in-harbor alternative were:

- a crude oil handling facility should offer environmental benefits over current practices
- a new facility should be financially self-sufficient

The first criterion requires minimizing the transfer and handling of crude oil. This suggests scaled down versions of the pipeline delivery systems described in Chapter Five. Any in-harbor site would also have to consider the routing of the oil pipeline and siting of associated facilities such as a tank farm and pumping stations.

The second criterion requires a determination of the minimum vessel size and channel depth needed to realize transportation cost savings which would make a facility economical. This determination was made from numerous discussions with oil company representatives and by examining the transportation economics of the larger tankers.

It was apparent that the economies offered by tankers smaller than VLCCs (that is, less than 175,000 dwt) would not be sufficient to pay the capital cost of constructing a new facility. Tankers in the 150,000 dwt to 175,000 dwt sizes with drafts of 53 feet to 57 feet offer cost savings which are significantly less than those in the VLCC class (see Figures 2 and 3 in Chapter One). However, savings from employing tankers near the bottom of the VLCC class (which ranges from 175,000 dwt to 299,999 dwt) do begin to achieve the economies of scale which would offset capital costs of a new terminal. Vessels in the 175,000 dwt to 200,000 dwt size range are the minimum size which yields significant transportation cost savings.

The economic analysis in this and subsequent chapters assumes, for planning purposes, the minimum vessel size to be 185,000 dwt. The draft for these vessels is between 59 feet and 62 feet. Again, for planning purposes, a 60 foot draft requirement is assumed. The vessel size of 185,000 dwt and the associated requirement for a channel depth of 60 feet constitutes the minimum threshold for the economic feasibility of an in-harbor deepdraft terminal.

It should be reiterated that the determination of economic feasibility is based upon a crude oil throughput of about 240,000 barrels per day for the northern New Jersey facility and about 560,000 barrels per day for the Delaware Bay (see Chapter Three). Also, the costs for channel deepening are not included in the facilities' capital cost estimates. Any decrease in the throughput estimate or the inclusion of dredging costs would require greater savings than those shown here and therefore the employment of larger VLCCs.

Examination of the in-harbor alternative

The study team explored a broad range of alternative deepwater facilities serving the refineries in the region. These included offshore DWPs serving separately the northern and southern groups of refineries. Each of these offshore alternatives proved to be uneconomical because, while the capital costs were slightly lower since onshore pipeline distances were reduced, potential throughput was also reduced significantly. Also, as with the DWP alternatives analyzed in Chapter Five, the offshore alternatives could not be scaled down easily. A fixed pier facility for Delware Bay was considered briefly. Due to the distance of existing deepwater from shore, however, such a pier would not be as practical or as economical as the SPM mooring concept described below.

The alternatives, examined on the following pages, require in-harbor or in-bay facilities to serve each group of refineries in the north and south separately. In-harbor sites were selected in both Delaware Bay and New York Harbor according to the following criteria:

1) minimal dredging requirements by virtue of naturally deep water;
2) minimal pipeline distances with locations near existing refineries;
3) avoidance of environmentally sensitive areas.

Despite the exclusion of the dredging of federally maintained channels from the quantitative analysis of economic and environmental impacts, general dredging requirements were considered in evaluating the practicality of certain sites. For instance, during the initial investigations of sites for the northern facility, several possible locations in Raritan Bay were studied. With one exception, these locations were generally considered less desirable since the channel improvements would involve considerably more dredging than locations in Upper New York Bay and provided little opportunity for use by vessels other than oil tankers. The one exception would have taken advantage of a plan by the U.S. Navy to improve its terminal for Earle Naval Weapons Station which would have involved substantial channel deepening. This project has been cancelled.

Vessel characteristics

The VLCCs which would use the in-harbor facilities are larger than the typical tankers now delivering both to the Delaware Bay and New York Harbor refineries. Certain characteristics of these larger vessels need to be considered both for terminal design and for the impact on port operations and the environment. As discussed earlier, the typical tanker would be about 185,000 dwt and would require at least a 60 foot channel.

If the trend in bulk carriers now being built by the Japanese continues, future tanker designs will permit an increase in cargo tonnage for a given draft. The beam of a 185,000 dwt tanker is presently about 160 feet, and this could increase by 20% to 40% for any new design shallow-draft vessels. These vessels now range between 1030 feet and 1075 feet in length. Such dimensions compare with a length of about 800 feet and a beam of 125 feet for an 85,000 dwt vessel.

Figure 17 shows a tank configuration typical of the size-class appropriate to this facility. Typically, the wing tanks are 20-30% smaller in capacity than the center tanks. The ballast tanks are generally located on either side of the amidships line on both the port and starboard sides. The number of center and wing cargo tanks is typically five or six and ten or twelve, respectively.

Wing tank capacity for vessels of this size-class range between 65,000 and 85,000 barrels. Center tank capacity averages 100,000 barrels. Cargo pump capacity is typically about 15,000 tons of water per hour or about 90,000 barrels of crude oil per hour.

Economic criteria for an in-harbor alternative

The principal economic criterion for an in-harbor alternative is the same as that set out for the offshore DWP in Chapter Five. This requires that the cost of the new facility be paid out of marine transportation savings due to reduced costs from the use of deepdraft tankers. As already mentioned, the estimated costs of the new facility have not included any federal channel dredging costs since traditionally these have been assumed by the public sector.

For purposes of estimating marine transportation costs, it has been assumed that the delivered costs of crude oil are the same to Delaware Bay and New York Harbor. This equation of delivery costs is justified primarily by the almost equal distances to each port from the major oil exporting areas. There are marginal differences in the delivery costs to the two ports. The lower costs for deliveries to Delaware Bay are due to 60 and 70 foot anchorages in the lower Bay. This advantage is offset somewhat by the need to lighter a larger portion of the cargo since the Delaware River channel is only 40 feet deep. Also, the greater distance from the channel entrance to the refineries in the Delaware River Valley (60 to 100 miles) increases delivery costs for both barge and tanker movements, creating additional offsets to the economies of scale in the larger tankers.

Typical Tank Configuration for a VLCC

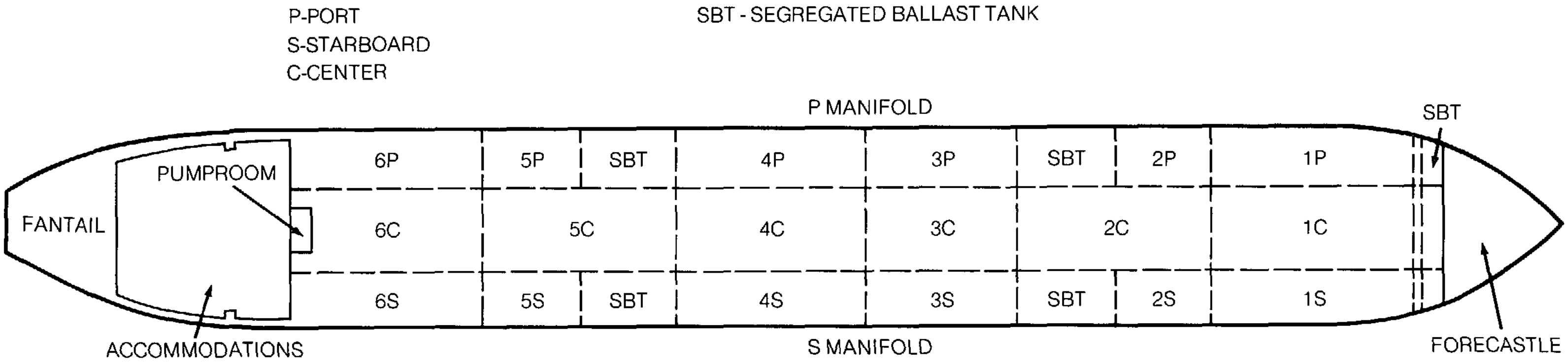


FIGURE 17

In-Harbor Deepwater Terminal Site: Delaware Bay

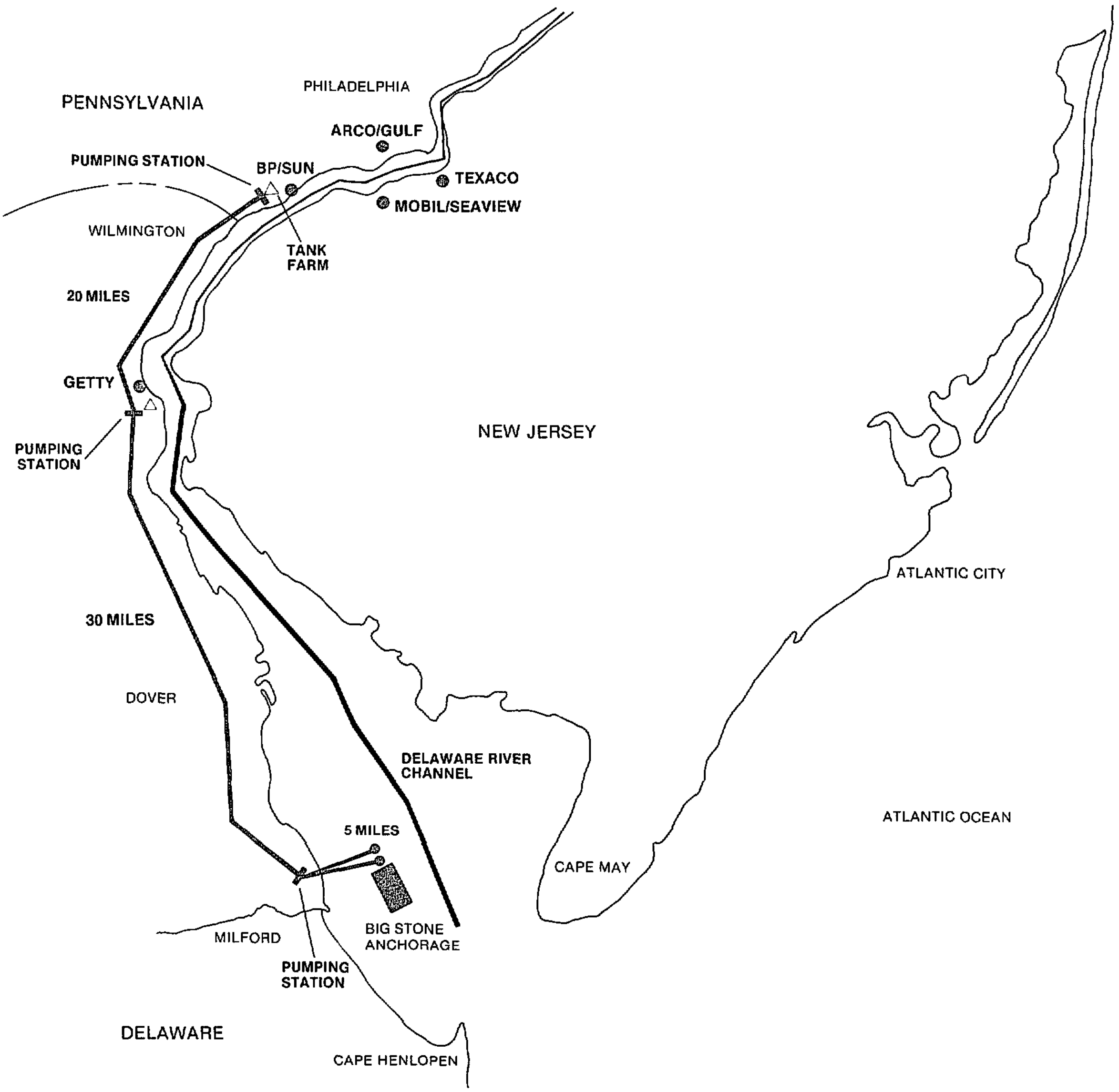


FIGURE 18

Description of in-harbor sites

The following descriptions of the in-harbor sites for deepdraft terminals are for the purpose of establishing a reasonable basis for making a determination of their environmental and economic feasibility. The descriptions of crude oil movements in the Delaware Bay and New York Harbor areas are based on the assumptions about throughput and tanker size presented in earlier chapters.

DELAWARE BAY: BIG STONE ANCHORAGE

An in-harbor deepwater terminal serving the Delaware River refineries would have to be located in lower Delaware Bay since there would be massive dredging involved in siting a terminal either in the upper Delaware Bay or in the Delaware River, itself. However, there are significant obstacles to siting an in-harbor facility in Delaware Bay despite the relatively deep water in the lower portion of the Bay. The entire New Jersey side of the Bay consists of large and productive oyster beds. This area could not sustain new construction or dredging operations without an in-depth study of the impact on the commercial fishing and recreation industries in the area (Walter, *et al*, 1981 and Haskin, 1982, Volume II).

As for the Delaware side of the Bay, there is a state law prohibiting new port facilities outside the Wilmington area. Any tanker terminal taking advantage of the deepwater close to the Delaware shoreline in the lower Bay could be built only by amending existing legislation prohibiting port development in that area.

The in-harbor site chosen for Delaware Bay is located just northwest of Big Stone Anchorage at 39 degrees 1 minute North, 75 degrees 14 minutes West (see Figure 18). The site is at the northernmost end of the 60 foot curve and provides 65 to 70 feet of water at the terminal. It is accessible through Big Stone Anchorage for vessels with up to 70 foot drafts with a small amount of dredging.

The terminal would consist of two single point mooring buoys with two 48 inch submarine pipelines running approximately 5 miles ashore to a pumphouse where they would meet a 48 inch pipeline connection to the refineries. The pipeline would come ashore between Big Stone Beach and the Mispillion River and continue west-northwest until it joins US Route 113 and north through Little Creek until it joins US Route 13 two miles north of Capital Park. There the corridor continues north along US 13 for about 31 miles to St. Georges, crossing the Chesapeake and Delaware Canal. At St. Georges the pipeline turns east northeast for approximately 3 miles to a point about 1 mile due west of the Getty Refinery in Delaware City. At this site there would be a second pumping station and about 500,000 barrels of storage capacity. Getty would install a connecting pipeline from here. Then the main pipeline turns northwest approximately 3 miles, rejoining US Route 13. The corridor follows the right-of-way (ROW) for US 13 into Wilmington and joins the ROW for Interstate 95 to a point one mile east of Marcus Hook, Pennsylvania. There would be a tank farm in this vicinity of 6,100,000 barrels on about 60 acres of land consisting of ten 250,000 barrel tanks and nine 400,000 barrel tanks. The remaining seven refineries would have to install their own connecting pipelines for final delivery from the tank farm. The total pipeline length would be approximately 65 miles, excluding final spur lines connecting the refineries.(For alternative pipeline ROW, see Walter, *et al*, 1981 in Volume II of this report).

Delaware Bay oil movements — The pattern of tanker and barge movements in Delaware Bay would be significantly changed with a deepwater terminal in the lower Bay and pipeline connections to the refineries. Although there would be little or no change in the total quantity of crude oil deliveries to the Delaware River refineries, the number of tanker and barge movements would be reduced by 15% and 68% respectively.

According to the estimates in Chapter Three, the volume of crude oil shipped through the facility would be about 560,000 barrels per day or about 204,400,000 barrels per year.

This volume amounts to about 60% of total deliveries and would require about 186 tanker visits per year by partially-laden tankers of up to 260,000 dwt carrying crude oil amounts equivalent to fully loaded 185,000 dwt tankers.

It is estimated that the remaining 40% of the crude oil would continue to be either delivered directly to the refineries or barged up from the lower Bay. This would require about 300 tanker visits and 300 barge movements per year.

The reduction in barge and tanker movements caused by this facility would have a substantial impact on traffic volume in the Delaware River channel. None of the 186 deep draft tankers per year delivering to the terminal in the lower Bay would transit the river channel. These vessels would replace 273 tankers now entering the lower Bay, most of which now make the transit to a refinery.

The rough project cost for the Delaware Bay facility is $700 million. Assuming a crude oil throughput of 560,000 barrels per day, the throughput cost per barrel is about $1.00 in 1986, the opening year assumed for the facility. (See Table 29.)

UPPER NEW YORK HARBOR

The naturally deep waters in The Narrows are an advantage to locating a deepwater terminal in New York Harbor's Upper Bay, limiting the amount of dredging needed in the Ambrose Channel and in an access channel at the terminal site. In the Upper Bay, only the western side of the harbor was considered for sites since the refineries are located to the west. No sites were considered north of the Battery at the southern tip of Manhattan because of tunnel depths in the lower Hudson River.

Two sites were found in New York Harbor which fell within the general framework of the siting criteria. These sites are the landfill pier at Port Jersey on the border between Bayonne and Jersey City and an area now occupied by abandoned piers at Stapleton, Staten Island.

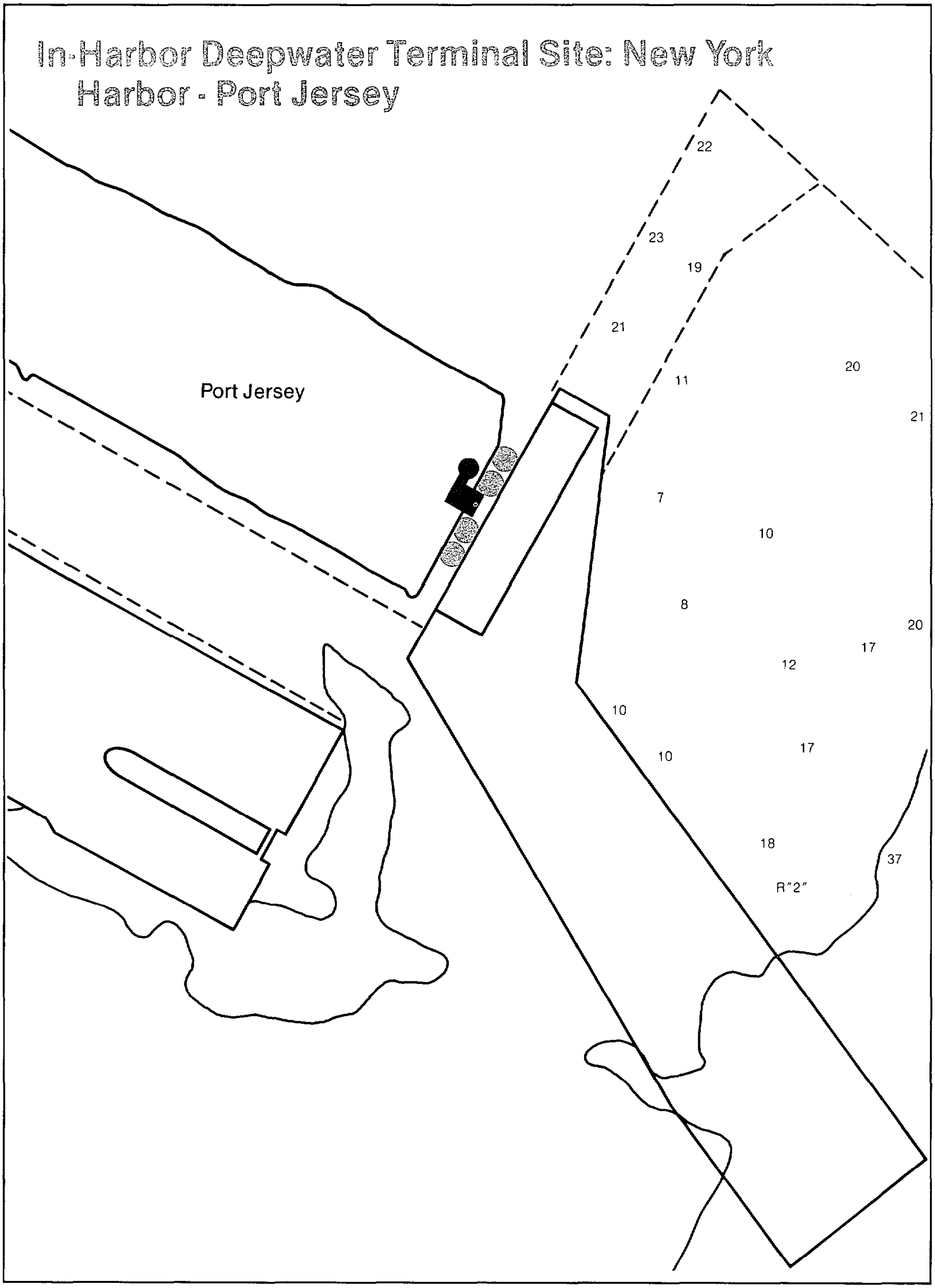
New York Harbor: Port Jersey — Port Jersey is one of the few sites north of Staten Island and south of the Battery which could be adapted to the engineering requirements for a terminal with the exception of water depth. The berth would be located at the eastern tip of the Port Jersey pier, at 40 degrees, 40 minutes North, 74 degrees, 4 minutes West (see Figure 19). Two 36-inch pipes would be buried along the northern edge of this landfill pier with a pumphouse nearby. The pipeline ROW could follow partially abandoned railroad tracks and would run southwest to Newark Bay.

After reaching the east bank of Newark Bay, the two pipes would turn south, crossing the Kill Van Kull just west of the Bayonne Bridge. A Newark Bay crossing would be more costly and cause more environmental problems than crossing both the Kill Van Kull and Arthur Kill. On the Staten Island side, the ROW would follow the old B & O railroad ROW crossing the Arthur Kill to a tank farm. A small tank farm (two 400,000 barrel and two 150,000 barrel tanks), would be located on about 20 acres of land south of the Goethals Bridge at which point Exxon and Chevron could provide their own pipeline connections.

New York Harbor: Stapleton, Staten Island — The second in-harbor site for a northern local facility is at Stapleton, Staten Island in an area presently occupied by piers 13 to 15. These piers are abandoned and are scheduled to be removed by the City of New York in its harbor clean-up program. This site is immediately adjacent to the naturally deep waters in The Narrows which would provide adequate maneuvering room for VLCCs (see Figure 20). Unlike the Port Jersey site, an unloading platform located at Stapleton would require a relatively short pipeline to connect with the refineries at Linden and Perth Amboy. The mooring arrangement would allow tankers to berth parallel to the shoreline with two 36 inch pipelines running from a fixed pier to a small pumphouse ashore. The pipelines would then follow the existing Staten Island Rapid Transit ROW south to Interstate 278, then west and north along the interstate and across the Arthur Kill to a point south of the Goethals Bridge. A tank farm would be sited at the same location as for the Port Jersey site. Chevron and Exxon again could provide their own pipeline connections to the tank farm.

A very preliminary cost estimate for a New York Harbor facility was $190 million. With a crude oil throughput of 240,000 barrels per day, this estimate of capital investment and an approximation of operating and maintenance costs produces an annual cost per barrel throughput of about $.40 in the first year of operation (1986). (See Table 29.)

Crude Oil Movements in New York Harbor — Crude oil movements for New York Harbor would be substantially altered by the employment of larger classes of tankers for an in-harbor alternative. The VLCCs which would use the in-harbor terminal would be significantly larger than the largest tankers presently delivering crude oil to New York Harbor.



In-Harbor Deepwater Terminal Site: New York Harbor - Port Jersey

FIGURE 19

In-Harbor Deepwater Terminal Site: New York Harbor - Stapleton, Staten Island

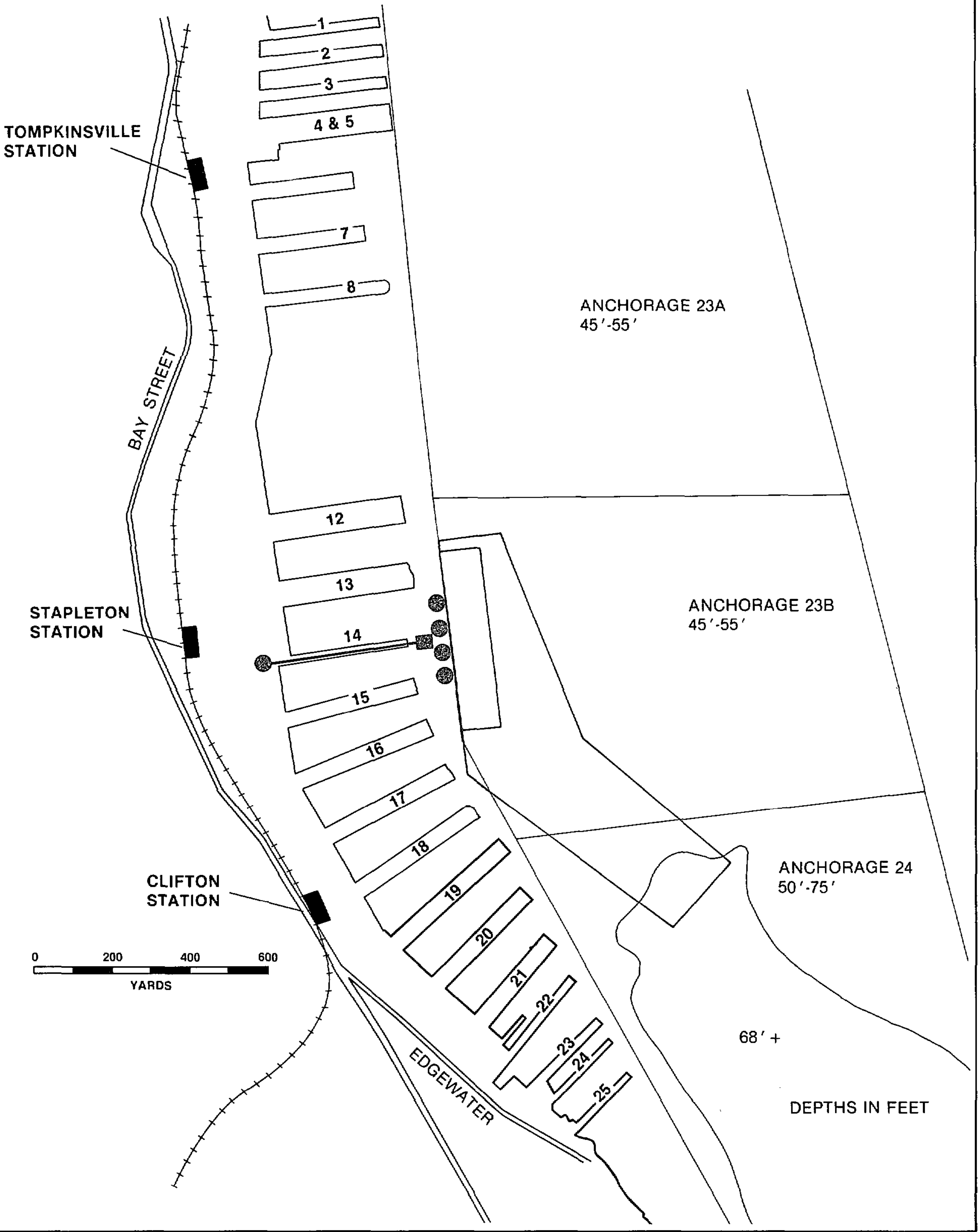


FIGURE 20

With the use of larger tankers to deliver crude oil to New York Harbor, there will be a reduction in tanker traffic of about 30%, although there will be no significant change in annual crude oil volume. The amount of crude oil handled by barges within the harbor would be reduced by 50% to 75% . Additionally, the in-port time of tankers would be reduced by more than half.

The crude oil throughput for a facility serving the northern New Jersey refineries is estimated to be 240,000 barrels per day or about 87,600,000 barrels per year (see Chapter Three). Deliveries of this magnitude would require about 60 to 70 visits per year by fully laden tankers of 185,000 dwt or by partially laden larger tankers. This frequency amounts to one tanker visit every five to six days. With a turnaround time of about 48 hours, the proposed terminal would be in use only 33% to 40% of the time.

Delivery by larger tankers would reduce the total number of crude oil tanker visits to New York from about 335 per year to about 230 per year, replacing some 175 visits by smaller tankers with 70 visits by the larger tankers.

The throughput estimates developed earlier indicate that slightly more than one-third of the crude oil requirements of the two refineries would continue to arrive in relatively small tankers. This would result in about 135 visits by smaller tankers, some of which would continue to require lightering.

The reduction in tanker visits would have significant impact on traffic in the Arthur Kill and Kill van Kull since about 175 tanker trips per year would be eliminated through these channels. None of the approximately 70 larger tankers would venture beyond either the Ambrose-Narrows-Stapleton or Ambrose-Narrows-Port Jersey area. Barge traffic in the congested channels would also be significantly reduced since the tankers with the greatest lightering requirements would be virtually eliminated from the harbor.

Transportation cost estimates for in-harbor alternatives

Results of crude oil transportation analyses, detailed in Chapter Seven following, are shown in Table 26. It gives estimates of transportation costs by major geographic sources for the U.S. East Coast, as described in Chapter Two, and estimated costs for an in-harbor deepwater terminal described above. The figures for current operations in column (a) include lightering, either in Delaware Bay or New York Harbor, and an estimate of cargo losses incurred in such lightering operations. In the case of deliveries from the Arabian Gulf, costs for transshipping and storage in the Caribbean as well as demurrage, penalties and losses are included. Column (b) gives costs for delivery in a 185,000 dwt vessel presuming an in-harbor deepwater terminal either in Delaware Bay or in New York Harbor.

Table 26
ESTIMATED MARINE TRANSPORTATION COSTS FOR CRUDE OIL DELIVERIES TO THE U.S. EAST COAST—II[1]
(1981 dollars per barrel)

From	(a) current operations[2]	(b) DWP w/ 185,000 dwt[3]
ARABIAN GULF[4]	$2.50	$2.00
WEST AFRICA	1.30	.90
NORTH AFRICA	1.10	.70

[1] Summary of analyses found in Chapter Seven.

[2] As described in Chapter Two.

[3] The in-harbor alternatives require some dredging of facility access channels.

[4] The figures for the Arabian Gulf include transshipment costs in the Caribbean as well as the cost of the smaller tankers making final delivery to the U.S. East Coast.

The estimates of marine transportation cost savings are shown in Tables 27 and 28. These are the simple differentials in the costs for the current operations case and the alternative case. As before, the term 'savings' does not include fees for the use of any new terminal. The calculated savings represent the difference in landed costs of crude oil under current practices and the landed cost less terminal and pipeline charges under the proposed future arrangement using the hypothetical facilities. The cost of using any new facility would have to be paid out of the transportation savings as defined.

The total savings which could be realized have been determined by weighted contributions to savings from the various export areas. Thus, the total savings are a composite of the savings realized on deliveries from the three principal source areas with the proportions based on recent trading patterns as discussed in Chapter Two. As shown in column (c) of Tables 27 and 28, in-harbor deliveries using a 185,000 dwt tanker would allow savings of about $.40 per barrel for deliveries into Delaware Bay and about $.50 per barrel for deliveries to New York Harbor in 1981 dollars or $.70 and $.80 in 1986 dollars, respectively.

Table 27
COST SAVINGS WITH IN-HARBOR ALTERNATIVE—DELAWARE BAY
(1981 dollars per barrel)

From	(a) estimated savings[1]	(b) % throughput from area[2]	(c) weighted average savings[3]
ARABIAN GULF	$.50	30%	
WEST AFRICA	.40	40%	$.43 or about $.40
NORTH AFRICA	.40	30%	

[1] Difference between columns in Table 26

[2] Derived from Table 19.

[3] For estimating purposes it has been assumed that there were no contributions to the weighted average savings from the "other" areas as shown in the tables in Chapter Three.

Table 28
COST SAVINGS WITH IN-HARBOR ALTERNATIVE—NEW YORK HARBOR
(1981 dollars per barrel)

From	(a) estimated savings[1]	(b) % throughput from area[2]	(c) weighted average savings[3]
ARABIAN GULF	$.50	80%	
WEST AFRICA	.40	15%	$.48 or about $.50
NORTH AFRICA	.40	5%	

[1] Difference between columns in Table 26.

[2] Derived from Table 20.

[3] For estimating purposes it has been assumed that there were no contributions to the weighted average savings from the "other" areas as shown in the tables in Chapter Three.

Economic comparison of the costs and transportation savings of the in-harbor alternatives

Certain key comparative features of the two in-harbor alternatives and a determination of the cost per barrel throughput for each in its opening year (1986) are shown in Table 29. This is followed by a comparison of the transportation cost savings and the cost per barrel of throughput for these in-harbor sites shown in Table 30. The cost of the facility for the Delaware Bay is about $1.00/barrel in 1986 dollars. This cost compares with a savings of about $.70/barrel in the same 1986 dollars. As mentioned in Chapter Five, the escalation of the transportation cost savings to 1986 dollars is probably optimistic given the stabilization of bunker fuel prices and the continued weakness in the VLCC charter market.

Table 29
ECONOMIC SUMMARY OF IN-HARBOR DEEPWATER TERMINAL ALTERNATIVES

	In-Harbor	
	South Delaware Bay	North New York Harbor
1. Facility crude throughput[1] (barrels/day)	560,000	240,000
2. Pipeline distance (miles)	65	10
3. Pumping requirements (millions barrel-miles/day)	36	2
4. Rough project cost (million $)	$700	$190
5. Variable O & M costs[2] (millions $/yr)	60	3
6. Fixed O & M (millions $/yr)	26	6
7. Approximate cost per barrel throughput ($/barrel)[3]	$.96 or about $1.00[4]	$.43 or about $.40[4]

[1] See Chapter Three.

[2] Includes primarily energy costs.

[3] Amortization over 20 years @ 14.5% per year with operation and maintenance costs for first year of operation. Annual amortization cost plus operation and maintenance costs are divided by the annual throughput to come up with a cost per barrel throughput for the first year of facility life.

[4] Rounded to nearest $.10

Table 30
COMPARISON OF TRANSPORTATION SAVINGS AND FACILITY COSTS: IN-HARBOR DEEPWATER TERMINAL

	facility cost/ barrel throughput (1986 $*)	transportation savings/barrel (1981 $/1986 $*)
In-Harbor—Delaware Bay	$1.00	$.40/.70
In-Harbor—New York Harbor	$ .40	$.50/.80

*1986 dollars derived by escalating 1981 dollars at 10% per year, compounded.

As with the offshore DWP proposals discussed in Chapter Five, the in-harbor Delaware Bay alternative does not appear economical. One important reason for the high cost of the Delaware Bay facility is the long pipeline distances to the refineries. Even if costs of a marine terminal could be shared in a multi-commodity terminal operation, the pipeline costs remain as a major expense. Also, it should be reiterated that the project costs estimated here do not take into account any special costs incurred by the mitigation of environmental impacts. These costs could become substantial in any major marine project in the Delaware Bay area.

The facility cost in New York Harbor during its first year of service (1986) of $.40/barrel of throughput is less than the estimate of transportation savings of $.80/barrel in 1986 dollars. This favorable comparison of costs and savings makes an in-harbor facility for New York Harbor appear to be worth further investigation. The roughness of both the savings estimate and the project cost, however, makes it difficult to prove decisively that a facility would be economically feasible. Also, as indicated before, this facility is very sensitive to tanker size, to channel deepening and to deepwater access at the terminal site.

The relatively modest cost of the New York Harbor proposal is due primarily to the short pipeline distances and the small storage requirements. The marginal feasibility of the facility makes it especially important that an in-harbor alternative be sited on the least costly of the two New York sites, barring major environmental considerations.

The $190 million estimate for the New York Harbor facility includes the higher costs of preparing the Port Jersey site compared to Stapleton, Staten Island. This cost differential primarily includes facility access dredging, an additional two miles of pipeline and one additional waterway crossing (Kill Van Kull). The longer in-harbor transit time and distance to Port Jersey are also disadvantages.

In summary, of the two in-harbor deepwater terminal proposals, a terminal for New York Harbor appears to be worth further consideration from an economic standpoint. The preferred site within New York Harbor is Stapleton, Staten Island because of its greater proximity to the two refineries it would serve. The Stapleton site also is preferred because of the reduced dredging requirements compared to the Port Jersey site. Costs of facility access dredging would likely be borne by the facility rather than by the public sector.

Pursuant to these conclusions, a more detailed economic evaluation of the Staten Island site is presented in the next two chapters.

CHAPTER SEVEN

NEW TRANSPORTATION PATTERNS AND COST ESTIMATES FOR CRUDE OIL DELIVERIES TO NEW YORK HARBOR

This chapter describes some possible transportation scenarios for deepdraft tanker deliveries of crude oil to New York Harbor. Estimates of transportation costs savings are developed from these scenarios with greater detail than the estimates presented in Chapters Five and Six. These estimated savings will be compared in Chapter Eight with the estimated costs of a deepwater terminal for New York Harbor to determine economic feasibility.

Estimates of the shipping costs of crude oil have been developed for the principal geographic source areas for the two refineries in Northern New Jersey. They, and the potential savings which are derived from them, result from the same methodology presented in Chapter Five. By comparing several possible future transportation cases with current practices, cost savings have been estimated for the employment of tankers larger than present facilities and harbor conditions permit.

As shown in Chapter Six, the relatively modest costs for an in-harbor facility serving the two northern New Jersey refineries make that facility worth further investigation. (See note.) Even in this chapter, the roughness of the transportation costs and savings estimate makes it difficult to prove decisively that a facility would be economically feasible. As discussed elsewhere, the economic feasibility of an in-harbor facility is very sensitive to tanker size, to the depth of the channels leading to the in-harbor facility and to demand for crude oil by refineries. The assumptions of a 60 foot deep channel as a minimum and an estimated demand of 240,000 barrels per day continue to guide the economic analysis in this chapter.

Crude oil transportation scenarios for New York Harbor

There are many possible alternative transportation scenarios for future crude oil deliveries to New York Harbor even without any port improvements. These could result from changes in the economics of transshipping and lightering operations, different ports of origin for the crude oil, changes in the availability of tankers, significant changes in import levels, etc. Any new facility designed to accommodate larger size vessels also would be subject to variations in transportation patterns affecting cost estimates.

Presently, Exxon and Chevron primarily employ company owned vessels for shipping crude to their refineries. The present costs of delivering crude oil are difficult to pinpoint even with access to company data. Since access to company data was not obtained, the figures presented in this chapter are intended to show only the general magnitude of savings in order to evaluate the economics of various crude oil delivery alternatives.

Discussions with several major oil companies, including Exxon and Chevron, have led to the development of four marine shipping cases which are considered to be the most meaningful for comparative purposes given the range of alternative futures. Cost estimates were then developed for each case. These cases are described below.

1. **Current operations** — Arabian Gulf oil is shipped to Caribbean transshipment points in VLCCs. Final delivery to New York Harbor is made by intermediate sized tankers of 75,000 to 90,000 dwt with lightering in harbor as described in Chapter Two. The majority of oil from other areas, including West Africa, North Africa and the Caribbean is delivered directly in tankers of less than 90,000 dwt.

2. **Current operations via Suez** — The deepening of the Suez Canal to 53 feet may provide for a reduction in delivery costs to the East Coast. A deepened Suez Canal allows VLCCs to return to the Arabian Gulf in ballast via the Canal thereby reducing the roundtrip distance by 2,600 miles. Oil from other sources would continue to be delivered by direct shipment.

Note: As discussed elsewhere, the costs described here do not include any dredging and spoil disposal costs. These costs typically have been assumed by the public sector and presently are the subject of proposed federal legislation.

3. **New terminal with 60 foot channels** — Deeper channels and a terminal for offloading crude oil into a pipeline network for the refineries would allow shipment by larger tankers. A 60 foot channel with an in-harbor terminal could accommodate a 185,000 dwt tanker fully loaded or a larger tanker of up to 260,000 dwt that is partially laden . This port improvement scenario would eliminate approximately two-thirds of the lightering currently taking place in the harbor. Direct shipments from other source areas would be made in tankers in excess of 100,000 dwt as volume and tanker availability allow.

4. **New terminal with 60 foot channels and return via Suez Canal** — The deepening of the Suez to 53 feet would allow the larger tankers to return to the Arabian Gulf by a shorter route when in ballast. This shorter roundtrip makes possible additional transportation savings for Arabian Gulf deliveries.

These scenarios are simplified and generalized instances of what continues to be a highly complex marine transportation system. The primary interest in specifying certain transport practices is to identify the principal cost components as well as to estimate differences in future costs.

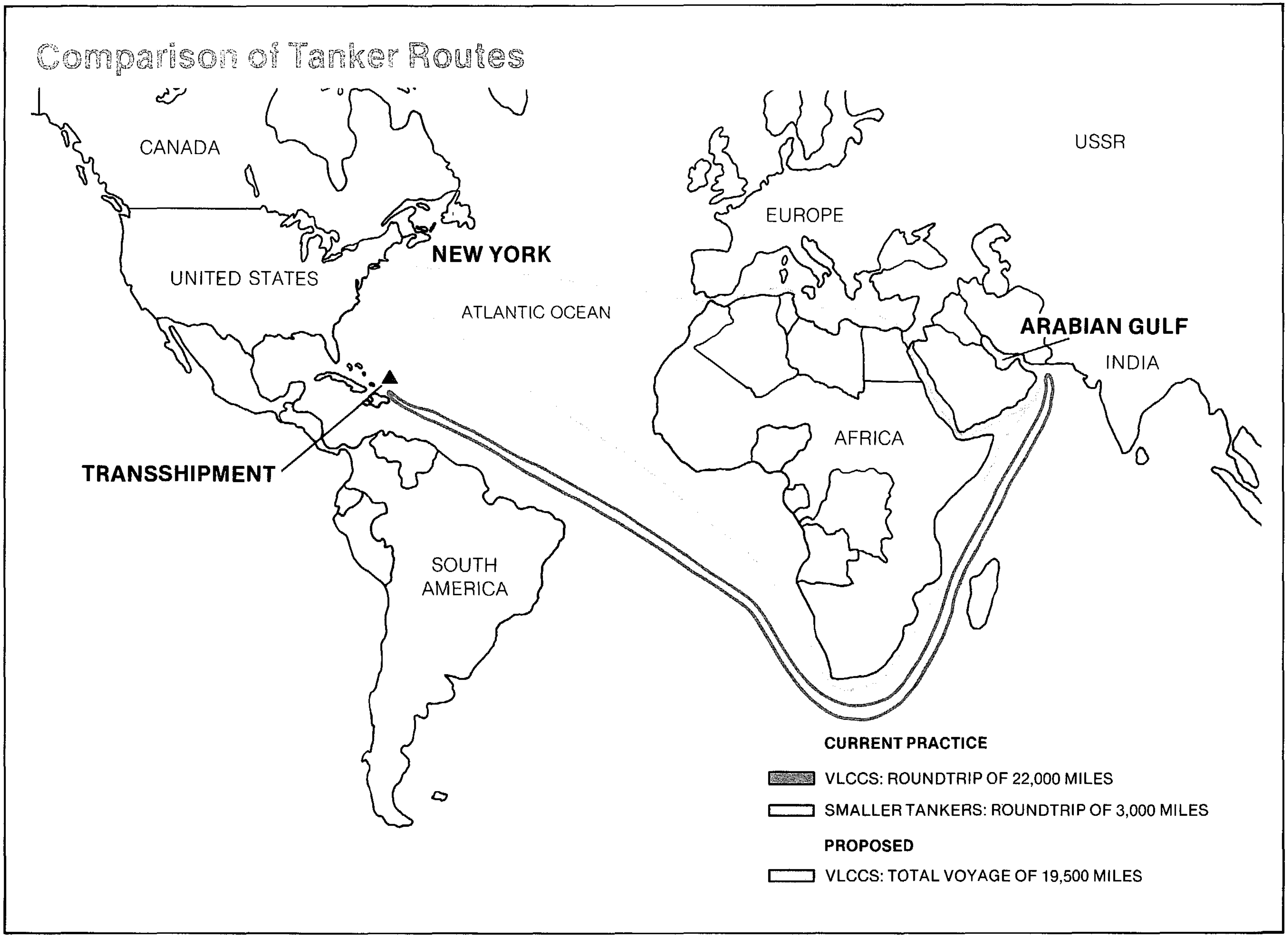
Figure 21 shows a comparison of tanker routes used in current operations with a possible future route. A roundtrip by VLCC making direct delivery to the East Coast and returning via the Suez Canal is about 5500 miles shorter than current practice permits.

The assumption most likely to change in these cases is tanker size. In the course of this study, tankers of varying sizes were used in estimating costs. The tanker sizes specified in the four scenarios above are considered to be the most typical or most likely given the situation described, although at the present time there are few tankers in the 60 foot draft category (i.e., between 185,000 dwt and 200,000 dwt). Additionally, the variables of speed and fuel consumption play a critical role in calculating the cost estimates for each scenario. Throughout these tables, fuel costs for roundtrip voyages have been calculated from an average fuel consumption for the entire voyage at maximum operating speed. The differences in vessel speed and fuel consumption between the laden and ballast legs of the transit therefore are averaged.

The current practice of slow steaming would affect these cost estimates. However, there are factors other than fuel efficiency which tend to dictate the practicality and frequency of slow steaming. Such considerations would complicate the generalized estimates presented here and should not alter substantially the conclusions concerning economic feasibility. A more detailed cost analysis will be required in the future to determine the exact magnitude of the savings when particular transportation scenarios appear more probable.

The cost estimates for each scenario are presented in Tables 31 through 34. The case numbers at the top of each column in these tables as well as in Table 35 correspond to each of the four scenarios described previously. In each case, it is assumed that the vessels are fully laden. The delivery cost per barrel (item AB) is based on a roundtrip voyage except for deliveries from the Arabian Gulf in Cases 2 and 4. In these two cases, the total delivery cost by VLCC is the sum of the delivery leg to either the Caribbean or New York and the return to the Arabian Gulf via the Suez Canal. In case 2, the costs are $.89/barrel to the Caribbean in a 260,000 dwt vessel and $.71/barrel for the return voyage for a total cost of $1.60/barrel. Likewise, Case 4 calculations show costs of $.99/barrel for delivery to New York with 185,000 dwt vessel and costs of $.73/barrel on the return leg via the Suez Canal. The total cost for deliveries from the Arabian Gulf in this case is $1.72/barrel as shown in Table 35.

For the West African and North African deliveries, there are no differences between Cases 1 and 2 and Cases 3 and 4, since there are no economically attractive alternative routes.



Comparison of Tanker Routes

FIGURE 21

Table 31

TRANSPORTATION COST ESTIMATES

		CASE 1	CASE 1	CASE 1/2
A	VOYAGE	ARAB. GULF/ CARIB. (R.T.)*	CARIB./ N.Y. (R.T.)	W. AFRICA/ N.Y. (R.T.)
B	TOTAL TRIP MILES	23,400	3,200	9,760
C	DEADWEIGHT TONS	260,000	85,000	85,000
D	KNOTS	15.5	15.5	15.5
E	FUEL CONSUMP. AT SEA	159	76	76
F	FUEL CONSUMP. IN PORT	40	19	19
G	FUEL $/TON	$200	$200	$200
H	DAYS SPENT AT SEA	62.9	8.6	26.2
I	DAYS SPENT IN PORT	4	4	4
J	VOYAGE TIME	66.9	12.6	30.2
K	$/OPERATING DAY	$17,954	$8,448	$8,448
L	OPERATING COST	$1,201,120	$106,445	$255,130
M	FUEL COST AT SEA	$2,000,220	$130,720	$398,240
N	FUEL COST IN PORT	$32,000	$15,200	$15,200
O	PORT CHARGES LOADING	$22,200	$1,200	$49,400
P	PORT CHARGES DISCH.	$0	$0	$0
Q	VOYAGE COST	$3,255,540	$253,565	$717,970
R	TONS FUEL	10,161	730	2,067
S	TONNAGE CARGO ADJUST.	0	0	0
T	SURPLUS BUNKERS	795	380	380
U	STORES AND WATER	496	389	389
V	DEDUCT FROM DWT	11,452	1,499	2,836
W	CARGO CARRIED	248,548	83,501	82,164
Y	UNIT COST, $/TON	$13.10	$3.04	$8.74
Z	FUEL % OF TOTAL COST	62	58	58
AA	BARELS/TON	7.46	7.46	7.46
AB	$/BARREL	$1.76	$0.41	$1.17

*R.T. = ROUND TRIP

SOURCE: Office of Energy, Port Authority of New York and New Jersey, September 1981.

Table 32

TRANSPORTATION COST ESTIMATES

		CASE 1/2	CASE 2	CASE 2
A	VOYAGE	N. AFRICA/ N.Y. (R.T.)*	ARAB. GULF/ CARIB.	CARIB./SUEZ/ ARAB. GULF
B	TOTAL TRIP MILES	8,040	11,700	9,100
C	DEADWEIGHT TONS	85,000	260,000	260,000
D	KNOTS	15.5	15.0	16.0
E	FUEL CONSUMP. AT SEA	76	159	159
F	FUEL CONSUMP. IN PORT	19	40	40
G	FUEL $/TON	$200	$200	$200
H	DAYS SPENT AT SEA	21.6	32.5	23.7
I	DAYS SPENT IN PORT	4	2	2
J	VOYAGE TIME	25.6	34.5	25.7
K	$/OPERATING DAY	$8,448	$17,954	$17,954
L	OPERATING COST	$216,269	$619,413	$461,418
M	FUEL COST AT SEA	$328,320	$1,033,500	$753,660
N	FUEL COST IN PORT	$15,200	$16,000	$16,000
O	PORT CHARGES LOADING	$15,500	$22,200	$0
P	PORT CHARGES DISCH.	$0	$0	$121,200
Q	VOYAGE COST	$575,289	$1,691,113	$1,352,278
R	TONS FUEL	1,718	5,248	3,848
S	TONNAGE CARGO ADJUST.	0	0	0
T	SURPLUS BUNKERS	380	795	795
U	STORES AND WATER	389	496	496
V	DEDUCT FROM DWT	2,487	6,539	5,139
W	CARGO CARRIED	82,513	253,461	254,861
Y	UNIT COST, $/TON	$6.97	$6.67	$5.31
Z	FUEL % OF TOTAL COST	60	62	57
AA	BARRELS/TON	7.46	7.46	7.46
AB	$/BARREL	$0.93	$0.89	$0.71

*R.T. = ROUND TRIP

SOURCE: Office of Energy, Port Authority of New York and New Jersey, September 1981.

Table 33

TRANSPORTATION COST ESTIMATES

		CASE 3	CASE 3/4	CASE 3/4
A	VOYAGE	ARAB. GULF/ N.Y. (R.T.)*	W. AFRICA/ N.Y. (R.T.)	N. AFRICA/ N.Y. (R.T.)
B	TOTAL TRIP MILES	23,600	9,760	8,040
C	DEADWEIGHT TONS	185,000	120,000	120,000
D	KNOTS	15.5	15.5	15.5
E	FUEL CONSUMP. AT SEA	128	97	97
F	FUEL CONSUMP. IN PORT	32	24	24
G	FUEL $/TON	$200	$200	$200
H	DAYS SPENT AT SEA	63.4	26.2	21.6
I	DAYS SPENT IN PORT	4	4	4
J	VOYAGE TIME	67.4	30.2	25.6
K	$/OPERATING DAY	$13,240	$10,186	$10,186
L	OPERATING COST	$892,376	$307,617	$260,762
M	FUEL COST AT SEA	$1,623,040	$508,280	$419,040
N	FUEL COST IN PORT	$25,600	$19,200	$19,200
O	PORT CHARGES LOADING	$16,800	$67,200	$18,000
P	PORT CHARGES DISCH.	$0	$0	$0
Q	VOYAGE COST	$2,557,816	$902,297	$717,002
R	TONS FUEL	8,243	2,637	2,191
S	TONNAGE CARGO ADJUST.	0	0	0
T	SURPLUS BUNKERS	640	485	485
U	STORES AND WATER	449	417	417
V	DEDUCT FROM DWT	9,332	3,539	3,093
W	CARGO CARRIED	175,668	116,461	116,907
Y	UNIT COST, $/TON	$14.56	$7.75	$6.13
Z	FUEL % OF TOTAL COST	64	58	61
AA	BARRELS/TON	7.46	7.46	7.46
AB	$/BARREL	$1.95	$1.04	$0.82

*R.T. = ROUND TRIP

SOURCE: Office of Energy, Port Authority of New York and New Jersey,September 1981.

Table 34

TRANSPORTATION COST ESTIMATES

		CASE 4	CASE 4
A	VOYAGE	ARAB. GULF/ N.Y.	N.Y./SUEZ/ ARAB. GULF
B	TOTAL TRIP MILES	11,800	8,490
C	DEADWEIGHT TONS	185,000	185,000
D	KNOTS	15.0	16.0
E	FUEL CONSUMP. AT SEA	128	128
F	FUEL CONSUMP. IN PORT	32	32
G	FUEL $/TON	$200	$200
H	DAYS SPENT AT SEA	32.8	22.1
I	DAYS SPENT IN PORT	2	2
J	VOYAGE TIME	34.8	24.1
K	$/OPERATING DAY	$13,240	$13,240
L	OPERATING COST	$460,752	$319,084
M	FUEL COST AT SEA	$839,680	$565,760
N	FUEL COST IN PORT	$12,800	$12,800
O	PORT CHARGES LOADING	$16,800	$0
P	PORT CHARGES DISCH.	$0	$88,700
Q	VOYAGE COST	$1,330,032	$986,344
R	TONS FUEL	4,262	2,893
S	TONNAGE CARGO ADJUST.	0	0
T	SURPLUS BUNKERS	640	640
U	STORES AND WATER	449	449
V	DEDUCT FROM DWT	5,351	3,982
W	CARGO CARRIED	179,649	181,018
Y	UNIT COST, $/TON	$7.40	$5.45
Z	FUEL % OF TOTAL COST	64	59
AA	BARRELS/TON	7.46	7.46
AB	$/BARREL	$0.99	$0.73

SOURCE: Office of Energy, Port Authority of New York and New Jersey, September 1981.

Cost Estimates

The summary of cost components for each marine shipping case is presented in Table 35. Under current operations, the round trip voyage for VLCCs from the Gulf to the Carribbean is about 23,400 miles. The tanker returns in ballast via the same route. The transfer costs, shown in the table for Arabian Gulf oil, include demurrage, losses (including 'breathing' or evaporation losses enroute) as well as some onshore storage costs for a small portion of the cargo at transshipment terminals. By some estimates the transfer cost, as defined here, can exceed $.25 per barrel.

The Caribbean to New York transit is made typically in 75,000 to 85,000 dwt tankers with about 25% of the cargo lightered in New York Harbor. The costs of transfer in New York Harbor are primarily lightering costs, although occasional demurrage costs, losses due to transfer, and other miscellaneous costs have been included.

Total delivery cost for Arabian Gulf oil, virtually all of which is transshipped, comes to about $2.48 per barrel (see Case 1). This compares with a cost for direct shipment in a 75,000 dwt tanker of over $3.00 per barrel. It appears that these costs could be reduced by about $.16 per barrel if the Suez Canal were used for the return voyage to the Arabian Gulf, shortening the roundtrip by 2600 miles (compare Case 2).

In both cases, deliveries from West Africa and North Africa have been calculated to be about $1.30 and $1.06 per barrel, respectively for an 85,000 dwt tanker. While there are some VLCCs carrying crude oil out of West Africa and North Africa for transshipment in the Caribbean, these deliveries are a small proportion of total transshipment volumes and of direct deliveries to the refineries.

The cost estimates for all deliveries in Cases 3 and 4 show sharp reductions. These two cases assume access to New York Harbor with at least 60 feet of water and a terminal able to accommodate VLCCs with a direct pipeline delivery.to the refineries. It is estimated that Arabian Gulf oil could be delivered to New York for about $1.95 per barrel and for about $1.72 per barrel if the Suez were used for the return voyage. West African and North African oil could be delivered for $1.04 and $.82 per barrel, respectively.

Estimated cost savings

The estimated savings from using larger tankers (Cases 3 and 4) are summarized in Table 36. Savings in delivery costs on a per barrel basis for Arabian Gulf oil range from $.37 (comparing Cases 2 and 3) to $.76 (comparing Cases 1 and 4). The savings for West African and North African deliveries are $.26 and $.24, respectively.

The percentages in column (b) of the table are used to give weighted average savings for all crude oil delivered from the principal long distance sources. These percentages are adapted from Table 20 in Chapter Three which presents estimated crude throughput for a bulk oil terminal serving the two northern New Jersey refineries. It is assumed that any savings that would accrue from source areas other than the three cited here, mainly the Caribbean, would be small and would not be a major contribution to the total savings.

The weighted average in column (c) of the table yields a savings from the use of the facility ranging from $.35 to $.66 per barrel. These savings are given in current (1981) dollars and can be expected to escalate with the general rate of inflation and, in particular, with any increases in the price of bunker fuel. Assuming an escalation rate of 10% per year compounded for 5 years, the savings in 1986 dollars would range from $.56 to $1.06.

The range in savings is determined by future changes in the costs of delivering Arabian Gulf oil and particuarly by the economies possible from taking advantage of the Suez Canal. If the entrance channel to New York Harbor were deepened beyond 60 feet, there could be even greater savings in transportation costs than are indicated here.

Table 35
SUMMARY OF ESTIMATED TRANSPORTATION COSTS
(1981 dollars per barrel)

1. Arabian Gulf	**Case 1[1]**	**Case 2[2]**	**Case 3[3]**	**Case 4[4]**
To Caribbean	1.76	1.60	—	—
Transfer[5]	.18	.18	—	—
To New York	.41	.41	1.95	1.72
Lightering, etc.[6]	.13	.13	—	—
TOTAL	2.48	2.32	1.95	1.72

2. West Africa	**Cases 1 & 2[7]**	**Cases 3 & 4[8]**
To New York	1.17	1.04
Lightering, etc.[6]	.13	—
TOTAL	1.30	1.04

3. North Africa	**Cases 1 & 2[7]**	**Cases 3 & 4[8]**
To New York	.93	.82
Lightering, etc.[6]	.13	—
TOTAL	1.06	.82

[1] Assumes roundtrip voyage to the Caribbean via Cape of Good Hope in a 260,000 dwt tanker and roundtrip voyage to New York in an 85,000 dwt tanker.

[2] Assumes one way delivery to Caribbean via Cape of Good Hope in a 260,000 dwt tanker with return via Suez Canal and roundtrip voyage to New York in an 85,000 dwt tanker.

[3] Assumes roundtrip voyage directly to New York in a 185,000 dwt tanker via Cape of Good Hope.

[4] Assumes voyage directly to New York in a 185,000 dwt tanker via Cape of Good Hope and return in ballast via Suez.

[5] Costs of transshipping include demurrage, losses and onshore storage for a small portion of the cargo.

[6] Includes costs of lightering about 25% of cargo, demurrage, penalties and losses.

[7] Assumes direct delivery in an 85,000 dwt tanker.

[8] Assumes direct delivery in a 120,000 dwt tanker.

Table 36
SUMMARY OF ESTIMATED TRANSPORTATION COST SAVINGS

	(a) Range of Savings[1]	**(b) % Throughput From Area**	**(c) Weighted Average Savings[2]**	
			1981 $	**1986 $[3]**
ARAB GULF	.37-.76	80%	.35-.66	.56-1.06
WEST AFRICA	.26	15%		
NORTH AFRICA	.24	5%		

[1] Derived from differences between Cases 1 and 4 or Cases 2 and 3 in Table 35.

[2] Savings from other source areas, primarily the Caribbean, have not been included.

[3] Escalation at 10% per year for 5 years, compounded.

CHAPTER EIGHT

CAPITAL, OPERATING AND MAINTENANCE COSTS OF AN IN-HARBOR CRUDE OIL HANDLING FACILITY

In this chapter, the capital construction costs of a Crude Oil Handling Facility (COHF) for New York Harbor are developed as well as annual operating and maintenance costs. Expressed as a charge per barrel of throughput, these costs of building, operating and maintaining the facility then may be compared to the estimated transportation savings per barrel throughput which result from using VLCCs.

During the search for potential in-harbor sites for the COHF, the area around Stapleton, Staten Island appeared to meet more of the siting criteria for the location of the input side of the facility than other potential sites. The marine pier could be located a relatively short distance from deep water in the vicinity of the pierhead line (outboard end) of Piers 13, 14 and 15. This site provides adequate landside space for a booster pump station and, leading from it, a possible route for pipeline connections to the tank farm.

Components of crude oil handling facility

The COHF may be divided into six components, each of which is made up of subcomponents. In sequential order of inbound use, the six components are:

Access channel
Conventional marine pier
Specialized marine oil pier equipment
Pipelines
Pumping stations
Tank farm

These components are served by major technical systems. Some examples would be communications, control, electrical, fire protection, metering, navigation and pollution control systems. A brief description of each of the components follows.

1. **Access channel.** The access channel links the naturally deep water of The Narrows with the first structural portion of the COHF. Its dimensions include a depth of at least 60 feet, approximate widths ranging from 700 feet at its Narrows' entrance to 1000 feet or so at its midlength dogleg to about 500 feet at its northern end and an overall length of about three quarters of a mile. Within its bounds, on its northwestern border, will be a tanker berth basin about 65 feet deep, 300 feet wide and 1300 feet long (see Figure 22).
2. **Conventional marine pier.** The marine pier portion of the COHF consists of mooring dolphins, an unloading platform and a vehicle causeway connecting the unloading platform to shore. Mooring dolphins are devices used for securing a tanker during its port stay. One type of mooring dolphin, called a breasting dolphin, is a single pile or a set of piles driven deeply into the river bed and equipped with a fendering system to absorb contact pressure from the tanker's hull during docking and afterwards. Other dolphins are located approximately fifty meters inboard from the edge of the berth to accommodate the lines that hold the vessel against the breasting dolphins. A cap sits on top of each dolphin on which is installed line handling equipment such as cleats, a capstan and quick-release hooks. The COHF's mooring dolphins are interconnected among themselves and to the unloading platform by catwalks. The unloading platform is located in the middle of the string of mooring dolphins and is a pile-supported deck approximately 80 feet long by 48 feet wide. It is connected to shore by a vehicle causeway about 1500 feet long and 15 to 20 feet wide, which also will serve to carry the twin 36-inch diameter pipelines from the unloading platform to landfall (see Figure 23).
3. **Specialized marine oil pier equipment.** All the equipment required to offload a cargo of crude oil from a VLCC, safely and expeditiously, is found on and around the platform. Some of this equipment would include four 16-inch diameter, articulated, steel-pipe connection arms (sometimes referred to as 'Chicksan Arms'), which couple the unloading manifold of the tanker to the unloading platform's

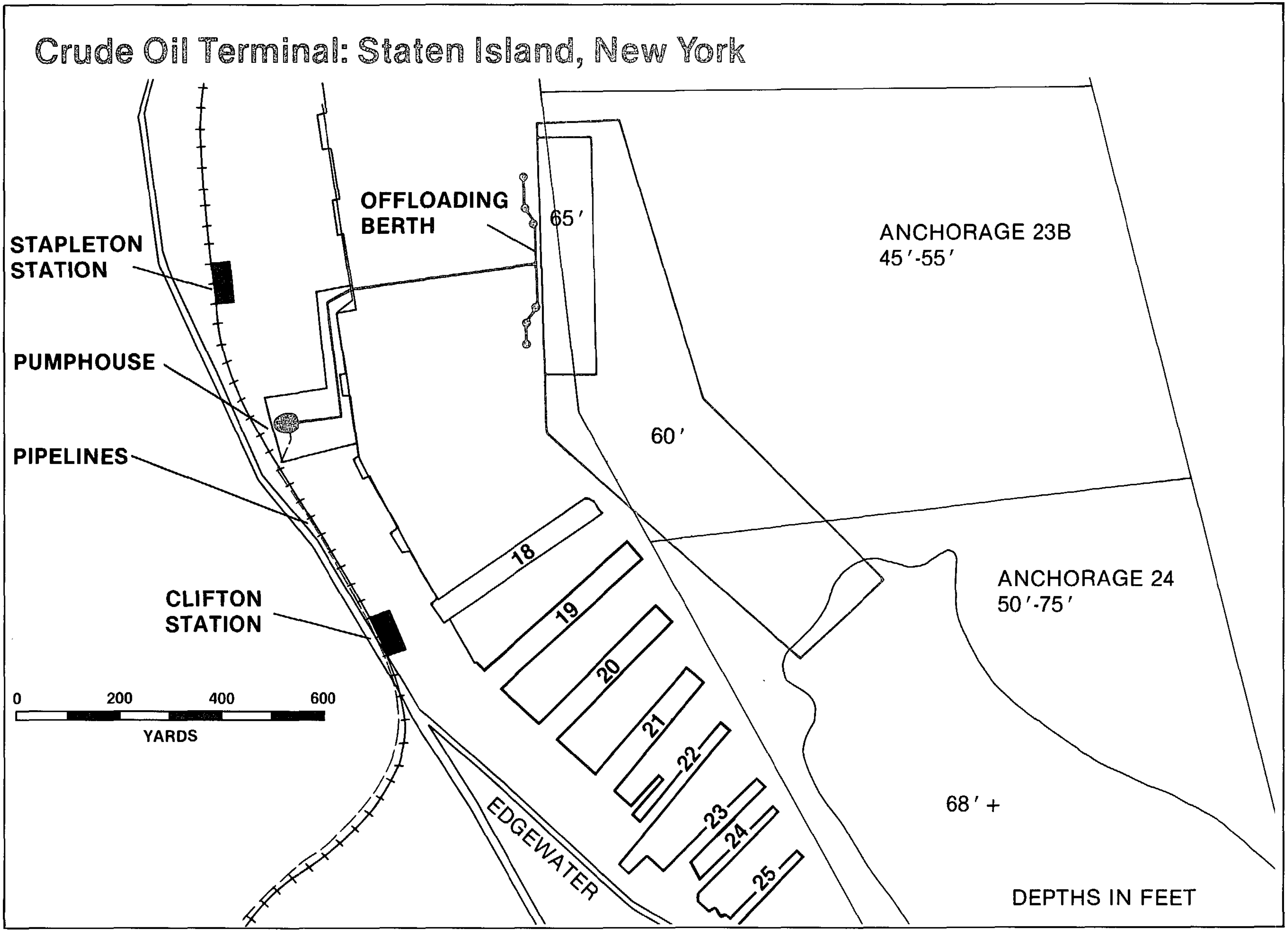
manifold serving the COHF's twin pipelines, a foam fire-fighting system, a back-up inert gas system, a control tower, a slop oil and oily-water collection system, a multi-station emergency shutdown system, operator's shacks along with a personnel gangway and utility connections to serve the tanker. Pollution control equipment will be located on and around the platform. Included among such equipment would be those devices required to contain and recover a small to medium sized spill such as oil containment booms, portable skimmers, pumps, sorbent materials, hoses and small boats (see Figure 23).

4. **Pipelines.** From the unloading platform off Staten Island's eastern shore to the west shore of the Arthur Kill, crude oil is pumped approximately 10 miles through twin 36-inch diameter pipelines. For the purposes of this study, two pipelines are assumed in order to provide for the simultaneous unloading of two grades of crude oil from a given tanker and to build in some operational flexibility and reliability. These pipelines are buried for most of their length except for the initial stretch from the platform to the booster pump station adjacent to the landfall. Leaving the pump station, the pipelines' path follows the Staten Island Rapid Transit's right-of-way to Interstate 278, then crosses Staten Island along I-278's right-of-way until it nears the approach to the Goethals Bridge where it heads south and west to the east shore of the Arthur Kill. The pipelines make a submarine crossing of the Arthur Kill and terminate in a tank farm south of the Goethals Bridge. A pipeline from each of the two refineries would be brought to this point by Exxon and Chevron, each of whom would be responsible for its own pipeline. Block valves will be installed at intervals along the entire pipelines' length to enable the isolation of any problem section. Corrosion protection and leak detection systems will be incorporated.

5. **Pumping stations.** Due to the wide variation in pumping capabilities from tanker to tanker, taken together with the distance and the elevation gradient to be accommodated from the unloading platform to the tank farm, a booster pumping station will be located adjacent to the pipelines' landfall at Stapleton. The station will contain two centrifugal pumps per 36-inch line connected in parallel, with each pump's rated capacity at 20,000 barrels per hour. The pump driver in each case will be a 1500 horsepower electric motor. In addition to the four pump/pump driver combinations, a maintenance spare pump/pump driver combination will be tied into the lines to serve as a standby for either line. Storage tank filling will be accomplished by the pressure boost provided by the Stapleton station. A second pumping station will be situated in the tank farm. From this station, crude oil will be distributed to the two refineries via their connecting pipelines. The station also will provide the pumping pressure to transfer crude oil from tank to tank within the farm itself. One centrifugal pump with a 15,000 barrel per hour capacity, driven by a 1000 horsepower electric motor, will feed each refinery line. An additional pump/pump driver combination of the same size will be tied into the system as a backup to either refinery line. Smaller pump/pump driver combinations will be located here for internal crude oil transfer and tank stripping purposes. A pipe scraper (pig) launcher for each line will be incorporated into the Stapleton pumping station with the receiver located at the tank farm pumping station. At each pump station, all necessary metering and control devices will be included.

6. **Tank farm.** A small tank farm will be constructed on the west shore of the Arthur Kill on a tract of about twenty acres. The tank farm's exact location has not been pinpointed. However, due to the location of the pier relative to the refineries, a site closer to Exxon than to Chevron is more likely. The farm will consist of two 400,000 barrel and two 150,000 barrel tanks. The tanks will be of floating roof design to minimize hydrocarbon vapor emissions and they will be fully diked with all drains feeding into oily-water separators. State-of-the-art tank gauging equipment will be installed. Additional facilities found at the tank farm site will include the tank farm pumping station, and a building housing administrative offices, a control center, a laboratory and maintenance services. There also will be metering and proving systems sufficiently accurate for custody transfer and operational control. Safety and fire protection systems appropriate for a modern storage tank farm will be included.

Cost estimates of the components, as described above, have been calculated in 1981 dollars. The level of detail and accuracy of these estimates is that of a preliminary evaluation. Much more design detail would have to be accomplished before an economic evaluation sufficient to commit capital could be performed. Figure 24 provides an example of all of the above elements as well as some of the additional subcomponents and systems that might be considered in the next level of analysis.

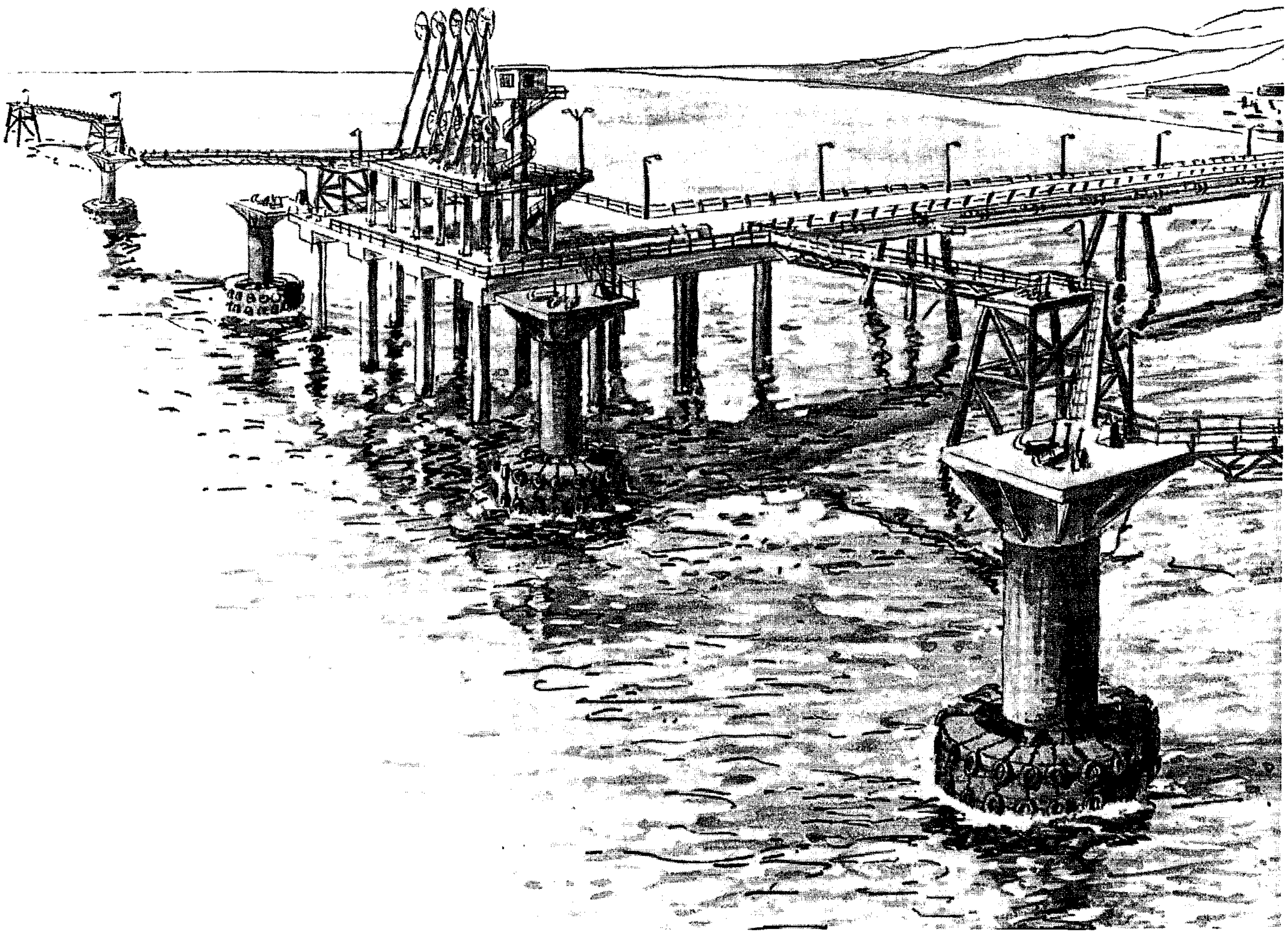


Crude Oil Terminal: Staten Island, New York

FIGURE 22

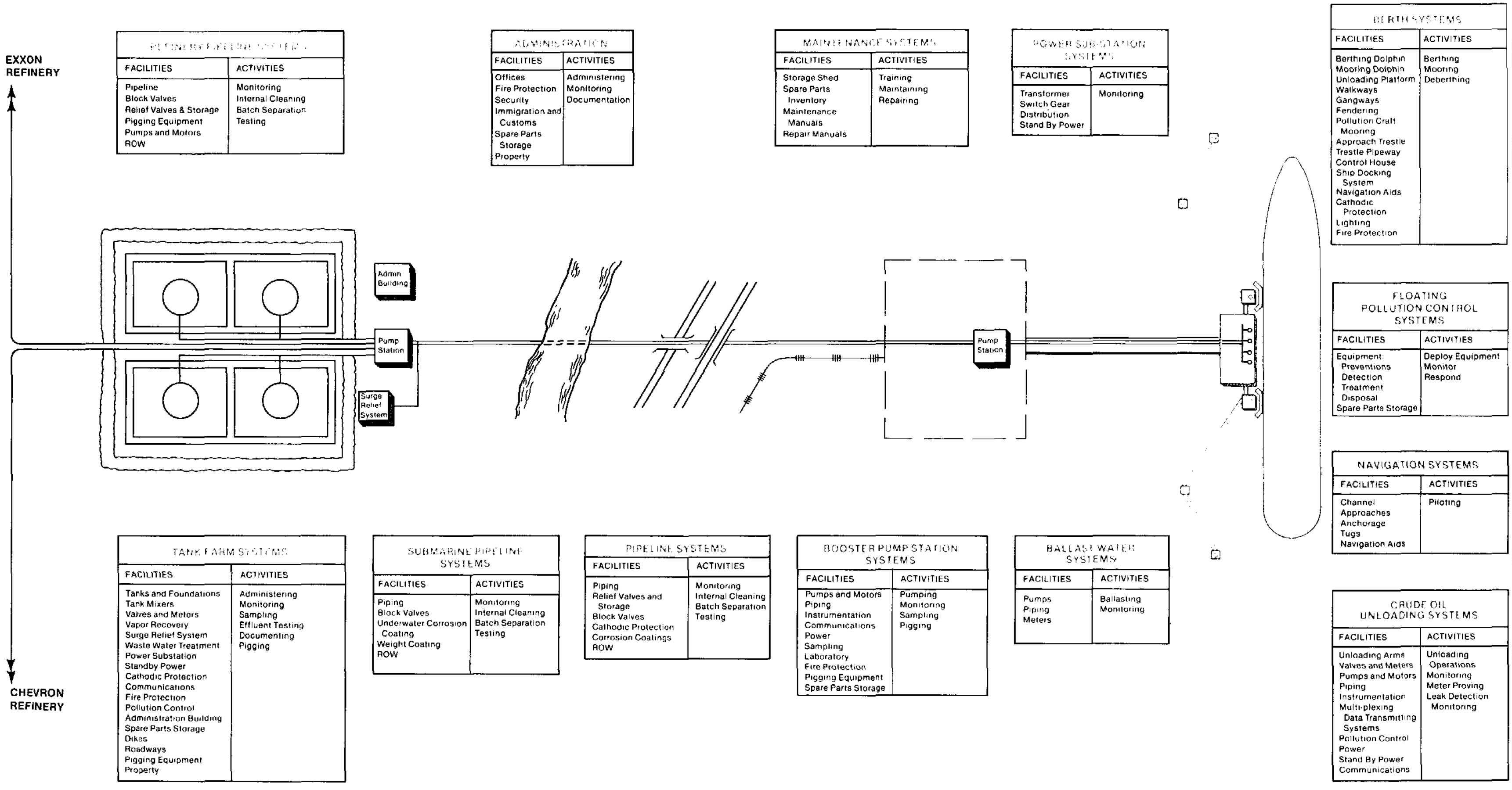
FIGURE 23

Marine Pier of Crude Oil Handling Facility



SOURCE: Seaward International Inc. Art By Fred Deweerd

Overview of Components and Systems of COHF



REFINERY PIPELINE SYSTEMS

FACILITIES	ACTIVITIES
Pipeline Block Valves Relief Valves & Storage Pigging Equipment Pumps and Motors ROW	Monitoring Internal Cleaning Batch Separation Testing

ADMINISTRATION

FACILITIES	ACTIVITIES
Offices Fire Protection Security Immigration and Customs Spare Parts Storage Property	Administering Monitoring Documentation

MAINTENANCE SYSTEMS

FACILITIES	ACTIVITIES
Storage Shed Spare Parts Inventory Maintenance Manuals Repair Manuals	Training Maintaining Repairing

POWER SUB-STATION SYSTEMS

FACILITIES	ACTIVITIES
Transformer Switch Gear Distribution Stand By Power	Monitoring

BERTH SYSTEMS

FACILITIES	ACTIVITIES
Berthing Dolphin Mooring Dolphin Unloading Platform Walkways Gangways Fendering Pollution Craft Mooring Approach Trestle Trestle Pipeway Control House Ship Docking System Navigation Aids Cathodic Protection Lighting Fire Protection	Berthing Mooring Deberthing

FLOATING POLLUTION CONTROL SYSTEMS

FACILITIES	ACTIVITIES
Equipment: Preventions Detection Treatment Disposal Spare Parts Storage	Deploy Equipment Monitor Respond

NAVIGATION SYSTEMS

FACILITIES	ACTIVITIES
Channel Approaches Anchorage Tugs Navigation Aids	Piloting

CRUDE OIL UNLOADING SYSTEMS

FACILITIES	ACTIVITIES
Unloading Arms Valves and Meters Pumps and Motors Piping Instrumentation Multi-plexing Data Transmitting Systems Pollution Control Power Stand By Power Communications	Unloading Operations Monitoring Meter Proving Leak Detection Monitoring

TANK FARM SYSTEMS

FACILITIES	ACTIVITIES
Tanks and Foundations Tank Mixers Valves and Meters Vapor Recovery Surge Relief System Waste Water Treatment Power Substation Standby Power Cathodic Protection Communications Fire Protection Pollution Control Administration Building Spare Parts Storage Dikes Roadways Pigging Equipment Property	Administering Monitoring Sampling Effluent Testing Documenting Pigging

SUBMARINE PIPELINE SYSTEMS

FACILITIES	ACTIVITIES
Piping Block Valves Underwater Corrosion Coating Weight Coating ROW	Monitoring Internal Cleaning Batch Separation Testing

PIPELINE SYSTEMS

FACILITIES	ACTIVITIES
Piping Relief Valves and Storage Block Valves Cathodic Protection Corrosion Coatings ROW	Monitoring Internal Cleaning Batch Separation Testing

BOOSTER PUMP STATION SYSTEMS

FACILITIES	ACTIVITIES
Pumps and Motors Piping Instrumentation Communications Power Sampling Laboratory Fire Protection Pigging Equipment Spare Parts Storage	Pumping Monitoring Sampling Pigging

BALLAST WATER SYSTEMS

FACILITIES	ACTIVITIES
Pumps Piping Meters	Ballasting Monitoring

SOURCE: PRC Harris, 1981

FIGURE 24

Basic assumptions for cost estimating

Throughout the term of the study, contacts were established and maintained with corporations, consultants, agencies and individuals involved in the design, construction, manufacture, operation and maintenance of the structures and equipment associated with marine crude oil handling facilities, both in this country and overseas. From these sources and from relevant publications, dollar amounts for comparable proposed or installed facilities, their components and systems were acquired.

As the in-harbor COHF concept evolved through its various stages, it was discussed with many of the above mentioned contacts, who generously commented on the concept as a whole and on its essential components. A synthesis of all these inputs is reflected in the cost estimating process for the in-harbor COHF. It is assumed that the inputs were sufficiently accurate to begin with and that the adjustments made to them to 'fit' a New York Harbor COHF were sufficiently conservative so that the estimates retain a validity commensurate with a preliminary economic evaluation.

In order to provide a further foundation for estimations, certain additional basic assumptions about the facility were required. Some of the critical assumptions were the following:

1. Ambrose Channel will have a depth of at least 60 feet, when the COHF becomes operational.
2. The combined service demand for Chevron and Exxon is 240,000 barrels per day. This translates to 87,600,000 barrels per year.
3. The maximum ship size to be handled at the facility will be in the 260,000 dwt range. Such a vessel will have offloaded a sufficient portion of its cargo elsewhere (probably, in the Caribbean) so as to have at most a 60 foot draft. Maximum cargo delivered will be approximately 1,250,000 barrels per visit in no more than two segregations.
4. Of the two 150,000 barrel tanks in the tank farm, one will be dedicated to each refinery. The two 400,000 barrel tanks will be used consecutively by the refineries.
5. When a given refinery's tanker arrives, that refinery must be prepared to receive in its own tank farm up to 450,000 barrels during the tanker's port stay. The balance of the cargo will be pumped into the COHF's tank farm to be transferred to the refinery prior to the arrival of the next tanker.
6. Although preliminary developmental and permitting work would begin earlier, actual construction is assumed to start in mid-1983 with facility completion in mid-1986.
7. The construction project is a 'turn-key' affair, and costs reflect fully installed and ready-to-operate components acceptable to whomever authorizes and finances the undertaking.
8. Since the COHF may draw power in different quantities from different utilities with different rate structures, an 'average' cost of $0.09 per kilowatt-hour in 1981 dollars was used.
9. Cost of land acquisition for the tank farm is included in the capital cost of that component.
10. Annual land use costs and other associated expenses paid to governmental entities for the marine pier, Stapleton pump station, pipeline right-of-way and tank farm are treated in the section on operating and maintenance costs.

Capital cost estimate

In Table 37 a capital cost estimate for the several components and major technical systems of the COHF is presented. Costs of these items are in millions of 1981 dollars and are proportioned across the years 1983 through 1986 as construction and installation progresses. Due to the nature of such a large-scale undertaking, extra work on any or all of the parts could be required and is accommodated by increasing each year's expenditures by 10%. Additionally, since the construction costs are in 1981 dollars, inflation is reflected by an escalation rate of 10% per year, compounded from 1981. The balance of the calculations are performed on the overall cost of building the facility. The cost for developmental and design work, for acquisition of necessary permits or licenses, for the broad insurance coverage associated with such a venture, for the supervision and inspection of work-in-progress and for the administration of the project is expressed as a lump sum of 10% of the escalated installed cost. After subtotalling the installed costs of components and systems, extra work, inflation and development, the unexpected is anticipated by increasing the cost of the project by 15%. Financing the construction of the COHF may be accomplished by any one of several methods. To compensate for the uncertainties of the present financial market, the cost of construction money is assumed to be a flat 10% of the project cost estimate, including contingencies. This actually represents 20% of the installed components and systems price and 13% of the escalated cost.

Table 37
IN-HARBOR CRUDE OIL HANDLING FACILITY, CAPITAL COST ESTIMATE
(in millions of dollars)

Note: Costs of items 1 through 7, below are in 1981 dollars.

Installed costs of:	**1983**	**1984**	**1985**	**1986**	**Totals**
1. Access channel		2.0	4.0	1.0	7.0
2. Conventional marine pier	2.0	4.0	5.0	1.0	12.0
3. Specialized marine oil pier equipment		2.0	3.0	1.0	6.0
4. Pipelines	2.0	6.0	9.0	3.0	20.0
5. Pumping stations		1.0	2.0	2.0	5.0
6. Tank farm	3.0	4.0	6.0	2.0	15.0
7. Major technical systems		1.0	5.0	4.0	10.0
Subtotal	7.0	20.0	34.0	14.0	75.0
Extra work @ 10% of each year's costs	.7	2.0	3.4	1.4	7.5
Subtotal	7.7	22.0	37.4	15.4	82.5
Escalation @ 10% per year from 1981	1.7	7.7	18.3	9.9	37.6
Subtotal	9.4	29.7	55.7	25.3	120.1
Development, design, permitting & licensing, insurance, supervision and administration @ 10% of escalated subtotal					12.0
Subtotal					132.1
Contingencies @ 15% of last subtotal					19.8
Subtotal					151.9
Construction financing @ 10% of last subtotal					15.2
TOTAL COHF CAPITAL COST					$167.1

Amortization

Table 38 presents the amortization of the facility expressed as an annual cost per barrel throughput. As derived in the previous section, the capital investment in the facility is estimated at $167.1 million. Due to wide variations in financing schemes and lack of agreement in financial circles as to the future cost of long term money, a conservative figure of 14.5% per year was selected. Since the sources and quantities of imported crude oil also change with time, a comparatively brief facility life of 10 years was chosen. The resultant annual amortization of the facility is $32.7 million. Annnual throughput is assumed to be 87.6 million barrels. Hence, the annual amortization can be expressed as a cost per barrel put through the COHF of $0.37.

Table 38
ANNUAL AMORTIZATION COST
OF AN IN-HARBOR CRUDE OIL HANDLING FACILITY

Capital investment:	$167,100,000
Cost of long term money:	14.5% per year
Life of facility	10 years
Annual amortization:	$32,660,000
Annual throughput:	87,600,000 barrels
ANNUAL AMORTIZATION PER BARREL:	$0.37

Computation of operating and maintenance costs

For a facility to be economically viable, there must be a high expectation of recovering not only the cost of constructing it but also the cost of running it. Usually, the amortization remains constant until such time as the capital investment is paid off. It is the operating and maintenance (O&M) costs which vary from year to year reflecting changes in the costs of energy, labor, materials and services. The development of the annualized O&M costs will be subdivided into the computation of a) energy costs; b) operational costs; c) maintenance costs; d) cost of miscellaneous services; and e) cost of land use and associated expenses. All are expressed in 1981 dollars.

a) **Energy costs.** Annually, 87.6 million barrels of crude oil are to be offloaded from VLCCs and transferred to Exxon and Chevron, part directly and part after an intermediate stay in the COHF's tank farm. Electrical energy will be used to accomplish the transfer. Energy costs are estimated as follows:

Stapleton Pumping Station—
60,000 barrels per hour at 75% of installed capacity
6,000 horsepower (1 horsepower = 0.75 kilowatts)
87,600,000 divided by 60,000 = 1,460 hours per year, pumping
6,000 x 0.75 = 4,500 kilowatts
1,460 x 4,500 = 6,570,000 kilowatt-hours
6,570,000 x $0.09 = $591,300

Tank Farm Pumping Station—
11,250 barrels per hour at 75% of installed capacity
1,000 horsepower (1 horsepower = 0.75 kilowatts)
87,600,000 divided by 11,250 = 7,790 hours per year, pumping
1,000 x 0.75 = 750 kilowatts
7,790 x 750 = 5,842,500 kilowatt-hours
5,842,500 x $0.09 = $525,825

Other energy used—
Assume all other electrical energy used amounts to 15% of the pumping electrical energy.

0.15 x (6,570,000 + 5,842,500) x $0.09 = $167,570

TOTAL ENERGY COST—
591,300 + 525,825 + 167,570 divided by 87,600,000 = $0.015 per barrel

b) **Operational costs.** Annually, 87.6 million barrels of crude oil are to be offloaded from VLCCs carrying a maximum of 1,250,000 barrels per visit. This will necessitate 70 tanker visits per year. The typical port stay for a VLCC will be two days. Manpower will be necessary to perform the required functions. Hourly wage rates include fringe benefits. These costs are estimated as follows:

Pier Operation — Line handling on arrival and departure, maneuvering of unloading arms, positioning gangway, transferring stores, fire watch, etc.

1 Pier Supervisor on duty whenever a ship is tied up.	
70 visits x 48 hours x $36 per hour =	$120,960
1 Unloading Master on duty aboard tanker whenever a ship is pumping.	
70 visits x 24 hours x $27 per hour =	$ 45,360
6 Line Handlers/Maintainers on duty for eight hours per tanker visit; four hours at arrival and four at departure.	
70 visits x 8 hours x 6 men x $20 per hour =	$ 67,200
2 Fire Watch/Pollution Control Men on duty for balance of hours per tanker visit when no line handlers/maintainers are present.	
70 visits x 40 hours x 2 men x $15 per hour =	$ 84,000
Pumping Operation — Start, monitor, stop pumps.	
2 Pump Operator/Maintainers on duty (one at each pump station) whenever a ship is pumping.	
70 visits x 24 hours x 2 men x $20 per hour =	$ 67,200
1 Pump Operator/Maintainer on duty in tank farm pumping station whenever crude oil is being transferred to a refinery.	
70 visits x 72 hours x 1 man x $20 per hour =	$100,800
Tank Farm Operation — Receive, test, log, transfer, discharge, inventory crude oil.	
1 Tank Farm Supervisor on duty around the clock	
365 days x 24 hours x $36 per hour =	$315,360
1 Equipment Serviceman on duty around the clock.	
365 days x 24 hours x $20 per hour =	$175,200
Labor cost subtotal	$976,080
Administrative and clerical support at 10% of labor cost	97,608
TOTAL LABOR COST	$1,073,688

Say $1,100,000 divided by 87,600,000 barrels = $0.013 per barrel

c) **Maintenance costs.** Major structural, electrical, mechanical and electronic maintenance, both of a periodic preventative nature and of a break-down nature, will be performed under annual time and material contracts with upset prices. Minor adjustments and repairs will be performed by operations staff on hand.

	Estimated Price
Structural	$100,000
Electrical	250,000
Mechanical	350,000
Electronic	75,000
TOTAL MAINTENANCE COST	$775,000

$775,000 divided by 87,600,000 barrels = $0.009 per barrel

d) **Cost of miscellaneous services.** Insurance, automotive needs, security/fire/tamper/flow alarm services, pollution control response, etc. will be provided by policy and contract. These costs are estimated as follows:

	Estimated Price
Insurance (0.4% of component costs)	$300,000
Automotive needs (2 station wagons, 2 pick-up trucks)	35,000
Security/Fire/Tamper/Flow Alarm services	50,000
Pollution control response retainer	75,000
Subtotal	460,000
Other (10% of subtotal)	46,000
TOTAL COST OF MISCELLANEOUS SERVICES	$506,000

$506,000 divided by 87,600,000 barrels = $.006 per barrel.

e) **Cost of land use and associated expenses.** In all likelihood, the marine pier, the Stapleton pump station, the pipeline right-of-way and the storage tank farm will incur some annual costs payable to various governmental entities. General guidance gained from marine pier, pipeline and tank farm operators indicated that an annual cost in 1981 dollars of $0.02 per barrel throughput should be used to approximate these expenses.

The above costs may be summarized as follows:

	1981 annual cost per barrel
a) Energy cost	**$0.015**
b) Operating cost	**0.013**
c) Maintenance cost	**0.009**
d) Cost of miscellaneous services	**0.006**
e) Cost of land use and associated expenses	**$0.020**
TOTAL OPERATING AND MAINTENANCE COSTS	**$0.063**

The annual cost per barrel in 1981 dollars may be escalated by 10% compounded annually to the 1986 opening date of the COHF. This results in a cost per barrel of $ 0.10 for O&M. Taken together with the $ 0.37 per barrel for amortization, the cost to the user for each barrel of throughput in 1986 would be $ 0.47.

Economic feasibility of a New York Harbor alternative

Throughout the study, a simple test for economic feasibility of alternative marine crude oil delivery proposals has been employed. A direct comparison between the transportation savings effected by employment of a given alternative and the cost of implementing that alternative is made. If the cost of implementation equals or exceeds the associated transportation savings, the alternative is judged to be economically infeasible. However, if the estimated implementation cost is less than the projected transportation savings, the alternative is judged to have survived the initial level of evaluation.

In Chapter Seven, the estimated cost savings in marine transportation associated with a New York Harbor COHF was calculated to be in the range of $0.58 to $1.06 per barrel throughput in 1986 dollars. This compares with a capital amortization, operating and maintenance cost per barrel throughput in 1986 of $0.47. Thus, the minimum difference is approximately $0.10 per barrel in favor of the facility, a significant enough amount to warrant further consideration.

CHAPTER NINE

REGULATORY CONSIDERATIONS RELEVANT TO ALTERNATIVE CRUDE OIL TRANSFER SYSTEMS

Economics play a key role in dictating initial engineering configurations for alternative marine crude oil transfer systems but regulatory limitations may alter the design and location of such systems. To facilitate a discussion of pertinent regulatory consideratons an overview of two basic federal laws is provided: the Federal Coastal Zone Management Act of 1972 and the Deepwater Port Act of 1974. A survey of these laws is necessary to understand the critical federal-state interaction involved with licensing offshore marine facilities as well as inshore facilities.

As stated previously, in-harbor facilities have the better economic potential under current conditions and for that reason regulatory issues associated with these facilities are examined in greater depth than for offshore facilities. The jurisdictional focus of the report is on New Jersey.

A table of permits required by the State for tanker terminals and ancillary facilities can be found in Appendix E. Additionally, international conventions and regulations relevant to Deepwater Ports or the supertankers which serve them are included in Appendix F.

It should be noted that this analysis does not represent a formal legal opinion of the State of New Jersey, The Port Authority of New York and New Jersey or other federal and state agencies discussed herein.

Principal federal laws regulating the location of marine crude oil transfer facilities

Two comprehensive federal laws affect the type and location of marine crude oil transfer facilities: the Coastal Zone Management Act of 1972, and the Deepwater Port Act of 1974.

A. The Coastal Zone Management Act of 1972

Spurred by the need to encourage coastal states to protect their unique resources from development pressures, Congress passed the Coastal Zone Management Act of 1972 (CZMA). In 1976, the act was substantially amended by PL 94-370, which, among other provisions, established the Coastal Energy Impact Program to assist states in planning for and mitigating the impacts of coastal energy development. This planning and mitigation effort specifically includes offshore oil and gas development efforts as well as other industrial uses of the marine environment such as marine terminal and deepwater port construction.

The CZMA provides planning and implementation assistance for participating states to develop comprehensive land and water use plans for their respective coastal zones. State plans are afforded some flexibility to define coastal zones but generally these zones include all tidal waters and upland areas, the uses of which can strongly influence the quality of these waters.

In the Coastal Zone Management Act of 1972, the potential for conflict between federal and state uses in the coastal areas was recognized by the inclusion of section 307, more commonly known as the federal consistency section. This section, which states that the conduct of federal activities and the issuance of permits must be consistent with state coastal zone management programs to the maximum extent practicable, has been the subject of considerable controversy and debate. More detailed information on section 307 is presented later in this chapter.

1. State Program Approval

The Coastal Zone Management Act provides specific criteria by which state programs may be approved by the National Oceanic and Atmospheric Administration (NOAA). In summary the program approval elements are:

(a) An identification and evaluation of those coastal resources recognized in the CZMA that require management or protection by the state.

(b) A re-examination of existing policies and development of new policies to manage these resources. These policies must be specific, comprehensive and enforceable and must provide an adequate degree of predictability as to how these coastal resources will be managed.

(c) A determination of specific uses and special geographic areas that are to be subject to the management program which should be based on resources capability and suitability analyses, socio-economic considerations and public preferences.

(d) An identification of the inland and seaward areas subject to the management program.

(e) Consideration of the national interest in the planning for and siting of energy facilities that meet more than local requirements.

(f) Sufficient legal authority and organizational arrangements to implement the program and ensure compliance with it.

2. **Section 307 - Federal Consistency.**

The federal consistency component of coastal zone management plans provides regulatory bargaining power for state coastal programs in individual cases. A general discussion of the process is warranted here.

The federal consistency provisions of the CZMA Section 307(c)(1) and (2) require that federal activities and development projects in or directly affecting the coastal zone be consistent with state Coastal Zone Management Programs to the maximum extent practicable. In this respect, consistency has never been construed as a 'burden of proof' which federal agencies must carry to demonstrate compatibility with state plans. Thus, where the national interest is compromised by a state refusing to grant a consistency certification, the Secretary of Commerce may exercise an override of the state program.

The federal consistency provision of the Coastal Zone Management Act has not been used in any previous litigation over the siting of oil terminals either in California or the recent Pelican Island controversy in Texas. To date, all the litigation involving federal consistency has concerned oil and gas exploration on the Outer Continental Shelf (OCS). Nevertheless, it remains a potent regulatory component of each federally approved state coastal zone program.

The potential of federal consistency provisions to stop major federal actions is illustrated in a recent District Court Decision in California (*California, et al. V. Watt, Docket 81-2080 (1) MRP (MX) U.S. District Court, Central District, CA*). This suit determined that activities preparatory to an offshore oil and gas sale must be consistent with state plans. The Department of the Interior contended that pre-lease activities do not directly affect the coastal zone and, thus that no consistency determination was required. The meaning of 'directly affected' has itself been the subject of controversy.

On July 8, 1981, NOAA published proposed final regulations to clarify which federal activities are considered as directly affecting the coastal zone and, therefore, subject to the consistency review of Section 307(c)(1). These regulations specified that a consistency review is required if a federal agency finds that the conduct of the activity itself produces an identifiable physical alteration in the coastal zone. A review also is required if the activity initiates a chain of events reasonably certain to result in such an alteration. Negative reaction to this proposal came from the state governments and congressional committee members with CZMA oversight responsibilities and the proposed regulations were withdrawn. (See 46 *Federal Register* 50938, October 16, 1981.)

In essence, the above-referenced District Court decision (although primarily concerned with OCS leasing policy) indicates that the federal consistency provision could be employed in litigating the proposed construction of an alternative crude oil receiving facility since the U.S. Corps of Engineers and the U.S. Department of Transportation would be involved in such a project. The California litigation will determine the probability of success with such an approach once it ultimately determines the meaning of 'directly affecting' the coastal zone.

3. **The national interest and tanker terminals**

Two tanker terminal siting controversies have arisen in recent years: SOHIO at Long Beach, California and Puget Sound Terminal, Washington. In neither of these cases, did the CZMA federal consistency section play a major role, but these case studies are directly relevant to the facilities under consideration here.

The impasse over the SOHIO Terminal centered on Clean Air Act issues while litigation on the Puget Sound Terminal involved an attempt by the State of Washington to regulate the size of tankers entering Puget Sound. The United States Supreme Court ultimately found in the Puget Sound case that the state law in question had been federally pre-empted. (See *Seaward Development*, National Academy of Sciences, 1980; *Ray v. Atlantic Richfield Company*, 435 US 151, 15 L. Ed 2d 179, 1978 and *The Deepwater Port Act of 1974*.)

B. The Deepwater Port Act of 1974

The Deepwater Port Act of 1974 (DWPA) was enacted as a general enabling statute but was drafted with the goal of authorizing the Louisiana Offshore Oil Port (LOOP) project. Planning for LOOP had started in the early 1970's. The DWPA reflects the influence of LOOP and the intense environmental concerns following the enactment of the Federal Water Pollution Control Act Amendment of 1972, the National Environmental Policy Act (NEPA), and the CZMA. The sole focus of the DWPA is the construction of offshore oil terminals rather than in-harbor facilities.

Under the act, a deepwater port means any fixed or floating man-made structure other than a vessel, or any such group of structures located beyond the territorial sea and off the coast of the United States, and which are used or intended for use as a port or terminal for loading or unloading and further handling of oil for transportation to any state. The U.S. territorial sea currently stands at three nautical miles. However, because of historical precedent and case law, Texas and Louisiana have slightly different areas of control from other states.

The single most important feature of the DWPA from a location constraint viewpoint is Section 1508, the Adjacent Coastal State provisions, which provides for a de facto veto of the facility. To obtain Adjacent Coastal State status, several steps are involved.

- The Secretary of Transportation must file notice of receipt of a deepwater port application and designate as a potential adjacent coastal state one which is:

  (a) directly connected by pipeline to a deepwater port as proposed in the application, or

  (b) would be located within 15 miles of any such deepwater water port.

- The Secretary will designate a state as 'Adjacent Coastal' if he receives a request from any such state, and if the Administrator of NOAA concurs in the petition. But the Secretary must determine that there is a risk of damage to the coastal environment of the adjacent state at least as great as the risk posed to the state directly connected by the pipeline.

After designation as an Adjacent Coastal State, the Secretary transmits the complete application to the state for a consistency review with its general environmental and social programs. If the governor of that state finds the application inconsistent with these programs, the Secretary is required to condition the license so as to make it consistent.

The Adjacent Coastal State provisions were the subject of considerable discussion in congressional hearings and committee discussions. The conditioning of the deepwater port license was viewed as an absolute veto on the facility (see 1974 *U.S. Code, and Administrative News* pg. 7537-8). Arguments in committee that state land use and environmental controls could adequately mitigate deepwater impacts were rejected. Further, pre-emption of state regulatory schemes for oil spills was considered and rejected.

The prevailing theme of the legislative history of the DWPA is one of coordination with the states and shared responsibility for identifying the impacts of a deepwater port and mitigation, where possible. Deepwater ports were viewed as essential to the national interest given the crude oil import figures of the early 1970's. However, the Deepwater Port Act was drafted to complement the goals and objectives of the CZMA.

Methodology for discussion of inshore regulatory issues

The jurisdictional focus of the following section is on New Jersey. A table of permits required by the state for tanker terminals and ancillary facilities can be found in Appendix E.

As explained in previous chapters, this study does not consider dredging issues, and therefore permits for dredging are not included. Historically, the federal government has taken responsibility for and borne the cost burden of the improvement and maintenance of designated navigable waterways. Presently, several bills are being deliberated before both Houses of Congress which address both the pace and the funding mechanism for waterway improvements such as channel deepening. The potential effects of the various bills are wide ranging. Economic, environmental and permitting issues associated with channel dredging and dredge spoil disposal are best left until such time as some legislation is enacted and its impacts can be evaluated thoroughly. Appendix G contains a summary of current proposals for port development legislation.

The regulatory network to be negotiated in the construction of an in-harbor terminal is complex; however, a general framework for analysis of the issues includes interstate regulatory issues, federal regulatory programs, state regulatory programs, and issues of local concern.

These topics are discussed in the following sections in relation to port development for the Delaware Bay and New York Harbor areas.

Delaware Bay and River regulatory issues

The Delaware River and Bay system can be broadly characterized as a fresh water drainage basin adjacent to four states, coupled to a coastal embayment subject to the jurisdiction of three states. The Delaware River exhibits tidal characteristics as far north as Trenton, New Jersey and the salinity levels are directly proportional to the tides. Although the River and Bay support heavy industrial and residential populations, the concentrations are not of the intensity of the New York Harbor Region. The biological characteristics of the Bay are detailed in Walter, *et al.*, 1981, in Volume II of this report.

Interstate regulatory issues

The prime interstate issues surrounding the construction of an oil port (SPM type) and pipelines at Big Stone Anchorage would involve the potential disruption of marine traffic within the Delaware River and Bay as well as detrimental impacts on the region's water quality. Air quality primarily is a function of the individual state's air pollution implementation plans. Pipeline crosings of the upper Delaware River to New Jersey refineries would be subject to the permit procedures of the affected states.

1. **Water quality**

Water supply and quality in the Delaware River and Bay are subject to the extensive powers of the Delaware River Basin Commission (DRBC) (*N.J.S.A.* 32:110 et seq). The DRBC was created in 1961 by concurrent legislation in Pennsylvania, New York, New Jersey, and Delaware and by an act of Congress. It is charged with the responsibility of developing plans and implementing policies for the Delaware River Basin.

The DRBC compact gives the Commission broad controls over water supplies, water quality, pollution control, flood protection, water shed management, recreation, fish and wildlife, hydroelectric power and regulation of water withdrawals and diversions. The compact further provides that no project having a substantial effect on water resources may be undertaken without the Commission's approval. Planning for and construction of public projects within the Delaware Basin must seek the advice of the Commission. Finally, the compact requires the preparation of a basin-wide plan which not only identifies policies but also guides regulatory decisions of the Commission.

The only statement by the Commission on deepwater ports is found in *The Draft Report and Environmental Impact Statement of the Level B Study.* The Study identifies several environmental issues associated with the siting of a deep draft oil terminal in the Bay. According to the study, 'These include massive dredging and (spoil) disposal and a potential for a massive supertanker oil spill. The effect of bay modification on salinity intrusion would need assessment.' (p. 80)

The Study offers no definitive policy on the siting of an offshore monobuoy or in-harbor facility. However, a consensus opinion attributed to the Level B Study's Energy and Navigation work group concluded that neither configuration of the oil port would be needed before the year 2000 and then only if significant oil reserves were developed on the Georges Bank or Baltimore Canyon Outer Continental Shelf. It would appear that a facility for the Bay would have to meet severe economic and environmental criteria before the Commission would authorize such a project. As amplified in other segments of this chapter and study, the feasibility for such a facility in Delaware Bay appears to be minimal. *The Final Report and Environmental Impact Statement of the Level B Study* deleted any reference to deepwater ports. No explanation is provided for the deletion.

Two other regional agencies with transportation responsibilities would be involved in the siting of a terminal. These are the Delaware River and Bay Authority and the Delaware River Port Authority. These agencies operate the bridges, ferry, and PATCO High Speed Rail Line to Lindenwald servicing southeastern Pennsylvania and southern New Jersey. These agencies possess no direct regulatory authority over an in-harbor oil terminal.

2. **Pipeline rights-of-way**

The Rutgers University Center for Coastal and Environmental Studies (CCES) has studied a potential pipeline right-of-way which traverses state highways through Delaware and Pennsylvania. The pipeline would terminate at Marcus Hook, Pennsylvania. This analysis is contained in the overall CCES assessment of Delaware Bay (Walter, *et al*, 1981, Volume II). New Jersey refineries which wanted this source of crude oil would either build pipeline branches to connect their facilities with the tank farm at Marcus Hook or barge the oil from Marcus Hook to their facilities. Right-of-way issues on state highways are subject to Delaware and Pennsylvania state and local law.

3. **Air quality**

As stated previously, air quality issues affecting the siting of a Delaware Bay in-harbor terminal are primarily a function of individual State Implementation Plans and the pollutant standards set by those plans. National Ambient Air Quality Standards (NAAQS) are enforced by the federal Environmental Protection Agency (EPA).

Air quality planning for the metropolitan Philadelphia Interstate Air Quality Control Region is authorized by a Delaware, New Jersey, Pennsylvania Interstate Cooperative Agreement on Air Pollution. This agreement dates from 1973. The objectives and purposes of the agreement are to coordinate activities as well as the respective governmental jurisdictions for the immediate and long-term management of the air quality of the metropolitan Philadelphia region. The immediate objectives are to:

a) coordinate surveys, studies, air monitoring activities;
b) coordinate control strategies to attain NAAQS for the region;
c) assemble and disseminate data delineating control strategies and implementation plans for the region; and
d) implement cooperative procedures during high pollution episodes.

Federal regulatory programs

The primary federal regulatory programs surrounding both the Delaware Bay and New York Harbor facilities concern waterway and shoreline modification aspects of the facilities. Waterway modification necessarily implies dredging. Since the Delaware Bay facility is subject to extreme environmental and economic constraints, a basic listing of laws and permit programs is deemed sufficient. These same programs would, of course, apply to the New York Harbor facility. The principal waterway regulatory programs are listed here.

a) The Rivers and Harbors Act of 1899 (Section 10) requires a permit for any work in navigable waters (33 U.S.C. 401 et seq.).
b) Section 404 of P.L. 92-500 requires a permit for the disposal of dredge spoils. The U.S. Environmental Protection Agency may withhold approval of the disposal site (33 U.S.C. 1251 et seq.).

c) Approval to dispose of dredge spoil at sea is subject to Titles I and II of the Marine Research, Protection and Sanctuary Act (33 U.S.C. 1401 et seq.).
d) The Fish and Wildlife Coordination Act of 1934 requires that the Corps of Engineers give due consideration to the impact of dredging activities on the habitats of fish and wildlife.
e) The National Marine Fisheries Service advises the Corps on impacts of its proposed projects on marine fish and the Corps usually gives substantial weight to these recommendations.

State regulatory programs

The regulatory programs of the three states bordering the Delaware Bay and River are described below.

1. The Delaware Coastal Management Program

Delaware enacted its Coastal Zone Mangement Act in 1971 which predates the federal CZMA. It was structured to prevent heavy industrial uses of the coastal ecosystem. As noted in the introduction to this study, many initiatives were undertaken with an eye toward constructing either in-harbor monobuoys or offshore monobuoys in the Delaware Bay vicinity. All these initiatives faced the intractability of the Delaware CZMA. Attempts to amend the act legislatively have not been successful to date.

Today the federally approved Delaware Coastal Management Program (CMP) has formulated a definitive policy with respect to an in-harbor facility as follows:

> Deepwater Ports on the Delaware side of the Delaware River and Bay are prohibited by the Coastal Management Program. Such ports are also prohibited within Delaware's Three Mile Jurisdiction along the Atlantic Ocean. (*Delaware Coastal Management Program and Final Environmental Impact Statement*, 1979, U.S. Department of Commerce (NOAA/OCZM at 5.D.3e, 504))

However, with respect to the Atlantic Ocean, the Delaware CMP is more balanced:

> Notwithstanding the Coastal Management Program objections to a Delaware Bay Deepwater Port the program supports the concept of a port off the Atlantic Coast, provided it meets certain environmental standards which include a location far enough offshore to minimize oil spill threats to the coast and obviate dredging requirements, stringent construction and operation safeguards, a demonstrated reduction of tanker traffic and lightering in the Bay, and assurances that state financial interests are protected. (*Delaware Coastal Management Program and Final Environmental Impact Statement*, 1979, U.S. Department of Commerce (NOAA/OCZM at 5.D.3e, 504))

The Delaware program recognizes that national and regional energy contingencies may require a reexamination of these policies. The Delaware Energy Act of 1978 requires that the state's cabinet level Energy Facilities Siting Liaison Committee seek regulatory and legislative amendments to energy facility siting policies. This procedure does not supercede the CMP but provides a mechanism by which individual developers can petition for 'authority' to construct projects.

Previous sections of this report have indicated that offshore oil port monobuoy facilities cannot operate on an economic basis in this region. Environmental assessments by Walters, *et al.*, and Haskin in Volume II of this study demonstrate the sensitivity of Delaware Bay to a proposed oil terminal. The impacts, as documented in these consultant reports, would not meet the policy criteria for siting under the Delaware Coastal Management Program.

2. The Pennsylvania Coastal Management Program

No explicit policy is written into the Pennsylvania Coastal Management Program (CMP) concerning offshore deepwater ports or Delaware Bay facilities. Clearly, the only impact on the Pennsylvania coast by these proposed facilities would be from the crude oil pipeline originating in Delaware Bay; the previously mentioned pipelines constructed from the New Jersey refineries to Marcus Hook; or the increased barge traffic from Marcus Hook to the New Jersey refineries. Policy VIII - 1 of the Pennsylvania CMP comes closest to offering guidance on deepwater in-harbor marine terminals:

> It is the policy of the Coastal Zone Management Program to ensure through regulations, by permit, that energy facilities such as oil and gas refineries, electric generating stations (coal, hydro, oil and gas), electric generating substations, gas drilling and liquefication of natural gas operations locating in coastal areas are sited in such a manner that the coastal areas ecosystems are not unreasonably adversely affected. *(Coastal Zone Management Commonwealth of Pennsylvania Program and Final Environmental Impact Statement*, 1980, U.S. Department of Commerce (NOAA/OCZM 1980 at policy VIII-1))

It would appear that the Pennsylvania CMP is, as a matter of policy, flexible with regard to accommodating the pipeline and support facilities for helping crude oil transfers from Marcus Hook to New Jersey refineries.

The New Jersey Coastal Management Program addresses the in-harbor and offshore monobuoy system specifically. Moreover, the question of locating the in-harbor facilities on the New Jersey side of Delaware Bay must be examined.

3. The New Jersey Coastal Management Program

The New Jersey Coastal Management Program uses a 'trade-off' methodology called the Coastal Location Acceptability Method (CLAM) to determine the suitability of development in New Jersey's coastal zone. The New Jersey CMP policies are unusual in that they have been incorporated into the New Jersey Administrative Code. As such, the policies become self-executing regulations. (The Delaware and Pennsylvania coastal policies rely on statutory authority or a network of regulations to implement their policies.) The New Jersey CMP policies' legal stature has been greatly enhanced by this technique. Specific policies are formulated for uses, locations, and resources of the coastal zone. The energy use policy concerning tanker terminals states:

> New or expanded tanker facilities will be acceptable only in existing ports and harbors where the required channel depths exist to accommodate tankers. Multi-company use of existing and new tanker terminals will be encouraged in the Port of New York and New Jersey and in the area bounded by the Delaware River Port Authority where adequate infrastructure exists to accommodate the secondary impacts which may be generated by such terminals such as processing and storage facilities. New tanker terminals will be discouraged in other parts of the coast. Offshore tanker terminals and deepwater ports are discouraged from the Bay and Ocean Shore Region, pending a thorough evaluation of the implications of such a facility.

This policy is amplified by the following rationale:

> Onshore tanker facilities pose potential adverse environmental impacts and could encourage secondary development activity that is not necessarily coastal dependent. Also, even medium sized tankers require minimum channel depths of 30 feet, which excludes locations within the Bay and Ocean Shore Region. New or expanded tanker terminals are, therefore, directed to New Jersey's established port areas. Deepwater ports appear attractive to industry due to increasingly larger tankers, limitations on dredging and the scarcity of waterfront land. However, a deepwater port may, depending on its location, cause severe adverse primary and secondary impacts on the built, natural, and social environment. (*N.J.A.C.* 7:7E-7.4(p))

Taken together the policy statement and rationale would appear to foreclose consideration of the New Jersey side of Delaware Bay for an in-harbor facility. Indeed, offshore tanker terminals are less favorably received under the New Jersey CMP than the Delaware CMP. Further, tank storage associated with either offshore or in-harbor facilities are discouraged from water's edge locations where they must meet stringent land buffering and air and water regulations. (*N.J.A.C.* 7:7E-7.4(o)). These criteria are particularly discouraging to the siting of such terminals on the New Jersey side of Delaware Bay.

Under the New Jersey CMP, the storage of crude oil, gases, and other potentially hazardous liquid substances is prohibited on barrier islands and discouraged elsewhere in the Delaware and Raritan Bay and Atlantic Shore region. (See note.) In the northern water front and Delaware River areas, such facilities are conditionally acceptable if they meet air and water resource policies and are compatible with or adequately

Note: Potentially hazardous liquid substances are defined in *N.J.A.C.*7:1E-1.1 under the Spill Compensation and Control Act (CFHIN.J.S.A. 58:10-23.11) buffered from surrounding uses. They are not acceptable along the water's edge unless they are supplied by ship in which case they are acceptable on the filled water's edge subject to the above conditions. They are not acceptable where they would limit or conflict with a potential recreational use. (*N.J.A.C.* 7: 7E-7.4(o)1).

The rationale provided for this policy is that major storage facilities for potentially hazardous substances are not entirely coastal dependent and will not be permitted where storage might limit or conflict with recreational or open space uses of the coast.

New Jersey and federal consistency

The siting of an in-harbor terminal at Big Stone Anchorage, Delaware would most assuredly be of interest to New Jersey CMP regulators. Federal permits to be issued in conection with such a facility could be subject to consistency review under the New Jersey CMP. If New Jersey denied certification of consistency, an interesting test case would develop if the Secretary of Commerce exercised the national interest override clause of the federal CZMA (see 16 U.S.C. 1456(c)(1).).

New Jersey State Implementation Plan and the Delaware Bay region

The New Jersey State Implementation Plan (SIP) is the implementation/regulatory plan to which the state is adhering in order to meet its air quality standards. The New Jersey plan is currently under revision, and several unresolved issues regarding the SIP could affect oil terminal siting in the metropolitan Philadelphia air shed. This area includes all of southern New Jersey and the Delaware Bay which has a non-attainment status for ozone.

Marine sources of volatile organic substances (VOS) emissions are not currently regulated by the Air Pollution Code. However, New Jersey, in order to win an extension to 1987 for its compliance program from the EPA, agreed to implement reasonable available control technology for all major sources. Marine activities are a major source of VOS emissions. If control of these sources is deemed reasonable then rules requiring such control are likely to be adopted.

The air pollution dynamics of pumping crude oil through a monobuoy system into a pipeline and thus eliminating barge lightering could have an overall beneficial effect on potential VOS emissions when compared to current practices. Depending upon the SIP's for Delaware and Pennsylvania and assuming the monobuoy at Big Stone Anchorage in Delaware, the VOS emissions reduction would accrue to those states. This advantage may be negatively offset if the pipelined oil at Marcus Hook, Pennsylvania were placed on barges for its ultimate delivery to the New Jersey refineries. This situation would depend upon the volume of oil delivered to these refineries and thus the quantity of VOS emissions. A submarine pipeline connection between Marcus Hook and the New Jersey refineries would eliminate this potential problem.

Conversely, the location of the monobuoy and pipeline system in New Jersey may be accommodated under New Jersey's SIP because of the aforementioned reduction of volatile organic substances. However, as previously noted, other environmental factors such as the need for massive dredging and the potentially devastating effects of oil spills on the oyster community foreclose such an option.

New York Harbor regulatory issues

This section will use the same method of analysis applied to Delaware Bay to isolate critical regulatory issues influencing the siting of an oil terminal in New York Harbor. Air and water pollution are the principal interstate issues. The primary focus again will be on New Jersey issues.

Interstate regulatory issues

1. Water Quality

The Interstate Sanitation Commission (ISC) established in 1933 is charged with monitoring both air and water pollution in the New York Harbor area (*N.J.S.A.* 17-1 et seq.). In practice, however, the issuance of permits and enforcement of water and air pollution standards are handled by agencies other than the ISC. This somewhat puzzling regulatory situation is explained below.

A 1948 court case defined the ISC as a compact among the signatory states for controlling and abating pollution of coastal and tidal waters (*Interstate Sanitation Commission v. Weehawken Township* 141 N.J. Eq. 536, 58 A. 2d 530 (1948)). The compact is a sanitary and police regulation of general public interest for elimination of pollution in New York Harbor. The signatory states are New York, New Jersey and Connecticut. The waters subject to ISC are defined at *N.J.S.A.* 32:18-3 and the authority to classify water quality is found at *N.J.S.A.* 32:18-7.

The ISC does not directly issue permits for discharge of effluent into the harbor. Applications for National Pollution Discharge Elimination System (NPDES) permits, issued by the EPA, or the New Jersey counterpart permits, are referred to the ISC for review. This review evaluates the proposed facility against ISC water quality standards. Mitigating measures or effluent limitations proposed by the ISC are directly incorporated into the federal or state permits. An in-harbor oil terminal may well require one of these permits, and thus be required to adhere to any mitigating measures or effluent limitations which the ISC may propose.

2. **Air pollution**

Interstate efforts to research, coordinate and control air pollution in the New York Harbor region is subject to several administrative mechanisms. At the formal level there is the Mid-Atlantic States Air Pollution Control Compact created in 1967 as a regional agency for the control and abatement of air pollution (see *N.J.S.A.* 37: 29-1 et seq). A commission was established with the following responsibilities:

a) to investigate the cause and source of air pollution and provide for research;
b) to establish standards for control of air emissions;
c) to administer plans and prepare to effectuate such regional air quality standards;
d) to promote research on air pollution as it affects regional concerns; and
e) to furnish technical services to the signatory parties.

The signatory states are New York, New Jersey, Delaware, Pennsylvania and Connecticut.

It would appear that this compact is not directly used on current air pollution issues. New York and New Jersey in 1981 signed an agreement on shared interstate air pollution issues. This agreement is popularly known as the Atlantic Alliance. Connecticut is not a signatory. The Alliance has a steering committee and several technical subcommittees that examine issues such as acid rain, powerplant conversions to coal, and other critical issues. The recommendations of these committees *guide* individual state permits, SIP revisions and other policy decisions. The Alliance does not enforce its recommendations directly.

New York Region air shed issues

The New York metropolitan air shed shares many of the characteristics of the Philadelphia air shed. The attendant benefits or impacts of an in-harbor oil terminal mentioned previously for Delaware Bay are also applicable to New York Harbor. However, it must be noted that the ozone problem for the New York air shed is more acute than for the Philadelphia air shed. Preliminary estimates by the New Jersey Department of Environmental Protection (DEP) indicate that it will be extremely difficult to achieve a 1982 compliance date for the ozone ambient standard unless all major sources are brought into compliance. Marine sources in this regard conceivably could be subject to an emission offset policy. A preliminary air pollution analysis of in-harbor facilities for New York Harbor is found in Volume II (Enviro Sciences, 1982).

State Regulatory Programs

The regulatory programs of New York and New Jersey as they pertain to New York Harbor are treated next.

New York State programs — The New York State Coastal Management Program will play the key regulatory role in New York Harbor. The New York State CMP has two components which directly affect the terminal. The Stapleton area of Staten Island is the marine pier site. This area has been classified by the New York City segment of the CMP as a Geographic Area of Particular Concern (GAPC). Of direct importance is the policy that states:

> To support increased public access to the waterfront, the management plan calls for consideration of incorporating public access in development plans, recycling unused city owned pier facilities and developing waterfront street end parks. (*Draft New York City Coastal Management Plan*, November 1979, p. 51.)

GAPCs are special areas within each state's plan which must contain specific identification of resources in the area and enforceable state regulations to implement the management policies of the plan for that area. Each state must have GAPCs for federal approval of its program.

The public access requirement of this draft plan will represent a key issue in determining whether an oil terminal can be accommodated at Stapleton under the New York State CMP. Additionally, the New York State CMP establishes a water dependency test for the siting of petroleum facilities. Policy 54 is:

> to provide for the siting of petroleum facilities, taking under consideration, state and national energy needs, the need to minimize adverse impacts on water and air quality; and if such facilities require a shore front location, provide this location within or adjacent to existing ports.

The criteria of the New York State plan do not impose unreasonable criteria for the oil terminal. Clearly, the oil terminal is water dependent and, as reports in Volume II indicate, reduction of lightering at the Stapleton anchorage may result in an improvement in water quality at least with respect to crude oil spillage. (see Hires *et al*, 1981; Farmanfarmaian, 1981 and Bartha, 1981, Volume II.)

New Jersey programs — As stated previously, the New York Harbor terminal envisions an offloading pier for tankers at the Stapleton area of Staten Island. Pipelines will traverse Staten Island, and cross the Arthur Kill to a tank farm which will be sited in New Jersey. The New Jersey Coastal Management Program policies which directly affect this infrastructure are the Storage of Crude Oil, Gases and Other Potentially Hazardous Liquid Substances Policy, and the Submerged Infrastructure Policy.

With regard to petroleum storage, the New Jersey CMP provides specific guidance for siting in the northern waterfront area of the program. Tanks are not acceptable at the water's edge if recreational uses are limited by the proposed facility.

The CMP tank storage policy is open to interpretation with respect to building the tanks on filled water's edge sites (see *N.J.A.C.* 7:7E-7.4(o)). It is unclear whether the implied water dependency test would determine that the water dependency of the Stapleton, Staten Island terminal would also extend to the associated storage tank farm in New Jersey. Another implied issue is whether siting of new storage facilities is strictly limited to filled areas. Thus, are wetlands or riparian lands in this area precluded as sites for tank storage? The policies of New Jersey's Tidelands Resource Council provide guidance on the question.

The Tidelands Resource Council — In New Jersey, submerged lands washed by the ocean tides are called riparian lands. Defined by statute, these are lands which are now or previously were covered by mean high tide to which the state has a claim. These lands also may include filled areas formerly subject to tidal action. The State owns the land as a trustee for the public and exercises its control either through its proprietary role as owner, or through its regulatory role under the Waterfront Development Law (see *N.J.S.A.* 12:5-3).

The State's ownership role is exercised by the Tidelands Resource Council which may grant, lease, or license the State-owned tidelands. A large portion of the State's riparian lands were sold in the nineteenth and early twentieth centuries. However, the present practice of the Council is to license the use of the land, unless exceptional circumstances warrant a grant.

The Council itself is composed of twelve citizens appointed by the Governor with the advice and consent of the State Senate. The council is independent of either the executive or legislative branches, although it does rely for staff support on the Division of Coastal Resources in the DEP. The DEP Commissioner and Director of the Division of Coastal Resources may veto the minutes of the council and return the affected applications to them for reconsideration. If the Council reaffirms its decision, administrative and judicial appeals options are available by the aggrieved party.

Traditional riparian case law allows the owners of land immediately upland of the submerged tracts to have the right to purchase or use the tide lands. Before any person may make use of these lands, however, the Council requires that they obtain a Waterfront Development Permit. The permit may be granted only if the activity is consistent with the Coastal Resource and Development Policies of the Coastal Management Program. This approach ensures that the use of the tidelands will be consistent with these policies.

In recent years, the Council has not been receptive to the filling of coastal wetlands for energy projects where non-water dependent sites are available or filled water's edge sites present an option.

Submerged infrastructure — The New Jersey Coastal Mangement Program contains definitions and policies with respect to submerged infrastructure as follows:

> Pipelines are hollow underwater pipes laid, buried, or trenched for the purpose of transmitting fluids. Examples would be crude oil, natural gas, water, petroleum product or sewage pipelines. Construction of an underwater pipeline may involve trenching, temporary trench spoil storage, and back filling or jetting as an alternative to trenching. (See *N.J.A.C.* 7:7E-4.10(n))

Minimum acceptable conditions for pipelines are provided in the program as follows:

1) trenching takes place to a sufficient depth and is backfilled, either through natural or mechanical means, to avoid puncturing or snagging anchors or sea clam dredges,
2) the pipeline is sufficiently deep to avoid uncovering by erosion of water currents, and
3) the conditions outlined for pipelines in the use policies are satisfied.

Temporary trench spoil storage and back filling as part of pipeline trenching is acceptable provided that bottom contours are reestablished to the original bottom contours prior to spoil removal to the maximum extent practicable. Jetting pipelines into bottom sediments is conditionally acceptable if trenching and back filling are impractical.

Summary

The three key issues associated with constructing an in-harbor crude oil handling facility in New York Harbor are:

(1) finding an existing site for the tank farm that will not generate major dredge and fill impacts;
(2) the disturbance of potentially contaminated bottom sediments in the Arthur Kill via the pipeline crossing; and
(3) whether marine sources of VOS emissions will be included as major sources on the revised New Jersey State Implementation Plan.

Presumably, an applicant for such a facility will try to utilize existing rights-of-way to the maximum extent practicable for the pipelines connecting the two refineries to the tank farm. Additionally, the applicant must ensure that all of the federal, state and local permits listed in Appendix E are obtained.

CHAPTER TEN

SUMMARY OF COMPARATIVE EVALUATIONS OF SELECTED ENVIRONMENTAL IMPACTS FOR DEEPWATER PORT ALTERNATIVES FOR NEW JERSEY

Economic feasibility and mitigation of adverse environmental impacts were the dual tests to which any of the deepwater port alternatives investigated in this study had to be subjected. Previous chapters primarily addressed the economic aspects of the alternatives. This chapter provides some of the details of the environmental aspects which were reviewed.

The first alternative considered was a conventional offshore deepwater port consisting of single point mooring buoys, pumping platform, offshore submarine and onshore buried pipelines and a storage tank farm. Two potential sites were hypothesized; a northern location approximately 15 miles east of Asbury Park, New Jersey and a southern location approximately 20 miles southeast of Atlantic City, New Jersey. From either location, the refineries of the region would be served by a throughput of about 800,000 barrels per day.

Although the economics of the first alternative proved negative, certain preliminary environmental evaluations were undertaken. Environmental impacts on water and air quality were examined both for the construction period and for the facility's operational life. During construction, the seabed in the area of the monobuoys and pumping platform, as well as along the route of the submarine pipeline, would be subjected to disturbances of at least a temporary nature. For the southern site, the submarine pipeline route might traverse very rich surf clam beds off Atlantic City. Pipeline landfalls for either the northern or southern site would be in important recreational areas with the southern site perhaps being even more sensitive than the northern.

Since heavy weather can interrupt operations at an offshore facility, the storage tank farm supporting a DWP must be sized to provide at least a ten-day inventory to supply the refineries connected to the system. Hence, at either the northern or southern site, an 8 million barrel storage tank farm would have to be constructed in areas which do not now have tank farms. Hydrocarbon vapor emissions might be a newly-introduced environmental impact at the tank farm site.

On the positive side, the offshore terminal reduces inshore tanker and lightering barge traffic with a corresponding reduction in risk of accidental crude oil spills both of the chronic small operational type and of the rare large catastrophic type. However, this positive aspect is offset somewhat by a history of small leaks and spills at monobuoys.

In summary, it seems that an offshore deepwater port can provide a mitigation of inshore environmental impacts arising from current marine crude oil delivery practices, but with its own environmental costs to marine life and air quality in areas which are not subjected to these stresses at present. No sufficiently significant environmental savings were discovered which would overrule the poor economics of such an undertaking.

Economic evaluations of potential in-harbor alternatives for Delaware Bay and New York Harbor showed more promise. Therefore, a detailed program of environmental evaluations was planned with an understanding that time constraints and budgetary limitations had to be accommodated. The program called for the performance of comparative analyses of the environmental effects of continuing current practices of marine delivery of crude oil to either location via relatively shallow draft tankers and involving lightering into barges versus establishing an in-bay or in-harbor delivery facility, handling deepdraft tankers with no lightering. The environmental effects to be compared were limited to those involving water quality and air quality, exclusive of the effects of channel deepening. Dredging and dredge spoil disposal appeared to present such complex environmental impacts, with the potential for absorbing such a disproportionate share of the budget, that these topics were deemed to be beyond the scope of this study. If either inshore alternative were to take on a life of its own beyond the pages of this report, then exhaustive studies of the environmental issues associated with dredging would be required.

The Office of Planning and Policy Analysis and the Coastal Energy Impact Program of the New Jersey Department of Energy provided invaluable assistance to the Port Authority of New York and New Jersey in locating recognized experts, principally from the academic community, who possessed local expertise on the marine environment or air quality of either Delaware Bay or New York Harbor and who agreed to act as consultants to The Port Authority of New York and New Jersey in conducting the Deepwater Port Alternatives for New Jersey study. All together, seven separate studies were commissioned and performed. The findings of these experts are reprinted verbatim in Volume II of this report along with a brief biography of each consultant. Summaries of their work are found in this chapter.

The following is a list of the experts and the subject matter of their contributions in the same order of appearance as in Volume II:

I.IMPACTS ON THE MARINE ENVIRONMENT

A. Biochemistry of Crude Oil in Water

'Biodegradation of Accidental Petroleum Spills in New York Harbor and Delaware Bay Now and After Completion of Bulk Oil Receiving Facilities', by Dr. Richard Bartha, Department of Biochemistry and Microbiology, Rutgers - The State University of New Jersey.

B. Impacts on Fauna in Delaware Bay

'Environmental Impacts Associated With A Proposed Crude Oil Receiving Facility Within Delaware Bay', by Chizuko M. Walter, James E. Brosius, and Dr. Norbert P. Psuty of the Center for Coastal and Environmental Studies, Rutgers - The State University of New Jersey and Dr. Robert W. Starcher, Department of Geology, Rutgers.

'The Current Status of the Oyster Community in Delaware Bay and its Projected Status if a Crude Oil Receiving Facility Were to be Built in Delaware Bay', by Dr. Harold H. Haskin, Professor of Zoology and Chairman, Department of Oyster Culture, New Jersey Agricultural Experiment Station, Rutgers - The State University of New Jersey.

C. Mechanics of Tides and Currents in New York Harbor

'Prediction of Oil Spill Trajectories in New York Harbor', by Dr. Richard I. Hires of Stevens Institute of Technology and Drs. George L. Mellor and Lie-Yauw Oey of Princeton University.

D. Impacts on Fauna in New York Harbor

'Effects of Crude Oil Spills on Marine Invertebrates and Vertebrates Related to Projected Accidental Crude Oil Discharges into New York Harbor', by Dr. A. Farmanfarmaian, Center for Coastal and Environmental Studies, Rutgers - The State University of New Jersey.

II.IMPACTS ON AIR QUALITY

'Deepwater Oil Port Air Quality Study for The Port Authority of New York and New Jersey', Enviro Sciences, Inc., Denville, New Jersey.

III. ENVIRONMENTAL ENGINEERING

'Pier End Platform Study', by Dr. Kenneth N. Derucher of Stevens Institute of Technology.

Inputs to consultants

In order to insure a uniformity of basic assumptions from which the environmental consultants could proceed, four scenarios were developed, drawing from material reported in earlier chapters. Current practices were described for the Delaware Bay/River crude oil delivery operations and future practices were postulated, assuming an in-bay, deepdraft crude oil handling facility. Similar descriptions were developed for current and alternative delivery systems in New York Harbor. Due to wide variations in almost every detail of day-to-day crude oil delivery operations among the eight different Delaware River refineries and between the two different New York Harbor refineries (and even within the same refiner's procedures), reflecting the exigencies of a dynamic industry, some normalization or, perhaps, rationalization of observations and information was required. Thus, scenarios describing the continuation of current practices are an honest attempt to reflect 'typical' occurrences, admitting that exceptions may outnumber the rule. Those dealing with a bulk receiving facility in place in either water body are equally honest educated guesses.

Likewise, projected crude oil spill locations, frequencies and sizes were postulated, both for a continuation of present procedures and for the establishment of an inshore facility. These projections were based upon United States Coast Guard oil spill incident reports for each water body from 1974 through 1980, details of which may be found in Chapter 2 and Appendix D. It was necessary to point out clearly that, even with the establishment of an inshore crude oil handling facility, a certain volume of crude oil would continue to be delivered in the same way as it is today, due to size of shipment, special characteristics of the crude oil or other factors. Hence, a receiving facility in place could be expected to reduce the probability of a crude oil spill in an anchorage or at a refinery pier but not to eliminate it.

The behavior of a crude oil spill is dependent upon many factors, not the least of which is the chemical composition of the crude oil spilled. Data for New York Harbor indicated that about 75% of the total crude oil handled was Saudi Arabian with this amount split around 70-30 between Arabian Light and Arabian Heavy. For Delaware Bay, the crude oils were more varied with Nigerian Bonny Medium accounting for about 25%, Arabian Light from Saudi Arabia about 20% and Algerian Zarzaitine accountng for some 17%. The balance of the total volume, some 38%, arrived from a variety of other source countries. This information was made part of the inputs to consultants. Some other key points among the inputs provided to the consultants included the following:

A. Delaware Bay/River

1. The in-bay facility will have a throughput of 560,000 b/d. The eight refineries on the Delaware have a daily requirement of 930,000 b/d. The delivery of the balance, 370,000 b/d, will be unaffected by the facility.

2. For the delivery of the 560,000 b/d, 120,000 dwt type tankers carrying about 750,000 barrels per visit, requiring 273 visits per year will be replaced with 260,000 dwt type tankers, partially laden, carrying about 1.1 million barrels per visit, requiring 186 visits annually. The 370,000 b/d not handled through the facility will require about 300 tanker visits per year.

3. Lightering barge loadings will be reduced from about 1,100 to about 300 with the facility in place.

4. With the facility, two new storage tank farms will be required. One, in the vicinity of Delaware City, Delaware, will consist of 2 tanks of approximately 250,000 barrels each. The other, in the Marcus Hook, Pennsylvania area, will consist of 9 tanks of approximately 400,000 barrels each and 10 tanks of about 250,000 barrels each, providing about 6.1 million barrels of storage.

5. Crude oil spills projected for the continuation of current practices:

a) Chronic small operational spills -

Location	Times Per Year	Quantity Per Spill (in gallons)
Anchorage	6	84
Refinery Pier	9	630

b) Catastrophic spill resulting from an underway incident -

Location	Times Per Year	Quantity Per Spill (in gallons)
Off Marcus Hook	.071	2,016,000

6. Crude oil spills projected with the in-bay facility inplace:

a) Chronic small operational spills -

Location	Times Per Year	Quantity Per Spill (in gallons)
Anchorage	2	84
Refinery Pier	5	630
Bulk Facility	4	945

b) Catastrophic spill resulting from an underway incident -

Location	Times Per Year	Quantity Per Spill (in gallons)
Between Cape May and Cape Henlopen	.034	2,814,000

B. New York Harbor

1. The in-harbor facility will have a throughput of 240,000 b/d. The two refineries on the Arthur Kill have a daily requirement of 390,000 b/d. The delivery of the balance, 150,000 b/d, will be unaffected by the facility.

2. For the delivery of the 240,000 b/d, 85,000 dwt type tankers carrying about 500,000 barrels per visit, requiring 175 visits per year will be replaced with 260,000 dwt type tankers, partially laden, carrying about 1.25 million barrels per visit, requiring 70 visits annually. The 150,000 b/d not handled through the facility will require about 137 tanker visits per year.

3. Lightering barge loads will be reduced from about 625 to 280 with the facility in place.

4. The approximately 24 tanker visits per year transiting New York Harbor to deliver crude oil to the Albany area, along with the barge loads associated with these visits, will be unaffected by the facility.

5. With the facility, a new storage tank farm will be required. Located on the west shore of the Arthur Kill, it will consist of 2 400,000 barrel and 2 150,000 barrel tanks.

6. Crude oil spills projected for the continuation of current practices:

a. Chronic small operational spills -

Location	Times Per Year	Quantity Per Spill (in gallons)
Anchorage	4	42
Refinery Pier	5	336

b) Catastrophic spill resulting from an underway incident -

Location	Times Per Year	Quantity Per Spill (in gallons)
Off Bergen Point	.041	1,680,000

7. Crude oil spills projected with the in-harbor facility in place:

a) Chronic small operational spills -

Location	Times Per Year	Quantity Per Spill (in gallons)
Anchorage	2	42
Refinery Pier	2	336
Bulk Facility	2	504

b) Catastrophic spill resulting from an underway incident -

Location	**Times Per Year**	**Quantity Per Spill (in gallons)**
Ambrose Channel Dogleg	.018	2,814,000

Summaries of the Comparative Evaluations

As mentioned, each consultant addressed the effects on water or air quality, either in New York Harbor or Delaware Bay, from a continuation of current practices and from the establishment of a crude oil handling facility. Brief summaries of their findings are given next with their complete reports appearing in Volume II.

Dr. Richard Bartha evaluated the biodegradation of accidential crude oil spills both in New York Harbor and the Delaware Bay/River. This report points out that crude oils vary greatly in composition and biodegradability, depending upon their sources and that, even under the best of conditions, no crude oil is completely biodegradable. For uniformity of comparisons the report assumes all spills are Saudi Arabian Light. The chronic small operational spills tend to biodegrade in a month's time at summer water temperatures and about three months' time at winter water temperatures. For the projected catastrophic spills, biodegradation proves to be a negligible removal mechanism if winter water temperatures are in effect at the time of the spill. A catastrophic spill in a confined waterway, winter or summer, will be more subject to non-biological removal mechanisms such as evaporation, beaching and tidal flushing than to biodegradation. To the extent that the establishment of a crude oil handling facility in either water body moves the probable site of a catastrophic spill from confined waterways to more open waters, the report considers the facility to be a qualified improvement. The report notes that containment and recovery of an oil spill in open waters are much more difficult.

The Center for Coastal and Environmental Studies reported on the ecological impacts associated with the establishment of an inshore crude oil receiving facility in Delaware Bay. A major feature of the Center's work is a detailed characterization of the Bay's biological communities which puts into sharp focus the sensitive nature of this water body. The effects of oil spills on the biological communities are indicated and high risk communities and organisms are identified, as predicted by oil spill simulations carried out as part of the study. The major components of the receiving facility are treated individually to determine biological, geological and institutional conflicts which could be anticipated during both construction and operational phases of the system. Alternative pipeline alignments are proposed to illustrate various options available to minimize the impacts of installation between landfall at Big Stone Beach, Delaware and final terminus at Marcus Hook, Pennsylvania. The study concludes that displacement of oil spills from the already polluted areas of the upriver portion of the Delaware Bay/River estuary to the relatively unpolluted lower reaches of the Bay will almost certainly result in the degradation of water quality in the shellfisheries located there.

Dr. Harold H. Haskin provided a detailed evaluation of the current status of the oyster community in Delaware Bay and projected the effects on this community from the establishment of an in-bay crude oil receiving facility. This report places the oyster in its environmental setting and traces its life history in the Bay to focus attention on its sensitivity to ecological changes. The work chronicles the slow recovery over the past three decades of the Bay's commercial oyster industry which had fallen on hard times from overfishing of natural seed beds exacerbated by the outbreak of a new oyster disease called MSX. Results of laboratory tests are published to establish threshold levels of petroleum hydrocarbon concentrations which are harmful to the larval stages and adult stages of oyster development. The report ends with projections of the effects on the oyster community from the chronic small operational crude oil spills and from the hypothetical catastrophic spill associated with an in-bay facility. The conclusion is drawn that under present ambient water conditions a safety margin in hydrocarbon concentrations exists, forestalling any expectation of oyster mortality or inhibition of reproduction. This safety margin is not exceeded by the chronic small spills. However, the catastrophic spill would provide hydrocarbon concentrations lethal to the resident oyster population for a period of several years.

Dr. Richard I. Hires, in collaboration with Drs. Lie-Yauw Oey and George L. Mellor, predicted the trajectories of crude oil spills postulated for New York Harbor. Hires, Oey and Mellor had participated in the development and testing of a two-dimensional mathematical model of water circulation in the Harbor which was used for this study. Through the use of computer simulation runs, the report was able to track hypothetical crude oil spills, representative of the present situation and projected for an in-harbor facility. The first task was to evaluate whether any significant change in tidal currents would result from deepening Ambrose Channel from its present 45-foot depth to 60 feet. It was concluded that there were no significant differences in tidal currents or tidal elevations leading to the assumption that spills occurring either at Stapleton Anchorage or at the refineries' piers would track the same with or without a facility and channel deepening. The report identifies the sensitivity of oil spill trajectories to the phase of the tide at the time of occurrence. The Hires-Oey-Mellor report concludes that, with one exception, the small operational spills would be moved through the Harbor and into the ocean in three to eight days. The trajectory of the catastrophic spill which is postulated for the facility in place is considered to pose a threat to recreationally important coastal waters of New Jersey and Long Island. But, it is pointed out, the likelihood of large spills should be less with a crude oil receiving facility than with present practices.

Dr. Allahverdi Farmanfarmaian treated the effects of crude oil spills on marine vertebrates and invertebrates in New York Harbor. The report presents details of the impacts on the marine environment resulting from the accidental discharge of large quantities of petroleum such as occurred with the Amoco Cadiz and IXTOC-I and recounts attempts at mitigation associated with these major events. With this information established as background, the study proceeds to identify the various life forms found in New York Harbor waters and discusses their diversities, densities, life cycles and sensitivities to hydrocarbons. Next, it discusses the effects of the crude oil spills postulated both for the maintenance of the status quo and for the establishment of a facility. For each spill, it outlines the biological hazard. The report strongly advocates maximum containment and cleanup response in the event of a spill in New York Harbor. It recommends against any attempts at dispersing or sinking the oil. The contention is that, due to low average depth, small total size, sluggish circulation, slow water turn over and the extant pollutant load in the sediment, no portion of the Harbor can be used as a sink for a large oil spill.

Enviro Sciences, Inc. performed the comparative air quality evaluations with and without an inshore facility in place for both New York Harbor and Delaware Bay/River. After establishing meteorological and dispersion characteristics and describing the air quality standards, the study concludes that construction of the proposed facility in either region will result in a net decrease in the amount of criteria pollutants emitted to the atmosphere. This conclusion is based upon emission calculations for continuing current practices compared to having a crude oil receiving facility in place.

Dr. Kenneth N. Derucher explored design criteria for a protective fendering system which would mitigate the risk of an accidental crude oil spill resulting from impact between a berthing tanker and a fixed structure, the unloading platform of an inshore crude oil receiving facility. The study uses a computer program which examines the time-oriented dynamics and stresses of the berthing maneuver to determine the capability of the system's components to absorb energy without failure of either the ship's hull or the structure. It advocates the use of a relatively new fendering system, the 'floating donut' for the facility's breasting dolphins. Each donut would react to changes in water elevation by riding on a flexible steel pile which would act as a cantilever spring. The results of this work indicate that oil spill risk mitigation can be an early design parameter and can be accomplished at relatively low cost.

Conclusions

Each of the consultants indicated the preliminary nature of the comparative evaluations. A continued interest in any of the Deepwater Port Alternatives for New Jersey would require more detailed, site-specific investigations of environmental impacts not only on air and water quality but also on a list of other qualities of life. The general consensus of the reports seems to be that no intrinsic environmental disaster lurks within the concept of an inshore crude oil receiving facility and that, in fact, some measure of improvement in air and water quality would result, especially in the case of a New York Harbor site.

CHAPTER ELEVEN

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. **A CONVENTIONAL OFFSHORE DEEPWATER PORT TO SERVE THE TEN REFINERIES IN NEW JERSEY AND ADJACENT STATES IS NOT FEASIBLE.**

The results of the study show that the estimated cost per barrel throughput for each of two offshore locations for a DWP is more than twice the transportation savings that could be expected. Although there would be environmental benefits from a DWP, such as reducing the size and number of oil spills in the harbors and rivers of the region, these benefits are not so great as to justify large subsidies for construction.

This conclusion would change if the demand for imported oil again increased at rates typical of the period prior to 1973 and the years 1975 to 1978 or if there were a greatly heightened concern about the environmental impacts of the current delivery system. In either case, once a commitment is made to build a local terminal to handle a portion of the region's crude oil imports, an offshore DWP almost certainly would be uneconomical.

Major additions to refinery capacity in the vicinity of existing refineries could make a conventional DWP economically feasible, but such additions are not likely for the foreseeable future.

2. **AN IN-BAY DEEPWATER CRUDE OIL TERMINAL FOR THE DELAWARE RIVER REFINERIES DOES NOT APPEAR FEASIBLE AT THIS TIME, ALTHOUGH FUTURE CHANGES IN CRUDE OIL REQUIREMENTS FOR THE DELAWARE RIVER REFINERIES COULD ENHANCE ITS FEASIBILITY.**

The cost of an in-harbor facility in the Delaware Bay is more than twice its estimated marine transportation savings. On the other hand, a pipeline delivery system for the Delaware River refineries would greatly reduce the risk of oil spills in the Bay and River compared with current practices. As with the conventional DWP, however, the environmental benefits do not appear to justify the subsidization of a major investment in a terminal for the Delaware River refineries. Furthermore, a major institutional barrier would have to be overcome since there is a law in the state of Delaware which prohibits port development along the Delaware Coast outside established port areas.

If there is an expansion of existing refineries, if large new refineries are built in the area or if there are major shifts in imported crude oil deliveries to a heavier dependence on long distance sources, then an oil terminal and pipeline could become feasible. Also, if a deepwater terminal were built which was designed for the importing and exporting of a variety of bulk commodities including oil, the construction costs could be shared.

3. **AN IN-HARBOR DEEPWATER OIL TERMINAL FOR NEW YORK APPEARS TO BE FEASIBLE.**

The study concludes that an in-harbor deepwater terminal may be feasible for New York Harbor and would reduce somewhat the risk of pollution from oil spills in the harbor and adjacent waterways. This terminal would require a channel access of at least 60 feet in depth and deeper channels would enhance the economic benefits of the terminal.

The feasibility of an in-harbor terminal depends on the continuing need to import large quantities of crude oil for the two refineries on the Arthur Kill and assumes that 240,000 b/d of those imports would pass through a deepwater terminal.

Recommendations

1. **THIS FINAL REPORT SHOULD BE MADE AVAILABLE TO ALL PUBLIC AGENCIES AND PRIVATE GROUPS CONCERNED WITH PORT DEVELOPMENT PROJECTS FOR DEEPDRAFT TANKERS IN NEW JERSEY AND NEARBY AREAS.**

The contents of this report should prove to be a major contribution to public policy discussions concerned with establishing the need for and desirability of new port facilities for deepdraft tankers. In particular, the consultants' reports in Volume II are important source documents for the New Jersey Department of Environmental Protection and the New Jersey Department of Energy, which can assist in identifying the environmental impacts of proposals to change the crude oil delivery system for New York Harbor and any similar projects in the state's jurisdiction. All government agencies concerned with such projects should weigh the findings and conclusions of this study and keep it available as a reference in the event there is any re-investigation of the subject.

2. **A DETAILED ENGINEERING FEASIBILITY STUDY OF AN IN-HARBOR DEEPWATER TERMINAL FOR NEW YORK HARBOR SHOULD BE CONDUCTED.**

This study has demonstrated that there is an opportunity for a major port development project for New York Harbor which deserves serious consideration by private industry and the appropriate public agencies. However, the practicality of an in-harbor terminal to accommodate deepdraft tankers depends on a large number of issues which are outside the scope of this study. These issues include the need to specify in greater detail the design of the facility, so that costs can be estimated more accurately and the environmental and socio-economic impacts can be identified for a site-specific proposal.

Glossary

Anchorage. An area set apart for anchored vessels. In most active U.S. ports, anchorages are controlled and assigned by the U.S. Coast Guard or other local authority.

API Gravity. Gravity (weight per unit volume) of crude oil or other liquid hydrocarbon as measured by a system recommended by the American Petroleum Institute. API gravity is related to specific gravity but is more convenient to use.

Arabian Gulf. The body of water traditionally known as the Persian Gulf. Usage has been shifted to Arab or Arabian Gulf in recent years.

Beam. The width of a ship, also called breadth.

Ballast. Heavy material, usually sea water, in the case of tankers, which is placed low in the ship to maintain proper stability or draft.

Ballast (in). A ship is said to be in ballast when it carries no cargo, but only ballast.

Bollard. Heavy post on a dock used in mooring ships.

Breasting dolphin. Pile or other type of structure against which a vessel rests when moored.

Bunker. To load fuel into a vessel's fuel storage compartment (also called a 'bunker') for its own use as distinguished from loading it as cargo.

Bunker 'C' fuel oil. A heavy residual fuel oil used in ships' boilers and large heating and generating plants.

CALM. (Catenary anchor leg mooring). A type of single point mooring which employs a stationary floating platform with a rotating bollard for mooring the vessel. The CALM is kept in position by six to eight chains (catenary anchor legs) anchored to the ocean floor. (See Figure 13 and discussion in Chapter Four.)

Chicksan arms. A trademarked name for the articulated metal arms used to connect the ship's manifold to the onshore pipeline system. At many marine oil piers, Chicksan arms have replaced hose connections.

Clean ballast tanks (CBT). Tanks which carry ballast but may not be completely separated from the cargo and fuel oil system. Such ballast tanks must be cleaned to meet the standard set by the International Conventions for the Prevention of Pollution from Ships of 1974. (See discussion in Appendix F.)

Conversion factors. The common conversion factors used in this study are:
1 barrel = 42 gallons
1 long ton = 7.4 barrels = 2240 lbs.
1 metric ton = 2205 lbs.

Controlling depth. Water depth which limits the use of the waterway to vessels whose drafts are less than this depth.

Crude oil refinery input. Total crude oil input to crude oil distillation units for processing.

Crude oil washing (COW). A process in which a part of the ship's cargo is used to spray the walls of the emptied cargo tanks during discharge so that the residues and sediments are liquefied and discharged with the rest of the cargo. (See discussion in Appendix F.)

Daily operating costs. The daily running costs of a vessel which are expressed as a fixed amount per day and which are not conditional on quantity of cargo, speed, etc. (see Chapter Three.)

Deadweight tons (dwt). In the commercial employment of merchant vessels, particularly tankers, the tonnage measurement used is deadweight tons. This figure represents the total carrying capacity of the ship in tons of 2,240 lbs. when loaded to summer marks, viz., when loaded to the appropriate freeboard during the summer season. The measure of deadweight tons includes cargo, bunker fuel, potable water and ballast.

Deepwater port. A term used throughout this study to designate an offshore mooring and cargo handling facility for tankers with drafts in excess of 45 feet. This mooring may use the single point buoy design or any other berthing arrangement.

Demurrage. Detention of a vessel by the charterer or receiver of cargo in loading or unloading beyond the time allowed in the charter contract. Therefore, the term also is applied to the cost of delays in loading and unloading.

Draft. The depth of a vessel below the waterline, measured vertically to the lowest part of the hull, propellers or other reference points.

Displacement. The number of tons of water displaced by a vessel afloat.

Dirty ballast. The washings of tanks in which crude oil, diesel oil or the heavier grades of fuel oil have been carried.

Energy/GNP ratio. The energy consumption per GNP dollar is a measure of the energy efficiency of the national economy. The ratio is calculated in thousands of BTUs consumed per 1972 constant dollar value of gross national product.

Freeboard. The vertical distance from the freeboard-deck to the loadline or Plimsoll line. The freeboard is measured at the middle of the ship's length from that uppermost continuous deck with a permanent means of enclosing all openings.

Heavy crude oil. Crude oil that has a high API gravity.

Inert gas system (IGS). A system which replaces the flammable gases in the spaces of the ship's cargo tanks with gases so low in oxygen content that there is no danger of combustion.

Knot. A unit of speed defined as one nautical mile traveled per hour.

Length overall (LOA). The total length from the foremost to the aftermost points of a vessel's hull.

Immersion scale. A scale showing the number of tons required to immerse or put down a vessel at its various drafts, often referred to as the curve of tons per inch (TPI) immersion.

Lightering. An oil transfer operation in which the cargo is pumped from tanker to barge usually for the purpose of reducing the draft of the tanker for access into shallow channels.

Mooring dolphin. Pile or other type of structure independent of the dock proper to which a ship's mooring lines are attached.

Nautical mile. Unit of distance used for navigation based on the length of a minute of arc of a great circle of the earth or approximately 6080 feet.

Net Capacity. A vessel's capacity for cargo in long tons when loaded to her permissible draft after allowing for bunkers, water, stores, etc.

Petroleum products. Products obtained from the processing of crude oil, unfinished oils, natural gas liquids and other miscellaneous hydrocarbon compounds. This includes aviation gasoline, motor gasoline, naphtha-type jet fuel, kerosene-type jet fuel, kerosene, distillate fuel oil, residual fuel oil, ethane, liquefied petroleum gases, petrochemical feedstocks, special naphthas, lubricants, paraffin wax, petroleum coke, asphalt, road oil, still gas and other miscellaneous products.

Pig or pigging. A line scraper pumped though a pipeline to remove wax, sediment and water deposits from the interior of the line to restore pumping efficiency. Occasionally pigs are used to separate dissimilar products being batched through the line. The design of scrapers changes in accordance with the service to be performed and the size of the pipeline.

Plimsoll line or mark. The mark painted on the ship's sides which indicates the limit to which a ship may be loaded according to the freeboard regulations, conditions of classification or conditions of service.

Pour point. The temperature at which a liquid ceases to flow or at which it congeals. Pour points for crude oils typically range from 30 degrees Fahrenheit for the principal types of Arabian crudes to well above 80 degrees Fahrenheit for certain types of Indonesian crudes.

Residual fuel oil. The heavier oils that remain after the distillate fuel oils and lighter hydrocarbons are boiled off in refinery operations. Included are products known as No. 5 and No. 6 fuel oil that conform to ASTM Specification D396, heavy diesel oil, Navy Special Oil, Bunker C oil, and acid sludge and pitch used as refinery fuels. Residual fuel oil is used for the production of electric power, commercial and residential heating, vessel bunkering, and various industrial purposes.

SALM. (Single anchor leg mooring). A type of single point mooring which employs a swivel housing with a vertical anchor leg attached to the ocean floor. (See Figure 14 and discussion in Chapter Four.)

Segregated ballast tanks (SBT). Tanks which are completely separated from the cargo oil and fuel oil system and permanently allocated to ballast other than oil or noxious substances.

Single point mooring (SPM). Any of several innovative mooring devices used for offloading oil tankers which employ a single buoy unit held in place either by vertical or catenary chains attached to the ocean floor. The vessel is moored only at the bow and is permitted to rotate 360 degrees about the SPM during the offloading operation. (See discussion in Chapter Four; also, see CALM and SALM).

Slow steaming. The practice of operating merchant vessels at a reduced speed for the purpose of increasing fuel efficiency. Many deepdraft tankers have a maximum operating speed of 15 to 16 knots with maximum fuel efficiency at speeds of 11 to 12 knots.

Tight line operation (tightlining). A pumping operation when one station pumps directly into the suction manifold of the pumps at the next station and no tanks are open to the suction manifold.

Transshipping. An oil transfer operation in which the cargo typically is passed from a VLCC to a smaller tanker either in port or underway.

Ullage. The free space left in the tanks after loading oil in bulk in order to leave room for expansion when oil is heated to a higher temperature.

ULCC. The Ultra Large Crude Carrier is defined generally as a tanker in excess of 300,000 dwt.

VLCC. The Very Large Crude Carrier is defined here as a tanker in excess of 175,000 dwt.

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Appendix A

SELECTED ANNOTATED BIBLIOGRAPHY OF RELATED STUDIES

Various public and private studies conducted in the past ten years have concluded that the logical areas to locate deepwater ports in the U.S. are in coastal waters near the major refining centers. In particular, there have been several studies which have examined the need and desirability of locating, deepwater ports (DWPs) near the East Coast refineries. There also have been other related studies which investigated the impact of any DWP development and the issues involved in site selection.

Previous deepwater port studies

The following is a brief description of each of the studies directly concerned with East Coast DWPs and a summary of the objectives, assumptions, findings or conclusions:

1. **Atlantic Coast Deep Water Port Facilities Study**. U.S. Army Corps of Engineers, Philadelphia District, North Atlantic Division, June,l973.

This study was conducted by the United States Army Corps of Engineers at the request of Congress. Its purpose was to determine 'the most efficient and logical means of developing facilities to accommodate very large bulk carriers....' The geographical area of review was the East Coast from Eastport, Maine to Hampton Roads, Virginia. The assumptions used in the study included projections of crude oil requirements for the East Coast refineries. The 'most likely' scenario showed requirements for imported crude of 2 million barrels/day by 1980 and 4 million barrels/day by 2000. Expansion of refinery capacity was also assumed, though only in the vicinity of existing refineries due to state and regional opposition. These and other related assumptions led to the observation that there was an urgent need to develop a method of accepting VLCCs for crude oil imports to the North Atlantic Coast.

The study's principal conclusions were that 'if any alternative can be made environmentally acceptable and logical in the future it must be located along the length of shore between the New York Harbor area and the Delaware Bay area' because this is where the major portion of refineries are located. It further concluded that the most feasible sites, considering environmental and socio-economic impacts, were in the Atlantic Ocean using either an artificial island or a single point mooring device. The two specific sites described were (1) 13 miles off the New Jersey Coast with pipelines coming onshore at Long Branch and a tank farm at the U.S. Earle Naval Supply Depot, in Monmouth County and (2) 25 miles off Delaware Bay with tank farms located at Bigstone Beach, Delaware or at Greenwich Township, Cumberland County, New Jersey. The most economically feasible of these alternative sites was determined to be the Atlantic Ocean site located 13 miles off Long Branch, New Jersey.

Another conclusion in the study was that the management and control of a deep draft terminal did not require public (federal) ownership to satisfy public concerns about the facility. Also, it was apparent from hearings and other public discussions of deepwater port proposals in the Mid-Atlantic region that there was almost unanimous opposition to deepwater port facilities as proposed by industry. In particular, the opposition was due to fears of large oil spills at sea and to industrialization induced by the facility.

2. **Coastal Effects of Offshore Energy Sytems, An Assessment of Oil and Gas Systems, Deepwater Ports and Nuclear Power Plants Off the Coast of New Jersey and Delaware,** United States Congress, Office of Technology Assessment, November 1976.

This study was conducted from l974 to l976 at the request of Congress. The purpose was to trace the likely consequences of three energy systems on the ocean and coastal environments and on the economies of the coastal states. These energy systems are the development of Outer Continental Shelf oil and natural gas, deepwater ports for the Mid-Atlantic region, and construction of offshore nuclear power plants.

Concerning deepwater ports, the study concluded that 'a deepwater port is not likely to be built to serve the Mid-Atlantic in the next ten years,' that 'industry is not likely to abandon its existing marine transportation system as long as there is no clear cost advantage,' and that 'expanded or new refinery capacity would be necessary to make a deepwater port economically feasible.' However, the study found that a deepwater port system would offer environmental advantages over small tankers operating in existing ports, since 'small tankers spill twice as much oil that can damage the coastal zone as would be spilled in a deepwater port system.' The study also noted the lack of interest, at that time, in the subject of deepwater ports for the Atlantic Coast by both government and industry.

3. **Potential for Deepwater Port Development in the United States**, Report to Congress by the Comptroller General of the United States, April 5, 1978.

This report raises certain issues concerning the economic and environmental benefits of deepwater ports, especially for the eastern United States. Its purpose is to justify the need for a 'definitive study' which would establish the feasibility of a deepwater port. The report recommends to Congress that the Secretary of Transportation undertake a study addressing the locations of such ports in the Mid-Atlantic area, the costs of construction, the potential for refined product use and other related technological, legal, regulatory and financial issues. Among other things, the report assumes that federal policies to reduce the growth rate in oil imports would fail and that U.S. crude oil imports in 1985 would be twice the 1978 projection which was 6 to 7 million barrels per day.

Comments on the GAO's recommendations by the Departments of Energy and Commerce were essentially negative. The USDOE stated that the limited refinery capacity on the East Coast did not justify a high priority study of the potential for a deepwater port. The Department of Commerce commented that the GAO's preliminary findings 'do not justify a deepwater port on the Mid-Atlantic Coast,' citing limited refinery capacity, cost, onshore secondary impacts, and potential outer continental shelf oil production which could reduce throughput volumes for such a facility.

4. **Atlantic Coast Deepwater Port Study**, Office of Deepwater Ports, U.S. Department of Transportation, July 1978.

The purpose of this study was to update earlier work on DWPs by federal agencies such as the Corps of Engineers and the Maritime Administration. It reexamined the oil supply and demand situation on the East Coast and the need for a DWP facility in view of energy events of the mid-1970's. The study found that between 1980 and 2000 a reasonable potential throughput for a DWP was 1.0 to 1.4 million bbls/day for refineries in the region of interest—New Jersey, Eastern Pennsylvania and Delaware. This was based on a very conservative estimate of refinery expansion in the region to the year 1990.

The study considered in some detail three alternative DWP sites and their associated costs and benefits using either a fixed berth or single point mooring (SPM) for a discharge terminal. These sites were (1) an offshore SPM system with landfall at Manasquan Inlet on the Northern New Jersey Coast, (2) an offshore SPM system located off Cape Henlopen, Delaware, and (3) a fixed pier facility off Big Stone Beach, Delaware. Facilities at sites (2) and (3) were designed to service either all the refineries in the region or the Philadelphia area refineries only. Site (1) was designed to serve the entire region.

The study concluded that 'a deepwater port for crude petroleum imports is technically feasible.' The economic viability was conditioned upon a minimum throughput of 1.0 million b/d over a 20 year life of the project. Other conclusions were that there were severe economic and technical obstacles to developing a deepwater terminal for petroleum products because of the dispersed delivery requirements and small unit quantities. Also, it was likely that any Atlantic Outer Continental Shelf oil production could reduce potential throughput for any DWP.

No explicit conclusions were drawn concerning site selection. However, project cost estimates revealed that the two most expensive alternatives were the offshore SPM systems at Manasquan Inlet and Cape Henlopen serving the entire region with cost estimates of $621 million and $704 million respectively (1978 dollars). The least costly alternative was the fixed berth facility at Big Stone Beach serving only the southern area refineries with an estimated project cost of $374 million.

Other related studies

There have been numerous other studies and published documents which relate to the subject of DWPs for the Mid-Atlantic Coast. Some of the most useful of these are listed below with a brief description of the sections relevant to this study.

1. **OCS Natural Gas Pipelines: An Analysis of Routing Issues**, Center for Coastal and Environmental Studies, Rutgers—The State University of New Jersey and the New Jersey Department of Energy, Office of Planning and Policy Analysis, March 1980.

This study examines the policy issues surrounding the siting, construction and operation of a pipeline which would transport natural gas from the Outer Continental Shelf to an onshore connection with the existing interstate gas transmission network. Many of the impacts of construction and operation of natural gas pipelines as well as some of the policy issues involved in pipeline routing are the same as for oil pipelines associated with DWPs. Therefore, the discussion and descriptions of impacts and policy issues of constructing pipelines in routing scenarios presented in this study were especially useful in selecting potential sites for a deepwater port.

2. **Present Uses, Potential Developments, and Crossing Requirements in the Lower Delaware River and Bay Area**, Prepared by URS Corporation and Arthur D. Little, Inc. for the Delaware River and Bay Authority, March 1980.

This study analyzes the adequacy of transportation systems in the Delaware Bay region including the need for additional crossings and the potential for further development. In one section, the study acknowledges the past interest in DWP development in the region and that Delaware Bay is a primary location to be considered. However, the study asserts that the 'future potential and viability (of DWPs) will depend on the region's refining capacity, on the volume and composition of crude oil imports to the region, and on the comparative costs and environmental risks of lightering and offshore ports.' The study concludes that the oil industry is now 'generally satisfied with the existing lightering operations and its capacity to handle projected crude oil imports in Delaware Bay.' The study also concludes that major port and pipeline projects in this region would require considerable public support and that offshore port development would probably require significant amounts of public investment.

3. **Analysis of Existing and Potential Navigation Hazards in Delaware Bay**, Engineering Computer Optecnomics,Inc. prepared for Cape May County Planning Board, October 1980.

The study was prepared by the Cape May County Planning Board under a NJDOE Coastal Energy Impact Program Grant. The objective was to identify existing aids to navigation and navigational procedures in Lower Delaware Bay and make recommendations for improvement where warranted.

4. **Environmental Impacts of Bulk Oil Storage Facilities in New York City**, by Helga Busemann, Carey Weiss, *et al*, New York City Department of Planning, March l980.

This analysis covers topics such as spills and seepages at bulk oil storage facilities, waste oil recovery and disposal and illegal disposal activities. It was prepared as part of a State of New York Coastal Energy Impact Program Grant.

5. **A Climatological Oil Spill Planning Guide**, No. 1 - The New York Bight. NOAA/Environmental Data and Information Service, February 1980.

This report summarizes appropriate environmental data, discusses the movement of oil at sea, and attempts to predict the effects of oil spills for the New York Bight.

6. **The CTARP Energy Facility Siting Study**, Prepared by the Center for Technology Assessment and Resource Potency at Stanford University for the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration, Washington, D.C., four volumes, April 1979.

This series examines energy facility siting within the context of state coastal zone management programs. Volume 2 contains case studies particularly relevant to the facilities examined here, notably the SOHIO Oil Terminal and Pipeline controversy, the Washington State Oil Transshipment Facility and the 'national interest' in siting of oil transfer facilities.

7. **Deepwater Ports in the United States**, by Tobey Winters, New York: Praeger Publishers, 1977.

This book is a general environmental and economic impact study of deepwater ports in the United States. The information in this book has been largely outdated by recent shifts in economics in the oil industry. It is a general treatment of offshore oil terminals.

8. **Final Environmental Impact Statement for the LOOP Deepwater Port License Application**, U.S. Coast Guard, Department of Transportation, Volumes 1-4, 1976.

This environmental impact statement consists of four volumes. It provides detailed descriptions of the LOOP project, including proposed offshore and onshore facilities, facility operations, and environmental impacts of both construction and operational phases. These documents were especially valuable in determining the major components of a DWP system and the basic engineering requirements and project costs.

9. **Final Environmental Impact Statement for the Seadock Deepwater Port License Application,** U.S. Coast Guard, Dept. of Transportation, Volumes 1-4, 1976; **Deepwater Port License Application**, Texas Deepwater Port Authority, August 23, 1978; 'Proposal For Texas Offshore Port,' Phillips Petroleum, Conoco, Dow Chemical, and Seaway Pipeline, January 1981.

This series of documents gives details of the various proposals submitted for a Texas-based DWP. A license for Seadock was granted at the same time as for LOOP and that license was later amended and extended on behalf of the Texas Deepwater Port Authority. The most recent proposal, submitted in January 1980, is a much scaled-down version of SEADOCK/TDPA to be called Texas Offshore Port (TOP).

10. **Energy Policy White Paper Containing Positions on Outer Continental Shelf Drilling for Oil and Natural Gas; Deepwater Port Construction; and the Governmental Placement of the State Energy Office**, Senator Frank J. Dodd, April 1975.

This analysis was prepared by a former state senator active on energy issues. It is useful for historical purposes to track New Jersey's involvement in the deepwater port issue.

11. **Oil Transportation by Tankers: An Analysis of Marine Pollution and Safety Measures**, U. S. Congress, Office of Technology Assessment, July 1975.

This study, although dated by domestic legislation and international agreements, is still a comprehensive reference work on marine tank vessel issues.

Appendix B

PETROLEUM PRODUCT FLOWS IN THE REGION

Definition of the region

Marketing areas for petroleum products in the Northeast do not conform to any political or administrative boundaries. Therefore, in organizing this analysis of the delivery of products, a region has been defined to include the entire state of New Jersey and the New York and Philadelphia metropolitan areas (see Figure B-1). This is a region of high population density, high consumption and a center for refining and distribution of product to the entire northeastern United States.

Total product flows

As shown in Table B-1, the largest source of petroleum products in the region is the ten refineries located there. These refineries accounted for about 42% of the product 'input' to the area in 1978. Refinery production is shown only in the 'inbound' column in Table B-1, even though a large but unspecified amount of this production in the region is marketed outside the region. The amount of refinery production shipped out of the region is included in the 'outbound' column for domestic waterborne shipments and pipelines.

Product which is inbound by pipeline accounts for 22% of the region's 'inbound' product. The balance arrives by water with about 21% coming from Gulf Coast refineries and about 15% from foreign sources.

In contrast to the one-way flow of crude oil into the region, the most striking aspect of product flows is the size of the flow out of the region. With the exception of residual oil, almost as much product is shipped out of the region as is consumed in the region. This outbound flow is destined primarily for the New England states and the western portions of New York and Pennsylvania. Deliveries to New England are by shallow draft barges out of New York Harbor.

Table B-1
PETROLEUM PRODUCT FLOWS IN REGION, 1978
(millions of barrels)

Source	Total		Less Residual	
	inbound	outbound	inbound	outbound
1. product by water				
domestic	207	196	145	160
foreign	141	<1	25	<1
2. product by pipe[1]	210	197	210	197
SUBTOTAL	558	393	380	357
3. additional input from refineries[2]	412		355	
4. consumption		577		378
TOTAL FLOWS	970	970	735	735

[1] Inbound column is by pipe only; outbound column is by pipe and truck.

[2] Refinery product is shown in the inbound column even though some refinery output is shipped out of the region.

Source: *Waterborne Commerce of the United Sates, Part I, Calendar year 1978,* U.S. Army Corps of Engineers and other sources of Office of Energy, PANYNJ, (May, 1981).

Waterborne shipments of products to the region

The well-developed port facilities in the New York and Philadelphia areas permit the delivery of significant quantities of product by tanker from the U.S. Gulf Coast and from foreign refineries, mainly in the Caribbean. Over one-third of the region's inbound petroleum product arrives by water. The approximate quantities of waterborne shipments of domestic and foreign products are given in Table B-2.

Domestic shipments from the Gulf Coast refineries consist primarily of residual fuel oil, distillates and gasoline. There is little published information about the origins and destinations of current domestic tanker shipments of products which accounts for the bulk of waterborne product shipments. We do know that most of the coastal tankers trading between the Gulf ports and the Northeast are small (less than 40,000 dwt), and that it is common for a tanker to make several port calls before discharging its entire cargo.

The transportation patterns for domestic shipments are similar to those for imported product. Tanker and cargo sizes are similar. Imports of product account for a large portion of total waterborne shipments (41%) and a significant proportion of total consumption (24%). However, when residual fuel oil is excluded, imported product is a small portion of waterborne shipments (15%) and of total consumption (7%). These remaining imports primarily consist of distillate fuel oil and gasoline. In order to illustrate the transportation patterns, detailed information on imports of distillates is shown in Table B-3. The data presented in the table show the relatively small quantities that are being imported and the size of tankers being used. Most of the tankers in this trade are less than 70,000 dwt. The average cargo size is small in proportion to the capacity of individual tankers giving evidence that these tankers make multiple port calls along the East Coast. These shallow draft tankers are able to make deliveries directly to many of the terminal facilities of fuel oil and gasoline dealers in the region's ports.

Table B-4 shows the leading ports of origin for these cargoes. In 1978 over two-thirds of distillate imports to New York originated from five ports in the Caribbean area. The figures confirm that this trade is conducted by small and intermediate size tankers (20,000 - 70,000 dwt) and that it is moving over relatively short distances (less than 2,000 miles).

Pipeline flows

Table B-1 indicates that 210 million barrels of petroleum product were delivered to the region by pipe in 1978. The Colonial pipeline system is the only pipeline that brings in significant quantities of product from outside the region. Colonial supplies product from U.S. Gulf Coast refineries, and the pipeline terminates in northern New Jersey. There is a small pipeline owned by Sun Oil which brings product from western Pennsylvania to Philadelphia.

Table B-2
WATERBORNE SHIPMENTS OF PRODUCT FOR PORTS OF NEW YORK AND PHILADELPHIA, 1978
(millions of barrels)

	DOMESTIC		FOREIGN		TOTAL	
Product	**inbound**	**outbound**	**imports**	**exports**	**inbound**	**outbound**
Gasoline	63	96	13	1	76	97
Jet Fuel	7	1	0	0	7	1
Kerosene	7	1	0	0	7	1
Distillates	68	58	12	2	80	60
SUBTOTAL	145	156	25	3	170	159
Residual Fuel Oil	62	39	116	1	178	40
TOTAL	207	195	141	4	348	199

Source: *Waterborne Commerce of the United States, Part I, Calendar year 1978,* U.S. Army Corps of Engineers.

Table B-3
DISTRIBUTION OF CARGO BY SHIP SIZE FOR IMPORTS OF DISTILLATES TO NEW YORK, 1978

ITEM	Under 20,000 dwt	20,000-39,999 dwt	40,000-69,999 dwt	Over 70,000 dwt
# Port calls	14	101	48	5
Total tonnage	242,305	1,790,206	1,001,403	216,301
as % total tonnage for New York	7%	55%	31%	7%
Average size cargo by ship class (dwt)	17,307	17,725	20,862	43,260

Source: Adapted from "Tanker imports for 1977 by Port Pair and Vessel Tonnage," computer report No. COS9071R. U.S. Maritime Administration, processed February 12, 1979.

Table B-4
LEADING PORTS OF ORIGIN FOR IMPORTS OF DISTILLATES TO NEW YORK, 1978

PORT	# CALLS	TOTAL CARGO (TONS)	AVERAGE SIZE CARGO BY PORT (TONS)
1) Aruba, N.A.	41	673,363	16,400
2) PT. A Pierre, Trinidad	30	433,023	14,400
3) Amuay, Venezuela	29	340,509	11,700
4) Gr. Bahama Island, Bahamas	13	469,464	36,100
5) Punta Cardor, Venezuela	9	243,807	27,100
Totals	122	2,160,166	—
as % of total for New York	73%	66%	—

Source: Adapted from "Tanker imports for 1977 by Port Pair and Vessel Tonnage," computer report No. COS9071R, U.S. Maritime Administration, processed February 12, 1979.

Pipelines are a particularly important means of delivery because of their low cost and reliability when compared with shipment by coastal tanker. In 1979 the transportation costs for domestic tankers between Houston and New York averaged $2.00 per barrel compared with a typical pipeline cost of $0.60 per barrel. Except for residual oil, therefore, delivery of product by water is a means of supplementing deliveries by pipeline and from local refineries and is not a primary means of supply. Any expansion of pipeline capacity to the region would likely reduce the flow of product over water.

Large quantities of product are also sent out of the region by pipe. Table B-1 indicates that 196 million barrels were outbound by pipe and truck in l978, though it is assumed that truck deliveries accounted for only a small portion of the total. The outbound pipeline flow is the only quantity in the table for which there is no ready measurement. The amount shown is simply the balance of product which cannot be accounted for by the consumption and outbound waterborne shipments. The capacities of outbound pipelines shown in Figure B-1 suggest that the estimate of the outbound pipeline flow is a reasonable one.

Residual fuel oil flows in the region

The northeastern United States and, more importantly this region in particular, consumes more residual fuel oil than any other region in the country. Residual fuel oil cannot be pumped long distances by pipe because of its relatively high pour point. For this reason, all of the residual oil delivered from refineries outside the region arrives by water in heated tankers. As shown in Table B-5, almost 50% of inbound residual oil is imported from refineries in the Caribbean area.

In evaluating the possibility of product throughput for a deepwater port, residual fuel oil would have to be discounted since it could not be pumped through an underwater pipe for a distance of more than a few hundred yards without heating and insulation. Local refineries maintain residual oil at a temperature of about 150 degrees fahrenheit for pumping short distances within the refinery complex. Any pumping of residual oil through an underwater pipeline over several miles would require similar heating capability which would be very expensive.

For this reason, the volumes of product flows shown in Table B-5 are also shown without residual fuel oil being included.

Feasibility of using a deepwater port for delivery of product

Despite the sizeable aggregate quantities of product being shipped into the region, it appears impractical that this product stream could be diverted through a deepwater port. The principal reasons for this are the economics of the domestic shipping operations, the impracticality of using very large tankers for transporting product short distances and the distribution requirements once the product is delivered to the region.

Most of the waterborne shipments of product are from domestic refineries on the Gulf Coast. Under the Jones Act (46 USC 688), shippers must use American flag tankers for the domestic trade. This requirement has resulted in transportation costs that are significantly greater than the costs of shipping petroleum products by foreign tankers.

Furthermore, there are no economical means of loading tankers in excess of 150,000 dwt on the Gulf Coast. Even if very large tankers could be used for the domestic trade, the distances involved are too short to allow the economies of scale which are possible for the crude oil trade between the Middle East and North America.

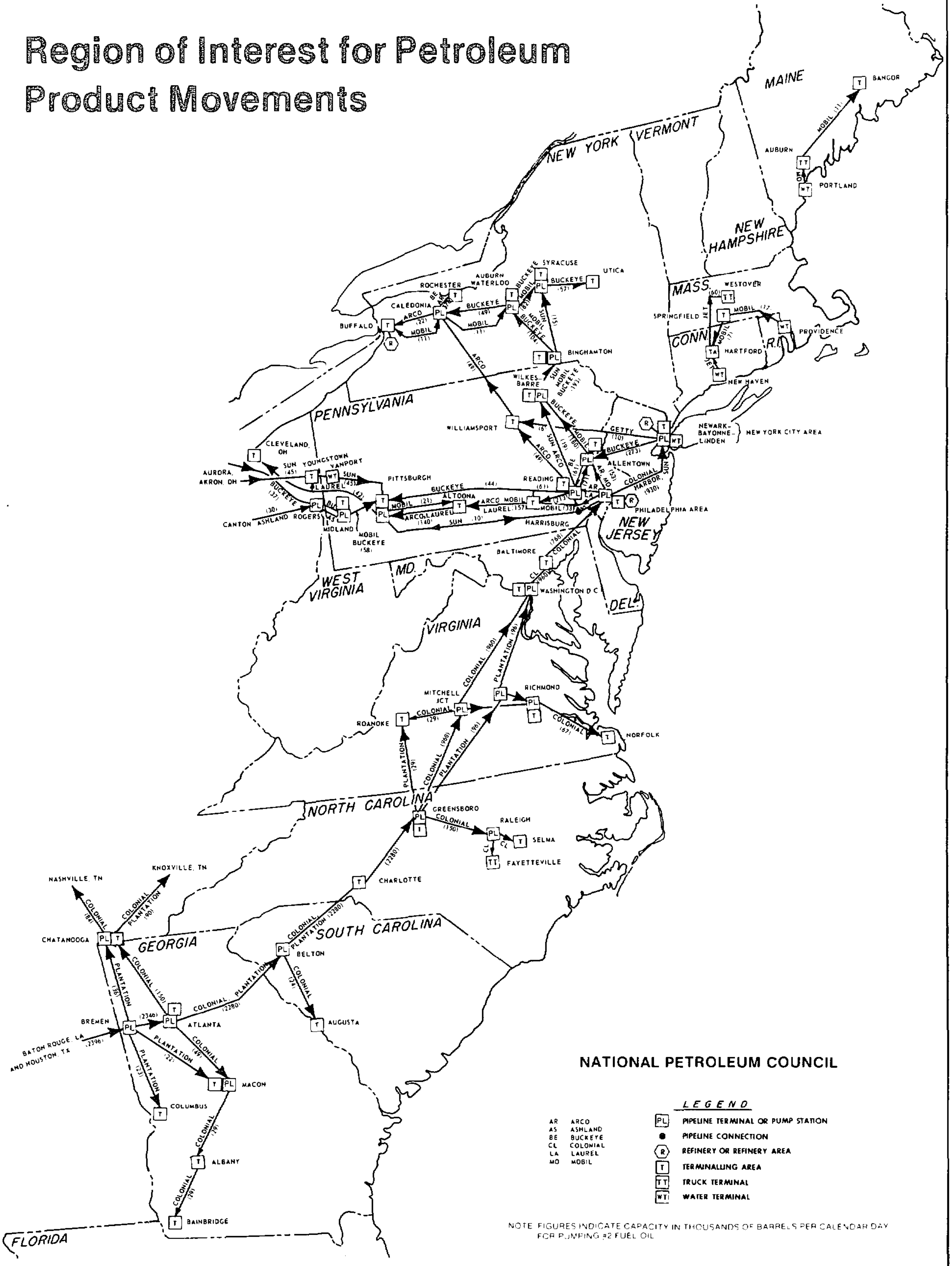
Similarly, it is not economical to use very large crude carriers for the trade in imported oil between the Caribbean and the East Coast. As previously discussed, the loading ports of origin for imported product to New York and Philadelphia are mainly in the Caribbean area, and the distances are comparable to those for the domestic trade. The product stream is steady but the quantities delivered at any one time are small. Additionally the small tankers in the trade are making multiple port calls before discharging their entire cargo which indicates that there would be severe physical as well as economic disadvantages in using very large tankers for the product trade.

Table B-5
RESIDUAL OIL FLOWS IN REGION, 1978
(Millions of Barrels)

SOURCE	INTO REGION	OUT OF REGION
by water		
domestic	62	36
foreign	116	0
by pipe	0	0
from refineries	57	—
consumption	—	199
TOTAL FLOWS	235	235

Source: *Waterborne Commerce of the United States, Part I, Calendar year 1978,* U.S. Army Corps of Engineers and other sources of Office of Energy, PANYNJ, (May, 1981).

Region of Interest for Petroleum Product Movements



NOTE: FIGURES INDICATE CAPACITY IN THOUSANDS OF BARRELS PER CALENDAR DAY FOR PUMPING #2 FUEL OIL

SOURCE: Adapted from "Petroleum Storage and Transportation Capacities", Volume III, National Petroleum Council, December 1979

FIGURE B-1

Finally, the large number of delivery points in the region of New York Harbor make it impractical to use a deepwater port. Unlike crude oil shipments to the region which are destined almost exclusively for one of ten refineries, product is delivered to hundreds of locations for further delivery to consumers. In New York Harbor alone there are over two hundred sites where product deliveries are made by barge and tanker, despite the fact that many of them are used infrequently. There are at least as many sites in the Delaware Bay and Philadelphia port region. Product deliveries are often made to utilities and fuel oil distributors in small quantities. There is also a large volume of outbound product from these facilities which is subsequently distributed in small shipments to similarly scattered destinations in New England.

This highly diffused pattern of product deliveries in relatively small quantities indicates the complexity of the product distribution network in the region. It would be very difficult to consolidate this supply and distribution system in order to accept delivery of large quantities of product from a centralized point such as a deepwater port. It would be impossible to impose such an arrangement on the region without disrupting the existing market and distribution network for petroleum product. Also, there is no evidence that any expanded capability to deliver product is needed. The existing facilities for handling product in both New York and Philadelphia are not being fully used now.

APPENDIX C
WORLDWIDE SINGLE POINT MOORING INSTALLATIONS 1978-1980

YEAR	COUNTRY	PORT/FIELD	OWNER	CONTRACTOR/ DESIGNER	MAX. VESSEL SIZE IN DWT
1978	United Kingdom	Buchan Field	BP	IMODCO	80,000
1978	Indonesia	Udang Field	Conoco	SBM	100,000 SBS
1978	Brazil	Enchova 4	Petrobras	SBM	53,000
1978	Philippines	Nido Field	Cities Service	SBM	90,000 SBS
1978	Mexico	Rabon Grande	Pemex	IMODCO	150,000
1978	U.S.A.	Louisiana	Loop	SOFEC	700,000 SALM
1978	U.S.A.	Louisiana	Loop	SOFEC	700,000 SALM
1978	U.S.A.	Louisiana	Loop	SOFEC	700,000 SALM
1978	Spain	Badalona	Campsa	SOFEC	50,000 SALM
1978	Tunisia	Ashtart	Serept	SBM	120,000 SBS
1978	Mexico	Dos Bocas	Pemex	IMODCO	250,000
1978	Nigeria	Qua Iboe	Mobil	IMODCO	300,000
1978	Egypt	El Alamein	Wepco	SBM	100,000
1978	Italy	Nilde Field	Agip	SBM	80,000 SALM
1978	Argentina	Caleta Cordova	YPF	IMODCO	60,000
1978	Argentina	Puerto Rosales	YPF	IMODCO	60,000
1978	Libya	Zuetina	Occidental	IMODCO	275,000
1978	Malaysia	Bintulu	Shell	SBM	210,000
1979	Angola	Quinfuquena	Petrangol	EMH	150,000 Tower
1979	Dubai	Fateh Field	Dupetco	IMODCO	120,000
1979	Oman	Mina-Al-Fahal	Shell-PDO	SBM	350,000
1979	Taiwan	Taoyuan	CPC	IMODCO	250,000
1979	Norway	Statfjord B	Mobil	SBM	150,000 Tower
1979	Cameroon	Limboh Point	Sonora	SBM	150,000
1979	Brazil	Tedut & Tefran	CEC/Petrobras	SBM	200,000
1979	Gabon	Gamba	Shell	SBM	140,000
1979	Cameroon	Kolé	Elf Serepca	BLUEWATER	250,000
1979	United Kingdom	Fulmar	Shell Expro	EXXON	Yoke Tower
1979	Gabon	Mayumba GMB	SNEA (P)	BLUEWATER	70,000 CALM
1979	Denmark	Gorm Field	Danbor	SBM	70,000 CALM
1979	Angola	Not disclosed	Texaco/Petrangol	IMODCO	220,000 CALM
1979	Philippines	Bataan	Mobil	SOFEC	300,000 SALM
1979	South Korea	Pusan	KOC	MITSUBISHI	325,000 CALM
1979	Singapore	Singapore	PSA	IMODCO	300,000 CALM
1979	Ivory Coast	Abidjan	SIR	IMODCO	250,000 CALM
1979	Qatar	Halul	QPPA (Shell)	SBM	500,000 CALM
1980	Mexico	Rabon Grande	Pemex	SBM	250,000 CALM

Source: *International Petroleum Encyclopedia*

Appendix D

ANALYSIS OF OIL SPILL DATA

The United States Coast Guard (USCG) provided records of petroleum spills (both crude oil and refined products) which occurred in New York Harbor and in the Delaware Bay/River from 1974 through 1980. Such records are on file and available upon request from the Pollution Incident Reporting System (PIRS) established as a result of the Federal Water Pollution Control Act of 1970.

Analyses of these records attempted to identify what part crude oil spills played in the overall petroleum spill problem. Table D-1 compares the number of crude oil spills and the volume of crude oil spilled to the total number of petroleum spills and the total volume of petroleum spilled year by year for New York Harbor. The column headings represent the most general categorization of the data and include spills on land as well as into the water. As an example, the 3,000,000 barrel petroleum spill in 1978 resulted from a storage tank rupturing and No.4 fuel oil being spilled. Throughout the seven-year period crude oil spill incidents were a small proportion of total petroleum spill incidents and the volume of crude oil spilled in every year except 1976 accounted for a small proportion of the total volume of petroleum reported spilled. Table D-2 presents the same information for the Delaware Bay/River where, for the seven-year period, crude oil played a more significant part than in New York Harbor. Since eight refineries are served through the Delaware Bay/River compared to the three served through New York Harbor (two in the immediate harbor locale and one around Albany, New York, served via the Hudson River), such a result is not surprising.

Table D-3 for New York Harbor and Table D-4 for the Delaware Bay/River contain the source material for Table 14 in Chapter Two, which presents summary data for marine vessel petroleum spills for the period. Tables D-3 and D-4 show what portion of total marine vessel petroleum spill incidents and volumes are accounted for by crude oil. This is the specific area of the marine oil spill problem which could be affected by the establishment of an offshore or inshore marine crude oil receiving facility.

Tables D-5 and D-6 for their respective regions identify marine vessel crude oil spills as coming from tankers, barges or other vessels. This information along with the material shown in Chapter Two's Tables 15 and 16 provides the background against which projections of crude oil spills with and without an in-harbor marine crude oil receiving facility in place in either Delaware Bay or New York Harbor were developed.

In Chapter Ten's Input to consultants section, the projections are found for the chronic small operational spills which could be expected under the assumption that current practices are continued and the assumption that a facility is in place. The location, annual frequency and magnitude of these crude oil spills result from judgments made upon the data rather than from any statistical calculations of "average" annual occurrences and sizes.

The projections of catastrophic spills for the Delaware Bay/River and for New York Harbor under the two scenarios of the continuation of current practices or the establishment of a marine crude oil receiving facility should be influenced by the past seven-year history of catastrophic spills in each region. However, during that time period, there have been few catastrophic marine crude oil spill incidents in the Delaware Bay/River and in New York Harbor to use as a basis for projections. Since 1974, the largest marine crude oil spill in the Delaware Bay/River was reported at 500,000 gallons and in New York Harbor at 277,200 gallons. Therefore, assistance was sought from individuals, organizations and documents which had treated petroleum spill projection and risk analysis in the recent past. Key among these sources were officers of the USCG stationed on Governors Island, in Washington, D.C. and in the Puget Sound area of the State of Washington. "Worst case" planning data were made available to the study by Clean Harbors Cooperative for New York Harbor. Two studies for the Pelican Island project in Galveston, Texas were consulted. Based upon these inputs catastrophic marine crude oil spill projections were made and are found in Chapter Ten.

Table D-1

ANNUAL SUMMARY OF PETROLEUM SPILLS NEW YORK HARBOR

Year	Number of Petroleum Spills	Number of Petroleum Spills With Quantity Reported	Total Quantity Reported Spilled in Gallons	Number of Crude Oil Spills	Number of Crude Oil Spills With Quantity Reported	Total Quantity Reported Spilled in Gallons
1974	593	336	301,463	15	15	8,112
1975	600	424	237,994	9	9	10,705
1976	438	284	652,310	8	7	277,695
1977	701	374	542,724	20	15	599
1978	641	420	3,571,249	20	17	912
1979	401	321	437,982	9	8	2,593
1980	253	206	317,583	6	6	127

Major Spill Incidents, By Year (100,000 Gallons or More):

1974 —
1975 102,000
1976 277,200 (Crude)
150,000

1977 150,000
100,000
1978 3,000,000
210,000

1979 210,000
120,000
1980 —

Table D-2

ANNUAL SUMMARY OF PETROLEUM SPILLS DELAWARE BAY/RIVER

Year	Number of Petroleum Spills	Number of Petroleum Spills With Quantity Reported	Total Quantity Reported Spilled in Gallons	Number of Crude Oil Spills	Number of Crude Oil Spills With Quantity Reported	Total Quantity Reported Spilled in Gallons
1974	243	215	376,329	32	31	19,587
1975	324	279	771,630	32	31	512,990
1976	358	266	457,355	19	18	165,572
1977	205	172	136,396	25	22	8,883
1978	196	163	691,109	23	20	13,750
1979	266	186	322,750	26	19	215,571
1980	194	135	45,760	17	14	2,698

Major Spill Incidents, By Year (100,000 Gallons or More):

1974 285,000
1975 500,000 (Crude)
1976 134,000 (Crude)
110,000

1977 —
1978 630,000

1979 189,000 (Crude)
1980 —

Table D-3

ANNUAL SUMMARY OF MARINE VESSEL PETROLEUM SPILLS NEW YORK HARBOR

Year	Number of Marine Vessel Petroleum Spills	Number of Marine Vessel Petroleum Spills With Quantity Reported	Total Quantity Reported Spilled in Gallons	Number of Marine Vessel Crude Oil Spills	Number of Marine Vessel Crude Oil Spills With Quantity Reported	Total Quantity Reported Spilled in Gallons
1974	216	175	166,949	8	8	6,352
1975	230	172	144,526	7	7	10,559
1976	170	150	325,336	7	7	277,695
1977	182	157	122,895	15	11	479
1978	225	198	235,213	13	11	557
1979	164	152	156,989	9	8	2,593
1980	127	116	37,571	5	5	122

Large Spill Incidents, By Year (10,000 Gallons or More):

1974	84,000
	30,000
1975	102,000
	10,000 (Crude)
1976	277,200 (Crude)
1977	100,000
1978	60,000
	50,000
	44,310
	37,800
1979	120,000
1980	—

Table D-4

ANNUAL SUMMARY OF MARINE VESSEL PETROLEUM SPILLS DELAWARE BAY/RIVER

Year	Number of Marine Vessel Petroleum Spills	Number of Marine Vessel Petroleum Spills With Quantity Reported	Total Quantity Reported Spilled in Gallons	Number of Marine Vessel Crude Oil Spills	Number of Marine Vessel Crude Oil Spills With Quantity Reported	Total Quantity Reported Spilled in Gallons
1974	90	87	312,531	17	17	17,862
1975	83	75	601,639	19	18	508,882
1976	109	94	227,722	12	11	134,764
1977	74	64	10,461	13	12	813
1978	56	46	637,269	8	6	2,450
1979	64	58	229,067	13	12	212,400
1980	65	53	7,595	10	8	1,331

Large Spill Incidents, By Year (10,000 Gallons or More):

1974	285,000
	13,000 (Crude)
1975	500,000 (Crude)
	73,000
	12,000
1976	134,000 (Crude)
	84,000
1977	—
1978	630,000
1979	189,000 (Crude)
	16,000 (Crude)
1980	—

Table D-5

ANNUAL SUMMARY OF MARINE VESSEL CRUDE OIL SPILLS NEW YORK HARBOR

Year	Number of Tanker Incidents	Total Quantity Reported in Gallons	Number of Barge Incidents	Total Quantity Reported in Gallons	Number of Other Vessel Incidents	Total Quantity Reported in Gallons	Total Number of Vessel Incidents	Total Quantity Reported in Gallons
1974	5	6,205	2	47	1	100	8	6,352
1975	5	10,497[1]	2	62	—	—	7	10,559
1976	4	277,585[2]	3	110	—	—	7	277,695
1977	8/7	284	7/4	195	—	—	15/11	479
1978	4	370	9/7	187	—	—	13/11	557
1979	5/4	2,005	2	453	2	135	9/8	2,593
1980	3	116	2	6	—	—	5	122

Note: For X/Y, the first entry represents the number of reported incidents and the second entry represents the number of reported incidents for which quantities were recorded.

[1] A single incident accounted for 10,000 gallons.
[2] A single incident accounted for 277,200 gallons.

Table D-6

ANNUAL SUMMARY OF MARINE VESSEL CRUDE OIL SPILLS DELAWARE BAY/RIVER

Year	Number of Tanker Incidents	Total Quantity Reported in Gallons	Number of Barge Incidents	Total Quantity Reported in Gallons	Number of Other Vessel Incidents	Total Quantity Reported in Gallons	Total Number of Vessel Incidents	Total Quantity Reported in Gallons
1974	13	15,132[1]	3	1,730	1	1,000	17	17,862
1975	12	502,931[2]	6/5	5,950	1	1	19/18	508,882
1976	8	711	3/2	134,003[3]	1	50	12/11	134,764
1977	12/11	812	1	1	—	—	13/12	813
1978	5/3	2,305	3	145	—	—	8/6	2,450
1979	8/7	19,670[4]	4	192,725[5]	1	5	13/12	212,400
1980	7/5	189	3	1,142	—	—	10/8	1,331

Note: For X/Y, the first entry represents the number of reported incidents and the second entry represents the number of reported incidents for which quantities were recorded.

[1] A single incident accounted for 13,000 gallons.
[2] A single incident accounted for 500,000 gallons.
[3] A single incident accounted for 134,000 gallons.
[4] A single incident accounted for 16,800 gallons.
[5] A single incident accounted for 189,000 gallons.

APPENDIX E—GOVERNMENT AGENCIES INVOLVED IN THE SITING OF AN IN-HARBOR OIL TERMINAL (1.)

Federal Agency	Activity Requiring Approval	Form	Statutory Authority
U.S. Coast Guard, U.S. Department of Transportation	Pipeline construction ways, requiring elevated crossings, bridges, causeways, etc.	Permit for work in navigable waters	Section 9, Rivers and Harbors Act of 1899, 30 STAT. 1151, 33 U.S.C. 401
U.S. Coast Guard, U.S. Department of Transportation	Designation of locations for roadsteads, moorages and vessel fairways offshore	Consent	33 U.S.C. 1221 et seq.
U.S. Coast Guard, U.S. Department of Transportation	Handling of explosives or other dangerous cargo on a vessel, barge or waterfront facility	Permit	33 CFR 125 & 110; 46 C.F.R. 146.20, 146.22 & 146.29
U.S. Coast Guard, U.S. Department of Transportation	Operation of marine oil transfer facility; oil pollution prevention regulations for marine oil transfer facilities and operations.	Acceptance of EIS and facility operations manual.	P.L. 92-500 33 U.S.C. 1321 et seq. 33 CFR 154,156
Corps of Engineers, U.S. Department of the Army	Pipeline construction across navigable waters	Permit for any work in navigable waters	Section 10, Rivers and Harbors Act of 1899, 30 STAT. 1151, 33 U.S.C. 403
Corps of Engineers, U.S. Department of the Army	Disposal of dredge spoils	COE regulates the disposal of dredge spoils with EPA holding veto power over the location of the disposal site	P.L. 92-500 Section 404.33 U.S.C. 1401 et seq.
Corps of Engineers U.S. Department of the Army	Dredging of waterway	Environmental Impact Statement	National Environmental Policy Act 42 U.S.C. 4321 et seq.
Corps of Engineers U.S. Department of the Army	Disposal of dredge spoils in New York Bight	Approval incorporated into COE permit	Title I, II of Marine Protection, Research and Sanctuary Act. 33 U.S.C. 1401 et seq.
U.S. Department of Transportation, Materials Transportation Bureau, Office of Pipeline Safety	Safe operation of petroleum pipelines	Formulate and enforce minimum federal safety standards for transportation of liquids and pipeline facilities	18 U.S.C. 831-835 49 U.S.C. 1655 49 CFR 195
U.S. Environmental Protection Agency	Discharge of pollutants into navigable waters of U.S., contiguous zone, and ocean from point sources	N.P.D.E.S. permit and review and comment on all dredging projects in navigable waters	F.W.P.C.A. of 1972; Section 301, 302, 307, 308, 403. Memorandum of Understanding between COE and EPA, July 13, 1967
U.S. Environmental Protection Agency	Operation of petroleum storage facility	Spill prevention control and containment plan for above and below ground storage of petroleum	P.L. 92-500 33 USC 1201 et seq. 40 CFR 112

Federal Agency	Activity Requiring Approval	Form	Statutory Authority
Coastal Zone Management, NOAA, U.S. Department of Commerce	State management program provides adequate consideration of national interest in siting energy facilities to meet requirements that are more than local in nature.	Secretary of Commerce approval of state management plan. Federal consistency determination appeal.	16 U.S.C. 1451-1464. P.L. 92-583
Fish and Wildlife Service, U.S. Department of the Interior	Construction on or across federal lands	Comments on proposed federal and/or state permits	16 U.S.C. 661 et seq.
Mid-Atlantic Fishery Management Council	Construction of pipeline in offshore waters	Consistency with Mid-Atlantic Fisheries Management Council Plans	P.L. 94-265, 16 U.S.C. 1801
Occupational Safety and Health Administration, U.S. Department of Labor	Maintenance of safe and healthy working conditions during construction such as excavation, trenching, shoring, blasting, and use of explosives	Safety regulations in *Code of Federal Regulations*	29 U.S.C. 651 et seq. 29 CFR 1926
Advisory Council on Historic Preservation	Pipeline construction as it affects historical and cultural resources	Approval that most recent listing of *National Register of Historic Places* consulted	16 U.S.C. 470 et seq.

Regional Agency	Activity Requiring Approval	Form	Statutory Authority
Delaware River Basin Commission	All construction projects affecting water resources within its special jurisdiction, that is, the drainage basin of the Delaware River and its tributaries, including Delaware Bay. Includes more than 200 municipalities in 14 counties	Certificate of compliance with the comprehensive plan by the commission	Delaware River Basin Compact P.L. 87-328 (federal), *N.J.S.A* 58:18-18 et seq.
Interstate Sanitation Commission	Review sources of pollution for water defined by the compact	Regulations with regard to pollution of coastal, estuarine and tidal waters of the Signatory States of Connecticut, New York and New Jersey	*N.J.S.A.* 32: 19-1 et seq.

State Agency	Activity Requiring Approval	Form	Statutory Authority
N.J. Department of Energy	Siting of energy facilities statewide	Co-extensive jurisdiction with other state agencies. Co-extensive federal consistency determination for New Jersey Coastal Management Program	P.L. 1977, C.146 *N.J.S.A.* 52: 27 F-1 et seq. Memorandum of Understanding DOE-DEP. August, 1978
Tidelands Resources Council	Conveyance of riparian grants and leases	Grants and leases	*N.J.S.A.* 12: 1-1 L. 1979. C.311
N.J. Department of Environmental Protection (DEP), Division of Coastal Resources	Construction of major residential, industrial, transportation, utility, and energy-related facilities in coastal zone	CAFRA permit	Coastal Area Facilities Review Act of 1973. *N.J.S.A.* 13:19-1• et seq. *N.J.A.C.* 7:7E-1.1 et seq.
N.J. DEP, Division of Coastal Resources	Construction, excavation, fill, dredging, installation of utilities or facilities in the delineated wetlands of New Jersey	Wetlands Type A or Type B permit	Wetlands Act of 1970. *N.J.S.A.* 13:9A-1 et seq. *N.J.A.C.* 7:7E-1.1
N.J. DEP, Division of Coastal Resources, Bureau of Coastal Project Review	Permit is required prior to the development of waterfront upon any tidal or navigable waterway. Waterfront development means docks, wharfs, piers, bulkheads, bridges, pipelines, cables, or pilings or dredgings or removing of sand or other materials from lands under tidal waters	Permit	*N.J.S.A.* 12:5-1 et seq. *N.J.A.C.* 7:7E-1.3
N.J. DEP, Division of Water Resources	Construction, installation, alteration of structures or fill or dredging along or across the channel or floodway of any stream	Stream encroachment permit	*N.J.S.A.* 58:1-26 et seq. *N.J.A.C.* 7:8-3.15
N.J. DEP, Division of Water Resources	Any alteration (dredging and filling) of any stream within the high water mark of 100 year flood as determined by the state	Permit	Flood Plain Act, *N.J.S.A.* 58: 16A-50 et seq.
N.J. DEP, Division of Water Resources	Discharge of pollutants onto the waters or lands of the state	Water quality certificate and compliance with water quality standards	FWPCA, P.L. 92-500, 33 U.S.C. 1171; N.J. Water Pollution Control Act, 1977, c. 74 *N.J.S.A.* 58: 10A-1 et seq.
N.J. DEP, Division of Water Resources	Diversion of surface or subsurface waters in excess of 100,000 gallons per day or 70 gallons/minute	1. Permit to divert surface waters 2. Permit to divert subsurface waters	*N.J.S.A.* 58:1-35 et seq. *N.J.S.A.* 58:4A-2 et seq.

State Agency	Activity Requiring Approval	Form	Statutory Authority
N.J. DEP, Division of Hazard Management	Construction and operation of petroleum tank storage	Discharge, Prevention, Containment or Countermeasures Plan and Discharge, Cleanup and Removal Plan	*N.J.S.A.* 58:10-23.11 *N.J.A.C.* 7: 1E-1.1
N.J. DEP, Division of Fish, Game and Wildlife	Accord special protection, maintain and enhance species or subspecies of rare and endangered species indigenous to the state	- - - -	Rare and Endangered Species Act of 1973, *N.J.S.A.* 23:2A et seq.
N.J. DEP, Division of Fish, Game, and Wildlife	Construction of a pipeline in New Jersey waters	Recommendations to permit authorizing agencies	P.L. 1979, c. 199
N.J. DEP, Division of Environmental Quality, Office of Pesticide Control	Purchase and use of chemicals in state of New Jersey and ROW pest control	Certification and registration of pesticide applicator. Business would also need to be registered	*N.J.A.C.* 7:30-1; *N.J.S.A.* 13:1F-1 et seq.
N.J. DEP, Division of Environmental Quality, Office of Noise Control	Installation or operation of machinery and equipment in the conduct of operations which may result in noise	Registration of persons involved in operations which may result in noise	*N.J.S.A.* 13:16-1 et seq. *N.J.A.C.* 7:29-1
N.J. DEP, Solid Waste Administration	Disposal of hazardous wastes, chemical wastes, bulk liquids and semi-liquids; methods of disposal of wastes	Owner or generator must label and identify such materials in accordance with federal regulations and assure that the carrier transporting the waste accumulated at offshore and onshore facilities will be disposed at a site authorized to accept the specific waste	*N.J.A.C.* 7:26-1 et seq.
N.J. DEP, Division of Environmental Quality, Bureau of Air Pollution Control	Permits to construct, install, or alter any equipment capable of causing the emission of contaminants into the air, either directly or indirectly, and/or control apparatus which prevents or controls the emission of air contaminants	Permit	*N.J.S.A.* 26: 2c-9.2 et seq.
N.J. DEP, Division of Environmental Quality, Bureau of Air Pollution Control	Preconstruction review to determine compliance with National Ambient Air Quality Standards	Compliance	40 CFR 51-61; 42 U.S.C. 7401 et seq.

State Agency	Activity Requiring Approval	Form	Statutory Authority
N.J. Department of Agriculture, Soil Conservation Committee	Construction requiring a building permit that disturbs 5,000 square feet or more of land surface	Soil Control District Certification of a plan for soil erosion and sediment control	*N.J.S.A.* 4:24-1 et seq.
N.J. Department of Labor, Office of Safety Compliance	Transportation, use, and storage of explosives	Permit	*N.J.A.C.* 12:190-193
N.J. Department of Transportation, Division of Consumer Services	Request for use or occupancy of state owned railroad property	Permit	*N.J.S.A.* 27:1A-25
N.J. Department of Transportation, Regional Office	Permit from regional DOT office to construct an attachment to a bridge on or over a state highway	Permit	*N.J.S.A.* 27:7-1 et seq.
N.J. Department of Transportation, Regional Office	Permit to open-cut state highway for purpose of installing, repairing, or relocating utility line	Permit	*N.J.S.A.* 27:7-1 et seq.

County Agency	Activity Requiring Approval	Form	Statutory Authority
County Planning Board	Subdivision or site plan of construction within or adjacent to county right-of-way	Subdivision or site plan approval. Building permit if structure within bed of county highway	*N.J.S.A.* 40:27-1 to 40: 27-11
County Highway Department	Construction or work along or adjacent to county highways	Permit	*N.J.S.A.* 40:27-1 to 40:27-11

Local Agency	Activity Requiring Approval	Form	Statutory Authority
Municipal Planning Board	Subdivision or site plan approval to construct a pipeline	Permit	*N.J.S.A.* 40:55D-1 et seq.

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1. Adapted from *OCS Natural Gas Pipelines: An Analysis of Routing Issues*, by Robert J. Golden, Jr. et al., Center for Coastal and Environmental Studies, Rutgers—The State University of New Jersey and the New Jersey Department of Energy, 1980.

Appendix F

INTERNATIONAL CONVENTIONS AND REGULATIONS RELEVANT TO DEEPWATER OIL TERMINALS AND TANKERS

International conventions concerning offshore jurisdictions

The Deepwater Port Act of 1974 is meant to be consistent with existing international law. Two international conventions are affected by the siting of a deepwater port which must, by statutory definition, be located outside the territorial limits of the United States. It is hoped that current United Nations Law of the Sea Conference will ultimately produce a convention amending seabed jurisdictions and control of the oceans' surface which could impact deepwater ports. Presently, the following conventions are applicable:

A. **Convention on the High Seas**. This treaty, which the United States has ratified, established certain activities on and under the High Seas (i.e., oceans beyond the three mile United States territorial sea) that are to be free from interference from any nation, whether adjacent coastal state or non-coastal state. These activities are freedom of navigation, fishing, cable and pipeline construction, and passage over, under, and through the high seas. In 1976, the Fishery Conservation and Management Act (P.L. 94-265, 16 U.S.C. 1801) extended the United States exclusive fishing jurisdiction out to 200 miles. However, the three mile limit on the United States territorial sea remains unaffected with respect to freedom of navigation.

B. **Convention on the Continental Shelf** This convention gives a coastal state exclusive jurisdiction over mineral rights on the Continental Shelf adjacent to the state. The Outer Continental Shelf is in fact treated as an extension of the land. The limitation of the state's jurisdiction (in this case, the United States) is to a depth of 200 meters or to a point where a distinct geographical continental shelf admits mineral exploitation. This convention contains explicit provisions for coastal state jurisdiction over the construction and maintenance of pipelines and cables.

In addition, ships participating in the construction of an OCS or deepwater port pipeline would be required to observe international navigation rules as such activity will take place beyond the three mile territorial limit of the United States. The Outer Continental Shelf Lands Act of 1953 (67 STAT. 462, 43 U.S.C. 1331 *et. seq.*) incorporated the provisions of this convention into domestic law.

A more extensive discussion of pertinent federal laws is found in 'Federal Jurisdictional and Regulatory Aspects of Planning for Offshore Ports,' by T.D. Clingan and G.J. Kovach, in *Handbook for Offshore Port Planning*.

International tanker regulations concerning safety and pollution prevention

The Intergovernmental Maritime Consultative Organization (IMCO), a specialized agency of the United Nations, has developed comprehensive rules concerned with the promotion of safety at sea and the elimination of marine pollution from ships. The most important conventions that have been adopted so far by IMCO are the International Convention for the Safety of Life at Sea (SOLAS) in 1974 which entered into force in 1980 and the International Convention for the Prevention of Pollution from Ships (MARPOL) in 1973 which, after major modifications in the 1978 Marine Pollution Protocol, is expected to enter into force sometime in 1982. Each of these two conventions has been modified by subsequent protocols. The important aspects of each of these two conventions, as they pertain to an alternative crude oil handling facility, are discussed below.

A. International Convention for the Safety of Life at Sea, 1974

The most important provision of the SOLAS Convention relating to crude oil tankers stipulates that inert gas systems shall be fitted to 1) all new tankers over 20,000 dwt; 2) all new and existing tankers, regardless of size, which use crude oil washing; 3) all existing crude oil tankers over 70,000 dwt by May 1, 1983; 4) all existing crude oil tankers between 40,000 dwt and 70,000 dwt by May 1, 1985; and 5) all existing crude carriers between 20,000 dwt and 40,000 dwt using high capacity crude oil washing machines by May 1,1985.

An inert gas system (IGS) is a system which replaces the flammable gases in the spaces of the ship's cargo tanks with gases so low in oxygen content that there is no danger of combustion. Under the SOLAS Convention, inert gas cannot contain more than 8% oxygen by volume. A properly operating IGS will greatly reduce the risk of a cargo tank explosion during transit, while discharging cargo or cleaning tanks, or in the event of a collision. The most efficient tank cleaning operations, such as crude oil washing, could not be safely performed without an IGS.

In addition to provisions for remote control steering gear on all cargo ships provided in the 1974 convention, the 1978 protocol provided that all tankers larger than 10,000 gross registered tons (grt) be provided with two remote steering gear control systems, each with its own electrical circuit and alarm system. All new tankers also must be provided with at least two independent steering gear power systems. The protocol also stipulates that all ships over 10,000 grt must be fitted with at least two radar systems, each capable of operating independently of the other. The 1978 protocol strengthened inspection and certification.

B. International Convention for the Prevention of Pollution from Ships, 1973

The International Convention for the Prevention of Pollution from ships and the 1978 Marine Pollution Protocol establish strict regulations aimed at minimizing any oil or oily waste discharge into the sea. When a tanker is within 50 miles of land, the only permitted discharge is from segregated ballast tanks and clean ballast tanks.

Segregated ballast tanks (SBT) are tanks which are completely separated from the cargo oil and fuel oil system and permanently allocated to carrying ballast other than oil or noxious substances. Clean ballast tanks (CBT) are those which are also dedicated to carrying ballast but may not be completely separated from the cargo oil and fuel oil system. These tanks must be so cleaned that the ballast discharge 'from a ship which is stationary into clear calm water on a clear day would not produce visible traces of oil on the surface of the water or on adjoining shorelines or cause a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines.'

It is relatively easy to convert a vessel to CBTs since no piping or bulkhead modifications are necessary. CBTs are thus required for existing tankers during an interim period after which conversions to SBTs are required.

Crude oil washing (COW) is a process in which a part of the ship's cargo is used to spray the walls of the emptied cargo tanks during discharge so that the residues and sediments are liquefied and discharged with the rest of the cargo. The solvent action of the crude oil, as a result, reduces the amount of sludge and clingage in the tanks by 75% to 80%. In terms of pollution prevention, the benefits are that less oil and sludge remain in the tanks to be mixed with ballast and/or tank cleaning water, which are eventually disposed of at sea.

The regulations of MARPOL 1973 as modified by the 1978 protocol, call for protectively located SBT and COW systems to be fitted to all new crude oil tankers of 20,000 dwt and larger. The capacity of the SBT is specified so that the tanker can operate safely under normal conditions on ballast voyages without having to use cargo tanks for water ballast. From the date of entry into force of the Protocol, every existing crude oil tanker over 40,000 dwt shall be provided with SBT/CBT, and COW.

Additional federal regulations

Many countries have not been content to wait for entry into force of IMCO conventions and have passed regulations, some of which are more stringent than the international conventions summarized above. The most significant of these are the regulations issued pursuant to the United States' Ports and Tanker Safety Act of 1978 which imposes SOLAS and MARPOL requirements on all tankers calling at U.S. ports. Additionally, the requirements contained in the Ports and Tanker Safety Act for SBT/CBT/COW, IGS and improved steering standards became effective on June 1, 1981.

The U.S. Coast Guard inspects and certifies vessels calling at U.S. ports and is charged with enforcing the law for domestic and foreign flag vessels. The Coast Guard has the authority to deny entry to vessels not complying with the regulations and/or to impose a fine up to a maximum of $25,000/day on those vessels which make no effort to comply with the law or which have serious deficiencies. In addition, the Coast Guard may refuse port entry to a foreign flag tanker if it: 1) has a bad record of accidents or pollution incidents; 2) fails to meet minimum manning levels; 3) has officers who are licensed by a certifying state which does not meet minimum U.S. standards; and, 4) does not have, at all times while in U.S. waters, at least one deck officer who is capable of clearly understanding English.

Appendix G

PORT DEVELOPMENT LEGISLATIVE PROPOSALS

Since 1980 dozens of proposals have been made to modify the procedures through which Congress and federal regulatory agencies approve the construction and maintenance of navigation channels. Presently, new federal channel improvements can take up to 24 years from the initial request to Congress for study authorization to the time of completion. Once constructed, federal channels must be maintained, and requests for maintenance funding by the Corps of Engineers are approved annually in the normal budget cycle.

Channels which are constructed and maintained by non-federal interests require a permit from the U.S. Army Corps of Engineers. Depending on the magnitude of the project and requirements for environmental studies, permit approval can take 4-6 years.

The development of ports in the United States is severely hampered by such time consuming procedures. The complexity of getting approvals for channel projects puts the U.S. at a competitive disadvantage compared with other nations. The question of how to simplify the procedures is being addressed by Congress with respect to five issues: (1) *improvements* — who is responsible for funding the construction, the local port, the federal government, or both; (2) *maintenance* — should the federal government, local port, or both undertake and pay for maintenance; (3) *funding mechanism* — should the federal government cover the cost, initially, with reimbursement by local interests or vice versa; (4) *streamlining* — how can Congressional and regulatory procedures be simplified to reduce the amount of time it takes to approve channel projects; (5) *user fees* — if local ports charge channel users a fee to help fund the constructon and/or maintenance of channel projects, who levies the fee (the federal government or the local port) and by what formula. One suggestion is to levy a national fee that would apply to all ports across the nation (uniform fee). Another suggestion is to allow local ports discretion in designing the fee (local port option).

The large ports in the nation and the small ports are divided on how to resolve these issues. The positions of these port coalitions and the contents of six major bills which Congress is considering as this report goes to press are outlined below.

Reagan Administration (HR 2959)

Improvements:	• 100% local port responsibility for funding
Maintenance:	• 100% local port responsibility for funding
Funding Mechanism:	• projects federally funded; local ports are required to reimburse federal treasury over long term
Streamlining:	• Congressional authorization is automatic if local port pays for project from the outset; permits required
User Fees:	• local port option

Abdnor-Moynihan (S. 1692)

Improvements:	• 100% local port responsibility
Maintenance:	• 75/25 (fed/local) cost sharing on existing channels; 50/50 on channels improved after enactment of legislation; cap on local share of costs of maintenance dredging
Funding Mechanism:	• no federal outlay for improvements; federal appropriations for maintenance dredging with local share reimbursed
Streamlining:	• maximum: only permits needed, no Congressional authorization
User Fees:	• local port option

Hatfield (S. 2217)

Improvements:	• 90% federal (trust fund) for channels to 45 ft. depth, 10% local; 100% local responsibility for depths beyond 45 ft.
Maintenance:	• 100% federal for channels to the depth of 45 ft.; 100% local for depths beyond 45 ft.
Funding Mechanism:	• appropriations for federal port projects from trust fund
Streamlining:	• partial: speeds land and water permits
User Fees:	• uniform & local fees on international and domestic movements

Biaggi (HR 4627)

Improvements:	• 50/50 cost sharing on channels deeper than 45 ft.; 100% federal for channels less than 45 ft.
Maintenance:	• 100% federal for existing channels (1981); 75/25 on incremental maintenance dredging
Funding Mechanism:	• either federal or local party can initiate project with the other reimbursing
Streamlining:	• significant: preconstruction review reduced to 2½ yrs; permit process expedited
User Fees:	• local user fees

Matsui (HR 5897)

Improvements:	• 90% federal (trust fund) for channels to 45 ft. depth, 10% local; 100% local responsibility for projects beyond 45 ft.
Maintenance:	• 100% federal for channels to the depth of 45 ft.; 100% local for depths beyond 45 ft.
Funding Mechanism:	• appropriations for federal portions from trust fund
Streamlining:	• partial: speeds land & water permits
User Fees:	• uniform & local fees on international & domestic vessel movements.

Roe (HR)

- not yet drafted

Major Port Coalition

- *Improvements*: 50/50 cost-sharing for channels deeper than 45 ft.; 100% federal for all others
- *Maintenance*: 100% for all existing (1981) channels; 50/50 cost sharing on incremental maintenance resulting from improvements.
- *Funding Mechanism*: either federal or local party can initiate project funding with the other providing reimbursement; diversion of customs revenues for federal portion
- *Streamlining*: significant; goal of one year for pre-construction procedures; consolidated permitting
- *User Fees*: local port option

Small Port Coalition

- *Improvements*: 100% federal (trust fund) for all but channels deeper than 45 ft. which are 100% local port responsibility
- *Maintenance*: 100% federal (trust fund)
- *Funding Mechanism*: federal appropriations from trust fund
- *Streamlining*: requests expedited procedures in vague terms
- *User Fees*: national uniform fees; revenues go into a national trust fund to serve as funding source as provided above.