US Army Corps
of Engineers
Philadelphia District

Philadelphia District
North Atlantic Division

Delaware River Main Channel Deepening Project

LIMITED REEVALUATION REPORT

Vessel Entering Philadelphia Harbor

Benjamin Franklin Bridge (PA/NJ)

Packer Avenue Terminal (PA)

Beckett Street Terminal (NJ)

February 1998

DELAWARE RIVER MAIN CHANNEL DEEPENING PROJECT (PENNSYLVANIA, NEW JERSEY, AND DELAWARE)

LIMITED REEVALUATION REPORT

U.S. Army Corps of Engineers, Philadelphia District

February 1998

SYLLABUS

The Delaware River Main Stem and Channel Deepening Project, Pennsylvania, New Jersey, and Delaware, was authorized by the Water Resources Development Act of 1992.

In May 1996, the results of the Preconstruction Engineering and Design (PED) Study, were documented in a Design Memorandum(DM). The Design Memorandum was approved by the District, as per guidance contained in CECW-EP Memorandum dated 31 May 1995, Subject: Engineering, Design and Dam Safety Guidance. With the completion of the DM the project design features for the proposed deepening to 45 feet of the Delaware River Main Channel were finalized. The PED study re-affirmed the recommended plan with no significant changes as presented in the approved 1992 Interim Feasibility Report as authorized for construction.

This Limited Reevaluation Report is to obtain approval to initiate construction of deepening the existing Delaware River Federal Navigation Channel (Philadelphia to the Sea Project). This report will serve as the decision document for budgetary purposes and the Project Cooperation Agreement.

The report includes current economics of the project costs and benefits. The report also summarizes results of additional studies that were an outgrowth of the Washington Level Review Center consideration and the Record of Decision for the Final Environmental Impact Statement as part of the Interim Feasibility Report and Environmental Impact Statement. In addition, the project costs sharing is updated as per Water Resources Development Act of 1996, enacted in October 1996.

The plan provides for modifying the existing Delaware River Federal Navigation Channel (Philadelphia to the Sea project) from 40 to 45 feet at mean low water following the existing channel alignment from Delaware Bay to Philadelphia Harbor, Pennsylvania and the Beckett Street Terminal, Camden New Jersey. The plan of improvement will also include appropriate channel bend widenings, partial deepening of the Marcus Hook anchorage area to 45 feet and relocation of and addition to aids to navigation.

Approximately 32 million cubic yards of material would be dredged and placed by hydraulic and hopper dredges in confined upland disposal areas and for beneficial uses in Delaware Bay. In addition, 229,000 cubic yards of rock would be removed in the vicinity of Marcus Hook, Pennsylvania.

The disposal plan calls for placement of 23 million cubic yards of dredged material from the Delaware River portion of the project to existing Federal upland confined sites

and to four new upland sites. The dredged material from the Delaware Bay (about 9 million cubic yards) comprised primarily of sand, will be used for wetland restoration areas and for stockpiling of sand along the beaches in State of Delaware.

The Delaware River Port Authority, the local sponsor for the project, would be required to acquire four new upland disposal sites as part of the local cooperation requirements.

The total cost of the project is $297,231,000. Applying the cost sharing provisions of Public Law 99-662 amended by Water Resources Development Act of 1996, the Federal share is $200,648,500 and the non-Federal share is $96,582,500. Additional associated costs of $26,858,000 were estimated for berth dredging and bulkhead modifications are a non-Federal responsibility. These costs are estimated fully-funded amounts based from October 1996 dollars.

The improved channel will have significant economic influence in allowing more efficient vessel loading, reducing the lightering requirements of crude oil tankers in the lower Delaware Bay, and attracting larger, more efficient container and dry bulk vessels. It is estimated that the deepening will result in annual transportation savings of $40,143,000.

In October 1996 dollars, the average annual project investment costs amount to $28,780,000 and average annual benefits to $40,143,000, producing a benefit to cost ratio of 1.4. Operation and maintenance costs, estimated at $2,679,000 annually, exclusive of berth area dredging, would be borne by the Federal government.

The project remains justified and is consistent with current policies, criteria and guidelines used for evaluation of a Federal construction plan.

Delaware River Main Channel Deepening Project
Limited Reevaluation Report

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LIMITED REEVALUATION REPORT

INTRODUCTION

BACKGROUND

The Delaware River Comprehensive Navigation Study Main Channel Deepening Interim Feasibility Report and Environmental Impact Statement was completed in February 1992. The Division Engineer's Public Notice for that report was issued in February 1992. Thereafter the report was reviewed by the Washington Level Review Center (WLRC). In June 1992, the WLRC concurred with the findings and recommendations of the reporting officers. A Record of Decision (ROD) for the Final Environmental Impact Statement was completed in December 1992. Copies of WLRC concurrence and ROD are included in **APPENDIX A.** The recommended project was authorized for construction by Public Law 102-580, Section 101(6) of the Water Resources Development Act of 1992. A copy of Section 101(6) is included in **APPENDIX A.**

In 1992, the Preconstruction, Engineering, and Design (PED) study was initiated. The objective of this study was to refine the recommended plan, respond to concerns raised by the WLRC review of the 1992 Interim Feasibility Report and to perform additional supplementary environmental analyses as recorded in the December 1992 Record of Decision for the Final Environmental Impact Statement. The Project Management Plan called for preparation of a Design Memorandum (DM) and an appropriate NEPA document.

With the completion of the DM and Supplemental Environmental Impact Statement as part of the PED study, the project design features for the proposed deepening to 45 feet of the Delaware River Main Channel were finalized. Minor refinements were made to the recommended plan as presented in the Interim 1992 Feasibility Report. These refinements did not alter the project features as authorized or the environmental impacts that were presented in the Final Environmental Impact Statement.

In May 1996, the results of the PED study were documented in a DM which was approved by the District, as per guidance contained in CECW-EP Memorandum dated 31 May 1995, Subject: Engineering, Design and Dam Safety Guidance. In addition, a Draft Supplemental Environmental Supplemental Impact Statement was prepared in December 1996 and made available to the public and agencies. The Final Supplemental Environmental Impact Statement was filed with US Environmental Protection Agency in July 1997. The July 1997 Final Supplemental Environmental Statement re-affirmed the environmental impacts that were presented in the 1992 Interim Feasibility Report

and Final Environmental Impact Statement. The Plans and Specifications for the first construction contract were completed and approved by the District in December 1996.

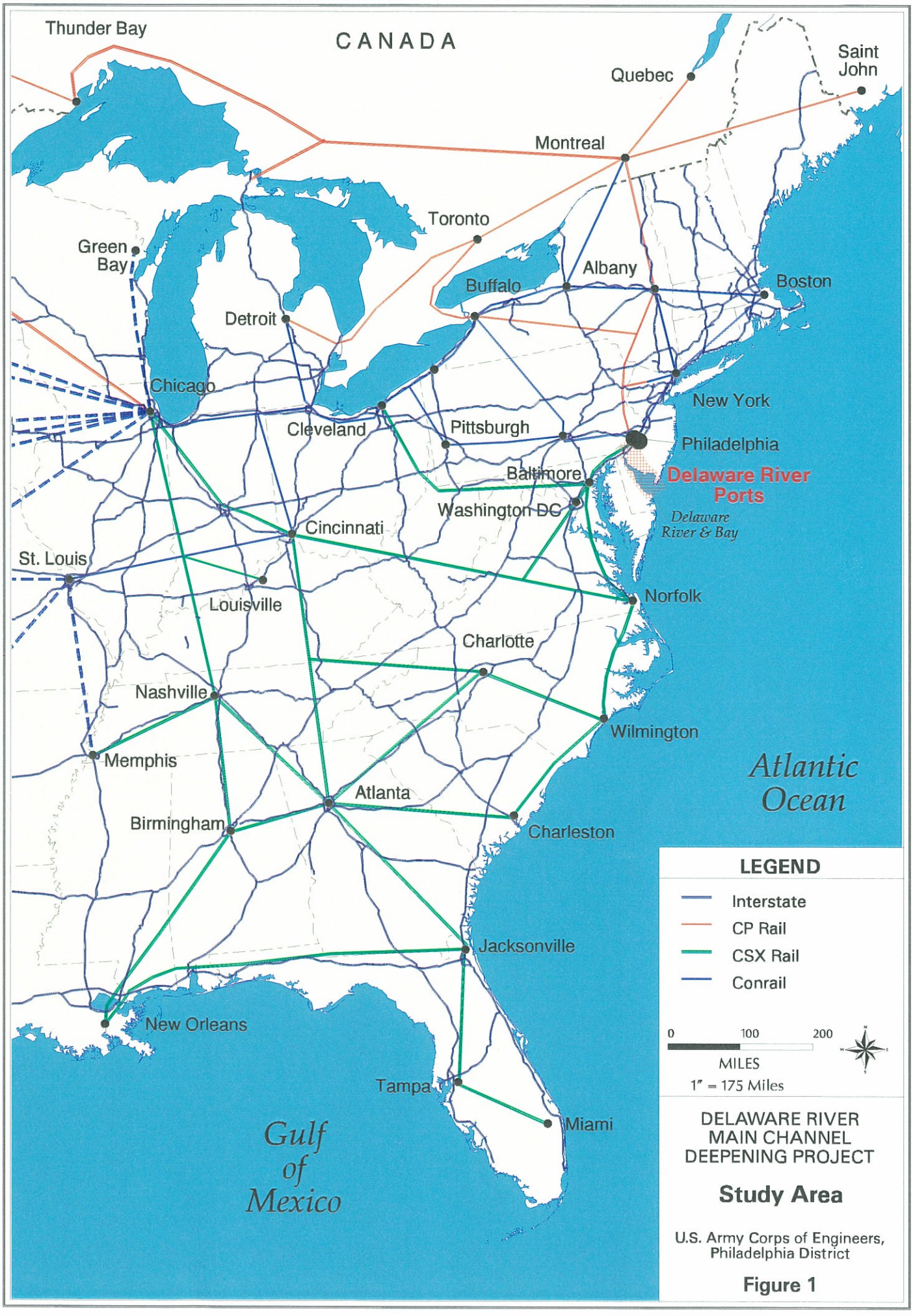
PURPOSE AND SCOPE

Based on recent guidance, the Design Memorandum is an implementation document. The PED study re-affirmed the recommended plan with no significant changes as presented in the approved 1992 Interim Feasibility Report as authorized for construction. The purpose of this Limited Reevaluation Report (LRR) is to obtain approval to initiate construction of deepening the existing Delaware River Federal Navigation Channel (Philadelphia to the Sea Project). The LRR will serve as the decision document for budgetary purposes and the Project Cooperation Agreement.

The report summarizes results of post-authorization studies that were dictated by the WLRC and the ROD. Also, the report includes current economics of the project costs and benefits. In addition, the project cost sharing is updated as per the Water Resources Development Act of 1996, enacted in October 1996.

STUDY AREA

The study area is located along the northeastern portion of the United States. The Delaware River Port System is located in the center of the Eastern industrial corridor of the United States. The port complex is served by a highly efficient rail and highway network that brings some of the greatest centers of commerce within easy reach. The proposed 45 foot project is located within the Delaware River and Bay and the borders of Commonwealth of Pennsylvania, and the States of New Jersey and Delaware. It extends over 100 river miles of the Delaware River and Bay, from Philadelphia, Pennsylvania to the mouth of Delaware Bay **(FIGURE 1)** following the alignment of the existing 40 foot Federal project.


Thunder Bay
CANADA
Quebec
Saint John
Montreal
Toronto
Green Bay
Buffalo
Albany
Boston
Detroit
Chicago
New York
Cleveland
Pittsburgh
Philadelphia
Baltimore
Delaware River Ports
Washington DC
Delaware River & Bay
Cincinnati
St. Louis
Louisville
Norfolk
Charlotte
Nashville
Wilmington
Memphis
Atlanta
Atlantic Ocean
Birmingham
Charleston
Jacksonville
New Orleans
Tampa
Miami
Gulf of Mexico
LEGEND
Interstate
CP Rail
CSX Rail
Conrail
0
100
200
MILES
1" = 175 Miles
DELAWARE RIVER MAIN CHANNEL DEEPENING PROJECT
Study Area
U.S. Army Corps of Engineers, Philadelphia District
Figure 1

DESCRIPTION OF THE PROJECT

RECOMMENDED PROJECT

The project as shown on **FIGURE 2** consists of a navigation channel extending from deep water in the Delaware Bay to Philadelphia Harbor, Pennsylvania and to Beckett Street Terminal, Camden New Jersey, a distance of about 102.5 miles. The plan provides for modifying the existing Delaware River Federal Navigation Channel (Philadelphia to the Sea Project) from 40 to 45 feet below Mean Low Water (MLW) with an allowable dredging overdepth of one foot. The channel side slopes are 3 horizontal to 1 vertical.

The channel width(same as the existing 40 foot project) would range from 400 feet in Philadelphia Harbor to 800 feet from Philadelphia Navy Yard to Bombay Hook and then 1,000 feet in Delaware Bay. The plan includes widening 12 of the 16 existing channel bends as well as provision of a two space anchorage for safety purposes to a depth of 45 feet at Marcus Hook. The bends will be widened to accommodate the handling characteristics of the design vessel operating at the 45 foot depth.

The existing turning basin adjacent to the Naval Shipyard will not be deepened as part of the 45 foot project. The project includes deepening of an existing 40 foot Federal project channel at a 45 foot depth to Beckett Street Terminal. The project also includes the acquisition of four new upland disposal sites (17G, Raccoon Island, 15D, and 15G) and relocation of and addition to aids to navigation.

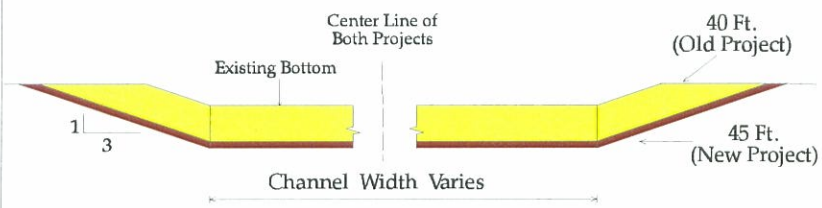
DREDGING QUANTITIES

For the initial deepening, 31,659,000 cubic yards of material would be dredged and placed by hydraulic and hopper dredges in confined upland disposal areas and for beneficial uses in Delaware Bay. In addition, 229,000 cubic yards of rock would be removed in the vicinity of Marcus Hook, Pennsylvania. The required maintenance dredging of the 45 foot channel will increase to 6,007,000 cubic yards per year (cy/yr) from the current 4,888,000 cy/yr for the 40 foot channel for a net increase of 1,119,000 cy/yr.

DISPOSAL PLAN

The initial dredging material (about 23 million cubic yards) from the river portion of the project (Reaches AA-D) will be disposed at eight existing Federal upland sites (National Park, Pedricktown North, Pedricktown South, Penns Neck, Killcohook, Reedy Point North, Reedy Point South and Artificial Island) and to four new upland sites identified

Typical Channel Cross Section



400 ft: Station 19 to 32
Transition: Station 32 to 43
800 ft: Station 43 to 326
Transition: Station 236 to 334
1000 ft: Station 334 to 515

MONTGOMERY COUNTY
BUCKS COUNTY
CHESTER COUNTY
DELAWARE COUNTY
BURLINGTON COUNTY
CAMDEN COUNTY
GLOUCESTER COUNTY
NEW JERSEY
NEW CASTLE COUNTY
SALEM COUNTY
ATLANTIC COUNTY
CUMBERLAND COUNTY
CAPE MAY COUNTY
SUSSEX COUNTY
DELAWARE

Trenton
133
125
120
110
Philadelphia
Schuylkill River
Rancocas Creek
40' Project Limit
45' Project Limit
Camden
Pennsauken
Ben Franklin Bridge
Beckett Street Terminal
Philadelphia Naval Base
Walt Whitman Bridge
A-A
A
BW9
BW12
90
National Park
17C
Commodore Barry Bridge
Marcus Hook Anchorage
Marcus Hook
Chester
BW10
BW11
BW8
Raccoon Island
15D
BW7
Oldmans
75
15G
Wilmington
Pedricktown North
Pedricktown South
Christina River
BW6
Delaware Memorial Bridge
B
C
BW5
200
Killcohook
Penns Neck
Salem River
Chesapeake Bay
Reedy Point North
Chesapeake & Delaware Canal
Reedy Point South
Salem
BW4
Alloway River
C
D
BW3
Artificial Island
BW2
50
300
Cohansey River
Smyma River
D
E
Smyma
Bombay Hook
Leipsic River
Maurice River
Kelly Island
Port Mahon
Dover
400
BW1
25
Egg Island Point
Stone Harbor
Mispillion River
Mispillion Inlet
500
Buoy 10
Slaughter Beach
MS-19
Milford
E
Cape May Point
Cape May / Lewes Ferry
0
L-5
Broadkill Beach
Lewes
Cape Henlopen
DE
NJ
Vineland

0 2 4 6
MILES
1" = 6.5 Miles

LEGEND

- 0 DRBC River Miles
- 100 Channel Stationing
- Bend Widening Location (BW)
- Existing Disposal Areas
- Proposed Upland Disposal Areas
- Proposed Beneficial Use Areas
- Main Channel
- Channel Reaches
- State Boundaries
- County Boundaries
- Water Features
- Ferry

DELAWARE RIVER MAIN CHANNEL DEEPENING PROJECT

Project Plan

U.S. Army Corps of Engineers, Philadelphia District

Figure 2

as 17G, Raccoon Island, 15D and 15G. The four new upland sites will be acquired by the sponsor, the Delaware River Port Authority. Reedy Point North and South disposal areas will only be used for disposal of dredged material from the construction dredging. The maintenance quantities will be placed at seven existing Federal upland sites (National Park, Oldmans, Pedricktown North, Pedricktown South, Penns Neck, Killcohook, and Artificial Island) and at the four new upland sites.

The construction dredged material (about 9 million cubic yards) from Delaware Bay (Reach E) comprised primarily of sand will be used for wetland restoration areas at Egg Island Point, New Jersey and Kelly Island, Delaware and for stockpiling of sand at two submerged areas in the vicinity of Slaughter (MS-19) and Broadkill (L-5) Beaches in the State of Delaware. The material from maintenance dredging will be disposed at an existing approved subaqueous site (Bouy 10).

The sponsor, the Delaware River Port Authority, will provide an equivalent amount of disposal capacity to the Federal Government from the four proposed sites to offset the loss of disposal capacity at the existing Federal sites incurred by the 45 foot deepening project (i.e., construction and subsequent 50-year incremental maintenance).

The management practices used at the existing Federal sites will be similar for the new proposed sites. Dikes will be raised at 10 foot increments and sluices will be replaced as part of a regular maintenance program. The new disposal areas will be initially developed with dikes and sluices. The costs for these features have been incorporated as part of the General Navigation Features. With the addition of four new upland disposal areas, 50 years of disposal capacity will be available for maintenance of the 45 foot project.

REAL ESTATE REQUIREMENTS

The real estate required for the proposed project involves the acquisition of four new upland disposal areas (17G, Raccoon Island, 15D, and 15G). This consists of the fee acquisition of approximately 1,537 acres of privately owned land. The sponsor will need to perform surveys, metes and bounds for these sites. There are no Public Law 91-646 relocations for this project. There is no present or anticipated mineral activity contained within the project area. The sponsor has sufficient experience and the ability to acquire the necessary real estate. The real estate plan is located in **APPENDIX B.**

PROJECT OPERATION

The Philadelphia District, Corps of Engineers would maintain the Federal channel and anchorage in accordance with the project dimensions, providing advance maintenance in high shoaling areas as per existing practice. The Corps of Engineers will be responsible for operation and maintenance of the existing Federal sites, the new upland disposal areas and the wetland restoration sites. Maintenance of navigation aids would continue to be performed by the US Coast Guard. Local service facility berth dredging and maintenance would be accomplished by each facility.

SUMMARY OF POST-AUTHORIZATION STUDIES

Navigation studies were performed to respond to WLRC recommendation on conducting additional studies to reinforce the feasibility study findings dealing with the viability of an asymmetrical channel. Also, additional environmental studies/analyses were performed as documented in the Record of Decision for the Final Environmental Impact Statement dated 17 December 1992. These included: three-dimensional hydrodynamic and salinity modelling of the Delaware Estuary to evaluate potential changes in salinity and circulation patterns and associated salinity impacts on surface and ground water or aquatic life; benthic invertebrate sampling to assess habitat quality at selected beneficial use sites in the Delaware Bay; biological effects based testing to determine the impact of open water disposal on aquatic ecosystems; detailed environmental assessment of selected upland dredged material disposal areas; consultation with both the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, pursuant to Section 7 of the Endangered Species Act; cultural resource investigations in dredging and disposal locations; and review of existing Delaware River oil spill contingency plans.

NAVIGATION STUDIES

The 1992 Interim Feasibility Report recommended full-width deepening of the channel, including the bay portion where the channel is 1,000 feet wide, through the upper bay and river section where the channel is 800 feet wide, up to Philadelphia Harbor where the channel width is 400 to 500 feet wide. The 1992 Interim Feasibility Report included a detailed methodical, step-by-step incremental economic optimization of channel depth (40 to 46 feet in one foot increments), channel width (full, minimum, asymmetrical, or more efficient asymmetric), outbound lane, and channel length. The analysis was structured incrementally and optimized the National Economic Development (NED) plan at a 45 foot channel depth with a full width channel. All combination of asymmetric channels and channel depths in one-foot increments were

investigated and presented in the 1992 Interim Feasibility Report. It was indicated by the WLRC that the NED plan (i.e., 45 foot channel depth with a full width channel) was correctly identified. The 1992 Interim Feasibility Report was approved, with a requirement by CECW that additional engineering criteria analysis be conducted by the performance of the Corps of Engineers Waterways Experiment Station (WES) ship simulation studies during PED study to confirm travel time delays between the asymmetric channel options considered in the plan formulation. The required additional analysis entailed studies of channel widths, vessel speed, and vessel maneuverability to verify the selection of the NED plan. Consequently, the objective of the modelling efforts was to merely re-affirm through simulation modelling that travel time differences do exist between the NED plan and asymmetric channel options.

It was readily recognized that any plan which reduced the width of the channel to be deepened would result in a corresponding decrease in project construction cost. However, local navigation interests, in particular, the Pilots' Association, expressed strong concern that any reduction in width of the deepened channel would lead to unacceptable compromises in vessel handling, safety, and transit time to destination facilities in the Wilmington to Philadelphia reach.

To meet the objective of the modelling efforts, a scope of work was prepared by WES and subsequently reviewed and approved by headquarters. The scope of work specified that depths of only 40 feet (existing) and 45 feet (recommended) would be analyzed, along with deepened channel width alternatives of 400 feet, 600 feet, and full-width (800 feet). The navigation studies were conducted by the Corps of Engineers Waterways Experiment Station, with coordination and input from the Philadelphia District and the Pilot's Association for the Bay and River Delaware. Also, during the modelling efforts, a meeting was held with Virginia Pilots to obtain input on modelling asymmetric channel options.

In order to evaluate the feasibility of asymmetric channel deepening for the project, the WES investigators recommended a physical model testing program. It was determined that computer-based ship simulations were not appropriate to evaluate the asymmetric channel alternatives. This was due primarily to limitations of the numerical simulators to accurately reproduce bank effects associated with transit in an asymmetric channel.

The physical model tests were performed by operating 1:100 scale ship models in a straight 800-foot wide (model scale) sand channel at WES. A three-dimensional video tracking system was used to track two points on each ship and to follow the movements of the rudder relative to the ship's axis. Four configurations of the navigation channel were tested: the existing channel at 40-feet deep; an asymmetric channel 45-feet deep

over half of the 800-foot width and 40-feet over the remaining half; an asymmetric channel 45-feet deep over 600-foot of the 800-foot wide channel, with the balance at 40-feet; and a full-width deepened 800-foot wide 45-feet channel. The model ships used in the testing program approximated the size of vessels presently using the Delaware River.

Physical model tests were performed for two basic scenarios. The first scenario represented vessels meeting and passing, in which the vessels are headed in opposite directions and pass port-to-port. Meeting tests were conducted in two manners. In the first tests, the ships (operated by remote radio control) were started in the center of the inbound and outbound lanes, respectively, steadied up, and then upon meeting, held steady on course with the minimum amount of rudder possible. In a second set of meeting tests, the ships were started in the center of the inbound and outbound lanes, steadied up, and then when the ships were within one ship length of each other, the rudder was centered and the ships were allowed to continue with no rudder control. In these tests, upon meeting the ship forces and moments would not be controlled with rudder responses and the course of the ship would primarily be determined by these forces and moments.

The second scenario represented overtaking conditions in which both vessels travel in the same direction, with the smaller ship overtaken by the larger ship. This situation occurs when slower moving tug/barge units or ships are overtaken by large ships moving at higher speeds. Delaware River pilots report that this operation normally is performed in or before entering the 1,000-foot channel in the Delaware Bay, when it is necessary for inbound vessels to be in proper order for arriving at their destinations. However, on occasion it may be necessary for a large vessel to overtake another in the 800-foot channel. This maneuver is attempted almost exclusively in areas of the river where an anchorage is adjacent to the channel. Tug/barge units normally move at about 7 knots versus 10 to 12 knots typical of inbound ships, and overtaking of tug/barge units by deeply laden ships is not unusual. In addition, tug/barge units are not piloted by members of the Delaware Pilots' Association and coordination in ordering these inbound vessels is not as effective as with the ships. Even if the tug/barge unit were not loaded deep enough to require it to stay in the deep part of an asymmetric channel, the rules-of-the-road require it to stay out of the outbound lane (i.e., it must keep to starboard). Since an overtaking maneuver requires a significant amount of time and occurs over a long distance, it is not considered an acceptable practice to move the the slower-moving inbound vessel to port into the outbound lane. Based on 1995 Water Commerce Statistics Center data, the project area recorded a total of 77,313 trips (38,666 inbound and 38,647 outbound). The average usage per day of the project is 212 movements, and a large number of overtakings and meetings occur on a daily basis.

RESULTS. Analysis of the meeting test results indicated that there was no significant difference in vessel handling between the full-width channel and asymmetric channel in the free-running tests, with the ships moving in different positions in the asymmetric channel. However, ships with a draft greater that 39 feet must move in the deepened part of the asymmetric channel. Therefore, they will no longer be able to balance the bank effects on both sides of the ship during the majority of the transit when they are not meeting or overtaking another ship. In the asymmetric channel they will have to constantly steer against the starboard bank. The model tests indicate that in order to move straight down the center of the right 400 foot inbound lane, substantial rudder must be applied. Technicians operating the models indicated that 15-20 degrees was required to hold the model ships on course. Use of this amount of rudder would reduce the efficiency of the propeller thrust and speed would be lost.

The Delaware River Pilots who participated in the physical model testing concluded that there were discernible differences in the handling of the vessels in the meeting situation for the asymmetric channel. They observed a greater amount of bank effect in the asymmetric channel tests than in the full width channel tests. As a result, they concluded that in order to maintain a safe navigation situation, it would be necessary to reduce vessel speeds prior to meeting in the asymmetric channel. The Delaware pilots generally regard a vessel as out of control when the amount of rudder and thrust required significantly exceed those normally used for a given situation. If a large increase in rudder or power is needed to maintain control of the ship, then the vessel is not considered to be in control, even though the vessel may not experience grounding or a collision.

The overtaking operations of two deeply loaded inbound ships were significantly impacted by the asymmetric channel. The effect of the deepened channel was to limit the separation distance between the two ships during overtaking. When the ships are closer together, the interactions between them are greatly increased, making control of the ships more difficult. There is also less room for the ship movements that occur when the ships are interacting and the possibility of grounding or collision increases.

Although the physical model testing program was not able to detect the level of speed reduction and subsequent increases in travel time associated with transit of the asymmetric channel alternatives, it was demonstrated that when a loaded inbound ship is restricted to the deeper starboard lane due to the shallower portion of the channel on the port side, the ship must maintain a significant amount of rudder to travel on course. This is due to the stronger forces from the near bank. As a result, there will be a loss in propulsion efficiency and a speed loss due to the constant application of rudder. The

closer the ship is able to stay to the center of the channel, the less rudder is required to keep a steady course and, hence, the less the reduction in speed.

The physical model tests also revealed that an asymmetric navigation channel will not be acceptable with respect to the safety of performing overtaking maneuvers. When the traffic is such that overtaking and passing are required anywhere in the navigation channel, then any reduction of the navigation channel to less than 800 feet results in unsafe overtaking conditions. This would be particularly true for inbound ships loaded to drafts deeper than 39 feet. Inability to perform the overtaking maneuver could result in the overtaking vessel "losing the tide" and delaying its arrival at its destination until the next tidal cycle.

Since the WES model was inconclusive in its ability to quantify exact speed reductions, the decision remained with the local pilots as detailed, employed, and approved by Washington Level Review Center review of the 1992 Interim Feasibility Report. As a result, the validity of the Delaware Bay and River Pilots information used in the 1992 Feasibility Report was verified and the NED selection process fully supported. Further support to this conclusion is provided by IWR Report 91-R-13, NED Procedures Manual-Deep Draft Navigation: "the amount of risk acceptance at any one port is effectively determined by ship pilots, since there is no law or regulation that defines vessel safety as such or minimum safe clearances. The amount of risk acceptance or risk avoidance varies from port-to-port because physical conditions differ and because different pilots are involved".

HYDRODYNAMIC AND SALINITY MODELING

The spatial and temporal distribution of salinity within the Delaware Estuary has been an important water quality issue for over 60 years. Although salt occurs naturally in Atlantic Ocean water at the bay mouth and in very low concentrations in upland discharges, the estuary system is susceptible to adverse impacts from man-made changes in the factors which affect salt distribution. There are two basic categories of human impacts which can affect salt distribution in the estuary. The first category includes impacts on the supply of freshwater to the system, such as: reservoir construction and management; out of basin transfers of water; and in-basin consumptive uses of water. The second category includes factors which may affect the interaction of freshwater inflows with ocean derived saltwater within the estuary, such as changes to the three dimensional geometry of the estuary. The proposed deepening of the Delaware River navigation channel falls within the second category.

In the region from Trenton, New Jersey downstream to Wilmington, Delaware the Delaware River water is utilized for a number of industrial and municipal water supply purposes. The City of Philadelphia obtains its municipal water supply by withdrawal of river water at Torresdale. Many industrial users directly obtain both process and cooling water from the river in the Trenton to Wilmington reach. Above River Mile (RM) 98, the river provides a significant fraction of the recharge to aquifers which supply groundwater in the Camden Metropolitan area in New Jersey. This heavily urbanized area of the river is thus sensitive to increases in salinity which might adversely affect industrial and municipal water uses, particularly under drought conditions. There are also zones in the estuary where living resources, both plant and animal, may be sensitive to salinity changes induced by the proposed deepening.

The principal goal of the modeling effort was to identify and quantify any impacts of the proposed 5 foot channel deepening on spatial and temporal salinity distribution. It was considered necessary that a number of modeling scenarios be developed to represent a range of boundary and forcing conditions of potential importance to both human and non-human resources of the Delaware Estuary.

The Philadelphia District coordinated with the Corps of Engineers Waterways Experiment Station to discuss options for model development and application to meet the specific needs of the PED study. Based on previous work at WES for the Philadelphia District and others, the decision was made to apply the 3 dimensional numerical hydrodynamic/salinity model, CH3D-WES (Curvilinear Hydrodynamics in Three Dimensions), in this study.

CH3D-WES simulates the most important physical factors affecting circulation and salinity within the modeled domain. As its name implies, CH3D-WES makes computations on a curvilinear, or boundary fitted, planform grid. Physical processes affecting baywide hydrodynamics that are modeled include tides, wind, density effects (salinity and temperature), freshwater inflows, turbulence, and the effect of the earth's rotation. The representation of vertical turbulence is crucial to a successful simulation of stratification in the bay. The boundary fitted coordinates feature of the model provides enhancement to fit the scale of the navigation channel and irregular shoreline of the bay and permits adoption of an accurate and economical grid schematization. The vertical dimension is Cartesian which allows for modeling stratification on relatively coarse horizontal grids.

Several data sets were selected for application in the three-dimensional model to address the impact of channel deepening on salinity distribution and subtidal circulation in the Delaware Estuary. The selection of these sets of conditions was based on coordination

accomplished through the interagency workshops meetings that were held on a regular basis. The model simulated salinity changes under a variety of low-flow or drought conditions of the 1960s as well as high flow periods. Simulations were run for both the existing 40 foot navigation channel, and then with the proposed 45 foot channel in place.

RESULTS. A fundamental conclusion from the model runs is that deepening the existing navigation channel from 40 to 45 feet will result in salinity (chlorinity) increases in the Philadelphia area during a recurrence of the drought of record. However, the increases will not have an adverse impact on water supply. The present Delaware River Basin Commission (DRBC) drought management plan, including reservoir storage added since the drought of record, prevents the intrusion of ocean salinity into the Philadelphia area in excess of standards.

Historic groundwater withdrawals from the Potomac-Raritan-Magothy (PRM) aquifer in Camden County, New Jersey, have depressed the potentiometric surface of the aquifer system to a level as much as 100 feet below sea level in the central portion of the county. This has led to a condition in which a portion of the total recharge to the PRM aquifer system in Camden County is derived from Delaware River water. The DRBC's drought management standard for RM 98 chlorinity is a maximum 30-day average of 180 parts per million (ppm). This standard was adopted in order to limit the recharge by river water with elevated chlorinity into the PRM aquifers exposed at the bed of the Delaware River above RM 98 under low flow conditions.

Investigations of Camden County groundwater resources by the US Geological Survey have indicated that the rate of aquifer recharge from the river is principally controlled by groundwater withdrawals. Deepening of the Delaware River navigation project will have a negligible effect on the recharge characteristics of the aquifer. Although the proposed channel deepening is predicted by the salinity model to increase RM 98 chlorinity under an assumed recurrence of the drought of record, the resulting 30-day average chlorinity will not exceed the DRBC standard of 180 ppm. Transient increases in chlorinity of the river water recharging the aquifer under drought conditions will cause no loss of potability in the groundwater resource. Thus, it is concluded that the proposed channel deepening will not have a significant adverse impact on groundwater resources of Camden County, New Jersey.

Since the deepening project will not significantly change the Delaware River's normal salinity distribution, adverse impacts to plant and animal life should also be negligible. Freshwater aquatic vegetation will experience temporary losses during a drought, but should recover afterwards as was the case in 1964. During normal to high flow periods

with the deepened channel, oyster bed areas in the lower bay will experience increases in salinity due to steeper longitudinal salinity gradients which accompany high flow conditions. The impact of those increases on oyster production is viewed as negligible. Changes in the subtidal circulation over the oyster beds due to channel deepening will also be minimal, e.g., less than one centimeter per second.

BENTHIC INVERTEBRATE SAMPLING

Benthic invertebrates sampling was conducted at the selected beneficial use sites over a two year period. The sampling considered four attributes: (1) physical characteristics, (2) presence of "unique" species, i.e., species which were not collected at other sites or in the surrounding Delaware Bay, (3) presence of commercially or recreationally important species, and (4) condition of the benthic macroinvertebrate community.

The benthic communities of Kelly Island and Egg Island Point wetland restoration sites would be eliminated and the bottom would be changed from subtidal to intertidal wetland. These sites were among those having the poorest quality benthic communities. They were characterized by a considerably less diverse assemblage than the background benthic communities in Delaware Bay. Kelly Island site was characterized by a different species composition between the two years it was sampled, which is a further indication of its unstable benthic community.

The sand stockpiles sites (i.e., vicinity of Slaughter Beach (MS-19) and Broadkill Beach (L-5)) would be covered with sand, changing the average depth from -8.0 feet MLW to about -3.0 feet MLW. The present substrate of L-5 has significantly more silt/clay content than MS-19 (51% versus 16%). A change to a total sand substrate at L-5 will have a greater likelihood to change the benthic community that is present than at MS-19 which presently has essentially a sand substrate. It is likely that both benthic communities will change since they are both less than 6 feet and will be subjected to greater exposure to physical stress caused by waves and surface currents. These effects may be most significant during storms when significant amounts of energy can be transferred from the surface to the sediments. L-5 is similar in quality to Kelly Island and Egg Island Point wetland restoration sites. Site MS-19 had one of the highest quality benthic communities compared to the other beneficial use sites, and would be expected to sustain greater impacts due to the lower recovery potential of its benthic macroinvertebrate community. Species richness was highest among the other sites at MS-19. It contained a higher abundance of equilibrium species, which are typically indicative of a stable, diverse, mature community, than the background benthic communities of the Delaware Bay. Site MS-19 also contained the highest frequencies of individuals and the greatest number of species with body length greater than 2

centimeters, again indicative of a stable, mature assemblage, as well as infaunal species having commercial/recreational value.

Although impacts will occur to the local populations of benthic resources, no significant differences were found between any candidate sites and the background conditions of the Delaware Bay that would preclude the use of the selected beneficial sites. Therefore, no significant impact will occur to the diversity of benthic resources in Delaware Bay due to the use of any of these sites as either wetland restorations or sand stockpiles.

BIOLOGICAL EFFECTS BASED TESTING

Bioassay and bioaccumulation tests have been run to directly test the toxic effects of Delaware River channel sediments on aquatic organisms. The water column and whole sediment bioassays exposed living organisms to sediments, to evaluate any differences in mortality between Delaware River channel sediments and clean laboratory sediments used as a control. Early life stages of fish, crustaceans, mollusks, zooplankton and polychaete worms were tested. Young organisms are more sensitive than adults to the effects of sediment contamination, and are considered to be better indicators of problems.

All water column and whole sediment bioassays resulted in 100 percent survival of all test species. The results of the water column bioassays suggest that sediment disturbance, and associated water column turbidity, at the point of dredging and at dredged material disposal locations would not result in mortality of aquatic organisms in the vicinity. Likewise, the results of the whole sediment bioassays suggest that aquatic organisms that colonize sediment placed for beneficial uses in Delaware Bay would also be unaffected by sediment contaminants.

With regard to bioaccumulation, there was no evidence that contaminants accumulated in clam tissue (Mercenaria mercenaria) exposed to Delaware Bay sediment at greater concentrations than clam tissue exposed to clean laboratory sediment. All of the tissue residues were representative of what one would expect in organisms exposed to uncontaminated material. With regard to bioaccumulation and the polychaete Nereis virens, there were no statistical differences between contaminants in worms exposed to channel sediments and worms exposed to reference sediments, with the exception of the heavy metal arsenic. The mean arsenic concentration in worms exposed to one channel sediment sample (0.700 ppm) was statistically higher than concentrations in worms exposed to reference sediment samples (0.360 and 0.460 ppm). The measured tissue concentration of arsenic in worms exposed to the channel sediment did not appear to be deleterious. No more mortality was observed in the channel sediment test worms than

in worms exposed to other sediments. Furthermore, a mean tissue concentration of arsenic in worms exposed to the control sediment (0.680 ppm), which was obtained in Maine where the worms were collected, was virtually identical to that measured for the channel sediment worms (0.700 ppm). Both of these values are well below the range of acceptable background tissue arsenic concentrations for test organisms from East Coast sites, which is reported to be 1.5 to 3.9 ppm in the USEPA Guidance Manual for Bedded Sediment Bioaccumulation Tests (EPA-600-R-93-183). Overall, test results suggest that open water placement of Bay sediment is acceptable with regard to bioaccumulation concerns.

DETAILED ENVIRONMENTAL ASSESSMENT OF UPLAND DISPOSAL AREAS

Detailed environmental assessments were performed for each of the new upland dredged material confined upland disposal sites (17G, Raccoon Island, 15D, and 15G). These assessments included wetland delineations, vegetation surveys, and wildlife habitat evaluations.

Three of the proposed dredged material disposal sites (17G, 15D, and 15G) are mostly used for the production of row crops, primarily corn and soybeans. The fourth site, Raccoon Island, is vegetated almost entirely with common reed (Phragmites australis), with some small patches of woodlands. Most of the wildlife habitat is rated as low to moderate quality.

Approximately 396 acres of jurisdictional wetlands (i.e., wetlands that are regulated under Federal and/or state law) will be impacted on the four sites. All of these wetlands are the result of past human activities. The most dominant type of manmade, jurisdictional wetland inside the four proposed disposal sites is about 355 acres of Phragmites australis, or common reed, comprising approximately 90 per cent of the wetlands present on the four sites. Common reed is generally a poor quality wetland in terms of wildlife habitat; however, it can improve water quality by removing sediment from runoff water.

Since all impacts to wetlands/habitat can not be avoided, the District coordinated with the New Jersey Department of Environmental Protection (NJDEP) and the US Fish and Wildlife Service (FWS) to find ways to manage these sites to restore environmental values that will be impacted. Both agencies recommended that each site be divided into cells, so that a portion could be managed as wetlands between the disposal of dredged material. The Philadelphia District tasked the research scientists at the Corps of Engineers Waterways Experiment Station to develop a management plan for each of the proposed upland disposal areas that would maximize their use as wetlands and wildlife

habitat, while maintaining their use for the disposal of dredged material. This plan was then coordinated with the NJDEP and the FWS, as well as the Environmental Protection Agency for their concurrence.

The plan results in a net increase of approximately 220 acres of wetlands. All of the wetlands that will occur in the disposal areas will be mostly palustrine emergent, non-tidal fresh marsh. The quality of these wetlands is expected to be better than the predominantly common reed dominated wetlands that presently occur. These wetlands will be less likely to be dominated by common reed because of the water level manipulations that will be possible using the weirs that will be present at strategic locations.

ENDANGERED SPECIES

In compliance with Section 7 (c) of the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.), biological assessments were prepared that evaluated the potential effects of the Delaware River Main Channel Deepening Project on species listed by either the US Fish and Wildlife Service (October 1995) or the National Marine Fisheries Service (September 1995). These assessments were prepared in accordance with the Joint Regulations on Endangered Species (50 CFR Section 402.12). Both of the biological assessments concluded that there will be no impact that would jeopardize the continued existence of any of the listed species, or their critical habitat, as a result of this project.

In a letter dated 18 January 1996, the U S Fish and Wildlife Service concurred with the District's determination that the proposed project is not likely to adversely affect Federally listed species under the Service's jurisdiction. This is based on implementation of the "reasonable and prudent measures to minimize impacts".

In a letter dated 26 November 1996, the National Marine Fisheries Service stated that dredging projects within the Philadelphia District are not likely to jeopardize the continued existence of any threatened or endangered species under their jurisdiction.

CULTURAL RESOURCES

In order to comply with the National Historic Preservation Act of 1966, as amended, the Philadelphia District has worked closely with the Pennsylvania, New Jersey and Delaware State Historic Preservation Offices (SHPO) to coordinate extensive cultural resources investigations in the project area. This work involved a synthesis of previous investigations, documentary research, a remote sensing survey, underwater investigations

and a shoreline survey. Project areas include bend widening, channel deepening, channel side-slope, wetland restoration and submerged sand stockpile areas. Cultural resources investigations were not conducted in the upland disposal areas and the Marcus Hook Anchorage due to previous dredging and disposal activities at these locations.

Based on the results of cultural resources investigations, the Philadelphia District finds that the proposed project will have "No Effect" on significant cultural resources. A report of the final cultural resources investigation and the District's finding of "No Effect" was submitted to the Pennsylvania, New Jersey and Delaware SHPO's. No further cultural resource investigations are anticipated for this project. Section 106 coordination and review is continuing and will be concluded prior to any project construction activity.

OIL SPILL CONTINGENCY PLANNING

Although the channel deepening project will enable oil tankers to bring larger quantities of oil directly to the oil refineries, this will be done more safely than it is under present conditions. Under present conditions, large oil tankers with full cargos need to transfer a portion of their cargos to smaller barges in the lower, deeper portion of Delaware Bay at Big Stone Beach Anchorage so that they can negotiate the 40 foot channel upriver. This process is called "lightering", and it is in this operation that there is a greater possibility for oil being spilled. With the new, deepened channel, lightering will be reduced by 40 percent for benefitting facilities. In addition, 12 of the 16 existing channel bends will be widened to enhance the safety of the Delaware River channel. In general, the Delaware Main Shipping Channel is safe. Despite its length, the volume of traffic and the number of turns required, there are few casualties and few oil spills occurring in the waterway. The high degree of skill and training by pilots, navigation aids built and maintained by the US Coast Guard, and an overall sense of cooperation amongst various waterway interests contribute to the navigation safety of the Delaware River. Based on historical spill data, the existing oil spill contingency plan for the Philadelphia port appears adequate to handle the vast majority (over 99 percent) of oil spills that could potentially occur in the area. From interviews with experts knowledgeable about the Delaware shipping channel, the channel deepening project, with its bend widenings, will continue the record of safety in the Delaware River that has been achieved by the local waterway users and the present oil spill plan appears to meet the future oil spill response needs of the port community. According to the US Environmental Protection Agency, the oil spill response network established by the US Coast Guard is considered to be as adequately prepared for oil spill response as any in the Nation.

COMPLIANCE WITH NEPA

The evaluation of environmental impacts associated with the proposed project included preparation of an Environmental Impact Statement as part of the Interim Feasibility Report dated February 1992 and coordination of this document with appropriate Federal, State and local agencies, as well as interested members of the public.

A Section 404(b)(1) evaluation was prepared as part of the 1992 Environmental Impact Statement. This evaluation concluded that the proposed action would not result in any significant environmental impacts relative to the areas of concern under Section 404 of the Clean Water Act. An exemption was granted under Section 404(r) when the project was authorized by Congress in October 1992, under the Water Resources Development Act of 1992.

The Record of Decision for the Final Environmental Impact Statement (FEIS) dated 17 December 1992, documented supplemental environmental analyses to be conducted during the Preconstruction, Engineering and Design phase of project development. The purpose of the additional studies was to re-affirm conclusions reached on some items during the Feasibility Study investigation. The need for these additional analyses was based on the comments received during the public coordination of the FEIS. As part of the PED study, a number of additional environmental studies were performed. The results of these studies have been summarized in this report.

In addition, a Draft Supplemental Environmental Impact Statement, prepared in December 1996, documented in extensive detail the results of additional environmental studies and associated impacts. This document was circulated for resource agency review and comment. Responses to comments have been prepared and included as part of the Final Supplemental Environmental Impact Statement. The additional environmental data that was collected and subsequent analyses re-affirmed the environmental impacts, as documented in the 1992 Final Environmental Impact Statement. The Final Supplemental Environmental Impact Statement was filed with US Environmental Protection Agency in July 1997. A Record of Decision for the FSEIS is being prepared to complete the NEPA process.

BENEFITS

The estimation of benefits was conducted following the guidelines and procedures established in ER 1105-2-100, Chapter 6, Section VII, NED Benefit Evaluation Procedures: Transportation (Deep Draft Navigation), and the National Economic

Development Procedures Manual: Deep Draft Navigation.

Benefits will result from the decrease in the cost per ton for shipping commodities into or out of the Delaware River Port System. A deeper channel depth will allow some current vessels to carry more cargo as well as allow a fleet shift to larger vessels, thus more efficiently apportioning operating costs over a greater amount of tonnage. Other vessels, such as large crude oil vessels that currently lighter in the naturally deep water of the lower Delaware Bay, will continue to carry equivalent tonnage but will also be able to operate more efficiently with a deepened channel. No induced tonnage from the project improvement is projected.

The estimation of benefits involved combining the transportation costs per ton by channel depth estimated for each pertinent vessel class by trade route by commodity with the annualized level of commodity projections. Benefits have been estimated for imported crude oil, exported scrap, imported iron ore, imported coal, and container movements. A detailed account of the benefit analysis is included in **APPENDIX C.**

The economic analysis estimated benefits that would result from the deepening of the Delaware River Main Channel from its current authorized and maintained project depth of 40 feet MLW to the recommended depth of 45 feet MLW. A comparison of project average annual benefits (annualized transportation savings) by commodity at October 1991 (authorized) and October 1996 Price Levels is displayed in **TABLE 1.**

COMPARISON OF BENEFITS. In total, there has been a narrow reduction in benefits compared to the 1992 Interim Feasibility Report. Crude oil benefits have dropped by $1,338,000, or 4%, because an increase in tonnage has been more than offset by the negative impact of transportation savings of a recent decrease in the cost per barrel to lighter in the lower Delaware Bay. Iron ore benefits have increased by $192,000, or 47.3%, because of increased tonnage. Coal import benefits, a small category, remained stable because the contract for the annual level of delivered tonnage has remained constant. Scrap benefits have dropped by $2,560,000, or 52.1%, because of a very large dropoff in tonnage to the benefitting destination of Turkey. Container benefits have increased by $1,651,000, or 57%, because of increased tonnage and additional trade routes benefitting from Post-Panamax vessels. Coal exports since the completion of the 1992 Feasibility Report have been moved by Conrail from Philadelphia, Pennsylvania to Baltimore, Maryland. Consequently, this benefit category has been deleted. Benefits during construction were not computed.

TABLE 1
COMPARISON OF AVERAGE ANNUAL BENEFITS ($000's)

Commodity	Benefits Authorized (1)	Benefits (2)
Crude Oil	$33,8200	$32,482
Scrap	$4,917	$2,357
Iron Ore	$406	$598
Coal Imports	$160	$160
Coal Exports	$311	0
Containers	$2,895	$4,546
During Construction	$195	0
TOTAL	**$42,889**	**$40,143**

(1) October 1991 Price Level, with a discount rate of 8-1/2%
(2) October 1996 Price Level, with a discount rate of 7-3/8%

COSTS

Due to the amount of material to be dredged (33 million cubic yards), disposal area capacity considerations and locations, and the availability of suitable dredges to accomplish the work, it is planned to construct the project in four years.

Initial project costs reflect October 1996 Price Level (for comparison to project benefits). The fully-funded project cost (Baseline Estimate) in October 1996 Price Levels, escalated to the mid-point of construction is shown in **TABLE 2.** MCACES cost estimate was prepared. Due to the voluminous nature of the cost estimate, the MCACES estimate has been retained in the District files.

A comparison of fully funded project costs for the recommended project to mid-point of construction at the October 1992 (authorized) and October 1996 Price Levels is displayed in **TABLE 3.** The decrease in project cost is primarily attributed to the reduction of dredging quantities (i.e., reduction of overdepth from 2 to 1 foot and

widening of bends from 16 to 12), development of more efficient manner to dispose the dredge material (i.e., use Federal and proposed new upland disposal sites for initial and subsequent maintenance dredging) and applying a less costly method for rock excavation.

TABLE 2
PROJECT BASELINE COST ESTIMATE
(October 1996 Base/Price Level) ($000's)

ACCOUNT	ITEM	October 1996 Price Level	Fully Funded*
	FEDERAL PROJECT		
01	Lands, Easements-Rights of Way	$18,598	$20,142
02	Relocations	0	0
12	Navigation, Ports and Harbors	$224,460	$243,090
12a	Navigation Aids	$946	$1,140
18	Cultural Mitigation	0	0
30	Engineering and Design	$7,681	$8,687
	Preconstruction Planning and Design (PED Study)	$10,000	$10,000
31	Construction Management	$12,531	$14,172
	FEDERAL PROJECT COST	$274,216	$297,231
	ASSOCIATED COST	$22,079	$26,858
	TOTAL PROJECT COST	**$296,295**	**$324,089**

* Escalated to mid-point of (four year) construction period

TABLE 3
CONSTRUCTION PROJECT COST COMPARISON*
(Fully Funded Dollars) ($000's)

ACCOUNT	ITEM	AUTHORIZED Oct. 1992 Base	Oct. 1996 Base
	FEDERAL PROJECT		
01	Lands, Easements-Rights of Way	$26,930	$20,142
02	Relocations	$4,530	0
12	Navigation, Ports and Harbors	$324,573	$243,090
12a	Navigation Aids	$1,300	$1,140
18	Cultural Mitigation	$662	0
30	Engineering and Design	$28,434	$8,687
	Preconstruction Planning and Design (PED Study)	$10,000	$10,000
31	Construction Management	$11,461	$14,172
	FEDERAL PROJECT COST	$407,890	$297,231
	ASSOCIATED COST	$33,610	$26,858
	TOTAL PROJECT COST	**$441,500**	**$324,089**

* Escalated to mid-point of (four year) construction period

Costs were prepared for channel maintenance dredging, operation and maintenance of upland disposal areas including dike raisings and operation and maintenance of wetland restoration beneficial use sites during the 50 year life of the 45 foot project. The incremental maintenance costs for the 45 foot channel deepening project is estimated at $2,679,000 annually.

BENEFIT TO COST RATIO

TABLE 4 presents the cost annualization and economic analysis at a 7-3/8% discount rate and October 1996 Price Level. The Benefit-Cost Ratio is equal to 1.4, and net

benefits are equal to $11,363,000. Interest during construction was calculated using a schedule defining costs, by individual year over the total construction period, broken out by individual cost category. The Single Payment Compound Amount Factor was applied to bring costs for each individual year forward to the project base year in order to place costs on an equal basis with the annualized project benefits.

TABLE 4
ANNUALIZATION OF PROJECT COST
(BENEFIT-COST SUMMARY)
October 1996 Price Level- Discount Rate 7-3/8%

Construction Year	Description	Cost*	Present Worth Factor	Present Worth Cost
1	Project Cost	$71,262,000	1.282806	$91,415,350
2	Project Cost	$69,894,000	1.194697	$83,502,185
3	Project Cost	$87,630,000	1.112640	$97,500,665
4	Project Cost	$15,886,000	1.036219	$16,461,376
1	Real Estate	$18,598,000	1.000000	$18,598,000
4	Navigation Aids	$946,000	1.036219	$980,263
4	Associated Costs	$22,079,000	1.000000	$22,079,000
1	PED Costs	$10,000,000	1.329268	$13,292,685
TOTAL ECONOMIC COST				$343,829,524
TOTAL PRESENT WORTH - WITHOUT INTEREST DURING CONSTRUCTION (IDC) CRF (50 Years, 7.375%) -0.075913				$296,295,000
AVERAGE ANNUAL COSTS(ECONOMIC COST & IDC)				$26,101,000
AVERAGE ANNUAL INCREMENTAL OPERATION & MAINTENANCE COSTS				$2,679,000
TOTAL AVERAGE ANNUAL COSTS				$28,780,000
TOTAL AVERAGE ANNUAL BENEFITS				$40,143,000
NET BENEFITS				$11,363,000
BENEFIT TO COST RATIO				1.4

* This cost represents the unesculated project cost.

COST SHARING

Public Law 99-662 (Water Resource Development Act of 1986) as amended by Water Resources Development Act of 1996 has established the basis for the Federal and Non-Federal sharing and responsibilities in the construction, and operation and maintenance of Federal water resources projects.

NON-FEDERAL COST SHARE

The non-Federal interests would pay at the outset of construction, 25 percent of the total costs of construction of General Navigation Features (GNF) which consists of the Federal navigation channel, anchorage area and construction of dredged material disposal areas. In addition, the non-Federal interests shall provide all lands, easements, and rights-of-way, including those lands necessary for dredged or excavated material disposal facilities that the Government determines the non-Federal interests must provide for the construction, operation or maintenance of the GNF and shall perform or ensure the performance of all relocations or deep draft utility relocations that the Government determines to be necessary for the construction, operation or maintenance of the GNF.

The sponsor is also responsible for an additional 10 percent of the cost of GNF, less value of lands, easements, rights-of-way, relocations, and deep draft utility relocations, including those lands necessary for dredged or excavated material facilities which can be repaid with interest over a period not to exceed 30 years.

FEDERAL COST SHARE

The Federal government is responsible for 75 percent of the cost of GNF as well as the cost of navigation aids. Operation and maintenance costs for the Federal navigation channel project, disposal areas and navigation aids are a Federal cost.

Cost sharing arrangements (fully funded dollars) for the 45 foot project as per Public Law 99-662 amended by Water Resources Development Act of 1996 are displayed in **TABLE 5**. The Federal Government is responsible for 75% of the costs for GNF features. The sponsor is responsible for 25% of the costs for GNF and the full costs of lands, easements, rights-of-way and relocations. In addition the sponsor is also responsible for an additional 10% of the GNF less credit for lands, easements, rights-of-way and relocations. Since the 10 percent of the GNF (**$27,594,900**) exceeds the lands, easements, rights-of-way and relocations by **$7,452,900**, the sponsor must pay this difference following construction or over a 30 year period at the Federal discount rate. Associated costs estimated at $26,858,000 are a non-Federal responsibility. The

associated costs are the cost of modifying the benefitting local service facilities. These include costs to dredge the berthing facilities to 45 feet and any structural modifications.

TABLE 5
COST SHARING OF
PROJECT CONSTRUCTION
(Fully Funded Dollars*-October 1996 Base)

GENERAL NAVIGATION FEATURES (GNF) Federal Navigation Channel and Anchorage (Initial Dredging), Construction of Dredged Material Disposal Areas and Preconstruction Engineering Design	$275,949,000(A)
AIDS TO NAVIGATION	$1,140,000
LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATIONS	$20,142,000
TOTAL PROJECT COST	**$297,231,000**
ASSOCIATED COST	$26,858,000

COST APPORTIONMENT			
	FEDERAL	**NON-FEDERAL**	**TOTAL**
GNF	$206,961,750 (75% x A)	$68,987,250 (25% x A)	$275,949,000
Long term repayment	- 27,594,900 (-10% x A)	27,594,900 (+10% xA)	
Navigation aids	1,140,000	N/A	$1,140,000
Lands, easements, rights of way, relocations	N/A	20,142,000	$20,142,000
Credit of lands, easements, rights of way, relocations	+20,142,000	-20,142,000	
TOTAL PROJECT COST	**$200,648,850**	**$96,582,150**	**$297,231,000**

APPENDICES

APPENDIX A

CORRESPONDENCE

Delaware River Main Channel Deepening
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APPENDIX A

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:

09 JUN 1992

CECW-PM (10-1-7a)

SUBJECT: Delaware River Comprehensive Navigation Study, Main Channel Deepening, New Jersey, Pennsylvania, and Delaware

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on the Delaware River comprehensive navigation study, main channel deepening. It is accompanied by the reports of the District and Division Engineers and the Board of Engineers for Rivers and Harbors. These reports are in partial response to a resolution passed by the Committee on Public Works of the U.S. House of Representatives on 2 December 1970 and resolutions dated 1 March 1954 and 20 September 1974 passed by the Committee on Public Works of the United States Senate. In the first resolution, the House committee requested that the Board of Engineers for Rivers and Harbors review reports on the Delaware River navigation system with a view to promoting and encouraging the efficient, economic, and logical development of Delaware River ports. The 1954 resolution requested review of channel dimensions. The 1974 resolution requested that reports be reviewed with a view to developing a regional dredged material disposal plan for the tidal Delaware River, its tidal tributaries, and Delaware Bay. A final report in response to the resolutions will be submitted later.

2. The reporting officers recommend a plan to deepen the existing 40-foot deep navigation channel to 45 feet below mean low water from the mouth of Delaware Bay to the Philadelphia, Pennsylvania, and Camden, New Jersey, harbors. The plan also provides for deepening part of the Marcus Hook anchorage, bend widening, and utility relocations as required. The recommended plan would reduce waterborne transportation costs by minimizing the need for lightloading and lightering of bulk shipments and by encouraging the use of larger and more efficient transport vessels. Based on information available at this time, the recommended plan is the national economic development plan.

3. Based on October 1991 prices, estimated first cost of the plan is $294,931,000, of which $195,767,000 would be Federal and $99,164,000 would be non-Federal. Average annual benefits and costs based on an interest rate of 8-1/2 percent are estimated at

$42,889,000 and $32,231,000, respectively, with a resulting benefit-cost ratio of 1.3.

4. Washington level review indicates that the proposed plan is technically sound, economically justified, and environmentally acceptable. The proposed project complies with applicable Army Corps of Engineers planning procedures and regulations.

5. The Board of Engineers for Rivers and Harbors concurs with the findings and recommendations of the reporting officers. The Board recommends additional post-authorization studies to determine whether asymmetric channel design alternatives could achieve greater net benefits at a lower project cost. The Board also supports additional studies to reinforce findings that there will be no significant adverse impacts on surface water and ground water resources, or on aquatic life in the bay due to deepening of the navigation channel. The Board supports the reporting officers' decision to seek section 404(r) exemption from permitting requirements specified by the Clean Water Act.

6. I concur in the findings, conclusions, and recommendation of the Board.

7. The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program nor the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to Congress as a proposal for authorization and implementation funding. However, prior to transmittal to Congress, the sponsor, the Delaware River Port Authority; the States of New Jersey, Pennsylvania, and Delaware; interested Federal agencies; and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

C. E. EDGAR III
Major General, USA
Acting Chief of Engineers

DELAWARE RIVER MAIN CHANNEL DEEPENING AUTHORIZATION

Water Resources Development Act of 1992-102 Congress - PL 102-580 Section 101(6)

(6) DELAWARE RIVER MAINSTEM AND CHANNEL DEEPENING, DELAWARE, NEW JERSEY, AND PENNSYLVANIA.—The project for navigation, Delaware River Mainstem and Channel Deepening, Delaware, New Jersey, and Pennsylvania: Report of the Chief of Engineers, dated June 29, 1992, at a total cost of $294,931,000, with an estimated Federal cost of $195,767,000 and an estimated non-Federal cost of $99,164,000.

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:

RECORD OF DECISION

DELAWARE RIVER COMPREHENSIVE NAVIGATION STUDY
MAIN CHANNEL DEEPENING PROJECT

We have reviewed the feasibility report and environmental impact statement addressing the navigational needs of the existing Delaware River, Philadelphia to the Sea Federal project. Based on this review and the views of interested agencies and the concerned public, we find the plan recommended by the Chief of Engineers to be economically justified, in accordance with environmental statutes, and in the public interest. The plan of improvement recommended by the Chief of Engineers is the National Economic Development (NED) plan and consists of the following features:

* Deepen the existing 40-foot mean low water (MLW) main channel of the Delaware River navigation channel to a depth of 45 feet MLW following the existing channel alignment and widths, which vary from 1000 feet to 400 feet from deep water in the Delaware Bay to Philadelphia Harbor and the Beckett Street Terminal, Camden, New Jersey;

* Widening of channel bends and deepening a portion of the Marcus Hook Anchorage for safety purposes; and

* Disposal of dredged material in several upland dredged material disposal sites in the riverine portion of the project area and at various beneficial use sites in Delaware Bay.

In addition to a "no action" alternative, various structural and nonstructural alternatives are identified and discussed in the U.S. Army Corps of Engineers report. Nonstructural alternatives included transhipment, use of tides, split deliveries, light loading, pilot regulations, tug assistance, vessel modification and traffic management. None of these were found to accommodate the area's maritime traffic or to provide benefits commensurate with the structural alternatives. Structural alternatives included deepening the entire width of the existing channel and two asymmetric channel designs that would deepen various widths of the inbound lane. The plan that has the greatest net benefits over costs without unacceptable environmental and social impacts was selected and recommended.

Coastal Zone Management Act certifications have been obtained from the Commonwealth of Pennsylvania, and States of New Jersey and Delaware. In order to implement the requirements of Section 404 of the Clean Water Act, an exemption is being sought under Section 404(r) as part of the Congressional authorization process in lieu of obtaining a Section 401 Water Quality Certificate from the States in which the disposal of dredged material is taking place.

Supplementary environmental analyses are planned for the Preconstruction, Engineering and Design phase of project development to verify conclusions reached during feasibility investigations. These analyses include: Three-dimensional hydrodynamic modeling of the Delaware estuary to evaluate potential changes in salinity and circulation patterns; Benthic invertebrate sampling to assess habitat quality at selected beneficial use sites in Delaware Bay; Biological effects based testing to determine the impact of open water disposal on aquatic ecosystems; Detailed environmental assessments of selected upland dredged material disposal sites; Consultation with both the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, pursuant to Section 7 of the Endangered Species Act; Cultural resource investigations in dredging and disposal locations; and Coordination with the regional oil spill response teams to review the adequacy of existing Delaware River spill contingency plans. The results of these analyses will be appropriately coordinated with interested agencies and the concerned public, pursuant to the National Environmental Policy Act.

Technical and economic criteria used in the formulation of alternative plans were those specified in the Water Resources Council's Principles and Guidelines. The U.S. Army Corps of Engineers considered all applicable laws, executive orders, regulations and local governmental plans in evaluating the alternatives. The transportation cost savings gained by construction of the recommended plan outweigh any adverse effects. The report incorporated into the recommended plan all practicable means to avoid or minimize adverse environmental effects.

Stanley G. Genega

STANLEY G. GENEGA
Brigadier General (P), USA
Director of Civil Works

17 Dec 92
DATE

APPENDIX B

REAL ESTATE PLAN

Delaware River Main Channel Deepening
TABLE OF CONTENTS

APPENDIX B

REAL ESTATE PLAN

1. This Real Estate Plan is for the Delaware River Main Channel Deepening Project. The Feasibility Report was issued in February 1992 and subsequently approved in June 1992. The recommended project was authorized for construction by Public Law 102-580, Section 101(6) of the Water Resources Development Act of 1992.

2. The recommended project would modify the existing Federal Delaware River, Philadelphia to the Sea Project which extends from Allegheny Avenue in the City of Philadelphia, Pennsylvania to its confluence with deep water where the Delaware Bay meets the Atlantic Ocean. The recommended plan would allow for modifying the existing Federal channel from Delaware Bay to the Philadelphia Harbor and the Beckett Street Terminal, Camden, New Jersey with a total project length of 102.5 miles. The Federal channel would be deepened from its existing depth of 40 feet below Mean Low Water (MLW) to 45 feet below MLW, with an allowable dredging overdepth of one foot. The project widths would range from approximately 400 feet wide at the Philadelphia Harbor to approximately 800 feet wide from the Philadelphia Navy Yard, Pennsylvania to Bombay Hook, Delaware and then approximately 1,000 feet in width for the remaining area between Bombay Hook and the deep water in Delaware Bay. The plan would also widen twelve channel bends, provide a two space anchorage at Marcus Hook and require the acquisition of four new upland disposal areas. Two beneficial use sites, Kelly Island, Port Mahon, Delaware and Egg Island, New Jersey, (See Figure 2 in the main report) have been recommended for wetland restoration purposes and will utilize geotextile tube and sand dike structures to retain pumped in dredged material. Wave action will overtop these structures and the restoration will result in approximately 60 acres of mostly sub tidal habitat adjacent to Kelly Island, which is a part of the Bombay Hook National Wildlife Refuge, and approximately 145 acres of sub tidal habitat adjacent to the Egg Island State of New Jersey Wildlife Management Area being restored to intertidal habitat and hundreds of acres of intertidal wetlands existing behind the restored areas will be protected from erosion. The geotextile tubes and sand dikes will be required to be tied-in at lands above mean high water line (MHWL) and the non-Federal sponsor will be required to acquire the necessary permits and/or easements for all tie-ins above the Mean High Water Line (MHWL).

3. The minimum estate required for this project is a channel improvement easement (Estate No. 8) for approximately 1,537 acres of upland disposal area contained within four disposal area sites. The non-Federal sponsor will acquire the four disposal areas in fee as the fee simple has been valued accordingly and the values for the perpetual easement is equivalent to fee. Fee simple acquisition will alleviate any potential problems

that could arise concerning the ownership/use of the fill material deposited on the sites. The underlying fee owners of the designated sites have also stated to the non-Federal sponsor that they prefer fee acquisition of their land for the project. The four disposal areas for the project are listed as follows:

SITE: 15G
LOCATION: Salem County, New Jersey
SIZE: 351.82 Acres
OWNERSHIP DATA: Sun Oil Corporation, Inc. - 351.82 Acres
ZONING: Agricultural/Residential (residential lots are presently vacant)
ACCESS: Public roads and highways (site has approximately 1,000 lineal feet of road frontage adjacent to Route 130)
IMPROVEMENTS: None
EXISTING EASEMENTS OR INTERESTS: None

SITE: 15D
LOCATION: Logan Township, Gloucester County, New Jersey
SIZE: 437.00 Acres
OWNERSHIP DATA: Site is composed of 53 lots with 36 ownerships (all private)
ZONING: Village Residential (residential lots are vacant)
ACCESS: Public roads and highways (Routes 130 and 322)
IMPROVEMENTS: None
EXISTING EASEMENTS OR INTERESTS: None (approximately 90% of the site is being used as farmland)

SITE: RACCOON ISLAND
LOCATION: Logan Township, Gloucester County, New Jersey
SIZE: 524.43 Acres
OWNERSHIP DATA: American Atlantic Company (Weeks Marine,Inc.)
ZONING: Marine Commercial Reserve
ACCESS: Public roads and highways (Routes 130 and 322)
IMPROVEMENTS: None
EXISTING EASEMENTS OR INTERESTS: Route 324 (abandoned);powerline easements granted to Atlantic City Electric Company and a gas pipeline easement owned by the Transcontinental Gas Company

SITE: 17G
LOCATION: West Deptford Township, Gloucester County, New Jersey
SIZE: 224.00 Acres
OWNERSHIP DATA: Tenneco, Inc.
ZONING: Light Manufacturing
ACCESS: Public roads and highways (Jobstown Road, Routes 44, 130 and I-295)
IMPROVEMENTS: None
EXISTING EASEMENTS OR INTERESTS: None (a railroad right-of- way exists on the front portion of the disposal site but will not impact the areas to be acquired)

4. The minimum estate language for the project is as follows:

CHANNEL IMPROVEMENT EASEMENT

5. A perpetual and assignable right and easement to construct, operate and maintain channel improvement works on, over and across the land described in Schedule A, for the purposes as authorized by the Act of Congress approved under Public Law 102-580, Section 101(6) of the Water Resources Development Act of 1992, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions therefrom; to excavate, dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

6. The lands to be acquired are privately owned dredged disposal areas and remnants of vacant/unimproved disposal areas. The properties are zoned residential, commercial and light manufacturing and are owned by corporations and private individuals. The properties are all located in rural undeveloped areas with common access being provided by state and municipal roadways.

7. Federally owned properties, in fee simple, are located adjacent to the disposal areas to be acquired and are identified as National Park, Oldmans, and Pedricktown (North and South), Penns Neck, Killcohook, and Artificial Island, disposal areas, New Jersey and Reedy Point (North and South), disposal areas, Delaware. See Figure 2 in the main report for the location of these Disposal Areas. The Philadelphia District currently leases approximately 249 acres, identified as Oldmans Disposal Area No. 1, for material

dredged from the Marcus Hook Anchorage portion of the project and currently in negotiations with the underlying fee owner, Sun Oil, Inc., for the purchase of the property.

8. Navigational Servitude will impact the property to be used for the project and the non-Federal sponsor will not acquire nor receive any credit for lands below the mean high water line (MHWL) at any of the disposal areas described above. On Site 17G, Map R-4, it has been determined that approximately 176 acres of artificially created fast lands are subject to the Navigational Servitude. These lands were created by the Government by dredged material disposal activities. The property impacted by the Navigational Servitude is delineated on Map R-4 and the total acreage for the site, including the created fast land, is approximately 400 acres, of which 224 acres must be acquired by the non-Federal sponsor.

9. The wetland restoration work at Kelly Island and Port Mahon, Delaware have been planned with the full knowledge and approval of the State of Delaware, Department of Natural Resources, which has been an active and interested party to this project. The non-Federal sponsor has the authority to acquire real estate in the State of Delaware and exercise the power of eminent domain. According to the sponsor, the taking power can extend to property already devoted to public use, with appropriate concurrence from the affected State or Commonwealth. It should be noted that the State of Delaware boundary line extends the mean low water line (tidal) at the State of New Jersey. Any use of Egg Island Point below the mean low water line would also require the non-Federal sponsor to obtain the necessary permits and easements from the State of Delaware.

10. There are no relocations under Public Law 91-646, as amended, associated with this project.

11. The Delaware River Port Authority (DRPA), acting by and through the Port of Philadelphia and Camden, Inc., is the non-Federal sponsor for this project. The DRPA was established under a joint compact between the State of New Jersey and the Commonwealth of Pennsylvania, duly approved by Congress, and governed by the respective statutes specially adopted for that purpose in both New Jersey and Pennsylvania. The non-Federal sponsor has quick take authority (eminent domain), granted under New Jersey statute N.J.S.A. 32:3-5.

12. The Baseline Cost Estimate for Real Estate, in M-CACES format, is enclosed. The estimated land, easements and right of way, and administrative costs at October 1996 Price Level are $18,598,000. The gross appraisal upon which the real estate cost is

based was approved by CERE-E on 27 June 1996.

13. Real Estate Maps for the project are enclosed with this real estate plan, Plates R-1 to R-4, which delineate the project lands and estates to be acquired and contain listings of all parcels to be acquired, private and corporate, with their estimated acreage.

14. There is no mineral activity either existing or anticipated within the project area.

15.The non-federal sponsor will officially initiate real estate acquisition activities after final execution of the Project Cooperation Agreement. We have requested from the Port of Philadelphia and Camden, Inc. input for an acquisition plan/schedule and detailed information concerning their real estate personnel, time-lines for surveys, appraisals, title work and administration activities, condemnation proceedings and any contract work associated with the acquisition of the required lands and estates for the project. Upon receipt of this information from the non-Federal sponsor, this office will prepare a detailed acquisition schedule as an exhibit for inclusion into this report.

16.There are no facility or utility relocations associated with this project.

17.There are no known hazardous or toxic waste sites existing within or adjacent to the project boundaries.

18. The project is considered to be essential by the local populace and commercial interests.

41 TAKINGS

01010401 Real Estate Acquisition Documents
(Cadastral prep. of R. E. Requirements Mapping)

0102----ACQUISITIONS	AMOUNT	CONTINGENCY	SUBTOTAL
010201---By Gov't			
010202---By Local Sponsor (LS)			
01020201-Survey & Legals (41 @ $700)	$28,700	$4,305	$33,005
1020202-Title Evidence (41 @ $600)	$24,600	$3,690	$28,290
01020203-Negotiations (41 @ $1,000)	$41,000	$6,150	$47,150
010203---By Gov't on behalf of LS			
010204---Review of LS			
01020401-Survey & Legals (41 @ $75)	$ 3,075	$ 461	$ 3,536
01020402-Title Evidence (41 @ $75)	$ 3,075	$ 461	$ 3,536
01020403-Negotiations (41 @ $75)	$ 3,075	$ 461	$ 3,536
0103----CONDEMNATIONS			
010301---By Gov't			
010302---By Local Sponsor (LS) (6 @ $3000)	$18,000	$ 2,700	$20,700
010303---By Gov't on behalf of LS			
010304---Review of LS (6 @ $250)	$ 1,500	$ 225	$ 1,725
0105----APPRAISALS			
010501---By Gov't			
010502---By Local Sponsor (LS) (41 @ $750)	$30,750	$ 4,613	$35,363
010503---By Gov't on behalf of LS			
010504---Review of LS (41 @ $180)	$ 7,380	$ 1,107	$ 8,487
0106----PL 91-646 ASSISTANCE	N/A	N/A	N/A
010601---By Gov't			
010602---By Local Sponsor (LS) (@ $1,000)			
010603---By Gov't on behalf of LS			
010604---Review of LS (@ $75)			

0107----TEMPORARY PERMITS/LICENSES/RIGHTS-OF-WAY	N/A	N/A	N/A
010701---By Gov't			
010702---By Local Sponsor (LS) (@ $100)			
010703---By Gov't on behalf of LS			
010704---Review of LS (@ $25)			
0115----REAL ESTATE PAYMENTS			
011501---Land Payments			
01150101-By Gov't			
01150102-By Local Sponsor (LS)	$17,532,595	$876,630	$18,409,225
01150103-By Gov't on behalf of LS			
01150104-Review of LS (41 @ $75)	$ 3,075	$ 461	$ 3,536
011502--PL 91-646 Assistance Payments	N/A	N/A	N/A
01150201-By Gov't			
01150202-By Local Sponsor (LS)			
01150203-By Gov't on behalf of LS			
01150204-Review of LS (@ $75)			
TOTALS	$17,696,825	$901,264	$18,598,089
		ROUNDED	$18,598,000

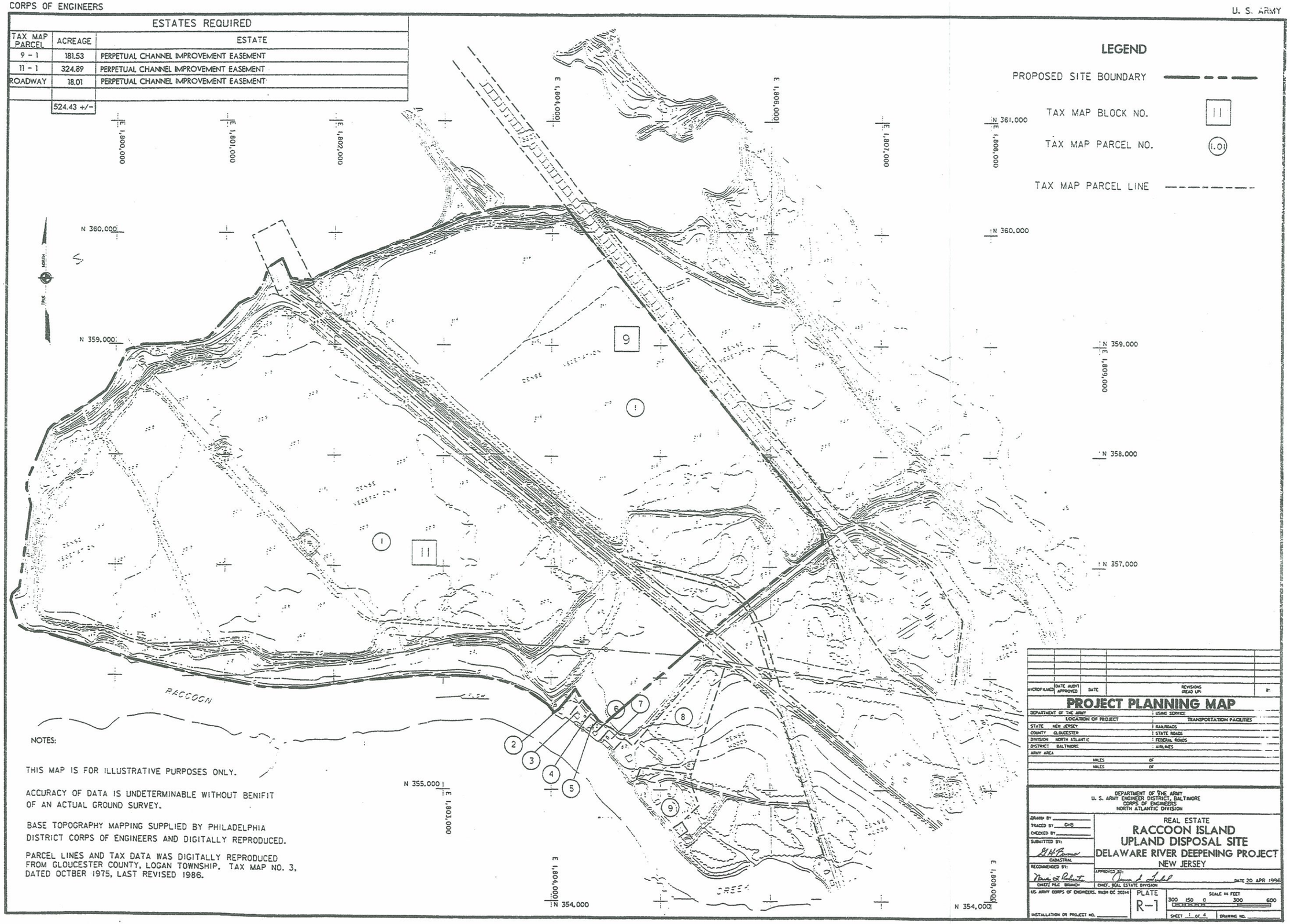
REAL ESTATE MAPS

CORPS OF ENGINEERS

U. S. ARMY

ESTATES REQUIRED

TAX MAP PARCEL	ACREAGE	ESTATE
9 - 1	181.53	PERPETUAL CHANNEL IMPROVEMENT EASEMENT
11 - 1	324.89	PERPETUAL CHANNEL IMPROVEMENT EASEMENT
ROADWAY	18.01	PERPETUAL CHANNEL IMPROVEMENT EASEMENT
	524.43 +/-	



LEGEND

PROPOSED SITE BOUNDARY

TAX MAP BLOCK NO. (11)

TAX MAP PARCEL NO. (1.01)

TAX MAP PARCEL LINE

NOTES:

THIS MAP IS FOR ILLUSTRATIVE PURPOSES ONLY.

ACCURACY OF DATA IS UNDETERMINABLE WITHOUT BENIFIT OF AN ACTUAL GROUND SURVEY.

BASE TOPOGRAPHY MAPPING SUPPLIED BY PHILADELPHIA DISTRICT CORPS OF ENGINEERS AND DIGITALLY REPRODUCED.

PARCEL LINES AND TAX DATA WAS DIGITALLY REPRODUCED FROM GLOUCESTER COUNTY, LOGAN TOWNSHIP, TAX MAP NO. 3, DATED OCTBER 1975, LAST REVISED 1986.

MICROFILMED	DATE AUDIT APPROVED	DATE	REVISIONS READ UP:	BY:

PROJECT PLANNING MAP

DEPARTMENT OF THE ARMY

LOCATION OF PROJECT

STATE NEW JERSEY
COUNTY GLOUCESTER
DIVISION NORTH ATLANTIC
DISTRICT BALTIMORE
ARMY AREA

MILES OF
MILES OF

USING SERVICE

TRANSPORTATION FACILITIES

RAILROADS
STATE ROADS
FEDERAL ROADS
AIRLINES

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
NORTH ATLANTIC DIVISION

DRAWN BY
TRACED BY CHB
CHECKED BY
SUBMITTED BY: J. H. Byrne, CADASTRAL
RECOMMENDED BY: Mark A. Roberts, CHIEF, P&C BRANCH

REAL ESTATE
RACCOON ISLAND
UPLAND DISPOSAL SITE
DELAWARE RIVER DEEPENING PROJECT
NEW JERSEY

APPROVED BY: James A. Seidel, CHIEF, REAL ESTATE DIVISION
DATE 20 APR 1996

US ARMY CORPS OF ENGINEERS, WASH DC 20314

PLATE R-1

SCALE IN FEET
300 150 0 300 600

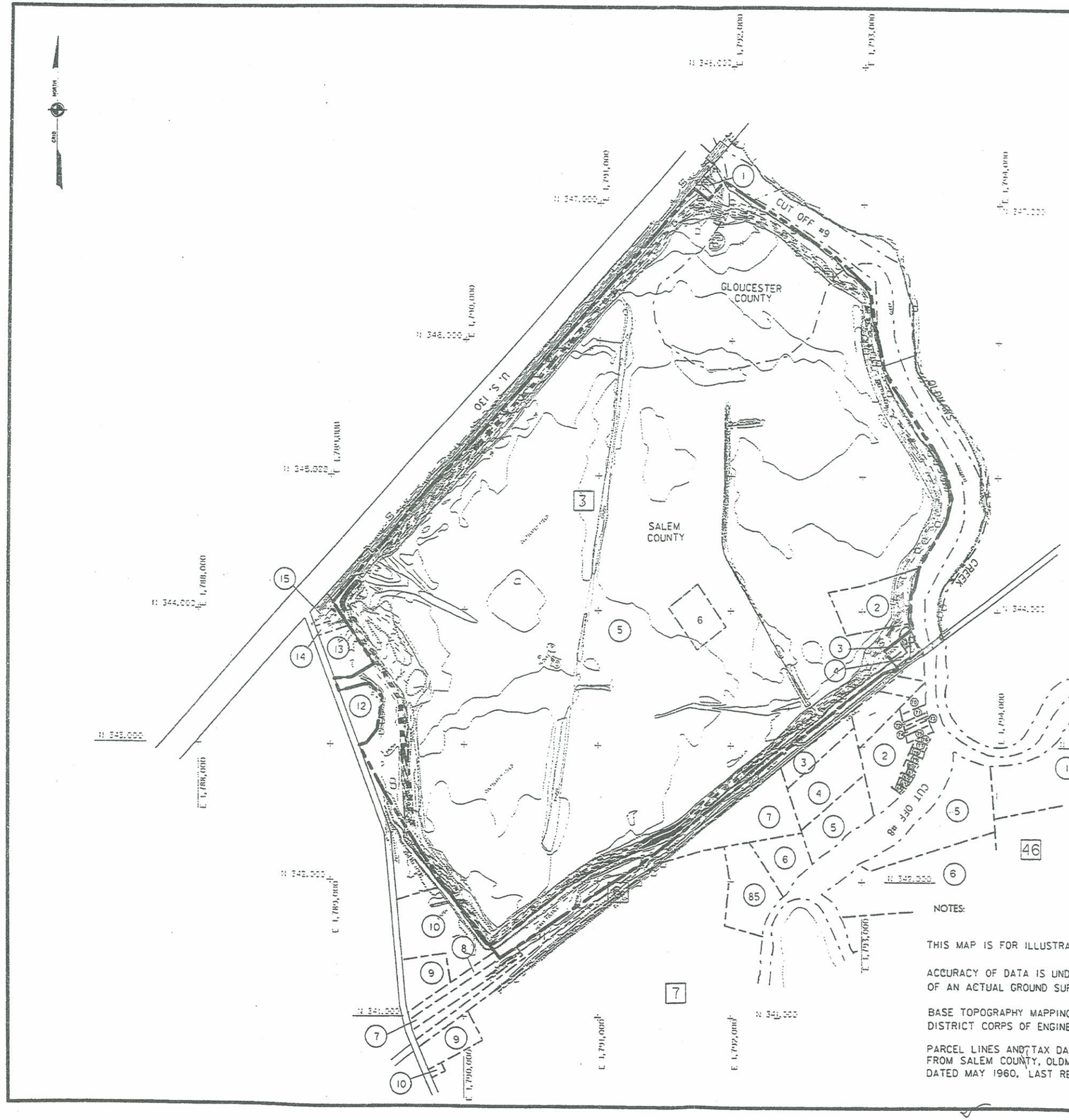
INSTALLATION OR PROJECT NO.

SHEET 1 OF 4

DRAWING NO.

U. S. ARMY

ESTATES REQUIRED		
TAX MAP PARCEL	ACREAGE	ESTATE
2	4.55	FEE
5	344.82	FEE
6	2.50	FEE
	351.87 +/-	



LEGEND

PERPETUAL EASEMENT BOUNDARY

TAX MAP BLOCK NO. [7]

TAX MAP PARCEL NO. (1.01)

TAX MAP PARCEL LINE

ORIGINAL SHORE LINE (FROM TAX MAP)

NOTES:

THIS MAP IS FOR ILLUSTRATIVE PURPOSES ONLY.

ACCURACY OF DATA IS UNDETERMINABLE WITHOUT BENIFIT OF AN ACTUAL GROUND SURVEY.

BASE TOPOGRAPHY MAPPING SUPPLIED BY PHILADELPHIA DISTRICT CORPS OF ENGINEERS.

PARCEL LINES AND TAX DATA WAS DIGITALLY REPRODUCED FROM SALEM COUNTY, OLDMANS TOWNSHIP, TAX MAP NO. 2, DATED MAY 1960, LAST REIVSED DECEMBER 1995.

MICROFILMED	DATE AUDIT APPROVED	DATE	REVISIONS (READ UP)	BY

REAL ESTATE PLANNING MAP

DEPARTMENT OF THE ARMY — USING SERVICE

LOCATION OF PROJECT — TRANSPORTATION FACILITIES

STATE NEW JERSEY — RAILROADS

COUNTY SALEM AND GLOUCESTER — STATE ROADS

DIVISION NORTH ATLANTIC — FEDERAL ROADS

DISTRICT BALTIMORE — AIRLINES

ARMY AREA

MILES OF

MILES OF

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
NORTH ATLANTIC DIVISION

DRAWN BY CMB
TRACED BY
CHECKED BY
SUBMITTED BY: CADASTRAL
RECOMMENDED BY: CHIEF, P&C BRANCH
APPROVED BY: CHIEF, REAL ESTATE DIVISION DATE 19 APR 1996

REAL ESTATE
SITE 15G
UPLAND DISPOSAL AREA
DELAWARE RIVER DEEPENING PROJECT
NEW JERSEY

US ARMY CORPS OF ENGINEERS, WASHINGTON 20314

INSTALLATION OR PROJECT NO.

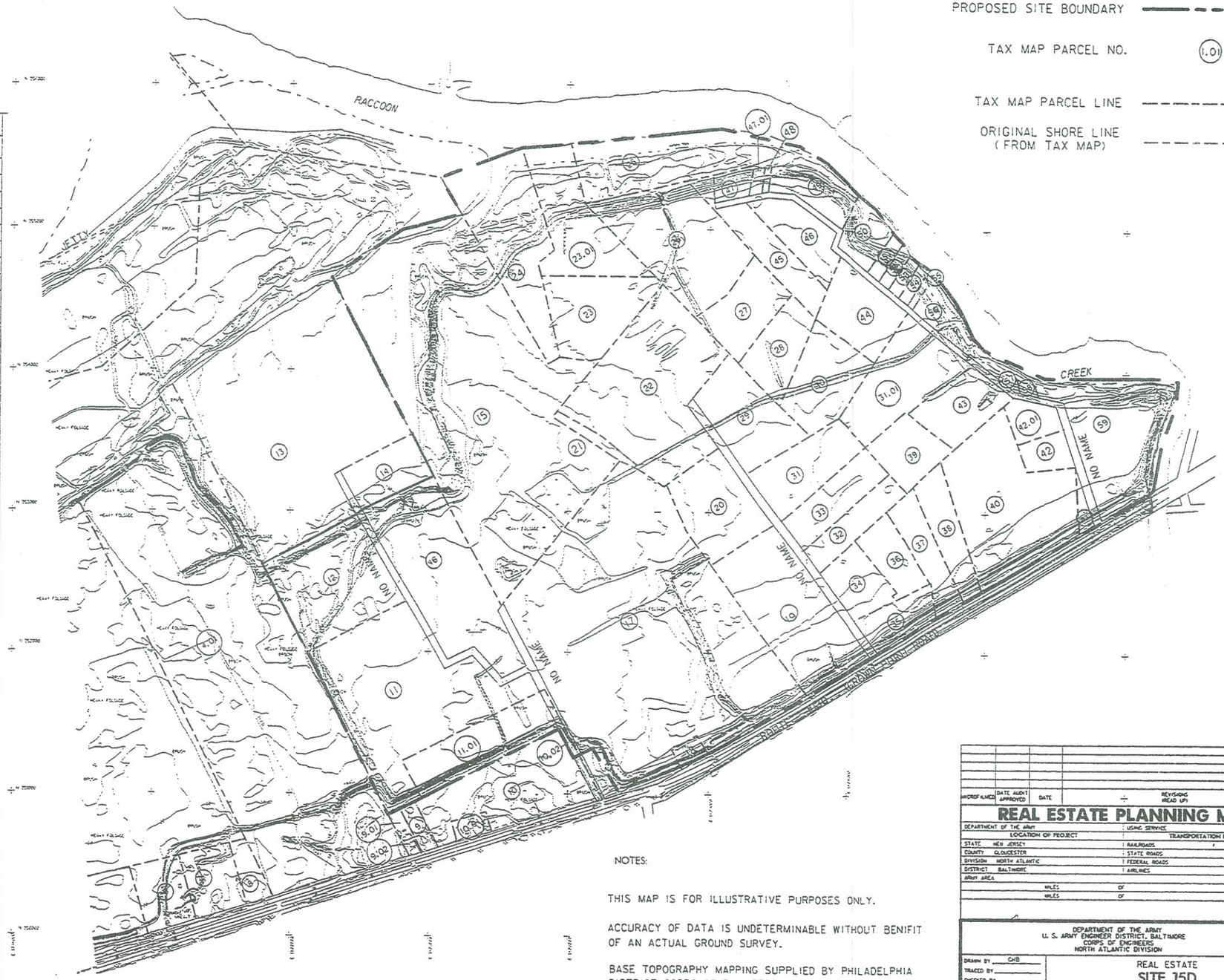
PLATE R-2

SCALE IN FEET
300 150 0 300 600

SHEET 2 OF 4

DRAWING NO.

ESTATES REQUIRED		
TAX MAP PARCEL	APPROX. ACREAGE	ESTATE
10.02	0.48	PERPETUAL CHANNEL IMPROVEMENT EASEMENT
11	24.21	FEE
11.01	7.47	FEE
12	12.77	FEE
15	61.04	FEE
16	16.57	FEE
17	63.42	FEE
18	0.74	FEE
19	14.28	FEE
20	7.91	FEE
21	0.93	FEE
22	20.71	FEE
23	7.94	FEE
23.01	9.33	FEE
24	12.70	FEE
25	10.93	FEE
26	13.54	FEE
27	5.56	FEE
28	4.68	FEE
29	7.88	FEE
30	6.97	FEE
31	6.29	FEE
31.01	8.77	FEE
32	3.73	FEE
33	4.82	FEE
34	3.84	FEE
35	3.30	FEE
36	3.55	FEE
37	4.02	FEE
38	4.19	FEE
39	4.34	FEE
40	16.51	FEE
41	0.61	FEE
42	1.97	FEE
42.01	2.14	FEE
43	5.31	FEE
44	5.92	FEE
45	5.04	FEE
46	4.19	FEE
47	1.28	FEE
47.01	0.42	FEE
48	0.22	FEE
49	4.41	FEE
50	2.75	FEE
51	0.77	FEE
52	0.61	FEE
53	0.62	FEE
54	0.59	FEE
55	0.36	FEE
56	2.61	FEE
57	0.97	FEE
58	0.52	FEE
59	13.51	FEE
ROADWAYS	10.51	
	437 +/-	



LEGEND

PROPOSED SITE BOUNDARY

TAX MAP PARCEL NO. (1.01)

TAX MAP PARCEL LINE

ORIGINAL SHORE LINE (FROM TAX MAP)

NOTES:

THIS MAP IS FOR ILLUSTRATIVE PURPOSES ONLY.

ACCURACY OF DATA IS UNDETERMINABLE WITHOUT BENIFIT OF AN ACTUAL GROUND SURVEY.

BASE TOPOGRAPHY MAPPING SUPPLIED BY PHILADELPHIA DISTRICT CORPS OF ENGINEERS.

PARCEL LINES AND TAX DATA WAS DIGITALLY REPRODUCED FROM GLOUCESTER COUNTY, LOGAN TOWNSHIP, TAX MAP NO. 2, DATED OCTOBER 1, 1946, LAST REIVSED OCTOBER 1 1994.

MICROFILMED	DATE AUDIT APPROVED	DATE	REVISIONS (HEAD UP)

REAL ESTATE PLANNING MAP

DEPARTMENT OF THE ARMY : USING SERVICE

LOCATION OF PROJECT : TRANSPORTATION FACILITIES

STATE NEW JERSEY : RAILROADS

COUNTY GLOUCESTER : STATE ROADS

DIVISION NORTH ATLANTIC : FEDERAL ROADS

DISTRICT BALTIMORE : AIRLINES

ARMY AREA

MILES OF

MILES OF

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
NORTH ATLANTIC DIVISION

DRAWN BY CHB
TRACED BY
CHECKED BY
SUBMITTED BY:
CADASTRAL
RECOMMENDED BY:
CHIEF, R&C BRANCH

REAL ESTATE
SITE 15D
UPLAND DISPOSAL
DELAWARE RIVER DEEPENING PROJECT
NEW JERSEY

APPROVED BY:
CHIEF, REAL ESTATE DIVISION
DATE 18 JUL 1996

US ARMY CORPS OF ENGINEERS, WASH DC 20314

INSTALLATION OR PROJECT NO.

PLATE R-3

SCALE IN FEET
300 150 0 300 600

SHEET 3 OF 4 DRAWING NO.

U. S. ARMY

ESTATES REQUIRED		
TAX MAP PARCEL	APPROX. ACREAGE	ESTATE
1	120	PERPETUAL CHANNEL IMPROVEMENT EASEMENT
1.03	72	PERPETUAL CHANNEL IMPROVEMENT EASEMENT
1.08	89	PERPETUAL CHANNEL IMPROVEMENT EASEMENT
1.09	119	PERPETUAL CHANNEL IMPROVEMENT EASEMENT (INCLUDES TIDAL FLAT ACRES)
	400	

LEGEND

PERPETUAL EASEMENT BOUNDARY ——————

ARTIFICIALLY CREATED FAST LAND (176 ACRES +/-) ▨

TAX MAP PARCEL NO. (1.01)

TAX MAP PARCEL LINE – – – – – – –

ORIGINAL SHORE LINE (FROM TAX MAP) – – – – – – –

NOTES:

THIS MAP IS FOR ILLUSTRATIVE PURPOSES ONLY.

ACCURACY OF DATA IS UNDETERMINABLE WITHOUT BENIFIT OF AN ACTUAL GROUND SURVEY.

BASE TOPOGRAPHY MAPPING SUPPLIED BY PHILADELPHIA DISTRICT CORPS OF ENGINEERS.

PARCEL LINES AND TAX DATA WAS DIGITALLY REPRODUCED FROM GLOUCESTER COUNTY, WEST DEPTFORD TOWNSHIP, TAX MAP NO. 26, DATED OCTBER 1 1951 LAST REIVSED OCTOBER 1 1995.

MICROFILMED	DATE AUDIT APPROVED	DATE	REVISIONS (READ UP)	BY
		3/14/97	EASEMENT LINE MOVED REDUCING ACREAGE	GHB

REAL ESTATE PLANNING MAP

DEPARTMENT OF THE ARMY	USING SERVICE
LOCATION OF PROJECT	TRANSPORTATION FACILITIES
STATE NEW JERSEY	RAILROADS
COUNTY GLOUCESTER	STATE ROADS
DIVISION NORTH ATLANTIC	FEDERAL ROADS
DISTRICT BALTIMORE	AIRLINES
ARMY AREA	
MILES OF	
MILES OF	

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
NORTH ATLANTIC DIVISION

DRAWN BY
TRACED BY
CHECKED BY
SUBMITTED BY: L.H. Barnes CADASTRAL
RECOMMENDED BY: Mary L. Roberts CHIEF, P&C BRANCH
APPROVED BY: James L. Imbert CHIEF, REAL ESTATE DIVISION DATE 12 APR 1996

REAL ESTATE
SITE 17G
UPLAND DISPOSAL
DELAWARE RIVER DEEPENING PROJECT
NEW JERSEY

US ARMY CORPS OF ENGINEERS, WASH DC 20314
INSTALLATION OR PROJECT NO.
PLATE R-4
SCALE IN FEET 300 150 0 300 600
SHEET 4 OF 4
DRAWING NO.

APPENDIX C

BENEFIT ANALYSIS

Delaware River Main Channel Deepening

TABLE OF CONTENTS

APPENDIX C

LIST OF TABLES

INTRODUCTION

This benefit analysis appendix for the Limited Reevaluation Report presents the benefits on the same basis as in the Interim 1992 Feasibility Report that would result from deepening the Delaware River main channel from its current authorized and maintained project depth of 40 feet (MLW) to the with project condition depth of 45 feet (MLW).

Benefits will result from the decrease in the cost per ton for shipping commodities into or out of the Delaware River port system. A deeper channel depth will allow some current vessels to carry more cargo as well as allow a fleet shift to larger vessels, thus more efficiently apportioning operating costs over a greater amount of tonnage. Other vessels, such as large crude oil vessels that currently lighter in the naturally deep water of the lower Delaware Bay, will continue to carry equivalent tonnage but will also be able to operate more efficiently with a deepened channel.

ECONOMIC CONSTRAINTS

The estimation of deep-draft navigation benefits was accomplished in accordance with ER 1105-2-100, Chapter 6, Section VII, NED Benefit Evaluation Procedures: Transportation (Deep Draft Navigation), and the National Economic Development Procedures Manual: Deep Draft Navigation. The following items constitute the economic constraints considered:

. Shippers are assumed to use the least cost mode of transportation provided there are no overriding noneconomic factors influencing modal preference to include shipment size and vessel availability.

. Shippers are expected to make maximum use of nonstructural measures in order to minimize transportation costs.

. Analyses of project benefits are to be conducted in accordance with Corps of Engineers' regulations

ECONOMIC CRITERIA

The following economic criteria were applied during plan evaluation:

. Tangible economic benefits must exceed project economic costs on a present worth basis. Measurement of the plan shall be based on the NED benefit-cost ratio being greater than 1.0 to 1.

. The benefits and costs are expressed in comparable economic terms.

. Annualized benefits and costs are based on a 50-year project life and the FY 1997 Federal discount rate of 7- 3/8 percent. Annualized costs for the recommended plan also includes interest during construction.

. The lower Delaware Bay anchorage at Big Stone Beach provides access for a maximum vessel sailing draft of approximately 55 feet for incoming tankers. Lightering is accomplished at this anchorage. The Big Stone Beach anchorage is the only location on the lower Delaware River where the transshipment of oil is allowed under the Delaware Coastal Zone Management Act. The topping-off of dry bulk commodities is not presently allowed at this location, and this situation is not expected to change in the foreseeable future.

EXISTING CONDITIONS

HISTORIC MARKET TRENDS

The major competing U.S. ports for the commodities being considered in this study are New York, Baltimore, and Norfolk/Hampton Roads. Historic data shows several definite trends concerning the amounts of shipping and market share allocated to Philadelphia. Of the commodities being considered, Philadelphia dominates in crude oil imports, and moves smaller levels of tonnage of iron ore imports, scrap metal exports, coal imports and container movements.

The market share for each port for the movement of commodities is largely a function of the presence of the necessary processing and handling facilities such as refineries, coal and bulk terminals, and container cranes. When demand for a commodity declines, the ports with the facilities offering the greatest competitive advantages will be able to retain their overall commodity flows, and likely increase their percentage of the total market share. Competitive advantages possessed by a port can include such factors as:

.Sufficient channel depth

.Better proximity to markets

.Proximity to the ocean

.Established processing facilities such as refineries with sufficient storage and processing capacity

.Newer high capacity loading and unloading equipment

.Better transportation linkages to hinterland markets or to hinterland supply sources

.Processing facilities with flexibility to handle variations in quality or composition of raw materials

.Barriers to entry that prevent development of competing facilities. These include the long lead time necessary to permit, construct, and bring on-line new processing and bulk handling facilities such as refineries, coal handling terminals, or to accomplish major channel deepening activities.

In the short run, a port's competitive advantages remain relatively fixed and the port is allowed to maintain market shares when global prices and demand for a commodity improve.

Over the long term, a port's market share of commodity flows will be more directly affected by supply and demand, and less by their competitive advantages. Ports will have the time necessary to bring new handling facilities or processing facilities on-line or take other actions which enhance the competitive advantages for a given commodity over other ports. Prime examples include the Port of Norfolk/Hampton Roads developing over the last ten years new, highly efficient coal handling terminals, and both the Ports of Baltimore and Norfolk/Hampton Roads deepening their shipping channels to 50 feet or greater.

Except for containers, each commodity is almost exclusively an import or an export. Crude oil, predominantly from West Africa, North Sea, Middle East, Far East, Bahamas, Mexico, and Venezuela is the largest single import commodity. Iron ore is imported from Atlantic Canada and Europe. Scrap metal is exported to many destinations, most importantly, Turkey, and is produced within the port's own metropolitan area. The South Jersey Port Corporation is importing bituminous coal from Colombia which is being marketed within the local region. Potentially benefitting container movements with trade route partners in locations such as Europe, the Mediterranean, the Far East and South America involve both the receipt of imports and the shipment of exports.

CRUDE OIL. Crude oil is by far the largest single commodity shipped through the Ports of Philadelphia. Philadelphia's market share of the total North Atlantic crude oil import market has risen steadily. The imports of crude oil through Philadelphia since the early 1980's have been increasing. Philadelphia is in direct competition with only the port of New York. Baltimore and Norfolk/Hampton Roads have not been significant oil importers. New York's oil imports have dropped considerably. Philadelphia's extensive refining capacity and hinterland pipeline network connections have made it the port of choice for crude oil in the region.

IRON ORE. The eastern Pennsylvania steel industry imports nearly all of its iron ore through the Ports of Philadelphia. The only other North Atlantic port that imports significant amounts of iron ore is Baltimore, which has several steel making plants in its metropolitan area.

SOUTH JERSEY PORT CORPORATION (SJPC). Scrap metal supplied from approximately a 250-mile radius area is exported to Turkey for use as a raw material in steel production. Turkey has recently replaced South Korea as the largest importing country of scrap metal from the U.S., and, of further note, SJPC is a major U.S. supplier.

GENERAL CARGO/CONTAINERS. The historic environment for general cargo movements (including container, RO-RO, and breakbulk) is very competitive, both internally within the port and with other North Atlantic ports. The port has attempted to maintain its market share by carving out market niches for specialized cargoes. The port community is actively engaged in port unification with the goal of bringing together widely divergent interests which have developed, at least partially, because of the three-state configuration of the Delaware River system. Within these unification efforts, a renewed emphasis has been placed upon improving general cargo movements through the ports of the Delaware River. Efforts are being undertaken, such as investments in intermodal rail improvements and new marketing strategies, to change the mixture of general cargo towards increased containerization. Through increased long term investments, the port community is attempting to develop into a "load port" for containers. Potentially benefitting trade routes for containers from the use of post-Panamax sized vessels in the future have been identified: Europe, the Mediterranean, the East Coast of South America, and Australia/New Zealand-Europe-East U.S. via the Suez Canal. A regional intermodal yard developed by the Delaware River Port Authority commenced operations in Philadelphia in 1992. This facility handles three separate rail systems, Conrail, CSX, and Canadian Pacific (through its Delaware and Hudson subsidiary). A recent new trend for Philadelphia has developed as a result of this facility. Cargo moving to or from Canada has been diverted from Halifax to Philadelphia, thus establishing a new landbridge.

EXISTING VESSEL OPERATING PRACTICES

Shippers have two basic responses to the deeper channel depth:

1) load existing vessels with more tonnage, which assumes that they are not being fully loaded at the existing channel or berth depth, or

2) bring in larger vessels offering economies of scale in commodity movements and therefore lower unit transportation costs.

Channel depth is not the only determinant of the size of the vessel that calls on a particular facility. Other factors that determine vessel size include:

.The berth depth of the facility.

.Channel depth characteristics at the other trade route port.

.Design and physical capacity of the loading or unloading equipment at a facility. Materials handling equipment is limited in terms of the beam and length of vessel they can handle. Vessels exceeding these dimensions either cannot be completely loaded or unloaded.

.Design capacity of the mooring structures. There are design limitations for mooring structures in terms of the amount of force that can be imposed upon them.

.Storage or processing capacity of landside facilities. The amount of tonnage coming into a facility in one load can be limited by the amount of material that can be stored on-site.

There are two ways to lower the delivered cost of commodities: load an underutilized vessel more fully, or use a larger vessel. Shippers, in an attempt to minimize transportation costs, normally tend to load vessels as fully as possible in order to apportion the operating costs over as great an amount of tonnage as possible. Loading a vessel more fully can increase substantially the tonnage over which to apportion the costs with only a small increase in total transportation costs. Larger carriers do provide economies of scale in lower unit shipping costs as the fixed and variable vessel costs rise much more slowly than the increase in capacity as vessel size is increased.

COMMODITY PROJECTIONS

Extensive commodity forecasts were developed by the economic consulting firm, DRI/McGraw-Hill, Inc. for use in this benefit analysis.

FUTURE FLEET TRENDS

The benefit analysis has incorporated impacts to vessel fleets over the project life with the proposed channel improvements. The analysis for crude oil vessels with sailing drafts

greater than 40 feet has not incorporated any potential shift in the fleet. The operators of these vessels have made an economic decision to lighter tonnage at Big Stone Beach Anchorage on to barges until the point where the sailing draft is sufficiently reduced to allow the vessels to travel upriver to the pertinent facility. With a deepened main channel, they are expected to continue to make the same economic decision and carry the equivalent amount of tonnage in the same vessels on the trade route. The analyses for crude oil vessels with less than 40 foot sailing drafts, and iron ore also have not included a shift in the vessel fleet over the project life. The benefitting commodities using the SJPC terminal (scrap exports and coal imports) are anticipated to continue the existing practice of chartering the most cost efficient vessel size as the channel is deepened. Container vessels are expected to utilize larger post-Panamax vessels on five major trade routes.

STATISTICAL ANALYSIS OF ACTUAL VESSEL OPERATING PRACTICES

The analysis utilized the Waterborne Commerce Statistics Center (WCSC) data base for actual historic vessel movements using the current 40 foot channel, for the potentially benefitting crude oil and iron ore facilities in the Delaware River system. The movement of bulk commodities through SJPC's Beckett Street Terminal and container movements were also analyzed in the benefit analysis and incorporated the expectation of optimal-sized vessel utilization based on channel depth. An econometric framework using a two-stage least squares multiple regression model was applied to simulate expected cargo tonnage carried by vessels in the fleet if the Delaware River federal navigation channel were to be deepened from the current 40 feet to 45 feet for crude oil and iron ore.

The theoretical basis for the econometric analysis incorporates the recognition that the economic goal of any firm is to maximize profits. The profit function is equal to revenues minus costs. The modelling of potential reductions in transportation costs caused by a navigation improvement is identical to analyzing the effect on a firm's cost function by changing its production function. The purpose of the statistical analysis applied in this report is to estimate a production function of vessel operations using actual voyage data. The production function, expressed as $Q=f(K,L,M)$, represents the utilization of particular combinations of input resources to produce a specific level of quantity output. The output of the production function, Q, or quantity, is defined as the amount of cargo carried (i.e., sailing deadweight tonnage). The input, L, represents labor which is considered fixed in a capital-intensive industry such as shipping. The input, K, represents capital, and is defined as the vessels themselves and can be measured by cargo carrying capacity (design deadweight tonnage and design draft). The input, M, represents change in technology (specifically, a change in the channel constraint to

vessels with a channel deepening). The production function model has been expanded to include sailing draft as an exogenous input variable directly related to sailing deadweight tonnage. The effort of developing an econometric model to represent a production function for ship operators involves estimating a technological process for individual ships. The individual ship's production process will represent the technical constraints faced by ship operators as well as their market constraints since the demand for ocean transportation services is a derived demand, meaning that the demand for other goods and services determines the demand for ocean transportation.

The amount of tonnage which can be carried by a ship leaving or entering a harbor should be positively correlated to its size. The larger the ship, the greater its capacity for transporting tonnage will also be. Since ship operating firms are assumed to be profit maximizers faced with a demand for their services derived by other markets, their optimal behavior should be characterized by them providing a supply of transportation services at minimum cost. In other words, ship operators should be using the most economically efficient ship available to transport cargo. Since ship operators who are behaving optimally should be supplying a cargo carrying capacity equal to the amount of cargo tonnage demanding their services,a fully laden vessel is generally more efficient than a less than full vessel. However, ship operators may physically be constrained from using the most efficient vessel because of its availability within the fleet or because the dimensions of the channel prohibit its optimal utilization. Channel dimensions generally constrain ship operators by limiting the amount of cargo which can be loaded upon their vessels. This constraint results in operators using efficient ships at less than their optimal load or optimally using less efficient ships. Either way, ship operators are confronted by higher costs directly caused by these economic inefficiencies. The objective of this statistical analysis is to produce a model which can be used as a tool to predict cargo tonnage carried by various sizes of ships, and, thus, simulate actual operating practices under different channel depths. Exogenous input data from the WCSC data base and Lloyd's Register of Ships included the following: vessel name, design draft (DESDWT), actual sailing draft (SDRAFT), commodity, trade route, export or import classification, design deadweight tonnage (DESDWT), actual sailing deadweight tonnage (SDWT), and dockcode. Dockcodes were converted from numeric to actual location by use of a U.S. Customs directory. Trade routes were converted from numeric to actual name by use of Schedule K-Classification of Ports By Geographic Trade Area and Country (U.S. Bureau of Census).

In order to incorporate the constraining effect of the depth of the channel, it was necessary to create a data element to act as a proxy measure for channel constraint. Ship operators, while ladening their vessels with cargo, are fully aware of the existing depth of the channel which they must navigate and the design draft of the vessel they have

selected to transport their tonnage. Since the design draft represents the maximum loaded draft at which a vessel can be safely operated, a value representing the difference between the design draft and the channel depth will serve as a reasonable proxy of the perceived constraint to ship operators caused by the channel. In the statistical analysis, the constraint variable was restricted to nonnegative values since a negative constraint is the same as no constraint on the vessel.

The two-stage least squares analysis involved many iterations in model testing and development, using the LOTUS spreadsheet and STATGRAPHICS software packages, to identify the variables which would serve as the best combination in order to develop an end product which would predict sailing deadweight tonnage as the channel was deepened.

Predicted tonnage by vessel was estimated for crude oil vessels with sailing drafts less than or equal to 40 feet, and iron ore vessels. Seven years of data provided by WCSC was utilized in the statistical analysis. Crude oil vessels with sailing drafts greater than 40 feet will not have an increase in tonnage carried due to a channel deepening. The operators of these vessels have made a decision currently to lighter at Big Stone Beach Anchorage until the vessel sailing draft is sufficiently reduced to allow for navigation upriver to the pertinent facility. Even with a deeper main channel they will continue to carry the same amount of tonnage, and benefits will be based on savings from reduced lightering requirements.

TRANSPORTATION COST ESTIMATION PROCEDURE

Vessel hourly costs at sea and in port were derived from the data contained in the IWR/OCE Deep Draft Vessel Cost Estimates, for foreign flag liquid bulk, dry bulk, and container vessels. Operating costs reflect actual voyage expenses regarding wages, allowances, subsistence, stores, supplies, maintenance, repairs, insurance, and fuel costs. Annualized capital costs were calculated based on current replacement cost data depreciated to average vessel age. The use of this data in this study required interpolation for relevant vessels situated between the representative vessel sizes in the handbook. Port charges, pilot fees, and tug boat costs were site specific to the Delaware River port system. Landside costs, such as transportation costs of the commodities after leaving the destination port or prior to entering the origin port, were considered identical per ton under the with and without project conditions and were, thus, not included in the transportation cost estimation.

TRANSPORTATION COSTS AND SAVINGS ESTIMATION

The economic analysis described in the following sections involves tonnage carried and the cost per ton for all vessel classes for sample trade routes for each of the commodities. Five analyses were performed to determine transportation costs and savings for vessel movements: crude oil greater than 40 foot sailing draft, crude oil less than or equal to 40 foot sailing draft, iron ore, South Jersey Port Corporation (SJPC) export scrap and import coal, and container vessel movements.

CRUDE OIL GREATER THAN 40 FOOT SAILING DRAFT. Crude oil vessels greater than 40 foot actual sailing draft are not expected to have an increase in tonnage carried due to a channel deepening. The operators of these vessels have made an economic decision to lighter tonnage at Big Stone Beach Anchorage on to barges until the point where the sailing draft is sufficiently reduced to allow them to travel upriver to the pertinent facility. Thus, even with a deeper main channel they are expected to continue to make the same economic decision and carry the same amount of tonnage. The data base was disaggregated by trade route and design draft. Average sailing draft, average design deadweight tonnage, average sailing deadweight tonnage, and fleet distribution were computed for each vessel design draft class by trade route. Individual transportation cost models were developed for each design draft class for each trade route. These cost models estimated tons lightered and transportation costs for the channel depths of 40 and 45 feet. By combining commodity projections with the fleet distribution, estimates of total tons lightered for each design draft class by trade route over the project life were made. Total transportation costs, including the costs of lightering, were computed for design draft class, trade route, project life decade, and channel depth. Subtracting the total transportation costs of each with project channel depth from the total transportation costs for the without project channel depth results in cost savings as a result of the reduced lightering with a deeper channel.

An example is the transportation model for the 57 foot design draft vessel class with an average design deadweight tonnage of 150,148 tons transporting crude oil from West Africa. Following is a line-by-line description of the transportation model to explain the transportation cost methodology that was applied:

a. Channel depths analyzed.

b. Vessel characteristics for design DWT, design draft, immersion factor, length, and beam are taken from data from Lloyd's Register of Ships and the IWR/OCE Deep Draft Vessel Cost Estimates.

c. Average actual sailing draft is from the WCSC data base.

d. Operating cost at sea, operating cost at port, and cruising speed at sea are based on IWR/OCE data for foreign flag tankers.

e. One-way haul distance is based on the publication Distance Between Ports, Dept. of the Navy Oceanographic Office, for the appropriate trade route based on the weighted average distance from ports in the West Africa region.

f. Time at sea is a function of one-way haul distance and cruising speed at sea.

g. Port charges are site specific to the Delaware River port system.

h. Time at port is a function of tonnage carried, lightering and port unloading rates, and tidal delays.

i. Vessel cost at sea is a function of operating cost at sea and time at sea.

j. Vessel cost in port is a function of operating cost at port and time at port.

k. Other port charges are a function of site specific data.

l. Total round trip cost is a summation of all of the transportation cost categories (i., j., and k. above).

m. Practical maximum operating draft is based on actual operating practice of vessels with the current 40 foot (MLW) channel.

n. Shut-out draft is the difference between actual sailing draft and practical maximum operating draft.

o. Lightered tonnage is calculated by combining shut-out draft and vessel immersion factors from IWR/OCE data

p. Average actual tonnage carried is determined from the WCSC data base.

q. Tonnage carried to dock is equal to actual tonnage carried minus lightered tonnage.

r. Cost per net cargo ton is equal to total round trip cost divided by actual tonnage carried.

Transportation costs and transportation savings associated with each channel depth were summed and annualized for each trade route.

CRUDE OIL LESS THAN OR EQUAL TO 40 FOOT SAILING DRAFT. This analysis was conducted in basically a similar manner to the crude oil greater than 40 foot sailing draft analysis. However, a key difference is that tonnage expected to be carried by each vessel for each channel depth was predicted by a two-stage least squares multiple regression statistical model.

The very large tankers that are currently not lightering have made a decision to load to a sailing draft that assures that lightering is not required in the Delaware Bay (i.e., 40 feet or less). With a deeper channel, these vessels will carry increased tonnage as predicted by the statistical model and will increase their sailing draft to take advantage of the channel improvement (while assuring that lightering of the vessel is still not required).

Individual transportation cost models were developed for each design draft class for each trade route. These cost models estimated the cost per ton based on predicted tonnage from the statistical model for each channel depth. By combining commodity projections with the fleet distribution, estimates of the total transportation cost for each design draft class by trade route over the project life by decade were made. The impact of a fleet shift due to operational efficiencies as the channel is deepened was also investigated in the analysis, but not felt to be appropriate.

For each with-project condition, the average sailing tonnage was estimated using the two-stage least squares model to simulate how vessel operators are expected to change their operating practices for increases in channel depth. Estimated with-project sailing deadweight tonnages were used with the transportation cost model to estimate the average transportation costs per ton for each vessel draft class and channel depth for the trade routes.

IRON ORE. This analysis was conducted in a similar manner to the crude oil less than or equal to 40 foot sailing draft data base. For each with-project condition, the average sailing tonnage was estimated using the two-stage least squares model to simulate how vessel operators are expected to change their operating practices for increases in channel depth. A transportation cost model was generated for each vessel draft class and trade route.

SOUTH JERSEY PORT CORPORATION BENEFITS. Coordination with the SJPC port agency determined that two dry bulk commodities, export scrap to Turkey and

import coal from Colombia, could potentially benefit from a channel improvement in excess of forty feet extending to Beckett Street Terminal.

Individual transportation cost models were developed for appropriate design deadweight tonnage vessel class for these trade route. Ship operators are expected to continue to behave optimally by utilizing chartered vessel cargo carrying capacity to the maximum extent allowed by the channel as it is deepened, since these movements are only economical within a very small range of marginal costs. The cost models which were developed estimated the cost per ton for each channel depth. By combining commodity projections with the potential vessel classes, estimates of the total transportation costs for each design deadweight tonnage vessel class by trade route was made. The impact of a shift in the chartered vessels due to operational efficiencies as the channel is deepened was also incorporated into the analysis. Subtracting the total transportation costs of the with project channel depth from the total transportation costs for the without project channel depth results in savings from the more efficient movement of tonnage with the channel improvement.

SCRAP EXPORTS. The company exporting scrap through the SJPC terminal historically has moved tonnage to destinations such as Turkey, South Korea, Japan, Mexico, Brazil, Colombia, Venezuela, Peru, the Middle East, Europe, India, and Bangladesh.

Benefitting Trade Route (Turkey):

The Nemrut Bay, Turkey scrap trade route is the most likely to benefit from a deepening of the Delaware River channel for the depths evaluated. The raw scrap material is used in the production of steel in Turkey. The depth at the berth is reported to exceed 45 feet. Thus, the channel and berth depths will not act as a potential constraint at the Turkish end of the trade route. Three grades of scrap, shredded auto, the highest grade, and two lesser grades, in descending order, heavy melted steel one (HMS1) and heavy melted steel two (HMS2) are exported. Different grades are placed in different vessel compartments.

The exporting company has a 250 mile U.S. market area radius for the supplying of scrap to its facility in Camden, New Jerey. Most of this scrap is supplied by truck, although some is supplied by rail, and the remainder by 1500 DWT barges from Norfolk, Richmond, and Baltimore.

Beckett Street Terminal previously had a channel depth in the access channel of only 37 feet (MLW). This limited fully loaded vessels to the Handymax-size (40,000 DWT). Construction of a federal navigation project to a depth of 40 feet to be commensurate

with the current Delaware River main channel was accomplished in 1992. With a 40 foot (MLW) access channel to the terminal, the chartered vessels to Turkey are of the fully loaded Panamax size (50,000 DWT, 40 foot design draft). With a 45 foot (MLW) Delaware River channel and SJPC access channel, chartered vessels are projected to be of the "OBO"-class (oil, bulk, ore) with design drafts of 43.6 feet to 45.5 feet and design DWTs of 70,000 tons to 80,000 tons.

SJPC Transportation Cost Model-Scrap. The transportation cost model estimated the cost per ton for the without project condition depth of 40 feet (MLW) and the with project condition depth of 45 feet (MLW). The following design deadweight tonnage vessel classes were analyzed: 40,000, 50,000, 60,000, 70,000, 80,000, and 100,000. Vessel characteristics (design deadweight tonnage, design draft, immersion factor, length, operating cost at sea, operating cost in port, cruising speed at sea, and fuel allowance) were extracted from the IWR/OCE Vessel Operating Cost data. An allowance of one foot for freshwater draft was made. Haul distance was based on the publication, Distances Between Ports, Dept. of the Navy Oceanographic Office. Port charges were site specific. Tonnage carried for each depth netted out shutout tonnage based on the immersion factor and the allowance for fuel.

SJPC Transportation Savings Estimation Model-Scrap. The cost per ton for each considered vessel class, as determined using the transportation cost model, was transferred to the transportation savings estimation model for each channel depth. Currently, vessel movements for scrap exports from the SJPC Beckett Street Terminal to foreign ports, not including those with shallow depth constraints (such as the 30 foot port depth in India), are accomplished by chartering the most efficient vessel size that can operate within the constraints of the 40 foot (MLW) access channel to the SJPC terminal. The methodology used in the transportation savings estimation model anticipates that the most cost-efficient vessel class will continue to be chartered as the Delaware River main channel is deepened.

As determined by the transportation cost model evaluation, the 50,000 DWT Panamax-size vessel will be the most efficient vessel class at the 40 foot depth. At 45 feet, the 70,000 OBO-size (oil, bulk, ore) vessel class will be the most efficient.

COAL IMPORTS. Minor average annual benefits for imports of Colombian bituminous coal to the Philadelphia area through SJPC were also developed by applying comparable transportation costs and savings models as for scrap exports. A larger, more efficient vessel class will be chartered if the channel is deepened to 45 feet.

CONTAINER MOVEMENTS. The Delaware River Port Authority (DRPA) has provided significant data on container traffic and vessel movements which have been applied to quantify benefits for the proposed channel improvements.

Market Area. The ports of Philadelphia domestic market reach is concentrated within a radius of 300 miles, similar to New York's market. The main foreign trading partners of Philadelphia ports are Brazil and Argentina in South America, Australia and New Zealand and West Germany and the Netherlands in Europe. Landbridging to Canada has a bright future with the recent introduction of Canadian Pacific Railroad trackage into the intermodal transfer facility at Philadelphia via its newly acquired subsidiary, the Delaware and Hudson Railroad.

Regional Intermodal Container Transfer Facility. A major plan by DRPA to improve container trade through Philadelphia involved the opening of a rail intermodal yard at the Greenwich Rail terminal adjacent to the Packer Avenue Marine Terminal. The underlying purpose of the intermodal yard has been to open the high cargo-generating area of the Midwest to Philadelphia through efficient rail operations near the port area. Conrail and CSX have access to the yard, and the D&H Railway Division of Canadian Pacific Railways is also open to the reach of Philadelphia. The intermodal yard also opened up the West Coast market, as well as the possibilities of landbridging Pacific Rim-European trade. The railyard serves as the key component to attract container lines to use Philadelphia as their load-center port. The intermodal yard is also designed to handle double-stack trains.

Historic Container Vessel Data. Trade routes were identified which could benefit based on existing vessels and trends for use of larger, post-Panamax vessels in the future.

Trends In Vessel Sizes. Over the last several decades, changes in the size and carrying capacity of ocean-going vessels have generally been the precursor of major changes in port design and operations. Vessel development has gone through a step-wise progression of a sudden upsizing followed by a period of "copy cat" construction before the next upsizing occurred. Each upsizing represents a new generation of vessel which essentially defined the terminal operating requirements for the period. The first generation of vessel actually predates these statistics and involved vessels of less than 800 TEUs followed by a second generation of vessels averaging around 1200 TEUs. In 1970, the average size of container ships suddenly jumped to around 1800 TEUs. This third generation construction lasted for about 14 years before a fourth generation of vessel carrying 2500 TEUs was launched in 1983. It took only another five years for a fifth generation of container ship averaging 3200 TEUs to be launched in 1988.

The change in the average design draft of these same vessels for the same period indicates that the average draft of container ships, although holding relatively steady during the third generation construction period, has grown significantly recently. In fact, many of the latest constructions have design drafts exceeding the 40 foot limit of the Delaware River channel and if current trends hold, the average draft of most new container vessels will exceed this standard.

Future Vessel Dimensions. These trends indicate that container ship sizes will continue to expand. The results indicate that container ships built during the next decade will exceed 4000 TEUs. The projections are considered to be well within the range of ships that the ocean carriers themselves are presently ordering or intend to order.

As in the past, the successful introduction of a new generation of ship appears to have brought about a reconsideration of ship design and construction strategies by other ocean carriers which has set off a new wave of construction of vessels in the 3500 to 4500 TEU range. It appears that the industry during the next decade may be seeing upwards of fifty new vessels of >=4000 TEUs in size depending on the trade routes that they serve. There is also a distinct potential for post-Panamax vessels reaching 5000 TEUs to be constructed within five years if the markets continue to expand. The main limitation on vessel sizes even greater than 5000 TEUs appears to be at the ports regarding their ability to handle peak throughputs in a reasonable time frame.

Prospective Markets. The initial operating trade routes for fifth generation container ships will be the Far East/S.E. Asia to U.S. Pacific coast itinerary. This trade route represents the largest and fastest growing container market in the world.

Excluding cross-Pacific trades, it appears that the most promising market for the post-Panamax vessels will be the Far East/S.E. Asia/S. Asia-Europe trade route westward via the non-restricting Suez Canal and the Europe to U.S. East Coast trades. By extending the service itinerary to include the U.S. North Atlantic, the carriers can supplement their Europe-Asia trade with U.S. bound traffic from the Asian Region as well as from Europe itself.

This traffic is substantial.The container traffic between the North Atlantic and Europe/Asia historically has amounted to 16 million tons (1.5 million TEUs) per year. It can be assumed that with the economies of scale that these ships can achieve that an Asia/Europe/North Atlantic service may erode into this market. Many ocean carriers are reevaluating their service strategies and vessel configurations in light of these successes. Considering the volume of this trade, its high growth rate and the fact that most of the

ports on the route already are equipped with the extended outreach cranes, it is reasonable to anticipate that this trade route will become the principal cargo corridor via the Suez Canal for Asia/Europe/U.S. trade during the next decade and be dominated by vessels upward of 5,000 TEUs.

SUMMARY OF CONTAINER INDUSTRY TRENDS. This analysis indicates that the impacts on the ports from the next generation of container vessels will vary considerably according to the type of service for which it is being employed. The impact will be greatest in a port to port high volume service. The basic Panamax-oriented terminal operating systems at ports will have to be modified, particularly at the ship to shore interface, to be able to handle, in an economical time frame, the very high volume short-term throughput surges that these ships generate per call.

In the itinerary type service with multiple port calls, the impacts of these vessels, other than draft and crane outreach, will not be as great as in the port to port services. Because the loads are spread over multiple ports, the amount of container boxes that are moved in any one port tend to be within the current capabilities of the major container ports. However, because of the added cost of the additional port calls, the carriers will doubtless be seeking faster turn around times to keep these ships moving efficiently. Although the ports generally can meet most of the carriers current operational requirements, it is clear that as the trade grows and more of the smaller ships are replaced by next generation of ships, the throughput volumes will begin to reach the point where upgrades will have to take place.

RESULTS OF CONTAINER BENEFIT ANALYSIS. Data provided by the DRPA listed individual container movements by trade route for Delaware River container terminal facilities. Most of the trade routes for the potentially benefitting facilities were judged to not have any expectation to benefit from a deepening of the Delaware River channel beyond its current 40 foot depth, either because the vessels currently servicing the trade routes are of relatively small size and are easily accomodated with the current Delaware River channel depth, or vessel usage of the Panama Canal (and its resultant constraint) on the trade route will continue to preclude the potential for benefitting by use of larger post-Panamax vessels with a deeper Delaware River channel.

However, five trade routes were identified as potentially using post-Panamax size container vessels in the future.

The transportation cost model estimated the cost per ton for the 40 and 45 foot channel depths for each considered vessel class (i.e., the average for the existing vessels by trade route and the projected post-Panamax vessel classes). Ship operators are expected to

behave optimally by utilizing vessel cargo carrying capacity to the maximum extent allowed by the channel as it is deepened without use of the tide because of schedule considerations. The cost per ton for each considered vessel class applying the transportation cost model was then transferred to the transportation savings estimation model. The methodology for the latter model anticipates that more cost-efficient post-Panamax vessel classes for the five trade routes will be used in the future to take advantage of operating cost efficiencies if the Delaware River main channel is deepened.

SUMMARY OF PROJECT BENEFITS FOR ALL COMMODITIES

The estimation of benefits involved combining the transportation costs per ton by channel depth estimated for each pertinent vessel class by trade route by commodity with the annualized level of commodity projections. Benefits have been estimated for imported crude oil, imported iron ore, export scrap and import coal from SJPC's Beckett Street Terminal, and container movements.

TABLE 1 summarizes annualized transportation savings equal to $40,143,000.

TABLE 1
AVERAGE ANNUAL BENEFITS
(October 1996 Price Level, 7-3/8 Discount rate)

CARGO	BENEFIT
Crude Oil	$32,482,000
Scrap	$2,357,000
Iron Ore	$598,000
Coal Imports	$160,000
Containers	$4,546,000
TOTAL	**$40,143,000**

COST ANNUALIZATION AND BENEFIT-COST RESULTS

TABLE 2 presents the cost annualization and benefit-cost results for the deepening from 40 to 45 feet. The benefit-cost ratio is equal to 1.4, and net benefits are equal to $11,363,000. Interest during construction was calculated using a schedule defining costs, by individual year over the total construction period, broken out by individual cost category. The Single Payment Compound Amount Factor was applied to bring costs for each individual year forward to the project base year in order to place costs on an equal basis with the annualized project benefits.

TABLE 2
ANNUALIZATION OF PROJECT COST
(BENEFIT-COST SUMMARY)
October 1996 Price Level- Discount Rate 7-3/8%

Construction Year	Description	Cost	Present Worth Factor	Present Worth Cost
1	Project Cost	$71,262,000	1.282806	$91,415,350
2	Project Cost	$69,894,000	1.194697	$83,502,185
3	Project Cost	$87,630,000	1.112640	$97,500,665
4	Project Cost	$15,886,000	1.036219	$16,461,376
1	Real Estate	$18,598,000	1.000000	$18,598,000
4	Navigation Aids	$946,000	1.036219	$980,263
4	Associated Costs	$22,079,000	1.000000	$22,079,000
1	PED Costs	$10,000,000	1.329268	$13,292,685
TOTAL ECONOMIC COST				$343,829,524
TOTAL PRESENT WORTH - WITHOUT INTEREST DURING CONSTRUCTION (IDC) CRF (50 Years, 7.375%) -0.075913				$296,295,000
AVERAGE ANNUAL COSTS(ECONOMIC COST & IDC)				$26,101,000
AVERAGE ANNUAL INCREMENTAL OPERATION & MAINTENANCE COSTS				$2,679,000
TOTAL AVERAGE ANNUAL COSTS				$28,780,000
TOTAL AVERAGE ANNUAL BENEFITS				$40,143,000
NET BENEFITS				$11,363,000
BENEFIT TO COST RATIO				1.4

MULTIPORT ANALYSIS

The analysis concluded that deepening the Delaware River main channel would not divert traffic from the competing ports. The current depths at New York, Baltimore, and Norfolk/Hampton Roads are sufficient to ensure that deepening from 40 feet to a channel depth of 45 foot Delaware River channel would not generate waterborne transportation cost savings significant enough to shift shipping patterns.