FEASIBILITY REPORT

for

New York and New Jersey Harbor Navigation Study

VOLUME II

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Plan Formulation

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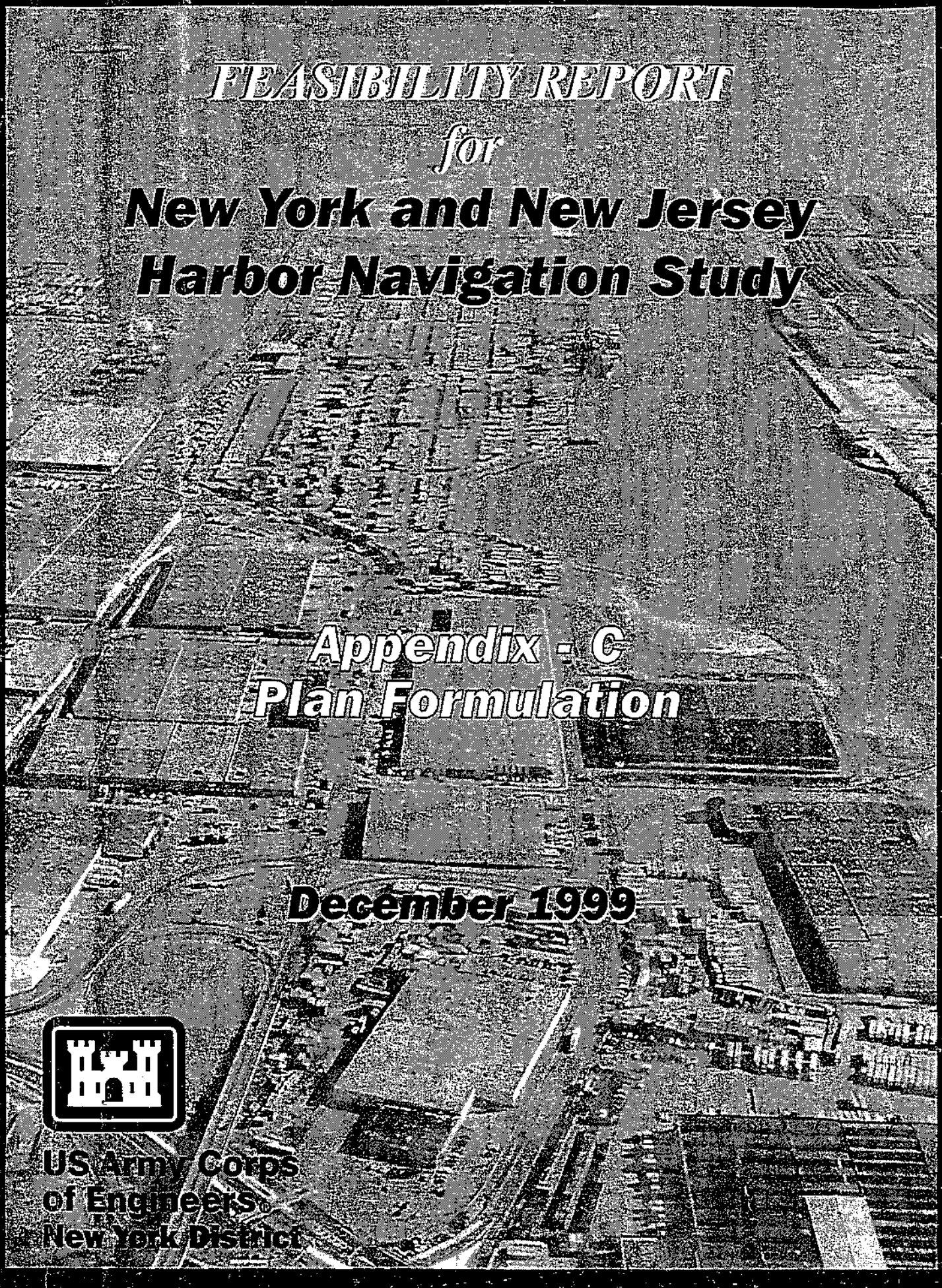
December 1999

US Army Corps
of Engineers
New York District



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for
New York and New Jersey Harbor Navigation Study

Appendix - C
Plan Formulation

December 1999

US Army Corps
of Engineers
New York District

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Glossary

Authorized Depth.....The excavated depth. In areas of rock or hard bottoms this depth is 2 feet deeper than maintained depth.

Base Year.....The first year of the project period of analysis. The base year for this report is 2010.

Berth.....The water area, at the waterfront edge of a wharf, reserved for a vessel. The term is sometimes used to refer to the dock or wharf structure.

Break-Bulk Cargo.....General cargo, conventionally stevedored and stowed (palleted or sling), as opposed to bulk or containerized cargo.

Bulk Cargo.....Usually a homogenous raw material shipped in shipload lots, *e.g.* scrap metal, grain, chemicals, petroleum products. Usually differentiated by dry and liquid bulk.

Containerized Cargo.....Cargo transported in boxes (containers) that are constructed with varying dimensions and to withstand transportation stresses.

Draft.....The depth of a vessel in the water.

Draft, Sailing.....The draft of a vessel taking in to account environmental and physical factors (*e.g.*, squat, trim, salinity).

Draft, Static.....The dead weight, design draft of a vessel.

Equimarginal Analysis.....A foot-by-foot of channel depth analysis of commodity flows, based on forecast fleet distributions, predicted vessel loading, terminal capacities, etc.

Excavated Depth.....This is the target, or minimum, depth of initial construction dredging. To provide added safety clearance, this depth is 2 ft deeper than maintained depth in areas of rock and hard bottom.

Float Bridge.....(Rail) A barge fitted with railroad tracks used for the transportation of rail cars across a waterway.

Glossary

Geologic Volume.....The volume of in situ material to be dredged.

Harbor.....Short for "New York and New Jersey Harbor"; this refers to the waterways in the analysis. However, it may be used interchangeably with the Port.

Hinterland.....Interior origins and destinations for commodities passing through the Port.

Land-side Improvements.....Improvements occurring on a terminal or facility adjacent to the waterway (as opposed to inland – away from the water).

Lift.....The movement of one container to or from a containership.

Macroeconomic Analysis.....The economics of aggregate income, output and employment.

Maintained Depth.....The depth of a channel maintained by operation and maintenance dredging.

Neo-bulk.....Used to refer to processed or manufactured goods that move by ship-lot lots, such as automobiles or lumber.

Overdredge Depth.....The maximum additional depth of a channel beyond excavated depth allowed by permit to account for dredging equipment inaccuracy. In order to assure that the excavated depth is achieved, contractors tend to dredge beyond the excavated depth. This additional depth is routinely permitted to vary up to an additional 2 feet from the excavated depth, depending on the type of dredged material and dredging method used. The contractor is not paid for this additional volume.

Port.....Short for "The Port of New York and New Jersey", this refers to the land-side facilities, operations, etc. in the analysis. However, it may be used interchangeably with the Harbor.

Post-Panamax Vessel.....Refers to a vessel too large to navigate the Panama Canal. The beam width is greater than 113 ft (34.5 m).

Glossary

Shoaling .....In terms of dredging, the deposition of sediments in a channel following dredging.

TEU.....Twenty-foot Equivalent Unit. In the current analysis, the ratio of TEU's to lifts is 1.7 to 1.

Water-side Improvements.....Improvements occurring in the water (*e.g.*, channel deepening, widening, etc.).

INTRODUCTION

Study Authority

C1. The New York District, U.S. Army Corps of Engineers (the District) has been authorized to conduct a feasibility study to evaluate Federal participation in navigation improvements in New York and New Jersey Harbor (the Harbor). The feasibility study was authorized by Section 435 of the Water Resources Development Act of 1996, which reads:

> *The Secretary shall conduct a comprehensive study of navigation needs at the Port of New York-New Jersey (including the South Brooklyn Marine and Red Hook Container Terminals, Staten Island, and adjacent areas) to address improvements, including deepening of existing channels to depths of 50 feet or greater, that are required to provide economically efficient and environmentally sound navigation to meet current and future requirements.*

C2. Figure 1 depicts the location of the study area, the existing terminals, and the channels that are the subject of this study.

Scope of Study

C3. The purpose of the New York and New Jersey Harbor Navigation Feasibility Study is to identify, screen, evaluate, and recommend a plan for channel improvements throughout the Port of New York and New Jersey (the Port). Channel improvement (*e.g.*, construction, deepening, widening, realignment, etc.) is an action that can be taken to meet the changing trend toward larger cargo vessels in the world's fleet. The investigation considers the following channels: Ambrose, Anchorage, Bay Ridge, Red Hook, Buttermilk, the Kill Van Kull, Claremont, Port Jersey, Newark Bay (including the Elizabeth and South Elizabeth Channels), and the Arthur Kill to Gulfport, as well as the anchorage areas at Stapleton, Red Hook Flats, and Gravesend Bay. Alternatives were selected for detailed study on the basis of estimated costs and benefits of the proposed navigation improvements. The basic premise of the formulation effort is that deeper channels will allow goods to move through the Harbor on the larger, more efficient vessels now entering the world fleet. The transportation cost savings associated with the more efficient vessels represents a benefit to the National Economic Development (NED) Account. Projected increases in trade used to analyze the transportation cost savings over the 50-year planning horizon are derived from macroeconomic theory whereby growth in trade is forecast on the basis of projected growth in worldwide population and income. Thus, the projected growth in trade is independent of changes in channel depth and the benefits derived do not imply any channel depth-induced growth in commerce, but rather merely reflect the transportation cost savings associated with moving the same forecast volume of goods on fewer, larger vessels. Benefits used to evaluate alternatives

considered in the study are constrained by existing and foreseeable near-term terminal capacity even when allowing for some reasonable increases in operating efficiency.

C4. A Final Environmental Impact Statement (FEIS) was prepared according to the National Environmental Policy Act (NEPA). The FEIS presents project alternatives, documented baseline conditions, and identifies direct, indirect, and cumulative impacts that are expected to result from plan implementation. For those impacts determined to be unavoidable, a mitigation plan is prepared. The FEIS, however, is limited only to the impacts associated with deepening the Harbor.

C5. There is a realization on the part of the Port stakeholders that terminal capacity will be insufficient to handle all the future cargo demand. This increased cargo demand is projected to stem from growth in worldwide population and income and is independent of any plans for further deepening of the Harbor's channels. Wishing to maximize their market share, the non-Federal partners have presented a vision of facility expansions described later in this report that is not considered as part of the Without-Project Condition used in the benefit analysis. In the past, such Port improvement plans have been evaluated individually. A copy of the MOU is provided in Appendix B-1.8 of the FEIS. The version provided contains the signatures of the parties as of the printing of this report. The CPIP's accompanying EIS will be the vehicle to address the environmental impacts related to further expansion of the Port's terminals.

Channels and Appurtenant Terminals

C6. The study area was divided into "pathways" (*i.e.*, a series of channels or channel segments) leading to the existing and proposed Port facilities in order to facilitate the formulation and analyses of alternatives. Alternatives considered involved each of the pathways at various depths and in various combinations with one another. Approved or planned terminal modifications or expansions were taken into consideration and a determination was made as to whether they should be included in the analysis or not, based on data provided by the Port Authority of New York and New Jersey (PANYNJ), the states of New York and New Jersey, and the City of New York. The designated pathways, all of which have Ambrose Channel and sections of the Anchorage Channel as common elements, are:

- Pathway 1 Kill Van Kull to Newark Bay to Elizabeth and South Elizabeth Channels;
- Pathway 2 Kill Van Kull to the Arthur Kill to Howland Hook;
- Pathway 3 Kill Van Kull to the Arthur Kill to Gulfport (at tanker design depth);
- Pathway 4 Port Jersey Channel to Port Jersey and the former Military Ocean Terminal at Bayonne (MOTBY);

- Pathway 5 Bay Ridge Channel to South Brooklyn;
- Pathway 5A Bay Ridge, Red Hook, Buttermilk Channels to Red Hook Marine Terminal;
- Pathway 6 Stapleton, Gravesend Bay, and Red Hook Flats anchorages, for container vessels;
- Pathway 7 Stapleton, Gravesend Bay, and Red Hook Flats anchorages, for tankers;
- Pathway 8 Claremont Channel to Claremont Terminal.

C7. In addition to the listed Pathways, two other structural alternatives were considered. One was the Bayonne-Newark Bay Canal, which would have extended the Port Jersey Channel through the Bayonne Peninsula to Newark Bay. The other was an off-shore structure that would have served as both a marine terminal and a dredged material placement facility. Both of these ideas were dismissed early in the planning process at the direction of the non-Federal partners.

Channel Depth

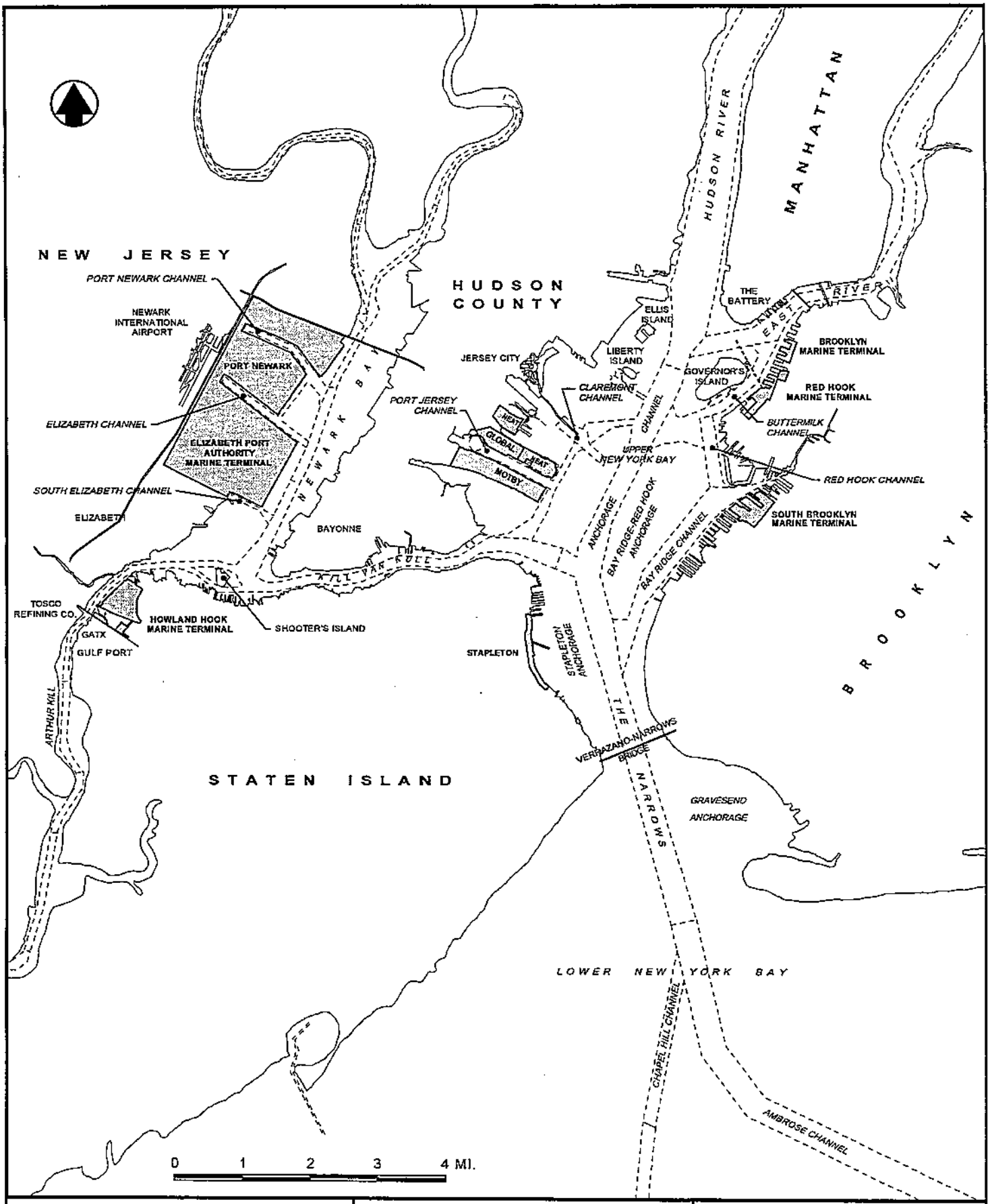
C8. A majority of the channels under consideration as part of this study already are, or soon will be Federally-maintained navigation channels. For the purpose of formulating further Harbor deepening, the previously authorized depths, where supported as necessary by favorable reports, have been considered as the baseline (*i.e.*, without-project conditions) for this study. Table 1 summarizes the baseline depths used in the formulation process.

TABLE 1 Baseline Channel Depths		
Channel Name		Depth (ft MLW)
Ambrose		45[1]
Anchorage		45[1]
Bay Ridge		40
Kill Van Kull		45[2]
Newark Bay		45[2]
Arthur Kill (to Howland Hook)		41[3]
Arthur Kill (from Howland Hook to Gulfport)		40[3]
Port Jersey		41[4]
Claremont		15-30+[5]
New Jersey Pierhead		20
Anchorages	Stapleton	33-70+
	Gravesend Bay	47
	Red Hook Flats	35-45

1 Authorized to 55 ft but is subject to a favorable report not pursued.
2 Channel is currently 40 ft. Construction has been initiated on the 45ft channel.
3 Channel is currently 35 ft. Construction to 41/40ft has been authorized. Awaiting construction appropriations.
4 Channel is not currently a federal channel. Federalization and deepening of the channel has been authorized. Awaiting construction appropriations.
5 Channel is not a federal channel and is not federally maintained.

Terminals

C9. The study considers the cargo throughput capacity for container terminals and oil terminals that exist, are to be expanded, or will be developed within the Port. The relevant container terminals are: Port Newark and the Elizabeth Port Authority Marine Terminal (together known as Port Newark/Elizabeth Marine Terminal) in New Jersey; Howland Hook Marine Terminal in Staten Island, New York; Port Jersey Peninsula, New Jersey, including both the Global Marine Terminal and the Northeast Auto Terminal (NEAT); the proposed conversion of the Military Ocean Terminal at Bayonne (MOTBY), New Jersey; and a proposed redevelopment of marine terminal facilities in South Brooklyn, New York, (from 29th Street to 65th Street). The Red Hook Container Terminal in the Red Hook section of Brooklyn is included in the Existing Condition Analysis, however, the non-Federal partners have indicated that the terminal will be phased out of container operations by approximately the year 2010 when its operations move to South Brooklyn. The non-Federal partners have also indicated there is no present intention to develop the Stapleton area on Staten Island as a container terminal due to the relatively high development costs and the lack of suitable land-side transportation infrastructure. There are two relevant petroleum facilities, TOSCO and GATX. These existing facilities are located along the Gulfport Reach of the Arthur Kill.



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CORPS OF ENGINEERS
NEW YORK, NEW YORK

NEW YORK & NEW JERSEY HARBOR NAVIGATION STUDY PLAN FORMULATION

FIGURE 1

LOCATION OF STUDY AREA

Inland Infrastructure

C10. It is important to determine whether or not the inland infrastructure (*i.e.*, highways, arterial roadways, railroads and off-port intermodal terminals) will be adequate to accommodate the cargo loaded and unloaded from vessels calling on the Port in the future. The project is not expected to induce commerce into the area beyond that which is forecast to occur without project implementation. Accordingly, it is anticipated that the intermodal transportation network capacity will keep pace with the projected Port growth. Thus, the inland transportation infrastructure will not constrain the realization of the potential benefits nor will improvements to it represent project costs. The inland transportation network is expected to grow independent of Harbor deepening, therefore, no additional analysis of inland infrastructure capacity was warranted.

Study Participants and Coordination

C11. The New York District Engineer is responsible for conducting the overall study in cooperation with the New York and New Jersey Harbor Navigation Study Executive Committee comprised of representatives from the non-Federal partners (the State of New York, assisted by the City of New York, the State of New Jersey, and the Port Authority of New York and New Jersey). The non-Federal partners collectively are contributing one-half the Feasibility Study costs in cash or in-kind services. Agreed to in-kind services include providing engineering, cost, and environmental information about planned land-side terminals and improvements, as well as berthing areas, and the upland environmental analysis.

C12. There are a number of agencies involved in the study process. The U.S. Environmental Protection Agency (EPA), the Federal Highway Administration, and National Marine Fisheries Service are serving as cooperating agencies in the National Environmental Policy Act (NEPA) process. As part of a public outreach program, the District formed an advisory group comprised of business and labor interests as well as citizens' groups. The District briefed the group at important points including the public scoping and the completion of the Alternative Formulation Briefing (AFB). Due to the complexity of the study and its fast pace, the District formed several workgroups to assist the District in completing this study. Participants of each workgroup came from each of the partners' organizations or the various resource agencies. The four major workgroups are in the following technical areas: Environmental, Engineering, Economics, and Infrastructure/Formulation. Ongoing meetings kept the workgroups abreast of the study progress. The workgroups input was invaluable in providing technical information, voicing environmental concerns, and ultimately in helping to steer the formulation process.

Desires of the Non-Federal Partners and Stakeholders

C13. The legislation authorizing the study is quite broad. The study has been limited to areas where requests for improvement have been voiced by the non-Federal partners during the reconnaissance phase and where such requests have a plausible basis in terms of engineering, environmental impact and economic return. In addition, other study authorities were considered in scoping the extent of this investigation.

Previous and Ongoing Studies

C14. Though this study is the first comprehensive Port-wide study of the New York and New Jersey Harbor, a number of reports have been previously prepared by the Army Corps of Engineers concerning the need for navigation channel and anchorage improvements in the study area. Some of the recommended projects have been authorized by Congress. Some of the authorized projects are complete, some are on hold, and still others are underway. Tables 2 and 3 list the previous authorizations and Federal reports addressing the Harbor.

TABLE 2
Prior Pertinent Authorizations
New York and New Jersey Harbor

Approving Legislation or Authority for Project Construction	Remarks
Ambrose & Anchorage Channels	
River and Harbor Act 5 August 1886	Authorized deepening Gedney and Main Ship Channels to the Narrows through Sandy Hook Bar to 30 feet deep and 1000 feet wide.
River and Harbor Act 3 June 1896	Authorized improvement of Gedney and Main Ship Channels to a depth of 35 feet and 1000 feet wide to the Narrows.
River and Harbor Act 3 March 1899	Authorized construction of a channel 35 ft deep, to be ultimately deepened to 40 ft and 2000 ft wide from the Narrows to the sea through East (Ambrose) Channel.
River and Harbor Act 8 August 1917	Authorized extending project of 1899 to include improvement of Anchorage Channel in Upper Bay to the same dimensions as Ambrose.
River and Harbor Act 8 August 1917	Authorized removal of Craven Shoal in the Lower Bay.
River and Harbor Act 3 July 1930	Authorized relocation of southerly section of Anchorage Channel.

TABLE 2 Prior Pertinent Authorizations New York and New Jersey Harbor	
Approving Legislation or Authority for Project Construction	**Remarks**
Ambrose & Anchorage Channels (con't)	
River and Harbor Act 26 August 1937	Authorized modification of existing Ambrose and Anchorage Channels to provide a channel 2000 feet wide, suitably widened at bends, 45 feet deep from the Atlantic Ocean to West 40th Street Manhattan, thence 48 feet to West 59th Street.
Section 201(b) of the Water Resources Development Act of 1986	Authorized deepening Ambrose Channel to a depth of 55 ft MLW, 770 ft wide; and deepening Anchorage Channel to a depth of 55 ft MLW, 660 ft wide, subject to a favorable report by the Chief of Engineers.
Kill Van Kull and Arthur Kill to Gulfport Reach	
River and Harbor Act 23 August 1874	Original project for a "channel between Staten Island and New Jersey", 150 feet wide, 16 feet deep.
River and Harbor Act 14 August 1876	Indicated that improvements recommended in 1873 and actually commenced in 1874 were no longer necessary and that a channel 11 feet deep and 500 feet wide would serve tows and sailing vessels most expeditiously.
River and Harbor Act 13 June 1902	Recommended a channel between New York and New Jersey passing south of Shooter's Island, 21 feet deep and 300 feet wide except at turns where width would be 400 feet.
River and Harbor Act 25 June 1910	Authorized channel north of Shooter's Island 1 mile long, 300 feet wide, 16 feet deep.
River and Harbor Act 22 September 1922	The original project for "New York and New Jersey Channels", provided for a channel 400 feet wide and 30 feet deep.
River and Harbor Act 30 August 1935	Provided for present project depth of 35 feet and channel 600-800 feet wide.
River and Harbor Act 27 October 1965	Provided for widening and deepening entrance to Kill Van Kull at Robbin's Reef at a 35 foot depth.
Section 202 of the Water Resources Development Act of 1986	Authorized deepening the Kill Van Kull to 45 feet MLW from deep water in the upper New York Bay to its junction with the Newark Bay Channels and the Arthur Kill Channel. (Also authorized deepening the Newark Bay Main and Pierhead Channels to 45 feet.)
Section 301(a)(12) of the Water Resources Development Act of 1996	Re-authorized the 45-foot project in the Kill Van Kull and Newark Bay at a higher cost in accordance with Section 902 cap procedures.
Section 202(b) of the Water Resources Development Act of 1986, subject to a Secretary of the Army Report	Authorized deepening the 35-foot Arthur Kill Channel to 41-foot MLW from its confluence with the Kill Van Kull and Newark Bay Channels in the vicinity of Shooter's Island westward to Howland Hook Marine Terminal in Staten Island. The legislation also authorizes a 40-foot deep channel to extend south to the Gulfport Reach.

TABLE 2 Prior Pertinent Authorizations New York and New Jersey Harbor	
Approving Legislation or Authority for Project Construction	**Remarks**
Kill Van Kull and Arthur Kill to Gulfport Reach (con't)	
Section 301b of the Water Resources Development Act of 1996	Authorized a further deepening of the Arthur Kill to Gulfport not to exceed 45-foot MLW.
Water Resources Development Act of 1999	Re-authorized deepening of the Arthur Kill to Howland Hook to 41 ft MLW and 40 MLW to Gulfport in accordance with the 23 July 1999 report.
Newark Bay	
River and Harbor Act 13 June 1902	Provided for a 12-foot deep channel, 200 feet wide on the main axis of Newark Bay.
River and Harbor Act 2 March 1907	Provided for a 20-foot deep channel, 300 feet wide on the main axis of Newark Bay.
River and Harbor Act 24 November 1915	Recommended 400-foot wide channels 20 feet deep in Newark Bay main channels and extending to Port Newark pierhead lines.
River and Harbor Act 22 September 1922	Authorized 30-foot channel in Newark Bay and 30-foot channel in Hackensack River below Central R.R. of NJ Bridge.
Rivers and Harbor Act 2 March 1945	Authorized a 35-foot, 400-foot wide project in the main channel of Newark Bay and the branch channel and inshore channel at Port Newark, along with removal of a portion of rock area at Bergen Point.
River and Harbor Act 23 October 1962	The Act modified the existing Federal project for Newark Bay, Hackensack and Passaic Rivers. The Chief of Engineers in a report to the Secretary of the Army, dated 29 November 1963, concurred with the views of the Board of Engineers for Rivers and Harbors and recommended modification of the existing project for Federal maintenance after non-Federal construction to a depth of 35 feet of: Port Elizabeth Branch Channel, 500 to 950 feet wide and 3,500 feet long from the junction with the existing 400-foot channel in Newark Bay to Port Elizabeth Inshore Channel; Port Elizabeth South Branch Channel to the Port Elizabeth East and South Channels, minimum width of 550 ft and 1,250 ft long from the junction with the 400-ft channel in Newark Bay to Port Elizabeth; Port Elizabeth Inshore Channel to Port Elizabeth and Port Newark, 500 ft wide and 5,250 ft long; Port Newark East Channel connecting Port Elizabeth and Port Newark Branch Channels, 200 ft wide and 4,150 ft long; Port Elizabeth East Channel 200 ft wide and 3,750 ft long; Port Elizabeth So Channel, 200 ft wide and 3,100 ft long; subject to certain conditions of cooperation.

TABLE 2 Prior Pertinent Authorizations New York and New Jersey Harbor	
Approving Legislation or Authority for Project Construction	**Remarks**
Newark Bay (con't)	
River and Harbor Act 7 November 1966	Authorized: a. Widening 35-foot main channel from Port Newark Branch Channel South, from 550 and 400 feet to 700 feet. b. Provision of maneuvering area south of the Central Railroad of NJ Bridge with a width of 300 feet and an effective length of 2,200 feet, of which the southern half would be 38 feet deep at MLW and the northern half 35 feet deep at MLW. c. Provision of maneuvering area north of the Central Railroad of NJ Bridge with a width of 300 feet, an effective length of 2,200 feet and a depth of 35 feet at MLW. d. Widening of the entrance into Port Elizabeth Branch Channel to 1,050 feet with additional removal of 250 feet of the north corner. Also, widening of the entrance into Port Newark Branch Channel to 800 feet. e. Deepening 32 foot main channel, north of Port Newark Branch Channel to the junction of Hackensack and Passaic Rivers, to 35 feet at mean low water and widening from 400 feet to 500 feet. f. Provision of turning basin 35 feet deep at MLW, 1,300 feet long and 900 feet wide at junction of Hackensack and Passaic Rivers.
Chief of Engineers on 2 June 1972 under discretionary authority contained in H.D. 494, 89th Cong., 2nd Session	Authorized modification for widening and deepening of private construction plans for service channel and turning areas adjacent to Port Elizabeth which base plans had been authorized for Federal maintenance after private construction.
Chief of Engineers on 28 May 1975 under discretionary authority contained in H.D. 494, 89th Cong., 2nd Session	Authorized the eastern entrance apron to the 30-foot South of Shooters Island Channel, hitherto included in the Federal project "NY and NJ Channels" to be included in the Federal project "Newark Bay, Hackensack and Passaic Rivers, NJ" at an improved depth of 35 feet to facilitate vessels turning into the Newark Bay Channels.
Chief of Engineers on 28 April 1975 under authority contained in H.D. 494, 89th Cong., 2nd Session	On 3 September 1974, Port Authority of NY and NJ indicated inability to procure reasonable bids for dredging Port Elizabeth Pierhead Channels and maneuvering areas thereto. This work, once privately constructed, was authorized for Federal maintenance under the River and Harbor Act of 23 October 1972. Port Authority requested such work be accomplished by Federal Government during next maintenance at Newark Bay Channels with Port Authority funding new portion. Subsequent to NY District letter report on matter, Chief of Engineers approved plan.
Section 202a of the Water Resources Development Act of 1986	Authorized deepening the 35-foot deep Newark Bay Main, Port Newark, Port Elizabeth, Port Newark Pierhead, and South Elizabeth Channels, all to 45 feet MLW. A turning basin off the Elizabeth Pierhead Channel was also approved. Removal of debris of the Central Railroad Bridge to 1,000 feet was also authorized. (Also authorized deepening the Kill Van Kull feeder Channel to 45 feet.)

TABLE 2
Prior Pertinent Authorizations
New York and New Jersey Harbor

Approving Legislation or Authority for Project Construction	Remarks
Newark Bay (con't)	
Section 301(a)(12) of the Water Resources Development Act of 1996	Re-authorized the 45-foot Kill Van Kull and Newark Bay Channels project at a higher cost in accordance with Section 902 cap procedures.
Anchorage Areas	
River and Harbor Act 30August 1935	Authorized dredging the southern end of Red Hook Flats to 40 feet and the remaining area south of the fairway to 30 feet. Also authorized dredging Liberty Island Anchorage and New Jersey Pierhead Channel to 20 feet deep, the latter being generally 500 feet wide.
River and Harbor Act 26 August 1937	Authorized modification of existing Ambrose and Anchorage Channels to 2000-foot width, 45 foot depth. Defined edge of Red Hook Anchorage Area.
River and Harbor Act 22 March 1962	Authorized widening Buttermilk Channel, which decreased available space in Red Hook Anchorage.
River and Harbor Act 27 October 1965	Authorized deepening Red Hook Flats (Anchorage 21) to 45 feet deep in the southern area, 40 feet deep in the middle section, and 35 feet deep in the northern section. Also authorized deepening Gravesend Bay to 47 feet deep.
Chief of Engineers Discretionary authority Contained in S.D. 17	Authorized expanding Red Hook Anchorage 200 yards to the west by shifting the Anchorage Channel 200 yards to the west.
Brooklyn Channel	
River and Harbor Act 3 March 1899	Authorized a channel 40 feet deep and 1,200 feet wide in the Bay Ridge and Red Hook Channels, NY.
River and Harbor Act 13 June 1902	Authorized a channel 1,200 feet wide and not less than 30 feet deep in Buttermilk Channel, NY
River and Harbor Act 2 March 1907	Authorized dredging Bay Ridge and Red Hook Channels to first 35 feet, then to 40 feet.
River and Harbor Act 3 July 1930	Authorized widening Bay Ridge Channel, up to 1,780 feet.
River and Harbor Act 30 August 1935	Authorized a channel 40 feet deep, 500 feet wide on the easterly side of Buttermilk Channel.
River and Harbor and Flood Control Act 23 October 1962	Authorized a channel 35 feet deep, 500 feet wide on the westerly side of Buttermilk Channel.
Port Jersey Channel	
Water Resource Development Act 17 October 1986	Authorized deepening the existing 35 ft MLW channel to a depth of 45 feet and a width of 450 feet, subject to a favorable report of the Chief of Engineers. The Chief of Engineers draft report recommended a channel 41 feet deep.
Water Resource Development Act of 1999	Re-authorized deepening the existing 35 ft MLW channel to a depth of 41 feet in accordance with the Chief of Engineers report.

TABLE 2 Prior Pertinent Authorizations New York and New Jersey Harbor	
Approving Legislation or Authority for Project Construction	**Remarks**
Claremont	
Water Resource Development Act 17 October 1986	Authorized deepening the existing 27-foot natural channel at a depth of 42 feet and a width of 300 feet, subject to a favorable report of the Chief of Engineers. The Chief of Engineers report recommended a channel 34 ft deep and 1,250 ft wide.

TABLE 3 Prior Pertinent Reports New York & New Jersey Harbor	
Where Published	**Remarks**
Ambrose & Anchorage Channels	
District Engineer Reconnaissance Report February 1944	A reconnaissance report was produced for deepening Ambrose and Anchorage Channels, waterfront to Stapleton and the Channel to Port Jersey for deep coal and oil shipments. This study subsequently went negative as coal plans for the Port were dropped.
Kill Van Kull and Arthur Kill to Gulfport Reach	
Waterways Experiment Station U.S. Army Corps December 1967 – Hydraulic model	Investigation into the effects of the removal of Shooters Island and shore modifications on tides, currents, & shoaling in the Kill channels. Study noted no detrimental effects..
District Engineer New York 21 September 1973	Investigation into deepening and widening NY and NJ Channels in response to House Committee on Public Works Resolutions 30 March 1955, and 27 June 1956 resulted in negative report.
District Engineer February 1979 – Report to Congress	Investigation into the impacts caused by the removal of Shooters Island; noted a lack of economic justification and significant potential environmental impacts. Chief of Engineers recommended 6 August 1979 that no Federal funds be provided.
District Engineer July 1980 – Survey Report	Investigation into deepening and widening Kill Van Kull and Newark Bay in response to House Committee on Public Works Resolution dated 14 June 1972. Currently under review by the Office of Management and Budget.
District Engineer Limited Re-Evaluation Report (LRR) December 1997	Re-engineered 45-foot project in the Kill Van Kull and Newark Bay Channels, found cost to be within 1996 authorized cap. This report re-analyzed the 41-foot and 40-foot channels authorized in 1980 and determined an accurate estimate of cost further breaks the "Maximum Cost of Project" Section 902 cap; both the 1986 and the 1996 authorizations require re-authorization by Congress. The report has been transmitted enroute to Congress.
Newark Bay	
H.D. 80, 61st Cong., 1st Session	Recommended against further improvements in Newark Bay as requested by private interests.
H.D. 1076, 62nd Cong., 3rd Session	Favorably reported on preliminary feasibility of a 30-foot channel in Newark Bay.

TABLE 3 Prior Pertinent Reports New York & New Jersey Harbor	
Where Published	**Remarks**
Newark Bay (con't)	
Not Published	Conducted in response to House Committee on Rivers and Harbors Resolution 12 February 1929, requesting a review of H.D. 206, 67th Cong., 2nd session with a view toward determining whether any modification to existing project was justified. Chief of Engineers in report to Congress 10 December 1930, recommended no change to project.
Not Published	Conducted in response to House Committee on Rivers and Harbors Resolution 21 May 1928, requesting a review of H.D. 206, 67th Cong., 2nd session with a view toward determining whether any modification to existing project to provide anchorage ground was justified. Chief of Engineers, in a report to the Secretary of War 9 December 1931 recommended against creation of anchorage grounds in the vicinity of Port Newark.
District Engineer Limited Re-evaluation Report December 1997	Re-engineered 45-foot Kill Van Kull and Newark Bay Channels project for construction, found cost to be within 1996 authorized cost cap.
Port Jersey Channel	
None	Original 35-foot commercial channel built and maintained by non-Federal commercial interests.
District Engineer Survey Report May 1997	This document summarized the status and findings of previous studies.
District Engineer General Re-evaluation Report (GRR) dated January 1998	The January 1998 GRR confirmed that a 41-foot deep MLW channel, as recommended in the Report of the Chief of Engineers of July 7, 1998, is justified on economic, environmental, and engineering grounds. The Report further found that an accurate estimate of project cost for a 41-foot MLW project exceeded the "maximum Cost of Project" as defined by Section 902.
Anchorage Areas	
District Engineer Reconnaissance Report January 1994	Determined that deepening Harbor Anchorages to 45 feet in expanded areas was feasible. Feasibility Report to follow.

C15. The three Federal studies described below are particularly germane to this study.

New York Anchorages Study

C16. A previous study, the New York Anchorages Study, authorized by a resolution of the Senate Committee on Environment and Public Works adopted December 5, 1980, was funded by Congress to investigate the feasibility of providing a deep water anchorage area in the Upper and Lower Harbor. A favorable reconnaissance report was

completed under that authority in January 1994, finding that deepening of the anchorages warranted further study. Accordingly, further study of the anchorages was included in the overall scope of this effort as well as an independent study under its own authority. Under this study, the anchorages are considered as part of an overall navigation system. Under the independent authority, they will be examined as an independent solution.

Study of the Arthur Kill South of the Gulfport Reach

C17. This section of the Arthur Kill was not originally in this study. Upon initiation of this study, local interests expressed an interest in extending the study area south of the Gulfport Reach. However, it was determined that expansion of this study could delay its completion. As a result, it was deemed that a separate study was warranted. A resolution authorizing a study of further deepening of the Arthur Kill south of the Gulfport Reach (sometimes referred to as, "the Arthur Kill Extension") was passed by the House of Representatives Committee on Transportation and Infrastructure on 6 May 1998. The study was included in the FY99 budget and examined the potential for deepening the Arthur Kill from Morses Creek (just south of the Gulfport Reach) to Perth Amboy, New Jersey. The reconnaissance level examination determined that further Federal interest was not warranted. The results of this study have been documented in an internal Corps of Engineers report, which is under coordination.

Dredged Material Management Plan (DMMP) for the Port of NY and NJ

C18. The DMMP for New York and New Jersey was initiated pursuant to Corps of Engineers policy as contained in Engineering Circular (EC) 1165-2-200, which requires each District to prepare a long-term plan (not less than 20 years) for maintaining Federal navigation channels. The study emphasizes the dual imperative of economically dredging the naturally shallow Port, and implementing environmentally suitable and cost-effective alternatives to the historic practice of ocean placement of dredged material at the Historic Area Remediation Site (HARS). The DMMP and its draft EIS are currently out for public review and will serve as the vehicle for identifying placement options for this navigation study. Accordingly, this study does not contain dredge material studies of its own, other than geotechnical characterization of the material to be dredged.

C19. The following three non-Federal studies described below are also germane to this study.

Port Authority of New York and New Jersey: Port Strategic Investment Options Analysis

C20. The PANYNJ conducted a study to identify the range of investments needed to maintain or upgrade Port facilities to service the needs of maritime commerce through

2040. The study notes that there are fundamental changes occurring in both the shipping industry and the world economy that could provide significant opportunities for the Port. Trade forecasts indicate that the Port's cargo volumes should grow 3 to 5% per year, which would at least double current volumes by 2015. The Port's existing marine facilities and related transportation infrastructure need to be enhanced to handle these new cargo volumes. The Port Strategic Investment Options Analysis provides the analytical framework for making decisions on which port development opportunities provide the greatest return to the region.

C21. The PANYNJ's analysis will address marine terminal development activities, and land-side access issues, including rail and highway capacity. Public access to the waterfront will be an important consideration in design alternatives.

Strategic Plan for the Redevelopment of the Port of New York

C22. The New York City Economic Development Corporation (NYCEDC) is currently in the process of developing strategies for improving and developing port facilities at three locations: Red Hook, Sunset Park (South Brooklyn Marine Terminal) in Brooklyn, and Howland Hook on Staten Island. The purpose of the study is to outline a series of targeted investments to develop marine cargo terminals, public access to the waterfront, improved highway and rail access, improved navigation channels, and environmental mitigation over the period from 1999-2020. Each site is being conceptualized as a "stand-alone" development with no dependence on development or improvements at the other sites.

Cross Harbor Freight Movement Major Investment Study (MIS)

C23. The NYCEDC and the Federal Highway Administration are funding this MIS. The MIS is based on positive recommendations of a 1997 Intermodal Goods Movement Study, which was co-sponsored by NYCEDC and NYC Department of City Planning. The MIS is aimed at determining effective cross harbor freight movement alternatives, (*e.g.*, cross harbor rail tunnel and/or increased cross harbor barge service) with regard to engineering, environmental, economic and financial factors. The final product will be the recommendation of a preferred alternative(s) for implementation. The study is scheduled for completion in April 2000.

EXISTING CONDITION

General

C24. The Harbor's waterways are intensively used navigation channels. The Corps presently maintains about 240 miles of navigation channels in the Harbor and additional channels are maintained by the PANYNJ, the City of New York, the State of New Jersey, and various commercial interests. Figure 2 provides an overview of the Harbor and identifies the various pathways and terminals under consideration.

Current Cargo Capacity

C25. The capacity of any given terminal to handle containers is the product of its land area and its theoretical productivity rate. Given conditions in this part of the country with respect to labor relations, the price and availability of land, and other less prominent factors, the theoretical productivity rate in the Port's terminals is estimated by the non-Federal partners to be about 1,500 lifts per acre per year. Table 4 shows the actual throughput and estimated capacity of the Port's current container terminals. Currently, the Port averages about 1,000 lifts per acre per year. Measured productivity is below theoretical productivity because at current levels of container traffic, fewer than 1,500 containers per acre per year are presented for lifting.

TABLE 4
Current Container Terminal Capacity

Terminal Name	Terminal size (acres)	1997 Measured Throughput (TEUs*/year) (Current Demand) (1,000's)	Actual Lifts per Acre	Estimated Capacity @1500 Lifts per Acre (TEU/acre/year) (1,000's)
Port Newark/Elizabeth	950	1900	1176	2423
Howland Hook	147	180	720	375
Port Jersey Peninsula	100	175	1029	255
South Brooklyn	0	0	0	0
Red Hook	79	80	596	201
TOTAL	1276	2335	(Avg) 1049	3254

*TEU: twenty-foot equivalent unit. Ratio of TEUs to lifts is approximately 1.7 to 1.

Port Operations

C26. The vessel operations of the Port are outlined below. The descriptions are limited to container and liquid bulk vessels and terminals. Ship and terminal operations for barges, automobile carriers, and break-bulk vessels are not discussed because these

vessels are not currently depth-constrained and their fleet mix is not expected to change significantly because of channel improvements.

Container Operations in the Port

Light Loading and Routing

C27. Many containerships arrive and depart the Port with less than full loads (light loaded). In general, this is undesirable from the carriers' point of view because average unit costs are increased if a ship is light loaded. There are three principal explanations for this light loading. First, some containerships have design drafts that exceed channel depths in the Port. In order to operate within the controlling channel depths of the Port, these containerships must discharge some of their cargo at a previous port-of-call. Second, containerships that call on the Port usually carry cargo bound for multiple ports and offload some of their cargo at other deepwater ports before reaching the Port. Third, considerations of service quality require that sailing schedules be strictly kept, regardless of the load accumulated on the ship.

Tidal Advantage

C28. Tidal advantage involves using the additional bottom clearance provided by high tides to transit from sea to berth (and vice versa). The pilot's ability to exploit high tides is facilitated in the Port by a Physical Oceanographic Real Tide System (PORTS) that allows the operators of vessels moving through the Port to know the precise tidal conditions at key locations in the Harbor. However, tidal advantage is rarely used by containership operators because carriers consider tidal delays (missed tidal advantage transits – also referred to as "institutional delays") as undesirable costs, so they tend not to rely on using tidal advantage. Instead the largest vessels currently using the Harbor arrive with drafts less than their design drafts due to light loading or prior port calls.

Impacts of Vessel Size

C29. Containerships of all sizes currently use the Port, including the world's largest container vessels. Depending on how they are loaded, the largest container vessels approach or exceed the limits of existing navigation conditions and practices at the Port. Air draft is also a concern on the Kill Van Kull due to the 151-ft vertical clearance at the Bayonne Bridge, but it is not yet a limiting factor.

Vessel Alliances and Deregulation

C30. International container shipping is in a state of constant change due to the increasing significance of vessel alliances, the increasing presence of post-Panamax vessels (vessels which exceed the dimensions of the locks in the Panama Canal), and recently enacted deregulation. In vessel alliances, carriers pool equipment, coordinate sailing schedules, place cargo on each other's ships, and share space at their terminals.

From the carriers' perspective, alliances are attractive arrangements that provide greater opportunity for vessels to carry fuller loads, as well as the means to offer clients improved scheduling and routing. The operational changes that result from improved cooperation among carriers promote the development of larger, more fully-laden containerships and the adoption of a "hub-port" system.

Petroleum Operations in the Port

C31. The world liquid bulk fleet is composed of a variety of tanker sizes. The largest tankers are used to transport crude oil on transoceanic voyages (e.g., crude oil imports from the North Sea, the Middle East, etc.). In general, many crude oil carriers have design drafts in excess of controlling depths in U.S. ports. Consequently, lightering is a common practice in many U.S. ports. To take advantage of economies of scale, the tankers arrive fully-loaded. Then some of their load is discharged (*i.e.*, lightered) onto liquid bulk barges to reduce their drafts and allow them to enter the port.

Transportation Costs

C32. Transportation costs or shipping costs are calculated using two primary inputs: vessel operating costs and the number of hours in-port and at-sea, in accordance with the Corps' Institute for Water Resources (IWR) Report 91-R-13, *National Economic Development (NED) Procedures Manual – Deep Draft Navigation.* As vessels get larger and deeper, they typically carry more cargo. While the total cost of operating a larger vessel is greater than that of a smaller vessel, the cost per-unit transported (*i.e.*, average cost) is typically smaller due to the increased number of units carried.

C33. Total fixed costs are the same for vessels in-port or at-sea. Total annual fixed costs consist of annual operating costs and replacement cost amortized using a capital recovery factor (CRF). Fixed annual operating costs include:

- Wages and benefits,
- Subsistence,
- Stores and supplies,
- Maintenance and repair,
- Insurance,
- Administration.

Terminal Descriptions

Port Newark/Elizabeth

Site Description

C34. The Port Newark/Elizabeth site is located on the west side of Newark Bay, just east of Newark International Airport (Figure 2). The general layout of the facilities can be seen in Figure 3, and an aerial photograph of the port facilities is presented in Figure 4. The area is defined by Newark Bay to the east, the Allied Signal property and North Avenue to the south, the New Jersey Turnpike and Newark International Airport to the west and the New Jersey Turnpike extension and bridge to the north.

C35. **Buildings, Berths, and Facility Layout**. The site is currently utilized for container operations as well as bulk, break-bulkl and roll-on/roll-off (RoRo) cargo. There are over 30 container cranes servicing more than 17,000 linear feet (LF) of wharf and 950 acres of dedicated container terminal area. Container activity on the portion of Port Newark south of the Port Newark channel is primarily confined to the Universal/Maersk terminal at the terminus of the Elizabeth Channel. The portion of Port Newark north of the Port Newark Channel is primarily used for vehicle operations, storage and processing. Activity on the Elizabeth peninsula is principally dedicated to container operations through SeaLand and Maher terminals, although there is some RoRo activity.

C36. **Current Throughput.** The marine terminal complex currently handles the majority of containers within the Port. Specifically, approximately 1.9 million TEUs per year are handled at Port Newark/Elizabeth. As a comparison, about 0.4 million TEUs per year are handled in all of the Port's other container facilities combined: Red Hook, Howland Hook, and Global Marine Terminal (on the Port Jersey peninsula).

Land-Side Access and Existing Infrastructure

C37. **Highways**. Land-side access to this site is provided by the New Jersey Turnpike and Routes 1 & 9 from the north and south and I-78 and US 22 from the west. The local streets that link these highways to the Port Newark/Elizabeth Marine Terminal are Port Street and Doremus Avenue from the north and North Avenue from the south.

C38. **Rail.** A Conrail Shared Asset rail line runs parallel to the NJ Turnpike and serves the Expressrail and Portside facilities. There are many sidings throughout the port at warehouses and transit sheds. The Expressrail lead track crosses Corbin Street at grade and causes considerable disruption to vehicular traffic throughout the port. This crossing is being replaced by a grade separation on McLester Street. Norfolk Southern and CSX Transportation (CSXT) have joint access via Conrail Shared Asset to the Port.

Water-Side Access and Navigation Channels

C39. Access to Port Newark/Elizabeth from the Anchorage Channel is provided by the Kill Van Kull to Newark Bay. The Kill Van Kull is presently maintained at its authorized width, ranging from 500 feet to 1000 feet, and at a depth of 40-ft MLW. The other existing navigation channels serving Port Newark/Elizabeth have water depths of 40 ft MLW. Construction has begun to deepen the Kill Van Kull and Newark Bay to 45 ft MLW.

Howland Hook

Site Description

C40. The Howland Hook site is located on the west side of the borough of Staten Island, just north of the Goethals Bridge. The general location of the Howland Hook Marine Terminal is shown in Figure 2. Layout of the existing facilities is shown in Figure 5, and an aerial photograph is presented in Figure 6. The site is currently the location of one of the two active container terminal operations in New York City (the other is Red Hook). It is located southwest of Shooters Island, with the existing berths adjacent to Arthur Kill. The area is bounded by the Arthur Kill to the west, Richmond Terrace to the north, the Proctor & Gamble facility to the east and railroad tracks and a rail bridge to the south. A portion of the land between Richmond Terrace and south of Shooters Island Reach is characterized as tidal wetlands.

C41. The area was originally developed by a private enterprise, was purchased by the City of New York in the early 1980's, and was subsequently leased to the PANYNJ. The terminal was to become home to United States Lines, but that firm was the subject of bankruptcy proceedings that resulted in its liquidation. With the demise of United States Lines, the terminal was vacant for several years, but a new tenant is in place and the facility is currently an operating marine terminal. The terminal, although near residential property, is relatively isolated.

C42. **Buildings, Berths, and Facility Layout**. The site is used for container operations. There are seven container cranes servicing 2500 LF of wharf on a 147-acre terminal. The site was recently upgraded to include a refrigerated warehouse facility. Other features of the terminal include a 200,000 square foot (SF) container freight station (CFS), maintenance and repair facilities, and an administrative office structure.

C43. **Current Throughput**. The Howland Hook Marine Terminal handled 180,000 TEUs in 1997.

Land-Side Access and Existing Infrastructure

C44. **Highways**. Local land-side access is provided by exits from both eastbound and westbound lanes of I-278, the Staten Island Expressway. Access to State Route 440, the West Shore Expressway, which provides access to New Jersey via the Outerbridge Crossing, is also nearby. The local streets that link this highway to the marine terminal include Gulf Avenue, Forest Avenue, Goethals Road North, and Western Avenue.

C45. **Rail**. Main line (on dock) rail access will soon be provided through reactivation of the Staten Island Railroad (SIRR) route via a rail bridge just south of the site.

Water-Side Access and Navigation Channel

C46. Access to the Howland Hook Marine Terminal from the Anchorage Channel is gained via the Kill Van Kull and Arthur Kill. Existing navigation channels in the vicinity of Howland Hook have low water depths averaging about 38 ft MLW. Two thousand linear feet of the wharf have been dredged to 42 ft MLW, while the remaining 500 LF is at 37 ft MLW due to high rock elevations in the area. As previously stated, the Kill Van Kull is currently maintained at 40 ft MLW. The Arthur Kill is presently maintained at 35 ft MLW, varying in width from 600 feet to 800 feet. Construction has begun to deepen the Kill Van Kull to 45 ft MLW. Section 338 of the Water Resources Development Act of 1999 authorizes construction of the Arthur Kill to Howland Hook at a depth of 41 ft MLW, substantially in accordance with the report of the Corps of Engineers dated July 23, 1999.

Port Jersey/Military Ocean Terminal at Bayonne

Site Description

C47. The Bayonne area features three adjacent peninsulas of land extending into Upper New York Bay (see Figure 2). As shown in Figure 7, the three peninsular parcels of land are the "Greenville Yards," the Northeast Auto Terminal (NEAT)/Global Marine Terminal area (Port Jersey peninsula), and the Military Ocean Terminal at Bayonne (MOTBY). An aerial photo of the area is presented as Figure 8. In order to avoid confusion, the NEAT/Global peninsula will be called the Port Jersey Peninsula for the remainder of this report. Both the Port Jersey Peninsula and MOTBY are rectangular-shaped peninsulas which parallel one another and are separated by the Port Jersey Channel. The Port Jersey Channel provides access to marine facilities located on the south side of the Port Jersey Peninsula and the north side of MOTBY. The 180-acre Port Jersey Peninsula is currently occupied by the Northeast Auto Terminal (NEAT) and the Global Marine Container Terminal. The 435-acre MOTBY site is scheduled to come

under the control of the City of Bayonne as a result of the Military Base Realignment and Closure Program and is being considered for a variety of uses.

C48. **Buildings, Berths, and Facility Layout**. The total area available for development is about 180 acres. NEAT currently occupies about 80 acres of the Port Jersey Peninsula. It consists of two berths, several administrative and operational buildings, and a large parking area for autos. The Global Marine Terminal occupies approximately 100 acres and is comprised of two berths, and several administrative and operational buildings. The Port Jersey Channel, which serves both the Port Jersey Peninsula and MOTBY, presently has a depth of about 35-ft MLW. Along the northern side of the channel, a 200-foot wide cut to 38 ft MLW is maintained to the western edge of the Global Marine Terminal.

C49. MOTBY served as the Department of Defense's primary materiel handling port in the northeast for many years. The terminal includes 10 berths and an U.S. Coast Guard Facility, which is located along the existing turning basin at the western end of the Port Jersey Channel. MOTBY is comprised of a relatively large number of buildings, a rail yard and a graving drydock at the eastern end of the peninsula. A large percentage of the MOTBY peninsula is suitable for container terminal development, pending structural rehabilitation of the wharves.

C50. **Current Throughput**. The Global Marine Terminal handled 175,000 TEUs in 1997.

Land-Side Access and Existing Infrastructure

C51. **Highways**. The Port Jersey and MOTBY sites are located near Route 169. This multi-lane, limited access highway connects with Exit 14A of the New Jersey Turnpike to the north and the Bayonne Bridge to the south. A signalized intersection provides access to and from MOTBY. Access to the NJ Turnpike is advantageous to truck traffic, however, alternative local routes to the cities of Newark, Elizabeth, and New York City exist.

C52. **Rail**. Primary rail service to Port Jersey/MOTBY is provided by a Conrail Shared Asset, serving both Norfolk Southern and CSXT. Port Jersey and the commercial/warehouse area adjacent to it are served by the Port Jersey Railroad, a short haul rail system.

Water-Side Access and Navigation Channels

C53. Navigational access to the site is provided by the Port Jersey Channel, which has a depth of 35 ft MLW, a width of 600 feet, and extends from the relatively deep waters of

Upper New York Bay to the Port Jersey Basin through relatively shallow areas (*i.e.*, the Jersey Flats on the north and Robin's Reef on the south). A 200-foot wide portion of the channel is maintained at 38 ft MLW alongside Global to service the terminal. Some vessels use the 1200-foot diameter turning basin at the terminus of the Port Jersey Channel to turn around.

South Brooklyn

Site Description

C54. The South Brooklyn site is located on the eastern shore of the Upper Bay, in the Sunset Park section of Brooklyn. The area is comprised primarily of commercial and light industrial developments and is bounded by First Avenue on the east, and by 29th and 65th streets to the north and south, respectively.

C55. Figure 2 illustrates the site's proximity to the Upper Bay. The South Brooklyn site has traditionally been used for marine terminal operations and has existing rail access facilities, including the Bay Ridge Branch of the Long Island Rail Road and float bridge at 65th Street. Ground transportation infrastructure needs for the area are currently being addressed as part of the NYCEDC's Cross Harbor Freight Movement Major Investment Study (MIS).

C56. **Buildings, Berths, and Facility Layout**. A portion of the site is presently occupied by the former Brooklyn Army Terminal and a portion of the Bush Terminal complex, as shown in Figure 9. The waterfront itself is composed of numerous finger piers, which are in generally poor condition. Several of these piers and adjacent warehouses have collapsed and if nothing is done to rehabilitate the remaining structures, a similar fate awaits them. Some of those determined to be in poor condition have been identified for removal as part of Brooklyn Reach 2B of the New York Harbor Collection and Removal of Drift Project. The existing marine terminal is shown in Figure 10.

C57. The northern end of the proposed site was the location of the now-defunct South Brooklyn Marine Terminal. Container cranes have been removed from that site and the yard area is currently being utilized for automobile storage. Additional maritime activity in the area includes an ongoing break-bulk operation at Berths 1 through 5 at the south end of the site.

C58. One of the piers west of this complex has been reconstructed and is now being utilized as a parking lot for a passenger ferry service to Manhattan. The area suitable for Port development extends from 29th Street to 65th Street. From 29th Street to 39th Street, the area extends from 2nd avenue to the pierhead line. From 39th Street to 65th Street, the area extends from 1st Avenue to the pierhead line.

C59. **Current Throughput.** Containers are not currently handled at this facility.

Land-Side Access and Existing Infrastructure

C60. **Highways.** The project study site consists of a relatively long, narrow strip of land bounded on the east by 1st and 2nd Avenues (see above) and the Upper Bay on the west. Access to the site is unusually difficult due to the high degree of road traffic congestion usually experienced in this vicinity.

C61. The area is adjacent to the Gowanus Expressway, which leads to I-278 and the Verrazano-Narrows Bridge.

C62. Although shipping companies and terminal operators traditionally were content to "truck" containerized cargo to and from dedicated intermodal terminals, recent efforts to improve rail service and reduce costs have led to a demand for on or near dock rail facilities. Nonetheless, it is likely that 70-80% of marine cargo will still be handled by trucks in the future. Such a likelihood poses constraints for container facilities in Brooklyn, where truck access is limited by available highway capacity.

C63. Local land-side access is provided with exits at 39th Street from both directions of the Gowanus Expressway. Leaving the terminal, however, requires extensive travel along local streets before it is possible to access the Gowanus Expressway. In this area, the Gowanus Expressway is elevated and Third Avenue is located below it. The local streets which link this highway to the South Brooklyn Marine Terminal include Second and Third Avenues from the north and south, and 39th Street from the east. The NYCEDC is currently working with the New York State Department of Transportation (NYSDOT) to develop additional improvements to the 39th Street and 65th Street interchanges and is studying additional modifications to the Gowanus Expressway which may improve truck access.

C64. **Rail.** The New York Cross Harbor Railroad (NYCHRR) provides the primary rail service to the waterfront area and interchanges with the New York and Atlantic Railroad at the 65th Street yard. There is no convenient connection to the main east-west interstate lines and westbound containers have to travel north to Albany before they can connect with rail services to the west. There is, however, an active float bridge at 51st Street serviced by the NYCHRR that is utilized to transport rail cars westward.

C65. As previously stated, the NYCEDC is currently studying alternative cross-harbor freight options, including a cross-harbor rail tunnel, or expanded barge service, to serve the city's commercial enterprises. The NYCEDC is constructing two new float bridges at the 65th Street rail yard. Upon completion, the float bridges will provide upgraded rail

service between Greenville, New Jersey and the Brooklyn waterfront. Limited road access means that some form of enhanced cross-harbor service is vital to the operational feasibility of a major container terminal in Brooklyn.

Water-Side Access and Navigation Channels

C66. Access to the South Brooklyn study area from the Anchorage Channel is provided by the Bay Ridge Channel and, further north, the Gowanus Bay Channel. The Bay Ridge Channel is maintained at its authorized dimensions of 40 ft MLW, with widths from 1,200 feet to 1,750 feet. The Bay Ridge Flats, a shallow area with water depths ranging from 10 ft MLW to 30 ft MLW, lie to the northwest of the Bay Ridge Channel, while the existing pierhead line defines the channel to the southeast.

Red Hook

Site Description

C67. The Red Hook site is located in Red Hook, Brooklyn on the Buttermilk Channel in the Upper Harbor directly across from Governors Island, as shown in Figure 2. As previously stated, Red Hook and Howland Hook are the two active container terminals in New York City. The Red Hook area was originally developed for break-bulk operations and was modified to accommodate containers during the late 1970's and early 1980's. The non-Federal partners have indicated their intentions to phase out container operations at the Red Hook Container Terminal by the year 2010 and consolidating break-bulk and neo-bulk functions there following rehabilitation of the South Brooklyn Marine Terminal. Existing conditions at Red Hook Container Terminal are presented in Figure 11. The area is bisected by the right of way for the Brooklyn Battery Tunnel. An aerial photograph of the site is presented in Figure 12.

C68. The Red Hook site is proximate to the relatively deep waters of the Upper Bay. Channels leading to the facilities from the Anchorage Channel are relatively short, compared with other terminal areas in the Port.

C69. **Buildings, Berths, and Facility Layout.** There are currently five container cranes serving the 79-acre Red Hook site. Figure 11 shows the main container berth area with three cranes. The remaining cranes are located on Pier 9A. There are four cargo sheds in the area, several of which are still being utilized for cargo operations.

C70. **Current Throughput.** The Red Hook Container Terminal handled 80,000 TEUs in 1997.

Land-Side Access and Existing Infrastructure

C71. **Highways**. The Brooklyn-Queens Expressway provides the major land-side access to the site from the north and the Gowanus Expressway provides access from the south. Local streets such as Columbia Street (from north), Van Brunt Street (from south) and Hamilton Avenue (from east) link these highways to Red Hook Container Terminal.

C72. **Rail**. There is no direct rail access to the site. Cross-harbor movement of containers from the container terminal are handled through a barge service to the PANYNJ's marine terminals at Port Elizabeth that is partially subsidized through the Federal Congestion Management/Air Quality (CMAQ) program.

Water-Side Access and Navigation Channels

C73. Access to Red Hook from the Anchorage Channel is provided by the Buttermilk Channel. Maintained at its authorized width of 1,000 feet, it is 35 ft deep MLW in the western half of the channel and 40 ft MLW in the eastern (Brooklyn) half. The Buttermilk Channel is bounded on the west by Governors Island.

Stapleton

Site Description

C74. The Stapleton site is located on the eastern shore of Staten Island in the Upper Harbor, adjacent to Stapleton Anchorage, as shown in Figure 2. It is very close to the Staten Island Ferry Terminal in St. George. The area includes the former U.S. Naval Homeport that was vacated as a result of the Military Base Realignment and Closure Program.

C75. The area is now vacant. The site lies just north of Fort Wadsworth and the Verrazano-Narrows Bridge, as shown in Figure 13. Channels leading to the site would be relatively short, relatively easy to construct and relatively easy to maintain vis-à-vis other areas of New York Harbor.

C76. **Buildings, Berths, and Facility Layout**. There are several warehouse, maintenance and administrative office structures on the site today as well as a 1,400-foot finger pier. None of these structures are compatible with or suitable for a modern container terminal application.

C77. **Current Throughput**. Stapleton does not currently handle cargo. Container terminal development at this site would require land creation around the existing Navy pier. A very thick layer of soft clay would have to be stabilized prior to any construction. Land creation would require installing an enclosure structure for placement of fill. This is likely to be an extremely expensive alternative.

Land-Side Access and Existing Infrastructure

C78. **Highways**. The site is located east of Bay Street between Hannah Street and Edgewater Street in the Stapleton section of Staten Island. Land-side access is provided via the School Road exit off the I-278 Staten Island Expressway. The local streets which link this highway to the proposed marine terminal site include Bay Street and School Road from the south.

C79. **Rail**. There is no freight rail access to the site. The electrified lines of the Staten Island Rapid Transit System are adjacent to the site, but accommodate passenger service only along the south shore of Staten Island to the ferry terminal in St. George.

Water-Side Access and Navigation Channels

C80. The study area is adjacent to the Anchorage Channel. The existing low water depths in the area range from 35 to 55 ft MLW.

TOSCO

C81. The Tosco Refining Company is located along the west coast of the Arthur Kill in Linden, New Jersey, as shown in Figure 2. The facility receives over 20 petroleum and petrochemical shipments per month. It also functions as a storage and distribution center.

GATX

C82. The GATX Oil Depot is a major facility located along the east coast of the Arthur Kill in Staten Island, New York, as shown in Figure 2. Though the facility is presently closed, the terminal has historically received petroleum and petrochemical shipments.

Anchorages

C83. The Harbor anchorages at Stapleton, Gravesend Bay and Red Hook Flats are integral to the waterborne commerce network. The anchorages are used to wait for berthing availability or favorable tides, and for lightering. Table 5 shows the types and typical numbers of vessels utilizing the anchorages.

TABLE 5 NY&NJ Harbor Anchorage Use (August 1998 – July 1999)	
Vessel Type	**Number of Vessels**
Tanker - Oil/Gas	286
Tanker – Chemical	19
Container Vessel	45
Bulk Carrier	66
Auto Carrier	5
Barge	724
Source: U.S. Coast Guard, Vessel Traffic Service New York	

Terminal Summary

C84. Table 6 provides a summary of the terminals and locations described above.

TABLE 6 Terminal Descriptions – Existing Condition		
Terminal	**Description**	**Figures**
Port Newark/Elizabeth	950-acre container terminal, including all facilities	3, 4
Howland Hook	147-acre container terminal, no current rail access	5, 6
Port Jersey/MOTBY	100-acre container terminal (Global Marine) adjacent to NEAT	7, 8
South Brooklyn	No existing container terminal	9, 10
Red Hook	79-acre container terminal, no current rail access	11, 12
Stapleton	No existing container terminal	13
TOSCO/GATX	Oil facilities	None
Anchorages	Stapleton, Gravesend Bay, Red Hook Flats	None

Regional Transportation

Commercial Trucking

C85. Commercial trucking remains the dominant means of transportation in the region. This is facilitated by the Port's proximity to the major I-95 corridor. While I-95 is the dominant "spine" of the North-South corridor, the majority of the commercial truck transportation travels on the other highways crisscrossing the region, which are all linked directly or indirectly to the Port through I-95. This system of highways provides ready access to the region's hinterlands (described in the Socio-Economic Profile section).

Rail

C86. The major rail lines in the region provide access to Port Newark/Elizabeth and the Port Jersey Peninsula. These lines connect to major east-west rail lines and provide the bulk of rail transportation to and from the region. Likewise, the Staten Island Railroad will provide similar service to Howland Hook Marine Terminal when it reopens in the future. Rail carriers provide service to Brooklyn and other East of the Hudson destinations via a crossing at Selkirk, NY and the rail line that runs down the east shore of the Hudson River. The New York Cross Harbor Railroad (NYCHRR) provides another crossing opportunity through the use of floating bridges between Brooklyn and Greenville, but service is limited. The New York City Economic Development Corporation (NYCEDC) is studying cross-harbor freight alternatives, which include expansion of float bridge service in the Port and/or construction of a cross-harbor freight tunnel. Figure 14 shows the current locations of the major railroads in the region.

C87. The region's major rail system has undergone a significant change as the assets of the former regional freight carrier (Conrail) have been divided bwteen CSX Transportation and Norfolk Southern. However, as part of the purchase of Conrail, a regional line called Conrail Shared Asset (owned jointly by Norfolk Southern and CSX) will serve all terminals in the Northern New Jersey Areas. The division of Conrail and the use of a neutral regional line are expected to result in a higher degree of competition and increased options for shippers. However, regional transportation organizations remain focused on rail line capacity as both freight and passenger carriers continue to grow and compete for limited rail lines.

Growth and Development

C88. Regional agencies, including the North Jersey Transportation Planning Authority (NJTPA) and the New York Metropolitan Transportation Council (NYMTC), have played a significant role in the continued development of the landside infrastructure in the Port. These organizations have identified freight-and-port-beneficial funding in their current Transportation Improvement Programs (TIP's) totaling over $1 billion. The planned improvements will enable carriers to meet the future transportation needs of regional shippers.

Environmental Setting

General

C89. The Harbor is naturally shallow, averaging a depth of approximately 19 ft MLW, with complex geography, hydrodynamics, and ecology. It is comprised of four large embayments: Upper New York Bay, Lower New York Bay, Newark Bay, and Raritan Bay. Upper New York Bay and Lower New York Bay are separated by a constriction - the Verrazano Narrows. Newark Bay, the smallest of the four, is linked to the other embayments by narrow, natural waterways. Newark Bay is connected to Upper New York Bay by the Kill Van Kull and to Raritan Bay by the Arthur Kill. The Harbor also consists of a network of public and private channels and berths, including those constructed and maintained by the agencies of the Federal, state, and local governments as well as by private companies. A detailed description of the environmental setting can be found in the DEIS contained in Volume I. The following briefly describes those elements of the Environmental Setting most germane to the formulation process.

C90. The Harbor is an estuary. Thus, it is strongly affected by tidal action, and within it sea water is mixed with stormwater runoff. The core area of the Harbor estuary is the Hudson-Raritan estuary, which extends from the Piermont Marsh in New York State to the Sandy Hook-Rockaway Point Transect. Habitat types that are found in the Harbor include: tidal rivers, salt and freshwater tidal marshes, woodlands, shallow bays, barrier beaches, and sand dunes.

C91. Several wildlife species are found in the Harbor, many of which rely on estuarine habitats for nesting, foraging, reproduction and early development, and survival. The Arthur Kill and Kill Van Kull support populations of nesting shore birds on Federal or state-protected islands which, combined, comprise the Harbor Herons Complex.

Hydraulics

C92. Waves in the Harbor are limited due to the protection afforded by the adjacent land masses. Currents generally range from 0.6 to 2 feet per second (fps) throughout the Harbor. Tides throughout the Harbor are semi-diurnal, with a mean tide range of approximately 5.0 feet. As a result of the hydraulic condition, sedimentation rates in the region vary widely depending on location: around the Elizabeth peninsula it ranges from 1.5 inches per year (in/yr) to 5 in/yr around the Newark peninsula, from 5 in/yr at the inshore end of Newark Channel to 18.8 in/yr at the Pierhead Channel. In the vicinity of Shooters Island it is approximately 11.7 in/yr and in the vicinity of Port Jersey it is approximately 2.7 in/yr.

Geology

C93. New York Harbor consists of numerous bays, rivers, and channels of complex shape that are connected to the Hudson River, the main element of the harbor complex. The area is underlain by both bedrock and unconsolidated materials. Coastal Plain deposits form a seaward-thickening wedge of poorly consolidated sediments, which dip gently to the east and unconformably overlie older rock units. Surficial deposits in the project area are either glacial or postglacial, being deposited either before or after the close of the most recent glaciation period. No economically significant mineral deposits are mapped in the study area, however, commercial sand mining periodically occurs in the Ambrose Channel (Lower Bay) and other locations in the Harbor.

Land Use

C94. The existing land use surrounding the Port supports the industrial, transportation and waterborne commercial nature of the area. Land use adjacent to the Harbor ranges from tidal wetlands to heavy urban development. Inland, the land uses are devoted more to residential, commercial and industrial purposes. The study area is in the northeast's north-south transportation corridor and is crisscrossed by major interstate highways.

C95. Generally, in all Harbor areas, as a result of long-established urbanization, the area's natural environment has been affected. Recreational opportunities are limited. Fish and wildlife resources use the area year round. With the exception of the wetlands and marshes along the Arthur Kill, limited natural shoreline habitat remains in the project area.

Upland Habitat

C96. In general, upland habitat in the study area has undergone substantial alteration as a result of dredging, filling, shoreline development, commercial and industrial activities, and runoff and discharge of pollutants. Due to extensive shoreline development and industrialization, upland habitat in the study area is generally limited to parks and the upland portions of area wetlands and marshes. Limited upland vegetation is present on the islands comprising the Harbors Heron Complex (Shooters Island and Pralls Island).

Marine Biota

C97. Over the years, the biotic communities within the project area have adapted to the existing environmental conditions. Species, which were able to tolerate or adapt to those conditions, take advantage of the available habitats. Because the Harbor estuarine system provides a physical passageway from the Atlantic Ocean to Newark Bay and the Passaic and Hackensack rivers, Raritan Bay and the Raritan River, Hudson River, and East River to Long Island Sound, many species utilize its waters during seasonal migrations, or only during a particular stage in their life history. Species presence on a seasonal schedule permits optimal use of the ecosystem and usually results in the avoidance of less than favorable conditions for organism growth and development.

Avian Fauna

C98. A wide variety of waterfowl, wading birds, and shorebirds use the waters and wetlands of the Port wherever shallow water, mudflats, or wetlands exist, primarily in Raritan Bay, the Arthur Kill, Kill Van Kull, Newark Bay, and the Constable Hook Area. These areas provide resting and feeding areas, as well as habitat for wintering waterfowl.

C99. The Harbor Herons Complex is located within the project area. This complex includes some colonial wading bird rookeries located on Prall's Island, the Isle of Meadows, and the associated foraging and resting habitat found along the Kill Van Kull and the Arthur Kill. Shooters Island, located at the juncture of the Kill Van Kull and Arthur Kill, is the oldest of the rookeries.

Wetlands

C100. Several large wetland areas exist along the shore of the Arthur Kill, with two located within the study area; one east of Howland Hook at Port Ivory and one on the shoreline under, and adjacent to, the Goethals Bridge. Some wetland fringes are also located at Shooters Island and an area of shallow mudflats that exists in the southwest corner of Newark Bay, bordering the Arthur Kill along the U.S. Dike. Large wetlands areas are located north of Constable Hook, in the vicinity of Caven Point, along the eastern shore of Staten Island, along the New Jersey shoreline of Raritan Bay, and around Coney Island. Throughout the area, there are numerous small marsh areas scattered amid shipwrecks and abandoned docks.

C101. In southwestern Newark Bay lies a rectangular shaped area generally known as the "mudflats." In addition, the Jersey Flats are located off the MOTBY and Port Jersey Peninsulas, and the Bay Ridge Flats are bordered by the Bay Ridge and Red Hook channels. These shallow areas are utilized by a number of fish and wildlife species. Greater benthic

activity and higher dissolved oxygen levels provide important habitat for fish species, as well as feeding and resting areas for waterfowl and shorebirds.

Water Quality

C102. The Harbor is a dynamic estuarine system. Water quality parameters reflect the quality of tributary (primarily freshwater) flow and the exchange with ocean waters. The Hudson River is the primary tributary to the Harbor, with secondary flows from the Raritan, Hackensack, and Passaic Rivers. In addition, the tidal East River exchanges water between the Harbor and Long Island Sound. Pollutant sources to the Harbor include municipal and industrial discharges, runoff (stormwater and combined sewer overflows), tributaries, landfill leachate, atmospheric deposition, accidental spills, and tidal waters.

Air Quality

C103. Six priority pollutants have been identified by the EPA as being of concern in the study area: carbon monoxide, nitrogen oxides, ozone, particulates, sulfur oxides, and lead. Qualitative levels of specific pollutants in the study area are as follows:

- Carbon monoxide levels have declined in recent years;
- Sulfur dioxide and sulfate levels have continued to decline;
- Area nitrogen dioxide concentrations continue to remain below the level of the air quality standard;
- 1996 particulate concentrations were the 2nd lowest recorded since particulate sampling commenced in 1986;
- Area lead concentrations have remained unchanged or have declined and have remained in compliance with air quality standards.
- Ozone levels have improved over time, however, New York City is listed as a "high-severe" ozone non-attainment area.

Archeological, Historical and Cultural Resources

C104. Archaeological resources within the study area are likely to be limited to prehistoric remains as the area has historically been inundated. Prehistoric resources may be present as much of the Harbor area was dry land at the end of the last ice age and now inundated areas may have been inhabited by Native American populations. Due to the submerged nature of the project area it is unlikely that traditional archaeological sites will be found, however, the paleoenvironment can be reconstructed through an analysis of soil borings. The results of recent analyses have allowed archaeologists to identify locations within the study area that were sensitive locations on the former landscape. Prehistoric archaeological sites on present-day dry land are generally located near certain key

physiographic resources such as fresh water and ecologically rich habitats. The same, it is believed, holds true for sites now submerged. The preservation of continental shelf sites was affected by many factors associated with a rising sea level but it appears that a number of locations may have survived this inundation.

C105. Areas considered to possess moderate sensitivity will be subject to additional studies in the form of remote sensing surveys and additional borings. These areas include, but are not limited to, the Jersey Flats adjacent to the Port Jersey Channel, the shallows in Newark Bay, the area northeast of Shooters Island in the Arthur Kill, and several areas in the Arthur Kill and Kill Van Kull where channel widening may impact derelict vessels deemed to be of historical significance.

Socio-Economic Profile

General

C106. The geographic scope of the socio-economic profile extends beyond the New York – New Jersey metropolitan area to include the domestic economic hinterlands of the Port, which reach into the continent's interior. The socio-economic conditions in the Port's hinterlands are relevant to this study because the intensity, character, and location of their economic activity will directly affect future commodity movements through the Port.

Domestic Economic Hinterland

C107. For this study, four different definitions of the Port's economic hinterland were used, as shown in Figure 15. The four hinterland definitions focus on container movements through the Port (petroleum products entering the Port are largely for local consumption or transshipment by barge to nearby states, and bulk commerce makes up a very small portion of commodity traffic through the port).

31-County Metropolitan Area

C108. The core of the Port's hinterlands is the New York and New Jersey metropolitan area. Approximately 70% of containerized cargo moving through the Port is destined for or originates in the metropolitan area. This area consists of 31 counties, including 14 counties in southern New York State (five in New York City, two in Long Island, and seven in the Mid-Hudson region); 14 counties in northern New Jersey; and three counties in southwestern Connecticut.

260-Mile Radius

C109. Another delineation consists of a 260-mile radius from the Harbor. This radius, which includes the 31-county metropolitan area, is used by the New York Shipping

Association to collect fees from carriers assessed on behalf of the International Longshoremen's Association. The 260-mile radius encompasses all or part of 13 states, including: New York, New Jersey, Massachusetts, Rhode Island, New Hampshire, Vermont, Connecticut, Maine, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, and Washington D.C. Approximately 82% of the containerized cargo that moves through the Port is destined for or originates within 260-miles of the Port.

17-State Region

C110. A third hinterland definition provides another description of the Port's primary hinterland, in this case a 17-state region that extends from New York to Missouri and from Maryland to Maine. This description of the hinterland was used to analyze costs associated with the transportation of cargo from Southeast Asia to New York for comparison with cargo destined for Los Angeles and Long Beach. The analysis compared the potential costs and delivery times to all states in the continental U.S. for vessels originating in Hong Kong. These 17-states met the criteria of being serviced through the Port at a lower cost and within a reasonably small time disadvantage, when compared to service through Los Angeles or through Long Beach. The resulting 17-state region encompasses New York, New Jersey, Massachusetts, Rhode Island, New Hampshire, Vermont, Connecticut, Maine, Pennsylvania, Delaware, Maryland, Ohio, Michigan, Indiana, Illinois, Iowa, Missouri, and Washington D.C.

31-State Secondary Hinterland

C111. The Port's secondary hinterland is defined as the remaining 31 states within the continental United States. In this 31-state region, the Port has a relatively small share of international trade. However, the Port actively competes in the secondary hinterland with other ports (especially west coast ports) to capture a greater market share of this trade. Figure 16 shows the general distribution of import and export movement through the Port and the hinterland.

Population

C112. The Port's primary hinterlands, including the 17-state region and the 260-mile radius, contain approximately 40 percent of the population of the entire continental United States. The populations in the Port's metro area and primary hinterlands (17 states and 260-mile radius) are expected to grow much more slowly than the national average due to the rapid population increases anticipated for the western states, as represented by the 31-state secondary hinterland.

Income

C113. Income levels in the Port's hinterland suggest their potential to generate imports for the Port because they imply consumer spending power and serve as broad measures of

economic activity. Per capita incomes in the metro area, the 260-mile radius, and the 17-state region exceed the national average by 32, 15, and 8 percent, respectively. Estimates of 1998 total personal income show that approximately 25 percent of the nation's total personal income is generated within the 260-mile radius, and the 17-state region accounts for approximately 42 percent of the nation's total personal income.

Employment

C114. For the 1998-2045 period, all-industry employment growth rates in the 31-county metropolitan area, in the 260-mile radius, and in the 17-state region are expected to be slower than projected national growth rates. This is consistent with the expected slower growth in total population for these regions relative to the nation. In contrast, projected employment growth for the 31-state secondary hinterland is expected to exceed national levels. The 1998-2045 sectoral employment forecasts suggest that the Port hinterlands – and the nation as a whole – will continue their current transitions from manufacturing to service economies. For the 31-county metropolitan area, the 260-mile radius, and the 17-state region, manufacturing employment is expected to decline, while employment in the construction and services sectors is expected to grow significantly. In contrast, manufacturing employment in the 31-state secondary hinterland is expected to experience modest gains over the 1998-2045 period.

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WITHOUT-PROJECT CONDITION

General

C115. The Without-Project Condition is defined by the Corps' Engineering Regulation (ER) 1105-2-100, *Policy and Planning Guidance for Conducting Civil Works Planning Studies (Planning Guidance Notebook)* to be the future condition expected to occur within the study area in the absence of project implementation. It is the baseline condition upon which the physical and beneficial impacts of proposed plan alternatives are measured. The vast majority of goods entering the Port are destined for the Port's primary hinterland, which encompasses a 260-mile radius around the Harbor. Forecasts indicate that as a result of population growth, development of worldwide markets, and shifts in the world trading routes that the quantity of goods passing through the Harbor can be expected to increase from 2.4 million TEUs today to over 19.1 million TEUs by the year 2060. Accordingly, the Without-Project Condition will likely include some Harbor improvements aimed at capturing a portion of the forecasted trade that otherwise could not be handled based on projected throughput capacity of the Port's container terminals. The nature and extend of the Without-Project improvements will depend on the investments deemed economically viable to the non-Federal partners. An assessment of future Without-Project Conditions is described in the following paragraphs.

Non-Federal Partners' Comprehensive Port Improvement Plan

C116. The non-Federal partners' developed a Comprehensive Port Improvement Plan (CPIP) which reflects their proposed terminal improvements. The plan is predicated on the assumption that they will desire to increase throughput capacity in order to handle a higher volume of trade. They have demonstrated some commitment to increasing capacity by devoting resources to detailed planning for their development. However, this plan is only reflective of the non-Federal partners' level of commitment without any Federal improvement. No inference of endorsement or other expression of approval of these plans on the part of New York District or any of the appropriate permitting agencies, including New York District Operations Division, is intended or should be drawn. In general, those plans put forward by the non-Federal partners to increase capacity via expansion of container terminals through the use of fills, have not been included in the Without-Project Condition.

Shortage of Throughput Capacity

C117. Unconstrained projections of the volume of commerce passing through the Port over the planning period (2010-2060) exceed the Port's projected theoretical throughput capacity. At the present theoretical productivity of 1,500 lifts per acre per year, the Port's terminals taken together are capable of handling 3.25 million TEUs (1.9 million

containers, given the current mix of container sizes) annually. Assuming that by 2040 theoretical productivity rises to 3,500 lifts per acre per year, as discussed in the following sections, the Port would then be capable of handling 7.1 million TEUs (4.2 million containers) annually. However, commerce volume is projected to grow to 19.1 million TEUs (11.2 million containers) annually by 2060 (even if the channels are not improved), leaving an annual throughput shortfall of 11.5 million TEUs (6.7 million containers). If this excess demand is to be fully or partly accommodated, throughput capacity must be increased further. This might be accomplished in any of several ways or a combination of them: productivity can be further increased, non-water dependent facilities can be relocated upland to provide additional container yard space, the terminals can be expanded or new facilities developed. On the assumption that they will find it to be in their interest to increase capacity sufficiently to satisfy all of the demand for container handling services implied by their economic forecast, the non-Federal partners have proposed expansion of terminal land area as the means of accommodating some portion of the future commodities seeking to pass through the Port. As there is a lack of available waterfront land, the expansion and development of new facilities would require new waterfront fills. The non-Federal partners have indicated in this vision of the future that they anticipate about 600 acres of new land for container terminals would be desired and that it will come mostly from new waterfront fills. The following paragraphs outline the non-Federal partners' vision of the proposed terminal changes. It is important to note that none of this additional contemplated increase in capacity, however it is to be accomplished, is necessary to justify improving any of the Port's channels and it was not deemed to be part of the Without-Project Condition.

Proposed New and Expanded Terminal Development in the CPIP

South Brooklyn

C118. The New York City Economic Development Corporation (NYCEDC) is planning the development of a 315-acre container terminal in South Brooklyn. The terminal will include the rehabilitation of the currently deteriorated waterfront area and the placement of 145 acres of waterfront fill. Execution of this plan relies on enhanced cross-harbor movement of goods from Brooklyn to New Jersey. The NYCEDC is exploring alternatives for this cross-harbor movement, including a rail tunnel and an enhanced barge operation. However, the results of their ongoing study of cross-harbor alternatives will not be available until after the present Feasibility Report is completed. Therefore, development of South Brooklyn hinges on several critical environmental and infrastructure-related issues that remain unresolved at the present time. In this regard, the viability and certainty of construction of this option are in question.

Military Ocean Terminal at Bayonne (MOTBY)

C119. At the present time, negotiations for purchase or lease of MOTBY or a portion thereof are continuing. Uncertainty surrounds both the development of the peninsula as a container terminal and the anticipated size of the developed terminal. The non-Federal partners currently envision a 130-acre container terminal to occupy a portion of the 435 usable acres. However, terminal development is contingent upon the transfer of land from the US Government to the City of Bayonne followed by the purchase or lease of the peninsula space by an interested developer.

Port Newark/Elizabeth Marine Terminals

C120. The PANYNJ expects to expand the existing terminals as follows:

- Reconfigure the existing container terminals;
- Expand terminals through the demolition of warehouses for an additional 100 acres of terminal space;
- Construct an intermodal terminal at Port Newark;
- Convert a 387-acre confined placement area (fill) to new terminal(s).

Howland Hook Marine Terminal

C121. Capitalizing on the re-activation of the Staten Island Railroad, the PANYNJ and the City of New York plan to expand operations at the Howland Hook Marine Terminal by acquiring the adjacent Proctor & Gamble site and expanding the facility north of Richmond Terrace via a land connection. The new terminal area will be used as an intermodal yard with floating bridge access and a 40-acre warehousing/distribution center.

C122. The existing berths at Howland Hook will be strengthened to provide stability for channel depths of up to 50 ft MLW.

Terminals Scheduled for Closure or Other Uses in the CPIP

Red Hook Container Terminal

C123. The non-Federal partners have indicated that container-handling operations at Red Hook Container Terminal will be phased out by approximately 2010. Moreover, no productivity increases are expected between 2000 and 2010.

Claremont Terminal

C124. The non-Federal partners have also indicated that there is no interest in developing the Claremont Terminal, currently a scrap metal import and export facility located at the head of the Claremont Channel, as a container terminal, either at its present size or through proposed expansions.

Oil Terminals

C125. The non-Federal partners have indicated that there will be no increase in the number of or spatial requirements for petrochemical facilities due to environmental and practical constraints. Navigation improvements are required only to increase the efficiency of deliveries to existing facilities and to reduce the exposure to risk of environmental damage stemming from lightering operations.

Summary of the Non-Federal Partners' CPIP

C126. Table 7 provides a summary of the terminal changes anticipated by the non-Federal partners' Comprehensive Port Improvement Plan.

TABLE 7
Summary of Non-Federal Partners' Comprehensive Port Improvement Plan

Terminal	Planned Terminal Acreage and Fill (Year 2060)	Description of Major Terminal Modifications
Port Newark/Elizabeth	1437 / 387	100-acre reconfiguration 387-acre terminal creation on 387 acres of fill (Port Elizabeth)
Port Jersey/MOTBY	310 / 0	80-acre reconfiguration (NEAT) 130-acre terminal (MOTBY)
Howland Hook	147 / 0	Additional acreage may be provided by Proctor &Gamble site acquisition
South Brooklyn	315 / 145	315-acre terminal creation on 145 acres of fill
Red Hook	0 / 0	Phased out by 2010
Total	2209/ 532	

Productivity Increases

C127. The land-side productivity of marine terminals located in the Harbor (*i.e.*, potential throughput per terminal acre) is anticipated to increase significantly due to advances in technology and changes in operating procedures. Theoretical land-side productivity is currently affected by the following equipment and operational factors:

- Number of berths at the terminal;
- Number and speed of cranes;

- Stevedoring productivity rate;
- Terminal yard area and storage technology;
- Utilization of terminal area;
- Container dwell time;
- Gates.

C128. As stated above, the Port's theoretical productivity per acre is expected to increase with a concomitant increase in throughput capacity. The non-Federal partners have predicted that theoretical productivity of land will increase at an average annual rate of about 2% per year. This will cause theoretical productivity to rise from 1,500 container lifts per acre now to about 3,500 container lifts per acre in 2040, the endpoint of their analysis. Because the period of analysis for the present study extends beyond 2040 to 2060, it was assumed for planning purposes that the theoretical productivity of land would level off at that point and remain essentially constant through the year 2060. At approximately 1.7 TEUs per container lift this means the throughput capacity will increase from about 2,550 TEUs/acre/yr to about 5,950 TEUs/acre/yr over the next forty years.

C129. The non-Federal partners' prediction of future theoretical land-side productivity is predicated on the Port Development and Investment Study completed for the PANYNJ. The study estimated the maximum practical throughput attainable by existing container terminals on the basis of several fundamental changes in the existing terminal configurations/operations. First, existing terminals would be re-configured to increase the net container yard area from the current average of 64% to 75% of the total terminal area. Second, the grounding of containers (*i.e.*, rather than storing containers on a wheeled chassis) would increase from the current average of 50% of all containers to 80% of all containers. Moreover, grounded containers would be handled using modern equipment, including rubber tire gantry's (RTG's), straddle carriers, or reach stackers, which allow for a relatively high storage density of containers in the future container yards. Third, the average dwell time for loads would be reduced from 6 to 5 days. Finally, the long-term storage of empty containers would be removed from the terminals with a reduction in empty container dwell time from 16 to 10 days. Throughput computations demonstrated that the above changes in existing terminal configuration/operation would increase theoretical terminal productivity from the existing 1,500 lifts/acre/year to the predicted 3,500 lifts/acre/year. The latter number is less than, but consistent with, the existing productivity achieved at other large ports throughout the world.

C130. The Ports of Long Beach and Los Angeles attain productivity from 2,500 to 3,500 lifts/acre/year and in the northwest (*e.g.*, the Port of Tacoma), rates as high as 4,500 lifts/acre/year are attained. It is also recognized that the great transshipment hubs of east and southeast Asia regularly reach productivity above 5,000 lifts/acre/year. The

difference between attainable productivity at the Port and the rates on the west coast of the U.S. and Asia is a matter of dwell time. The Port value of around 3,500 lifts/acre/year is due to the fact that its market is nearly all local (70% within 75 miles). Thus, its terminals serve as both ship discharge platform and customer holding yard. On the west coast in Southern California, 50% of their traffic is placed immediately on trans-continental double stack unit trains and speeds across the country. In the Pacific northwest, over 80% of the traffic is moved by train as soon as possible from the terminal. In Asia (*e.g.*, Hong Kong or Singapore) most containers are transshipped directly back across the berth to feeder vessels. Thus, the relatively modest productivity target for the Port (3,500 lifts/acre/year) follows from the fact that most containers are destined for local markets.

C131. The Port study indicates that the increase in productivity cannot be expected to occur immediately. Rather, increases in productivity will occur gradually over the period from 1999 to 2040. The growth in productivity will occur over time as the terminals are re-configured, investments are made in new equipment to handle grounded containers, changes are made to terminal and inventory control systems, and changes are made in work rules that make the grounding of containers less expensive relative to wheeled containers.

C132. As evidenced by the recent purchase of 4 new cranes for the Global Marine Terminal, it is reasonable to anticipate that the terminals will be investing in the necessary upgraded equipment over the planning horizon and that pressure to increase throughput through existing terminals to meet rising demand will result in the enhanced operating procedures discussed above. Therefore, the growth in theoretical productivity of land predicted by the non-Federal partners is considered a reasonable assumption for all the terminals except South Brooklyn.

C133. Estimates of future South Brooklyn Marine Terminal productivity (*i.e.*, container lifts/acre/year) were adjusted to reflect uncertainties regarding the specifics of the cross-harbor improvements presently under study by the NYCEDC. Discussions with those involved in the study indicate that the cross-harbor improvement may consist of a rail tunnel, truck/rail tunnel or barge system. Productivity of the South Brooklyn container terminal will be closely tied to the type of cross-harbor improvement constructed and may be less than, or exceed, the other terminals in the Port. Moreover, there may be additional costs associated with moving containers through the terminal (*e.g.*, it may be necessary to place a container on a truck after it has been moved through a rail tunnel from the South Brooklyn terminal.). Inasmuch as the plans for the cross-harbor improvement have not yet been completed, future productivity rates have been reduced to 75% of the productivity estimated for the other terminals in the Port. This reduction was made on the basis of professional judgement in order to facilitate a prudent assessment of the feasibility of the South Brooklyn terminal.

Without-Project Condition

C134. The non-Federal partners' Comprehensive Port Improvement Plan (CPIP) for the Port's terminals is predicated on maximizing market share by providing capacity to meet all of the demands for container handling services predicted in their economic analysis. However, the plan calls for development and expansion through land reclamation that is uncertain at this time. The Port Newark/Elizabeth expansion will impact the Newark Bay mudflats and the South Brooklyn development will impact fish habitat in the vicinity of the former Bush Terminal. As discussed previously, these plans have a strong level of commitment from the non-Federal partners, but the regulatory agencies responsible for permitting these developments have indicated that alternatives to fills must be evaluated. A separate environmental analysis of the non-Federal partners' actions must be completed prior to construction. Based on coordination between the Environmental Protection Agency, the New York District, and the non-Federal partners, it was determined that a Comprehensive Port Improvement Plan EIS (CPIP-EIS) would be required to determine how to prioritize and screen potential terminal expansions put forth in the non-Federal partners' CPIP. Recent reclamation projects have been permitted in the ports of Long Beach and Los Angeles. Accordingly, it might reasonably be expected that a permit could eventually be granted for some or all of the proposed fills, however, the District is not considering any regulatory decisions at this time.

C135. The project was formulated on the basis of a Without-Project Condition that does not include fills as the most likely future condition. The terminal reconfiguration at Port Newark that consists of demolishing existing warehouses (Figure 17) to provide 100 acres of additional productive container terminal yard area is included in the Without-Project Condition. Similarly, as shown in Figure 18, the rehabilitated 100-acre terminal at the South Brooklyn Marine Terminal was included in the formulation process as part of the Without-Project Condition. The configuration of the proposed terminal does not require or include any waterfront fills. The Without-Project Condition for Port Jersey Channel is shown in Figure 19 and consists of the existing 100-acre Global Marine Terminal, a 130-acre portion of the former MOTBY property, and the reconfiguration of the 80 acres that currently comprise the Northeast Auto Terminal (NEAT). Combined, these anticipated Without-Project actions result in an additional 410 acres of terminal area. This will result in an increase in Port terminal capacity from 7.1 million TEUs to 9.6 million TEUs at the predicted theoretical productivity of 3,500 lifts per acre per year. Table 8 summarizes the Without-Project Condition for the terminals as used in the plan formulation, none of which require the placement of fill for land reclamation.

TABLE 8 Terminal Descriptions – Without-Project Condition	
Terminal	**Description**
Port Newark/Elizabeth	1050-acre container terminal, including all facilities (950 acres + 100 acres reconfiguration) – no fill
Howland Hook	147-acre container terminal – no fill
Port Jersey/MOTBY	310-acre container terminal, incl. MOTBY (100 acres + 80 acres NEAT + 130 MOTBY acres) – no fill
South Brooklyn	100-acre container terminal – no fill
Red Hook	No container terminal (phased out by 2010)
TOSCO/GATX	Oil facilities

Channel /Anchorage Maintained Depths

C136. Table 9 presents the authorized dimensions of the navigation channels and anchorages in the Harbor along with their presently maintained depths. As indicated in Table 9, it is anticipated that the Without-Project Condition depths will coincide with the authorized depths except for the Arthur Kill where reauthorization of an interim depth is pending, and the Ambrose and Anchorage Channels in which authorization was subject to a favorable report by the Chief of Engineers which was not pursued.

TABLE 9
Navigation Channels and Anchorages in New York & New Jersey Harbor
(Federally Authorized & Maintained)

Waterway	Authorized Depth	Without-Project	Authorized Width	Presently Maintained Dimensions
Ambrose Channel	55 ft MLW, subj to a favorable rpt by the Ch.of Eng.	45 ft MLW	2000 ft	Authorized width is maintained. Depths are greater than the constructed 45 feet MLW in many areas due to commercial sand mining.
Anchorage Channel	55 ft MLW, subj to a favorable rpt by the Ch.of Eng.	45 ft MLW	2000 ft	Same as presently constructed and maintained. Little maintenance is required.
Kill Van Kull and Newark Bay	45 ft MLW	45 ft MLW	500-1000 ft	Authorized width maintained. Interim depth of 40 ft MLW is maintained pending construction of the 45 ft MLW depth.
Arthur Kill to Gulfport	45 ft MLW, subj to a favorable rpt by the Ch.of Eng.	41 ft MLW to Howland Hook, 40 ft to Gulfport	600-800 ft	Authorized widths maintained. The previously authorized depth of 35 ft MLW is currently maintained, pending reauthorization of a 40 ft MLW interim depth. A GRR is underway for the 45 ft MLW channel.
Port Jersey Channel	41 ft MLW, subj to a favorable rpt by the Ch.of Eng	41 ft MLW	370-600 ft	Authorized width maintained. A 35ft/38ft MLW depth is maintained. Construction of a deeper Federal channel will federalize maintenance requirements.
Bay Ridge- Red Hook Channels	40 ft MLW	40 ft MLW	1200-1750 ft	Same as authorized.
Buttermilk Channel	35 ft MLW west half, 40 ft MLW east half	35 ft MLW / 40 ft MLW	1000 ft	Same as authorized.
Claremont Channel	42 ft MLW, subj to a favorable rpt by the Ch.of Eng.	15-30 ft MLW	300 ft, subj to a favorable rpt of Ch.of Eng	A natural channel, 27 ft deep MLW, roughly at the authorized width, exists and is utilized, pending construction of the authorized channel.
Stapleton	None, naturally 45 to 75 ft deep	Same		None
Gravesend Bay	47 ft MLW	Same		Same as authorized.
Red Hook Flats	45, 40 and 35 ft MLW south to north in federally maintained portions; 10 to 20 ft MLW in the NE, unmaintained barge anchor.	Same		Same as authorized.

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PROBLEM IDENTIFICATION, NEEDS, AND OPPORTUNITIES

Problem Identification

General

C137. In terms of cargo volume, the Port is the largest container port on the East Coast of North America and the third largest container port in the U.S. (after the Ports of Los Angeles and Long Beach). According to American Association of Port Authorities (AAPA) figures, container traffic through the Port in 1997 totaled 12.6 million metric tons of cargo in 1.3 million containers, equaling 2.4 million twenty-foot equivalent units (TEUs). The Port provides more than 166,000 jobs and $20 billion in economic activity, while serving more than 17 million consumers in the States of New York and New Jersey, in addition to a larger 31-state hinterland. Additionally, the 30 billion gallons of petroleum and petroleum products delivered to or originating from the Port each year make it also the largest petroleum port in the country.

C138. The Port handles this large volume of commerce in spite of the fact that it lacks sufficient depth to serve fully loaded ships of the latest designs. In general, channel depths range from 35 ft MLW in the Arthur Kill to 45 ft MLW in the Ambrose and Anchorage Channels, with no more than 40 ft MLW presently to any of the major container terminals.

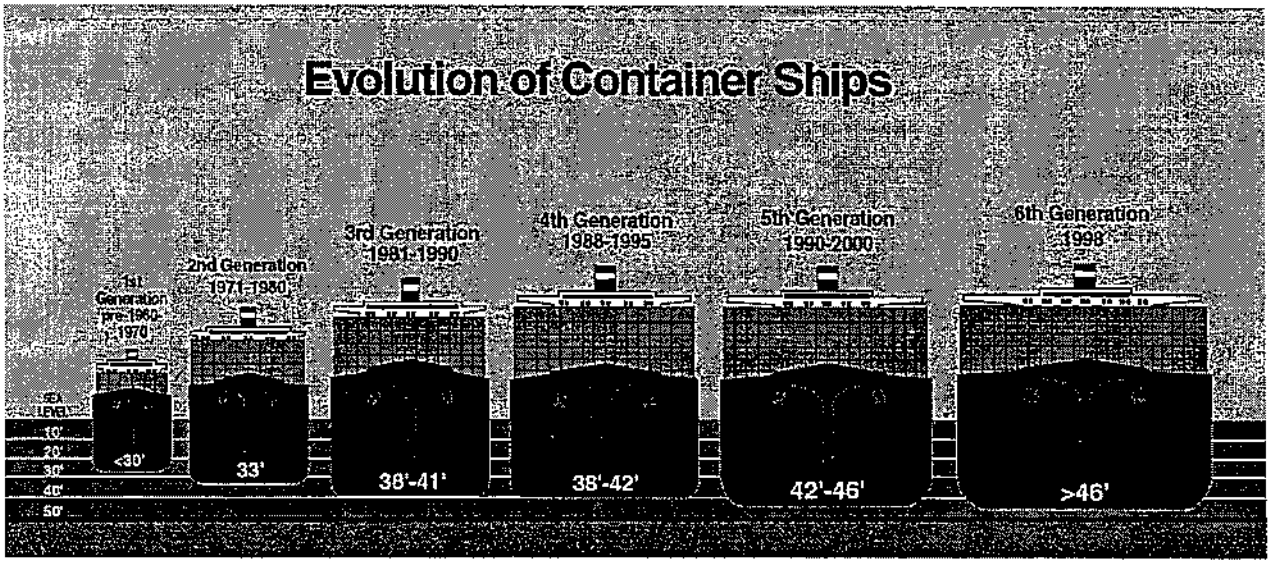
C139. Assuming that the volume of cargo grows at an average annual rate of 3% (this rate matches the average annual rate of growth of the U.S. gross domestic product (GDP) in this century), container traffic through the Port will reach 11.2 million containers (over 19 million TEU) by 2060. Since the end of World War II, the dollar volume of world trade has grown at a little over twice the annual rate of U.S. GDP growth. Therefore, the 3% annual growth assumption for the volume of commerce is probably conservative.

C140. By 2060, the number of vessel passages required to transport cargo through the Port would be six times the number required in 1996 if channels were not deepened and there was no concomitant change in the vessel fleet. Some of the containerships that currently utilize the Port Jersey Channel, the Kill Van Kull and the Arthur Kill can do so now only under favorable tide conditions. To increase the number of vessel passages during the period of favorable tide by a factor of six or more may not be physically possible and certainly would pose a grave increase in the probability of accidents.

C141. As the volume of water-borne commerce has grown, however, it has become possible for shipping lines to realize the economies of scale offered by ships with larger

carrying capacity. Since the introduction of containerized cargo in the 1950s, six generations of container ships have evolved. Periodic channel deepening projects have been initiated in order to keep the Port accessible to the newest, most cost-efficient vessels. The fourth generation of container ships, with drafts of up to 42 feet, necessitated the most recent improvements of the Kill Van Kull and Newark Bay, which will include deepening those channels to 45 ft MLW. The rapid production of larger, fifth and sixth generation vessels has generated the need for even deeper channels. The evolution of container ships is illustrated in Figure 20. By the end of 1999, the largest vessels will account for 34% of the world fleet's containership capacity, but only 18% of the hulls. Therefore, the world's containership fleet is moving to a new composition with a high proportion of larger vessels. At their design drafts, these ships cannot reach the majority of the container handling facilities in the Port. To reach the facilities, these ships must be light loaded, anchor in deeper water awaiting favorable tide conditions, call on a deeper port and transship some of their cargo on smaller ships of shallower draft or by road or rail, or use some combination of these techniques. All of these approaches require the operator to surrender potential transportation cost savings stemming from the economies of scale associated with the larger ships. These same considerations apply to tankers and bulk carriers. Therefore, ships using the Port in the near future must either be of a relatively economically inefficient design or be economically efficient design but operated in an economically inefficient manner.

Figure 20
Evolution of Container Ships



Source: Final EIS/Environmental Impact Report and Final Feasibility Study (FEIS/R/FS) - Port of Oakland and the USACE, 1998

Channels Leading to Existing Container Terminals

C142. Citing existing and future generations of container vessels which are unable to fully load, Port interests have expressed a desire for improved channels of 50 ft MLW, or greater, to container terminals at Newark Bay, Port Jersey, Howland Hook, and at a future improved terminals in South Brooklyn. Previously authorized studies showed that the Claremont Channel optimized at 38 ft MLW. Until such time that other plans have been advanced for the area in the vicinity of Claremont Channel, there is no need for further deepening of this channel.

Channels Leading to Oil Terminals on the Arthur Kill

C143. Similarly, local interests and petroleum terminals along the Arthur Kill have requested deepening the existing 35 ft MLW channels so as to reduce the need for lightering and in-harbor transfer systems. At the time this study was initiated, local interest in deepening the Arthur Kill south of the Gulfport Reach had not yet been determined. It was only after the study was initiated that local interests made their desires to deepen the Arthur Kill to Perth Amboy known. As a result, a separate study was authorized to specifically investigate this area and funds were allocated in the FY 99 budget to do so. An internal reconnaissance level report, completed in the later part of fiscal year 1999, concluded that a favorable cost-to-benefit ratio could not be attained. The report is now under coordination.

Anchorages

C144. In the event that this study recommends deepening the common Ambrose and Anchorage Channels, operators of oil facilities throughout the Harbor desire the expansion of the harbor anchorages to facilitate safer in-harbor lightering.

C145. No other area of the harbor has been identified as being in need of further improvement.

Needs

C146. The Port needs a long-term solution that will reduce unit transportation costs by providing an environmentally acceptable means to accommodate the growing fleet of larger merchant ships. The specific needs are as follows:

Navigation Needs

- Need for a channel or channels of sufficient depth and width, and with proper alignment to allow safe access to Port container terminal(s) by the newest class of deep draft container vessels;

- Need for deeper anchorages to minimize or help ensure safer lightering and in-harbor transfer operations for petroleum tankers.

Environmental Needs

- Need to ensure minimal impacts to environmental resources;

- Need to reduce the potential for environmental damage resulting from petroleum product spills occurring during in-harbor transfer operations.

Regional Needs

- Need to protect jobs and insure revenue generation by limiting the motive (*i.e.*, shallow port) for carriers to move to alternative ports or to otherwise reduce the levels of maritime cargo passing through the Port's marine terminals.

Opportunities

C147. Planning opportunities that have been identified include:

- The opportunity to bring the forecast volume of goods into the Harbor on fewer ships;

- The opportunity to eliminate or reduce navigational restrictions and inefficiencies (*i.e.*, channel depth limitations) to enable maritime carriers to realize the transportation economies of scale without adversely impacting their shipping operations;

- The opportunity to reduce the risk of adverse environmental impacts due to oil spills occurring during lightering and in-harbor transfer operations.

- The opportunity to ensure efficient use of the Port's marine cargo terminals.

PLAN FORMULATION

Federal Planning Requirements

Principles and Guidelines

C148. The formulation process used in this study is consistent with the national objectives as stated in the *Planning Guidance Notebook.* In accordance with the *Planning Guidance Notebook*, plans must contribute to the National Economic Development (NED) consistent with protecting the nation's environment. Plans to address the needs in the study area must be formulated to maximize NED benefits while providing a complete, effective, efficient, and acceptable plan of protection. These objectives impose general planning constraints within any study area.

- Completeness is defined in ER 1105-2-100 as,

  "the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. This may require relating the plan to other types of public or private plans if the other plans are crucial to realization of the contributions to the objective."

- Effectiveness is defined as,

  "the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities."

- Efficiency is defined as,

  "the extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment."

- Acceptability is defined as,

  "the workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies."

National Economic Development (NED) Plan

C149. The NED plan is the alternative that reasonably maximizes net excess benefits and is the baseline against which other alternatives are compared. Normally, the Federal share of the NED plan is the limit of federal expenditures on any more costly plan.

Locally Preferred Plan

C150. Although the NED plan must normally be recommended, the planning process recognizes that the non-Federal partners may have additional desires for channel development or navigation improvement beyond that provided by the NED plan. A locally preferred plan may be recommended provided the non-Federal partner agrees to pay the difference in cost.

Planning Objectives and Constraints

Study Objectives

C151. The fundamental study objective is to develop an optimal plan that can accommodate existing and future vessel traffic. The optimal plan must also be acceptable from the NED perspective, as directed by the *Planning Guidance Notebook*, as well as from Environmental Quality (EQ) and Regional Economic Development (RED) perspectives, and to account for Other Social Effects (OSE). Plans were formulated to be complete, effective, efficient and acceptable, and to reasonably maximize net benefits. In summary, these objectives are:

- To produce a comprehensive harbor water-side improvement plan to address the projected challenges, needs, and opportunities for safe and economically efficient navigation and cargo movement through the Port, which includes:
  - To increase the value of the nation's output of goods and services and increase national economic efficiency (*i.e.*, NED);
  - To reduce the forecasted diseconomies of shipping in the study area attributable to current and future channel/shipping configurations;
- To preserve and maintain existing environmental resources;
- To provide a plan which is compatible with future, regional economic development opportunities.

Constraints

C152. Channel improvement alternatives that satisfy area needs and objectives are partially limited by current channel alignments and depths, existing terminal infrastructure, and environmental and structural constraints. The list of constraints is as follows:

Economic Constraints

- Plans must be justifiable, that is, plan benefits must exceed plan costs (there must be net excess benefits);
- Plans must be efficient. They must represent near optimal use of resources in an overall sense. Accomplishment of one economic purpose cannot unreasonably impact another economic system.

Environmental Constraints

- Plans cannot unreasonably impact environmental resources;
- Where a substantial impact is established, plans must consider mitigation or replacement and should adopt such measures, if justified.

Regional and Social Constraints

- The needs of the region must be considered and one area cannot be favored to the unacceptable detriment of another;
- No favoritism can be shown; all reasonable opportunities for development within the study scope must be weighed, one against the other.

Technical Constraints

- The encroachment on public and private lands by expansion of the channel side slopes should be avoided where possible;
- Plans must be technically achievable and cannot contain obstructions which obviate accomplishment of the desired output;
- Plans must be realistic and utilize existing technologies;
- Plans must represent sound, safe, acceptable engineering solutions;

- Design of channel depths with the use of high tide is unsafe;

- The channel widths at bridge crossings cannot be expanded if widening could impact the structural integrity of bridge support.

Institutional Constraints

- Plans must be consistent with existing Federal, state, and local laws;

- Plans must be locally supported to the extent that local interests must guarantee local pier, berths, and other works necessary to realize benefits since the Federal government is constrained from construction of these works;

- Works cannot be adopted which would benefit a single user to an unreasonable degree;

- The plan must be fair and find overall support in the region.

Plan Formulation Rationale

General

C153. The Port contains a variety of channels, anchorages, and berths, which support commercial navigation. In general, the deep draft channels and anchorages have been constructed and are maintained as part of Federal navigation projects and berthing areas are maintained by non-Federal institutions or organizations (public and private). The existing Federal channels have been authorized by Congress and constructed over the Port's long history as a variety of separate projects.

C154. The purpose of this investigation is to consider the Harbor in its entirety and to comprehensively evaluate plans to improve navigation in the Harbor. The formulation process is conducted consistent with Federal statutes and Corps' policy. Specifically, the principal focus of this investigation is the anticipated effects of alternative plans on the National Economic Development (NED) account. Although the Port is an important contributor to the New York and New Jersey regional economy, Federal decision making regarding infrastructure improvements are primarily based on anticipated effects on the national economy. In navigation studies, the costs of navigation improvements are compared to national benefits expected to result from reduced transportation costs. For the purpose of this investigation, reduced transportation costs were computed using commodity projections based on macroeconomics dictated by growth in world population and income. These projections are independent of channel improvements and no attempt was made to capture induced trade. Procedures for estimating NED effects are specified

in the *Economic and Environmental Principles and Guidelines for Water Related Land Resources Implementation Studies* (U.S. Water Resources Council, 10 May 83), Corps' ER 1105-2-100, and other Corps Guidance, such as the *National Economic Development Procedures Manual: Deep Draft Navigation* (November 1991).

C155. Therefore, the preliminary assessment of plans was measured in terms of contributions to the primary objective in water resources project planning, namely, National Economic Development. The assessment's result is the identification of plan(s) which best serve the objectives. The study considered three categories of alternative plans:

- A No-Action Plan;
- Non-structural plans which would provide for the more efficient use of the existing waterways and shipping facilities;
- Structural plans involving new channels, interim terminal facilities, deepening and widening existing channels in the study area, and/or terminal expansions.

Economic Principles

C156. The assessment of the alternative plans was carried out using several economic and environmental principles:

C157. Projected Commerce Levels. Projected commerce levels were derived from worldwide macroeconomic trends. They were compared to the Without-Project Condition terminals' and channels' capacities to determine whether terminal or channel throughput capacity is expected to constrain the volume of commerce anticipated to enter the Harbor.

C158. Costs. Costs that were considered in the analysis include dredging costs; operating costs; mitigation costs; project-dependent terminal expansion costs.

C159. Benefits. The primary benefit to offset the construction costs associated with deepening the navigation channels is the transportation cost savings associated with the operation of deeper draft vessels. The analysis compares marginal (incremental) benefits to marginal costs on a channel by channel and foot by foot basis. Capacity at any given terminal is constrained by land area, berths, cargo handling equipment (including cranes), and carrier practices with respect to leases, alliances, and exclusive use of particular terminals.

C160. Benefit Optimization. The combination of pathways and channel depths that maximizes the net excess benefits was identified. For each pathway evaluated, the total difference in transportation costs under Without- and With-Project Conditions for various channel depths was compared to the annualized investment cost for its respective pathway and channel depth. For each pathway and channel depth combination that results in net excess benefits, the pathway and channel depth that maximizes the net excess benefits was identified. This pathway and channel depth then became the "first-added" increment of the project. In the next iteration, the incremental costs of all of the remaining pathway/channel depth combinations were compared to any remaining benefits that were not realized by the "first-added" increment. The pathway/channel depth combination that provided the greatest positive net benefits was then identified and became the "second-added" increment of the project. In order to identify the NED plan, this process was continued until none of the remaining pathway/channel depth combinations have positive net benefits.

SCREENING OF STUDY ALTERNATIVES

Screening of Preliminary Plans

No Action Plan

C161. In the event that no proposed alternative meets the Federal criteria of having a benefit-cost ratio (BCR) greater than 1.0 (*i.e.*, positive net excess benefits), the No Action Plan would become the study's recommended plan. Future conditions under such a plan are detailed in the "Without-Project Condition" section of this document.

Non-Structural Plans

C162. Non-structural measures were examined as a means of achieving the planning objectives or portions thereof. Non-structural measures generally do not improve the available depth or width of navigation channels, but rather fall into two other effect categories:

- **Measures that allow for greater unit vessel loading economies with no deepening of navigation channels.** Several measures that allow for greater vessel loading economies are currently in use in the Port and are discussed in the "Port Operations" section. These measures include: light-loaded vessels, high tide transits (tidal advantage), and lightering. The largest vessels currently in the fleet have maximum navigational drafts in excess of Harbor channel depths, therefore, non-structural port operation measures will not allow carriers to realize transportation cost savings and will only exacerbate problems facing carriers as they attempt to reduce transportation costs;

- **Alternate sites for, or means of, commerce delivery.** This non-structural measure generally refers to an alternative site either within or outside the port. Existing sites within the port are usually being used for other types of cargo transportation (*e.g.*, bulk cargo). Sites outside the port would require transportation back to the region by other means. The scope of this study considers all container terminal sites in the Port, including existing, expanded, and planned terminals. Moreover, the non-Federal partners have not identified any other alternative terminal sites. Therefore, no additional Port terminal sites have been identified or proposed for cargo routing or handling. The delivery of goods to an alternative site outside the Port (*i.e.*, another East Coast port) with cargo transported back to the region via road or rail is inherently more costly to the carrier. Accordingly, this alternative has not been included as a likely alternative in the present report.

Structural Plans

C163. Structural plans consist of deepening and widening the Port's navigation channels to permit the flow of goods on the larger, more cost effective ships. To facilitate the screening process for structural plans, the Harbor was divided into "pathways" (*i.e.*, a series of existing channels or channel segments) leading to the existing and proposed Port facilities. Alternatives considered involved each of the pathways at various depths and in various combinations with one another. In addition, as described below a new channel across the Bayonne Peninsula and an off-shore island were evaluated. The designated pathways, all of which having Ambrose Channel and sections of the Anchorage Channel as common elements, are:

- Pathway 1 Kill Van Kull to Newark Bay to Elizabeth and South Elizabeth Channels;
- Pathway 2 Kill Van Kull to the Arthur Kill to Howland Hook;
- Pathway 3 Kill Van Kull to the Arthur Kill to Gulfport (at tanker design depth);
- Pathway 4 Port Jersey Channel to Port Jersey and MOTBY;
- Pathway 5 Bay Ridge Channel to South Brooklyn;
- Pathway 5A Bay Ridge, Red Hook, Buttermilk Channels to Red Hook Marine Terminal;
- Pathway 6 Stapleton, Gravesend Bay, and Red Hook Flats anchorages, for container vessels;
- Pathway 7 Stapleton, Gravesend Bay, and Red Hook Flats anchorages, for tankers;
- Pathway 8 Claremont Channel to Claremont Terminal.

Design Criteria

General

C164. Structural plans for providing access to the Port's container terminals were developed on the basis of the 46-ft static draft Maersk K Class container vessel as the design vessel. Although, newer and larger container vessels are currently being deployed, this is occurring more rapidly than ship modeling studies and fleet forecasts can be prepared, rendering these studies as "point in time" forecasts. Therefore, in order to compute project benefits, it was necessary to establish a fleet forecast based upon the best information available at the time, recognizing that even larger vessels might be introduced before the study could be completed. Accordingly, the District has incorporated vessels with sailing drafts up to 48 ft in our fleet forecast. The forecast was "capped" at 48 ft for several reasons. First, discussions with shipping lines have indicated that 48 ft is approaching the maximum practical draft of container vessels

without employing a twin screw design (which would result in a significant cost per TEU increase). Instead, the experts consulted during the study expect that, for the foreseeable future, additional TEU capacity will be obtained by increases in length and beam, not draft.

C165. Second, container vessel sailing drafts are a function of a variety of factors, only one of which is design draft. These other factors (including fleet deployment, loading patterns, ship schedules, and prior port-next port considerations) would all have to align perfectly to assume that vessels would arrive in the Port in excess of 48 ft at any time in the foreseeable future. Finally, while vessels even larger than the *Regina (or Sovereign) Maersk* are expected to enter the world fleet in the future, the District does not believe there is sufficient data available to incorporate a specific number of these vessels (including required drafts, TEU capacity, and operating costs) into the study's fleet distribution at specific dates, on specific routes. Therefore, the District has chosen to use a maximum static draft of 46 ft, recognizing that this may be a conservative estimate.

C166. It is emphasized that the Maersk vessels are simply examples of the largest container vessels. Similar sized vessels owned by other shipping lines would also use any structural plans that are developed in connection with this present study. The 55-ft draft Suezmax oil tanker was the design vessel for channels providing access to the Port's petrochemical facilities along the Arthur Kill.

Design Vessel Parameters

C167. **Factors Increasing Design Vessel Draft.** Factors increasing the static vessel draft, including squat, trim, and salinity, were included in the channel design as listed below (see Figure 21). A complete discussion of the development of the design vessel parameters is included in the Channel Design Appendix.

DESIGN PARAMETERS FOR CONTAINER VESSELS	
Static Draft = Maersk "K Class" or equivalent	= 46 ft
Squat + Trim + Salinity	+ 2 ft
Sailing Draft	= 48 ft

DESIGN PARAMETERS FOR TANK VESSELS	
Static Draft = Suezmax tanker	= 55 ft
Squat + Trim + Salinity	+ 3 ft
Sailing Draft	= 58 ft

C168. **Design Vessel Underkeel Clearance.** Underkeel clearance or "safety clearance" for the design vessels is different for "soft" and "hard" (*e.g.*, rock) channel bottoms as previously described and listed below (see Figure 21):

DESIGN PARAMETERS FOR CONTAINER VESSELS	
Design Vessel = Maersk "K Class" or equivalent	
Sailing Draft	= 48 ft
Safety (soft bottom)	+ 2 ft
Safety (hard bottom)	+ 4 ft
Safety (soft bottom + waves) [Ambrose]	+ 5 ft
Channel Depth(1) [soft]	= 50 ft
Channel Depth(2) [hard]	= 52 ft
Channel Depth(1)(2) [Ambrose]	= 53 ft

DESIGN PARAMETERS FOR TANK VESSELS	
Design Vessel = Suezmax tanker	
Sailing Draft	= 58 ft
Safety (soft bottom)	+ 2 ft
Safety (hard bottom)	+ 4 ft
Safety (soft bottom + waves) [Ambrose]	+ 3 ft
Channel Depth(1) [soft]	= 60 ft
Channel Depth(2) [hard]	= 62 ft
Channel Depth(1)(2) [Ambrose]	= 61 ft

(1) Maintained depth.
(2) Excavated depth.

Channel Design

C169. The channel section designs were developed with 3H:1V side slopes in non-rock material and 1H:1V in areas of rock. Channel widths and alignments were developed to provide for safe navigation of all vessels.

C170. There are four bridges spanning the channels under consideration: the Verrazano Narrows Bridge, the Bayonne Bridge, the Goethals Bridge, and the Arthur Kill Lift Bridge. The Verrazano-Narrows Bridge spans a naturally deep channel (the Anchorage Channel - approximately 90 ft deep under the bridge), therefore, channel excavation beneath it would not be required. No widening of the Kill Van Kull is expected beneath the Bayonne Bridge. Horizontal channel clearance under the Goethals Bridge and Arthur Kill Lift Bridge, located south of the Howland Hook Marine terminal in the Arthur Kill, is limited by the position of the bridge piers and the fender and dolphin protective structures. If channel improvements are proposed to this section of the Arthur Kill, expansion of the channel widths at these bridge crossings may be limited as the structural stability of these structures must not be threatened.

C171. The channels listed below were considered to have a "hard" bottom (*i.e.*, rock or glacial till) and require a 4-ft underkeel safety clearance.

- Kill Van Kull,
- Newark Bay,
- Arthur Kill,
- Port Jersey.

C172. The initial dredging in hard material will include the 4-foot safety clearance, which corresponds to a deepening 2 feet below the maintained depth. This additional 2 feet of safety clearance will then be permitted to silt in over time effectively creating a "soft" bottom, which only requires a safety clearance of 2 feet.

C173. Environmental conditions (*e.g.*, waves, currents, salinity) are different for each channel in the Harbor, as shown in the previous "Design Vessel Parameters" section. In order to provide a consistent level of service along a pathway from sea to berth it may be necessary to construct and/or maintain the various channels along that pathway at different depths in order to account for the environmental variations. For example, consider Pathway 1 (which goes from sea to Port Newark/Elizabeth). The 46-ft Maersk K Class design vessel requires a channel depth of 53 ft MLW in Ambrose Channel but only a 50 ft MLW depth in the Anchorage Channel. Likewise, this vessel requires a 52 ft MLW channel depth in the Kill Van Kull and Newark Bay due to the "hard" bottom, but the channel will be maintained at 50 ft MLW, essentially allowing a "soft" bottom of sediment to deposit in the lower 2 ft of the channel. For convenience, "maintained depth" refers to the limiting or controlling depth along a path. It should be noted that quantities and costs developed for maintained depths are based on the parameters described above (*i.e.*, that is, estimated quantities for "hard" bottom channels include the additional 2 ft of depth beyond maintained depth). Due to imprecision in dredging technology and to ensure that they perform their contract obligation fully, contractors will dredge beyond the required depth. Historically, by permit, this "overdredge" has been allowed to be up to an additional two feet.

Bayonne-Newark Bay Canal

C174. A plan to construct a canal across Bayonne, New Jersey was considered. The Bayonne-Newark Bay (BNB) Canal was to extend the Port Jersey Channel to Newark Bay across the Bayonne Peninsula near the Bayonne-Jersey City limits, as shown in Figure 22. This plan allows for the deepening of the Port Jersey Channel as well as Newark Bay (northern portion), including the Elizabeth and South Elizabeth channels. In this way, there would be access via 50 ft deep MLW channels to terminals representing

80% of the existing container handling capacity in the Port without having to deepen the Kill Van Kull.

C175. This plan reduced the distance to be dredged to reach Port Newark/Elizabeth from over 8 miles via the Kill Van Kull to approximately 5.3 miles and provided deepwater access to the terminals along the existing Port Jersey Channel. In addition, a significant portion of this route would have crossed what is now dry land and could be excavated using conventional land-based equipment. The canal alignment would require relocating several major roadways and rail lines that were expected to add significantly to the project cost. The following are the most significant advantages and disadvantages of this plan.

Advantages:

- Eliminate the need to dredge (*i.e.*, excavate underwater) 8+ miles of the Kill Van Kull (rock);
- Provide access to Newark Bay without significant turns (*e.g.*, Bergen Point);
- Eliminate the potential air draft problem posed by the Bayonne Bridge.

Disadvantages:

- Significant real estate costs would be associated with buying-out or relocating approximately 300 structures in the channel footprint, as well as the additional structures in the road or rail tunnel footprints;
- Significant costs associated with the placement and/or remediation of hazardous, toxic, and radioactive waste (HTRW) sites within the proposed channel and tunnel footprints;
- Large amounts of rock excavation would be required with associated blasting impacts on adjacent structures;
- Relocation of rail lines and roadways and the construction of several road or rail tunnels under the canal;
- A high rate of sedimentation would be expected in the canal, necessitating frequent maintenance dredging;
- Increased sedimentation rates, due to changed hydraulics, could result in significantly increased O&M dredging quantities throughout the Harbor.

C176. In addition to the listed disadvantages, garnering public support, which would be critical to constructing this plan, would be difficult and unlikely due to the significant quality of life changes resulting from construction, including the displacement of residents and the increased traffic congestion due to limited channel crossings. In addition, cursory estimates showed construction costs to be very high. Based on these factors, the non-Federal partners requested that the plan be eliminated from further consideration.

Off-Shore Island Port

C177. The construction of an off-shore island port or terminal was evaluated. This terminal was conceived as an interim solution to addressing the Port's depth constraints. It was identified as an interim solution because the proposed island terminal would not be large enough to handle the deep draft container volume forecasted for the Port.

C178. The terminal would be located on top of a portion of an offshore confined placement facility (*i.e.*, an "island" of dredged material) as shown in Figure 23, with pier-side depths in excess of 60 ft MLW, thus providing access for the largest container vessels. The terminal would be used to offload a portion of a large container vessel's cargo such that the vessel's draft would be reduced to a level where the vessel could then safely transit to a container terminal at existing channel depths. However, the following advantages did not outweigh the significant disadvantages of this plan.

Advantages:

- Little or no construction dredging of the Harbor would be required;
- The terminal would provide unrestricted access of vessels with sailing drafts of 60 feet or more to the Port, depending on final siting;
- The terminal could potentially reduce the depth requirements of the Harbor as a whole.

Disadvantages:

- The location of the island terminal/port will be relatively unprotected, as conceived, hampering vessel dockings/sailings and barge operations during inclement weather conditions;

- Carriers would have to incur the additional expense to transship cargo from the island port to in-Harbor terminals as well as require two vessel stops in one port;

- It would be a short-term solution only – the island port would not have enough capacity for all deep draft vessel cargo;

- Upon implementation of a permanent solution, post-operational use/benefits of the island port (*e.g.*, as an island habitat) may not offset environmental impacts associated with construction.

C179. As envisaged, the Off-Shore Island Port was not intended to fully meet the planning objectives but rather to serve as an interim solution by providing a terminal for the deepest draft vessels while other channel improvement plans were developed or implemented. This study has identified channel improvements that can meet the planning objectives in a reasonable timeframe and, therefore, the non-Federal partners requested that the plan be eliminated from further consideration.

Channel Deepening Plans

C180. Channel deepening plans were the final structural plans considered. The alternatives focused on deepening the channels or channel segments so as to provide access for fully-loaded deep draft vessels to the Port's container and petrochemical terminals. Additionally, channel widening and/or realigning, and turning basin construction were considered to improve large vessel traffic flow and reduce the potential for maritime accidents. The study evaluated deepening all or some of the designated channels/pathways, at various navigational depths, in order to develop a plan that would realize the maximum net benefits.

Evaluation of Channel Deepening Alternatives

Tanker Channel Deepening Alternative

C181. Interviews with oil company personnel indicate that tanker operations in the Port would change significantly if harbor depth were increased under the With-Project Condition. First, vessels with fully loaded drafts of 42-45 ft, which currently arrive light-loaded at oil terminal facilities in the study area, would be able to arrive fully loaded. Second, the volume of individual deliveries would increase. The Port would no longer need to be scheduled as the last leg of a multi-port delivery, which would allow the oil terminal to utilize land-side storage capabilities more fully. Third, as channel depths increase, the volume of liquid cargo transferred during lightering operations and the

frequency of lightering operations would decrease. At channel depths approaching 55 ft, the 150,000 Dead Weight Tons tankers that currently lighter offshore would be able to transit the Port at or near capacity, thereby eliminating the need for offshore lightering operations.

C182. The fourth change in tanker operations would be that larger vessels would make direct calls on Port oil terminals. Currently, oil companies charter vessels best suited to local conditions (*i.e.*, requisite draft) to make regularly scheduled calls on the Port. With increased channel depths, oil companies could charter larger vessels to take advantage of new local conditions.

C183. Pathway 3, the channel deepening alternative providing unconstrained access to the two petrochemical facilities identified in the study, was evaluated. This alternative included deepening Ambrose Channel, the Anchorage Channel, the Kill Van Kull, and the Arthur Kill to Gulfport (Pathway 3) to depths sufficient for safe passage of the Suezmax design vessel (*i.e.*, a 60 ft MLW maintained depth). As stated in the study scope, no additional petrochemical facilities that would require access by the tanker design vessels are anticipated. Benefits derived from channel deepening would be transportation cost savings associated with the elimination of the need for lightering in order to safely transit to berth. The economic analysis estimated $1 million in benefits could be realized by this alternative. These benefits will support less than $15 million in construction costs given the current federal discount rate. The estimated construction cost for a 60 ft MLW channel depth to Gulfport as a last-added increment to a 50 ft MLW depth container vessel alternative through the Kill Van Kull is approximately $1.3 billion. Accordingly, it was concluded that the tanker deepening alternative is not economically viable even as a last-added feature to a plan based on container vessels and Pathway 3 was dropped from further consideration.

Anchorage Deepening Alternative

C184. Pathways 6 and 7 considered deepening alternatives for the Harbor's major anchorages. Due to the ongoing New York Anchorages Study (discussed in the "Previous and Ongoing Studies" section), which is entering the Feasibility Study Phase, further evaluation of anchorage deepening alternatives will be deferred until completion of that Feasibility Study.

Container Vessel Channel Deepening Alternatives

C185. The remainder of the structural alternatives focused on access to the Port's container terminals by the Maersk K Class or equivalent design vessel. The non-Federal partners indicated that container terminal operations will be terminated at Red Hook Container Terminal by the year 2010. As a result, the Red Hook and Buttermilk

Channels, which provide access to the terminal from the Bay Ridge Channel, were removed from further consideration for deepening, hence, Pathway 5A was eliminated as a viable pathway in the economic analysis. The non-Federal partners also indicated that there is no interest in developing the Claremont Terminal as a container terminal, either at its present size or through proposed expansions. The terminal located at the head of the Claremont Channel is currently a scrap metal import and export facility serviced by shallow draft barges and bulk vessels with insufficient trade volume to support a Federal interest in further deepening the channel. Therefore, Pathway 8 was eliminated from consideration for channel deepening. The following describes the analysis used to screen the remaining pathways; 1, 2, 4, and 5.

Preliminary Quantities and Costs

General

C186. Project costs are borne by the Federal Government and the non-Federal partners in accordance with Federal Cost Sharing guidelines as stated in the Water Resources Development Acts (WRDA's) of 1986 and 1996, ER 1165-2-131 (*Local Cooperative Agreements for New Start Construction Projects*), and Project Guidance Letter (PGL) #62, dated 29 July 1999. Alternative plan costs include the following:

- Channel dredging costs,
- Construction costs (*i.e.*, bulkheads, wharves, dredged material placement areas, etc.),
- Aids to navigation relocation,
- Utility relocation,
- Operation and Maintenance (O&M) costs,
- Land-side terminal expansions/improvements undertaken only because a deeper channel is made available,
- Environmental mitigation costs,
- Pre-construction Engineering and Design (PED) costs,
- Construction Supervision, Inspection and Administration (SI&A) costs,
- Contingency costs.

Estimated Dredged Material Quantities

C187. The estimated dredged material quantities are based upon the draft of the design vessel plus the total underkeel clearance required for the channel bottom type. Quantity estimates were based on the results of a comprehensive boring plan conducted throughout the Harbor and assumed that the channels were maintained at their authorized depths as listed in Table 1. Quantities were calculated for a maintained depth of 50 ft MLW. Estimated quantities were then calculated for two other depths at 2-foot intervals.

Quantities for additional depths were interpolated from the calculated depths using regression equations and curve fitting techniques.

C188. For all Federally-maintained channels it is assumed that all O&M material will be removed independently of and prior to project construction. No O&M material quantities, with the exception of additional, incremental O&M material quantities which result from channel sedimentation rate changes, are included in the estimated quantities. For channels without rock, the total quantity of material was calculated by generating a 3-dimensional surface profile from the channel surveys. Rock quantities, however, were developed using material contours generated from the boring analyses. As no chemical or biological testing was performed, the thickness of the material layer unsuitable for placement at the HARS was estimated from the presence of hydrocarbons, moisture content, and color of the borings. Table 10 provides a summary of the estimated dredged material quantities for deepening the Harbor channels based on geological (*in situ*) conditions, exclusive of the Arthur Kill beyond Howland Hook and the Red Hook and Buttermilk Channels.

C189. Due to imprecision in dredging technology and to ensure that they perform their contract obligation fully, contractors will dredge beyond the required depth. Historically, this "overdredge" has averaged two feet. This additional quantity is not included in following table.

TABLE 10
Estimated Geologic Dredged Material Quantities – NY&NJ Harbor

Maintained Channel Depth	Dredged Material Category (millions of cu. yds.)			Total
	Rock	Non-Rock	Unsuitable for HARS	
48 ft	2.52	16.66	8.17	27.35
50 ft	4.21	25.92	8.17	38.30
52 ft	5.81	36.51	8.17	50.49

Unit Costs

C190. Table 11 summarizes the unit costs used in the analysis. The unit costs reflect current cost levels being utilized by the Corps for the costing of navigation improvement projects in the Port of New York and New Jersey as of October 1999. The range of unit costs for dredging is due to differences in material types, dredge productivity, dredge type, and placement costs.

TABLE 11 Channel Deepening Alternatives – Unit Costs			
Category		**Unit**	**Unit Cost**
Dredged Material	Rock	CY	$13 to $18
	Non-Rock	CY	$7 to $33
	Unsuitable for HARS	CY	$5 to $8 dredging plus $29 (tipping fee)
	Blasting/Drilling	CY	$57 to $81
Bulkheads		LF	$1,000 to $2,000
Wave Screen and Pier (Elizabeth Marina)		Ea	$2,300,000
Berthing		Ea	$1,500,000 to $14,600,000
New Aids to Navigation (Bay Ridge)		Ea	$3,100 to $15,500
Utility Relocation		LF	Anchorage 36" Water - $1,700 42" Water - $2,300 Newark Bay 12" Gas - $1,200
Mitigation		Acre	$250,000
Mobilization		Ea	$3,000,000
Preliminary Engineering & Design (PED)		%	5
Supervision & Administration (S&A)		%	5
Contingency		%	15 to 20

Utility Relocations

C191. Channel depth alternatives for the Harbor include the relocation of the following utilities. Due to their shallow depth and the risk of damage during initial construction and future maintenance dredging, these utilities must be relocated. The relocation of all utilities as a result of project implementation is cost-shared between the non-Federal partners and the utility owners in accordance with the Water Resources Development Act of 1986.

- **Upper Bay.** Two water mains (36-inch and 42-inch) currently located at depths (minimum) of 53 ft and 53.7 ft MLW, respectively, in the Anchorage Channel. These water mains cross Upper New York Bay between Brooklyn and Staten Island: one crosses the Bay Ridge Channel, the southern portion of Red Hook Flats Anchorage and Anchorage Channel, and the other crosses the Anchorage Channel and Bay Ridge Channel. These relocations are a primary project cost affecting all pathways. The current cost estimate (first cost) for relocation of these lines is approximately $35 million.

- **Newark Bay**. A 12-inch natural gas pipeline currently located at depth (minimum) of 36 ft MLW crosses Newark Bay south of the entrance to the South Elizabeth Channel. This pipeline is at a depth of 36 ft MLW on the westernmost side of the bay and at a depth of 127 ft MLW on the easternmost side of the bay. This relocation cost is reflected in the Pathway 1 first costs. The current cost estimate for relocation of the pipeline is approximately $3.7 million.

C192. Three additional pipelines exist beneath channels considered for improvements: a Coastal/IMTT oil pipeline (12-inch) and two TOSCO refinery oil pipelines (8-inch and 12-inch) cross lower Newark Bay and the upper reaches of the Arthur Kill. These pipelines are scheduled for relocation as part of the Kill Van Kull/Newark Bay 45 ft Deepening Project. At their new depths, they will not be impacted by the channel deepening considered in plan formulation.

Mitigation Costs

C193. Mitigation costs were developed by identifying the direct environmental impacts of channel deepening, estimating costs for additional archeological investigations and mitigation, and estimating costs associated with beneficial use of dredged material. Specifically, environmentally sensitive areas that would be impacted by dredging were identified and the costs of mitigating these areas developed as part of an overall Mitigation Plan. Where possible, preliminary channel designs were modified to avoid or minimize dredging impacts on environmentally sensitive areas. Sites of potential archeological significance were also identified as part of the cultural resources investigations and were prioritized for additional investigations. Costs associated with beneficial use of dredged material were also estimated based on proposed beneficial uses in the DMMP. Discussions regarding the significance of the environmental impact and cultural resources impacts are contained in the FEIS and are summarized in the section titled "Environmental Impacts of the Recommended Plan". Table 12 lists the sizes of environmentally sensitive areas impacted by the channel deepening alternatives. The first cost of mitigating unavoidable environmental impacts was estimated to be $13,000,000. The cost of the Mitigation Plan does not vary significantly with the different channel improvement depths.

TABLE 12 Preliminary Area of Environmental Impact				
Channel	Environmental Areas Affected (acres)			
	Wetlands	Inter-tidal (MHW to MLW)	Littoral (MLW to –6ft)	Sub-littoral (-6ft to –15ft)
Ambrose	0	0	0	0
Anchorage	0	0	0	0
Kill Van Kull	0	0	0.06	1.41
Newark Bay	0	0	2.72	7.79
Elizabeth	0	0	0.25	1.42
South Elizabeth	0	0	0	15.84
Arthur Kill	0	0	3.23	3.22
Port Jersey	0	0	0	12.35
Bay Ridge	0	0	0	0
TOTAL	0	0	6.26	42.03

Land-side Infrastructure Costs

C194. Land-side infrastructure costs were developed by the non-Federal partners and reviewed and confirmed by the study team. These include project-related costs for terminal improvements and modifications necessary to handle, process, and store containers carried on the fleet of larger ships that would be expected following channel improvement project implementation. Costs of scheduled equipment or facility improvements, upgrades, and replacements that would have occurred at the terminals regardless of channel deepening are not related to project implementation and are not included in project costs. It was determined for the purpose of economic analysis of the project that no increased volume of goods would be induced by the channel deepening and, therefore, no project related land-side infrastructure costs were warranted.

NED Investment Costs

C195. In addition to the first cost of construction, NED Investment Costs include Interest During Construction (IDC). IDC represents the opportunity cost of capital incurred during the construction period. The investment cost of a project, which is the sum of construction and other initial costs plus IDC is the cost incurred from the start of construction to the project base year (2010). Costs incurred during the construction period are increased by adding compound interest at the 6-7/8% discount rate from the date the expenditures are incurred to the base year. For plan formulation, the IDC was calculated considering costs and construction duration for all pathways included in the alternative being considered. The total NED Investment Costs were calculated using the compound interest for the series of payments over the anticipated construction duration

on a pathway-by-pathway basis with consideration of channel elements already constructed. The IDC was calculated on the basis of total alternative costs, including Pre-construction Engineering and Design (PED), Supervision and Administration (S&A), and mitigation. Table 13 lists the estimated IDC for each of the channels considered in final plan formulation.

TABLE 13
Summary of IDC by Channel

Channel	Maintained Depth	IDC (Million $)
Ambrose Channel	46 ft	11.8
	48 ft	14.0
	50 ft	17.0
	52 ft	20.9
Anchorage Channel	46 ft	5.9
	48 ft	14.4
	50 ft	16.6
	52 ft	17.9
Kill Van Kull	46 ft	119.4
	48 ft	213.7
	50 ft	243.7
	52 ft	285.1
Arthur Kill	46 ft	78.8
	48 ft	83.2
	50 ft	93.9
	52 ft	105.3
Newark Bay/ Elizabeth Channels	46 ft	76.2
	48 ft	115.1
	50 ft	140.7
	52 ft	174.6
Port Jersey Channel	46 ft	14.8
	48 ft	18.2
	50 ft	21.6
	52 ft	25.1
Bay Ridge Channel	46 ft	11.9
	48 ft	12.3
	50 ft	13.0
	52 ft	13.9

Annual Costs

C196. The annual costs comprise the interest and amortization of the Investment Costs over the life of the project plus the project-related increase in annual Operation and Maintenance (O&M) costs. Investment Costs are annualized from the project base year of 2010 using the Capital Recovery Factor over a 50-year project life at the current Federal Discount Rate of 6-7/8%. The O&M costs are associated with the dredging

required to maintain the channel at the desired depth. The majority of the channels are already maintained at an authorized depth under the Without-Project Condition. Accordingly, the O&M costs associated with this project are only the incremental costs necessary to maintain the deeper channel.

C197. The O&M costs reflect the sedimentation rates in each channel. Sedimentation rates depend on a number of factors, including current velocity, direction of flow, and depth of the channel, and differ from channel to channel. The various sedimentation rates found throughout the Harbor are discussed in detail in the Channel Design Appendix. Table 14 shows the annual sedimentation rates expected for each channel. It should be noted that further channel deepening will improve the hydraulic characteristics in some channels and may actually reduce maintenance dredging needs. Such reductions have not been included in the formulation process. In summary, sedimentation rates in Newark Bay and the Port Jersey Channel are higher than the Upper New York Bay and the Kill Van Kull. These different sedimentation rates are reflected in the different O&M costs.

TABLE 14
Anticipated Annual Change in Sedimentation Rates with the Recommended Plan

Channel	Without-Project Condition Sedimentation Rate (cy/yr)	Shoal Index	With-Project Condition Sedimentation Rate (cy/yr)	Sedimentation Rate Allocated to Project (cy/yr)
Ambrose	400,000	1.08	432,000	32,000
Anchorage	0	1.00	0	0
KVK Con Hook	20,800	0	23,600	2,800
KVK Bergen Pt	4,000	1.04	4,200	200
Newark Bay-Main	211,000	1.01	213,000	2,000
NB Port Elizabeth	121,000	1.02	123,700	2,700
NB Port Newark	226,000	1.08	244,600	18,600
AK N. Shooters Is.	115,000	1.31	151,000	36,000
AK Eliz.-Gulfport	7,000	1.30	9,200	2,200
Bay Ridge (east)	520,000	0.89	464,700	(55,300)
Port Jersey	58,000	0.89	51,500	(6,500)
Claremont	25,000	1.07	26,900	1,900
NJ Pierhead	40,000	0.99	39,500	(500)
Red Hook Flats	145,000	0.95	138,000	(7,000)
Gravesend Bay	28,000	0.87	24,500	(3,500)
Stapleton	0	1.00	0	0
Total	1,920,800	1.01	1,946,400	25,600

KVK – Kill Van Kull, NB – Newark Bay, AK – Arthur Kill

Costs by Pathway

C198. For each of the remaining potentially viable pathways, costs were developed for providing access from the open ocean to each pathway-served terminal. Each pathway

was considered as a stand-alone-path, thus each included elements common to other pathways such as Ambrose and Anchorage channels which are common to all pathways. The Construction Cost, Investment Cost, and Annual Cost for each pathway are shown in Table 15 for various depths. Construction Costs include PED Costs and S&A Costs.

TABLE 15
Construction Costs, Investment Costs, and Annual Costs by Pathway*

Pathway	Costs (million $)	Maintained Channel Depth				
		45 ft	46 ft	48 ft	50 ft	52 ft
1 Port Newark/ Elizabeth	Construction Costs	N/A	618.9	1017.9	1195.1	1422.1
	Investment Costs	N/A	791.9	1306.3	1532.6	1825.0
	Annual Costs	N/A	55.4	93.5	111.0	133.2
2 Howland Hook	Construction Costs	281.6	716.9	1029.1	1174.3	1345.8
	Investment Costs	347.0	897.1	1296.6	1478.4	1695.3
	Annual Costs	25.8	65.2	94.3	107.8	123.9
4 Port Jersey/ MOTBY	Construction Costs	N/A	234.1	345.4	408.3	472.1
	Investment Costs	N/A	264.5	389.2	460.2	532.1
	Annual Costs	N/A	18.4	27.6	33.0	38.4
5 South Brooklyn	Construction Costs	N/A	242.5	310.2	354.0	401.4
	Investment Costs	N/A	268.7	343.9	392.6	445.1
	Annual Costs	N/A	14.8	21.3	25.8	30.7

*Pathways are from sea (Ambrose) to the major terminal served by the pathway.

Benefits Model

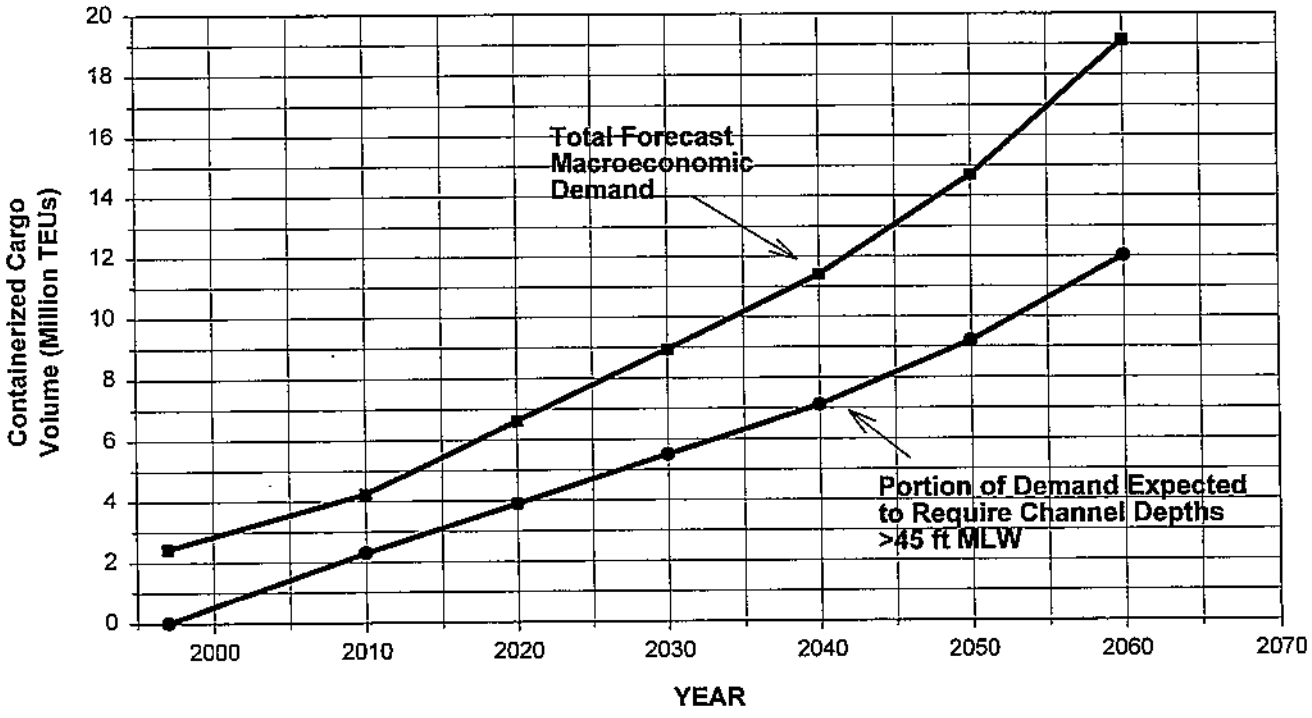
C199. The primary objective of the Benefits Model is to integrate the fleet forecasts, associated transportation cost savings, and channel and terminal capacity constraints to identify the benefits attributable to each pathway/alternative over a series of depths in order to identify the NED plan. As part of this analysis, which is fully described in the Economics Appendix, the model is structured to look at the various pathways as first- and last-added elements in order to develop the overall plan that provides the greatest net excess benefits. Benefits are distributed to a particular pathway on the basis of terminal and channel capacity in relation to forecast demand. Under the Without-Project Condition, the deepest available pathway into the Harbor is anticipated to be a maintained channel depth of 45 ft MLW leading to Port Newark/Elizabeth. The vast majority of transportation cost savings and thus benefits associated with this study are attributable to vessels requiring a maintained channel depth in excess of 45 ft MLW. The volume of commodities projected to be carried on this class of vessel is the focus of the analysis. In other words, allowing for 2 feet of underkeel clearance, vessels with sailing drafts in

excess of 43 feet provide the majority of the benefits. Benefits to vessels with sailing drafts between 39 and 43 feet were also evaluated for those pathways in which the without-project condition depths were less than 45 ft MLW.

Port Outlook

C200. During the 2010-2060 period, the growth rates of containerized imports and exports for primary bulk commodities passing through the Port are expected to be relatively low. In contrast, the growth rates for containerized manufactured goods are anticipated to be significant. Overall, containerized imports and exports through the Port are expected to increase significantly during the period of analysis, from approximately 2.4 million TEUs in 1999 to over 19 million TEUs in 2060, as shown in Figure 24.

Figure 24
Forecast Container Terminal Demand



Expected Fleet Distribution

C201. The containership fleet projected to call at the Port was estimated by applying a gradual shift in fleet capacity to larger vessels based on the actual 1998 port fleet composition. The Maersk K Class design vessel has the maximum projected vessel sailing draft for this estimate. Three projected fleet sailing draft distributions are used to account for the different mix of vessels on major (long haul – high volume), minor (short haul – low volume), and northern European routes. The three fleet sailing draft distributions are based on the current (1998) dead weight tonnage distributions for containerships calling at the Port.

C202. The growth rate implied by the gradual shift in fleet capacity is less than the historic growth rate in fleet capacity at New York Harbor and is assumed to be zero after the midpoint in the study period (2010 through 2060). The projected number of large containerships required to maintain weekly service to the Harbor on the Major and northern European routes is fewer than the number of large containership vessels that will be added to the fleet calling at the Harbor between the years 2000 and 2010. The allocation of commodity share for each vessel size on the three routes is based on the assumption that vessels are sailing with an efficient load (although only a portion of the load is bound for or originates out of New York Harbor). Under this assumption, the resulting transportation costs are the minimum transportation costs required to move the cargo. Table 16 presents the expected distribution of vessels, by sailing draft (*i.e.*, static draft plus 2 ft due to squat/trim/etc.), expected to call on the Port over the planning horizon.

TABLE 16 Expected Fleet Distribution (Calling on the Harbor)				
Sailing Draft	Year			
	2010	2020	2030	2040*
<31	3.91%	3.10%	2.34%	1.95%
31	1.30%	1.03%	0.78%	0.65%
32	1.30%	1.03%	0.78%	0.65%
33	1.30%	1.03%	0.78%	0.65%
34	2.19%	1.73%	1.29%	1.07%
35	2.69%	2.12%	1.59%	1.32%
36	2.67%	2.11%	1.58%	1.31%
37	4.68%	4.97%	5.33%	5.50%
38	3.35%	3.65%	4.00%	4.18%
39	2.73%	3.04%	3.39%	3.56%
40	5.77%	6.05%	6.41%	6.59%
41	2.55%	2.85%	3.20%	3.37%
42	5.64%	5.04%	4.50%	4.23%
43	4.84%	3.80%	2.81%	2.30%
44	4.84%	3.80%	2.81%	2.30%
45	10.42%	11.05%	11.56%	12.15%
46	15.86%	17.06%	18.19%	18.41%
47	15.86%	17.06%	18.19%	18.41%
48	8.09%	9.47%	10.50%	11.39%
Total	100.00%	100.00%	100.00%	100.00%
*Fleet distribution beyond 2040 is expected to remain the same.				

C203. The benefit analysis does not assume a perfect match between carrying capacity and projected traffic. Instead, it was assumed that the loading pattern is determined by controlling depth and market forces, including considerations of service quality and ship routing. The method was as follows:

- Determine the current loading pattern (both inbound and outbound) for vessels of each design draft calling the Port.

- Impose the observed loading pattern for the deepest design draft vessels calling on the Port currently onto the deepest design draft vessels that could call on the Port in the with-project condition.

- Impose the observed loading pattern for the second deepest design draft vessels calling the Port currently onto the second deepest design draft vessels that could call on the Port in the with-project condition.

- Repeat this process until each design draft classification has been assigned a market determined loading pattern that is related to the controlling depth of the channel in the with-project condition

Ship Transportation Cost Savings

C204. The trend in the containership industry is to maximize the economies of scale that occur with the largest vessels. Current industry efforts towards exploiting economies of scale can be seen in the consolidation of container transport by vessel alliances and increased containership size and drafts. Carriers constrained by the controlling depths described in the Port's Without-Project Condition will not be able to take advantage of the economies of scale of the most efficient vessels. Adequate depths to allow safe passage by post-Panamax vessels are necessary for the largest and most efficient vessels operating in vessel alliances that frequent the Port. The potential transportation cost savings which will likely result from increased competition among alliances and the deployment of post-Panamax vessels are reduced if vessels are regularly light loaded, as they must be in order to currently transit the Port.

C205. Numerous sources of transportation cost savings have been identified through analyses of vessel operations, port and terminal operations, and vessel deployments. The sources of transportation cost savings can be categorized as:

- Vessel efficiencies. In the category of transportation cost savings resulting from vessel efficiencies, sources of benefits have been identified based on the shift to larger vessels on specific trading routes. Vessel efficiencies have been identified for containerships servicing the following routes:
  - Major routes: Far East, South East Asia, and the Middle East (including the Indian sub-continent);
  - Minor routes: west coast of South America, east coast of South America, Central America, Caribbean, West Africa, East and South Africa, Australia and New Zealand, Eastern Europe, and Mediterranean;
  - Hybrid route: Northern Europe.
  - Some ports on these routes having channels depths ≥ 50 ft MLW:
    - Hong Kong — Kobe
    - Singapore — Pusan
    - Halifax — Norfolk
    - Kaoshiung — Baltimore
    - Colombo — Rotterdam
    - Tacoma — Seattle
    - Los Angeles — Long Beach

- Operational efficiencies. Benefits resulting from operational efficiencies have been identified for:

    - Reduced tide delays,
    - Reduced queuing delays,
    - Reduced liquid bulk lightering,

- Improved safety. Identified benefits resulting from improved safety in the Harbor include:

    - Reduced natural resource injury: Deeper channels would reduce the overall number of vessel calls, reduce congestion, and lightering operations in the harbor, thereby reducing the expected value of natural resource damages;
    - Reduced disruptions of services: As described above, deeper channels would reduce the probability of oil spills or other contaminant spills in the harbor. Reducing the probability of such incidents in the harbor would also reduce the probability of waterway closures and service disruptions that result from related clean-up, salvage, and restoration activities. The reduction in incident probability would reduce the expected value of damages related to disruptions of waterway services.

C206. Although each of the benefit types identified above is reasonable and anticipated, few can be quantified to a reasonable level of certainty. Therefore, only a small sub-set of benefit types has been quantified in the Benefits Model.

C207. Economic benefit calculations include only the transportation cost savings associated with vessel efficiencies for containerships on the Hybrid and Major routes. Benefits related to operational efficiencies are not quantified because the multitude of operational options available in the Harbor pose a high level of uncertainty for future alternative scenarios. Benefits related to improved safety are not quantified due to the high level of uncertainty related to projecting spill magnitudes and frequency. Benefits accruing from vessel efficiencies for containerships on the nine Minor routes are also not quantified because of the uncertainty associated with projected fleet distributions for these routes. Since the projected Minor route fleet would not be constrained under without-project conditions there is a high level of uncertainty associated with predicting the way that vessels on the Minor routes would be replaced by larger vessels displaced from the Major and Hybrid routes. Given this level of uncertainty, the projected fleet for the Minor routes portrays the same characteristics as the existing fleet.

Multi-Port Analysis

Introduction

C208. Transportation cost savings estimations were done within the context of a multi-port analysis. Multi-port analysis is defined in the NED Procedures Manual (IWR Report 91-R-13 p. 155) as "a systematic assessment of the effects of the with project condition on other ports". In this systematic assessment traffic forecasts are adjusted to account for diversion of traffic to or from competing ports resulting from navigation improvements in the harbor and from authorized projects at other ports. Multi-port analysis focuses on commodities destined for or originating from competitive hinterlands that can be handled at alternative ports. The overall objective of the multi-port analysis is to upgrade fleet forecasts and commodity movement projections by accounting for the potential of cargo traffic to move to the least cost port.

C209. The competitive hinterlands of the Harbor serve as the origin or destination for a relatively small percentage of overall commodity traffic. A large distribution network of warehouses, regional and national distribution centers, and infrastructure has been built around the harbor. As discussed in the Economics Appendix, approximately 70% of all commodity movements are destined for or arrive from the greater New York Metropolitan area. Approximately 82% of all commodity movements have their origin or destination with in a 260-mile radius of the port. The 260-mile radius is a conservative estimate of a single day delivery distance by truck. The competitive hinterland is defined as existing at the fringe of traffic origins and destinations which can be expected to affect a small portion of traffic beyond the 260-mile radius.

Application

C210. The commodity projections used in this analysis include the effects of multi-port adjustments. As discussed in the Economics Appendix, the core hinterlands of the harbor are expected to show slower growth in population, employment, and income compared to the rest of the nation. This slower growth is incorporated into the commodity projections for the harbor. Similarly, the current major international trade region of the Port, Northern Europe, is expected to exhibit slower growth than other trading areas, such as South East Asia, that have larger presence at competing ports. Uneven growth in trade regions is also incorporated into the commodity projections. The combination of these factors causes traffic volume in the Harbor to grow at a slower rate than traffic at other ports and causes the Harbor to lose market share over the course of the study period. The fleet forecast was also developed using the concepts of multi-port analysis. The fleet forecast recognizes that other ports have a competitive advantage, due to their geographic location, to accommodate the world's largest containerships. When the world's largest vessels enter service they generally do so on Trans-Pacific routes where distances are

greater and hub service is currently more readily available. The fleet forecast does not include the soon to enter service 10,000+ TEU vessels. These vessels are not included in the Harbor's fleet forecast because it is anticipated that New York Harbor is at a geographic disadvantage with regard to vessels of this size creating a high level of uncertainty concerning their deployment to New York harbor.

Other Considerations

C211. A recent PANYNJ study indicates that the Harbor's market share of the competitive hinterland is very sensitive to waterborne transportation costs, trucking and rail costs, and delivery time. Relatively small changes in any of these factors may cause an increase or decrease in market share. The potential instability of market share at the fringe of the harbor's hinterland increases the uncertainty of predictions in this area. Given that 1) the competitive hinterland accounts for a small portion of overall commodity traffic volume at the harbor, 2) the effects of macroeconomic changes regarding the Harbor's market share are included in the commodity forecast, 3) the effects of the geographic disadvantage of New York Harbor are included in the fleet forecast, and 4) the high level of uncertainty concerning market share projections for the fringe hinterlands, no additional projections of commodity traffic diversions were attempted for this analysis.

Benefits by Pathway

C212. The transportation cost savings were determined using the Benefit Model and ranked for the four pathways. In order to assign benefits to individual pathways, the current and anticipated port operating procedures at terminals were assessed to determine their capacity to handle vessels with sailing drafts deeper than 43 ft. Only these vessels are capable of generating transportation cost savings for the channels that are to be 45 ft deep MLW under without-project conditions, therefore, determining "greater than 43 ft capacity" effectively allocates a majority project benefits. For those channels that have without-project condition depths less than 45 ft MLW benefits can also be realized by deepening the channels to 45 ft MLW. These channels are the Arthur Kill to Howland Hook, Port Jersey Channel, and Bay Ridge Channel to South Brooklyn. The benefits were calculated by allowing the fleet distribution to those segments to increase by one-foot increments until their distributions matched the port-wide distribution at 45 ft MLW. In this way, each segment with a channel depth of 45 ft MLW then faced the same forecasted fleet distribution. Benefits generated by deepening these segments beyond 45 ft MLW accrue only to vessels requiring more than 45 ft MLW as previously discussed.

C213. The operational criteria used to allocate "greater than 43 ft capacity" include the formation of carrier alliances, the share of New York Harbor containerized cargo handled

by the alliances, and the carriers' preferences for dedicated berths and terminals. Six carrier alliances and two large independent carriers accounted for 87% of the loaded TEUs handled in the harbor in 1998. Each of these alliances and large independents has the ability to direct greater than 43 ft sailing draft vessels to the Harbor. Two alliances currently use, and others are negotiating for, dedicated terminals and berths in the Harbor. Some terminal operators have long-term leases with the PANYNJ. Additionally, more than 35 carriers currently use common (multi-carrier) terminals. Therefore, only a portion of the berths at any of the Harbor's largest facilities (Port Elizabeth, Port Newark, and Port Jersey/Global) can be dedicated to an alliance or large independent carrier. At Port Newark/Elizabeth, 11 out of 18 berths are currently dedicated to single users and the remaining 7 berths are operated as common facilities. At Port Jersey/Global Marine Terminal, it is assumed that the low acreage to berth ratio (52 acres per berth), configuration, and productivity constraints restrict the allocation of dedicated berths to one major alliance or large independent carrier using 3 of the 6 berths. The remaining 3 berths at Port Jersey/Global are allocated to common usage. Berths at South Brooklyn and Howland Hook are assumed to be available for dedicated use by smaller alliances or independents. Overall, 20 of 26 berths (77%) are assumed to be available for dedicated use.

C214. Utilizing the foot by foot distribution of benefits procedure, benefits were computed for each pathway at various depths. Table 17 displays the benefits by pathway.

TABLE 17
Pathway Annual Benefits

Pathway	Maintained Channel Depth	Annual Benefits (Million $)
1 Port Newark/ Elizabeth	46 ft	22.2
	48 ft	60.6
	50 ft	99.0
	52 ft	99.0
2 Howland Hook	46 ft	30.3
	48 ft	35.9
	50 ft	41.6
	52 ft	41.6
4 Port Jersey/ MOTBY	46 ft	60.0
	48 ft	71.4
	50 ft	82.6
	52 ft	82.6
5 South Brooklyn	46 ft	15.9
	48 ft	21.0
	50 ft	26.1
	52 ft	26.1

Channel Deepening Economics

C215. In order to identify the first element of construction the annualized benefits and costs were compared for each pathway and the pathway with the greatest net excess benefits was identified. Table 18 presents the investment costs, annual costs, benefits, and net excess benefits for each pathway over a range of depths.

TABLE 18
Economic Summary by Pathway

Pathway	Maintained Channel Depth	Invest. Costs	Annual Costs	Annual Benefits	Net Excess Benefits	BCR
		(Million $)				
1 Port Newark/ Elizabeth	46 ft	791.9	55.4	22.2	(33.4)	0.40
	48 ft	1306.3	93.5	60.6	(32.9)	0.65
	50 ft	1532.6	111.0	99.0	(12.0)	0.89
	52 ft	1825.0	133.2	99.0	(34.2)	0.74
2 Howland Hook	45 ft	347.0	25.8	27.1	1.3	1.05
	46 ft	897.1	65.2	30.3	(34.9)	0.46
	48 ft	1296.6	94.3	35.9	(58.4)	0.38
	50 ft	1478.4	107.8	41.6	(66.2)	0.39
	52 ft	1695.3	123.9	41.6	(82.3)	0.34
4 Port Jersey/ MOTBY	46 ft	264.5	18.4	60.0	41.6	3.26
	48 ft	389.2	27.6	71.4	43.8	2.59
	50 ft	460.2	33.0	82.6	49.6	2.50
	52 ft	532.1	38.4	82.6	44.2	2.15
5 South Brooklyn	46 ft	268.7	14.8	16.0	1.2	1.08
	48 ft	343.9	21.3	21.0	(0.3)	0.99
	50 ft	392.6	25.8	26.1	0.3	1.01
	52 ft	445.1	30.7	26.1	(4.6)	0.85

C216. Pathway 4 to Port Jersey/MOTBY, Pathway 5 to South Brooklyn, and Pathway 2 at 45 ft MLW only to Howland Hook are the only pathways as "stand-alone" pathways to provide positive net excess benefits. Pathway 4 to Port Jersey/MOTBY at a 50 ft MLW provides the greatest net excess benefits and is clearly the "first added" element: Pathway 5 to South Brooklyn at 50 ft MLW provides the next greatest amount of net excess benefits. Pathway 2 to Howland Hook at 45 ft MLW provides positive net excess benefits because at that depth only the Arthur Kill requires further deepening for the pathway to realize the projected benefits.

C217. Pathway 1 to Port Newark/Elizabeth as a "stand-alone" pathway results in a BCR of less than unity. Therefore, it would not appear, at first glance, to warrant further

consideration as a viable alternative. However, a portion of Pathway 1 is common to Pathway 4 to Port Jersey (Ambrose Channel and portion of Anchorage Channel) which has shown to yield positive net excess benefits at a maintained depth of 50 ft. MLW. Therefore, Pathway 1 to Port Newark/Elizabeth was re-evaluated as a last-added increment to Pathway 4; only the incremental costs of dredging the Kill Van Kull and Newark Bay Channels were included in the Pathway cost. The results of considering Pathway 1 as a last-added increment to Pathway 4 are shown in Table 19.

TABLE 19
Economic Summary of Pathway 1 as a Last-Added Element to Pathway 4

Pathway	Maintained Channel Depth	Incremental		Annual Benefits	Net Excess Benefits	BCR
		Invest. Costs	Annual Costs			
		(Million $)				
1	46 ft	634.1	44.2	21.2	(23.0)	0.48
	48 ft	1,061.7	75.8	57.9	(17.9)	0.76
	50 ft	1,243.0	89.9	94.6	4.7	1.05

C218. As indicated in Table 19 Pathway 1 as a last-added element to Pathway 4, yields net excess benefits above unity with the 50 ft MLW channel providing the greatest net excess benefits. The incremental investment cost for the 50 ft MLW channel is estimated to be $1,243 million with a an annual cost of $89.9 million. When compared to the annual benefits of $94.6 million associated with extending the channel through the Kill Van Kull and Newark Bay Channels to Port Newark/Elizabeth, Pathway 1 yields $4.7 million in net excess benefits and a Benefit to Cost Ratio (BCR) of 1.05. Therefore, Pathway 1 to Port Newark/Elizabeth at a maintained depth of 50 ft MLW was considered viable as a last-added element to Pathway 4.

C219. Pathway 2 to Howland Hook was only justified at 45 ft MLW because at that depth only the Arthur Kill had to be dredged to complete the pathway. As a last-added element to Pathway 1, additional depths up to 50 ft MLW could be considered on a similar basis. Therefore, Pathway 2 to Howland Hook was re-evaluated as a last-added element to Pathway 1 with only the cost to dredge the Arthur Kill in the evaluation. Table 20 presents the results of that analysis.

TABLE 20 Economic Summary of Pathway 2 As Last-Added Element to Pathway 1						
Pathway	Maintained Channel Depth	Invest. Costs	Annual Costs	Annual Benefits	Net Excess Benefits	BCR
		(Million $)				
2	45 ft	347.0	25.8	27.1	1.3	1.05
	46 ft	362.4	27.0	29.7	2.7	1.10
	48 ft	382.4	28.8	34.2	5.4	1.19
	50 ft	431.7	32.6	38.7	6.1	1.19

C220. As indicated in Table 20, when considered in conjunction with Pathway 1, Pathway 2 at a maintained depth of 50 ft MLW provides the most net excess benefits and is the optional plan for that Pathway.

Summary of Environmental Issues by Channel

General

C221. Environmental issues that all of the channels under consideration have in common are discussed below:

- The benthic community in all disturbed areas will experience short-term impacts as a result of channel deepening; however, no long-term adverse impacts are projected. Channel deepening in the Lower and Upper New York Bay channels will not result in any change in substrate so recolonization by benthos should be rapid. In the channels where rock will be exposed, the channel will be deepened an additional 2 ft and then left to silt in to the maintenance depth which will minimize benthic habitat loss. Aquatic populations (fish and invertebrates) seasonally use the channels for growth and development and as migratory routes, therefore, minor short-term disruptive influences will result from channel deepening operations; however, no long-term influences are projected.

- Modeling efforts indicate that there would be minimal to non-detectable changes in hydraulic conditions and in water quality parameters including water temperature, salinity, and dissolved oxygen as a result of proposed navigation channel improvements. Water surface elevations throughout the Harbor would increase on the order of 0.4-in or less. Modeling results show that changes in salinity would be variable, with the maximum change projected for the Passaic and Hackensack Rivers, which would increase, on average, less than 0.1 parts per thousand. The channel deepening influences

on dissolved oxygen would be minor, with the greatest difference, a decrease of up to 0.03 parts per million, predicted for the Arthur Kill, Kill Van Kull and Newark Bay Channels. No detectable changes in water temperature are projected.

- No significant habitat or habitat of concern is found in the channel areas of the Upper and Lower New York Bays. Essential fish habitat (EFH) was evaluated for ten species that occur in the Harbor; however, no adverse or long-term impacts are projected that would preclude the designated species from using the deepened channels.

- With the exception of potential Peregrine Falcon nesting on Port bridges, the presence of threatened, endangered, or species of concern is projected to be incidental. No adverse impacts are projected due to channel deepening.

Kill Van Kull and Newark Bay

C222. Deepening the Kill Van Kull and Newark Bay channels will result in disturbance to approximately 6.3 acres of littoral zone (shore zone and flats areas) habitat and no disturbance to the intertidal zone. Some areas may be permanently converted to deeper habitat. The greatest littoral zone (MLW to –6.0 ft MLW) disturbance is projected for Newark Bay: primarily the flats area on the west side of the Bay south of the Elizabeth Port Authority Marine Terminal, and the flats area located to the east of Port Newark between the Port Newark Pierhead Channel and the Middle Reach of the Newark Bay Channel. No disturbance to marsh areas or wetlands is projected. The Peregrine Falcon, a federal and state listed threatened and endangered species, has been reported to be nesting on the Bayonne Bridge. Shooters Island and the northern shore of Staten Island in the vicinity of Shooters Island is a listed significant habitat area and the island is a component of the Harbor Herons Complex. The Kill Van Kull and Port Newark Channels have been described as important habitat for overwintering winter flounder and blue crab, and the area may be important for winter flounder spawning; however, evaluation of the biological data collected as part of a one-year baseline monitoring program, indicates that the area is a minor overwintering and reproductive area for these species.

Arthur Kill (from the Kill Van Kull to Howland Hook)

C223. Environmental concerns for this section of the Arthur Kill include the Significant Habitat area on Staten Island and Shooters Island. Littoral zone habitat disturbance is projected along the north shore of Staten Island. Some portions may be permanently converted to deeper habitat.

Gulfport Reach of the Arthur Kill

C224. Peregrine Falcon nesting on the Goethals Bridge, Goethals Bridge support pier stabilization, and impacts on the Old Place Creek marsh area are the environmental concerns identified for this channel. Wetlands surrounding the Goethals Bridge, including the project under construction by the Salt Marsh Restoration Team, New York City Parks and Recreation Department, may be impacted. Estimates of acres impacted are not available at this time.

Port Jersey Channel

C225. The greatest environmental influence related to deepening the Port Jersey Channel is the disturbance to several acres of sub-littoral habitat of the Jersey Flats, the extensive flats located east of Port Jersey. Port Jersey has been described as an important overwintering area for winter flounder and blue crab and a winter flounder spawning area; however, recent data indicates that the navigation channel is not a preferred area.

Bay Ridge Channel

C226. The use of the interpier area and the channel adjacent to the South Brooklyn piers may be important overwintering area for striped bass and the channel appears to be a seasonal migratory route between the Harbor and the Hudson River and Long Island Sound. No habitat alteration is projected for this channel.

Harbor Anchorages

C227. No environmental concerns have been identified for the Harbor Anchorages.

Claremont Channel/New Jersey Pierhead Channel

C228. Extensive littoral and sub-littoral zone disturbance to the Jersey Flats is projected for these channels. Areas of impact are along the New Jersey Pierhead Channel, Port Jersey Channel, and the Claremont Channel. The shallow water areas in the vicinity of the Claremont Channel may be an important site for overwintering winter flounder and blue crab; however, limited biological information does not indicate that the channel area is a significant overwintering area.

Summary of Preliminary Plans Screening

C229. The screening of study alternatives showed that the structural plans involving deepening Pathways 4 and 5, and Pathways 1 and 2 as a last-added element to Pathway 4 all meet the planning objectives and support a Federal Interest. None of the aforementioned four pathways appear to involve insurmountable environmental issues. Pathway 3, the Tanker Channel Deepening Alternative to TOSCO and GATX and Pathway 8 to the Claremont Terminal do not support a Federal Interest. Pathway 5A is not viable due to the planned termination of the Red Hook Container Terminal as a container facility. Evaluation of the anchorages, Pathways 6 and 7, has been deferred to a separate study authority. The Bayonne-Newark Bay Canal was determined to be costly and institutionally unacceptable and the Off-shore Island Port did not to meet the long-term planning objectives. Thus, neither plan was supported by the non-Federal partners. The Non-Structural Plan and No Action Plan do not meet the planning objectives of meeting the needs of the changing world fleet. Thus, only the structural plans using Pathways 1, 2, 4 and 5 need to be considered further in the formulation process.

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IDENTIFICATION OF THE NED PLAN

C230. For each pathway not previously eliminated in the screening process, alternatives consisting of pathway combinations were evaluated using an Equimarginal Analysis as required by the *Planning Guidance Notebook* to identify the NED Plan. As shown in Table 18, Pathway 4 to Port Jersey provides the greatest net excess benefits and is therefore considered the "first-added" element. The incremental costs for each of the other remaining pathways was compared to the remaining benefits not realized by the "first-added" increment. The next pathway that provided the greatest net excess benefits was then identified and became the "second-added" increment of the alternative. This process continued until none of the remaining pathways resulted in a positive change in net excess benefits.

Alternatives Analysis

C231. To identify the NED Plan individual pathways were combined to form Plan Alternatives. Taking Pathway 4 at a maintained depth of 50 ft MLW as the "first-added" element, the "next-added" analysis builds on Pathway 4 plus the non-common segments leading to other terminals. Table 21 provides a summary of the costs and benefits for each alternative considered as a "second-added" element.

TABLE 21
Economic Summary by Alternative for Second-Added Feature

Alternative	Pathway	Additional Channel Segments	Invest. Costs	Annual Costs	Annual Benefits	Net Excess Benefits	BCR
			(Million $)				
A	4_{50}	Port Newark/Elizabeth$_{52}$	1,997.9	145.2	177.3	32.0	1.22
A1	4_{50}	Port Newark/Elizabeth$_{50}$	1,703.2	122.8	177.3	54.4	1.44
A2	4_{50}	Port Newark/Elizabeth$_{48}$	1,521.8	108.8	143.2	34.4	1.32
A3	4_{50}	Port Newark/Elizabeth$_{46}$	1,094.3	77.1	104.8	27.7	1.36
B	4_{50}	South Brooklyn$_{52}$	651.8	45.1	108.8	63.7	2.41
B1	4_{50}	South Brooklyn$_{50}$	594.6	40.0	108.8	68.8	2.72
B2	4_{50}	South Brooklyn$_{48}$	586.7	38.5	103.7	65.2	2.69
B3	4_{50}	South Brooklyn$_{46}$	582.3	37.3	98.6	61.3	2.64

C232. Based on the results displayed in Table 21, Pathway 4 to Port Jersey/MOTBY at 50 ft MLW combined independently with South Brooklyn at 50 ft MLW provides more net excess benefits than the pathway to Port Jersey alone. In addition, the 50 ft MLW depth at South Brooklyn is shown to be the optimum depth. To further develop the NED Plan, the pathway combination from Table 21 that provides the greatest net excess benefits was then regrouped into additional alternatives to identify the plan providing the most net excess benefits. Since the South Brooklyn Pathway in combination with the

Port Jersey Pathway (Alternative B1) provides the greatest net excess benefits for a dual-pathway plan, this combination is common to subsequent alternatives. Table 22 summarizes the alternatives evaluated.

TABLE 22
Economic Summary by Alternative for Comprehensive Plan Alternatives

Alternative	Additional Channel Segments	Invest. Costs	Annual Costs	Annual Benefits	Net Excess Benefits	BCR
		(Million $)				
C	PJ_{50}+ SB_{50}+PNE_{50}	1,837.6	129.8	203.8	73.9	1.57
D	PJ_{50}+ SB_{50}+HH_{45}	941.6	65.7	135.0	69.3	2.05
E	PJ_{50}+ SB_{50} +HH_{50}	1,783.4	126.7	149.5	22.8	1.18
F	PJ_{50}+ SB_{50}+PNE_{50}+HH_{45}	2,184.6	155.6	230.9	75.3	1.45
G	PJ_{50}+ SB_{50}+PNE_{50}+HH_{50}	2,269.2	162.4	238.5	76.1	1.47

PJ_{50} = Port $Jersey_{50}$; PNE_{50} = Port $Newark/Elizabeth_{50}$; SB_{50} = South $Brooklyn_{50}$; HH_{50} = $Howland\ Hook_{50}$; HH_{45} = $Howland\ Hook_{45}$

The NED Plan

C233. The incremental plan that provides the greatest amount of net excess benefits is a harbor-wide channel improvement plan with maintained 50 ft deep MLW channels to the existing or proposed terminals at Port Jersey, South Brooklyn, Port Newark/Elizabeth, and Howland Hook. This plan is the NED Plan. It is institutionally acceptable because it provides deep water access to both sides of the Harbor. It meets NED criteria in that it maximizes net excess benefits and does not result in insurmountable environmental impacts.

RECOMMENDED PLAN

Overview

C234. The Recommended Plan is the NED Plan. It provides for navigation improvements to the nine major channels in the Harbor that provide access to the five main existing or proposed container terminals (Port Newark/Elizabeth Marine Terminal, Howland Hook Marine Terminal, Global Marine Terminal and NEAT on the Port Jersey Peninsula, the former MOTBY, and South Brooklyn Marine Terminal).

Description of the Recommended Plan

C235. The Recommended Plan requires deepening the nine major navigation channels serving the Harbor. The following describes the recommended action, as summarized in Table 23 and shown in Figures 26 through 33.

Ambrose Channel

C236. The plan requires deepening the entire 10.6 nautical miles of the Ambrose Channel extending from deep water in the Atlantic Ocean to the Narrows. The channel will be excavated (i.e., deepened) and maintained at a depth of 53 ft MLW. The existing channel will be extended along its present bearing an additional 2,400 ft toward the Atlantic Ocean in order to provide the desired depth. The trapezoidal channel will be 2,000 ft wide at its base with three horizontal to one vertical (3H:1V) side slopes excavated primarily in sand. The Ambrose Light will not be impacted by the project. As part of the project cost, a large mound northwest of the previous site of the Ambrose Light Tower will be excavated to the proposed channel depth of 53 ft MLW. The proposed channel alignment is shown in Figure 27.

Anchorage Channel

C237. The Anchorage Channel will be dredged for 19,000 feet from the Narrows to the point 1,000 feet north of the junction with the Port Jersey Channel. The recommended channel will remain at its present width of 2,000 ft. The channel will be deepened and maintained at a depth of 50 ft MLW. The trapezoidal channel will be cut through soft material comprised of silt and clay in the southern portion of this channel and sand in the northern portion. The channel will be constructed with 3H:1V side slopes. Two watermains will be relocated below the proposed channel as part of this segment of the project. The relocations consist of 8,500 LF and 7,200 LF of 36-inch and 42-inch diameter watermains, respectively. The proposed channel alignment is shown in Figure 28.

TABLE 23
Recommended Plan – Pertinent Features

Channel Name:	Ambrose	Anchorage	Port Jersey	Kill Van Kull	Newark Bay	Elizabeth	South Elizabeth	Arthur Kill	Bay Ridge
Improvement Features									
Length of Improvement	63,600 ft	19,000 ft	10,000 ft	31,800 ft	14,000 ft	8,800 ft	2,700 ft	14,400 ft	18,000 ft
Maintained Depth (ft MLW)	53	50	50	50	50	50	50	50	50
Initial Depth Excavated (ft MLW)	53	50	52	52	52	52	52	52	50
Channel Bottom Width	2000 ft	2000 ft	500 ft	800 ft	800-2200ft	500-800 ft	500 ft	800 ft	600 ft
Predominant Side Slope:	3:1	3:1	3:1	Varies between 1:1 & 3:1	3:1 western side; 1:1 eastern side	3:1; 1:1 on western end.	Varies between 1:1 & 3:1	3:1 & 1:1 compound	3:1
Predominant Channel Bottom Material Type:	Sand-Classified as Soft	South: silt and clay, north: sand	Sand, Pleistocene sand, clay	Rock, glacial till, sand and silt	Silty sand, silt and clay, rock	Silt and clay, rock	Sand, silt and clay	Rock, silt and clay, silty sand and gravel	Blk silt & clay, silty sand
Special Design Features	Extend channel 2,400 ft along bearing to sea, Remove debris hump from old Ambrose Tower	Deepening 1,000 ft beyond Port Jersey Channel junction	Tapered channel width: 1,500 ft at Anch Chl junction to 500 ft at NJ Pierhead Chl;Berth deepening (3 berths X 1,200 ft X 150 ft)	Shore line stabil. – NYC Parks near Richmond Terrace S.I.-1450 LF; Shore line stabil. – Atlantic Salt Co. Property, S.I.-1050 LF.	Channel deepening 1,500 ft north of Elizabeth Chl Berth deepening PANYNJ Marine Terminal (2 berths X 1,200 ft X 150 ft)	Berth deepening (3 berths X 1,200 ft X 150 ft)	Berth deepening (1 berth X 1,200 ft X 150 ft)	Berth deepening (1 berth X 1,200 ft X 150 ft)	Eastern 600ft of chl deepened, 1600ft turning basin; berth deep/strength (2 berths X 1,200 ft X 150 ft)
Lands Easements & Rights-of-Way									
Permanent Easement:	None	None	None	None	None	None	None	None	None
Temporary Easement:	None	None	None	1.43A: Richmond Terr-.83A, Atlantic Salt -.6A)	None	None	None	None	None
Utility Relocations									
Type:	None	Water	None	None	None	None	Gas	None	(see Anch)
Diameter:	None	36" / 42"	None	None	None	None	12"	None	None
Length:	None	8,500 LF / 7,200 LF	None	None	None	None	2,700 LF	None	None
Env. Disturbances									
Littoral Zone (MLW to –6 ft. MLW)	None	None	None	0.06 A	2.72 A	0.25 A	None	3.23 A	None
Sub-Littoral Zone (-6 to –15 ft. MLW)	None	None	12.35 A	1.41 A	7.79 A	1.42 A	15.84 A	3.22 A	None

Port Jersey Channel

C238. The Port Jersey Channel is to be deepened to 52 ft MLW and maintained at a depth of 50 ft MLW allowing 2 ft of the naturally-hard bottom to fill with soft sediments. The channel will be deepened for a distance of 10,000 ft from its juncture with the Anchorage Channel through the berthing areas at the Global Marine Terminal and MOTBY Peninsula. The berths at each of the two facilities will be deepened. The existing 1,200 ft turning basin at the head of the Port Jersey Channel will not be deepened. The turning basin is inadequate for the K-class containership, which has an overall length of 1,044 ft. Without a turning basin, vessels will be required to either back into or out of Port Jersey. In order to facilitate the backing maneuvers, the northern channel limit will be straightened, removing a narrow portion of the New Jersey Flats. Deepening the Anchorage Channel 1,000 ft to the north of the channel junction will permit inbound vessels to bring the bow past Port Jersey Channel, swing the stern around, and then back into berth.

C239. The channel will be improved to a width of 500 ft between the Global Marine Terminal and MOTBY Peninsula. To facilitate turning into the channel on a flood tide, the entrance to the Port Jersey channel will flare out. The flare will be 1,500 ft at the junction with the Anchorage Channel and taper to 500 ft at the intersection with the New Jersey Pierhead Channel. The channel will be trapezoidal in shape with generally 3H:1V side slopes except in areas of where the side slopes will transition to 1H:1V. Construction of the proposed channels will remove a narrow portion of the New Jersey Flats impacting 12.35 acres of sub-littoral zone (6 to 15 ft deep MLW) habitat. The proposed channel alignment is shown in Figure 29.

Kill Van Kull

C240. The Kill Van Kull is to be deepened to a depth of 52 ft MLW and maintained at a depth of 50 ft MLW allowing the bottom 2 ft of the channel to fill with soft sediment over time. Extending from its juncture with the Anchorage Channel to its juncture with the Newark Bay Channel near Bergen Pont, 5.3 nautical miles of channel will be cut through a variety of geologic conditions including rock, glacial till, sand, and silt. Side slopes of the 800 ft wide trapezoidal channel will vary from 3H:1V to 1H:1V as the channel passes from soft deposits to rock with many of the sections being a compound of both. The alignment of the proposed channel will require two sections of 1,450 LF and 1,050 LF of Staten Island shoreline to be stabilized with rip rap along NYC Parks property north of Richmond Terrace and Atlantic Salt Co. property, respectively. As described in the Real Estate Appendix, construction activities associated with the bulkhead and shoreline stabilization will require a temporary easement of 1.43 acres; 0.83 acres near to NYC Parks property north of Richmond Terrace and 0.6 acres near property owned by the Atlantic Salt Co. on Staten Island, NY. As proposed, the channel will

impact 0.06 acres of littoral zone (MLW to -6 ft. MLW) and 1.41 acres of sub-littoral zone (-6 to -15 ft. MLW) habitat. Mitigation is provided for the littoral zone impact. The proposed channel alignment is shown in Figure 30.

Newark Bay Channels

C241. The Newark Bay Channels are comprised of the Main Channel (South, Middle and North Reaches) plus numerous access channels (South Elizabeth Channel, Elizabeth Channel, Elizabeth Pierhead Channel, Port Newark Pierhead Channel and Port Newark Channel). Together, these channels service over 60 berths at the Port Newark/Elizabeth Marine Terminal on the west shore of Newark Bay. The main Newark Bay Channel will be dredged from its juncture with the Kill Van Kull near Bergen Point to a point located 1,500 ft north of the Elizabeth Channel. The channel will extend north of the Elizabeth Channel to aid vessels in turning and backing into berth. The Port Newark Pierhead Channel and Port Newark Channel are not anticipated to be deepened in connection with this investigation. The 14,000 LF of improvement proposed for the main Newark Bay Channel remains at its present width varying from 800 ft at its northern terminus to 2,200 ft near Bergen Point. The channel will follow its present alignment.

C242. Similarly, the 8,800 ft long Elizabeth Channel will also remain at its present width, which varies from 500 to 800 ft, and alignment. The 2,700 ft long South Elizabeth Channel will be significantly widened from its present 290 ft to 500 ft. In addition, the berths at Port Elizabeth will be widened to 150 ft and deepened.

C243. Each of the aforementioned channels will be dredged to 52 ft MLW and maintained at 50 ft MLW. The main north-south Newark Bay Channel, including the Elizabeth Pierhead Channel, will generally be constructed with a composite trapezoidal channel having side slopes of 3H:1V along its western side and as a result of rock paralleling the channel, and 1H:1V along the eastern side.

C244. The South Elizabeth and Elizabeth Channels will have side slopes varying from 3H:1V to 1H:1V as the channel passes through changing strata. Construction of the South Elizabeth Channel will require relocating 2,700 LF of 12-inch diameter gas line. The line will be relocated away from the proposed channel template. The proposed channel alignments are shown in Figure 31.

C245. As displayed in Table 24 the alignment of these channels will impact on a total of 2.97 acres of Littoral Zone and 25.05 acres of Sub-Littoral Zone habitat. The Littoral Zone impacts will require mitigation.

TABLE 24 Littoral Zone Impacts of Newark Bay Channels		
	Impacted Area (Acres)	
	Littoral Zone (MLW to –6 ft. MLW)	Sub-Littoral Zone Habitat (-6 ft. MLW to –15 ft. MLW)
Newark Bay Channel	2.72	7.79
South Elizabeth Channel	0	15.84
Elizabeth Channel	0.25	1.42
Total	2.97	25.05

Arthur Kill Channel

C246. The Arthur Kill Channel is proposed to be deepened from its juncture with the Kill Van Kull near Bergen Point to the Howland Hook Marine Terminal. This 2.4 nautical mile segment of channel will be dredged to a depth of 52 ft MLW and maintained at 50 ft MLW. The channel will generally follow the alignment of the 41 ft MLW channel presently under final design and anticipated to be in place in the Without-Project Condition. The existing channel varies in width from 500 to 800 ft, but will be widened to 800 ft as part of the 41 ft MLW project. This width will be maintained for this project. The trapezoidal shaped improvement is generally a compound section with 3H:1V side slops in the softer upper portions of the excavation and 1H:1V in the underlying rock. The alignment of the channel will impact 3.23 acres of Littoral Zone habitat requiring mitigation and 3.21 acres of Sub-Littoral Zone habitat. The proposed channel alignment is shown in Figure 32.

Bay Ridge Channel

C247. The nearly 3 nautical mile long Bay Ridge Channel is proposed to be improved and maintained to a depth of 50 ft MLW. The proposed channel will parallel the eastern side of current channel at a width of 600 ft, reduced from the current width of 1,200 to 1,750 ft. The width of the existing channel was based upon the fact that the existing finger piers required that a ship turn perpendicular to the channel before berthing. The 600 ft. one-way channel will be adequate for the two deep draft berths as anticipated in the Without-Project Condition. A proposed turning basin, with a diameter of 1,600 ft, is to be located opposite the terminal, enabling vessels to back out of or into berth. The development of this channel will require relocating two aids to navigation and the purchase of an additional eight. As a result of the channel alignment, 0.12 acres of Sub-Littoral Zone habitat will be impacted. The proposed channel alignment is shown in Figure 33.

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ECONOMIC ANALYSIS OF THE RECOMMENDED PLAN

Overview

C248. Federal participation in project construction requires a demonstration of economic feasibility, which is established by determining whether the benefits to the national economy exceed annual economic costs. This was demonstrated by an Equimarginal Analysis in previous sections, which identified the NED Plan. The NED Plan was also determined to be the Recommended Plan. The following section outlines the economic analysis specific to the Recommended Plan. The overall study's economic analysis is discussed in detail in the Economics Appendix.

General

C249. All benefits and costs are calculated using October 1999 price levels. Average annual benefits and costs have been amortized over a 50-year period of analysis beginning at the anticipated project base year of 2010. Computations use the fiscal year 1999 Federal Discount Rate of 6-7/8%.

Cost Estimates

First Costs

C250. Cost estimates for the Recommended Plan were prepared using the MicroComputer Assisted Cost Estimating System (MCACES) and include the appropriate contingencies for each item. Project First Costs include costs arising from the project construction elements as well as the costs of design and construction management. The summary of project costs is provided in Table 25. The detailed estimates include blasting and dredging, placement of dredged and excavated material, replacing and/or stabilizing structures affected by dredging operations, relocation of aids to navigation, utility relocations, and real estate acquisitions. Detailed estimates of the First Costs of the Recommended Plan are presented in the Costs Appendix. Costs presented are NED costs and do not necessarily reflect the financial costs. Pre-construction Engineering and Design, and Supervision and Administration, and Contingencies are included in the cost analysis.

TABLE 25 Recommended Plan - First Costs (October 1999 Price Level)	
General Navigation Features (cost shared)	**Total Cost**
Dredging and Excavation	$1,485,687,000
Atlantic Salt Bulkhead	1,176,000
Richmond Terrace Bulkhead	3,060,000
Elizabeth Marina Wave Screen & Wharf	2,619,000
Associated General Items	168,000
Engineering & Design (PED)	47,323,000
Construction Management(S&A)	105,863,000
Total General Navigation Features	$1,645,897,000
Non-Federal Responsibility Costs	**Total Cost**
Dredge Berthing Areas	$95,950,000
Relocate Newark Bay Utilities	3,726,000
Relocate Upper Bay Utilities	35,662,000
Total Non-Federal Resp. Costs	$135,338,000
Total First Costs	$1,781,235,000

Annual Costs

C251. The annual costs comprise the interest and amortization of the Investment Costs over the life of the project plus the project-related increase in annual Operation and Maintenance (O&M) costs. The Investment Costs are comprised of the Construction Costs, including PED and S&A, plus Interest During Construction.

Interest During Construction

C252. Interest During Construction (IDC) represents the opportunity cost of capital incurred during the construction period. Costs incurred during the construction period are increased by adding compound interest at the 6-7/8% discount rate from the date the expenditures are incurred to the base year. For plan formulation, the IDC was calculated considering costs and construction duration for each pathway included in the alternative being considered. The total NED Investment Costs were calculated using the compound

interest for the series of payments over the anticipated construction duration on a pathway-by-pathway basis with consideration of channel elements already constructed. The IDC was calculated on the basis of total alternative costs, including Pre-construction Engineering and Design (PED), Supervision and Administration (S&A), and mitigation. Total IDC is therefore calculated to be $497,233,000.

Operation and Maintenance (O&M) Costs

C253. The O&M costs are associated with the maintenance dredging required to maintain the channels at the desired depths. Since the majority of the channels are already maintained at the authorized depth under the Without-Project Condition, the O&M associated with this project are the incremental costs necessary to maintain the deeper channel. The volumes are based on the 2-D modeling results from WES. Similarly, the unit costs for maintenance material are based on estimates for each channel, assuming all sedimentation material will be unsuitable for HARS placement, except for the Ambrose Channel, which is assumed suitable for use at the HARS. Assumptions regarding O&M material suitability are consistent with the DMMP. The estimated annual O&M costs of the Recommended Plan are $3,401,000.

Summary of Annual Costs

C254. Table 26 provides a summary of the annual costs required to implement and maintain the project.

TABLE 26
Recommended Plan – Summary of Annual Costs
(October 1999 Price Level, 6-7/8% Discount Rate, 50-Year Period)

Costs	Total
First Cost	$1,781,235,000
Interest During Construction	497,233,000
Total Investment Cost	2,278,468,000
Interest and Amortization	162,494,000
Operation and Maintenance	3,401,000
Total Annual Cost	***$165,895,000***

Benefits

General

C255. Project benefits are equal to the gains to the National Economic Development (NED) as determined by the difference between the With- and Without-Project Conditions. Specifically, the benefits identified in this analysis are the transportation costs savings realized through the use of larger more efficient vessels and through the increased safety and operational efficiencies resulting from navigation improvements in the Harbor. Reduced transportation costs result in reduced production and distribution costs thereby increasing the net value of the national output of goods and services.

C256. Numerous sources of transportation cost savings have been identified through analyses of vessel operations, port and terminal operations, and vessel deployments. The sources of transportation cost savings are discussed in the "Screening of Study Alternatives" section and the Economics Appendix.

C257. The economic benefits quantified in the Benefits Model are benefits that can be quantified with a reasonable level of certainty. These benefits are the transportation cost savings resulting from vessel efficiencies for containerships on the Hybrid and Major routes. The reasonableness of quantifying these benefits stems from observed existing practices, upon which the fleet forecasts and benefit calculations are based.

Benefits During Construction

C258. As soon as individual portions of the project are completed and provide direct access to a container terminal from sea, transportation costs savings can begin to be realized, resulting in a realization of project benefits. To account for these benefits, compound interest is added to these pre-base year benefits in the same manner that interest was applied to construction costs. Based on the preliminary project schedule, channel improvements will first be completed to the Port Jersey Peninsula/MOTBY by the year 2008, at which time large vessels with benefit-generating cargo loads may begin to call on the Port and project benefits may begin to be realized. No other channel improvements to container terminals in the Port are expected to be completed prior to the base year.

Summary of Annual Benefits

C259. Table 27 provides a summary of average annual benefits expected upon completion of the project.

TABLE 27 Recommended Plan – Summary of Annual Benefits (October 1999 Price Level, 6-7/8% Discount Rate, 50-Year Period)	
Benefits	**Total**
Annual Transportation Cost Savings	$238,500,000
Total Annual Benefits	***$238,500,000***

Feasibility

C260. Project feasibility is based on comparisons between benefits and costs. As seen in Table 28, project benefits outweigh the project cost. As discussed in the section titled "Identification of the NED Plan", the Recommended Plan, which is the NED Plan, yields the greatest net excess benefits of all project alternatives.

TABLE 28 Recommended Plan – Summary of Annual Benefits and Costs (October 1999 Price Level, 6-7/8% Discount Rate, 50-Year Period)	
Benefits/Costs	**Total**
Annual Benefits	$238,500,000
Annual Costs	$165,895,000
Net Excess Benefits	$72,605,000
BCR	1.4

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SENSITIVITY ANALYSIS

General

C261. This sensitivity analysis examines the influence of critical factors on project net excess benefits. In sensitivity analysis, varying critical factors identifies the conditions under which alternative plans are justified. Sensitivity analysis is used to address the uncertainty in the most significant inputs of the benefit-cost analysis. The criteria for selecting the critical factors included in the sensitivity analysis are the level of influence on optimal plan formulation and uncertainty of input values.

C262. Overall, this analysis of net excess benefits of navigation improvements to New York harbor has been structured to reduce the influence of uncertain factors. As stated earlier, many sources of benefits have been identified, but due to the high degree of uncertainty associated with monetizing those benefits, only the transportation cost savings on four out of fourteen shipping routes are used to calculate project benefits. The resulting net excess benefits represent a conservative estimate of the minimum level of benefits generated by the project.

C263. Two critical factors are included in the sensitivity analysis: the commodity projections and the fleet forecast. Commodity projections have a high level of influence on net excess benefits because they are directly used in the calculations of capacity constraints in the Harbor and in the calculations of transportation cost savings. Although the commodity projections are the product of a state of the art forecasting model, there remains a significant degree of uncertainty in the estimates, especially in the outer years. The fleet forecast strongly influences benefit calculations because the projected fleet mix directly affects transportation costs. Uncertainty in the fleet forecast is the product of the many unspecified factors that influence the decisions of the shipping industry.

Commodity Projections

C264. Commodity projections are developed and presented in the Economics Appendix. The nature of current and projected commodity traffic through the Harbor is that there is no single commodity that dominates containerized trade. Similarly, there is no single trading partner or trade route with an extraordinary influence on containerized trade. Also, the relative significance of individual commodities and trading partners is expected to shift over the course of the study period. In consideration of these factors, the sensitivity analysis identifies the effects of reducing the annual growth rate of total projected commodity flows.

C265. The commodity projections used in the benefit-cost analysis exhibit varying levels of growth in the near, mid, and long term. The overall average annual rate of commodity growth throughout the study period is 3.3%. For the Recommended Plan, Table 29 presents annualized costs, annualized benefits, net excess benefits, and the benefit-cost ratio resulting from annual growth rates of 0% - 3%.

TABLE 29
Average Annual Equivalent Values for the Recommended Plan At Various Annual Growth Rates for Commodity Traffic (Million $)

Annual Growth Rate	Annual Benefits	Annual Costs	Net Excess Benefits	Benefit-Cost Ratio
3.3% (forecast)	$238.5	$165.9	$72.6	1.44
3.0%	$203.6	$165.9	$37.7	1.23
2.0%	$184.8	$165.9	$18.9	1.11
1.0%	$163.5	$165.9	($2.4)	0.99
0.0%	$157.0	$165.9	($8.9)	0.95

C266. As evidenced by Table 29, the Recommended Project remains justified even if the commodity projection is reduced to just slightly over a modest 1% growth, which is a highly unlikely scenario. Thus, it can be safely assumed that within realistic tolerances of the projections in commodity growth the Recommended Plan will remain justified.

Fleet Forecast

C267. The fleet forecast sensitivity analysis identifies the impact of reducing the proportion of TEUs projected for the largest vessels in the fleet. As described in Economics Appendix, the forecasted fleet for each of the four trade routes used to calculate benefits is composed of small, mid, and large size vessels. This sensitivity analysis shifts a proportion of TEUs from large size vessels into mid size vessels. Reductions of large size vessel TEUs are calculated at 5% increments from 5% - 15%. The results of the sensitivity analysis are presented in Table 30.

C268. From Table 30 it is apparent that with up to a 15% shift in TEU transport from large size vessels to midsize vessels, the fleet forecast will not impact the previous justification of the Recommended Plan.

CONCLUSIONS

C269. The study authorized by the Water Resources Development Act of 1996 is complete with the exception of the analysis of anchorage deepening in New York and New Jersey Harbor; the Feasibility Report and DEIS present the findings of the study conducted for proposed navigation improvements to the Harbor. The following is a summary of the study's conclusions:

- Conclusions regarding improvements to the Harbor's anchorages were deferred pending completion of the separate New York Harbor Anchorages Study, currently entering the Feasibility Phase;

- A range of alternatives was considered. Besides the No Action Alternative, non-structural alternatives, which would allow the design vessels to call on the Port without channel improvements, were considered. These alternatives were dropped from consideration, as they are currently in use in the Harbor and continued reliance on non-structural measures would only exacerbate the problems facing carriers as they attempt to use larger vessels in maritime trade;

- Two structural alternatives, one of which also included channel deepening as an element, were also considered: the Bayonne-Newark Bay Canal and an Off-Shore Island Port. Both of these plans were dismissed from extensive evaluation at the request of the non-Federal partners after the preliminary assessment determined that the plans' disadvantages far outweighed the advantages.

- The alternative to deepen the channels to tanker design vessel depth from sea to the major petrochemical facilities in the Gulfport Reach of the Arthur Kill did not support a Federal interest and was eliminated as a navigation improvement alternative during plan formulation;

- Four structural channel improvement alternatives for the container design vessel were considered that increase maintained channel depths in the Harbor to 46 ft, 48 ft, 50 ft, and 52 ft MLW to improve deep-draft transportation of cargo. These alternatives all have similar dredging equipment and dredged material placement requirements;

- Underwater blasting will be required in portions of the Kill Van Kull, Newark Bay and Arthur Kill for all channel improvement alternatives that were considered;

- With the exception of Ambrose Channel and the Anchorage Channel, the remaining channels identified for deepening have an estimated 2 feet of contaminated material (material unsuitable for HARS placement) to be dredged and managed;

- Direct environmental impacts as a result of channel improvements were determined to be minimal as the recommended project consists of improving existing channels and berths and does not involve new channel and terminal construction;

- The NED Plan was identified using an equimarginal analysis and consists of improving channels to the existing and proposed container terminals at Port Jersey, Port Newark/Elizabeth, Howland Hook, and South Brooklyn. Construction of the Channel Improvement to South Brooklyn will be subject to commitment to rehabilitate the South Brooklyn marine terminal and transportation infrastructure needed to realize project benefits.

C270. The New York District has considered all significant aspects of these conclusions. These aspects include environmental, social and economic effects, engineering feasibility, and compatibility of the project with the desires and capabilities of the states of the New York and New Jersey, the Port Authority of New York and New Jersey, and other interested parties.

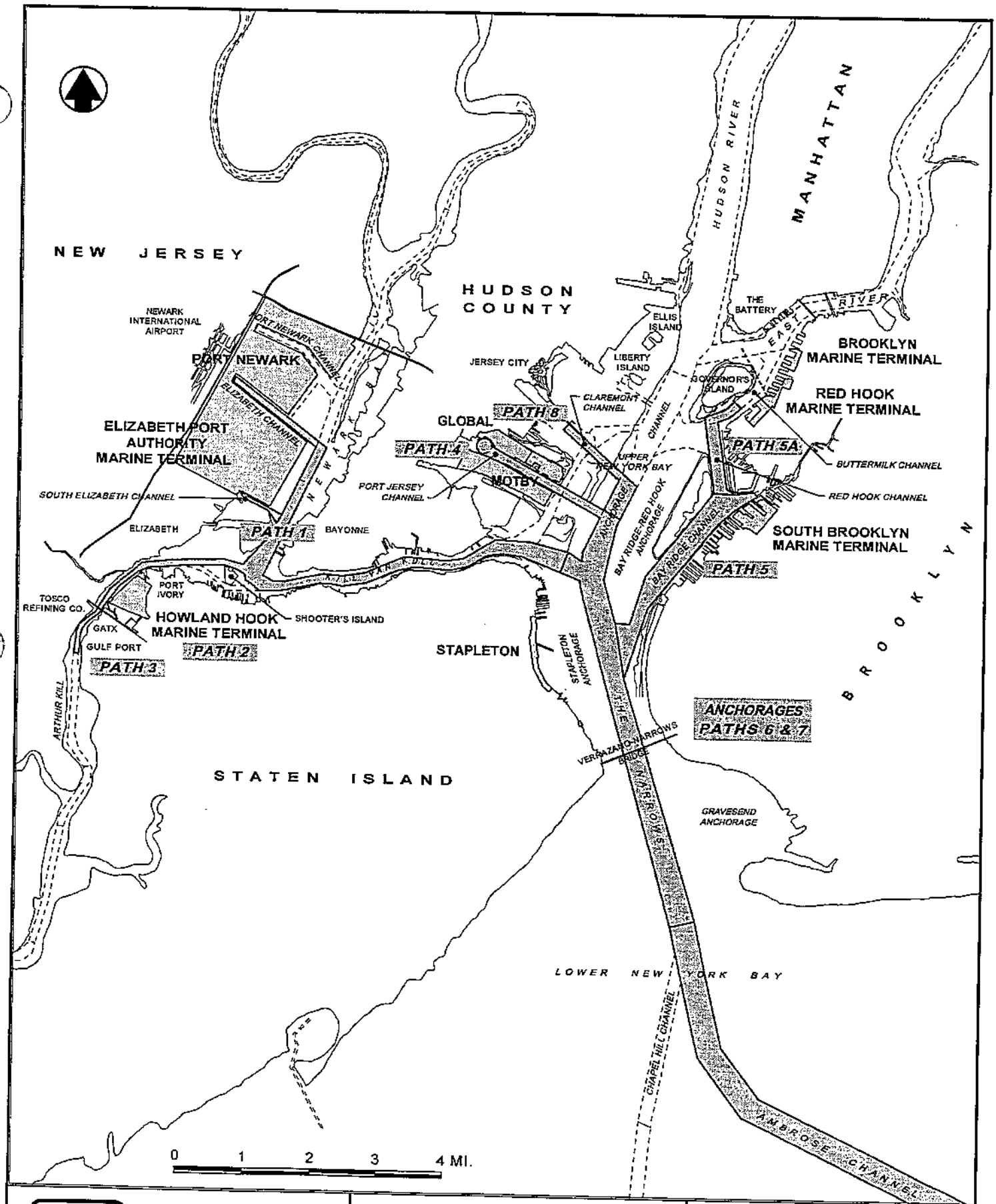

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FIGURE 2

LOCATION MAP OF EXISTING CONDITION

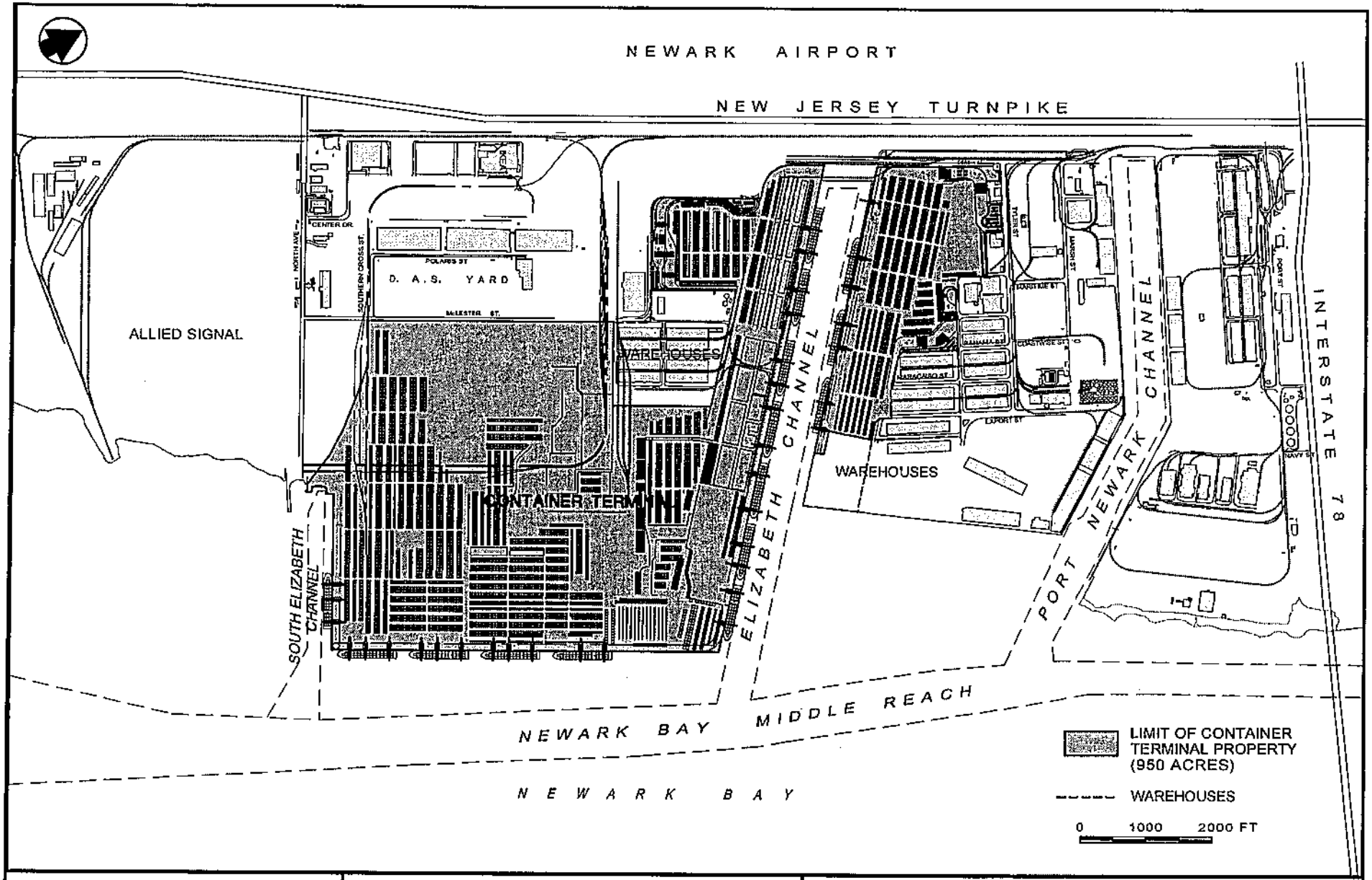

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FIGURE 3
PORT NEWARK & ELIZABETH MARINE TERMINALS
EXISTING CONDITION

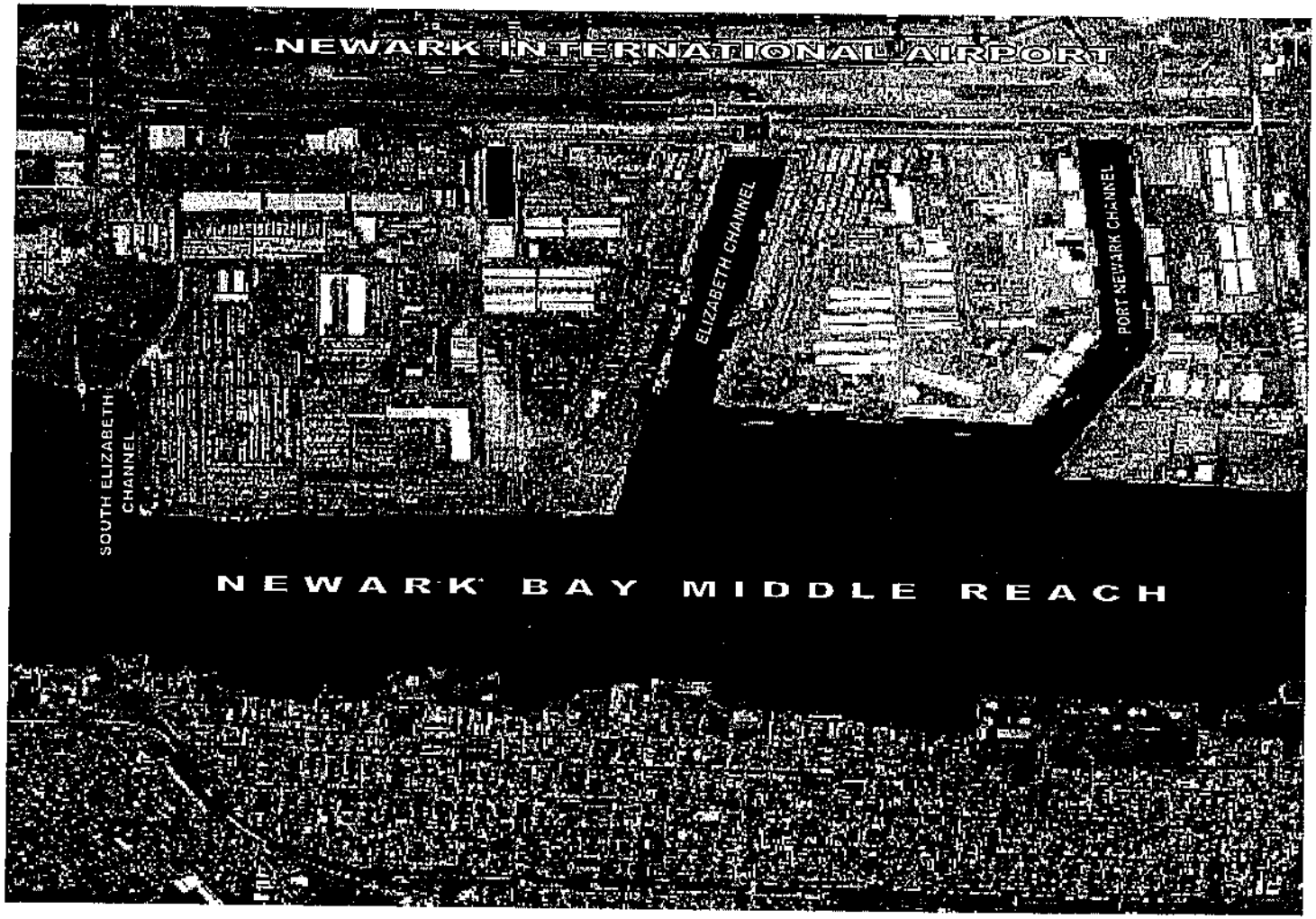

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FIGURE 4
PORT NEWARK & ELIZABETH TERMINALS
AERIAL VIEW

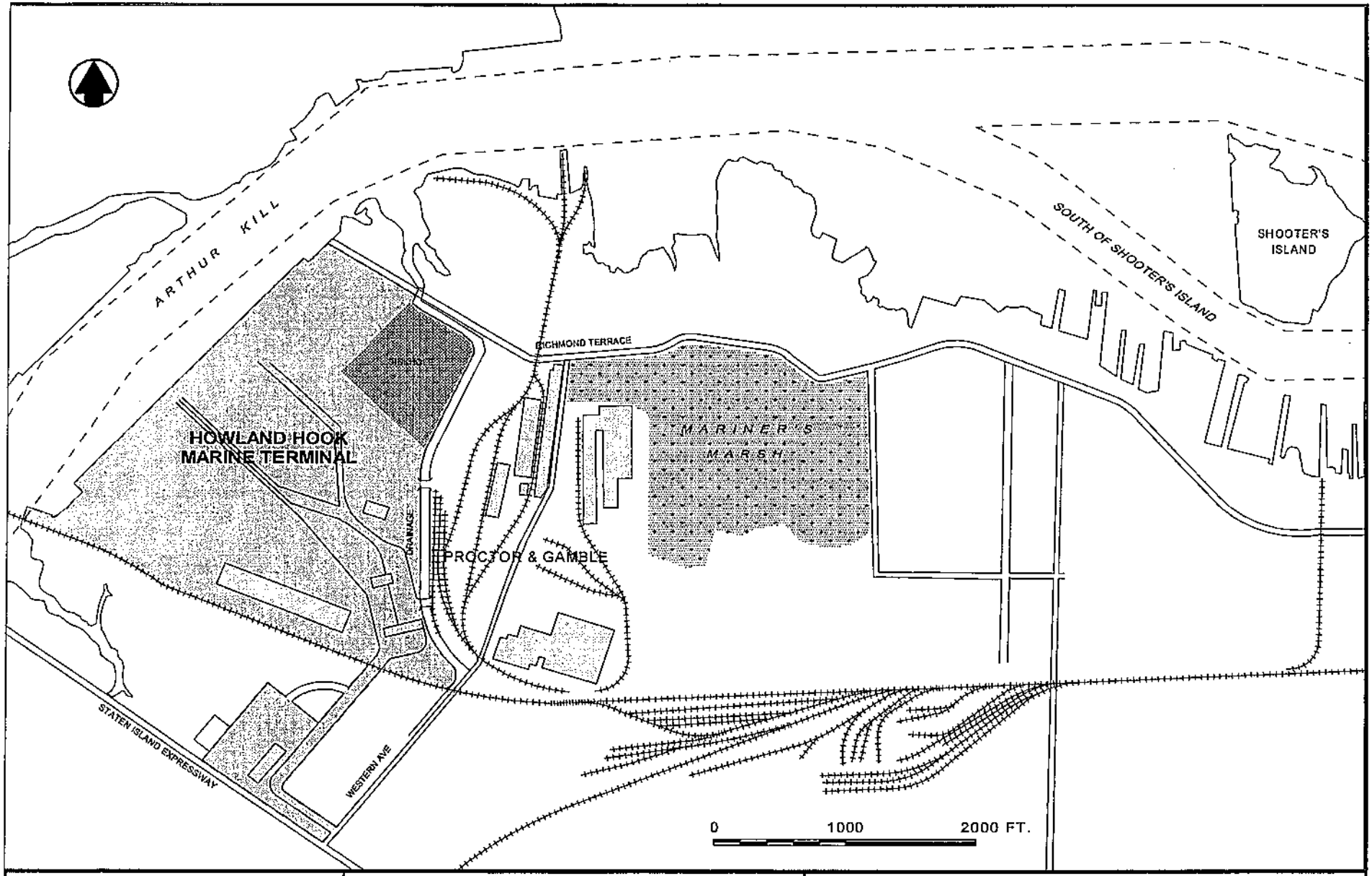

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FIGURE 5
HOWLAND HOOK MARINE TERMINALS
EXISTING CONDITION

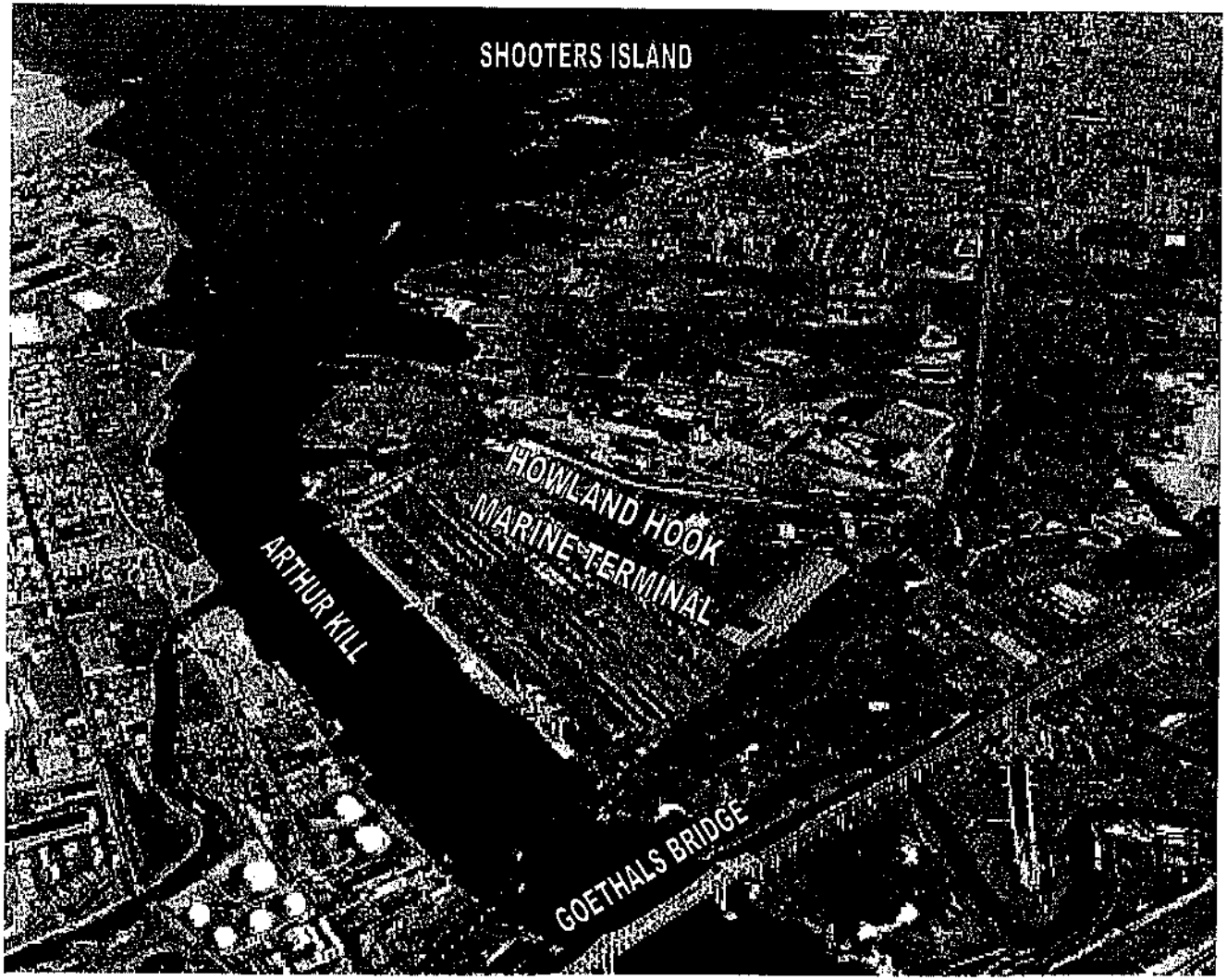

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FIGURE 6
HOWLAND HOOK MARINE TERMINAL
AERIAL VIEW

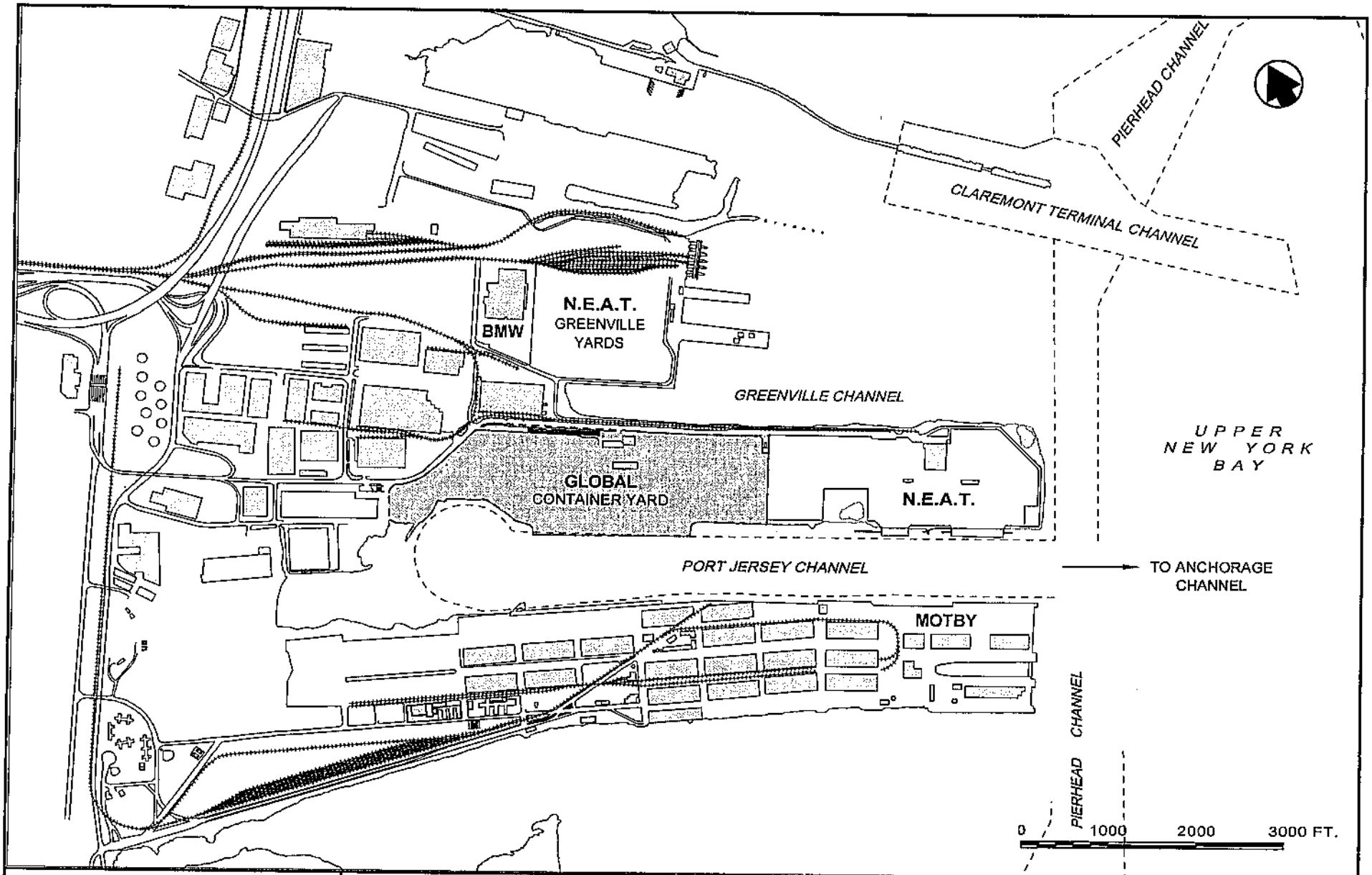

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FIGURE 7
PORT JERSEY & MOTBY MARINE TERMINALS
EXISTING CONDITION

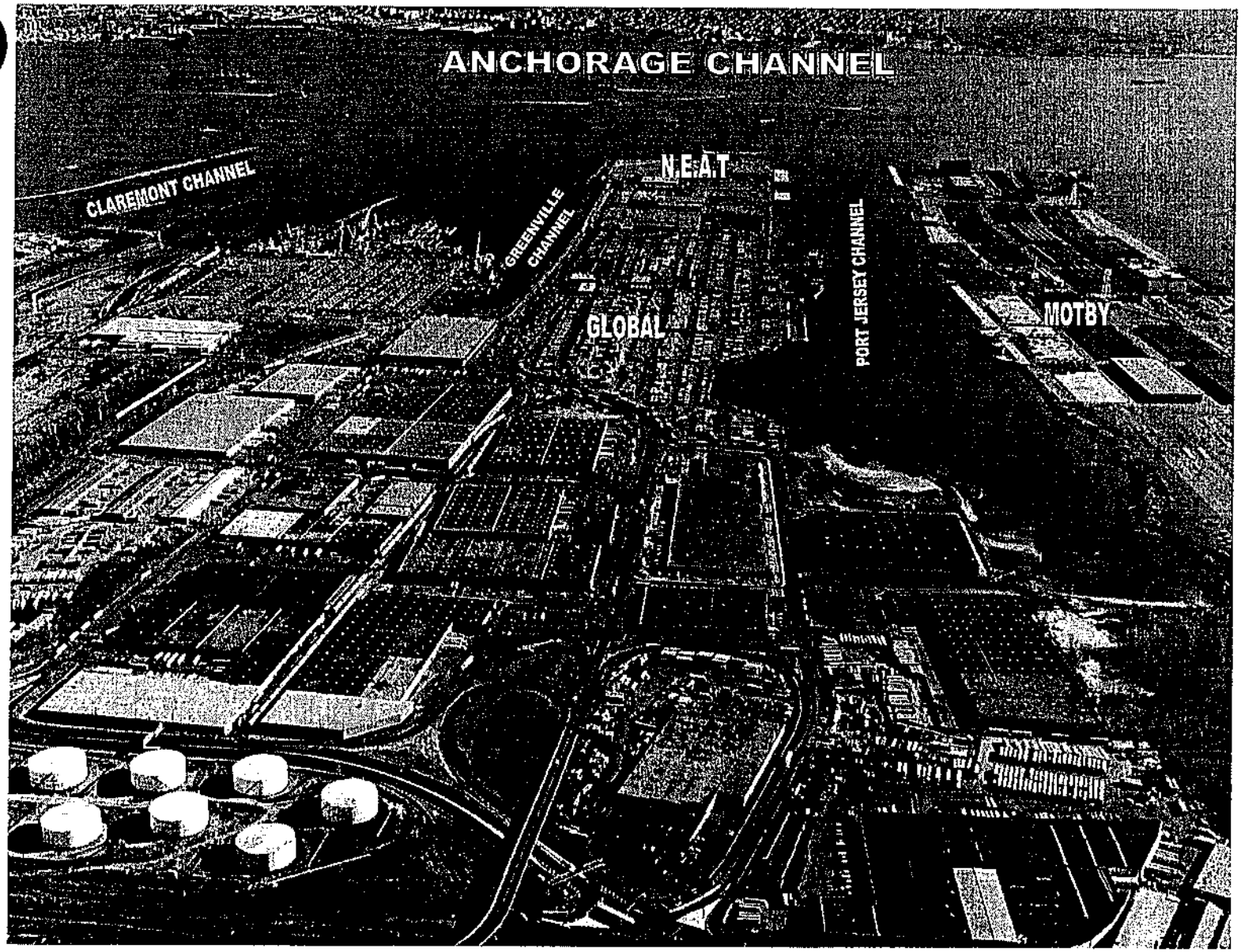

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FIGURE 8
PORT JERSEY & MOTBY MARINE TERMINALS
AERIAL VIEW

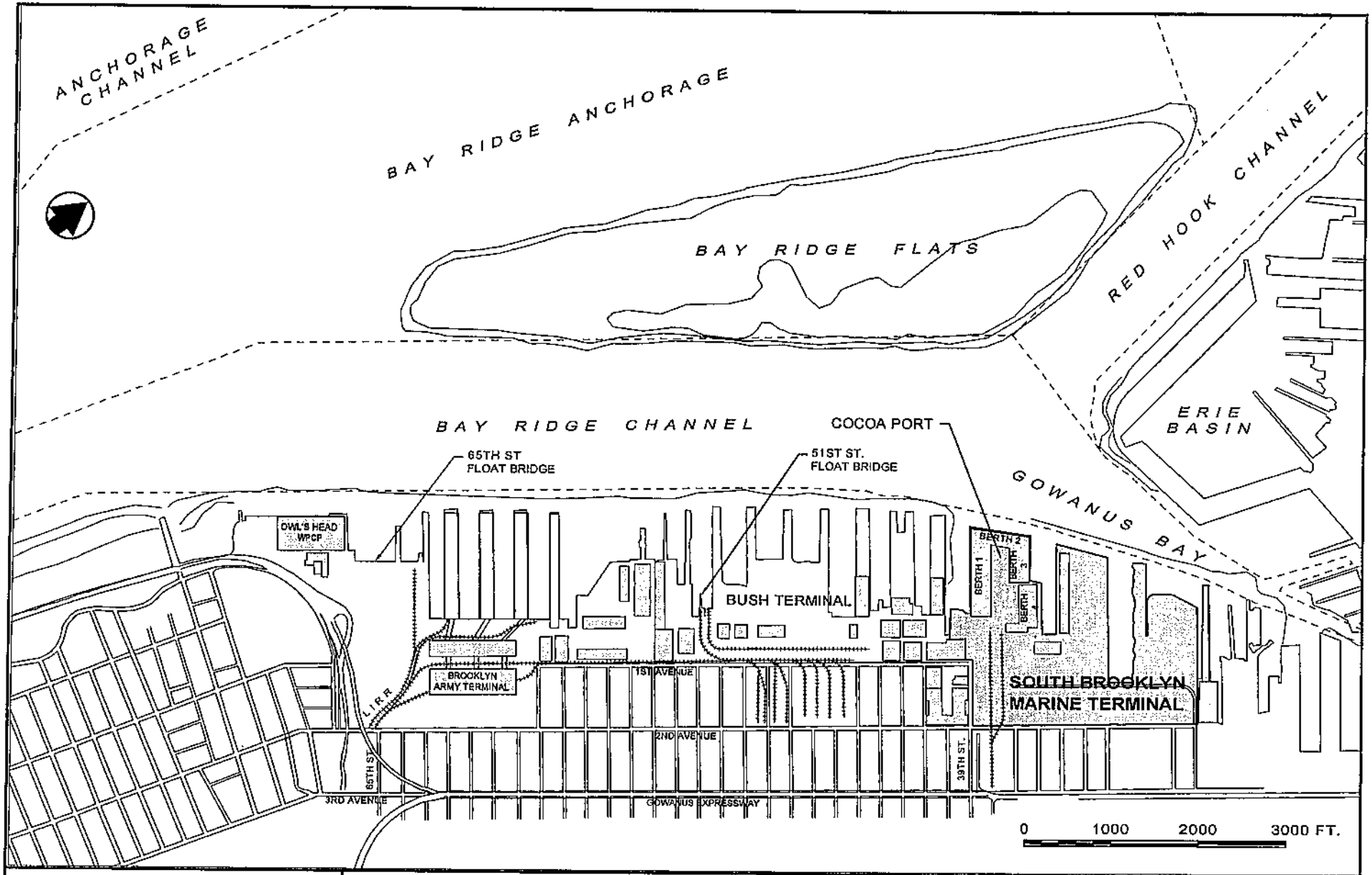

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FIGURE 9
SOUTH BROOKLYN MARINE TERMINAL
EXISTING CONDITION

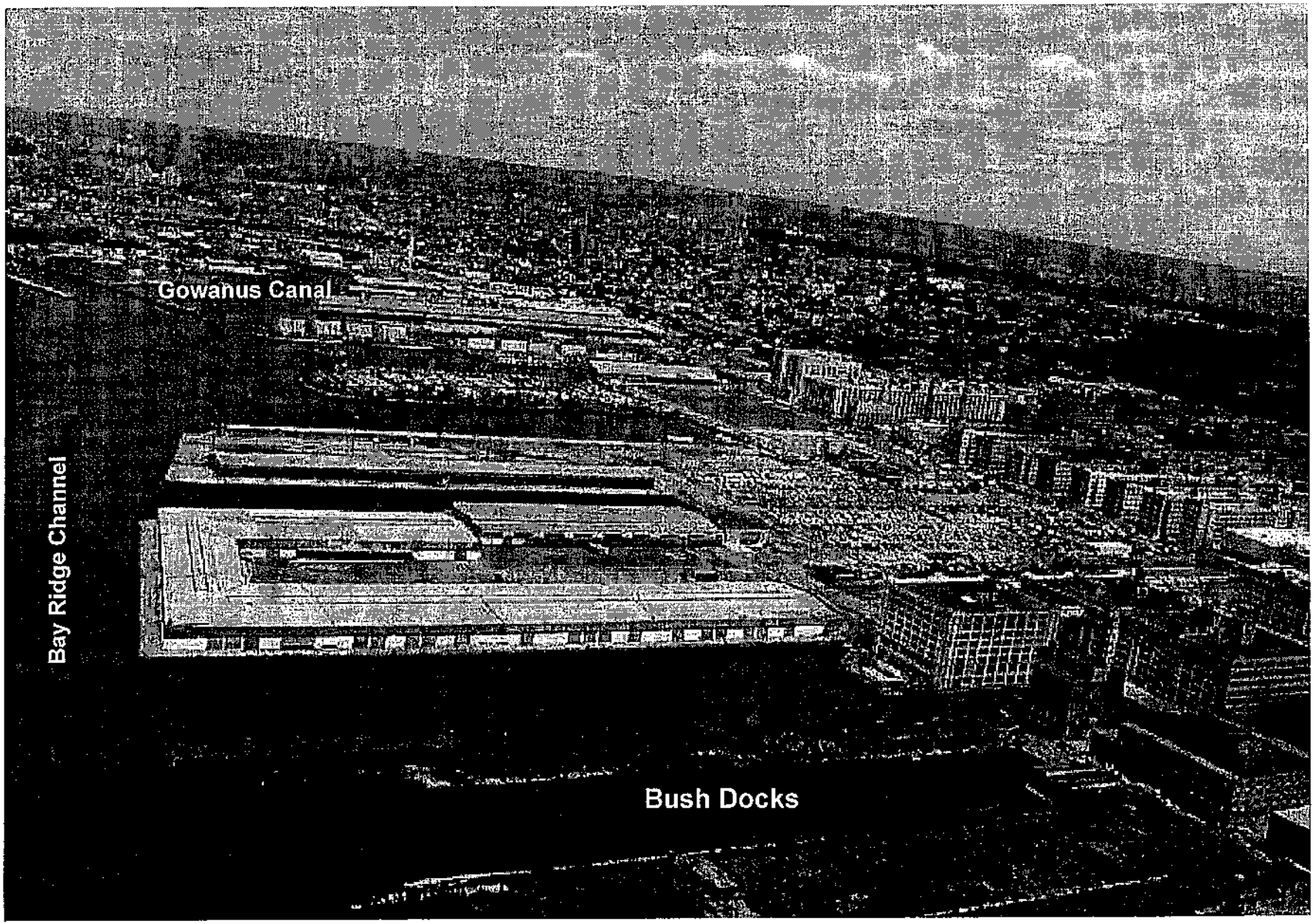

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FIGURE 10
SOUTH BROOKLYN MARINE TERMINAL

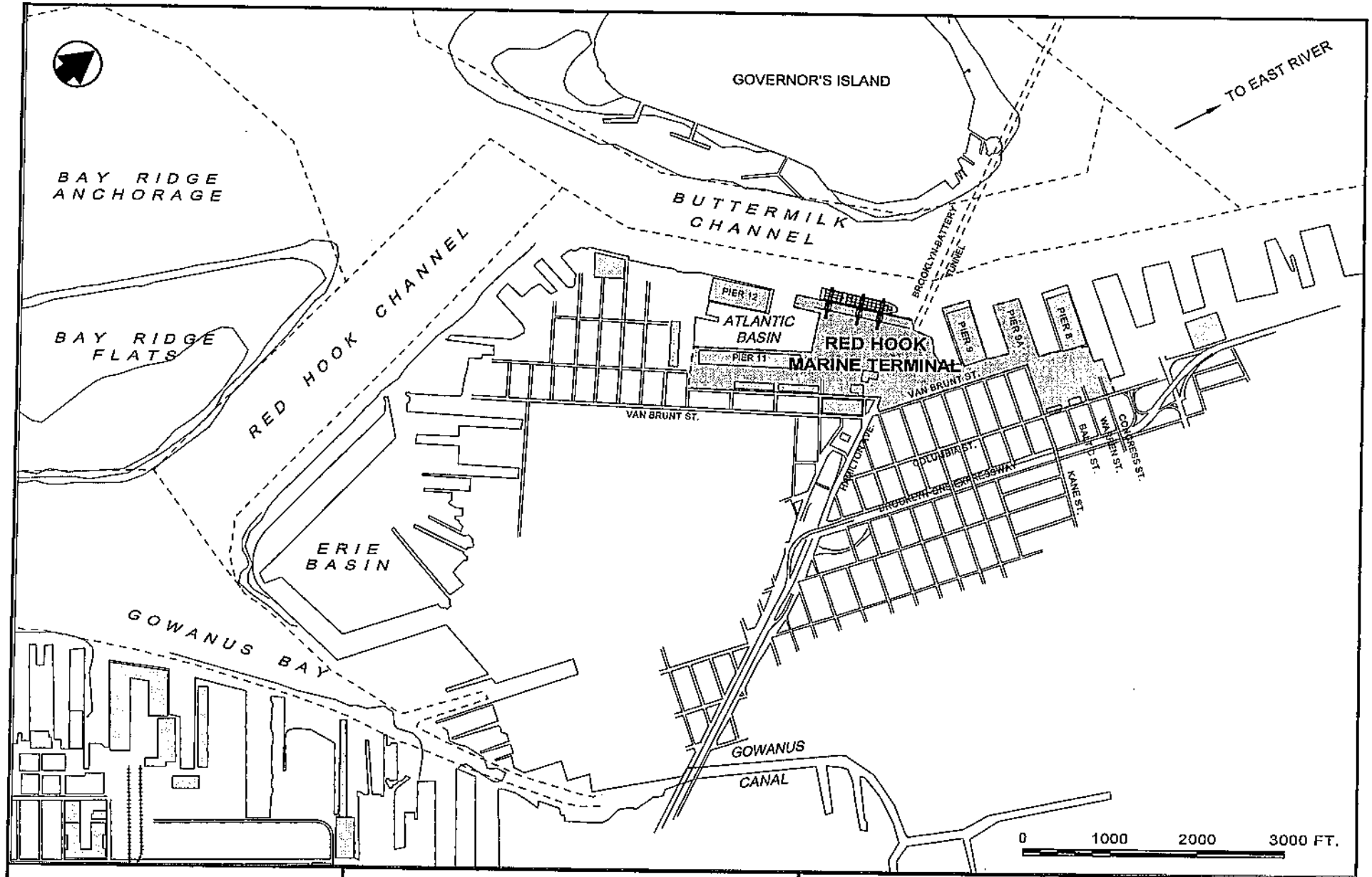

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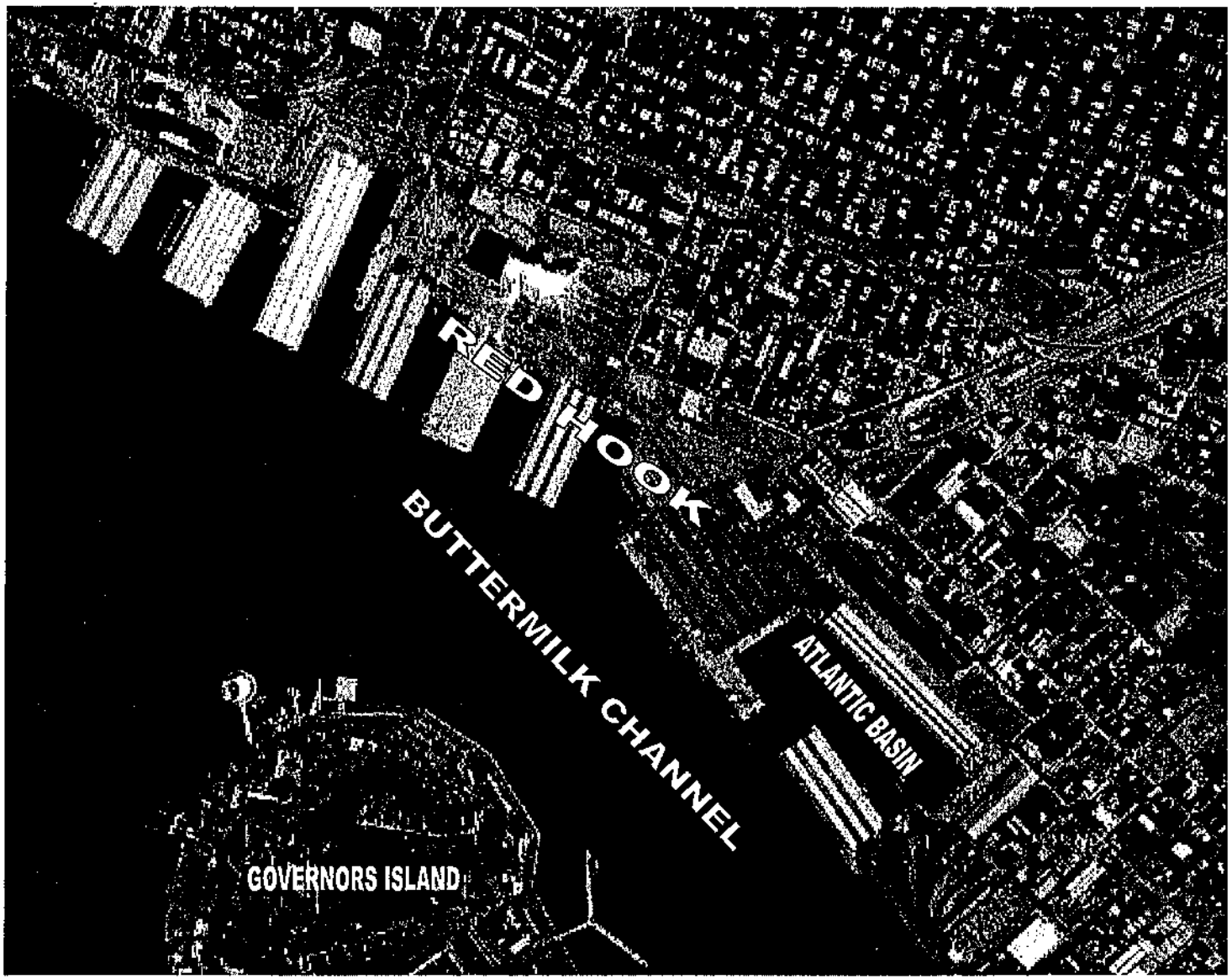
FIGURE 11
RED HOOK MARINE TERMINAL
EXISTING CONDITION



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NAVIGATION STUDY
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FIGURE 12
RED HOOK CONTAINER TERMINAL
AERIAL VIEW

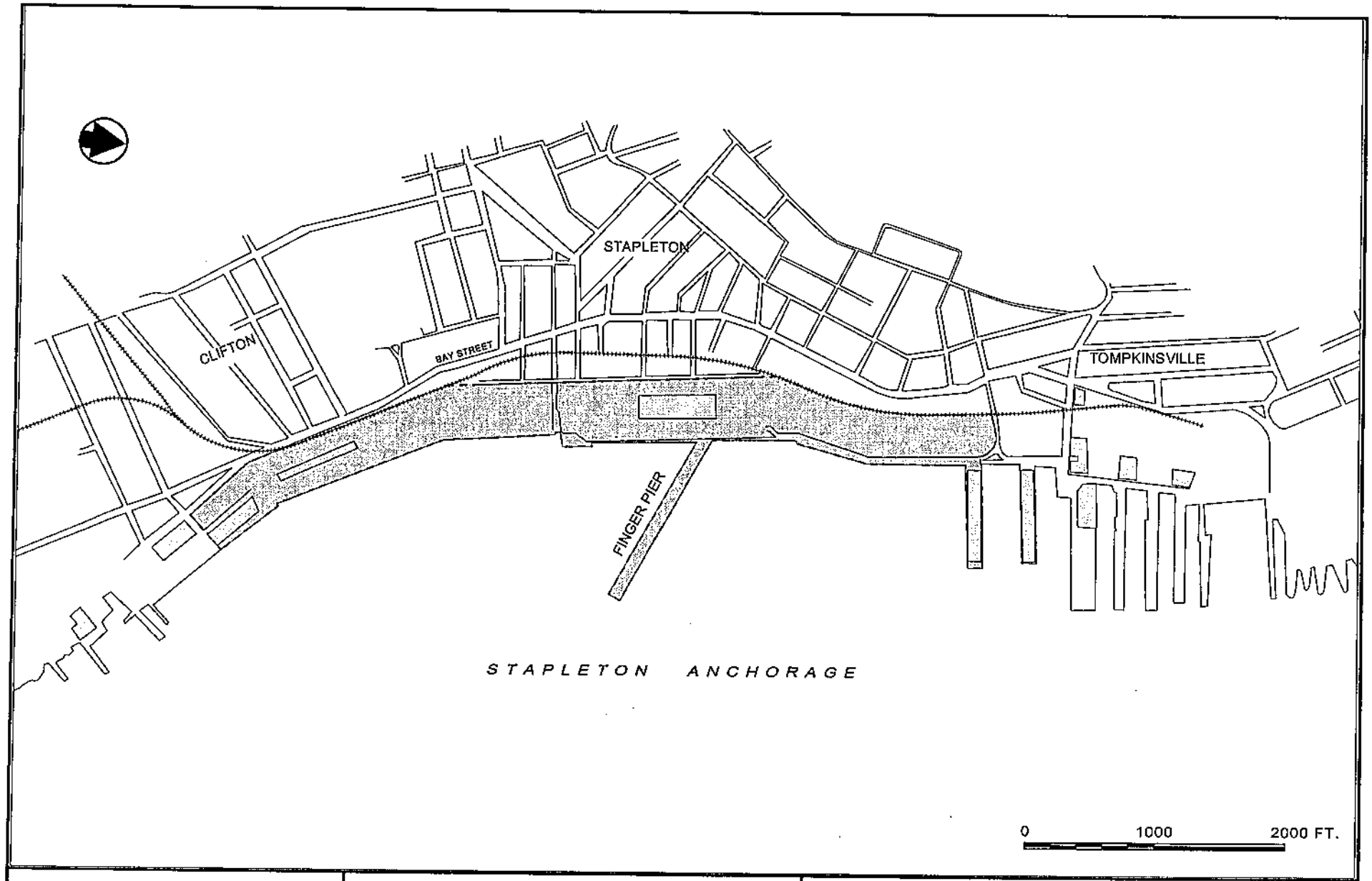

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FIGURE 13
STAPLETON SITE
EXISTING CONDITION

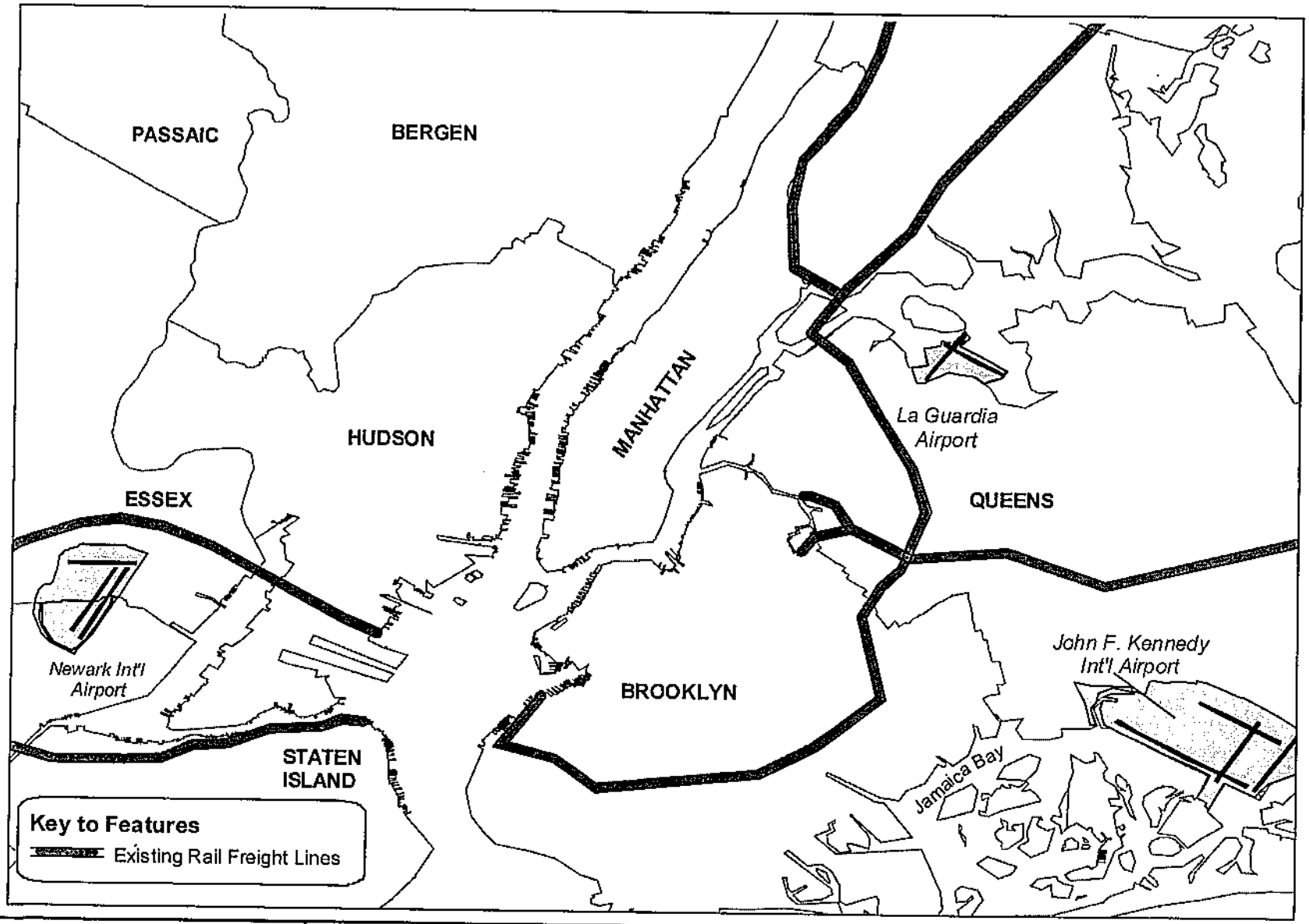

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FIGURE 14
Existing Rail Freight Lines

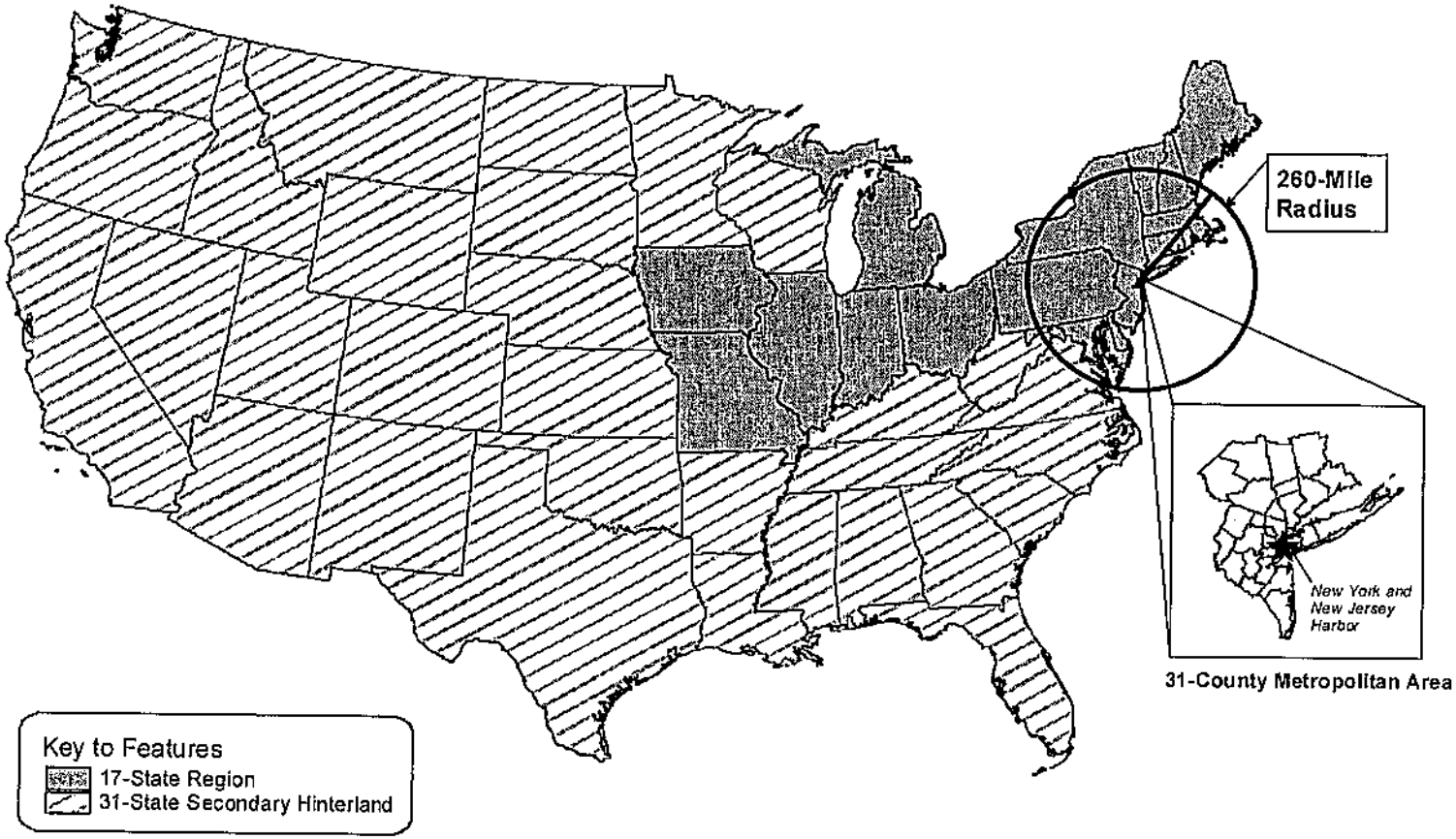

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FIGURE 15
Domestic Economic Hinterland

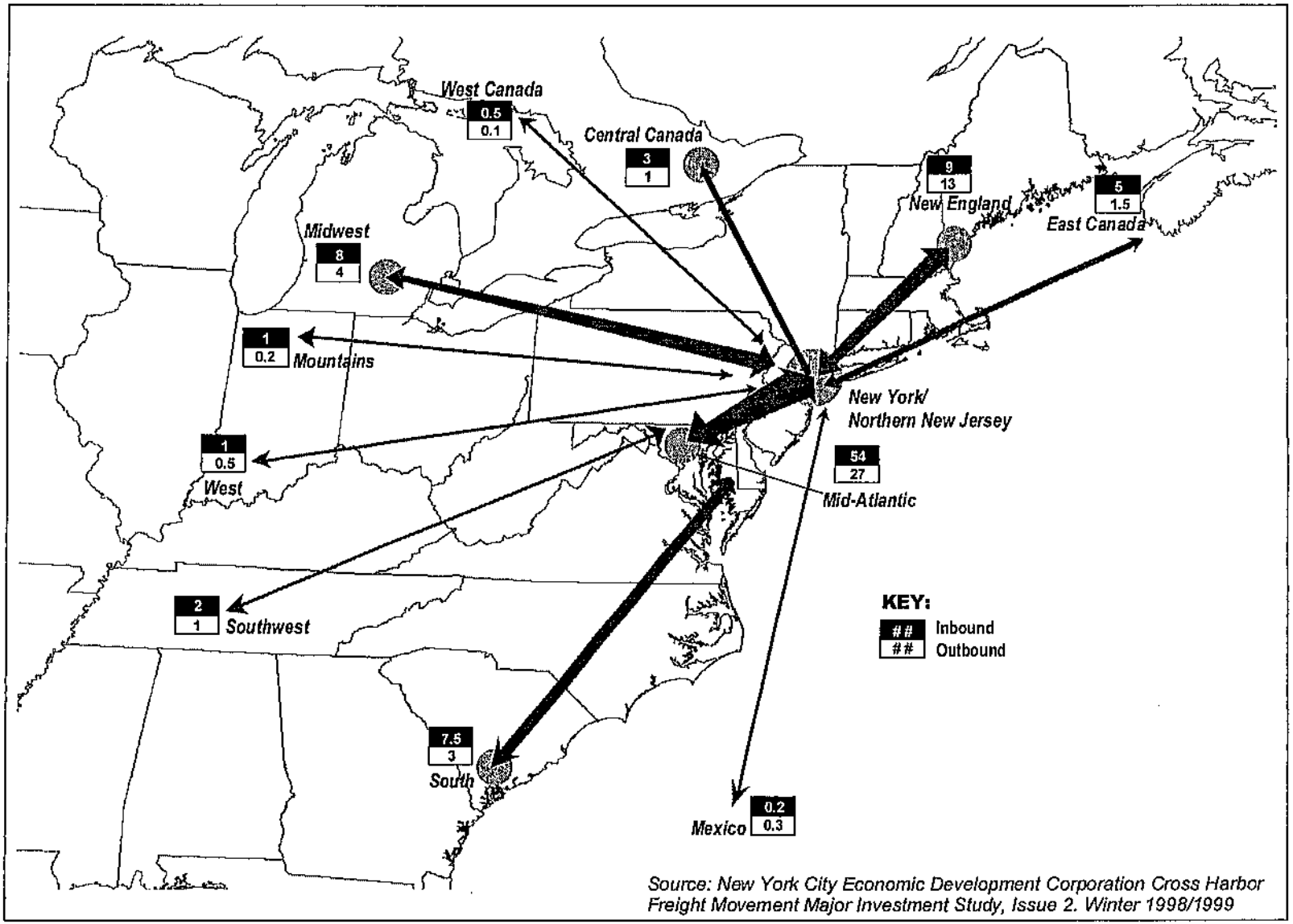

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FIGURE 16
Commodity Flows To and From New York Metro Region (in Millions of Tons)

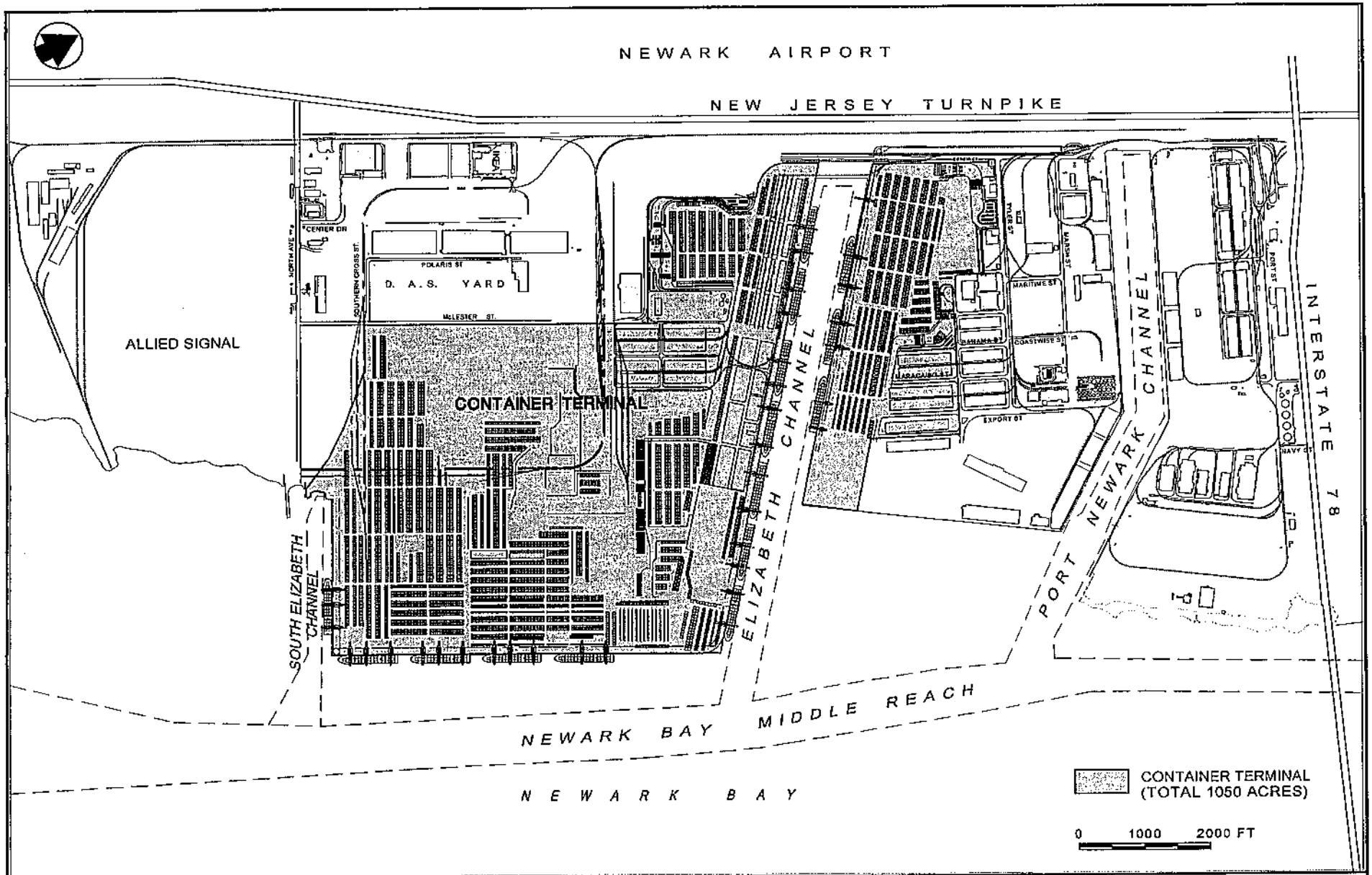

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FIGURE 17
PORT NEWARK & ELIZABETH MARINE TERMINALS
WITHOUT-PROJECT CONDITION

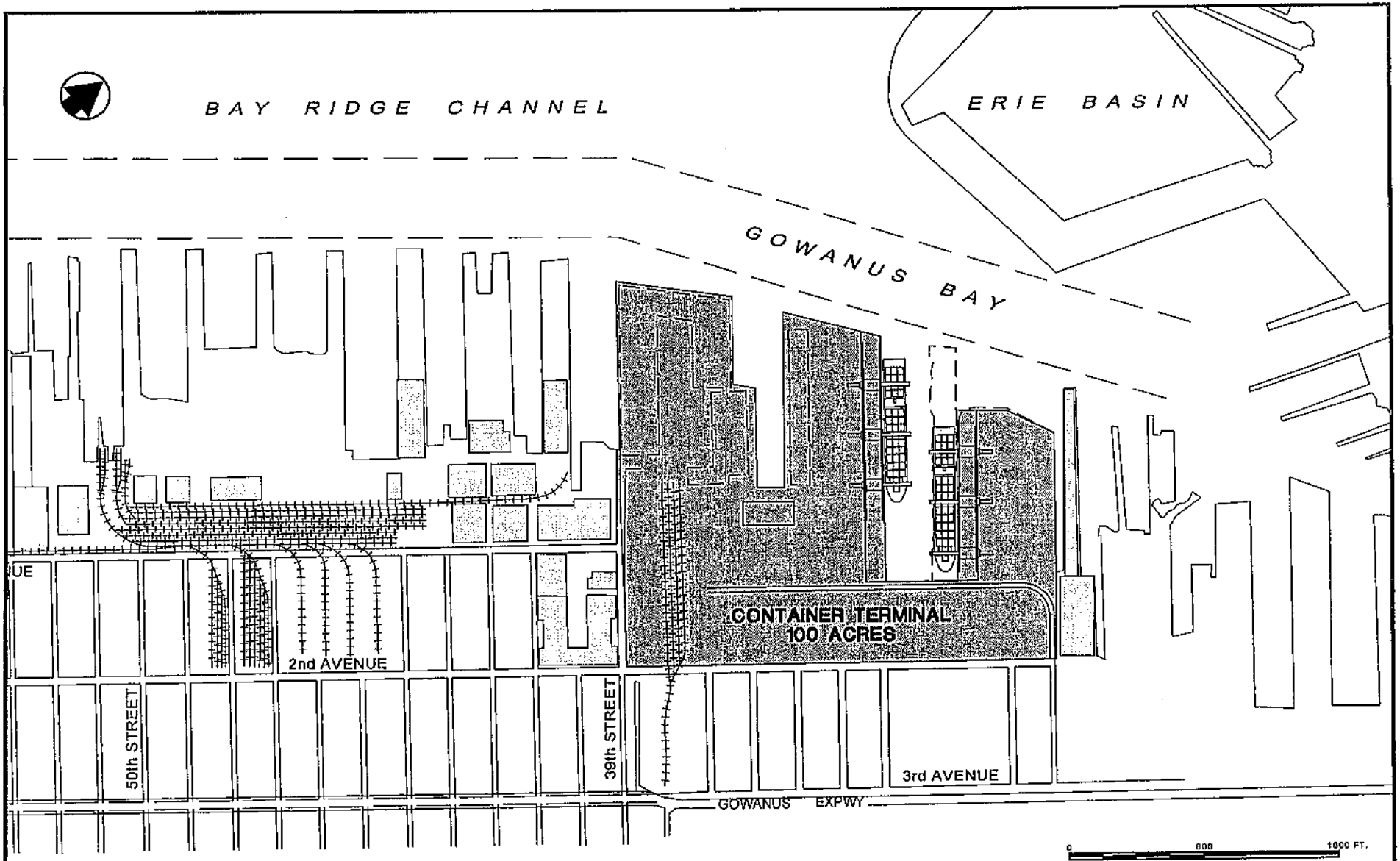

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FIGURE 18
SOUTH BROOKLYN MARINE TERMINAL
WITHOUT-PROJECT CONDITION

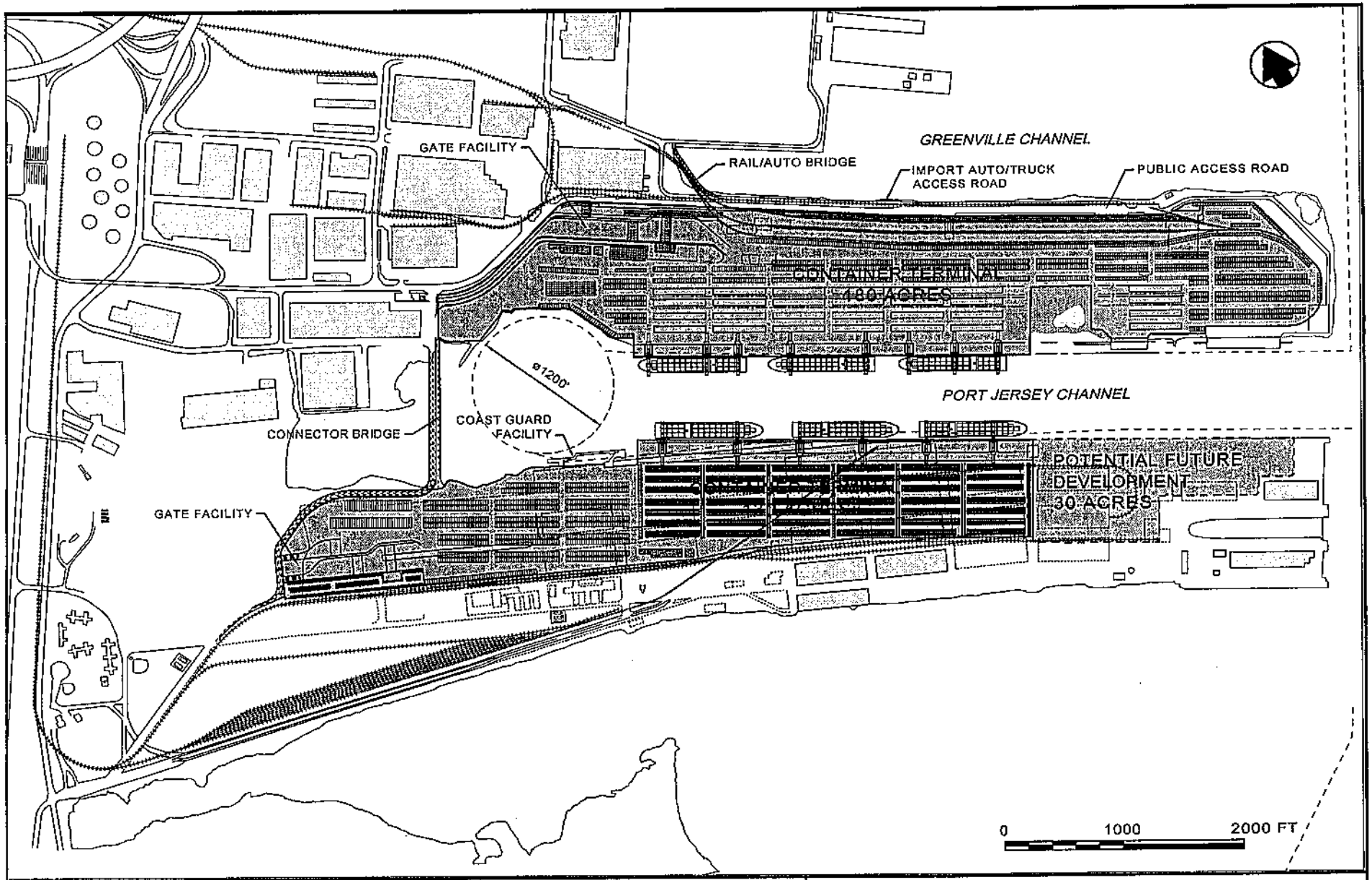

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FIGURE 19
PORT JERSEY & MOTBY MARINE TERMINALS WITHOUT-PROJECT CONDITION

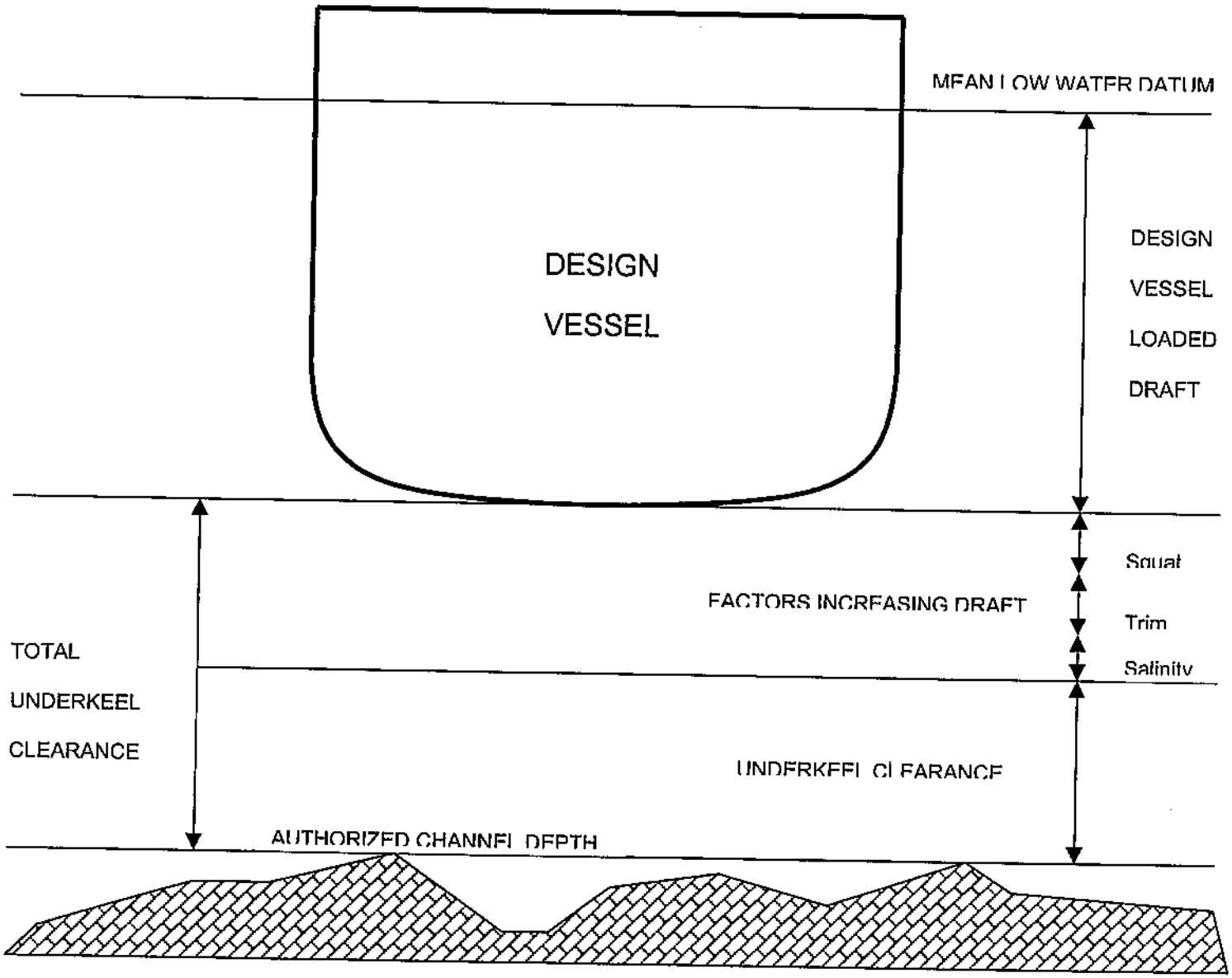

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FIGURE 21
DESIGN VESSEL PARAMETERS

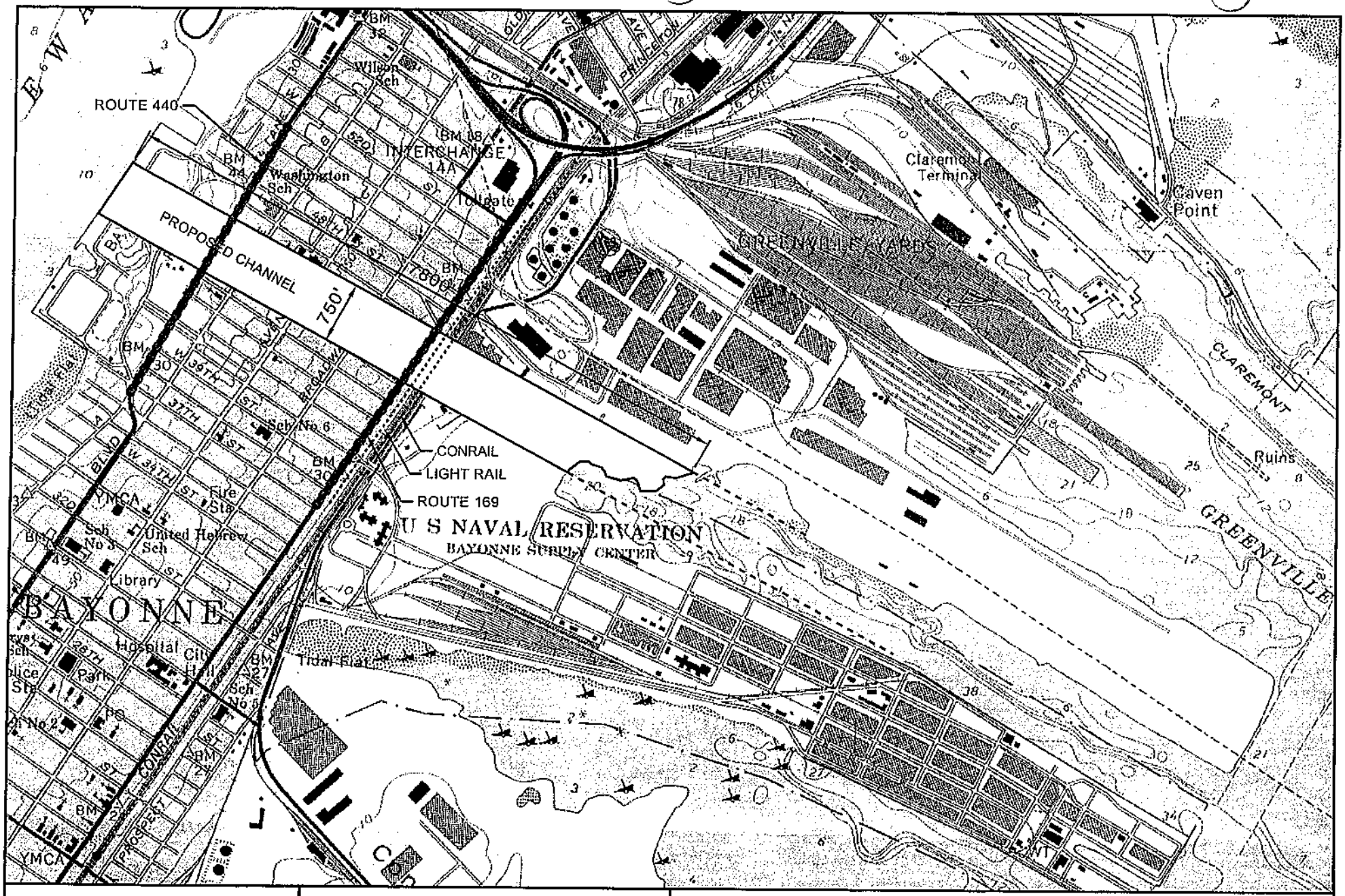

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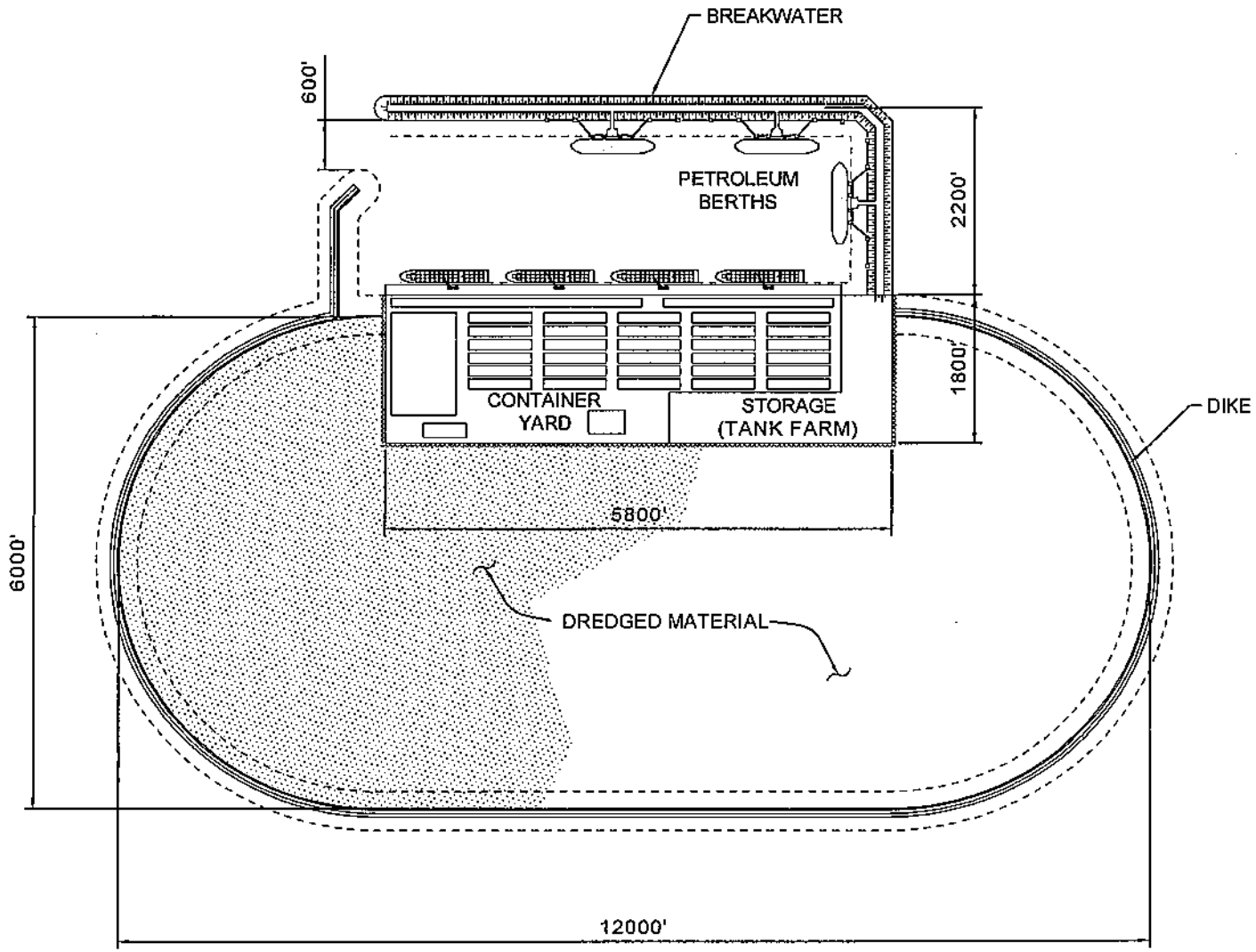
FIGURE 22
BAYONNE - NEWARK BAY CANAL

FILE:



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HARBOR NAVIGATION STUDY
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FIGURE 23
CONCEPT FOR OFFSHORE ISLAND PORT

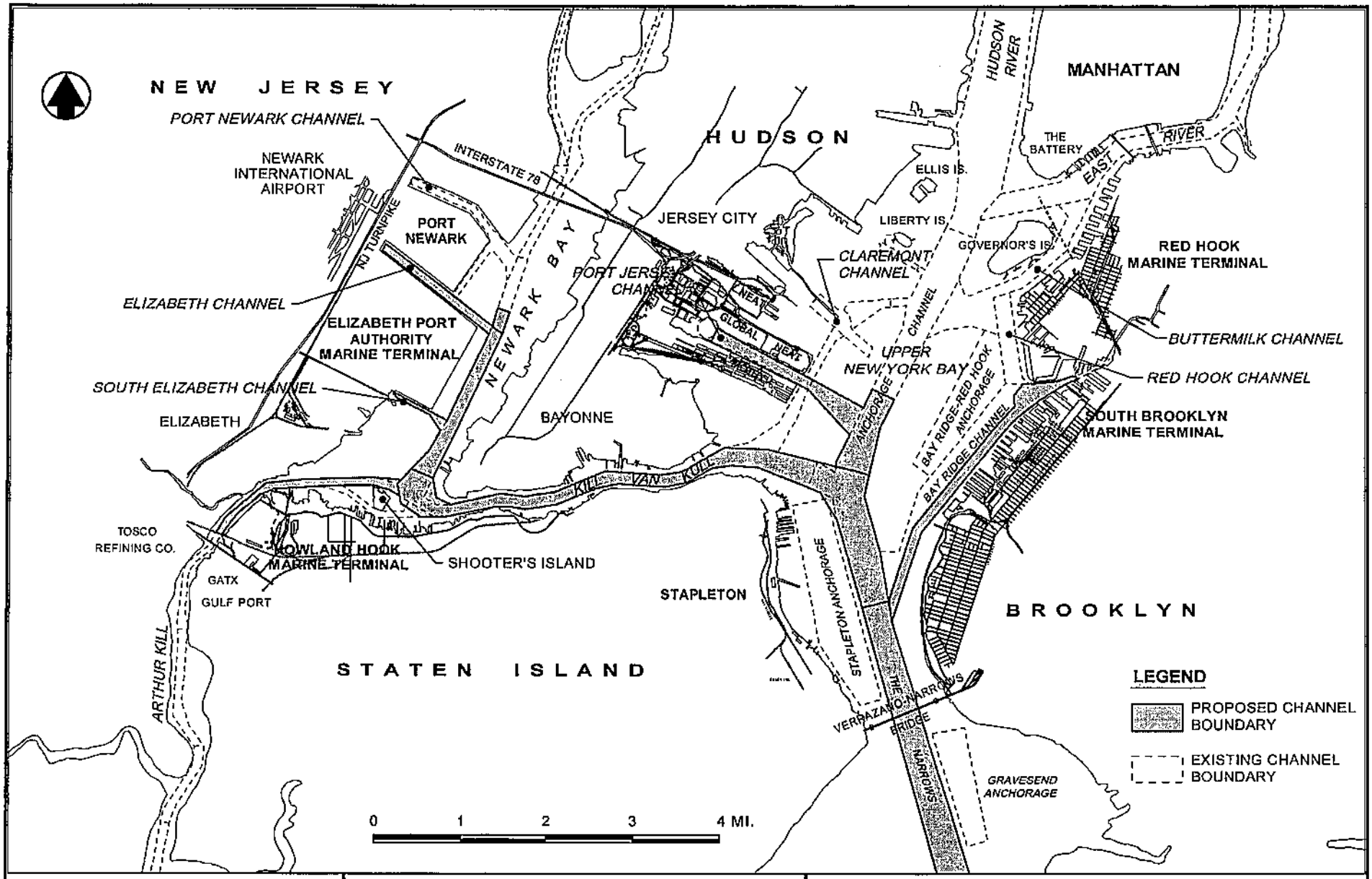

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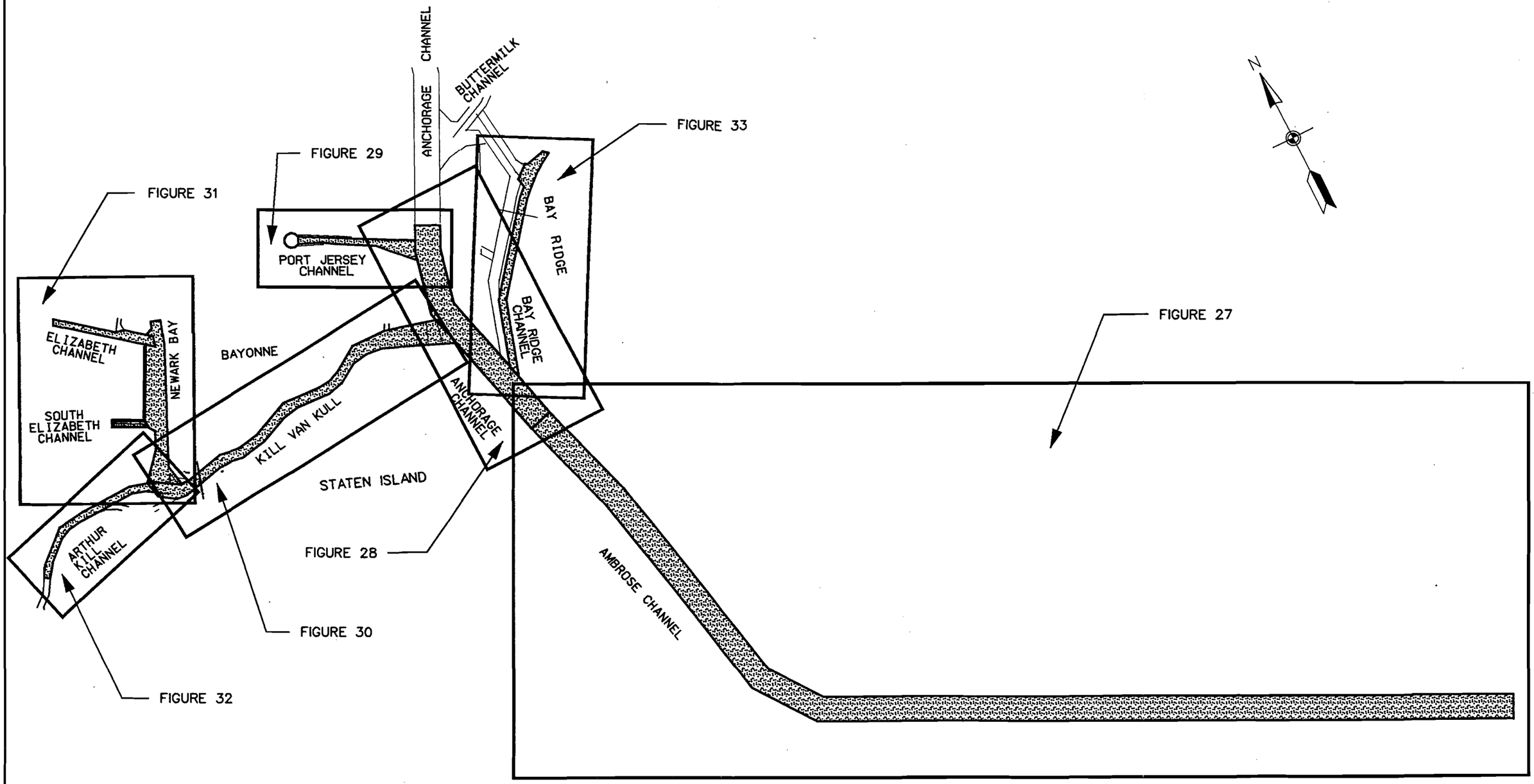
FIGURE 25
RECOMMENDED PLAN
PROPOSED CHANNEL ALIGNMENTS



GRAPHIC SCALE

8000 4000 0 8000 16000FT

SCALE 1 INCH = 8000 FEET

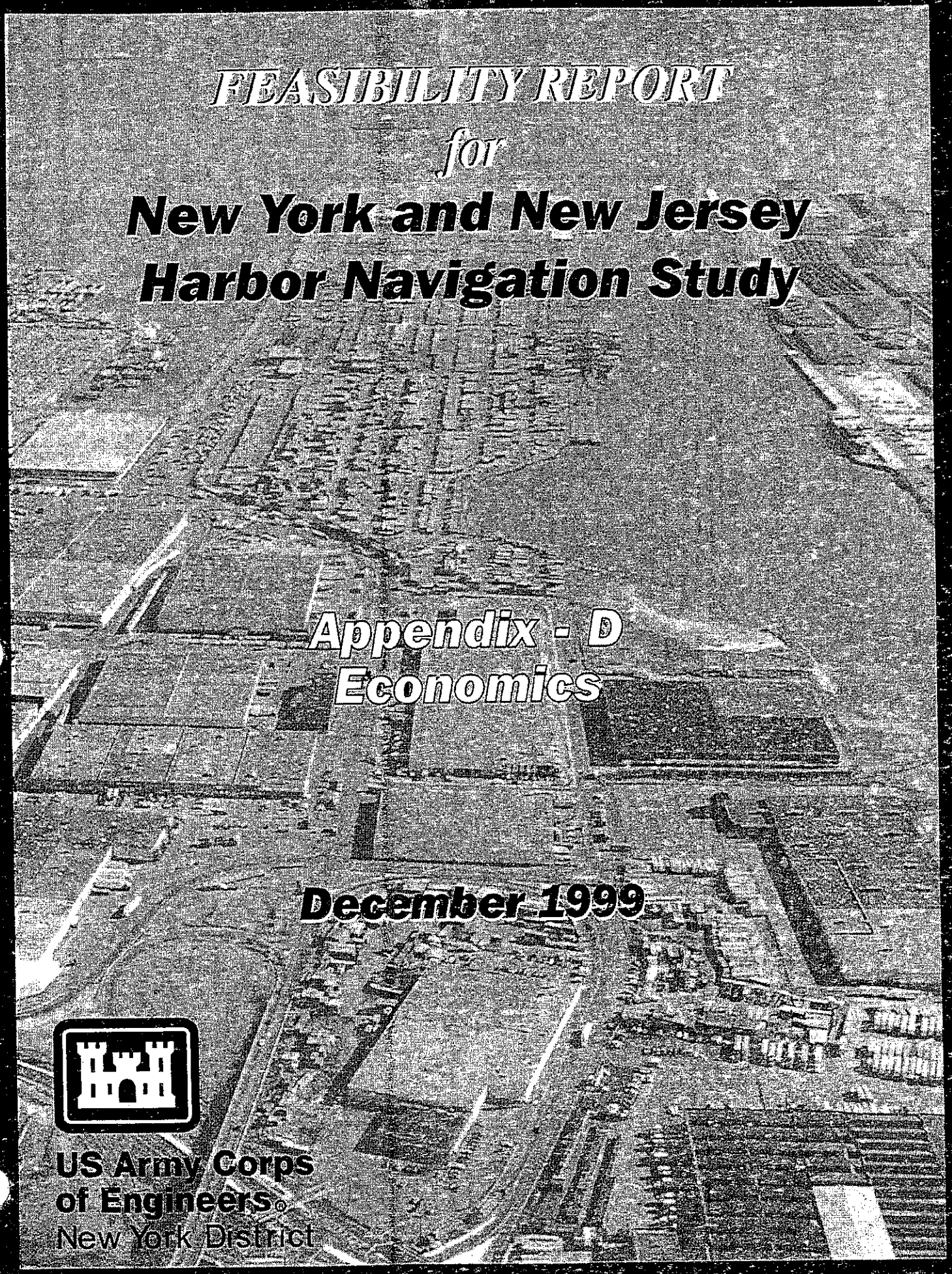
DEPARTMENT OF THE ARMY
NEW YORK DISTRICT CORPS OF ENGINEERS
NEW YORK, NEW YORK 10278

NEW YORK AND NEW JERSEY HARBOR
NAVIGATION STUDY
FEASIBILITY REPORT

RECOMMENDED PLAN

INDEX SHEET

FIGURE 26



FEASIBILITY REPORT

for

New York and New Jersey Harbor Navigation Study

Appendix - D
Economics

December 1999

US Army Corps of Engineers
New York District

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INTRODUCTION

Background

D1.The Port of New York and New Jersey (the Port) is the largest petroleum port in the country and the third largest container port in the U.S. (following the ports of Los Angeles and Long Beach). The Port provides more than 166,000 port-related jobs, generates $20 billion per year in economic activity, and serves more than 17 million customers in the states of New York and New Jersey, in addition to the larger 26-state hinterland.

D2.In 1996, Congress authorized the U.S. Army Corps of Engineers (Corps) to conduct the New York and New Jersey Harbor Navigation Study. In the authorizing legislation (the Water Resources Development Act of 1996, Section 435), Congress directed the Secretary of the Army to:

> "...conduct a comprehensive study of navigation needs at the Port of New York-New Jersey (including the South Brooklyn Marine and Red Hook Container Terminals, Staten Island, and adjacent areas) to address improvements, including deepening of existing channels to depths of 50 ft MLW or greater, that are required to provide economically efficient and environmentally sound navigation to meet current and future requirements."

D3.The New York District, U.S. Army Corps of Engineers is conducting this feasibility study in cooperation with the Port Authority of New York and New Jersey (PANYNJ) and the states of New York and New Jersey (the non-Federal partners). This comprehensive investigation evaluates the current and future navigation requirements of the Port of New York and New Jersey (the Port) to determine whether improvements to the navigation channels will contribute positively to increases in net national income. This feasibility study considers all types of deep-draft navigation traffic in the harbor (e.g., container vessels; tankers; bulk, neo-bulk, and break-bulk vessels). The period of analysis for this investigation is 2010 to 2060.

D4.The study area encompasses the complex of Federal and non-Federal channels, berthing areas, and anchorages in the Port (see Figure 1). However, because this investigation is concerned with international waterborne commerce, the study also discusses international trade issues involving origin and destination patterns between the domestic economic hinterlands of the Port and the Port's overseas trading partners. This study includes the following channels along with their appurtenant terminals:

- Harbor Entrance Channels (Ambrose and Anchorage Channels);
- Brooklyn Channels (Bay Ridge – Red Hook and Buttermilk Channels);
- New Jersey Channels (Port Jersey and Claremont Channels);

- New York and New Jersey Channels (Kill Van Kull, Newark Bay Channels and Arthur Kill from Shooters Island to Gulfport Reach); and
- Anchorages (Stapleton, Bay Ridge – Red Hook, and Gravesend Bay Anchorages.

Purpose of This Investigation

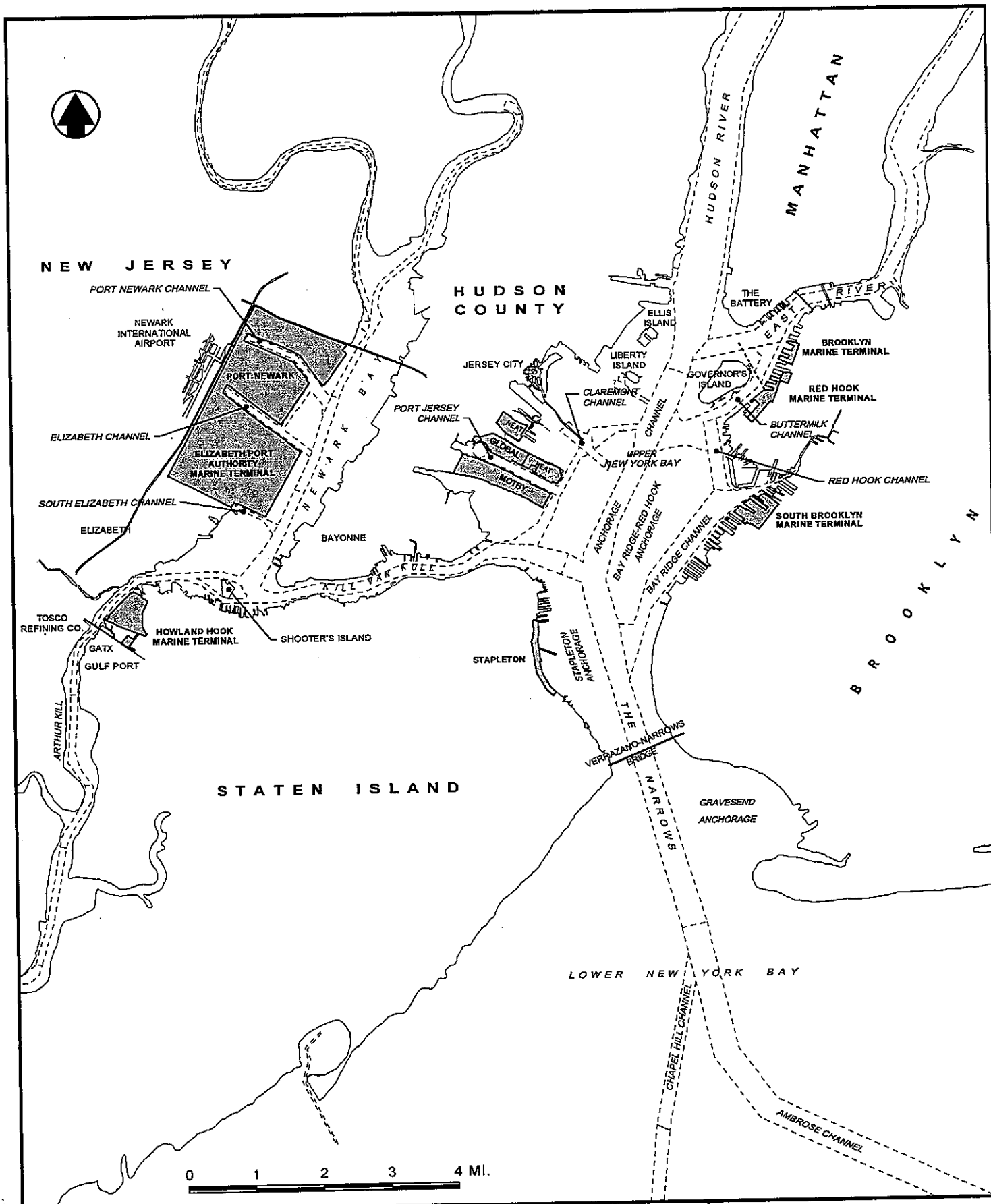
D5.The purpose of this investigation is to evaluate the economic feasibility of the alternative plans to improve navigation in the New York and New Jersey Harbor. These economic analyses were conducted consistent with Federal statutes and Corps policy. Specifically, the principal focus of this investigation was on the anticipated effects of the alternative plans on the National Economic Development (NED) account. Although the Port is an important contributor to the New York and New Jersey regional economy, Federal decision making regarding infrastructure improvements is primarily based on anticipated effects on the national economy. In navigation studies, the costs of navigation improvements are compared to NED benefits expected to result from reduced transportation costs. Procedures for estimating NED effects are specified in the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (U.S. Water Resources Council, 10 May 1983), Engineering Regulation (ER) 1105-2-100, and other Corps publications, such as the National Economic Development Procedures Manual: Deep Draft Navigation (November 1991).

General Method

D6.The economic effects of the alternative plans are estimated by comparing alternative future conditions in the study area for the period of analysis (2010 to 2060). Specifically, the expected conditions with each of the alternative plans (*i.e.*, the with-project conditions) are compared with the conditions expected to exist in the absence of Federal navigation improvements (*i.e.*, the without-project conditions). There will likely be a wide variety of changes in commercial navigation in the Port over the 50 year study period, including commodities shipped through the Port, improvements in marine terminals, and improvements in intermodal infrastructure. Those changes which can be reasonably anticipated at this time have been incorporated into the without-project condition. However, it is important to recognize that only those changes directly attributable to the alternative plans (*i.e.*, the difference between with-project and without-project conditions) are relevant to determining the feasibility of alternative plans.

Prior Studies, Reports, and Projects

D7.A comprehensive literature review of navigation in the Port was conducted early in this investigation to gather knowledge from previous studies and to avoid duplication. The annotated bibliography that was produced as part of this effort was circulated among Port institutions to ensure the completeness and accuracy of this literature review. Many of these studies were conducted by or for the PANYNJ, or the Corps, or both. These



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NEW YORK & NEW JERSEY HARBOR NAVIGATION STUDY ECONOMICS APPENDIX

FIGURE 1

LOCATION OF STUDY AREA

studies were critical in projecting future without-project conditions, specifically the channel dimensions and landside facilities that can be assumed to exist in the absence of any navigation improvements that may result from this feasibility study.

Organization of This Appendix

D8.The Existing Conditions section provides general information about the Port and its hinterlands. It includes information about port institutions and facilities and about the economy of the region and the Port's domestic economic hinterlands. Section II also describes the operation of the Port and its waterborne commerce, including current commodity movements, the deep-draft vessel fleet, intermodal connections to domestic origins and destinations, and costs of commodity movements.

D9. Sections 3 and 4 present an economic perspective on the Port's projected future navigation needs. These future needs will result from a combination of increasing waterborne commerce through the Port (discussed in The Future Commodity Movement section) and changes in the global fleet of vessels calling at the Port (discussed in The Projected Containership Fleet section).

D10. The Economic Benefits of Navigation Improvements section estimates future costs of commodity movements under with- and without-project conditions. The alternative plans consist of incremental deepening of selected waterways within the Port. The comparison of the with- and without-project conditions form the basis for benefit estimates associated with each of the alternative plans.

D11. The benefit-cost analysis of navigation improvements is presented in The Benefit-Cost Assessment Of Alternative Plans section and the net excess benefits of the alternative plans are assessed. The method used to estimate net excess benefits and identify the optimal plan is developed and discussed. The Benefit-Cost Assessment Of Alternative Plans section also provides includes the results of multi-port and sensitivity analyses performed during the feasibility study.

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EXISTING CONDITIONS

Introduction

D12. In this section, a comprehensive snapshot of navigation in the Port of New York and New Jersey is presented. It includes discussions of waterborne commodities that are currently moving through the Port, the types of vessels transporting these commodities, the origin and destination patterns of commodity shipments, and the costs of transporting these commodities. The discussions in this section provide a foundation for in-depth analysis of alternative future conditions in the Port, which are presented in subsequent sections of this appendix. This section includes the following discussions (in order of presentation):

- The Port's facilities and channel dimensions;
- The socio-economic conditions in the Port's domestic economic hinterlands;
- Institutions and organizations that affect the Port's waterborne commerce;
- The marine terminals in the study area;
- Port operations in terms of movements of vessels and commodities;
- Current waterborne commodity movements through the Port;
- The fleet of ocean-going carriers currently calling on the Port;
- Intermodal connections between the Port and its hinterlands; and
- Current costs of waterborne commodity movements through the Port.

Physical Profile of the Port

D13. The Port contains a variety of channels, anchorages, and berths which support commercial navigation. In general, the deep-draft channels and anchorages have been constructed and are maintained as part of Federal navigation projects. Berthing areas are maintained by non-Federal institutions or organizations (public and private). The Federal channels have been authorized by Congress and constructed over the Port's long history as a variety of separate projects. Table 1 summarizes the analytical assumptions about Port waterway dimensions that have been made for this investigation over the period of analysis. The rationale for these assumptions about future without-project conditions is presented in detail in the Without-Project Conditions section of the main report.

Table 1 Without-Project Channel Conditions New York and New Jersey Harbor				
Waterway	Authorized Dimensions		Presently Maintained Dimensions	Without-Project Future Conditions
	Depth (MLW)[1]	Width		
Ambrose Channel	45'	2000'	As authorized	Same
Anchorage Channel	45'	2000'	As authorized	Same
Kill Van Kull & Newark Bay	45'	500'– 1000'	40' pending construction of 45' depth	45'
Arthur Kill to Gulfport	45'[2]	600' – 800'	35' pending reauthorization of 40'	41'/40' to Howland Hook & Gulfport[3]
Port Jersey Channel	45'[2]	600'	35' privately maintained	41'[3]
Bay Ridge–Red Hook Channels	40	1200'-1750'	As authorized	Same
Buttermilk Channel	35'/40'	1000'	As authorized	Same
Stapleton Anchorages[4]	47' to 75'		none	Same
Gravesend Bay Anchorages	47'		As authorized	Same
Bay Ridge – Red Hook Anchorages	45'/40'/35'		As authorized	Same

[1] Mean Low Water
[2] Subject to final authorization
[3] Based on pending Limited Re-evaluation Report
[4] Natural depth, no authorization

D14. The marine terminals under consideration in this study include those listed below. Additional information about the marine terminals is presented in the institutional analysis contained later in this section of the economics appendix.

- Port Newark/Elizabeth,
- Howland Hook Marine Terminal,
- Port Jersey/Military Ocean Terminal at Bayonne,
- South Brooklyn,
- Red Hook, and
- Tosco Oil Refinery at Bayway.

Socioeconomic Profile of the Domestic Economic Hinterlands

D15. The following discussions present a socio-economic profile of the study area, including current economic and demographic data and forecasts of future population, income, and employment. The geographic scope of the socio-economic profile extends beyond the New York – New Jersey metropolitan area to include the domestic economic hinterlands of the Port, which extend into the continent's interior. The socio-economic conditions in the Port's hinterlands are relevant to this investigation, because the intensity, character, and location of their economic activity will directly impact future commodity movements through the Port.

D16. The Port's hinterlands encompass the domestic origins and destinations for waterborne commodities that pass through the Port. These interior origins and destinations are linked to the Port through the existing intermodal network, which includes rail, truck, air, and water (barges). In general, the extent of the economic hinterlands of the Port is the result of shipping decisions made by individual commercial enterprises in the hinterlands and overseas. These enterprises are seeking the most effective and efficient means to ship their commodities to or from the Port's domestic hinterlands. Their shipping decisions involve: (1) the port through which to route their shipping and (2) intermodal connection to or from the selected port. These choices are typically made on the basis of shipping costs, delivery schedules, and cargo handling requirements.

D17. Truck transport dominates the land transport of containerized goods to and from the Port, especially within the region that can be reached in a single day's drive (*i.e.*, several hundred miles). Rail transport becomes increasingly important for more distant origins and destinations. For example, while rail currently (1998) accounts for only 11% of all transport of containerized goods to and from the Port, it provides 93% of the transport beyond a 260-mile radius from the Port. Truck and barge transport account for the remainder of non-rail transport to more distant locations (4% and 3%, respectively).

D18. In general, the relative attractiveness of shipping through a given port declines with distance. This distance decay makes the extent of a port's hinterlands fuzzy at the edges as the hinterlands of competing ports overlap. At the hinterland margins, even small changes in transportation efficiency or effectiveness can affect a port's market share of commodity traffic to and from a given area.

D19. Economic hinterlands of a port can be delineated using a variety of measures, including shipping data. Hinterlands of imports and exports can also be distinguished, as can those of alternative transport modes. Current data regarding commodity movements through the Port suggest that the economic hinterlands of the Port consist of a concentric core, primary, and secondary markets zones.

Alternative Perspectives on the Port's Domestic Economic Hinterland

D20. For the socio-economic profile of the study area, four different zones were used to delineate the Port's economic hinterland. The results are presented in a series of tables below with corresponding information for the continental United States. The four hinterland zones focus on container movements through the Port. Petroleum products entering the Port are largely for local consumption with only a small percentage transported by barge to nearby coastal communities, and bulk commerce makes up a very small proportion of commodity traffic through the Port. The first hinterland definition defines the core area of the Port's primary hinterland, which is the area within the primary port hinterland that accounts for most of the containerized traffic through the Port. Two definitions of the primary port hinterland were then applied. Finally, a fourth definition was used to delineate the secondary hinterland. The benefit-cost analysis of

navigation improvements to the Port are based on all container movements through the Port, which includes primary and secondary hinterland traffic.

31-County Metropolitan Area

D21. The core of the Port's primary hinterland is the New York and New Jersey metropolitan area. Approximately 70% of containerized cargo moving through the Port is destined for or originates in the metropolitan area. In The Strategic Plan for the Development of the Port of New York, July 1998, prepared for the New York City Economic Development Corporation (NYCEDC) and the New York Metropolitan Transportation Council (NYMTC), this area is defined as 31 counties, including: 14 counties in southern New York State (five in New York City, two in Long Island, and seven in the Mid-Hudson region); 14 counties in northern New Jersey; and three counties in southwestern Connecticut.

260-Mile Radius

D22. The first delineation of the Port's primary hinterland consists of a 260-mile radius from the harbor. This radius, which encompasses all of the core area (31-county metropolitan), is used by the New York Shipping Association (NYSA) to collect fees from carriers assessed on behalf of the International Longshoremen's Association. The 260-mile radius encompasses all or part of 13 states (New York, New Jersey, Massachusetts, Rhode Island, New Hampshire, Vermont, Connecticut, Maine, Pennsylvania, Delaware, Maryland, Virginia, and West Virginia), and the District of Columbia. Virginia and West Virginia are not included in this delineation of the Port's primary hinterland, because the portions of these states and related Port commerce that fall within the 260-mile radius are negligible. Approximately 82% of the containerized cargo that moves through the Port is destined for or originates within 260-miles of the Port. Currently, containerized cargo movements between the Port and origins or destinations within the 260-mile radius are assessed $2.50 per ton by the NYSA. Containers destined for or originating beyond this radius are currently assessed at a lower rate of $0.50 per ton.

17-State Region (and the District of Columbia)

D23. A second definition of the Port's primary hinterland, which was used in the 1998 Port Development and Investment Planning Study (prepared for the PANYNJ), is the 17-state region (plus the District of Columbia) that extends from New York to Missouri and from Maryland to Maine. In that study, the Port's primary hinterland was estimated by comparing the costs of routing Southeast Asian imports through the Port with the costs of similar routing through the port of Los Angeles and the port of Long Beach. The analysis compared the potential costs and delivery times to all states in the continental U.S. for vessels originating in Hong Kong. These 17-states and the District of Columbia met the criteria of being serviced through the Port at a lower cost and within a reasonably small time disadvantage, when compared to service through Los Angeles or through Long

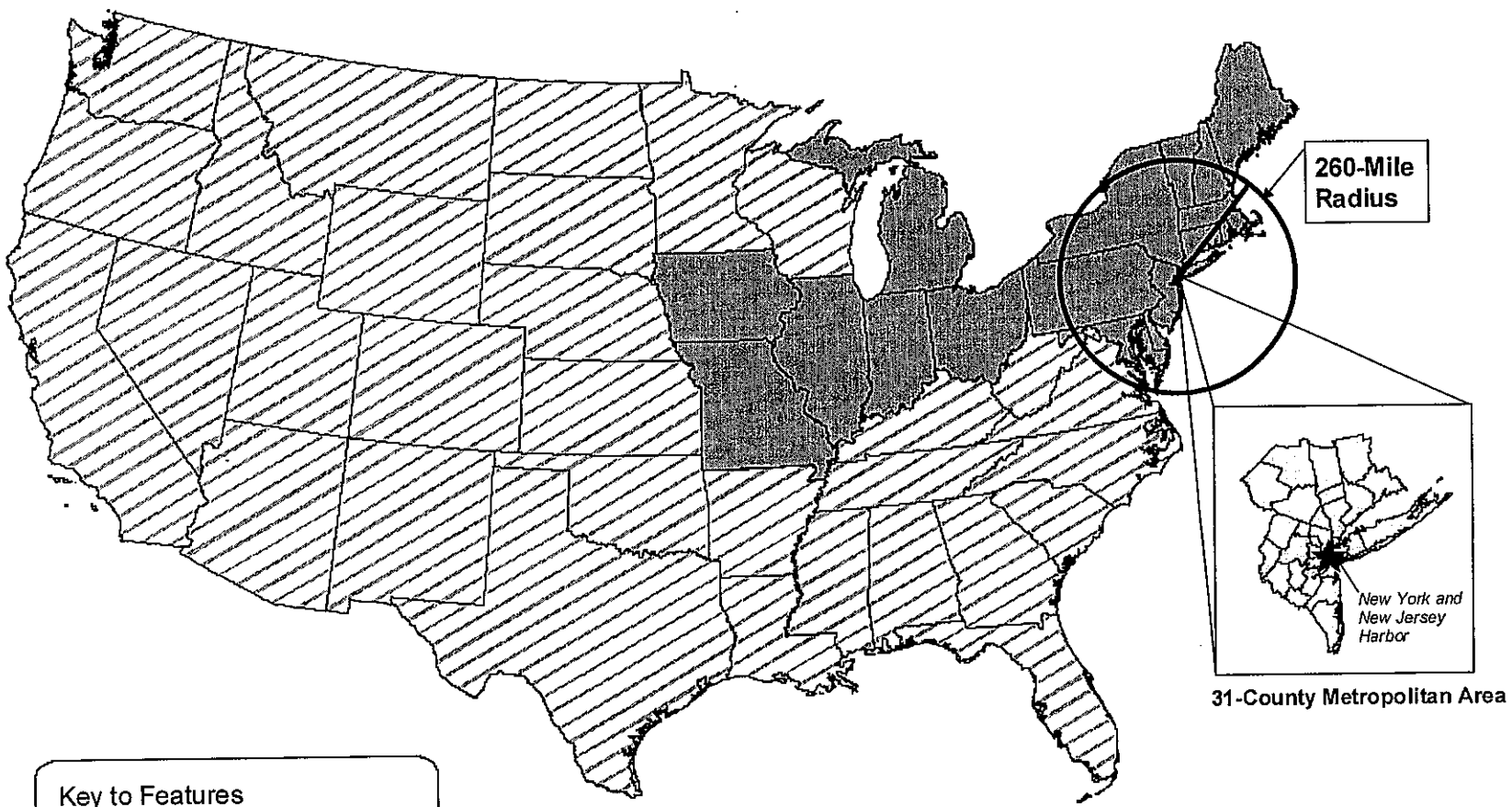

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FIGURE 2
Domestic Economic Hinterland

Beach. The resulting 17-state region encompasses New York, New Jersey, Massachusetts, Rhode Island, New Hampshire, Vermont, Connecticut, Maine, Pennsylvania, Delaware, Maryland, Ohio, Michigan, Indiana, Illinois, Iowa, Missouri, and the District of Columbia. This region is consistent with the primary hinterland described in The Strategic Plan for the Development of the Port of New York, July 1998, prepared for the NYCEDC.

30-State Secondary Hinterland

D24. For this investigation, the Port's secondary hinterland is defined as the remaining 31-states within the continental United States. This definition is consistent with The Strategic Plan for the Development of the Port of New York, July 1998, prepared for the NYCEDC. In addition, the definition of the secondary hinterland was confirmed through discussions with PANYNJ personnel and others involved with the Port's waterborne commerce. In this 31-state region, the Port has a relatively small share of international trade. However, the Port actively competes in the secondary hinterland with other ports (especially west coast ports) to capture a greater market share of this trade.

Data Sources

D25. Socio-economic data for the 31-county New York and New Jersey metropolitan area was obtained from regional statistics and forecasts prepared by and for the New York Metropolitan Transportation Council (NYMTC). However, the NYMTC projections extend only to the year 2015. Projections to the year 2045 we estimated by applying the U.S. Department of Commerce, Bureau of Economic Analysis (BEA) projected growth rates for the New York and New Jersey – Connecticut Census Consolidated Metropolitan Statistical Area (CMSA) for the years 2015 to 2045 to the NYMTC data. The counties included in the CSMA are not entirely equivalent to those of the 31-county area. The CSMA contains one additional county from both Connecticut and Pennsylvania, but excludes two New York Counties from the Hudson region. Where NYMTC data were not available, BEA data for the NY-NJ-CT CMSA were used. These occurrences are noted in the tables.

D26. For the primary and secondary hinterlands, state-level data were obtained from the BEA. Regional data for the 17-state (plus the District of Columbia) primary hinterland, and the 260-mile radius from the port, were aggregated from BEA state-level data. Data for the continental United States were calculated by subtracting individual state data for Alaska and Hawaii from BEA data for the entire United States.

Population

D27. Table 2 shows projected population levels for the alternative definitions of the Port's hinterlands. The 17-state (plus the District of Columbia) delineation of the Port's primary hinterlands contains approximately 40 percent of the population of the entire continental United States. The populations in the Port's core area (31 counties) and

primary hinterlands (17 states and 260-mile radius) are expected to grow more slowly than the national average due to the rapid population increases anticipated for the western states, as represented by the 31-state secondary hinterland.

Table 2
Estimated Population of Port Hinterlands (000s)

Year	31-County Area*	260-Mile Radius	17-State Region**	30-State Secondary Hinterland	Continental U.S.
1998	20,363	59,040	106,339	160,612	268,836
2015	22,164	65,038	117,102	191,496	310,857
% change 1998-2015	9%	10%	10%	19%	16%
2045	25,394	76,488	138,111	238,082	378,986
% change 1998-2045	25%	30%	30%	48%	41%

Sources: Transportation Models and Data Initiative Technical Memorandum No. 8.9 Population Forecasting and Analysis NYMTC; U.S. Department of Commerce, Bureau of Economic Analysis
*Estimated by applying the percentage growth from BEA projections (2015-2045) for the NY-NJ-CT CMSA to the NYMTC 2015 population estimate. ** Includes the District of Columbia.

Income

D28. Income levels in the Port's hinterland suggest their potential to generate imports and exports for the Port, because they imply consumer spending power and serve as broad measures of economic activity. Table 3 shows projected per capita and total personal income levels for the Port's alternative hinterlands. Per capita incomes in the metro region, the 260-mile radius, and the 17-state (plus the District of Columbia) region exceed the national average by 32, 15, and 8 percent, respectively. Estimates of 1998 total personal income show that approximately 25 percent of the nation's total personal income is generated within the 260-mile radius, and the 17-state (plus the District of Columbia) region accounts for approximately 42 percent of the nation's total personal income. Total personal income is expected to grow by a smaller percentage in the 31-county sub-region than in the 260-mile radius or in the 17-state (plus the District of Columbia) region. The area of largest expected income growth is the secondary hinterland.

Table 3 Estimated Per Capita & Total Income of Port Hinterlands						
Income Category	Year	31-County Area*	260-Mile Radius	17-State Region**	30-State Secondary Hinterland	Continental U.S.
Per Capita Income	1998	22,888	20,030	18,771	16,378	17,344
	2015	26,476	23,490	22,052	19,536	20,504
	% change (1998-2015)	16%	17%	17%	19%	18%
	2045	33,420	29,623	27,949	25,074	26,144
	% change (1998-2045)	46%	48%	49%	53%	51%
Total Income	1998	466,073	1,182,557	1,996,086	2,666,490	4,662,575
	2015	586,814	1,527,764	2,582,377	3,791,497	6,373,873
	% change (1998-2045)	26%	29%	29%	42%	37%
	2045	848,671	2,265,805	3,860,118	6,047,923	9,908,041
	% change (1998-2045)	82%	92%	93%	127%	113%

Source: U.S. Department of Commerce, Bureau of Economic Analysis.
*Regional income projections were not available from NYMTC, therefore, BEA estimates for the NY-NJ-CT CMSA are presented for the 31-county metropolitan area. ** Includes the District of Columbia.

Employment

D29. Table 4 presents estimated employment by sector for the Port's alternative hinterlands for the years 1998, 2015, and 2045. For the 1998-2045 period, all-industry employment growth rates in the 31-county metropolitan area, in the 260-mile radius, and in the 17-state (plus the District of Columbia) region are expected to be slower than projected national growth rates. This is consistent with the expected slower growth in total population for these regions relative to the nation. In contrast, projected employment growth for the 30-state secondary hinterland is expected to exceed national levels.

Table 4
Estimated Employment Characteristics of the Port Hinterlands
Thousands of Jobs (% change from 1998)

Employment	Year	31-County Area	260-Mile Radius	17-State Region**	30-State Secondary Hinterland	Continental U.S.
All-Industry Total	1998	10,690	33,382	60,477	90,276	151,944
	2015	12,469 (17%)	38,126 (14%)	68,916 (14%)	110,394 (22%)	180,751 (19%)
	2045	13,534* (27%)	42,330 (27%)	76,665 (27%)	128,811 (43%)	207,133 (36%)
Farm	1998	n.a.	236	835	2,165	3,017
	2015	n.a.	217 (-8%)	756 (-9%)	1,195 (-8%)	2,767 (-8%)
	2045	n.a.	188 (-20%)	648 (-22%)	1,738 (-20%)	2,401 (-20%)
Mining	1998	2	48	127	696	836
	2015	2 (-14%)	41 (-15%)	109 (-15%)	608 (-13%)	730 (-13%)
	2045	1.8 * (-23%)	36 (-25%)	95 (-25%)	525 (-25%)	632 (-24%)
Construction	1998	262	1,450	2,745	4,801	7,610
	2015	332 (27%)	1,645 (13%)	3,097 (13%)	5,842 (22%)	9,015 (18%)
	2045	358* (36%)	1,818 (25%)	3,432 (25%)	6,819 (42%)	10,338 (36%)
Manufacturing	1998	991	3,723	8,040	10,753	18,834
	2015	619 (-38%)	3,313 (-11%)	7,528 (-6%)	11,126 (3%)	18,697 (-1%)
	2045	556* (-44%)	3,109 (-16%)	7,394 (-8%)	11,707 (9%)	19,146 (2%)
Transportation, Communication, Utilities	1998	561	1,538	2,803	4,203	7,084
	2015	613 (9%)	1,682 (9%)	3,090 (10%)	5,046 (20%)	8,230 (16%)
	2045	641* (14%)	1,808 (18%)	3,355 (20%)	5,806(38%)	9,268 (31%)
Wholesale & Retail Trade	1998	1,865	6,806	12,837	19,592	32,669
	2015	2,050 (10%)	7,645 (12%)	14,404 (12%)	23,739 (21%)	38,434 (18%)
	2045	2,180* (17%)	8,393 (23%)	15,874 (24%)	27,541 (41%)	43,752 (34%)
Financial, Insurance, & Real Estate	1998	888	2,941	4,824	6,153	11,065
	2015	1,051(18%)	3,286(12%)	5,441(13%)	7,495(22%)	13,042(18%)
	2045	1,129* (27%)	3,605(23%)	6,022(25%)	8,714(42%)	14,859(34%)
Services	1998	3,029	11,550	19,453	26,891	46,692
	2015	4,190 (38%)	14,804 (28%)	24,906 (28%)	37,062 (38%)	62,435 (34%)
	2045	4,820* (59%)	17,492 (51%)	29,507 (52%)	46,236 (72%)	76,313 (63%)

Sources: Transportation Models and Data Initiative Technical Memorandum No. 8.8 Employment Forecasting and Analysis NYMTC; U.S. Department of Commerce, Bureau of Economic Analysis Estimated by applying the percentage growth from BEA projections (2015-2045) for the NY-NJ-CT CMSA to the NYMTC 2015 population estimate. **Includes the District of Columbia.

D30. The 1998-2045 sectoral employment forecasts suggest that the Port hinterlands – and the nation as a whole – will continue their current transitions from manufacturing to service economies. For the 31-county metropolitan area, the 260-mile radius, and the 17-

state (plus the District of Columbia) region, manufacturing employment is expected to decline, while employment in the construction and services sectors is expected to grow significantly. In contrast, manufacturing employment in the 30-state secondary hinterland is expected to experience modest gains over the 1998-2045 period.

Institutional Profile of the Port

D31. There are a number of public institutions and private-sector organizations that influence commercial navigation and land-side shipping operations in the Port. The following institutional profile for the Port begins with a discussion of the principal public institutions that influence shipping operations in the Port. Subsequent discussions provide a similar examination of private organizations.

Public Institutions

D32. A number of public institutions have significant roles in the operations of the Port. They include several Federal agencies, the states of New York and New Jersey represented through the interstate operations of PANYNJ, and local governments.

D33. Federal agencies involved in port operations include the United States Coast Guard (USCG), the United States Customs Service (USCS), and the Corps of Engineers. The USCG performs numerous enforcement and safety related functions, including operation of Vessel Traffic Service in New York (VTSNY). VTSNY monitors the movements of all vessels in the harbor and promote safe navigation by providing real-time information about vessel traffic. The U.S. Customs Service monitors and regulates the flow of imports and exports through the port. The Corps of Engineers plans, constructs, and maintains Federal navigation channels, anchorages, and turning basins within the Port.

D34. The PANYNJ was established to administer the common interests of the states of New York and New Jersey in the Port. As summarized below, PANYNJ is involved in port operations in diverse ways. First, PANYNJ owns the land and terminal facilities at Red Hook in Brooklyn and at Port Elizabeth in New Jersey. Second, PANYNJ leases land for the Howland Hook marine terminal and Port Newark from the City of Newark and the City of New York, respectively. Third, PANYNJ leases operating rights to Port Elizabeth, Port Newark, Howland Hook, and Red Hook to private terminal operators. Finally, the PANYNJ also maintains responsibility for development and marketing of port facilities.

Private Organizations

D35. Private organizations involved in the Port's operations include pilot associations, labor unions, and commercial associations. Three groups of pilots operate in the Port, and they are differentiated by the type of vessel and area of the Port that they serve. The first group of pilots, who are members of the Sandy Hook Pilots Association, operate

under state license and bring foreign-flag vessels from the sea (Ambrose Light) into the harbor. After they have entered the harbor and have been met by their assisting tugs, a second group of pilots, which operate under federal license, bring foreign-flag vessels to berth. Many of these pilots belong to the Metropolitan Pilots Association, or they may be affiliated with a tug company. The third group of pilots are inter-port pilots. These federally licensed pilots are independent operators who bring U.S.-flag vessels from the sea to the dock. There is also no association for this last category of pilots.

D36. Labor unions can have significant influence on port operations. In particular, the International Longshoremen's Association (ILA), which represents waterfront labor, is an important determinant of handling costs for cargo that moves through the Port. The labor rates specified in the ILA's contract with the PANYNJ can impact the arrival and departure times of commercial vessels calling at the Port. In particular, container vessels have significant incentive to arrive for unloading and loading during the regular business hours of the weekdays. If they arrive at night or on weekends, the premium pay for waterfront workers can be significant. Depending on their schedules, some of the vessels may arrive at night or on weekends and postpone their unloading or loading until the regular workday hours in order to avoid paying overtime rates.

D37. There are three other organizations that have important roles in the operation of the Port. The New York Shipping Association represents the interests of waterfront employers. The Maritime Association of the Port of New York and New Jersey is a commercial organization that serves the interests of the Port's maritime industry. The Harbor Safety, Navigation, and Operations Committee consists of representatives from the marine industry, such as vessel and terminal operators, and representatives from government agencies, such as the USCG and the Corps of Engineers. The Committee assesses and make recommendations on issues of navigational and operational safety in the Port's waterways.

New York and New Jersey Harbor Marine Terminals

D38. This section provides profiles of the principal marine terminals in the Port. The discussions first address container terminals, followed by petroleum, auto, break-bulk, and other terminals.

Container Terminals

D39. There are both privately and publicly-owned container terminal facilities in the Port. The ownership of the major container terminals in the Port is summarized in Table 5. As indicated in this table, the single privately owned container terminal facility is the Global Marine terminal in Jersey City, NJ. As described above, PANYNJ owns two container terminal facilities (Port Elizabeth and Red Hook) and leases operation of these facilities. In addition, the container terminal facilities at Port Newark and Howland Hook are municipal-owned, and PANYNJ leases the terminal operating rights to private

terminal operators. Current terminal operators and lease expiration dates are also presented in Table 5.

Table 5
Terminal Operators and Lease Arrangements

Terminal Complex	Land Owner	Lease Holder (lease expiration)	Marine Terminal	*Terminal Operator (lease expiration)*
New Jersey				
Port Elizabeth	PANYNJ		Mahr Fleet St.	Mahr (2011)
			Mahr Tripoli St.	Mahr (2000)
			Sea-Land	Sea-Land (2000)
			Bay Ave.	Mahr/American Stevedore (annual)
Port Newark	City of Newark	PANYNJ (2031)	Maersk	Maersk (2000)
			Maersk/Universal Maritime	Maersk/Universal Maritime (1999)
Jersey City	Global Marine	Global Marine	Global Marine	Global Marine
New York				
Red Hook	PANYNJ		Red Hook	American Stevedore (2001)
Howland Hook	New York City	PANYNJ (2033)	Howland Hook	How. Hook Container Services (2020)

Oil Terminals

D40. The Port is the largest petroleum port by volume in the U.S., with over 30 billion gallons of crude petroleum and petroleum products in annual throughput. There are 30 oil terminals in the Port ranging in size from small heating oil facilities servicing the local area to large refineries with east coast distribution networks. Most of these oil terminals are privately owned and operated. The Ambrose Channel, Arthur Kill and the Kill Van Kull are the three waterways which serve the majority of these terminals.

Auto, Break-Bulk, and Other Terminals

D41. The PANYNJ leases port facilities on the Port Jersey and Greenville peninsulas in upper New York Bay and at Ports Newark and Elizabeth to five auto marine terminal operators. Two of the auto terminal operators are public processors for several manufacturers, and three operators are exclusive port processors for individual manufacturers. In general, the roll on/roll off (RO/RO) vessels that serve these facilities are not constrained by channel dimensions in the Port.

D42. Break-bulk operations take place at numerous private (owned and operated) facilities throughout the Port. The volume of break-bulk trade in the Port is very small relative to containerized cargo, and it is not expected to grow significantly in the future. Excluding vehicles, break-bulk consists largely of wastepaper, bananas, lumber, coffee,

cocoa, sugar, and numerous other commodities. In general, break-bulk vessels are also not constrained by channel dimensions in the Port.

D43. There are also numerous specialty terminals in the Port, including facilities to handle chemicals, hazardous materials, sand and stone, bulk orange juice, and edible oils. These privately owned and operated facilities are mainly located along the Kill Van Kull. In general, operations at these facilities are also not constrained by channel dimensions in the Port. A single exception, the scrap metal terminal on Claremont Channel, is depth constrained. In this operation, vessels are loaded to the depth of the berth and then "topped off" from barges at anchorage in deeper water.

Port Operations

D44. The operation of the Port is explored in the following discussions, including current operating practices and the effects of channel depths on those operations. The discussions are limited to container and liquid bulk vessels and terminals. Ship and terminal operations for barges, automobile carriers, and break-bulk vessels are not discussed, since in general these vessels are not currently depth-constrained and are not expected to change significantly with channel improvements. The single exception may be a reduction in intra-port barge traffic which could result from the reduced frequency of lightering operations if channel deepening occurred.

D45. The information presented in these discussions of port operations was derived from interviews with pilots, shippers, terminal operators, and maritime association personnel. Interviews concerning land-side operations are supplemented with information from previous studies performed for the PANYNJ and the NYCEDC. The discussions begin with an examination of container operations in the Port.

Container Operations in The Port

D46. In 1997, 67 carriers transported more than 1.7 million loaded twenty-foot equivalent units (TEUs) through the Port. The 10 largest carriers in the harbor moved 63% of the total TEUs, and the 20 largest carriers moved 84% of the total TEUs. The movement of containerized freight through the Port is conducted through a complicated web of operational relationships. Shippers, carriers, and non-vessel operating common carriers (NVOCCs) play important roles in container movements. Shippers typically make arrangements for container pick-up and delivery at the origins and destinations. Carriers are the owners and operators of the vessels that carry the containers, and NVOCCs lease container space on vessels. There is significant overlap in the services provided by these entities. For example, some carriers have their own land-side facilities and provide door-to-door service for their larger customers. In addition, shippers often use NVOCCs instead of negotiating directly with a carrier for space on a vessel.

D47. Containers are transported to or from their immediate domestic origin or destination via truck, rail, and barge. The larger shipping companies (agents, carriers, or NVOCCs) maintain operating agreements with rail and trucking companies to provide their clients with international door-to-door service that includes intermodal transport to and from the origin or destination in the Port's domestic hinterland. Smaller shipping companies often use third-party consolidators to arrange intermodal transport of containers.

Light Loading and Routing

D48. Many containerships arrive and depart the Port with less than full loads. In general, this is undesirable from the carriers' point of view, since unit costs are increased if the ship is lightloaded. There are two principal explanations for lightloading. First, some containerships have design drafts that exceed channel depths in the Port. In order to accommodate controlling channel depths within the Port, these containerships must discharge some of their cargo at a previous port-of-call. Second, containerships that call on the Port usually carry cargo bound for multiple ports. For example, some containerships operate along the North Atlantic coast and routinely call upon multiple ports (e.g., Halifax, New York and New Jersey, Baltimore, Norfolk, etc.). Consequently, the Port is often not the first port of call for these containerships. These two explanations are intertwined, because the liner service operational pattern for the containerships supports the goal of lightloading to accommodate controlling channel depths, and channel depth restrictions make the Port less likely to be the first or last port of call for the larger vessels.

D49. As will be explored in detail later in this appendix, the effects of channel depths are becoming increasingly significant as containerships increase in size (and draft) and schedule fewer port calls on the mainline routes. Channel depth constraints hinder the carriers' ability to realize the economies of scale associated with larger vessels and increase transportation costs associated with the port.

Tidal Advantage

D50. Many vessels, particularly liquid bulk carriers, currently use the additional bottom clearance provided by high tides. Their use of high tides is facilitated in the Port by a physical oceanographic real tide system (PORTS) that allows vessels moving through the Port to know the precise tidal conditions in the harbor. In general, pilots prefer to arrive at the Port with the incoming high water and follow the crest to the dock. Arriving with the incoming high tide provides greater underkeel clearance and allows vessels to transit the Kill Van Kull with the force of the incoming tide. For departures, the reverse is true for outgoing tides. Containerships generally make limited use of tidal advantage in the Port. The larger containerships are on global schedules that require consistent arrival and departures that would be disrupted by waiting for the tides. The recent increases in competitiveness among carriers brought about by negotiated shipping rates has caused carriers to look at the comparative quality of their service. A key component of service



quality for the major carriers is on-time regularly scheduled service. Discussions with carriers, shippers, and industry consultants indicate that carriers will either bypass a port or use smaller vessels rather than tolerate an institutionalized delay, such as waiting for the tide.

Impacts of Vessel Size

D51. Containerships of all sizes currently use the Port, including the world's largest container vessels. The trend in containerized shipping is for a greater share of the world's containerized cargo to be transported on a growing number of the largest containerships. However, the newest and largest vessels deployed to the Port, which have fully loaded drafts of 46 feet, must arrive and depart the Port lightloaded due to current channel depth restrictions in the Port, specifically in the Kill Van Kull and Newark Bay.

D52. The largest container vessels (currently 8,400 TEUs) approach the limits of existing navigation conditions and practices at the Port. No-meeting zones (*i.e.*, areas where the largest containerships may not pass each other when heading in opposite directions) may be required in the Kill Van Kull to accommodate safe passage of the largest (post-Panamax) container vessels. Containership lengths are also approaching the limits of entry and exit from container facilities in Newark Bay, but the dimensions of the longest containerships can still be accommodated by the Port. Air draft is also a concern on the Kill Van Kull due to the 151 foot vertical clearance at the Bayonne Bridge, but it is not yet a limiting factor.

Vessel Alliances and Deregulation

D53. International container shipping is currently in a state of change due to the increasing significance of vessel alliances, the increasing presence of post-Panamax vessels, and recently enacted Ocean Shipping Reform Act. In vessel alliances, carriers pool equipment, coordinate sailing schedules, place cargo on each other's ships, and share space at their terminals. From the carriers' perspective, alliances are attractive arrangements which provide greater opportunity for vessels to carry fuller loads, as well as the means to offer clients improved scheduling and routing. The operational changes that result from improved cooperation among carriers promotes the development of larger containerships.

D54. In 1997, 54% of the TEUs that moved through the Port were transported by carriers that participate in vessel alliances. There are currently five vessel alliances operating in the harbor. However, alliances are dynamic marriages of convenience. They form and dissolve with relative ease according to the current needs of the carriers. The carriers in vessel alliances tend to be among the largest carriers. Ten of the 15 largest carriers in the harbor participate in vessel alliances. Some container terminals within the harbor, such as those operated by Maersk/Universal and Sea-Land, exclusively service their respective vessel alliances. Other terminals in the harbor split their

operations between vessel alliances and non-alliance carriers. Table 6 presents estimates of the current percentages of TEUs moved by carriers that participate in vessel alliances for each container terminal facility. The percentages in this table are approximate, because some carriers use different facilities for different trade routes but only the aggregate numbers of TEUs per carrier are available.

Table 6
Percent of TEUs Moved by Carriers That Participate in Alliances (by Terminal)

Terminal Complex	Marine Terminal	%Alliance Cargo	% Non-Alliance Cargo
New Jersey			
Port Elizabeth	Mahr Fleet St.	30%	70%
	Mahr Tripoli St.	0%	100%
	Sea-Land	100%	0%
Port Newark	Maersk	100%	0%
	Maersk/Universal Maritime	100%	0%
Bayonne	Global Marine	50%	50%
New York			
Red Hook	Red Hook	69%	31%
Howland Hook	Howland Hook	33%	67%

D55. Currently, alliances encourage the use of larger vessels and the development of hub ports which would distribute cargo from large mainline vessels to smaller feeder vessels or to intermodal transportation networks. Statements by carrier industry representatives suggest a continuing increase in the importance of vessel alliances, because they allow carriers to offer superior rates and services compared to smaller independent carriers. In addition, alliances allow shippers to maintain the same level of port access through negotiations with fewer carriers than has been possible in the past. A common perspective of industry analysts is that many smaller independent carriers will be absorbed by alliance carriers in the near future.

D56. Interviews with representatives of the carriers suggest that industry deregulation resulting from the Ocean Shipping Reform Act of 1998 will encourage further formation and expansion of vessel alliances for container shipping. The Ocean Shipping Reform Act allows shippers to enter into confidential rate-setting contracts with individual carriers and alliances. Previously, rates were set and published by carrier conferences, which are collaborations of carriers operating on the same trade routes. Carrier conferences restricted their coordination to setting rates. Deregulation has been creating greater competition between alliances in terms of rates and services. This increased competition provides incentives for the introduction of larger container vessels and other cost cutting measures. Other observed and anticipated effects of deregulation include efforts to reduce costs and improve customer services, through: (1) consolidation of carriers through mergers and acquisitions, and (2) increased carrier and alliance presence in land-side transport, including terminal operations, intermodal services, and land-side logistical operations.

Petroleum Operations in the Port

D57. Within the study area there are a variety of large and small oil facilities with marine terminals. Among these facilities are the Amerada Hess and Exxon terminals on the Kill Van Kull, the British Petroleum (B.P.) terminal at Port Elizabeth, and the Tosco oil refinery at Bayway (located on the Gulfport reach of the Arthur Kill). The GATX oil refinery across the Arthur Kill from Tosco has recently been vacated.

D58. The world liquid bulk fleet is composed of a variety of tanker sizes. The largest tankers are used to transport crude oil on transoceanic voyages (e.g., crude oil imports from Mexico, Venezuela, the North Sea, the Middle East, etc.). Many crude oil carriers have design drafts in excess of controlling depths in U.S. ports. Consequently, lightering is a common practice in many U.S. ports. To take advantage of economies of scale, the tankers make the bulk of their trip fully loaded, arriving at a pre-determined deep water area off the coast or at an anchorage. They then discharge (*i.e.*, lighter) some of their load onto liquid bulk barges or smaller tankers, thereby reducing their drafts and allowing them to enter the port.

D59. For U.S. oil markets, medium-sized tankers are frequently used to distribute petroleum products from western hemisphere (often domestic) refineries to regional distribution facilities. Many of these vessels can enter U.S. ports fully-loaded, and their shipment sizes are commensurate with local product demands. Smaller tankers are often employed – along with liquid bulk barges – to move petroleum products from regional distribution facilities to individual customers and smaller distribution centers.

D60. The marine oil terminals in the study area were contacted to determine the scope of their waterborne shipping operations. Most of these terminals receive medium-sized tanker shipments of petroleum products from domestic refineries. These facilities serve as regional distribution facilities that store petroleum products (e.g., heating oil, automobile and aviation fuel, and marine bunker fuel) and distribute them to regional customers via pipeline, small tanker, truck, and barge. In the Port, there are at least a dozen companies operating small tankers, fuel barges, and tugs to distribute petroleum products to local users and distribution centers. Barges and small tankers depart the oil terminals in the Port for destinations in the New York and New Jersey metropolitan region and in southern New England. These product-distribution vessels are not depth-constrained by Port waterways.

D61. In general, the medium-sized tankers that deliver petroleum products to the Port's oil terminals have operating drafts in the 40 to 45-foot range. Some of these vessels can navigate the Port's waterways freely. Others experience minor delays needed to take advantage of additional bottom clearance provided by high tides, and a few vessels require lightering to enter the Port. In some instances, tankers arrive lightloaded because they have already stopped at other East Coast ports prior to stopping at the Port facility. Under future without-project conditions, the channel depths of the Kill Van Kull and Newark Bay are assumed to be deeper than at present (from 40 to 45 ft MLW). Channel

deepening in the Kill Van Kull and Newark Bay is expected to have a minimal effect on tidal delays and lightering for tankers carrying petroleum products into the Port due to the controlling depths of the Arthur Kill (35 and 40 ft MLW). Regardless of channel deepening, the petroleum product terminal operators in the Port do not anticipate using larger vessels under with-project conditions due to limitations of berth depths and land-side storage facilities. Consequently, those facilities which bring in petroleum products are not expected to benefit from channel modifications, and they have been removed from any further analysis in this investigation.

D62. The Tosco refinery at Bayway differs from the other oil facilities in the study area, because it imports crude oil, rather than petroleum products. Currently, this refinery imports crude oil primarily from the North Sea and from west Africa. The North Sea crude is carried on Very Large Crude Carriers (VLCCs) to Tosco's Point Tupper transshipment facility in Nova Scotia. At Point Tupper, the crude is offloaded to land-side storage tanks and then reloaded on Tosco's Eagle-class tankers with 42-foot design drafts for transport to the Arthur Kill facility. These vessels are lightloaded to 36-foot operating drafts, because the Arthur Kill currently has a channel depth of 35 feet MLW. With these operating drafts, the Eagle-class tankers experience tidal delays in order to use high tides to achieve three feet of underkeel clearance. The west Africa crude is carried on Suez-max 150,000 dead-weight ton (dwt) tankers. These vessels lighter onto Tosco's Eagle-class tankers offshore, and both vessels come into the Port lightloaded to accommodate the Arthur Kill channel depth. Many of the 150,000 dwt tankers have air drafts in excess of available clearance under the Arthur Kill railroad bridge. Those vessels off load entirely onto two Eagle-class tankers, which proceed lightloaded to the Bayway refinery.

D63. Under the future without-project conditions, it is assumed that the Arthur Kill to Gulfport reach will be deepened to 40 ft MLW. Under these conditions, the Eagle-class vessels would be able to come to the Tosco refinery fully-loaded if they continue the practice of riding high tides into port. According to Tosco representatives, no changes in shipping operations would occur under with-project conditions that have channel depths below 55 feet MLW. At that threshold, the company would discontinue lightering of their west African Suez-max vessels. The Point Tupper operations would continue unchanged even at channel depths greater than 55 feet. The Point Tupper transshipment facility provides their Arthur Kill refinery with operational flexibility, because crude oil deliveries can be made with a two-day voyage, compared to a five-day journey from the North Sea. Given the 55-foot threshold for the start of benefits to Tosco, further investigation of crude oil imports to this facility is not warranted. As a result petroleum movements in the study area are no longer under consideration in this investigation.

Container Movements Through The Port

D64. As a result of the above removal of liquid bulk, break-bulk, auto, and other commodities from further consideration in this analysis, the following discussions of

current commodity movements through the Port focus on containerized cargo. These discussions provide a baseline for detailed forecasts of container movements under future with- and without-project conditions. The analysis of current commodity movements through the Port includes: (1) an overview of container imports and exports moving through the Port, (2) a profile of commodities in these containers, (3) a description of the origin/destination patterns for container movements between the Port's hinterlands and its overseas trading partners, and (4) an examination of patterns of intermodal transport between the Port and its hinterlands.

Data and Data Sources

D65. International container movements: This analysis of international container movements is based on commodity-specific trade data covering 160 countries, developed from United Nations trade information by Statistics Canada. The data reflects Statistics Canada's estimates of bilateral trade flows.

D66. Container origin and destination patterns: Container origin and destination patterns are taken from the Journal of Commerce Port Import-Export Registration System (PIERS). The PIERS data, which is collected at each U.S. port, reports manifest data, including consignee location. There is a significant limitation with this data because the location of the consignee is often the headquarters or major office of the consignee, which may not be not the actual origin or destination of the cargo.

Container Imports and Exports

D67. Table 7 presents estimates of container movements through the Port for the 1992-1997 period. The estimates of international container flows, inbound and outbound, were derived from Statistics Canada data and adjusted to account for movements not included in the Statistics Canada data, such as empty containers; military cargo; trade with Puerto Rico, Boston, and Montreal and other Canadian ports; and shipments through the New York free-trade zone. TEU volume adjustments were derived from an analysis of 1996 Port container movements conducted for PANYNJ. As indicated in this table, container imports through the Port have been consistently larger than exports. In addition, the growth of container imports for this period (4.9 percent) has outpaced the growth of exports (2.4 percent) and the growth of other (empties, domestic, military, etc.) container movements (3.9 percent).



Table 7 Annual Container Movements Through the Port (TEUs)						
	1992	1993	1994	1995	1996	1997
International						
Imports	737,099	768,721	848,470	870,969	864,617	937,338
Exports	552,776	530,145	546,881	629,106	586,905	622,421
Subtotal	1,291,867	1,300,859	1,397,345	1,502,070	1,456,518	1,561,756
Other	633,015	637,421	684,699	736,014	713,694	765,260
Total	1,924,882	1,938,280	2,082,044	2,238,084	2,170,212	2,327,016
Annual Change		0.70%	7.40%	7.50%	-3.00%	7.20%

Source Data: Statistics Canada.

D68. The growth of container movements through the Port faltered in 1996, when total container movements through the Port declined by three percent. Both imports and exports contributed to this decline. The 1995-1996 decline in container exports and exports through the Port can be at least partially attributed to downturns with the trading partners presented in Table 8. Although the data was not available for this report, the decline identified above was reversed by the 1997–1998 increase in container movements, which was larger than projected.

Table 8 Declines in Container Exports and Imports for Selected Trading Partners (TEUs) 1995, 1996			
	1995	1996	% Decline
Export Partner			
Netherlands	41,485	39,999	-27.7%
Italy	16,090	12,349	-23.3%
Venezuela	14,134	10,881	-23.0%
Indonesia	30,522	26,257	-15.5%
South Korea	43,331	37,811	-12.7%
Brazil	27,485	25,642	-6.7%
Persian Gulf	23,116	22,317	-3.5%
Import Partner			
Denmark	92,290	82,137	-11.0%
Belgium	15,948	14,237	-10.7%
Hong Kong	14,025	12,562	-10.4%
Taiwan	32,338	29,358	-9.2%
South Korea	14,006	12,829	-8.4%
Brazil	31,370	28,870	-8.0%
United Kingdom	52,904	51,403	-2.8%

Source Data: Statistics Canada.

Containerized Commodities

D69. Table 9 presents the top 10 commodities carried in containers imported and exported through the Port in 1995. This table was derived from Statistics Canada data. As indicated in this table, container imports are led by food commodities, and the largest export commodity category is waste paper. Together, the top 10 import containerized commodities account for approximately 63 percent of container imports through the Port. Similarly, the top 10 export commodities account for approximately 68 percent of container exports.

Table 9
Ranked Imports and Exports by Top 10 Commodity Types
1995

Commodity Category	TEUs	% of Total
Imports		
Food	118,231	13.6%
Beverages	89,370	10.3%
Other Manufacturing, nec.	55,492	6.4%
Wearing Apparel	53,189	6.1%
Furniture and Fixtures	49,596	5.7%
Non-Metallic Products, nec.	42,902	4.9%
Motor Vehicles and Parts	42,493	4.9%
Agriculture, Hunting, Fishing, Forestry	41,453	4.8%
Synthetic Resins	27,856	3.2%
Metal Products	25,822	3.0%
Exports		
Paper and Products	153,120	24.3%
Motor Vehicles and Parts	53,579	8.5%
Synthetic Resins	46,175	7.3%
Food	42,008	6.7%
Mining and Quarrying	29,832	4.7%
Agriculture, Hunting, Fishing, Forestry	24,478	4.0%
Machinery and Equipment, nec.	23,447	3.9%
Textiles	21,070	3.7%
Other Manufacturing, nec.	16,524	3.3%
Chemical Products, nec.	16,081	2.6%

Source Data: Statistics Canada. nec = not elsewhere classified

Origin-Destination Patterns

D70. Table 10 presents the major overseas trade regions and the 1996 Port container movements (imports and exports) for those regions. Northern Europe dominates container imports and exports through the Port, accounting for 33 percent and 34 percent of the total imports and exports, respectively. The Southern Europe - Mediterranean trade region accounts for 19 percent of total imported containers, and China represents 11 percent. The Hong Kong – Taiwan – Korea trade region accounts for 14 percent of total

container exports, and Southeast Asia represents 10 percent. Note that origin-destination data are obtained from a different source (PIERS) than the commodity specific data (Statistics Canada) sited above. Therefore, summations and comparisons between the two data sets are not entirely comparable.

Table 10
Container Imports and Exports with Global Trade Region/Partner
1996

Imports		Exports	
Trade Region	**TEUs**	**Trade Region**	**TEUs**
Northern Europe	277,315	Northern Europe	185,804
Southern Europe-Mediterranean	159,146	Hong Kong/Taiwan/Korea	75,448
China	90,565	Southeast Asia	54,280
Hong Kong/Taiwan/Korea	62,693	East Coast South America	39,977
Indian Subcontinent	53,906	Southern Europe-Mediterranean	34,904
Southeast Asia	51,203	Middle East	33,867
East Coast South America	32,448	West Coast South America	22,321
West Coast South America	22,910	Central America/Caribbean	22,047
Japan	21,798	China	21,864
Middle East	18,350	Eastern Europe	14,974
Central America/Caribbean	13,487	Japan	12,196
Eastern Europe	9,826	Indian Subcontinent	10,145
Southern Africa	8,513	Southern Africa	6,845
North Africa	5,363	West Africa	5,522
West Africa	2,888	Australia/New Zealand	4,460
East Africa	1,574	North Africa	3,754
Australia/New Zealand	806	East Africa	1,835
Canada	663	Other/Ocean	214
Other/Ocean	434	Canada	164
Total	833,886	Total	550,619

Source Data: PIERS.

D71. Table 11 summarizes the domestic origin/destination patterns for current container imports and exports through Port. In this table, container imports and exports are distributed among the major domestic trade regions. As suggested in the previous discussion of the Port's hinterlands, the Middle Atlantic states represent the core of the Port's domestic markets for container imports and exports. These states serve as the origin/destination for 64 percent of the containers moving through the Port. Although the Port has a relatively small share of the enormous container traffic to/from the Pacific states, these states account for 11 percent of the container movements through the Port, followed by the New England and the Northeast Central states with 8.6 percent and 7.6 percent, respectively.

Table 11 Hinterland Distribution of Imports and Exports (TEUs) 1995						
	Imports	%	Exports	%	Total	%
Mid Atlantic	604,012	72.4%	283,185	51.4%	887,197	64.1%
Pacific	46,150	5.5%	111,452	20.2%	157,602	11.4%
New England	85,773	10.3%	33,898	6.2%	119,671	8.6%
NE Central	43,712	5.2%	60,917	11.1%	104,629	7.6%
South Atlantic	24,251	2.9%	22,935	4.2%	47,187	3.4%
NW Central	12,612	1.5%	14,627	2.7%	27,239	2.0%
SW Central	11,149	1.3%	8,384	1.5%	19,533	1.4%
SE Central	3,553	0.4%	9,197	1.7%	12,750	0.9%
Mountain	2,674	0.3%	6,024	1.1%	8,698	0.6%
Total	833,886	100.0%	550,619	100.0%	1,384,505	100%

Source: PIERS. 1993-1994.

Intermodal Transport To/From Port Hinterlands

D72. A modal split analysis was conducted to evaluate the intermodal connections between the Port and its hinterlands. The methodology used to estimate modal shares for intermodal transport of international cargo matched commodity movements with commodity modal allocations by inland state or region from the Reebie database (a proprietary freight logistics database). Individual states were computed using the modal split for the Reebie region. Data used in this analysis is for the years 1993 and 1994. According to statements by PANYNJ personnel and industry analysts, there have been no significant changes in modal shares since this data was collected. However, the recent restructuring of the railroad industry will have a significant impact on modal shares in the near future (see discussion below).

D73. In the estimation of the rail modal share, a portion of TEUs movements take place in carload units, since some of commodities are not entirely containerized. These carload allocations were included in the rail share of container movements.

D74. Intermodal connections to the Port's hinterlands includes rail, truck, air and water transport. The distributions of international container imports and exports through the Port are presented in Table 12.

Table 12 Transport Modal Shares by Volume International Cargo Movements Through the Port 1993 – 1994		
Transport Mode	**Imports**	**Exports**
Rail	2.9%	18.5%
Truck	92.8%	77.8%
Air	2.9%	2.4%
Water	1.5%	1.4%

D75. Intermodal movements (imports and exports) of international containers between the Port and its domestic hinterlands are predominately by truck. As seen in Table 12, approximately 93% of the international container imports are moved by truck to their final destinations, and 78% of container exports are transported by truck. These averages are corroborated by similar information for individual states contained in Table 13. In this table, the modeled shares of truck transport in nearby states are significantly greater than the shares of more distant states. These results are consistent with the declining role of truck transport beyond several hundred miles (*i.e.*, a one-day drive).

D76. The role of truck transport for export containers is somewhat less significant than for import containers, and, conversely, the role of rail transport is somewhat more significant for exports than imports. Rail captures more export containers than import containers, since there is greater availability of high-capacity, reliable double-stack train services eastbound (relative to westbound). In addition, export containerized cargo is generated by a smaller number of origins in the domestic interior (relative to more numerous import destinations). There are also state-specific explanations of the relative shares of truck transport for imports and exports. For example, the relatively low truck share for exports from Michigan reflects the state's commodity mix (e.g., autos and auto parts) and the growing use of auto-racks for rail transport of cars.

Table 13 Percent of Truck Container Movements (TEUs) To/From the Port 1993 – 1994		
State (Destination)	**Imports**	**Exports**
Selected Proximal States		
Connecticut	89.7%	72.4%
Delaware	99.9%	91.1%
Maryland	87.1%	88.3%
Massachusetts	86.4%	89.7%
New Hampshire	92.5%	83.1%
New Jersey	99.5%	98.0%
New York	95.7%	87.5%
Pennsylvania	95.5%	87.5%
Rhode Island	91.3%	89.3%
Vermont	89.0%	85.0%
Selected Distant States		
Illinois	72.2%	62.5%
Indiana	84.8%	52.9%
Ohio	79.9%	61.0%
Michigan	68.1%	29.7%
Tennessee	83.9%	86.4%

D77. The rail and truck shares of inland transportation of international containers movements through the Port were also explored in a 1998 study, Port Development Investment Planning Study (PDIPS), conducted for the PANYNJ by Frederick R. Harris, Inc. The PDIPS analysis of intermodal transport notes the importance of truck transport in the shipment of imported and exported containers through the Port to/from the nine nearby states contained in Table 13. This conclusion was based on data indicating that 83.2 percent of imported containers are destined for the nine states and 58.0 percent of exported containers originate in these states. The PDIPS analysis indicates that trucks are expected to account for at least 80 percent of the Port's inland distribution of imports. The export truck share was believed to be closer to 70 percent, because a lower percentage of Port container exports originate in this 9-state region.

D78. The takeover of the major northeastern US railroad, Conrail, by CSX and Norfolk Southern railroads has the potential to affect the share of future volumes handled by rail. For more than two decades, only one Class 1 railroad, Conrail, served New York Harbor with freight service connecting to other parts of the US and Canada. Historically, Conrail focused on intermodal rail freight between the New York metropolitan area and the Midwest, especially Chicago. The original Norfolk Southern and CSX rail networks covered the South Eastern part of the US. Coordination among the separate rail lines was

inefficient and costly, limiting intermodal traffic between the Port and the South Eastern U.S.

D79. Currently, the Conrail network combined with the networks of CSX and Norfolk Southern serve the entire US east of the Mississippi. Anticipated efficiencies in rail operations will make longer distance rail moves into and out of the Port more attractive. Both CSX and Norfolk Southern management has told investors and government regulators that the primary justification for the Conrail purchase is the potential for increased north – south intermodal traffic. Substantial new capital investment is being made by both CSX and Norfolk Southern to leverage their newly expanded networks, including expansions to their intermodal terminal network and rail traffic handling capacity to and from the Port. They have also negotiated agreements, some under Surface Transportation Board direction, to gain competitive access to shippers in the North East.

D80. Other, unrelated developments in the Port's intermodal capacity include the privatization of the freight component of the Long Island railroad and new trackage rights granted to the Canadian National railroad.

Transportation Costs

D81. The previous discussions described existing conditions in the Port, including descriptions of the economy of the Port's hinterlands, major port institutions, marine terminals, port operations, the current container fleet, and intermodal connections with the hinterlands. In combination, these aspects of commercial navigation in the Port shape the current transportation costs of container movements through the Port. The estimation of transportation costs will be presented later in this appendix as a baseline for the forecasts of future with- and without-project conditions. The following sections describe future navigation needs of the Port, which are driven by a combination of the: (1) rapid growth in container movements through the Port and (2) increasing size of the world container fleet, resulting from the pursuit of transportation economies of scale.

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FUTURE COMMODITY MOVEMENTS

Introduction

D82. The navigation needs of the Port during the period of analysis are a combination of: (1) large increases in container movements through the Port, (2) shifts in the origin-destination patterns of containers passing through the Port, and (3) increases in the size of the world containership fleet. This section of the appendix addresses the first two elements of the identification of future navigation needs of the Port. The subsequent section of this appendix explores the significance of increasing dimensions of containerships.

D83. For this investigation, future container movements through the Port were forecast using a state-of-the-art World Trade Model (WTM). A "top down" approach was employed to develop the forecasts. The WTM was first used to forecast global trade, including U.S. imports and exports for the 1995-2040 period. These international trade forecasts were then successively disaggregated to estimate trade levels for the U.S., the North Atlantic (U.S.) region, and for the Port. Since the end of the study period for this investigation is 2060, individual country trade flows through the Port were extrapolated beyond the end of the forecast period (2040) by applying the average annual growth rate for the years 2030 – 2040 to the remaining years of the study period (2041 – 2060).

D84. This section of the appendix consists of three parts that describe the forecasting process and results: (1) a profile of the WTM, (2) the method used to disaggregate world trade forecasts to national, regional, and Port shares, and (3) the detailed forecasts of Port imports and exports. The discussion begins with a description of the structure and function of the world trade model.

World Trade Model

D85. The WTM was developed to estimate current and future international trade. It has been used to project commodity flows for other deep draft navigation projects, such as the feasibility study for the Savannah River Harbor Deepening Project, the ongoing National Dredging Needs Study of Ports and Harbors, and various channel deepening projects in the Port of Baltimore. The following profile of the WTM includes discussions of: the relationship between trade and economic development, the structure and function of the WTM, trade data used in the model, and the strengths and weaknesses of the WTM relative to other trade models. The discussions begin with a recognition of the causal relationship between a country's economic development and the character and scale of its international trade.

Trade and Development

D86. As countries progress from developing to emerging to mature economy status, they experience changes in domestic production and consumption, as well as in international trade relationships. Developing countries typically have limited import capacity due to infrastructure constraints and capital limitations. Emerging nations tend to increase imports to fill gaps in their domestic production, which are often export-oriented. As emerging countries continue to develop, domestic enterprises begin to produce substitutes for imported foreign products. Eventually, countries reach a mature stage of development in which: (1) imports increase as foreign producers replace domestic producers; domestic producers use more inputs of all kinds, including imported inputs, to produce a larger gross domestic product; and higher incomes increase the consumer demand for everything, including imports,, (2) the production base shifts from low-value to high-value products, and (3) the economy transforms from a manufacturing to a service orientation. In addition, the consumer markets of mature economies eventually become saturated. At this stage, consumption replaces old products, but there is relatively little real growth. Although mature economies also typically have relatively slow population growth, their absolute volume of consumption is relatively high.

Model Structure and Function

D87. Given the relationship between economic development and trade in which the level of imports are affected by the stage of a country's development, the WTM was designed with a nonlinear structure to allow long-term trade forecasting. The model is based on a micro-economic structure which assumes that each commodity trade flow represents a universe of individual decisions by companies and consumers. In the WTM, each trade represents a single commodity trade flow between two partners among the model's 48 countries and 12 regions (see Table 14), creating a bilateral matrix of world trade. Total world trade is the aggregate interaction of 3600 individual trade routes for each of the 84 commodities that are contained in the model. Most of the importer-exporter relationships for each commodity were independently forecast. Controls are imposed for some commodities to ensure consistency with historic trade flows and to develop realistic forecasts for future growth.

D88. The commodity classification system used for this investigation is contained in Table 15. Two groups of international trade commodities (Primary and Manufacturing) are used to organize the 84 commodity groups, which are identified according to their International Standard Industrial Classification (ISIC) code (see Table 15). The Primary commodity group consists of two subgroups: (1) Agriculture, Hunting, Fishing, and Forestry commodities and (2) Mining and Quarrying commodities, which include Crude Petroleum and Scrap Metal. The Manufacturing Group consists of 46 diverse subgroups.

Table 14 Region and Country Coverage in WTM			
Developed Countries		**Developing Countries**	
Region	**Country**	**Region**	**Country**
North America	U.S.	**Asia**	South Korea
	Canada		Taiwan
Asia	Japan		Indonesia
Europe	Germany		Malaysia
	France		Philippines
	U.K.		Philippines
	Italy		Singapore
	Austria		Thailand
	Belgium		Vietnam
	Denmark	**Indian Subcontinent**	India
	Finland		Pakistan
	Greece		Other Indian Subcontinent
	Ireland	**Latin America**	Argentina
	Netherlands		Brazil
	Norway		Venezuela
	Portugal		Other E. Coast, S. America
	Spain		Chile
	Sweden		Colombia
	Switzerland		Peru
	Turkey		Other W. Coast, S. America
	Other W. Europe		Mexico
Oceania	Australia		Caribbean Basin
	New Zealand		Costa Rica
			Panama
			Other Central America
		CIS*/Eastern Europe	Former Soviet Union
			Eastern Europe
		Middle East	Israel
			Mediterranean
			Persian Gulf
			Northern Africa
			Eastern Africa
			Western Africa
			Other Southern Africa
		Other	Other Region

* Commonwealth of Independent States

Table 15
Commodity Classification – World Trade Model

ISIC Code	Description	ISIC Code	Description
Primary		**Manufacturing (continued)**	
C1	Agriculture, Hunting, Forestry, Fishing	C3513	Synthetic Resins
C1A	Grain	C3521	Paints, Varnishes and Lacquers
C1B	Oil Seeds	C3522	Drugs and Medicines
C1C	Vegetables, Fruits, and Eggs – Refrigerated	C3523	Soap and Cleaning Preparations
C1D	Vegetables and Fruits - non-Refrigerated	C3529	Chemical Products, nec.
C1E	Cork and Wood	C353	Petroleum Refineries
C1F	Natural Rubber	C354	Petroleum and Coal Products
C1G	Cotton	C354A	Briquettes, Lignite, Peat and Coke
C1H	Other Raw Textile Materials	C354B	Residual Petroleum Products
C1I	Other Agriculture	C355	Rubber Products
C2	Mining and Quarrying	C356	Plastic Products, nec.
C2A	Stone, Clay and Other Crude Minerals	C361	Pottery, China etc.
C2B	Crude Fertilizers	C362	Glass and Products
C2C	Ores	C369	Non-Metallic Products, nec.
C2D	Coal and Coke	C371	Iron and Steel
C2E	Crude Petroleum	C372	Non-Ferrous Metals
C2F	Natural Gas	C381	Metal Products
C2G	Scrap	C3821	Engines and Turbines
Manufacturing		C3822	Agricultural Machinery
C311	Food	C3823	Metal & Wood Work. Machinery
C311A	Meat/Dairy/Fish Requiring Refrigeration	C3824	Special Industrial Machinery
C311B	Other Meat/Dairy/Fish/Fruit/Vegetables	C3825	Office and Computing Machinery
C311C	Sugar	C3829	Machinery and Equipment, nec.
C311D	Animal Feed	C3831	Electrical Industrial Machinery
C311E	Animal and Vegetable Oils	C3832	Radio, TV, & Comm. Equipment
C311F	Other Food	C3832A	Radio and Television
C313	Beverages	C3832B	Semi-conductors, Elect. Tubes, etc
C314	Tobacco	C3832C	Other Communications Equip.
C321	Textiles	C3833	Electric Appliances & Houseware
C322	Wearing Apparel	C3839	Electrical Apparatus, nec.
C323	Leather and Products	C3841	Shipbuilding and Repairing
C324	Footwear	C3842	Railroad Equipment
C331	Wood Products	C3843	Motor Vehicles and Parts
C332	Furniture and Fixtures	C3843A	Motor Vehicles
C341	Paper and Products	C3843B	Parts of Motor Vehicles
C341A	Waste Paper	C3844	Motorcycles and Bicycles
C341B	Pulp	C3845	Aircraft
C341C	Paper and Paperboard and Products	C3849	Transport Equipment, nec.
C342	Printing and Publishing	C3851	Professional Equipment
C3511	Basic Industrial Chemicals	C3852	Photographic and Optical Goods
C3511A	Organic Chemicals	C3853	Watches and Clocks
C3511B	Inorganic Chemicals	C390	Other Manufacturing, nec.
C3512	Fertilizers and Pesticides		

D89. The WTM is structured as an import demand model. In the model, import demands are based on: (1) aggregate demand and (2) relative prices for imported products. Aggregate demand is based on personal consumption expenditures, business investment, and consumption structure. Export supplies are derived from import demands from specific regions or countries. The success of exporters is based on relative prices, productivity, and prevailing exchange rates. To model the nonlinear relationships between trade and economic development, the WTM estimates long-term trends in a country's demand for imports. The model has a hybrid specification framework that mixes time-series data with cross-section data.

D90. Cross-section models reflect stages of economic development by utilizing information from more than one country in a joint estimation procedure. The advantages of the approach are many, including the ability to incorporate long-term trends. Short-term patterns require inputs of more country-specific time-series data. The WTM uses a pooled data set containing cross-section and time-series data from 60 countries and regions and fifteen years of international trade data.

D91. The WTM reflects imperfect competition and limited information available to potential trading partners. Trade moves along pre-defined routes with a limited ability to quickly shift suppliers. Competition between exporters is modeled by forcing the trade forecast for each exporter to equal the estimated import demand from a group of importers. Using this approach, differential price and production factors are taken into account, because market shares are determined by the relative competitiveness of each exporter.

Trade Data

D92. The WTM incorporates commodity-specific trade data covering 160 countries, developed from United Nations trade information by Statistics Canada. These data reflects Statistics Canada's estimates of bilateral trade flows. The current version of the WTM utilizes 1994 Statistics Canada data for most countries. However, 1995 U.S. Department of Commerce data has been incorporated for U.S. trade routes.

D93. The lack of consistent, trade-specific prices for commodities has led to the WTM's hybrid methodology which uses U.S. price statistics, exchange rates, and general export price indices for exporting countries and regions. In order to account for the effects of nominal values, the WTM includes price and exchange rate information in the trade forecast calculations.

D94. The WTM's import-demand equations also include import demand price indices and exporter performance measures – relative wages and relative rates of productivity growth. Import demand price indices are based on United States Bureau of Labor Statistics (BLS) trade price indices. The BLS indices were developed using survey data from U.S. importers and exporters. Although the import-demand indices are commodity-specific, they are not specific to any one partner country or region. BLS forecasts are

based on private forecasts derived from U.S. inter-industry models, reflecting the macroeconomic developments and factors specific to related industries. Exporter performance measures are based on World Trade Organization data on wages and productivity.

Model Strengths & Weaknesses

D95. The WTM specification represents a compromise between sectoral detail and regional detail. The model's hybrid structure (using pooled cross-section and time-series data) incorporates long-term relationships between trade and economic growth using a cross-country structure. This is preferable to a simple time-series model, since it allows national economies to develop. The WTM's pooled data set, which combines country-specific information over time with multi-country information, offers an effective means to assess development-related determinants of trade.

D96. Because of the large number of trade flows forecast and their interdependence, it is critical that the WTM incorporate internal tests and limits to insure that valid, reasonable forecasts are developed. The logarithmic forms used in the econometric models are sometimes explosive, therefore, limits are imposed in the WTM to assure the quality of the trade forecasts. Testing is done in the WTM using a self-contained expert system. A set of decision rules continuously checks the results against past trends in trade. Whenever a preliminary flow is found to be moving erratically, an alternative, more stable, estimation technique is substituted.

D97. The Standard Error of the base equation is used as an initial test for statistical accuracy for each importer-exporter equation. Forecasting accuracy is tested against historical data in order to determine which countries and regions require additional cross-country modeling and which countries and regions require alternative, simplified parametric, specifications.

Commodity Forecast Method

D98. The following discussions describe the method used to forecast container movements through the Port for the period of analysis (2010-2060). The development of trade forecasts for the Port involved a sequence of distributing world trade to national (U.S.), regional (North Atlantic), and local (Port) shares. The trade forecasts were developed using the WTM, in combination with professional judgement and empirical historic and current trade data (from Statistics Canada, as explained above). More specifically, the WTM was used to forecast U.S. commodity-specific trade for the 1995-2040 period. Within the model, the commodity forecasts in tons are converted to TEUs using (1) commodity-specific containerization rates and (2) commodity-specific tons per TEU, both of which are anticipated to increase over time. The commodity-specific TEU movements at the national scale were then disaggregated to the regional and local scales using historic trade shares and professional judgement. The following discussions

describe the trade outlooks for these scales of analysis and explain the disaggregation process. The discussions are intended to provide a framework for the subsequent detailed commodity forecasts for the Port. The discussions move from the broad (global) to the narrow (Port), in accordance with the methodology employed. They begin with qualitative assessments of the global and U.S. trade outlooks.

Global Trade Outlook

D99. During the 1991 to 1998 period, global trade grew at approximately twice the annual rate of growth of real world economic output (6 percent versus 3 percent). It is anticipated that growth in the world economy will average about 3 percent per year for the 1998-2000 period and will rise to approximately 3.3 percent per year in the longer term to 2040 (and beyond).

D100. Much of the boom in world trade can be attributed to changes in production and investment patterns in the global marketplace. Less integrated production has led to more steps in the production process, stimulating world trade. In addition, the boom in world trade has also been supported by changing patterns of business investment (*e.g.*, Japanese investments in Asia; European investments in North America and Latin America; and U.S. investments in Asia, Europe, and Latin America). In 1997, the volume of global maritime trade was approximately 4.5 billion metric tons. Approximately 4 billion tons of this total is transported on bulk (liquid and dry) vessels; the remainder of this volume was transported as containerized cargo.

D101. The growth in world containerized trade also reflects the increasing integration of the global economy. Over the 1990-1995 time period, the volume of world container trade grew at an average annual rate of 6.5 percent. Strong growth in trade over the 1990-1995 period and an expected surge in world trade due to lower prices in Asia (combined with a collapse in Asian imports and intra-Asian trade), suggest a 7.3 percent real growth rate for the value of the global container trade during the 1995-2000 period. The medium-term (*i.e.*, 2000-2015) growth rate is expected to be approximately 6.2 percent. Containerized trade dominates total trade when measured in real value measures (rather than volume measures). Real growth in metric tons has been significantly less, because many of the heavier commodities are experiencing slower grow rates. For the 1995-2040 period, it is expected that the real growth in weight measure for non-containerized cargo is approximately 2 percent less per year than for the container trade.

U.S. Trade Outlook

D102. U.S. maritime trade has grown steadily over the past 20 years. Foreign trade currently comprises a much larger share of U.S. domestic economic output than in the past. When measured in terms of constant prices, annual U.S. exports in 1996 were worth nearly $600 billion (in 1987 prices and exchange values). Annual imports in 1996 were equal to approximately $700 billion. As indicated in Table 16, during the 1992-1996 period, the value of U.S. exports grew at an annual rate of approximately 7 percent,

and the value of U.S. imports expanded at an 8 percent annual rate. It is expected that during the 1996-2010 period, the growth of export value will slow to just over 6 percent per year, and imports will increase at only a 5 percent annual rate. As a result, it is expected that the annual difference in value between exports and imports, which was approximately 21 percent in 1996, will decline to just 6 percent by 2010 and that by 2040 exports will exceed imports. Long-term growth in U.S. exports is expected to be approximately 4.7 percent, and long-term growth of imports is anticipated to be approximately 3.9 percent per year.

Table 16
Forecast of Total United States Trade with the World

	1992	1996	2010	2040
Imports				
Estimated annual value ($1987 billions)	$516	$703	$1,434	$4,550
Average annual growth rate (%)	--	8.0%	5.2%	3.9%
Exports				
Estimated annual value ($1987 billions)	$441	$577	$1,352	$5,322
Average annual growth rate (%)	--	6.9%	6.3%	4.7%

D103. The importance of different markets and different commodity categories to U.S. trade growth can vary over time. For example, 1996 exports were valued at $135.4 billion more than 1992 exports (in 1987 prices and exchange values). East Asia and Southeast Asia/Oceana accounted for 43 percent of the net increase during this period, which was significantly more than that of any other region. However, over the 1996 – 2010 period, U.S. exports are expected to increase by about $774 billion, and Asia's share of this growth anticipated to be less than 28 percent.

D104. In 1995, U.S. imports of containerized cargo were approximately 55 million tons and exports were approximately 56 million tons. Table 17 provides additional detail on the anticipated future of U.S. trade by presenting expected growth rates of U.S. containerized imports and exports by overseas trade region. As indicated in this table, exports are expected to eventually surpass imports. In addition, container trade with the Asia/Pacific region, Latin America, and Other Regions are expected to grow more rapidly relative to trade with Europe and Canada.

D105. The commodity mixes of imports and exports are also significant determinants of future patterns and levels of the U.S. container trade. In the medium term – through 2010 – the relative shares of semi-manufactures, electronics, machinery, and transport equipment exports are expected to increase. In the long term, the higher growth commodities for American exporters will continue to be electronics, machinery and transport equipment. At the same time, the potential for agriculture to drive total growth is diminished.

Table 17 Observed and Expected Growth Rates of U.S. Container Trade (Tons) By Partner Region						
	Europe	Asia/Pacific	Latin America	Canada	Other Region	World
Imports						
%1990-1995	8.7%	4.8%	4.5%	-0.3%	3.7%	5.7%
%1995-2000	3.5%	5.3%	5.7%	4.3%	7.6%	4.9%
%2000-2015	3.1%	6.0%	4.7%	1.1%	5.8%	4.9%
%2015-2040	1.9%	3.9%	3.1%	4.0%	3.4%	3.4%
Export						
%1990-1995	1.9%	5.3%	10.5%	9.4%	2.5%	5.0%
%1995-2000	3.4%	1.2%	6.4%	1.4%	3.5%	2.7%
%2000-2015	5.2%	5.2%	7.0%	2.6%	6.7%	5.7%
%2015-2040	3.1%	3.9%	4.3%	2.2%	4.9%	3.9%

Disaggregation of U.S. Container Trade

D106. The WTM was used to forecast U.S. trade for the 1995 – 2040 period. This national-level trade was then successively disaggregated to the North Atlantic (U.S.) regional share and then to the share for the Port of New York and New Jersey. This disaggregation process is described below, first for imports and then for exports. In addition, factors expected to influence future trade growth are summarized, including overviews of the potential effects of global economic conditions on the Port's trade and of the factors affecting growth in trade for all ports within the North Atlantic (U.S.) region.

D107. The ports of the U.S. are typically grouped into six major ranges: North Atlantic, South Atlantic, Gulf Coast, South Pacific, North Pacific and Great Lakes. Within the North Atlantic region, four port categories are typically employed, including: New York/New Jersey, Baltimore, Norfolk, and other ports (including Philadelphia and Boston).

D108. Commodity movement data for 1990-1995 were used to develop baseline regional and Port shares of the U.S. container trade. The share of trade for any single port within a port-range, such as the North Atlantic (U.S.) region depends upon a variety of factors. Some of these factors are external to the Port, including: the economic health of the port's hinterland, the geographic mix of suppliers and buyers, and the relative success of those products that pass through the port. Other trade factors are affected by conditions within the port, including channel dimensions, port facilities, intermodal infrastructure, labor costs, and port marketing efforts. The external and internal factors were forecast outside of the WTM to estimate the regional and Port shares of U.S. imports and exports during

the period of analysis. Although the causal elements underlying the regional and Port shares of the U.S. container trade could fluctuate significantly over time, the effects of fluctuations on the Port's container traffic may not be immediate. Therefore, the WTM constrains the fluctuations in the regional and Port shares to no more than 2 percent per year. This dampens the effects of sharp, short-term fluctuations in world or regional economic indicators on the trade forecast.

D109. The regional shares of 1996 U.S. containerized imports and exports are presented in Table 18 by overseas trade region. As indicated in this table, the North Atlantic ports account for 60 percent of European containerized imports and 22 percent of U.S. containerized exports to Europe. As suggested by these data, the North Atlantic ports provide the principal U.S. container connection with European markets.

Table 18
Regional Shares of 1996 Containerized Trade by Partner Region

	Europe	Asia/Pacific	Latin America	Canada	Other Region	World
Imports						
North Atlantic	60.2%	30.7%	36.8%	10.3%	64.6%	44.2%
South Atlantic	17.2%	10.1%	24.4%	43.9%	11.4%	17.7%
Gulf	7.4%	5.2%	19.0%	2.7%	14.0%	11.8%
Great Lakes	0.3%	0.0%	0.0%	29.3%	0.1%	0.2%
North Pacific	0.8%	7.1%	4.1%	9.7%	0.8%	3.6%
South Pacific	14.3%	46.8%	15.7%	4.1%	9.2%	22.5%
United States	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Exports						
North Atlantic	22.2%	2.5%	12.3%	12.4%	15.9%	7.8%
South Atlantic	21.3%	5.3%	36.4%	0.1%	13.6%	11.7%
Gulf	40.6%	15.9%	43.4%	0.0%	53.8%	25.3%
Great Lakes	1.1%	0.0%	0.2%	59.0%	0.7%	0.5%
North Pacific	4.3%	40.8%	3.4%	25.0%	6.0%	28.5%
South Pacific	10.5%	35.5%	4.4%	3.5%	10.0%	26.3%
United States	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Import Forecasts

D110. Europe is expected to remain the principal source of containerized imports to the North Atlantic, with the greatest proportion of future import growth is expected to come from Asia/Pacific, Latin America, and the Other Regions. The growing importance of the Asia/Pacific region to the North Atlantic ports reflects two facts: 1) the large volume of Asia/Pacific trade as a proportion of total U.S. imports and 2) the increasing economic

viability of the all-water routing from Asia/Pacific to the North Atlantic (via the Suez Canal). In the future, the fastest growth of North Atlantic imports, however, is expected to occur from the Other Regions.

D111. The North Atlantic's proportional share of total U.S. containerized imports is expected to decline in the future from all regions even as the absolute volume of containerized imports increases. This decline in market share is expected to result from increasing competition from other U.S. regions for maritime imports, faster growth in other U.S. regions, and from changing patterns of world trade. Faster growth in U.S. imports is forecast for trade with Latin America and Asia/Pacific, where the North Atlantic region's share is comparatively small. Similarly, slower growth is projected for U.S. imports from Europe, where the North Atlantic region dominates.

D112. The mix of commodities also affects the forecast share and the gateway through which these imports enter the country. For example, imports of electronics products are expected to grow by 9.4 percent per year for the U.S. as a whole. However, the North Atlantic region has only a 6 percent share of U.S. electronics imports. The forecast growth for electronics into both the North Atlantic and Port is 4.5 percent per year over this period. Therefore, the North Atlantic will lose share in this commodity group. Similarly, consumer product imports come primarily from the Asia/Pacific region. Growth is at a rate of 6.8 percent into the U.S. as a whole, but only 3.9 percent into the North Atlantic. This is due to the geographic location of the exporting nations. For example, consumer goods from China are growing in double digits and enter the U.S. primarily through the Pacific ports. Consumer goods from Western Europe enter primarily through the North Atlantic ports, but growth from Western Europe is expected to be flat at best.

D113. Total imports of containerized cargo through the Port equaled approximately 7.5 million tons in 1995. Port containerized imports are projected to reach over 25 million tons by 2040, representing an annual growth rate of 2.7 percent. The projected growth in imports through the Port is relatively similar to the North Atlantic region, although the market shares are somewhat different for different routes. For example, the Port share of Asia/Pacific traffic to the North Atlantic region is quite high (over 50 percent) and is expected to remain reasonably stable. Also, the Port share of Latin American imports to the North Atlantic is expected to remain relatively stable. However, the Port share of European traffic to the North Atlantic region is significantly less and is forecast to decline as other ports in the North Atlantic region capture more of this traffic over time. One explanation for this trend is the declining importance of the New York metropolitan area as a manufacturing/distribution base for the East Coast. Overall, the forecast suggests a significant growth in total Port containerized imports by volume, but a loss of port share to competitors.

Export Forecasts

D114. In 1995, total U. S. exports of containerized cargo were approximately 56 million metric tons. Of this total, about 8.3 million metric tons (14.8 percent) were shipped through North Atlantic ports. The Port accounted for exports of about 3.6 million metric tons (6.4 percent of U.S., 43.2 percent of North Atlantic port range). By 2040, the volume of U.S. containerized exports is projected to increase by about a factor of seven, to approximately 381 million metric tons. While there will be some variation in the relative shares between different port ranges and ports within each range, similar growth rates are expected for both the North Atlantic region and the Port during the planning period.

D115. The volume of containerized exports through the Port is expected to reach approximately 22.6 million metric tons per year by 2040. This represents a slight decrease in market share for the Port, to approximately 5.9 percent of U.S., and 37.6 percent of the North Atlantic region's containerized exports.

D116. Significant changes are anticipated in the distribution of U.S. exports during the planning period. The importance of the Asia/Pacific region as a market for U.S. containerized exports is expected to decline from about 56 percent to about 48 percent between 1995 and 2040. Europe's importance is also expected to decline (19 percent to 15 percent), while Latin America's importance as an export market for U.S. containerized cargo is expected to grow significantly – from 15 percent to 24 percent. Significant growth in the proportion of U.S. exports to Other Regions, which primarily include Africa, Middle East, and Indian Subcontinent, is anticipated (8 percent to 13 percent).

D117. Overall, the North Atlantic share of total U.S. containerized exports to the world, as well as to most regions, is expected to remain relatively stable through 2040. Major reductions in export trade share to Canada are expected, although the Canada trade represents a small percentage of total containerized exports by volume.

D118. The distribution of North Atlantic containerized cargo exports is different from that of the country as a whole. Europe is currently the principal recipient of North Atlantic containerized exports (40 percent for North Atlantic ports in 1995 versus 19 percent for the U.S.). While trade projections indicate that Europe will continue to be the principal trading partner for North Atlantic ports in the future, its share is expected to fall from 40 percent in 1995 to 31 percent by 2040.

D119. The Asia/Pacific region, the North Atlantic's second most important export market, is expected to experience a slight decline in export share from 33 percent in 1995 to 29 percent in 2040. The decline in export shares from the North Atlantic to both Europe and Asia is consistent with the overall U.S. trend. Between 1995 and 2040, the share of North Atlantic export trade to Latin America and Other Regions is expected to grow from 13 percent to 20 percent, and from 12 percent to 19 percent, respectively.

D120. The Port is the largest exporter of containerized cargo in the North Atlantic region, accounting for 43 percent of total exports (by volume). The Asia/Pacific region remains the largest export market for the Port, accounting for 1.5 million metric tons and 41 percent of total containerized exports. The Asia/Pacific market share of Port exports is expected to continue, virtually unchanged, throughout the planning period. In 1995, Europe represented 34 percent of Port containerized exports. Europe's importance is expected to decline to about 21 percent by 2040.

D121. As in the case of the North Atlantic region and the U.S. as a whole, export trade from the Port to Latin America and Other Regions is expected to grow over the planning period, from 11 percent to 16 percent, and from 13 percent to 22 percent, respectively. However, expected shifts in tonnage share should not be reflected in commodity value, since much of the containerized cargo previously exported through the Port has been low-value commodities such as scrap metals and waste paper.

D122. Growth in containerized exports is expected to be relatively flat in the near term, but strong in the medium term. Medium-term growth in containerized metric tons is forecast to be close to 6 percent for Port. This would represent a major improvement over the short-term, when growth is not expected to exceed 3 percent, due to the recent depression in the Asian economies.

D123. The stronger growth in 2000 through 2015 is partly due to the importance of Other Regions in U.S. trade performance. Growth in both Latin America and Other Regions and a recovery in Asia/Pacific will contribute to stronger growth in U.S. containerized exports. Increased growth is expected to come from a recovery in the U.S. export performance in semi-manufactured commodities – iron and steel, aluminum, paper, wood, etc. Exports of chemical products are also expected to expand slightly – from 5 percent to 6 percent between 2000 and 2015.

Detailed Forecasts of Port Commodity Movements

WTM Results

D124. The WTM forecasted imports and exports through the Port over the 50-year period of analysis (2010-2060). As outputs, the model generated two sets (imports and exports) of 60 spreadsheets (for each potential trading partner). Each spreadsheet consists of an 84 (commodity) x 50 (year) matrix. Currently, the model is configured to forecast the 1990 to 2040 period. For this investigation, individual trading partner estimates for the 2040 to 2060 period were calculated by applying the average annual trade growth rate for the 2030-2040 period. The WTM results include international container movements only and do not include domestic, coast-wise container shipping, military containers, or the movement of empty containers.

D125. The WTM commodity forecasts for the Port's imports and exports for the 2000-2040 period are summarized in Tables 19 and 20. Table 19 displays Port import and export commodity forecasts by commodity type. The data indicate the declining significance of primary goods through out the study period. Table 20 displays the same commodity forecasts by trading region. The data in Table 20 indicate the ascending significance of Asia, the Indian sub-continent, and Latin America. Europe, currently the Port's major trading region, is displaced in this role by Asia prior to the mid-point of the study period.

Table 19
WTM Forecasts of Port Imports and Exports (TEUs) by Commodity Type

Commodity	1995	2000	2010	2020	2030	2040	2060
Imports							
Primary	43,990	56,386	80,187	104,024	131,078	154,162	213,252
Manufacturing	826,980	1,006,962	1,464,753	2,194,545	2,874,726	3,538,972	5,363,572
Subtotal	870,970	1,063,348	1,544,940	2,298,569	3,005,804	3,693,134	5,575,454
Exports							
Primary	54,310	44783	63,149	83,138	102,119	114,835	145,223
Manufacturing	574,799	690519	1,241,226	2,051,781	2,895,294	3,846,288	6,788,328
Subtotal	629,109	735,302	1,304,375	2,134,919	2,997,413	3,961,123	6,918,053
Total	1,500,079	1,798,650	2,849,315	4,433,488	6,003,217	7,654,257	12,493,507

Table 20 WTM Forecasts of Port Imports and Exports (TEUs) by Trade Region							
	1995	2000	2010	2020	2030	2040	2060
Imports							
Europe	441,472	503,966	594,077	704,818	786,975	826,563	911,845
Asia	247,496	303,028	480,654	752,918	978,547	1,185,980	1,742,147
Latin America	80,286	101,362	156,704	247,701	347,871	458,282	795,392
Indian Subcont.	52,038	84,032	185,750	378,243	602,960	862,368	1,764,184
Middle East	21,835	28,059	54,487	95,417	131,737	167,015	268,459
CIS-EE*	13,198	15,935	30,511	53,509	72,230	87,809	129,785
Africa	11,865	23,605	38,035	59,178	76,075	91,222	131,170
Canada	798	984	1,238	1,830	3,070	6,002	22,941
Other	1,112	1,318	1,845	2,300	2,402	2,335	2,207
Oceana	868	1,058	1,640	2,654	3,937	5,556	11,065
Exports							
Europe	249,399	273,009	442,261	662,815	856,805	974,510	1,260,772
Asia	178,266	183,339	344,948	584,627	819,312	1,154,067	2,289,953
Latin America	106,659	146,261	269,528	462,162	695,570	982,074	1,957,803
Middle East	38,537	55,092	114,190	213,477	331,983	473,085	960,759
Africa	21,698	28,238	49,133	79,740	108,152	135,553	212,951
Indian Subcont.	11,063	15,500	27,751	46,955	76,716	116,702	270,085
CIS-EE*	19,655	24,628	39,301	54,895	62,812	62,936	63,190
Oceana	3,648	8,740	16,317	28,350	42,784	57,287	102,717
Other	170	264	514	1,028	1,651	2,278	4,337
Canada	12	228	430	869	1,629	2,629	6,848

* Commonwealth of Independent States / Eastern Europe

Adjusted Forecasts

D126. The WTM forecasts the volume of international trade in loaded TEUs. Vessels and terminal facilities however, also handle domestic, military, and coastwise cargo. There is also a considerable volume of empties that transits the port. Adjustments for these factors were made based on U.S. Department of Commerce data, PANYNJ data, and information provided by the carriers. Table 21 presents the adjusted commodity forecast used throughout the benefits analysis.

Table 21 Adjusted Forecasts of Port Imports and Exports (TEUs)						
	2010	2020	2030	2040	2050	2060
Imports	2,300,117	3,422,140	4,474,074	5,493,824	7,069,000	9,183,086
Exports	1,942,875	3,179,733	4,463,720	5,898,153	7,611,832	9,937,258
Totals	4,242,993	6,601,873	8,937,793	11,391,977	14,680,832	19,120,344

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PROJECTED CONTAINER SHIP FLEET

Introduction

D127. The characteristics of a containership fleet are determined by the carriers' expectations of TEU demand. In this analysis, the projected volume of TEUs transiting the Port during the study period was made independently of channel depths at the harbor. As discussed previously in the Future Commodity Movement section, the volume of TEUs flowing through the Port by 2010 is projected to be 1.7 times the 1998 volume of trade. Growth is projected to continue at a moderate rate so that by 2030 the volume of trade is 3.7 times 1998 levels. By the end of the study period (2060) the volume of TEUs flowing through the Port is projected to be 7.8 times greater than the 1998 level of trade.

D128. The fleet forecast, which projects the characteristics of the future fleet, is a critical component of problem identification, benefits analysis, and overall plan formulation. Total transportation costs are closely related to the size of the vessels calling at the port. Larger vessels imply increased efficiency and reduced transportation costs for the projected TEU volume. Current and without project conditions impose a constraint on the size of vessels that can maintain scheduled global service. This constraint increases the cost of commodity movement through the Port.

D129. The characteristics of the containership fleet projected to call at the Port are based on growth estimates of the existing world fleet and on anticipated deployment patterns. The fleet characteristics most pertinent to identification of the NED plan include 1) vessel design and sailing drafts, 2) TEU capacity and the share apportioned to the Port, 3) the distribution of vessels sizes among shipping routes, and 4) vessel operating costs. The guiding premise of the fleet forecast is that carriers will continue to take advantage of economies of scale available on the long distance, high volume trade routes by deploying the largest vessels on those routes and by deploying smaller vessels on shorter distance, low volume routes and specialty trades.

D130. Actions that exploit economies of scale have affected the structure and operations of the industry. Short term efforts to realize economies of scale associated with the largest vessels include slot sharing and vessel alliances. Recent developments indicate that carriers are also investing in long term measures to capture economies of scale. One example of such a development is the continued growth in new orders of the largest vessel sizes. From 1990 to 1998, the average per vessel TEU capacity of new additions to the world fleet, for vessels larger than 3,000 TEU, increased by more than 36%. Another example is the frequency and size of recent corporate mergers among carriers. Other developments have been spurred by the enactment of the Ocean Shipping Reform Act, such as joint contracts among multiple carriers and a single shipper.

D131. The rest of this section of the Economics Appendix is organized as follows. Data and data sources used to forecast fleet characteristics are presented and discussed in the

next sub-section. The discussion of data and data sources is followed by a presentation and discussion of the method and reasoning used to forecast fleet characteristics. Assumptions used in the projection are also identified and discussed. The discussion of method is followed by a presentation and analysis of the fleet forecast results.

Data Description and Discussion of Sources

Introduction

D132. Estimates of projected fleet characteristics are based on current and historical data, as described in detail below.

- Vessel calls: The U.S. Customs Service provided data on each foreign trade vessel call at the Port for six months (April though October) of 1998. This data includes vessel name, identification number, sailing draft, date and time of arrival, last and next port of call, vessel owner, and shipping agent. More than 700 vessel calls were included in the usable data set after cleaning and cross referencing.

- Vessel deployment: Individual vessels were allocated to specific trade routes through an analysis of the U.S. Customs Service data set combined with ship deployment data from the Journal of Commerce and vessel deployment data from individual carriers.

- Vessel design characteristics: Vessel design drafts, dead weight tonnage, and TEU capacities were identified by cross referencing the Customs Service data with the 1997 Clarkson's Research data set for the world fleet of containerships.

- Vessel operating costs: Vessel operating costs were taken from the tables and regressions provided in Economic Guidance Memorandum 99-05, Deep Draft vessel Operating Costs.

- Vessel time in port: Vessel time in port was estimated using Customs Service and PANYNJ data, and incorporated additional information from terminal operators and industry consultants.

- Trade route distances: Trade route distances were taken directly from Table IV-6: Trade Route Round Trip Distances, IWR Report 91-R-13, National Economic Development Procedures Manual Deep Draft Navigation.

- TEU trade route allocation: The allocation of TEUs to each trade route by year was taken directly from the commodity forecast described in the Future Commodity Movement section.

- TEUs per call at the Port: The volume of TEUs loaded and unloaded per vessel call was estimated for each vessel size (one foot increments of sailing draft) based on an analysis of data collected by the Panama Canal Commission that relates specific port cargo volume to vessel size. The proportion of TEUs per vessel call for Panamax vessels was applied to post-Panamax vessels.

Containership Size

D133. Of the many changes have taken place in the industry since the 1950's, two very general trends can be identified: 1) increasing market penetration, and 2) increasing vessel size. The trend in increasing market penetration is expected to continue as new terminal facilities and supporting infrastructure continue to be built in developing countries. This trend is not expected to have a significant impact on the characteristics of the fleet projected to use the Port.

D134. The trend of increasing vessel size will have a significant impact on fleet characteristics. Although this trend is expected to continue, there appears to be a natural limit to the size (particularly the draft) of single screw containerships. In the foreseeable future, containerships are expected to remain single screw vessels mainly because the increase in beam due to an additional engine and propeller would make these vessels too wide for nearly every port and crane configuration available. As single screw vessels increase in size to accommodate more cargo they are designed longer and wider which results in a deeper draft. However, as these vessels increase in capacity and size, vessel draft increases at a slower rate due to the displacement characteristics of larger vessels. Analysis of trends in vessel capacities and sailing drafts indicates that the sailing draft of single screw containerships can reasonably be expected to reach a maximum at 48', implying a design draft of approximately 50'.

D135. Since 1990, there has been a rapid surge of growth in the post-Panamax class of vessels. These are vessels are larger than the dimensions of the Panama Canal. In general, post-Panamax vessels have a minimum beam of 106 feet and a minimum design draft of 42 feet. Currently, the largest post-Panamax vessels have a beam of 146 feet and a design draft of 48 feet. On average, more than 9 post-Panamax vessels have been added to the fleet each year from 1990 to 1998, exhibiting an average annual growth rate of 45% in that vessel class. Table 27 shows the growth of average vessel size for vessels entering the world fleet and the growth of new TEU capacity attributed to the largest vessels. However, simple extrapolation of this recent trend would be misleading. Therefore, this fleet forecast is based on recent and historic data concerning vessel and terminal characteristics and depends heavily on interviews with numerous professional contacts in the shipping and consulting industries. Due to the considerable uncertainty associated with a fleet forecast that extends to the year 2060 (the end of the study period), projected fleet characteristics are held constant from year 2035 (the mid-point of the study period).

Table 22 Annual Additions to the World Fleet: Containerships with 3,000 TEU Capacity and Greater						
	All Vessels			Post Panamax Vessels		
Year	Total Vessels	Total TEUs	Avg TEUs Per Vessel	Total Post Panamax	Total Post Panamax	% additional Panamax TEUs
1990	10	36,677	3,668	0	0	0%
1991	15	56,232	3,749	1	4,427	8%
1992	24	92,717	3,863	8	35,625	38%
1993	23	88,064	3,829	0	0	0%
1994	32	119,356	3,730	1	4,112	3%
1995	48	201,102	4,190	19	90,379	45%
1996	42	194,112	4,622	19	106,105	55%
1997	59	269,904	4,575	24	129,324	48%
1998	30	150,046	5,002	13	82,400	55%

Source: WEFA, unpublished report.

Containership Cargo Capacity and Port Share

D136. Data on existing containership cargo capacity has been collected from a number of sources. The basic reference source is Economic Guidance Memorandum EGM 99-05. Data in the guidance memorandum was augmented by data on individual vessels supplied by various carriers and through data collected by Clarkson's Research Service. Table 23 presents generalized sailing draft and TEU capacity data for the existing world fleet.

Table 23 TEUs to Sailing Draft Relationship	
TEU Range	Sailing Draft Maximum Range (Feet)
300 to 500	21 to 23
500 to 1,000	23 to 30
1,000 to 1,500	30 to 34
1,500 to 2,000	34 to 36
2,000 to 3,000	36 to 40
3,000 to 4,000	40 to 42
4,000 to 5,000	42 to 43
5,000 to 6,000	43 to 45
6,000 to 8,500	45 to 48

Source: WEFA, unpublished report.

D137. Regardless of the number of containers a vessel carries into and out of the Port, only a percentage of those containers will be handled (*i.e.*, on- or off-loaded) at Port facilities. The projection of import and export TEUs transiting the harbor only includes containers that are loaded or unloaded at Port facilities. The percentage of a vessel's total cargo that is either loaded or unloaded at the Port is estimated from an analysis of Panama Canal Commission (PCC) data collected during 1972 – 1997. The PCC data set identifies the port of origin and destination for all cargo on each canal transit. Vessel loading patterns are incorporated into the data set. Estimates for post-Panamax vessels

use the same proportion as Panamax vessels. The percentages applied in this analysis range from 22% to 26% throughout the period of study. The minor fluctuations in the Port's share of total TEUs on-board is due to variations in cargo growth rates among different trade routes and the differentiation of cargo among trade routes.

Vessel Deployment

D138. Vessel deployment patterns are a significant component of the fleet forecast. As stated above, carriers are expected to take maximum advantage of economies of scale available on long distance, high volume trade routes. Carriers are also expected to continue the current practice of accommodating growth in volume along any given trade route by increasing the size of vessels on that route. According to carriers, shippers, and industry consultants, increased trade route volume is best accommodated by increasing vessels size, not by adding additional ships of the same size or by calling on the same ports more frequently. This response to increased volume is corroborated by the current practice of alliance carriers chartering slot space on each other's vessels as a means of maintaining schedules and increasing efficiency as cargo volumes increase.

D139. The origins and destinations of international trade flowing through New York Harbor are projected to change significantly over the course of the study period. This shift will have a significant effect on vessel deployment patterns. As discussed previously in The Future Commodity Movement section and presented in Table 24, the proportion of New York Harbor TEU volume from Northern Europe and the Mediterranean declines and the proportion from South East Asia and the Indian Sub-continent increases throughout the study period. The implication of this shift in trade is that there will be greater opportunities for carriers to realize economies of scale as the volume of trade grows more quickly on the longer distance trade routes. Carriers are also expected to continue taking advantage of cost reductions and operational efficiencies made possible by routing vessels through the Suez Canal. Table 24 presents the change in proportional volume of TEUs by trade route and the change in the weighted average distance traveled for TEU's serviced at the Port during the study period.

Trade Routes	Table 24 TEU Share and Weighted Average Distance Year						Overall
	2010	2020	2030	2040	2050	2060	Change
WC South America	2.55%	2.62%	2.65%	2.71%	2.74%	2.74%	0.20%
EC South America	6.08%	5.85%	5.92%	5.97%	5.96%	5.89%	-0.20%
Caribbean	3.07%	3.58%	4.04%	4.45%	4.85%	5.23%	2.16%
North Europe	27.27%	23.15%	20.73%	17.89%	15.28%	12.91%	-14.36%
Mediterranean	10.28%	8.88%	7.81%	6.75%	5.76%	4.87%	-5.41%
Far East	22.77%	22.97%	21.86%	21.72%	21.35%	20.76%	-2.01%
West Africa	0.64%	0.60%	0.57%	0.54%	0.51%	0.47%	-0.17%
South & East Africa	1.69%	1.77%	1.74%	1.70%	1.64%	1.57%	-0.12%
Australia & New Z	0.63%	0.70%	0.78%	0.82%	0.86%	0.89%	0.26%
South East Asia	7.40%	8.77%	10.00%	11.06%	12.10%	13.11%	5.71%
Middle East	11.90%	14.69%	16.87%	18.70%	20.51%	22.25%	10.36%
Central America	3.27%	3.97%	4.79%	5.71%	6.73%	7.84%	4.57%
East Europe	2.45%	2.45%	2.25%	1.97%	1.71%	1.46%	-0.99%
Total	100%	100%	100%	100%	100%	100%	
Weighted Average Distance (naut. miles)	7,559	7,922	8,113	8,333	8,527	8,693	1,134

Sources: WEFA, unpublished report and IWR Report 91-R-13.

Forecasting Method

Introduction

D140. The characteristics of the projected fleet are forecasted by modifying the characteristics of the existing fleet to account for incremental increases in channel depth. The relative allocation of vessel sizes and TEUs per vessel size among trade routes are the same for the existing and projected fleets. The two differences between characteristics of the existing and projected fleet are:

- the existing fleet is constrained by 40 ft MLW channel depth and the projected fleet is constrained by channel depths ranging from 45 ft MLW to 50 ft MLW, and
- the historical growth in the proportion of TEUs allocated to the largest vessel sizes is significantly greater than the growth applied to the projected fleet.

Existing Fleet Characteristics by Route

D141. The projected sailing drafts of the fleet calling on the Port during the study period are based on an analysis of the 1998 allocation of total TEU volume by vessel size. In this analysis, Customs Service data on vessel calls were categorized into three trade route categories: major, minor, and hybrid. The major routes are the long haul, high volume routes to Southeast Asia, the Far East, and the Middle East, which includes the Indian

Sub-continent. Minor routes are identified as routes serving the African continent, Australia and New Zealand, the South American continent and the Caribbean, Eastern Europe, and Mediterranean countries. The single hybrid route is identified as the Northern European route which is characterized by high volume and short distances.

D142. Vessel calls were allocated to the three route categories according to last and next port of call data provided by the Customs Service, data from ship deployments listed in the Journal of Commerce, and data provided by carriers. Overall, data from more than 700 vessel calls, handling an estimated 662,000 TEUs in the Port, was included in the analysis. Table 25 displays the distribution of New York TEUs by foot of design draft for each route category.

D143. The most significant deployment characteristics displayed by the vessel size distributions are:

- Minor routes are served by smaller size vessels;
- Major routes are served by the largest vessels;
- On the hybrid and major routes, the largest vessels handle most of the TEUs; and
- The largest vessels on the major routes carry a greater proportion of TEUs than the largest vessels on the hybrid route, e.g., the four largest vessel sizes account for 76% of the TEUs on major routes and 66% on the hybrid route;

D144. These observations confirm that carriers are taking advantage of economies of scale available on the long distance, high volume trade routes by deploying the largest vessels on those routes and by deploying smaller vessels on shorter distance, low volume routes.

Table 25
Existing Fleet Characteristics – 1998

Design Drafts	Hybrid Route N = 149 calls TEUs	%	Minor Routes N = 311 calls TEUs	%	Major Routes N = 242 calls TEUs	%	Totals N = 702 calls TEUs	%
<33	4,966	2.90%	48,132	25.48%	1,146	0.38%	54,244	8.19%
33	0	0.00%	9,975	5.28%	0	0.00%	9,975	1.51%
34	0	0.00%	13,041	6.90%	1,701	0.56%	14,742	2.23%
35	0	0.00%	12,957	6.86%	4,319	1.43%	17,276	2.61%
36	9,990	8.88%	25,308	13.40%	4,662	1.54%	39,960	6.03%
37	0	0.00%	17,138	9.07%	3,895	1.29%	21,033	3.18%
38	8,880	0.60%	13,320	7.05%	19,536	6.46%	41,736	6.30%
39	34,000	1.77%	32,000	16.94%	29,000	9.59%	95,000	14.34%
40	2,212	0.70%	12,166	6.44%	5,530	1.83%	19,908	3.01%
41	13,442	8.77%	4,888	2.59%	80,652	26.67%	98,982	14.94%
42	17,926	14.69%	0	0.00%	9,653	3.19%	27,579	4.16%
43	79,588	3.97%	0	0.00%	106,148	35.10%	185,736	28.04%
44	0	0.00%	0	0.00%	33,098	10.95%	33,098	5.00%
45	0	0.00%	0	0.00%	0	0.00%	0	0.00%
46	0	0.00%	0	0.00%	0	0.00%	0	0.00%
47	0	0.00%	0	0.00%	0	0.00%	0	0.00%
48	0	0.00%	0	0.00%	3,045	1.01%	3045	0.46%
Totals	171,004	100.00%	188,925	100.00%	302,385	100.00%	662,314	100.00%

Sources: U.S. Customs Service

Projecting Future Fleet Characteristics

D145. Projections of the future fleet TEU distributions for each of the route categories are based on the relationship between design draft and channel depth exhibited by the Customs Service data presented in Table 26. For example, given the existing 40 ft MLW channel, the distribution for the hybrid route does not include vessels with design drafts greater than 43ft and the TEU distribution among the largest vessels are predominantly in the 42ft and 43ft sizes (averaging 28.5% of the total hybrid route TEUs each). The current distribution for the major routes, again given the existing 40 ft MLW channel, displays a grouping of the largest vessels in the 41ft to 44ft sizes with an outlier at 48ft. This grouping of the largest vessels averages 19.2% of the total major route TEUs, per each of the four vessel sizes (41ft to 44ft).

D146. These relationships are extrapolated to a 45 ft MLW channel (the without-project condition) based on the propensity to use efficient size vessels as indicated by the analysis of 1998 port statistics. The projected change includes 1) shifting the percentage TEU distributions into larger size vessels, 2) truncating vessel sizes by channel depth requirements *i.e.*, for a 45 ft MLW channel the size distribution is truncated at 45ft sailing

draft[1], and 3) maintaining the relationships among vessel sizes across route categories. The projected fleet distribution for a 45 ft MLW channel results in 28.5% of the total hybrid route TEUs allocated to each of the 43ft and 44ft vessel sizes and 19.2% of the total major route TEUs allocated to each of the 42ft through 45ft vessel sizes. The projected Minor route vessel distribution truncates at 44' vessels. Table 26 presents the projected Port fleet for the three route categories in 2010 at 45 ft MLW and 50 ft MLW channel depths.

D147. Historically, the percentage of Port TEUs carried by the 4 largest vessel sizes has increased from 30.3% in 1982 to 50.2% in 1998, which represents a 66% increase over a 16 year period. The percentage of Port TEUs carried by the 4 largest vessel sizes in the projected fleet forecast increases from 50.2% in 2010 to 60.4% in 2035, which represents a conservative 20% increase in 25 years. Projected percentage distributions were held constant after 2035.

Table 26
Projected Fleet TEU Allocations at 45 ft MLW and 50' Channel Depths - 2010

	45 ft MLW Channel Depth			50 ft MLW Channel Depth		
Sailing Drafts	Major Routes	Minor Routes	Hybrid Route	Major Routes	Minor Routes	Hybrid Route
<33	0.00%	21.25%	0.00%	0.00%	21.25%	0.00%
33	0.00%	4.25%	0.00%	0.00%	4.25%	0.00%
34	1.73%	5.28%	2.91%	0.65%	5.28%	1.09%
35	1.73%	6.90%	2.91%	0.65%	6.90%	1.09%
36	1.73%	6.86%	2.91%	0.65%	6.86%	1.09%
37	5.96%	13.40%	8.56%	0.65%	13.40%	1.09%
38	5.96%	9.07%	8.56%	0.65%	9.07%	1.09%
39	5.96%	7.05%	8.56%	0.65%	7.05%	1.09%
40	19.23%	16.94%	8.56%	0.65%	16.94%	1.09%
41	19.23%	6.44%	28.51%	0.65%	6.44%	1.09%
42	19.23%	2.59%	28.51%	5.96%	2.59%	8.56%
43	19.23%	0.00%	0.00%	5.96%	0.00%	8.56%
44	0.00%	0.00%	0.00%	5.96%	0.00%	8.56%
45	0.00%	0.00%	0.00%	19.23%	0.00%	8.56%
46	0.00%	0.00%	0.00%	19.23%	0.00%	28.51%
47	0.00%	0.00%	0.00%	19.23%	0.00%	28.51%
48	0.00%	0.00%	0.00%	19.23%	0.00%	0.00%
Totals	100%	100%	100%	100%	100%	100%

Source: U.S. Customs Service

1 All vessels are assumed to be loaded at less than design draft potential. For example, a 45' design draft vessel is expected to have a 43' static draft fully loaded. An additional 2' of draft is required to account for squat, trim, and salinity when the vessel is underway. The resulting sailing draft for a 45' design draft vessel is 43 + 2 = 45'.

D1.———————

Fleet Projections

D148. As described above, fleet distributions for each trade route category are projected in terms of the percentage of Port TEUs carried on each one foot increment in vessel size, based on the existing relationships between TEU allocation and design draft shown in Table 25. The projected growth in the proportion of TEUs allocated to the largest vessel sizes is less than 1% annually, which is significantly less than the historical rate. Minor routes are projected to be serviced by vessels with drafts less than 45ft throughout the study period. Therefore, vessels deployed on minor routes do not generate any monetary benefits for channel deepening beyond 45ft MLW.

D149. Vessel distributions were calculated on an annual basis (from 2010 – 2060) for hybrid and major routes for each alternative channel depth (from 45 ft MLW – 50 ft MLW). Table 27 presents the projected fleets for 2010, 2035, and 2060 for hybrid and major routes at representative channel depths of 45 ft MLW (the without project condition) and 50 ft MLW.

Table 27
Projected Hybrid and Major Route Fleet TEU Allocations: 2010 and 2035 - 2060

	2010				2035 - 2060			
Sailing	Major Routes		Hybrid Route		Major Routes		Hybrid Route	
Drafts	45 ft	50 ft	45 ft	50 ft	45 ft	50 ft	45 ft	50 ft
<33	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
33	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
34	1.73%	0.65%	2.91%	1.09%	0.87%	0.32%	1.46%	0.55%
35	1.73%	0.65%	2.91%	1.09%	0.87%	0.32%	1.46%	0.55%
36	1.73%	0.65%	2.91%	1.09%	0.87%	0.32%	1.46%	0.55%
37	5.96%	0.65%	8.56%	1.09%	2.98%	0.32%	4.28%	0.55%
38	5.96%	0.65%	8.56%	1.09%	2.98%	0.32%	4.28%	0.55%
39	5.96%	0.65%	8.56%	1.09%	2.98%	0.32%	4.28%	0.55%
40	19.23%	0.65%	8.56%	1.09%	22.12%	0.32%	4.28%	0.55%
41	19.23%	0.65%	28.51%	1.09%	22.12%	0.32%	39.26%	0.55%
42	19.23%	5.96%	28.51%	8.56%	22.12%	2.98%	39.26%	4.28%
43	19.23%	5.96%	0.00%	8.56%	22.12%	2.98%	0.00%	4.28%
44	0.00%	5.96%	0.00%	8.56%	0.00%	2.98%	0.00%	4.28%
45	0.00%	19.23%	0.00%	8.56%	0.00%	22.12%	0.00%	4.28%
46	0.00%	19.23%	0.00%	28.51%	0.00%	22.12%	0.00%	39.26%
47	0.00%	19.23%	0.00%	28.51%	0.00%	22.12%	0.00%	39.26%
48	0.00%	19.23%	0.00%	0.00%	0.00%	22.12%	0.00%	0.00%
Totals	100%	100%	100%	100%	100%	100%	100%	100%

Source: U.S. Customs Service

D150. Table 28 displays the effects of alternative channel depths on a single route category for a single year. Transportation cost savings calculations are based on similar data for each route, each year, and each alternative channel depth.

Table 28
Major Routes
Projected Fleet TEU Allocations at Alternative Channel Depths - 2010

Sailing Drafts	Channel Depths 45'	46'	47'	48'	49'	50'
<33	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
33	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
34	1.73%	1.30%	1.04%	0.87%	0.74%	0.65%
35	1.73%	1.30%	1.04%	0.87%	0.74%	0.65%
36	1.73%	1.30%	1.04%	0.87%	0.74%	0.65%
37	5.96%	1.30%	1.04%	0.87%	0.74%	0.65%
38	5.96%	5.96%	1.04%	0.87%	0.74%	0.65%
39	5.96%	5.96%	5.96%	0.87%	0.74%	0.65%
40	19.23%	5.96%	5.96%	5.96%	0.74%	0.65%
41	19.23%	19.23%	5.96%	5.96%	5.96%	0.65%
42	19.23%	19.23%	19.23%	5.96%	5.96%	5.96%
43	19.23%	19.23%	19.23%	19.23%	5.96%	5.96%
44	0.00%	19.23%	19.23%	19.23%	19.23%	5.96%
45	0.00%	0.00%	19.23%	19.23%	19.23%	19.23%
46	0.00%	0.00%	0.00%	19.23%	19.23%	19.23%
47	0.00%	0.00%	0.00%	0.00%	19.23%	19.23%
48	0.00%	0.00%	0.00%	0.00%	0.00%	19.23%
Totals	100%	100%	100%	100%	100%	100%

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ECONOMIC BENEFITS OF NAVIGATION IMPROVEMENTS AT THE PORT

Introduction

D151. The economic benefits considered in this analysis are National Economic Development (NED) benefits that increase the value of the national output of goods and services. Specifically, the benefits quantified in this analysis are the reduced costs of transportation realized through the use of larger more efficient vessels and operational efficiencies resulting from navigation improvements at the harbor. Reduced transportation costs result in reduced production and distribution costs thereby increasing the net value of the national output of goods and services.

D152. The process described in this section is a purposefully conservative approach to benefit estimation. The intent is to always err, if at all, on the side of understatement and to rely on observed existing conditions and practices as a guide to developing future scenarios. As stated in The Projected Containership Fleet section of this appendix, which describes the fleet forecast method, there is a large degree of uncertainty in projecting future conditions and practices in the ocean shipping industry. Given this level of uncertainty, radical assumptions are avoided and each step of the process must pass a test of reasonableness. As described below, types of economic benefits with high levels of uncertainty are identified but not quantified in this analysis. Therefore, the economic benefits quantified in this analysis represent the minimum value of NED benefits that would result from navigation improvement to the Port.

D153. Economic benefits are calculated for each year of the study period, 2010 – 2060. All project costs and benefits are discounted at the current federal discount rate of 6.875%.

D154. This rest of this section of the Economics Appendix focuses on the development of project benefit estimates. First, there is a discussion of potential benefits and of the sub-set of potential benefits selected for estimation. Data and data sources are then presented and reviewed. Next, the method of benefit estimation is presented, including discussions of the constraints imposed on the estimation process and a discussion of the calculations used in the analysis. Finally, there is a discussion of the process used in the incremental analysis and benefit estimates are presented for individual pathways to specific terminals and for selected pathway and terminal combinations.

Identifying Sources of Benefits

D155. Numerous sources of transportation cost savings have been identified through analyses of vessel operations, port and terminal operations, and vessel deployments. The sources of transportation cost savings can be categorized as:

- Vessel efficiencies
- Operational efficiencies, and
- Improved safety.

Vessel Efficiencies

D156. In the category of transportation cost savings resulting from vessel efficiencies, sources of benefits have been identified based on the shift to larger vessels on specific trading routes. Vessel efficiencies have been identified for containerships servicing the following routes:

- Major routes: Far East, South East Asia, and the Middle East (including the Indian sub-continent)
- Minor routes: west coast of South America, east coast of South America, Central America, Caribbean, West Africa, East and South Africa, Australia and New Zealand, Eastern Europe, and Mediterranean
- Hybrid route: Northern Europe.

D157. Vessel efficiencies have also been identified for break-bulk vessels servicing the scrap metal trade.

Operational Efficiencies

D158. Benefits resulting from operational efficiencies have been identified for

- Reduced tide delays: Deeper channels would allow some of the vessels that require the advantage of high tides access to port facilities in the without-project condition to gain access regardless of the tide
- Reduced queuing delays: Given the volume of TEUs projected to be handled in the Port, the number of daily vessel calls required to serve the TEU demand under without project conditions will cause queuing delays as vessels wait for berth space and right of way in the Kill Van Kull, Arthur Kill, and Newark Bay channels.
- Reduced liquid bulk lightering: Deeper channels would allow some of the liquid bulk vessels that require lightering to access port facilities with reduced or no lightering.
- Reduced break-bulk transfers: Deeper channels would allow break-bulk vessels that top-off their load from barges at deep water anchorage to load completely at the dock.



- Benefits during construction: Benefits would accrue during the construction phase due to partial project completion such as, deepened one-way and partial port facility access.

Improved Safety

D159. Identified benefits resulting from improved safety in the harbor include:

- Reduced natural resource injury: Deeper channels would reduce the overall number of vessel calls, reduce congestion, and lightering operations in the harbor. All other things being equal, reductions in each of these elements would reduce the probability of oil spills or other contaminant spills that would injure natural resources in the harbor, thereby reducing the expected value of natural resource damages.

- Reduced disruptions of services: As described above, deeper channels would reduce the probability of oil spills or other contaminant spills in the harbor. Reducing the probability of such incidents in the harbor would also reduce the probability of waterway closures and service disruptions that result from related clean-up, salvage, and restoration activities. The reduction in incident probability would reduce the expected value of damages related to disruptions of waterway services.

Quantified Benefits

D160. Although each of the benefit types identified above are reasonable and anticipated benefits of navigation improvements to the harbor, few of the benefit types can be quantified to a reasonable level of certainty. Therefore only a sub-set of benefit types is quantified in this analysis. Economic benefit calculations include only the transportation cost savings associated with vessel efficiencies for containerships on the hybrid and major routes.

D161. Benefits related to operational efficiencies are not quantified because the multitude of operational options available in the harbor pose a high level of uncertainty for future alternative scenarios. Benefits related to improved safety are not quantified due to the high level of uncertainty related to projecting spill magnitudes and frequency. Benefits accruing from vessel efficiencies for containerships on the 9 minor routes are also not quantified because of the uncertainty associated with projected fleet distributions for these routes. Because the projected minor route fleet would not be constrained under without project conditions there is a high level of uncertainty associated with predicting the way that vessels on the minor routes would be replaced by larger vessels displaced from the major and hybrid routes. Given this level of uncertainty, the projected fleet for the Minor routes portrays the same characteristics as the existing fleet.

D162. As indicated above, the only economic benefits quantified in this analysis are benefits that can be quantified with a reasonable level of certainty. These benefits are the transportation cost savings resulting from vessel efficiencies for containerships on the hybrid and major routes. The reasonableness of quantifying these benefits stems from observed existing practices, upon which the fleet forecasts and benefit calculations are based.

Data and Data Sources

Introduction

D163. Transportation cost savings (benefits) are based on data pertaining to the projected fleet and projected commodity flows. Benefits, however, are also constrained by the cargo handling capacity of the port. Capacity constraints reduce the potential benefit pool in two ways. First, benefits are constrained by the overall TEU throughput capacity of total port facilities. Second, benefits are constrained by the capacities of individual facilities to service vessels requiring channel depths greater than 45 ft MLW. Descriptions of pertinent data and data sources follow.

Vessel Operating Costs

D164. Vessel operating costs: Vessel operating costs were taken from the tables and regressions provided in Economic Guidance Memorandum 99-05, Deep Draft Vessel Operating Costs.

Projected Containership Fleet

D165. Projected containership fleet: a full discussion of the data, method, and procedures used to forecast the containership fleet projected to call on the Port is presented in The Projected Containership Fleet section. Table 29 presents the projected fleet distribution for a 50 ft MLW channel depth.

Projected Commodity Flow

D166. Projected commodity flow: a full discussion of the data, method, and procedures used to forecast commodity movements through the Port is presented in The Future Commodity Movement section.

Table 29
Projected Fleet Distribution Assuming 50 ft MLW Channel Depths
All Routes Combined: 2010 – 2060

Sailing Drafts	Year 2010	2020	2030	2040	2050	2060
<33	6.51%	5.16%	3.90%	3.25%	3.25%	3.25%
33	1.30%	1.03%	0.78%	0.65%	0.65%	0.65%
34	2.19%	1.73%	1.29%	1.07%	1.07%	1.07%
35	2.69%	2.12%	1.59%	1.32%	1.32%	1.32%
36	2.67%	2.11%	1.58%	1.31%	1.31%	1.31%
37	4.68%	4.97%	5.33%	5.50%	5.50%	5.50%
38	3.35%	3.65%	4.00%	4.18%	4.18%	4.18%
39	2.73%	3.04%	3.39%	3.56%	3.56%	3.56%
40	5.77%	6.05%	6.41%	6.59%	6.59%	6.59%
41	2.55%	2.85%	3.20%	3.37%	3.37%	3.37%
42	5.64%	5.04%	4.50%	4.23%	4.23%	4.23%
43	4.84%	3.80%	2.81%	2.30%	2.30%	2.30%
44	4.84%	3.80%	2.81%	2.30%	2.30%	2.30%
45	10.42%	11.05%	11.56%	12.15%	12.15%	12.15%
46	15.86%	17.06%	18.19%	18.41%	18.41%	18.41%
47	15.86%	17.06%	18.19%	18.41%	18.41%	18.41%
48	8.09%	9.47%	10.50%	11.39%	11.39%	11.39%
Totals	100%	100%	100%	100%	100%	100%

Throughput Capacities

D167. TEU throughput capacity: PANYNJ provided current data and projections for facilities such as cranes, berths, acreage, and lifts per acre. The throughput capacity for each container terminal is estimated as the product of terminal acreage and the projected average lifts per acre. Individual terminal capacities for vessels requiring drafts greater than 45ft are based on the expected number of berths at each terminal to be deepened to depths greater than 45 ft MLW.

D168. Table 30 presents the overall throughput capacity of the harbor in terms of annual TEUs. This table also presents projected total quantity of container handling services (measured in TEUs) demanded and the percentage of that quantity that can be satisfied, given the port's throughput capacity. Beginning in approximately 2027, projected total Port capacity will fall short of total quantity of container handling services (measured in TEUs) demanded. Transportation cost savings related to navigation improvements in the Port are thereby constrained by port capacity.

Table 30 Overall Throughput Capacity ('000s TEUs): 2010 - 2060						
	2010	2020	2030	2040	2050	2060
Total TEU Demand	4,243	6,602	8,938	11,392	14,681	19,120
Average Lifts per Acre	1.66	2.41	3.17	3.50	3.50	3.50
Port TEU Capacity	4,535	6,589	8,660	9,562	9,562	9,562
Serviceable Demand	100%	100%	97%	84%	65%	50%

D169. Table 31 presents the projected quantity of container handling services (measured in TEUs) demanded by vessels with drafts greater than 45ft. This table also presents the projected capacity of the Port in terms of handling the volume of TEUs carried on vessels with drafts greater than 45ft. This capacity is limited by the number of berths that would be able to service vessels with drafts greater than 45ft. Capacity projections are based on observed port operations concerning the current distribution of carriers and vessels among the Port's terminal facilities.

Table 31 Throughput Capacity* for Vessels Drawing More Than 45ft ('000s TEUs): 2010 - 2060						
	2010	2020	2030	2040	2050	2060
Total >45' TEU Demand	2,337	3,858	5,473	7,139	9,200	11,983
Average Lifts per Acre	1.66	2.41	3.17	3.50	3.50	3.50
Port >45' TEU Capacity	2,804	4,074	5,354	5,912	5,912	5,912
Serviceable Demand	100%	100%	98%	83%	64%	49%

*Assumes navigation improvements at all project segments

D170. Specifically, capacity projections for TEUs carried on vessels with drafts greater than 45ft are based on current and anticipated single-user and multi-user terminal configurations. Single-user terminal facilities are container terminals that are dedicated to serving a single carrier or alliance. These facilities are generally operated by or on behalf of the major carriers and alliances, and are designed to service the largest vessels. Multi-user terminal facilities are container terminals that serve many carriers and generally have shallower berths and smaller cranes than single-user terminals.

Method

Introduction

D171. At the most basic level, the benefit estimation methodology is simply an assessment of the difference in transportation costs between the without-project condition and alternative with project conditions. A layer of complexity is added because the analysis must account for two capacity constraints based on 1) overall port throughput capacity and 2) throughput capacity related to vessels with drafts deeper than 45ft. The geographic layout of the Port causes additional complexity because navigation improvements to the harbor can be seen as a collection of individual project segments. Following the procedures laid out in the NED Procedures Manual – Deep Draft

Navigation, IWR–91–R-13, benefits (and net benefits in the plan formulation process) are estimated for individual segments both independently and collectively.

Throughput Constraints

D172. Overall port throughput constraints are imposed on both with and without project conditions. Throughput constraints related to vessels with drafts greater than 45ft are imposed on with project alternative plans. Each alternative plan, at a given depth, includes a different combination of project segments. Therefore, each alternative plan is constrained at a different level of throughput capacity related to vessels with drafts greater than 45ft.

D173. The capacity constraints are assumed to interact in a cumulative manner. For example, in 2030 the overall capacity constraint limits overall throughput to 97% of quantity demanded, and the throughput capacity related to vessels with drafts greater than 45ft limits that throughput to 98% of quantity demanded (in the all project segments scenario). Given the observation that the port cannot discriminate by optimally allocating overall throughput capacity to the deepest vessels, the effect of the combined capacity constraints limits benefits to 95% (.97 * .98 = .95) of the potential transportation cost savings implied by total quantity of container handling services (measured in TEUs demanded. The limits of the effective benefit pool are calculated for each year and for each alternative plan combination of project segments.

Transportation Cost Savings

D174. Annual transportation cost savings for each route are calculated as the difference between weighted costs per TEU in the without and with project conditions. Costs per TEU are weighted by the allocation of TEUs among vessel sizes in the projected fleet distribution for each route. Differences in fleet distributions and differences in sailing distances are the reasons for variation in weighted TEU costs among routes in any given year. Weighted TEU costs for a single route in any given year vary according to the fleet distributions that can be accommodated under alternative project depths. As an example, table 32 presents the projected fleet distributions and the annual weighted costs for the without project condition (45 ft MLW channel depth) and alternative with project depths (46 ft MLW – 50 ft MLW) for the Northern European route in the year 2010.

D175. Table 33 illustrates the calculations used to estimate the transportation cost savings for alternative channel depths for TEUs on the Northern Europe route in 2010. The weighted costs per TEU are taken from Table 32. The total TEUs for the Northern Europe route in 2010 are estimated in the commodity forecast (see The Future Commodity Movement section). The process presented in table 33 is repeated for each of the 4 routes contributing to transportation cost savings (Northern Europe, Far East, Southeast Asia, Middle east) and for each year of the study period (2010 – 2060). The results of the calculations illustrated in table 33 are then discounted at the federal interest

rate (6.875%) and summed. Average annual equivalent cost savings are calculated to facilitate comparisons among alternative project depth and project segment combinations.

Table 32
For Alternative Channel Depths: 2010

Sailing Drafts	Raw Cost Per TEU	Channel Depths (ft MLW) 45'	46'	47'	48'	49'	50'
33	$94.46	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
34	$90.05	2.91%	2.18%	1.75%	1.46%	1.25%	1.09%
35	$86.10	2.91%	2.18%	1.75%	1.46%	1.25%	1.09%
36	$86.05	2.91%	2.18%	1.75%	1.46%	1.25%	1.09%
37	$80.92	8.56%	2.18%	1.75%	1.46%	1.25%	1.09%
38	$78.68	8.56%	8.56%	1.75%	1.46%	1.25%	1.09%
39	$76.64	8.56%	8.56%	8.56%	1.46%	1.25%	1.09%
40	$68.75	8.56%	8.56%	8.56%	8.56%	1.25%	1.09%
41	$61.65	28.51%	8.56%	8.56%	8.56%	8.56%	1.09%
42	$59.70	28.51%	28.51%	8.56%	8.56%	8.56%	8.56%
43	$58.27	0.00%	28.51%	28.51%	8.56%	8.56%	8.56%
44	$56.79	0.00%	0.00%	28.51%	28.51%	8.56%	8.56%
45	$53.48	0.00%	0.00%	0.00%	28.51%	28.51%	8.56%
46	$50.47	0.00%	0.00%	0.00%	0.00%	28.51%	28.51%
47	$48.04	0.00%	0.00%	0.00%	0.00%	0.00%	28.51%
48	$45.92	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Totals		100%	100%	100%	100%	100%	100%
Weighted Cost Per TEU		$68.33	$65.58	$63.00	$59.95	$56.94	$54.48

Table 33
Transportation Cost Savings for Alternative Channel Depths
Northern Europe Route: 2010

	Channel Depth (ft MLW) 45'	46'	47'	48'	49'	50'
Weighted Cost Per TEU (A)	$68.33	$65.58	$63.00	$59.95	$56.94	$54.48
Total TEUs (B)	776,418	776,418	776,418	776,418	776,418	776,418
Total Transportation Costs (A * B = C)	$53,052,642	$50,917,492	$48,914,334	$46,546,259	$44,209,241	$42,299,253
Transportation Cost Savings	---	(45'–46') $2,135,150	(45'–47') $4,138,308	(45'–48') $6,506,383	(45'–49') $8,843,401	(45'–50') $10,753,389

Comparative Benefit Assessments

Introduction

D176. Navigation improvements to the Port are allocated to project segments which are pathways to individual terminal facilities. Alternative plans are formulated as combinations of pathways. As mentioned above, benefits (and net benefits in the plan formulation process) are estimated for individual segments both independently and collectively.

Independent Segment Benefits

D177. The average annual equivalent benefits of independent channel segments at alternative channel depths are presented in Table 34. These benefits are calculated under the assumption that each segment is the only segment deepened to alternative channel depths and therefore cannot be summed as a meaningful representation of multiple project segment benefits. Although these benefit estimates are instructive of the benefit potential of each project segment, they do not indicate the comparative benefits of implementing one alternative plan versus another.

Multiple Segment Benefits

D178. Benefit assessments are calculated under the assumption that terminal capacities are cumulative. The combined throughput capacity of all of the project segments equals the total TEU capacity of the Port, which may be greater or less than the projected quantity of container handling services (measured in TEUs) demanded. However, all terminals may not be used at full capacity during some years, especially early in the planning horizon. No additional transportation cost savings were calculated for any excess capacity, once total demand was satisfied.

Table 34
Average Annual Equivalent Benefits for Alternative Channel Depths
Independent Pathway Estimates (Million $)

		Channel Depth (ft MLW)					
		45'*	46'	47'	48'	49'	50'
Port Newark/ Port Elizabeth (PNE)	*Marginal*	---	*22.2*	*18.3*	*20.1*	*19.7*	*18.7*
	Total	---	22.2	40.5	60.6	80.3	99.0
Port Jersey (PJ)	*Marginal*	*53.5*	*6.5*	*5.4*	*6.0*	*5.8*	*5.5*
	Total	53.5	60.0	65.4	71.4	77.2	82.7
Howland Hook (HH)	*Marginal*	*27.1*	*3.2*	*2.7*	*2.9*	*2.9*	*2.7*
	Total	27.1	30.3	33.0	35.94	38.83	41.6
South Brooklyn (SB)	*Marginal*	*12.9*	*3.0*	*2.4*	*2.7*	*2.7*	*2.4*
	Total	12.9	15.9	18.3	21.0	23.7	26.1

* Includes benefits due to deepening from 41 ft MLW to 45 ft MLW

D179. The effects of cumulative terminal capacities are illustrated in the following example. At 50 ft MLW, the total average annual equivalent benefits of combining the Port Newark – Port Elizabeth (PNE) and Port Jersey (PJ) segments would be $181.6 ($99.0 + $82.6 = $181.6) if one simply added the benefits estimated for the individual segments. However, by taking into account the excess TEU capacity that this combination provides in the early years of the project life, the more accurate benefit estimate becomes $177.3, which is a reduction of $4.3 ($181.6 - $177.3 = $4.3). The average annual equivalent benefits of multiple project segments at alternative channel depths are presented in Tables 35 – 37.



BENEFIT ASSESSMENT OF ALTERNATIVE PLANS

Introduction

D180. This section of the Economics Appendix presents the incremental benefits of the alternative plans. This section continues with a discussion of the of the multi-port analysis. The section closes with a discussion of the sensitivity analyses performed for the study and their results. Benefit-cost analyses performed for the various increments of project depths and channel segments are presented in the Plan Formulation Appendix.

D181. The benefit estimates used in the following analyses are developed and presented in The Economic Benefits of Navigation Improvements section of this appendix The incremental approach to identifying the NED plan uses marginal analysis to identify the optimal plan, *i.e.*, the alternative plan that maximizes net excess benefits. This approach assesses the benefits and costs of each incremental foot of channel deepening for each project segment, as described in the Plan Formulation Appendix.

Incremental Benefit Method

Introduction

D182. Navigation improvements to the Port are identified for numerous project segments that include the existing navigable channels in the Port. Combinations of these project segments are identified as pathways to the four container terminal areas in the Port: Port Elizabeth/Port Newark, Port Jersey, South Brooklyn, and Howland Hook. Individual pathways contain some common project segments, for example, Ambrose Channel is common to all pathways and the Kill Van Kull is common to Port Elizabeth/Port Newark and Howland Hook.

D183. The benefits of deepening each project segment are calculated for one foot increments starting at the without project depth for each project segment and continuing to the depth at which project benefits decline. The optimal alternative plan is the project segment/channel depth combination that maximizes total net excess benefits. There are numerous potential alternative plans. The method and procedure used to identify the optimal plan is briefly described below.

Incremental Analysis Method

D184. Marginal analysis is used to identify the NED plan. In marginal analysis the universe of potential alternative plans (project segment/channel depth combinations) is dis-aggregated into discrete one foot depth increments for each project segment. Applying marginal analysis requires the calculation of the additional (marginal) benefits and costs associated with the implementation of each discrete increment. Alternative plans are developed as combinations of discrete increments. Discrete increments that contribute the most net excess benefits of all other available discrete increments are

identified as components of the optimal plan. The optimal plan is the sum of the net excess benefit maximizing discrete increments.

D185. Benefits only accrue to a project segment/channel depth combination when that combination includes a terminal facility. For example, there are no calculated benefits resulting from only deepening Ambrose Channel. This practicality causes the marginal analysis to begin with the comparison of the net excess benefits accruing to each individual pathway. The individual pathway providing the most net excess benefits is identified as the base element (or first added element) of the optimal plan. The benefits of deepening the individual pathway are presented in Table 34 above.

D186. The next component of the optimal plan is identified as the additional discrete increment (or combination of discrete increments if the single discrete increment does not reach a terminal facility) that adds the largest possible contribution to total project net excess benefits. If the maximum contribution of the next component is negative, the optimal plan would simply be the pathway identified as the base element.

D187. The contribution to gross benefits generated by pathways as added elements are less than the contribution to gross benefits generated by these same pathways as individual elements. This difference is due to the operational and capacity constraints of the terminal facilities in the harbor as discussed in The Economic Benefits of Navigation Improvements section. The incremental benefits used in assessing the second added element are presented in Table 35.

D188. As long as the maximum net excess benefits accruing from additional discrete increments remain positive, those additional increments are included into the optimal plan. Decision points in the analysis occur at the level of discrete increments. At each decision point the selected discrete increment is the net benefit maximizing increment. The iterations end and the optimal plan is identified when there are no more positive net excess benefits to be added. Tables 36 and 37 present the incremental benefits of the third and fourth added elements.

Table 35
Average Annual Equivalent Benefits for Alternative Channel Depths
Second Added Pathway Estimates (Million $)

		Channel Depth (ft MLW)				
		46'	47'	48'	49'	50'
Port Newark/ Port Elizabeth (PNE)	*Marginal*	*81.2*	*22.9*	*25.2*	*24.7*	*23.4*
	Total	81.2	104.1	129.3	153.9	177.3
Howland Hook (HH)	*Marginal*	*90.4*	*8.1*	*8.9*	*8.7*	*8.2*
	Total	90.4	98.5	107.4	115.9	123.7
South Brooklyn (SB)	*Marginal*	*76.0*	*7.8*	*8.7*	*8.5*	*7.9*
	Total	76.0	83.8	92.4	100.9	108.8

Table 36 Average Annual Equivalent Net Excess Benefits for Alternative Channel Depths Third Added Pathway Estimates (Million $)						
		Channel Depth (ft MLW)				
		46'	47'	48'	49'	50'
Port Newark/ Port Elizabeth (PNE)	*Marginal*	*97.2*	*25.4*	*27.9*	*27.4*	*25.9*
	Total	97.2	122.6	150.5	177.9	203.8
Howland Hook (HH)	*Marginal*	*106.5*	*10.4*	*11.4*	*11.2*	*10.5*
	Total	106.5	116.4	127.8	139.0	149.5

Table 37 Average Annual Equivalent Net Excess Benefits for Alternative Channel Depths Fourth Added Pathway Estimates (Million $)						
		Channel Depth (ft MLW)				
		46'	47'	48'	49'	50'
Howland Hook (HH)	*Marginal*	*126.0*	*26.8*	*29.5*	*29.0*	*27.3*
	Total	126.0	152.8	182.2	211.2	238.5

NED Plan Identification

D189. The NED plan is the sum of the four added elements that maximize total project net excess benefits. Through the use of marginal analysis the optimal plan for navigation improvements to the Port is identified as a 50 ft MLW channel to each of the four pathways: Port Elizabeth/Port Newark, Port Jersey, South Brooklyn, and Howland Hook (see the Plan Formulation Appendix). Any alternative plan that does not include each of these added elements is sub-optimal because it would leave positive net excess benefits unrealized.

Multi-Port Analysis

Introduction

D190. Estimates of transportation cost savings and identification of the NED plan were done within the context of a multi-port analysis. Multi-port analysis is defined in the NED Procedures Manual (IWR Report 91-R-13, p. 155) as "a systematic assessment of the effects of the with project condition on other ports". In this systematic assessment traffic forecasts are adjusted to account for diversion of traffic to or from competing ports resulting from navigation improvements in the Port and from authorized projects at other ports. Multi-port analysis focuses on commodities destined for or originating from competitive hinterlands that can be handled at alternative ports. The overall objective of the multi-port analysis is to improve fleet forecasts and commodity movement projections by accounting for the potential for cargo traffic to move to the least cost port.

D191. The competitive hinterlands of the Port serve as the origin or destination for a relatively small percentage of overall commodity traffic. A large distribution network of

warehouses, regional and national distribution centers, and infrastructure has been built around the Port. As discussed in The Existing Conditions section, approximately 70% of all commodity movements are destined for or arrive from the greater New York Metropolitan area. Approximately 82% of all commodity movements have their origin or destination with in a 260 mile radius of the port.

Application

D192. The commodity projections used in this analysis include the effects of multi-port adjustments. As discussed in The Existing Conditions section, the core hinterlands of the harbor are expected to show slower growth in population, employment, and income compared to the rest of the nation. This slower growth is incorporated into the commodity projections for the harbor. Similarly, the current major international trade region of the harbor, Northern Europe, is expected to exhibit slower growth than other trading areas, such as South East Asia, that have larger presence at competing ports. Uneven growth in trade regions is also incorporated into the commodity projections. The combination of these factors causes traffic volume at the Port to grow at a slower rate than traffic at other ports and causes the harbor to lose market share over the course of the study period.

D193. The fleet forecast was also developed using the concepts of multi-port analysis. The fleet forecast recognizes that other ports have a competitive advantage, due to their location, to accommodate the world's largest containerships. When the world's largest containerships enter service they generally do so on Trans- Pacific routes where distances are greater and hub service is currently more readily available. The fleet forecast does not include the soon to enter service 10,000+ TEU vessels. These vessels are not included in the Port's fleet forecast because it is anticipated that the Port is at a geographic disadvantage with regard to vessels of this size creating a high level of uncertainty concerning the timing of their deployment to the Port.

Other Considerations

D194. A recent PANYNJ study indicates that the Port's market share of the competitive hinterland is very sensitive to waterborne transportation costs, trucking and rail costs, and delivery time. Relatively small changes in any of these factors may cause an increase or decrease in market share. The potential instability of market share at the fringe of the Port's hinterland increases the uncertainty of predictions in this area. Given that 1) the competitive hinterland accounts for a small portion of overall commodity traffic volume at the Port, 2) the effects of macro economic changes regarding the Port's market share are included in the commodity forecast, 3) the effects of the geographic dis-advantage of the Port are included in the fleet forecast, and 4) the high level of uncertainty concerning market share projections for the fringe hinterlands, no projections of commodity traffic diversions were attempted for this analysis.

Sensitivity Analysis

Introduction

D195. This sensitivity analysis examines the influence of critical factors on project benefits. In sensitivity analysis, varying critical factors identifies the conditions under which alternative plans are justified. Sensitivity analysis is used to address the uncertainty in the most significant inputs of the benefit-cost analysis. The criteria for selecting the critical factors included in the sensitivity analysis are the level of influence on selection of the NED plan and uncertainty of input values.

D196. Overall, this analysis of the benefits of navigation improvements to the Port has been structured to reduce the influence of uncertain factors. As stated in The Economic Benefits of Navigation Improvements section, many sources of benefits have been identified, but due to the high degree of uncertainty associated with monetizing those benefits, only the transportation cost savings on four out of fourteen shipping routes are used to calculate project benefits. The resulting benefits represent an estimate of the minimum level of benefits generated by the project.

D197. Two critical factors are included in the sensitivity analysis: the commodity projections and the fleet forecast. Commodity projections have a high level of influence on project benefits because they are directly used in the calculations of capacity constraints in the harbor and in the calculations of transportation cost savings. Although the commodity projections are the product of a state of the art forecasting model, there remains a significant degree of uncertainty in the estimates, especially in the outer years. The fleet forecast strongly influences benefit calculations because the projected fleet mix directly affects transportation costs. Uncertainty in the fleet forecast is the product of the many unspecified factors that influence the decisions of the shipping industry.

Commodity Projections

D198. Commodity projections are developed and presented in The Future Commodity Movement section. The nature of current and projected commodity traffic through the Port is that there is no single commodity that dominates containerized trade. Similarly, there is no single trading partner or trade route with an extraordinary influence on containerized trade. Also, the relative significance of individual commodities and trading partners is expected to shift over the course of the study period. In consideration of these factors, the sensitivity analysis identifies the effects of reducing the annual growth rate of total projected commodity flows.

D199. The commodity projections used in the benefit analysis exhibit varying levels of growth in the near, mid, and long term. The overall average annual rate of commodity growth throughout the study period is 3.3%. Table 40 presents annualized benefits resulting from annual growth rates of 0% - 3%. The NED plan exhibits positive benefits under each commodity growth scenario addressed in the sensitivity analysis, including

the no growth scenario. The no growth scenario is the most extreme and least reasonable of the sensitivity analysis scenarios because of the highly unlikely and desperate regional, national, and international economic conditions that would cause no growth in Port commodity volumes for 50 years.

Table 38
Average Annual Equivalent Values for the NED Plan
At Various Annual Growth Rates for Commodity Traffic (Million $)

Annual Growth Rate	Benefits
3.3% (forecast)	$238.5
3.0%	$203.6
2.0%	$184.8
1.0%	$163.5
0.0%	$157.0

Fleet Forecast

D200. The fleet forecast sensitivity analysis identifies the impact of reducing the proportion of TEUs projected for the largest vessels in the fleet. As described in The Projected Containership Fleet section, the forecasted fleet for each of the four trade routes used to calculate benefits is composed of small, mid, and large size vessels. This sensitivity analysis shifts a proportion of TEUs from large size vessels into mid size vessels. Reductions of large size vessel TEUs are calculated at 5% increments from 5% - 15%. The results of the sensitivity analysis are presented in Table 41. The NED plan exhibits positive benefits under each fleet forecast scenario addressed in the sensitivity analysis.

Table 39
Average Annual Equivalent Values for the NED Plan
At Various Fleet Mix Specifications (Million $)

Large Vessel Reduction	Benefits
0.0% (forecast)	$238.5
5.0%	$232.9
10.0%	$230.5
15.0%	$220.8

FEASIBILITY REPORT

for

New York and New Jersey Harbor Navigation Study

Appendix E
Channel Design

December 1999

US Army Corps
of Engineers
New York District

NEW YORK AND NEW JERSEY HARBOR NAVIGATION STUDY

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NEW YORK AND NEW JERSEY HARBOR NAVIGATION STUDY

CHANNEL DESIGN APPENDIX

INTRODUCTION

Existing Federal Channels

General

E1. The Harbor's waterways are intensively used navigation channels for both commercial and recreational vessels. The Corps of Engineers presently maintains about 240 miles of navigation channels within the port. Additional channels are also maintained by the Port Authority of New York and New Jersey (PANYNJ), the City of New York, and various commercial interests. **Figure E1** shows the study area and the existing navigation channels within the port. Those channels of interest to this study are described in detail below.

Ambrose Channel

E2. Ambrose Channel is the entrance channel to New York Harbor. From the sea buoy to the Narrows in the Lower Bay, Ambrose Channel extends 10.2 miles at a width of 2000 ft. Two bends in the channel, 27.6 and 23.4 degrees at mile 7.5 and 8.5, respectively, align the channel from its approach course of 296deg,58'true into the Narrows. Ambrose Channel is flanked by East Bank Shoal on the east and West Bank and Romer Shoals on the west, all of which are approximately 10 to 15 ft deep. The authorized depth is 45 ft mlw, but actual depths are greater in many locations due to commercial sand mining. Traffic in Ambrose Channel is two-way for deep draft vessels, with occasional overtaking of one vessel by another in the same direction.

Anchorage Channel

E3. Anchorage Channel, 2000 ft in width, is the primary channel in the Upper Bay. It links Ambrose Channel through the Narrows with Kill Van Kull and Port Jersey Channels and Stapleton Anchorage to the west, the Hudson River and East River Channels to the north and Bay Ridge, Red Hook and Buttermilk Channels and Red Hook Anchorages to the east. Virtually all vessel movements through the Harbor utilize Anchorage Channel. The authorized depth is 45 ft, however the naturally scouring portions in the Narrows have depths of up to 100 ft.

New York and New Jersey Channels

E4. New York and New Jersey Channels is a 31mile long channel between Staten Island, New York and New Jersey. The channel extends from the Anchorage Channel in the Upper Bay to the Chapel Hill Channel in Sandy Hook Bay. This channel is comprised of the Kill Van Kull, Arthur Kill and Raritan Bay Channels, as described in the paragraphs below.

Kill Van Kull

E5. The Kill Van Kull is an 800 ft wide channel (with additional widenings in the bends, 2000 ft at entrance), approximately 5.3 miles in length, that links the Upper Bay to the east with Newark Bay and the Arthur Kill to the west. The Kill Van Kull is the segment of the New York and New Jersey Channels along the north shore of Staten Island that separates Staten Island, New York and Bayonne, New Jersey. The channel has 9 bends which range from 13.6 to 33.7 degrees. At the western limit, vessels entering Newark Bay must negotiate a severe 126degree bend at Bergen Point. Although authorized to 45 ft mlw, the present depth is 40 ft. Construction to deepen the channel to 45 ft is currently underway. Traffic in Kill Van Kull is two-way, however post-panamax vessels will choose optimum locations for passing where both vessels can readily maneuver to the outer portions of the channel.

Newark Bay Channels

E6. The Newark Bay Channels are comprised of the Main Channel (South, Middle and North Reaches) plus numerous access channels (South Elizabeth Channel, Elizabeth Channel, Port Newark Pierhead Channel and Port Newark Channel). Together, these channels service over 60 berths at the Port Newark/Elizabeth Marine Terminal on the west shore of Newark Bay. The Main Channel varies in width from 800 ft opposite Port Newark to 2200 ft in the Bergen Point Bend. In addition to providing access into Newark Bay from the Kill Van Kull, the Bergen Point Bend is also used as a turning basin for containerships backing into or out of the Arthur Kill. A 1550-1830 ft combined channel/maneuvering area opposite Port Elizabeth provides unrestricted access to the Elizabeth Pierhead berths. Access channels vary in width from 290 ft at South Elizabeth to 500 ft at Port Newark. Construction to deepen Newark Bay Channels from their current depth of 40 ft to 45 ft is scheduled to be completed in 2004. With the exception of the bend at Bergen Point, traffic in the Main Channel is two-way. Although the Bergen Point Bend was originally designed to permit two way (deep + shallow) traffic, current practice indicates that smaller vessels will hold, to allow unrestricted movement for deep draft vessels through the bend. Traffic in the access channels is limited to one way.

Arthur Kill

E7. The Arthur Kill is a 13.2. mile segment of the New York and New Jersey Channels along the west side of Staten Island which separates Staten Island, NY from Union and Middlesex Counties, NJ. The reach under consideration for this study extends from Newark Bay, where it connects with the Kill Van Kull and Newark Bay Channels, 2.4 miles to Howland Hook. The existing channel, with a depth of 35 ft, varies in width from 500 to 600 ft. Improvement to deepen the Arthur Kill to Howland Hook Reach to 41ft and widening portions to 800 ft are in the final design phase and are considered to be in place for the without project condition. There are two bends in the project reach: a 16 degree bend in the North of Shooters Island Reach, and a 35 degree bend between the North of Shooters Island reach and the Elizabethport reach. Deep draft traffic in the project reach is essentially one way, however in the straight portion of the North of Shooters Island reach, vessels occasionally may pass in accordance with fair tide rules. Typically, tanker traffic is inbound only, with light tankers departing southbound through Raritan Bay. Containerships bound for the Howland Hook Marine Terminal will either turn at Bergen

Point and back into port, or back out of port, turn at Bergen Point and proceed outbound through Kill Van Kull.

Raritan Bay Channels

E8. The Raritan Bay portion of the New York and New Jersey Channels is a 12.5 mile segment that connects the Arthur Kill at Perth Amboy to the Chapel Hill Channel in the Lower Bay. The 35 ft deep channel, which varies in width from 600 to 800 ft, is outside the limit of this study.

Port Jersey Channel

E9. The existing Port Jersey channel is a non-federal channel, approximately 35 ft deep, which provides access to the Global Marine Terminal and the North East Auto Terminal (NEAT) on the north and the Marine Ocean Terminal at Bayonne (MOTBY) to the south. At the head of the channel there is a 1200 ft diameter turning basin. Within this channel, the Port Authority of New York and New Jersey has constructed a 200 ft wide, 38 ft deep channel to Global Marine Terminal. Deep draft traffic in Port Jersey Channel is one way. Smaller containerships turn in the turning basin; however, larger ships turn in Anchorage Channel and back into port, or back out of port and turn in Anchorage Channel, depending on which side of the ship is needed to face the berth.

The Channel along New Jersey Pierhead Line

E10. The Channel along New Jersey Pierhead Line is a 3 mile long channel connecting the Kill Van Kull with the Anchorage Channel south of Liberty Island. The 20 ft deep channel is 500 ft wide, with additional widening to 800 ft at the bends.

Claremont Channel

E11. Claremont Channel is an existing non-federal channel , approximately 27 ft deep and 300 ft wide, extending west from Anchorage Channel in the Upper Bay. Claremont Channel provides access to the scrap metal facilities at Claremont Terminal.

Bay Ridge & Red Hook Channels

E12. Bay Ridge & Red Hook Channels is a 4 mile long channel adjacent to the South Brooklyn waterfront. The Bay Ridge Channel, 40 ft deep, is 1200 ft wide from the Narrows to Bay Ridge Ave (~1 mile), and 1750 ft wide from Bay Ridge Ave to the junction with Red Hook Channel (~2 miles). Red Hook Channel is 1200 ft wide to the junction with Buttermilk Channel (~1 mile). The widths in Bay Ridge Channel are adequate to support vessels perpendicular to the channel maneuvering into the finger piers along the Brooklyn waterfront with sufficient channel available to permit vessels to pass. However, most of these piers are no longer in use and one way traffic would be adequate.

Buttermilk Channel

E13. Buttermilk Channel is a 1000 ft wide channel, 2.3 miles long , that connects Anchorage Channel to the East River through the waterway between Brooklyn and Governors Island. The

eastern 500 ft of the channel is 40 ft deep; the western 500 ft is 35 ft deep. Additional widenings at the junctions of the East River and Anchorage Channel at a depth of 35 ft are provided for vessel maneuverability at the bends.

Red Hook Flats Anchorage

E14. Red Hook Flats Anchorages, immediately east of Anchorage Channel in the Upper Bay, are comprised of 3 anchorage areas. Area 21A, a barge anchorage, is restricted to vessels with a draft less than 12 ft. Area 21B, with a depth of 35 ft, is restricted to vessels with a draft less than 34 ft. Area 21C, with a depth of 40 north of the Con Hook Range and 45 ft south of the Con Hook Range, is restricted to vessels over 33 ft in draft.

Stapleton Anchorage

E15. Stapleton Anchorage, immediately west of Anchorage Channel in the Upper Bay, is comprised of 3 anchorage areas. Area 23A is restricted to vessels less than 670 ft in length. Area 23B is restricted to vessels greater than 670 in length. Area 24 is restricted to vessels greater than 800 ft in length and 40 ft in draft. Actual depths in Stapleton range from 40 ft in the north (Area 23A) to over 70 ft near the Verrazano-Narrows Bridge (Area 24). Vessels may anchor in Stapleton Anchorages for no more than 48 hour. Stapleton Anchorage is not a Federal Anchorage, and therefore is not maintained by the Corps.

Gravesend Anchorage

E16. Gravesend Anchorage, located immediately east of Ambrose Channel, just south of the Verrazano-Narrows Bridge in the Lower Bay, is an unrestricted anchorage area with a depth of 47 ft. Being outside of the Upper Bay and subject to a more energetic wave climate, as well as being farther from all port facilities, Gravesend Anchorage has become the anchorage of last resort. It is only used if no anchorage space is available at Red Hook Flats or Stapleton Anchorages in the Upper Bay.

E17. **Table E1** summarizes the baseline data for the existing navigation channels and anchorage areas.

Table E1 Existing Navigation Channels and Anchorage Areas				
	Depth (ft MLW)		Width , W/O Project (ft)	
Channel	Existing	W/O Project	Channel	Max in Bend/ Entrance
Ambrose	45	Same as exist.	2000	2000
Anchorage	45	Same	2000	2000
Kill Van Kull	40	45	800	2000
Newark Bay Main (South & Middle Reach)	40	45	800	2200
NB Port Elizabeth Channels	40	45	290-500	800
NB Port Newark Channels	40	Same	290-500	800
Arthur Kill to Gulfport	35	41/40	500-800	800
AK Gulfport to Perth Amboy	35	Same	500 – 600	800
Bay Ridge and Red Hook	40	Same	1200-1750	1750
Buttermilk	35/40	Same	1000	2100
Port Jersey	38	41	370	1500
Claremont	27	Same	300	600
NJ Pierhead	20	Same	500	800
Red Hook Anchorage	35/40/45	Same		
Gravesend Anchorage	47	Same		
Stapleton Anchorage	40-70	Same		

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PHYSICAL CONDITIONS

Climate

E18. New York Harbor has a predominantly continental climate of warm summers and cool winters with some maritime influence. This results in frequent short-term meteorological changes. Southeast winds, often in the form of local sea breezes, have a moderating effect on temperature, particularly during the spring and summer months.

E19. General climatic conditions in New York Harbor are described herein from National Weather Service surface observations at nearby Newark Airport. They are based upon 68 years of records as summarized in the NOAA National Climatic Data Center – Local Climatological Data Annual Summary. Predominating winds are from the Southwest. Winds from the Southwest are prevalent from May to December; winds from the Northwest are prevalent from January to April. The average annual wind speed is 10.2 mph, with calm winds occurring 2.9% of the time.

E20. The mean annual temperature is 54.1 degrees F, with the maximum extreme of 105 degrees F occurring in July 1993, and minimum extreme of –8 degrees F occurring in January 1985. Temperatures of 90 degrees F and above occur, on the average, of 23 days/year, while temperatures of 0 degrees or less occur less than 1 day/year. The average relative humidity measures 64%.

E21. The average annual precipitation is about 43 inches/year and is distributed equally throughout the year. The mean average snowfall is 27.4 inches/year. Snowfall of 1 inch or more occurs on about 7 days/year. Occurrences of light freezing rain and drizzle average a total of about 6.9 and 7.2 days/year, respectively. Heavy fog occurs on the average of 16 days/year.

Tides

E22. The tide in New York Harbor is semi-diurnal, with a period of approximately 12.4 hours. In each tidal day of 24.8 hours, two high tides and two low tides occur, with one of the high tides higher than the other. The mean tide range at the Battery is 4.56ft, the spring tide range is 5.52 ft. The highest observed tide at the Battery was 10.23 ft above mlw, occurring on 9/12/60 (Hurricane Donna). The lowest observed tide level was –4.07ft mlw, occurring on 2/2/76. The plane of mean low water (mlw) is 1.66 ft below the National Geodetic Vertical Datum (NGVD) 1929; mean lower low water (mlw) is 1.88 ft below NGVD. Tide ranges at various locations through out New York Harbor and their relative time differences, extracted from the NOAA-NOS Tide Tables 1999, are provided in **Table E2** below.

Currents

E23. Tidal currents in New York Harbor are moderate, with average maximum flood currents ranging from 0.6 to 1.8 knots, and average maximum ebb currents ranging from 0.4 to 2.3 knots. At the Narrows, ebb currents are typically stronger than flood currents, with a maximum ebb current of 2.7 knots coinciding with spring tide. At Bergen Point, flood currents are typically

Table E2 Tide Data				
	Tide Range (ft)		Time Difference (h:mm)	
Location	Mean	Spring	High Water	Low Water
The Battery	4.56	5.52	0	0
Ft. Hamilton/ The Narrows	4.7	5.7	-0:26	-0:22
Bayonne Br/ Bergen Point	5.0	6.05	-0:07	+0:05
Port Newark	5.1	6.1	+0:03	+0:21
Sandy Hook	4.66	5.60	-0:28	-0:29

stronger than ebb, with the maximum flood currents of up to 2.6 knots coinciding with spring tide. High water slack tide at the Narrows occurs approximately 1.5 hours after high water at the Battery; high water slack tide at Bergen Point occurs approximately 1 hour before high tide at the Battery. The currents at Ambrose Light are weak, averaging 0.2 knots. Extracted from the NOAA-NOS Tidal Current Tables 1999, tidal currents at various other locations through out New York Harbor and their relative time differences are provided in **Table E3** below.

Salinity

E24. Seasonal salinity variations within the New York Harbor estuary are primarily a function of the variation in the fresh water discharges of the Hudson River (and Passaic and Hackensack Rivers to a lesser extent), with the lower salinity levels in the spring and summer correlating directly with the high spring runoff. The harbor can be considered well mixed with bottom levels slightly higher than surface concentrations. Salinity concentrations can vary by several parts per thousand (ppt) throughout the tidal cycle.

E25. In the Upper Bay, typical salinity concentration of 25 - 28 ppt occur during low flow conditions and drop to 20 – 25 ppt during periods of higher freshwater discharges. Within the Arthur Kill, salinity levels range from a low of 12 ppt to a high of 20 ppt.

Table E3 Current Data				
	Ave Max Current (knots)		Time Difference (h:mm)	
Location	Flood	Ebb	Flood	Ebb
Ambrose Chan. @ Transect	1.6	1.7	-1:10	-0:07
The Narrows	1.7	2.0	0	0
Anchorage Chan. Near Red Hook	1.3	2.3	1:06	0:52
Bergen Point @ Bayonne Bridge	1.8	1.4	-2:13	-1:44
Kill Van Kull @ Con. Hook	1.3	1.9	-2:08	-1:43
Arthur Kill @ Elizabethport	1.4	1.1	-0:09	+0:04
Newark Bay @ South Reach	0.7	0.7	-1:45	-1:06

Sedimentation

Sources

E26. Sedimentation within Ambrose Channel is caused primarily by offshore wave energy which produces the westward littoral transport of sand along the south shore of Long Island as well as the northward littoral transport along the New Jersey shore and Sandy Hook. This wave energy also results in the movement of sand across the East Bank Shoal on the east side of Ambrose Channel and Romer Shoal south west of Ambrose Channel, which deposits into Ambrose Channel.

E27. Estuarine sediments within New York Harbor have a variety of sources. For the interior channels within the New York Harbor estuary, the primary sources of sediment are the Hudson, Passaic and Hackensack Rivers as well as other tributary rivers, and wastewater discharges from combined sewer outfalls (CSO's) and storm sewers. To a lesser extent, the resuspension of bottom sediments and local runoff contribute sediment as well.

Rates

E28. Sedimentation rates were developed from the New York District navigation channel maintenance dredging records. The dredging records include dates, pay quantities dredged, and locations for both maintenance dredging and new work construction for most of the channels within the Port. Typically, the time period for the analyses began with the most recent new work construction, since any shoaling rates prior to that time would not be applicable to the current channel configuration. The average maintenance rate was determined by dividing the total volume of maintenance material removed by the number of years between the last maintenance operation and the last new work construction. Historically, the pay yardage (the material within the channel prism plus paid overdepth) was recorded rather than gross yardage (total material removed). (Most recent records include both pay and gross volumes). Utilizing the gross yardage in the analyses would better predict the actual sedimentation rate. However, the pay yardage was used since it is more suited for determining the cost of the channel maintenance, and with that, the increased channel maintenance cost due to the channel deepening.

E29. Ambrose Channel was last improved in 1952. Between 1952 and 1984, 20 separate maintenance operations were performed, resulting in an average annual maintenance rate of approximately 400,000 cy/yr. Since 1984, sand mining within or adjacent to Ambrose Channel has eliminated the need for maintenance dredging. Currently there are approximately 371,000 CY of maintenance material within the channel prism.

E30. Anchorage Channel was last improved in 1953. Between 1953 and 1973, 4 separate maintenance operations resulted in an average maintenance rate of 22,000 cy/yr. for that time period. Anchorage channel has not required maintenance dredging since 1973. Currently there are approximately 12,000 CY of maintenance material within the channel prism.

E31. Kill Van Kull was last improved in 1994 when it was deepened to 40 ft. Since that time, no maintenance dredging has been performed. However, in 1997, a reprofiling operation leveled approximately 4,000 CY. (Reprofiling consists of dragging a heavy beam over the channel bottom to eliminate high shoals).

E32. Newark Bay was last improved in 1990, when it was deepened to 40 ft. Since that time, two maintenance operations have occurred. In 1997, 205,000 CY were removed from the South Elizabeth and Elizabeth Pierhead Channels, and in 1998, 416,000 CY were removed from the Elizabethport Channel. This results in an average shoaling rate of 78,000 cy/yr.

E33. Arthur Kill (N. Shooters Is to Gulfport) was last improved in 1962. The Shooters Island Dike was rehabilitated in 1964. Since that time, there have been 6 maintenance operations in the North of Shooters Island Reach, resulting in an average shoaling rate of 82,000 cy/yr. The Elizabethport and Gulfport reach was maintained in 1984 and then most recently in 1999, resulting in an average shoaling rate of approximately 5000 cy/yr.

E34. Bay Ridge and Red Hook Channels were last improved in the 1940's. Since 1960, there have been 27 maintenance operations, resulting in an average annual maintenance rate of approximately 520,000 cy/yr.

E35. Port Jersey Channel is not a Federal Channel. A 200 ft wide channel was deepened to 38 ft by the locals in 1998. The base condition of Port Jersey Channel is assumed to be the 41 ft channel as proposed in the 1992 GDM. Prior to the last deepening, sedimentation rates for the 35 ft channel were calculated to be .15 in/yr. The GDM predicted a sedimentation rate of .21 in/yr. for the 41 ft channel, which would result in a maintenance rate of approximately 58,000 cy/yr.

E36. Claremont Channel is not a Federal Channel. No historic dredging records are available. The 1992 GDM predicted a sedimentation rate of .16 in/yr. for the existing channel, which would result in a maintenance rate of approximately 25,000 cy/yr.

E37. NJ Pierhead Channel was last improved in 1961. The channel was maintained in 1964 and 1973, resulting in an average maintenance rate of 40,000 cy/yr. for that time period. The NJ Pierhead Channel has not been maintained since 1973.

E38. Bay Ridge Flats Anchorage was last improved in 1975. Since that time, there have been 8 maintenance operations resulting in an average maintenance rate of 145,000 cy/yr.

E39. Gravesend Anchorage was last improved in 1984. Since that time, there have been 4 maintenance operations resulting in an average maintenance rate of 28,000 cy/yr.

E40. **Table E4** contains a summary of maintenance requirements for the various channels within the Port. Greater confidence should be placed on the maintenance rates for those channels where long term dredging records over multiple dredging operations at the existing depths are available, such as Ambrose Channel, Bay Ridge Channel, Red Hook Flats Anchorage. The long term averages tends to eliminate the fluctuation in computed maintenance rates resulting from the inconsistencies in spatial extent and overdepth dredging in each maintenance operation. Short term rates developed from one or two maintenance operations will not be as accurate as long term rates for many reasons. A single maintenance operation that removes material from only a portion of the channel will not include material that may have shoaled in the remainder of the channel but is still below project depth. Also, the volume of overdepth material a dredging contractor removes may vary, resulting in different post maintenance and post new construction depths. Statistically, longer periods of record and more data are always preferred when developing long term trends.

E41. As can be seen in the summary table, the short term rates for the Kill Van Kull and Newark Bay do not agree well with the published information from the GDM. This may be due to the fact that portions of the Kill Van Kull and Newark Bay channels were constructed in rock or hard material which provided an additional 2 ft of safety clearance (down to –42 MLW). These channels would only require maintenance if they shoaled in above project depth (-40 MLW), allowing two ft of accumulation. In the short time frame since the new work construction was completed, this accumulated material tends to underestimate maintenance rates. The last column in the above table represents the best estimate of the without project (base) conditions shoaling rates based upon available data. Long term shoaling rates are utilized wherever available. For those channels recently improved, or channels where the base conditions are different from existing conditions, previously published data projected for the improved conditions or base conditions are used.

Table E4 Existing Maintenance Requirements						
Channel	Last Improv.	Last Maint'd	Average Mainten. Interval (years)	Average Mainten. Rate (Existing) (cy/yr.)	Previous Published Rate (Adj to Base) (cy/yr.)	Use (Base) (cy/yr.)
Ambrose	1951	1984	1.7 years	400,000		400,000
Anchorage	1953	1973	6.7	0		0 (1)
K V K Con Hook	1994	1997	3.0	1300	20,800	28,000
K V K Bergen Pt	1994	(1)			4,000	4000
Newark Bay Main	1990	(1)			211,000	211,000
NB Port Elizabeth	1990	1998	7.5	78,000	121,700	121,700
NB Port Newark	1990	(1)			226,200	226,200
AK N.Shooters Is	1962	1999	5.7	82,000	154,000	115000 (3)
AK Eliz. – Gulf	1964	1999	14	5,000	0	7000 (3)
Bay Ridge (+ RH)	1940	1992	1.2	520,000		520,000
Port Jersey	1998	1984	10 (4)		58,000	58,000
Claremont			12.5 (4)		25,000	25,000
NJ Pierhead	1961	1973	6.0	40,000		40,000
Red Hook Anch.	1975	1992	2.1	145,000		145,000
Gravesend Anch.	1984	1998	4.7	28,000		28,000
Stapleton Anch.	-	-	-	0		0

(1) No maintenance since last improvement
(2) Not maintained in past 25 years
(3) Existing rate adjusted to base conditions
(4) From previously published reports

CHANNEL DESIGN

Design Criteria

E42. The navigation channels in this study were designed in accordance with the guidelines and criteria contained in the following documents:

- EM 1110-2-1613 "Hydraulic Design of Deep Draft Navigation Channels", 8 April 1983, 8 January 1994 (Draft Revision)
- ER 1110-2-1404 "Hydraulic Design of Deep Draft Navigation Channels", 31 January 1996
- PIANC PTC II-30 "Approach Channels – A Guide for Design", June 1997

E43. In addition, numerous coordination meetings were held with the various pilot organizations (Sandy Hook Pilots, harbor pilots, docking pilots, etc), the US Coast Guard, and local sponsors to insure that the proposed channel improvements would provide the safest navigation for all vessels while meeting the needs of the port facilities and the maritime community.

Design Vessels

E44. The design vessels are based upon economic projections of the vessels most likely to call on the Port of New York and New Jersey in the near future. Two design vessels were selected to represent the future fleet – a Maersk K-Class container ship and a Suezmax tanker. The dimensions of these design vessels are provided in **Table E5**.

Table E5
Design Vessel Dimensions

Vessel	Maersk K-Class	Suezmax	Maersk Extended K-Class
Type	Container Ship	Tanker	Container Ship
Maximum Draft	46 ft	55 ft	48 ft
Length Overall (loa)	1044 ft	926 ft	1138 ft
Length between Perpindiculars (lpp)	991 ft	880 ft	1088 ft
Beam	140 ft	144 ft	140 ft

E45. Also included in the table are the dimensions of the Maersk Extended K-Class container ship. Although not considered as a design vessel for this study at this time, a check was made to determine if the extended K-class vessel could use the proposed channels. The draft of this ship is 2 ft greater

than the design vessel. This could safely transit the proposed 50 ft channels if it light loaded to a draft of 46 ft, or if it scheduled its transits to coincide with 2 ft of additional tide above mlw. The width of the navigation channels designed for the k-class would be adequate for the extended k-class as well, since the beam of the extended K-class is the same as that of the k-class, and the width of the channel is a function of the vessel beam.

E46. The channel features designed as a function of the vessel length include the turning basins which are a direct multiple of the vessel length, and the width of channel bends which are function of the ratio of the channel bend radius to ship length. The three major turning areas, Anchorage Channel for ships entering Port Jersey, Newark Bay for ships entering South Elizabeth and Elizabeth Channels, and the Bergen Point Bend for ships entering Howland Hook, are all adequate for both vessels. The 1600 ft turning basin at Bay Ridge channel is only 1.4 times the length of the extended k-class, which may restrict the turning maneuver to a period around slack tide when currents are less than 0.5 knots.

E47. It is expected that the 9% decrease in the ratio of the channel bend radius to ship length of the extended K-class as compared to the K-class vessel will have a minimal effect on the channel width in bends. The detailed design of the individual bends will be conducted in the design phase of the study utilizing ship simulation studies.

Pathways

E48. The design of the various channels was conducted utilizing the concept of pathways, wherein each pathway defines the entire ship transit from deep water to port. This was necessary since the design of a particular channel would depend not only upon the design vessel but also upon the final destination of that vessel. For example, in the evaluation of Kill Van Kull for vessels entering the Arthur Kill, tankers would require a 60 ft channel straight through Bergen Point, while container ships would require a 50 ft channel plus a turning basin for backing into or out of the Arthur Kill. To simplify the analyses, these paths coincided with economic reaches. 7 pathways, each of which have Ambrose Channel and a portion of Anchorage Channel in common, were proposed based upon ship destination.

- Pathway 1 - Kill Van Kull, Newark Bay to Port Elizabeth
- Pathway 2 - Kill Van Kull, Arthur Kill to Howland Hook
- Pathway 3 - Kill Van Kull, Arthur Kill to Gulfport
- Pathway 4 - Port Jersey Channel
- Pathway 5 - Bay Ridge Channel
- Pathway 6 - Red Hook Flats, Stapleton and Gravesend Anchorages for Containerships
- Pathway 7 - Red Hook Flats, Stapleton and Gravesend Anchorages for Tankers

E49. Final destinations were subsequently modified based upon facilities proposed in the final "Without Project" and "With Project" conditions. For more details, see "Without Project Conditions Report" and "With Project Conditions Report"

Channel Alignment

E50. The alignment of the proposed channels follows the existing alignment in most cases. Where new or expanded facilities are proposed, the channels are aligned to provide a berthing area of 150 ft between the channel and the proposed bulkhead.

Channel Width

E51. The channel width for the entrance channel, Ambrose Channel, was based upon guidance contained in PIANC PTC II-30 for outer channels exposed to open water. The guidance takes into account such factors such as ship speed, prevailing cross winds, both cross currents and longitudinal currents, significant wave height, aids to navigation, bottom surface, depth to draft ratio, cargo hazard level, bank conditions and traffic density. The results of the analysis indicate that, for the severe wind, wave and current conditions that could be encountered offshore, the recommended channel width is approximately 2100 ft for two way traffic. However, based upon the consistency of the ship track plots from the ship motion study, and meetings with the various harbor pilots, the existing width of 2000 ft is judged to be adequate.

E52. The width of the proposed interior channels was designed in accordance with guidance contained in EM 1110-2-1613. This guidance is based upon such factors as traffic pattern (one way or two way), design vessel dimensions, channel cross section shape, current speed and direction, quality of aids to navigation and variability of channel and currents. For one way channels, widths can vary from 2.5 times the vessel beam for a well defined channel with minimal currents to 5.5 times the vessel beam for a variable channel with stronger currents. Two way channels can vary from 4 to 8 times the vessel beam. The recommended channel widths for the various navigation channels within the Port are provided in **Table E6**.

E53. The channel width in bends is increased because the swept path of a ship making the turn is wider than the path of the ship in a straight channel. The width of the swept path is dependent upon the ratio of the turn radius/ship length and the deflection angle. Other factors to be taken into account are ship yaw angle, ship dimensions, ship rudder angle, bank effects, aids to navigation and current and other physical conditions. The guidance recommends turn width increase factors (a multiple of the vessel beam) of 0 to 2.0, with a recommended turn radius ratio not less than 3, based upon the maneuverability of the vessels. However, many of the interior channel bends in the Port have turn radius ratios less than 3. These channel bends are safely transited since vessels typically utilize tug support and/or bow and stern thrusters. Turn width increase factors for these channel bends may increase to 3 or more.

Table E6 Recommended Channel Widths									
	Traf-fic	Cross section		Cur-rent	Beam Multi -plier	Ship – Beam (ft)	Width (ft)	Exist. Width (ft)	Use (ft)
		Type	Config.						
Ambrose	2 Way	Trench	Constant	High	14.8 15.3	T-144 C-140	2131 2142	2000	2000
Anchorage	2 Way	Trench	Constant	High	6.5	T-144	936	2000	2000 (1)
Kill Van Kull	2 Way	Trench	Constant	Mod.	5.5	T-C av142	781	800	800
Newark Bay	2 Way	Trench	Variable	Mod.	5.5	C-140	770	800	800
Newark Bay S. Elizabeth	1 Way	Trench	Constant	Mod.	3.25	C-140	455	300	500
Arthur Kill	1 Way	Trench	Variable	Mod.	4.0	T-144	576	500-600	600 (2)
Bay Ridge	1 Way	Trench	Constant	High	4.0	C-140	560	1200-1750	600
Port Jersey	1 Way	Canal	Constant	Mod.	3.0	C-140	420	200	500
Claremont	1 Way	Trench	Constant	Mod.	3.25	C-140	455		500
NJ Pierhead	1 Way	Trench	Constant	Mod.	3.25	C-140	455	500	500

(1) Deepening of the full width (2000 ft.) of the existing channel is recommended due to the high volume of traffic and the fact that Anchorage Channel provides access to anchorage areas and adjacent channels on both sides of the harbor.

(2) Although a 600 ft. channel is recommended, physical constraints, such as bulkheads, bridge piers and berthing areas, preclude full widening of the channel at certain locations.

Channel Depth

E54. The maximum channel depth is designed to permit the safe and efficient transit of a fully loaded design vessel at any phase of the tide. The determination of the navigation channel depth is based upon the loaded static summer salt water draft of the design vessel, plus allowances for various underkeel clearances such as ship squat, water density, ship response to waves, and

safety clearance. See **Figure E2** below. The selection of the actual project design depth is determined by economic analysis of the expected project benefits compared with the project cost at various alternative depths. Refer to the economic appendix for details of the optimization analyses.

Squat

E55. Squat is the tendency of a vessel underway to sink and trim in the waterway, thereby reducing the underkeel clearance. The sinkage is due to the reduction in pressure on the ship's hull resulting from the increased water velocity passing the ship. In a shallow or confined channel, squat tends to increase because the blockage caused by the ship creates a higher water velocity around the hull, lowering the actual water surface. Another component of squat is dynamic trim, or the change in pitch of a vessel due to the forward motion. Generally it has been found that most full bodied ships such as tankers and bulk carriers trim down at the bow, and sleeker containerships trim down at the stern. The magnitude of the squat depends on several factors including ship speed, dimensions, ship blockage coefficient, and channel depth. Allowances for squat for various channels within the Port are provided in **Table E7** below.

Table E7
Ship Squat (ft)

Channel	Width	Container	Tanker
Ambrose	2000 ft	See Ship Motion Study Below	
Anchorage	2000 ft	1.3	2.0
Kill Van Kull	800 ft	1.0	1.5
Arthur Kill	500 ft	1.2	1.9
Bay Ridge	600 ft	1.2	N/A

Ship Motion from Waves

E56. The ship response from waves can be an important factor in the design of navigation channels. The ship motion from waves is more pronounced in entrance or bar channels which tend to be exposed to ocean waves, than it is in interior channels where wave energy is limited. There are 3 modes of vertical motion: pitch (rotation about the transverse axis), roll (rotation about the longitudinal axis) and heave (vertical displacement), as shown on **Figure E3**. The magnitude of vertical motion is a function of many factors, including wave parameters (height, period, duration, direction, celerity), ship characteristics (length, beam, draft, speed direction of transit), currents, winds, etc. The ship motion due to waves in Ambrose Channel was determined by a numerical modeling study conducted at WES.

Ship Motion Study

E57. A vertical ship motion study was conducted at WES to determine the total underkeel clearance required for the design vessels in Ambrose Channel. The study included wave modeling in the NY Bight and Lower Bay to determine incident wave conditions, a ship tracking study (utilizing DGPS receivers on board vessels inbound and outbound) to measure vertical ship motions, and a ship motion model to predict the vertical ship motion of vessels under various wave conditions.

E58. The ship transits monitored in the ship tracking study were modeled using wave data obtained at the time of the ship transit and ship models that represented the type, size and draft of the vessels, in an attempt to reproduce the actual vertical motion of the ships in transit. Adjustment factors were determined based upon a comparison of the measured data from the tracking study and the computed data from the ship motion model. The ship motion model was then applied for design conditions, evaluating both design vessels (tanker and container ship) for both inbound and outbound transits, and normal as well as design (1 year) wave conditions.

E59. The results of the model study concluded that, for the design wave condition, the design container ship would require 7 ft of underkeel clearance and the design tanker would require 6 ft of underkeel clearance. Details of the model study can be found in Draft Report "Entrance Channel Depth Design, Ambrose Channel, New York Harbor".

Water Density

E60. The design draft is given in relation to ocean salt water, which has a salinity concentration of 33 ppt. When a vessel enters a port with brackish or fresh water, the draft of the vessel will increase in proportion to the decrease in water density. The decrease in unit weight of water, from 64.0 lb/cu ft at 33 ppt to 62.4 lb/cu ft at 0 ppt, will increase the draft of a vessel by 2.6%. **Table E8** contains the water density allowances for the design vessels for the various channels within the port.

Safety Clearance

E61. A safety clearance is provided between the hull of the ship in transit and the design channel bottom to minimize the risk of damage to the vessel due to bottom irregularities and debris. The safety clearance also accounts for uncertainties such as tide stage, survey tolerances, etc. A safety clearance of 2 ft is provided for channels with a soft bottom; for channels consisting of rock or other hard material such as consolidated sand or clay, the safety clearance is increased to 4 ft. The additional 2 ft in safety clearance is required only for the initial construction of the navigation channel in hard material. In time, as the channel begins to shoal, a safety clearance of 2 ft will be maintained since the recently deposited material tends to be soft.

Table E8 Water Density Allowances					
Location	**Channel**	**Salinity (ppt)**	**Density (lb/ft3)**	**Container (ft)**	**Tanker (ft)**
Lower Bay	Ambrose	33	64.0	0	0
Upper Bay	Anchorage Bay Ridge Port Jersey	20	63.4	0.4	0.5
The Kills	Kill Van Kull Newark Bay Arthur Kill	12	63.0	0.7	0.9

Total Underkeel Clearance

E62. The total underkeel clearance required for initial construction for the various channels in the port are provided in **Table E9** below:

Table E9 Total Underkeel Clearances (ft)											
	Ambrose		Anchorage		Kill Van Kull		Arthur Kill		Newark Bay	Bay Ridge	Port Jersy
Vessel Type	C	T	C	T	C	T	C	T	C	C	C
Vessel Draft	46	55	46	55	46	55	46	55	46	46	46
Squat	See Below		1.3	2.0	1.0	1.5	1.2	1.9	1.2	1.2	1.2
Wave Motion			0	0	0	0	0	0	0	0	0
Water Density			.4	.5	.7	.9	.7	.9	.7	.4	.4
Safety Clearance			2	2	4	4	4	4	4	2	4
Total Underkeel Clearance	7.0 *	6.0 *	3.7	4.5	5.7	6.4	5.9	6.8	5.9	3.6	5.6
Required Channel Depth (Calculated)	53	61	49.7	59.5	51.7	61.4	51.9	61.8	51.9	49.6	51.6
Use	53	61	50	60	52	62	52	62	52	50	52
Maintained Channel Depth	53	61	50	60	50	60	50	60	50	50	50

C – Container ship, T – Tanker, * - From Ship Motion Study

DESCRIPTION OF THE PROPOSED CHANNEL IMPROVEMENTS

Pathway 1 – Kill Van Kull, Newark Bay (Design Vessel – Container Ship)

E63. Ambrose Channel, deepened to –53 ft mlw, will remain at its present width of 2000 ft and will follow its present alignment. It will be extended 2400ft seaward along its present bearing out to deep water. Ambrose Light Tower is presently being relocated 1.5 nautical miles ESE of its present location. A large mound (possibly construction rubble?) immediately NW of the present Ambrose Light Tower will be removed to project depth. This mound, now marked by the light tower, would become a hazard to navigation once the existing tower is relocated, since it would be situated along the pilot area between the new tower and the sea buoy marking the entrance to Ambrose Channel. The pilots use this area to bring their pilot boat along side the incoming and outgoing vessels for boarding.

E64. Anchorage Channel, deepened to –50 mlw, will remain at its present width of 2000 ft, but will be deepened only from the Narrows to the junction with the Kill Van Kull.

E65. Kill Van Kull, deepened to –52 mlw, will remain at its present width of 800 ft and will follow its present alignment.

E66. Newark Bay South Reach, and Elizabeth Channel, deepened to –52 mlw, will remain at their present width and will follow its present alignment. Improvements to the main channel will extent 1500 ft north of the Elizabeth Channel to facilitate vessels turning and backing into port. The South Elizabeth Channel will be widened to 500 ft. The berthing areas along the Elizabeth Port Authority Marine Terminal will be widened to 150 ft.

E67. The layout of Pathway1 is shown in **Figure E4.**

Pathway 2 - Kill Van Kull, Arthur Kill to Howland Hook (Design Vessel – Container Ship)

E68. Ambrose Channel, Anchorage Channel and Kill Van Kull will be improved as previously described in Path 1. In addition, the portion of the Newark Bay South Reach immediately adjacent to the Kill Van Kull will be deepened to –52 mlw to provide a turning basin for container ships to turn and back into (or out of) Howland Hook.

E69. The Arthur Kill will be deepened to –52 mlw from the junction with the Kill Van Kull to the western limit of the Howland Hook facility, along the alignment of the 41 ft (without project) channel. In addition, the channel will be widened to the north opposite Howland Hook back to the limits of the existing channel.

E70. The layout of Pathway 2 is shown in **Figure E5.**

Pathway 3 - Kill Van Kull, Arthur Kill to Gulfport (Design Vessel – Tanker)

E71. Ambrose Channel, deepened to –61 mlw, will remain at its present width of 2000 ft and will follow its present alignment. It will be extended 5400 ft seaward along its present bearing out to deep water. The mound of construction rubble would be removed as previously described in Path 1.

E72. Anchorage Channel, deepened to –60 mlw, will remain at its present width of 2000 ft, but will be deepened only from the Narrows to the junction with the Kill Van Kull.

E73. Kill Van Kull, deepened to –62 mlw, will remain at its present width of 800 ft and will follow its present alignment. Tanker traffic in the Kill Van Kull is one way (westbound). Tankers enter the Kill Van Kull from Anchorage Channel and sail west into the Arthur Kill. These tankers depart southbound through the Arthur Kill and Raritan Bay. Theoretically, a step channel deepened for tankers (60ft MLW) to accommodate one way traffic would be adequate. However, there are nine separate bends in the Kill Van Kull as it meanders between New York and New Jersey. In such a channel, large deep draft vessels tend to straighten their course to the greatest extent possible, in effect, crossing from one side of the Kill Van Kull to the other. Should an oncoming vessel be encountered, each vessel must maneuver to the outside of the channel to pass at a safe location. Considering the vessel traffic practices, size of the vessels, the density of traffic, the hazardous nature of the cargo, the rock channel bottom and the problems associated with marking a step channel, a step channel for one way traffic in the Kill Van Kull was judged to be unsafe. All pilots interviewed concurred with that decision. Through the Bergen Point Reach, however, the channel improvement would remain a constant 800 ft since tankers entering the Arthur Kill would exit southbound and not turn around at Bergen Point as containerships do.

E74. The Arthur Kill, deepened to –62 mlw from Bergen Point to Howland Hook, would be deepened along the same alignment as described for Path 2. From Howland Hook to Gulfport, the channel would be widened, and in some cases narrowed, to provide a 550 ft channel. The narrowings, from 600 ft to 550 ft, are necessary to provide adequate berthing areas of 150 ft for the facilities at Tosco and GATX outside the limits of the channel.

E75. The layout of Pathway 3 is shown in **Figure E6.**

Pathway 4 - Port Jersey Channel (Design Vessel – Container Ship)

E76. Ambrose Channel will be improved as previously described in Path 1.

E77. Anchorage Channel, deepened to –50 mlw, will remain at its present width of 2000 ft, but will be deepened only from the Narrows to a point 1000 ft north of the junction with Port Jersey Channel.

E78. Port Jersey Channel, deepened to –52 mlw, will be improved to a width of 500 ft between the Global Marine Terminal and MOTBY peninsulas. The entrance flare will be 1500 ft at the junction with Anchorage Channel and taper to 500 ft at the intersection with the NJ Pierhead Channel. The wide flare of the approach channel was necessary due to the fact that vessels inbound on a flood tide will be turning broadside across the current and be set (drift) to the north.

E79. The existing 1200ft turning basin at the head of Port Jersey Channel is inadequate for the k-class container ship, which has a length over all of 1044 ft. Widening of the existing turning basin is not a practical solution since it would require the construction of sheet pile retaining structures to stabilize existing structures. Without a turning basin, vessels must either back into or out of Port Jersey. In order to facilitate the backing maneuvers, the northern channel limit is straightened, removing a narrow portion of the New Jersey flats. Deepening Anchorage Channel 1000 ft to the north will permit inbound vessels bring the bow past Port Jersey Channel, and readily swing the stern around and then back into port.

E80. The layout of Pathway 4 is shown in **Figure E7.**

Pathway 5 - Bay Ridge Channel (Design Vessel – Container Ship)

E81. Ambrose Channel will be improved as previously described in Path 1.

E82. Anchorage Channel, deepened to –50 mlw, will remain at its present width of 2000 ft, but will be deepened only from the Narrows to the junction with Bay Ridge Channel.

E83. The proposed width of Bay Ridge Channel, deepened to –50 mlw, will be 600 ft, reduced from the current width of 1200 to 1750 ft. The width of the existing channel was based upon the fact that the existing finger piers required that a ship turn perpendicular to the channel before berthing. The 600 ft one way channel would be adequate for the proposed facility with two deep draft berths. The proposed turning basin, with a diameter of 1600 ft, is located opposite the terminal, enabling vessels to back out of or into port.

E84. The layout of Pathway 5 is shown in **Figure E8.**

Pathway 6 – Red Hook Flats Anchorage, Stapleton Anchorage and Gravesend Anchorage (Design Vessels – Containership)

E85. Ambrose Channel will be improved as previously described in Path 1.

E86. Anchorage Channel, deepened to –50 mlw, will remain at its present width of 2000 ft, but will be deepened only from the Narrows to the northern limit of Red Hook Anchorage.

E87. Red Hook Flats Anchorages 21B and 21C would be deepened to –50 mlw. In addition, the portions of Areas 21B and 21C adjacent to the existing Bay Ridge Channel would be expanded eastward 600 – 1100 ft to the channel limits of the proposed Bay Ridge Channel.

E88. Stapleton Anchorage and Gravesend Anchorage would be deepened to –50 mlw at their present limits.

E89. The layout of Pathway 6 is shown in **Figure E9.**

Pathway 7 – Red Hook Flats Anchorage, Stapleton Anchorage and Gravesend Anchorage (Design Vessels – Tanker)

E90. Ambrose Channel will be improved as previously described in Path 3.

E91. Anchorage Channel, Red Hook Flats Anchorages 21B and 21C, Stapleton Anchorage and Gravesend Anchorage, will be deepened to –60 mlw to the limits described in Pathway 6

E92. The layout of Pathway 7 is also shown in **Figure E9,** since it is the same as the layout for Pathway 6.

IMPACTS OF THE PROPOSED CHANNEL

Numerical Modeling Study

Background

E93. A numerical modeling study, conducted at Waterways Experiment Station (WES), was formulated in cooperation with CENAN-EN-HH personnel as the most effective means of studying the effects of the deepening of the navigation channels within the New York and New Jersey Harbor. The effects of concern to this study are hydrodynamics, and sedimentation. Water quality concerns are being independently addressed by a parallel study.

Model Approach

E94. The issues that have a bearing on sediment transport within the harbor area are those that affect the basic hydrodynamics. The effects of the project on the hydrodynamics when properly addressed will, in turn, result in appropriate estimates of influences of the project on the sedimentation environment. In deepening the navigation channels, the potential exists for the accentuation of the effects of density variations over the water column associated with salinity intrusion on currents. Deepening of the channel will lead to reduced current velocities within the channel, less vertical mixing and the ability for the salt water to move farther upstream. The modeling approach taken for the study therefore must deal with these effects on the salinity regime in the vertical. Therefore, the model study here includes the use of a three-dimensional hydrodynamic/sediment transport model (RMA-10-WES). That model was applied to the entire domain of the study, but focuses attention on the fine sediments of the inner harbor channels above the Narrows where the greatest effects on density currents are expected.

Two Dimensional (2-D) Model

E95. The sedimentation within Ambrose Channel is primarily the result of sand shoaling associated with the littoral supply of sediment. For the Ambrose Channel, where the sedimentation is wave-dominated, the effects of the changes in channel depth on density currents are assumed to be overwhelmed by the effects of the wave environment. Therefore, the sediment transport modeling for the Ambrose Channel was performed using the two-dimensional depth-averaged version of the TABS modeling system: RMA-2 for hydrodynamics and SED-2D-WES for the sediment transport. The models were modified for this study to include the effects of the wave climate on the currents. A wave model was developed to propagate waves from deep water into the harbor and to develop locally generated wind waves. The wave field was then interpolated onto the TABS-MD finite element mesh and the radiation stresses computed and included in the momentum equations for the model. This approach resulted in wave induced currents within the littoral zone that, when combined with the tidal forcing, lead to very complex current patterns. The sediment transport model was then driven by both the currents from the combined wave and tidal forcing for net water movement, and the wave field itself for the additional shear stresses associated with the short period orbital velocities. The wave induced current velocity capability was also added to the three-dimensional model.

Model Description

E96. The mesh developed for the Ambrose Channel sedimentation study has 29511 nodes and 9436 elements, as shown in **Figures E10a & b**. The overall domain of the model includes a portion of New York Bight outward in a circular arc about 40 miles from Sandy Hook, approximately 100 miles of Long Island Sound from Montauk Point to East River, and most of the major tributaries to their head of tide. The Hudson River runs approximately 150 miles from the Battery to the head of tide at Albany, NY. The model includes Raritan River below Fieldview Dam and South River below Duhernal Dam, to its confluence with the Raritan River. The Passaic River below Dundee Dam and the Hackensack River below Oradel Dam are included in the mesh. All of the major bays in the harbor (i.e. Jamaica Bay, Raritan Bay, Upper Bay, and Newark Bay) are included with significant resolution.

2-D Model Verification

E97. The 2D model was verified for tidal propagation throughout the harbor using tidal amplitude variations and phasing as the measure of model performance. The prototype field tidal data was extracted from NOAA/NOS predicted tide tables. The model tidal forcings were selected as a repeating tide of an amplitude midway between a mean tide range and the average spring tide range. This was felt to be a representative tide and would serve well in the sediment transport simulations. Details of the tidal verification will be included in the draft modeling report.

E98. The current velocities in the harbor were verified against a set of acoustic Doppler current profilings (ADCP) collected by CEWES in 1994. The locations of these profiling cross sections and the comparison of the 2D model current velocity distribution with the depth-averaged velocities from the ADCP data will be included in the draft modeling report.

E99. The sediment transport verification was performed by developing a set of representative wave conditions to drive both the hydrodynamic model and the sediment transport model. Initial simulations with tide only, without wave energy, showed that negligible sediment movement occurred for the Ambrose channel. This validated the assumption that the sediment transport is dominated by the waves for the bar channel.

E100. A wave model (STWAVE) was developed to propagate waves from deep water into the harbor. Two grids were utilized. A seaward grid had a uniform spacing of 200 m. The boundary conditions for this portion of the model were derived from the sea buoy located near the outer grid boundary. The results of the 200 m grid were then used to develop the boundary conditions for the finer, 100 m grid. The results of the 100 m grid, which extended into the harbor, were interpolated onto the TABS finite element grid. The wave model is based on a spectrum of wave heights, periods and directions, and outputs significant periods, heights and directions over the grid domains. The wave propagation, refraction and diffraction were performed as a steady state computation. The wave conditions simulated are presented in **Table E10**. For the Ambrose channel simulations no locally generated waves were included because they have minimal impact on the channel shoaling when compared to the larger ocean waves.

E101. The "no wave" condition in the table was the collection of all the wave directions measured at the sea buoy that were moving away from the harbor. For the geometry of New York bight, that is essentially about 270 degrees of the wave directions.

Table E10
Wave Conditions Tested

Wave Period (sec)	Wave Direction (deg.)	Wave Height (m)	Frequency
No wave	All Other Directions	No wave	0.538
4	135	2.5	0.100
6	112	2.5	0.142
6	135	1.0	0.030
6	135	2.5	0.030
6	157	2.5	0.130
8	135	2.5	.030
		Total	1.000

Three-Dimensional (3-D) Modeling

E102. The three-dimensional modeling effort was designed to assess the sedimentation issues associated with the channel deepening of the inner harbor channels. Inner harbor sedimentation is predominantly associated with fine sediments. The 3D model RMA-10-WES was applied using the cohesive sediment formulation of the model. The technical approach was to use the verified two-dimensional mesh developed for the bar-channel analysis as a starting point for the 3D-model mesh.

Mesh revisions

E103. The 3D-model domain was identical to the overall domain of the 2D modeling effort. This allowed the use of common boundary condition specifications. The model mesh from the 2D effort was revised so that overall less resolution was used in the ocean and Lower Bay portions of the mesh. The resolution was reduced in the vicinity of the Claremont channel, but resolution was added in the Newark Bay area.

3D Resolution

E104. The 3D mesh took advantage of the ability to specify certain zones of the system as 2D while limiting the 3D resolution to only the deeper channels of the harbor. The majority of the ocean area was modeled as 3D, with the zone of 3D resolution beginning at a distance where the water depth reaches 100 feet in the natural channel between the harbor and the bight. The 3D resolution is extended to the ocean shoreline into relatively shallow water, and is 2D into the surf zone. At the harbor entrance transect the model is 3D from Sandy Hook to Rockaway Point. Inside the transect the 3D resolution extends through the primary deep channels connecting the Lower Bay with Upper Bay via the Narrows and Arthur Kill via the Raritan bay channel. The shallower areas of Lower bay were simulated as depth averaged (2D).

E105. The deepest channels in the mesh were simulated with 3 elements over the water column. Because the velocity and salinity are represented by quadratic basis functions, this gives seven nodal values over the water column. This was believed to be adequate to resolve any vertical variations in the current velocity structure expected in the harbor.

Model Description

E106. The model RMA-10-WES is a three-dimensional (3D) finite element model that solves the full Navier-Stokes equations of motion. The model formulation includes the hydrostatic assumption in the vertical momentum equation. Turbulence closure is handled by the Boussinesq approximation, invoking an eddy viscosity. The eddy viscosity can either be set as a spatially varying constant or can be varied spatially and temporally computed by either a Peclet number specification or by the Smagorinsky method. The horizontal momentum equations also include the advective terms, coriolis forces, bottom friction, wind stress and wave induced stresses. The finite element formulation uses a mixed interpolation scheme of linear basis functions for water depth and quadratic basis functions for velocities and constituents (salinity, temperature and sediment concentration). Nonlinear terms in the equations are solved via a Newton-Raphson iterative scheme within each model time step. The time dependence terms are formulated using a finite difference method.

E107. The model utilizes the technique of marsh porosity, a statistical representation of the sub-element scale spatial variability in bathymetry or topography. This was used primarily in the study mesh to include the effects of the Hackensack Meadowlands. The marsh porosity parameters were set so that the water depth never went negative. This approach left a very thin layer of water (effective depth) in the wetlands at low tide that was hydraulically inactive due to the relationship between water depth and friction. The 3D-model mesh is designed to be a vertical modification to a 2D mesh by specifying the vertical resolution as a property of the 2D mesh.

Hydrodynamic Verification

E108. The 3D model was verified to two basic hydrodynamic conditions. The first verification test was a repetitive tidal condition with a forcing tide between a mean and spring tide range. This test was driven by the same boundary conditions as used in the 2D model verification of the

same conditions. The second test was of a period in the late summer of 1995, as a portion of the Battelle data collection effort.

E109. The purpose of the repeating tide verification test was to provide a comparison to the general long-term tidal propagation and phasing within the harbor, for which extensive documentation has been performed. The conditions for the tides were a repeating tide of a period of 12.5 hours with an amplitude of between a mean and spring tide; 5.15 ft at Sandy Hook and 2.6 ft at Montauk Point in Long Island Sound. For this verification run the river inflows were set to mean flows. The time step in the model was 0.5 hour.

E110. The 3D model test for repeating tide was run for 125 hours to allow for the spin up of tidal energy and for the development of a dynamic equilibrium for the flow and salinity fields. The propagation characteristics within the harbor were then developed and compared with field observations extracted from the NOAA manual of tides.

E111. The 3D model was also run to verify the model against the Battelle 1995 data set. The verification period was for the period of 12-15-1995 through 12-30-95. The ocean boundary conditions for the Atlantic were developed by filtering and averaging the Battelle field data at Shark River Inlet and Jones Inlet. An amplification of 15 % was necessary to match the Sandy Hook tide signal. That amplification is consistent with previous modeling experience in modeling the harbor for specification of the ocean boundary in the Bight. The Long Island Sound boundary condition was developed from filtering the field data from NOS Montauk Point, Fort Pond Bay Station. These boundary conditions are summarized in the table below. The river inflows were taken from USGS data sources when available for September 1995, and when unavailable lower flows from historical data from September were approximated. The model was run for 100 hours with a time step of 0.5 hour.

Sediment Modeling

E112. The sediment model capabilities in RMA10-WES were implemented using a single sediment class. The hydrodynamic model was initialized and operated for 125 hours to reach a dynamic equilibrium with respect to flows and salinity fields. A 12.5 hour repeating tide and steady freshwater inflows (12,000 cfs in Hudson River) were used at the model boundaries. The last tidal cycle from this run was used repeatedly to drive the sediment model hydrodynamics.

E113. The sediment model bed was initialized with seven layers which had solids content increasing vertically downward. The model was operated dozens of tidal cycles while currents and shear-stresses eroded the bed to bring the bed into quasi-equilibrium with the flow.

E114. The sediment model was adjusted by comparing suspended material concentrations to field data. No harbor-wide synoptic data sets exist. Data collected by Battelle in 1991 and the City of New York in 1990 and 1991 were used to compare to the model results. The goal was to reproduce reasonable suspended sediment concentrations which were in quasi-dynamic equilibrium, which changed with tidal flows but whose mean values did not change appreciably between tidal-cycles. There is a large gap between freshwater and other input sediment sources, and total shoaling rates in the Harbor. By reproducing normal ranges in suspended solids concentration it was assumed that the model would be reproducing important sediment

recirculation processes within the Harbor. Highest observed suspension concentrations occur in the Hudson River at the north end of Manhattan Island, and the model successfully reproduced a concentration maximum in this area. The salinity and density stratification effects are greatest in this area, and contribute to sediment trapping.

E115. After the model bed was eroded to equilibrium, the model water column was then re-initialized at 30 mg/l of suspended sediment and the model operated 300 hours, the last 50 hours of which were used to compute depositional quantities. The deposition rates were then extrapolated to a year and a dredging analysis performed on the resulting bathymetry.

Alternatives tested

E116. Four alternatives were tested in the model: the existing channel condition, the "base" condition, the Plan 1 (nominal 50 ft channel) and the Plan 2 (nominal 60 ft channel) channels. The existing channel condition represents the geometry (width, depth and alignment) of the current navigation channels within the Port. The model verification was performed utilizing the existing conditions geometry.

E117. The base conditions represent the channel geometry expected to be in place immediately prior to the construction of this project. Base conditions include deepening of the Kill Van Kull and Newark Bay Channels to -45 mlw; deepening of the Arthur Kill, from the confluence with the Kill Van Kull to Gulfport to depths of -41/-40 mlw; and deepening of the Port Jersey Channel to a depth of -41 mlw. The base condition for all other channels in the port is the existing geometry.

E118. Plans 1 and 2 were designed to evaluate the maximum potential impacts of the various project alternatives. Plan 1 includes all of the improvements for Paths 1, 2, 4, and 5. In effect, the recommended plan of improvements for the containerships.

E119. Plan 2 includes all of the improvements for Paths 1, 2, 3, 4, 5, 6 and 7; that is, Plan 1 plus the -60 ft mlw channel to Gulfport (with Ambrose Channel at -61 mlw) and the anchorage areas. Plan 2 will evaluate the maximum potential impacts of this project.

Conditions Tested

E120. The conditions tested for all four of the alternatives were the same as used in the model verification. This was the representative repeating tide between a mean and a spring range. The river discharges were held at their mean values used in the verification. The wave conditions from the verification were repeated for all of the design alternatives.

Results

E121. The results of the 3-D hydrodynamic model simulations have been summarized for 27 gage locations selected throughout the navigation channels in the harbor. These locations were chosen for their interest for navigation purposes. The locations are shown in **Figure E11**. The summary of the effects of the channel deepenings on the tidal elevations in the harbor are presented in **Table E11**; the effects of the deepening on current velocity magnitudes are presented in **Table E12**.

E122. The effects of the channel deepenings on tides indicate that there is an increase in tide range into the harbor with a maximum increase of 0.05 ft for Plan 1 and 0.19 ft for Plan 2. The 0.19 ft increase in tide range represents a .09 ft increase in high tide and a .10 ft decrease in low tide. The increases in tide range in the rest of the harbor are a proportion of that maximum change as a function of distance into the harbor. In the Arthur Kill, the farthest point from the Upper Bay, the increase in tide range averages less than half of the maximums.

E123. The effects of the channel deepenings on current velocities are generally a reduction of currents for the locations that lie within the channels that are deepened. Those reductions are the result of an increase in the cross sectional area of the channel that carries the tidal discharge. For those stations in Upper Bay where the channels are not deepened, there is a general increase in current velocities. In general, velocity changes for Plan 1 are minor (less than 0.1 fps) with maximum decrease of .27 fps occurring in the Arthur Kill. The maximum decrease in velocity for Plan 2 was 0.78 fps in the Upper Bay.

Table E11 Tide Stage Effects (ft,mlw)*											
	Base			Plan 1				Plan 2			
Station	Max	Min	Range	Max	Min	Range	Change	Max	Min	Range	Change
Ambrose 1	5.53	-0.1	5.63	5.53	-0.11	5.64	0.01	5.52	-0.11	5.63	0
Ambrose 2	5.46	0.12	5.34	5.46	0.11	5.35	0.01	5.47	0.09	5.38	0.04
Ambrose 3	5.45	0.19	5.26	5.46	0.18	5.28	0.02	5.47	0.15	5.32	0.06
Ambrose 4	5.32	0.23	5.09	5.33	0.22	5.11	0.02	5.38	0.19	5.19	0.1
Ambrose 5	5.36	0.33	5.03	5.37	0.31	5.06	0.03	5.44	0.26	5.18	0.15
Ambrose 6	5.36	0.34	5.02	5.38	0.32	5.06	0.04	5.45	0.26	5.19	0.17
Ambrose 7	5.35	0.36	4.99	5.37	0.34	5.03	0.04	5.46	0.27	5.19	0.2
Ambrose 8	5.25	0.41	4.84	5.26	0.4	4.86	0.02	5.32	0.33	4.99	0.15
Red Hook 1	5.36	0.29	5.07	5.37	0.27	5.1	0.03	5.44	0.21	5.23	0.16
Red Hook 2	5.39	0.35	5.04	5.41	0.32	5.09	0.05	5.48	0.25	5.23	0.19
Buttermilk 1	5.36	0.34	5.02	5.37	0.32	5.05	0.03	5.45	0.24	5.21	0.19
East River 1	5.17	0.43	4.74	5.18	0.42	4.76	0.02	5.23	0.37	4.86	0.12
Hudson River 1	5.24	0.47	4.77	5.25	0.46	4.79	0.02	5.31	0.41	4.9	0.13
Port Jersey 1	5.38	0.36	5.02	5.4	0.33	5.07	0.05	5.47	0.27	5.2	0.18
Kill Van Kull 1	5.40	0.42	4.98	5.42	0.39	5.03	0.05	5.49	0.33	5.16	0.18
Kill Van Kull 2	5.47	0.44	5.03	5.48	0.44	5.04	0.01	5.55	0.36	5.19	0.16
Kill Van Kull 3	5.56	0.44	5.12	5.58	0.43	5.15	0.03	5.63	0.38	5.25	0.13
Bergen Point 1	5.60	0.43	5.17	5.61	0.43	5.18	0.01	5.64	0.39	5.25	0.08

Table E11 (con't) Tide Stage Effects (ft,mlw)											
	Base			Plan 1				Plan 2			
Station	Max	Min	Range	Max	Min	Range	Change	Max	Min	Range	Change
Newark Bay 1	5.63	0.45	5.18	5.65	0.45	5.2	0.02	5.68	0.4	5.28	0.1
Newark Bay 2	5.68	0.47	5.21	5.69	0.46	5.23	0.02	5.71	0.43	5.28	0.07
Newark Bay 3	5.69	0.49	5.2	5.71	0.49	5.22	0.02	5.73	0.45	5.28	0.08
Arthur Kill 1	5.71	0.23	5.48	5.72	0.23	5.49	0.01	5.77	0.22	5.55	0.07
Arthur Kill 2	5.69	0.29	5.4	5.7	0.29	5.41	0.01	5.73	0.27	5.46	0.06
Arthur Kill 3	5.65	0.33	5.32	5.67	0.33	5.34	0.02	5.71	0.31	5.4	0.08
Arthur Kill 4	5.64	0.35	5.29	5.66	0.36	5.3	0.01	5.7	0.32	5.38	0.09
Arthur Kill 5	5.64	0.38	5.26	5.66	0.38	5.28	0.02	5.71	0.33	5.38	0.12
Arthur Kill 6	5.64	0.41	5.23	5.67	0.41	5.26	0.03	5.72	0.36	5.36	0.13

* Table contains minor rounding errors

Table E12 Current Velocity Magnitude Effects (ft/sec)					
Station	Base (Max)	Plan 1 (Max)	Change	Plan 2 (Max)	Change
Ambrose Channel 1	1.76	2.02	0.26	2.08	0.32
Ambrose Channel 2	2.73	2.81	0.08	2.96	0.23
Ambrose Channel 3	2.8	2.89	0.09	2.74	-0.06
Ambrose Channel 4	3.3	3.46	0.16	3.09	-0.21
Ambrose Channel 5	2.59	2.49	-0.10	1.81	-0.78
Ambrose Channel 6	2.11	2.08	-0.03	1.73	-0.38
Ambrose Channel 7	2.59	2.64	0.05	2.56	-0.03
Ambrose Channel 8	3.45	3.47	0.02	3.48	0.03
Red Hook Anchorage 1	2.06	1.92	-0.14	1.86	-0.20
Red Hook Anchorage 2	1.41	1.32	-0.09	1.25	-0.16
Buttermilk Channel 1	2.48	2.49	0.01	2.38	-0.10
East River 1	4.25	4.31	0.06	4.33	0.08
Hudson River 1	2.74	2.9	0.16	2.72	-0.02
Port Jersey 1	1.1	1.11	0.01	1.1	0.00
Kill Van Kull 1	2.55	2.52	-0.03	2.59	0.04
Kill Van Kull 2	2.84	2.84	0.00	2.75	-0.09
Kill Van Kull 3	2.06	1.8	-0.26	1.83	-0.23
Bergen Point 1	1.74	1.57	-0.17	1.74	0.00

Table E12 (con't) Current Velocity Magnitude Effects (ft/sec)					
Station	Base (Max)	Plan 1 (Max)	Change	Plan 2 (Max)	Change
Newark Bay 1	1.58	1.6	0.02	1.71	0.13
Newark Bay 2	1.25	1.24	-0.01	1.29	0.04
Newark Bay 3	1.19	1.23	0.04	1.29	0.10
Arthur Kill 1	1.54	1.45	-0.09	1.42	-0.12
Arthur Kill 2	1.49	1.55	0.06	1.43	-0.06
Arthur Kill 3	1.74	1.71	-0.03	1.08	-0.66
Arthur Kill 4	1.65	1.38	-0.27	0.92	-0.73
Arthur Kill 5	1.49	1.22	-0.27	1.18	-0.31
Arthur Kill 6	0.92	0.94	0.02	1.35	0.43

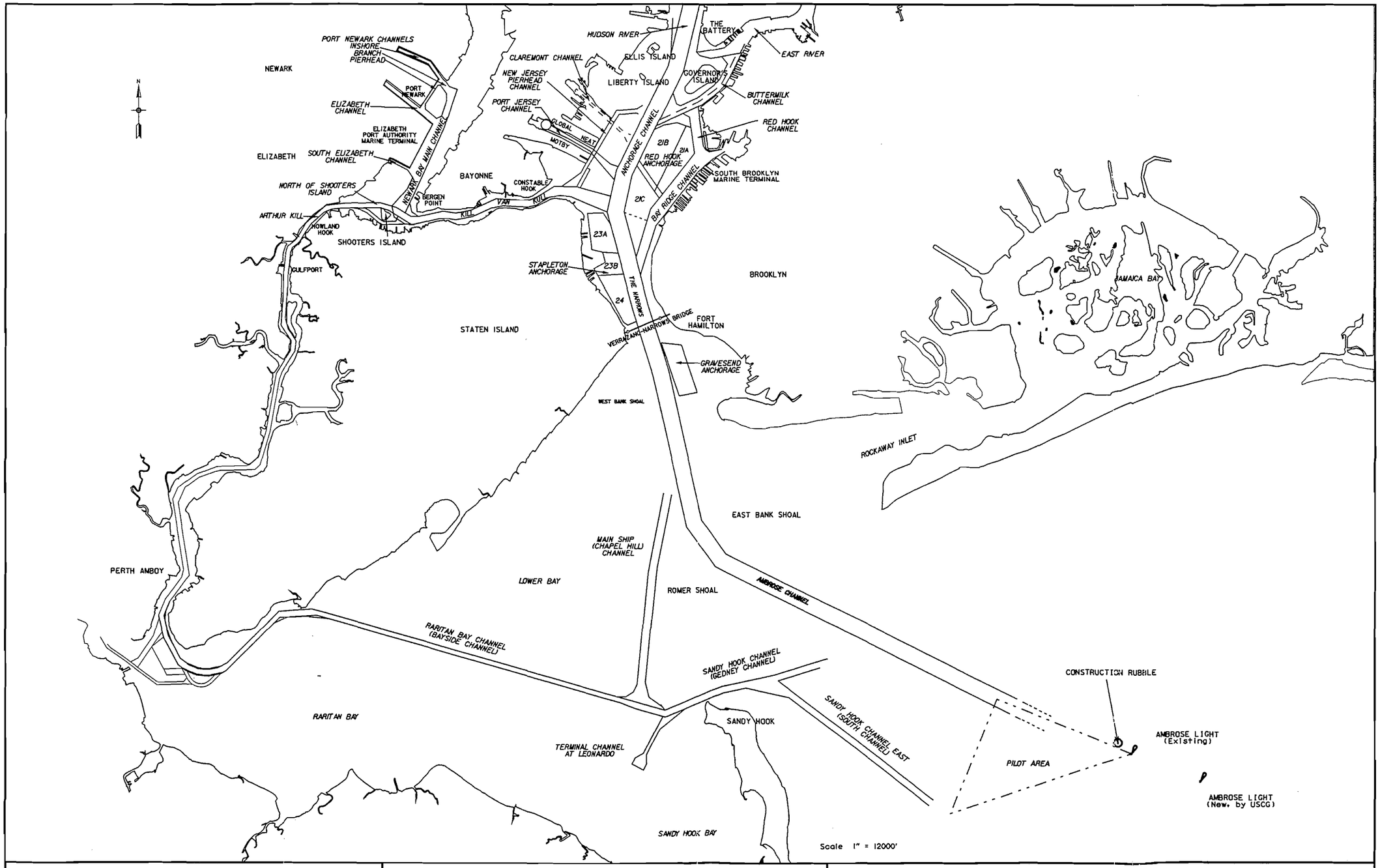
* Minor rounding error

E124. The effects of the channel deepening on shoaling in the portions of the Ambrose Channel that will require dredging are presented in **Table E13**. These volumes were derived from an extrapolation of the shoaling rates in the navigation channels as developed in the model simulations, applying the frequencies above. The volumes were then obtained by integrating the deposition over the zones of the channel where dredging will be required.

E125. The results generated for the interior channel maintenance requirements were developed by applying the 3-D sediment transport model for cohesive sediment transport. The model was applied to all four alternatives and the resulting deposition patterns extrapolated to represent a year for dredging requirements. The results of those simulations are also presented in **Table E13.** These results are summarized by channel reach within the harbor. Because of the nature of these simulations, the best indication of the impacts of the channel deepening will be the shoaling indexes, which are the ratios of the plan dredging volumes to the base dredging. These ratios can then be applied to the actual historical dredging volumes by reach.

Table E13 Improved Conditions Shoaling Rates							
		Plan 1			Plan 2		
Channel	Base (cy/yr.)	Shoal Index	Shoaling Rate	Increase	Shoal Index	Shoaling Rate	Increase
Ambrose	400,000	1.08	432,000	32,000	1.16	464,000	64,000
Anchorage	0	0.90	0	0	1.85	0	0
KVK Con Hook	20,800	1.26	26,200	5,400	1.29	26,900	6,100
KVK Bergen Pt	4,000	1.13	4,500	500	0.83	3,300	-700
Newark Bay Main	211,000	1.00	211,100	100	0.90	189,400	-21,600
NB Port Elizabeth	121,000	1.13	136,700	15,700	1.05	126,900	5,900
NB Port Newark	226,000	1.04	235,100	9,100	1.03	233,400	7,400
AK N.Shooters Is	115,000	0.97	111,700	-3,300	0.70	80,700	-34,300
AK Eliz. – Gulf	7,000	1.25	8,800	1,800	1.97	13,800	6,800
Bay Ridge (+ RH)	520,000	0.99	512,700	-7,300	1.22	635,100	115,100
Port Jersey	58,000	0.92	53,200	-4,800	1.14	66,400	8,400
Claremont	25,000	1.13	28,300	3,300	1.30	32,500	7,500
NJ Pierhead	40,000	1.07	42,700	2,700	1.14	45,700	5,700
Red Hook Anch.	145,000	0.97	140,300	-4,700	1.57	227,200	82,200
Gravesend Anch.	28,000	1.10	30,800	2,800	1.02	28,600	600
Stapleton Anch.	0	1.18	0	0	1.07	0	0
Totals	1,920,800	1.02*	1,974,100	53,300	1.11*	2,173,900	253,100

* Calculated from Totals



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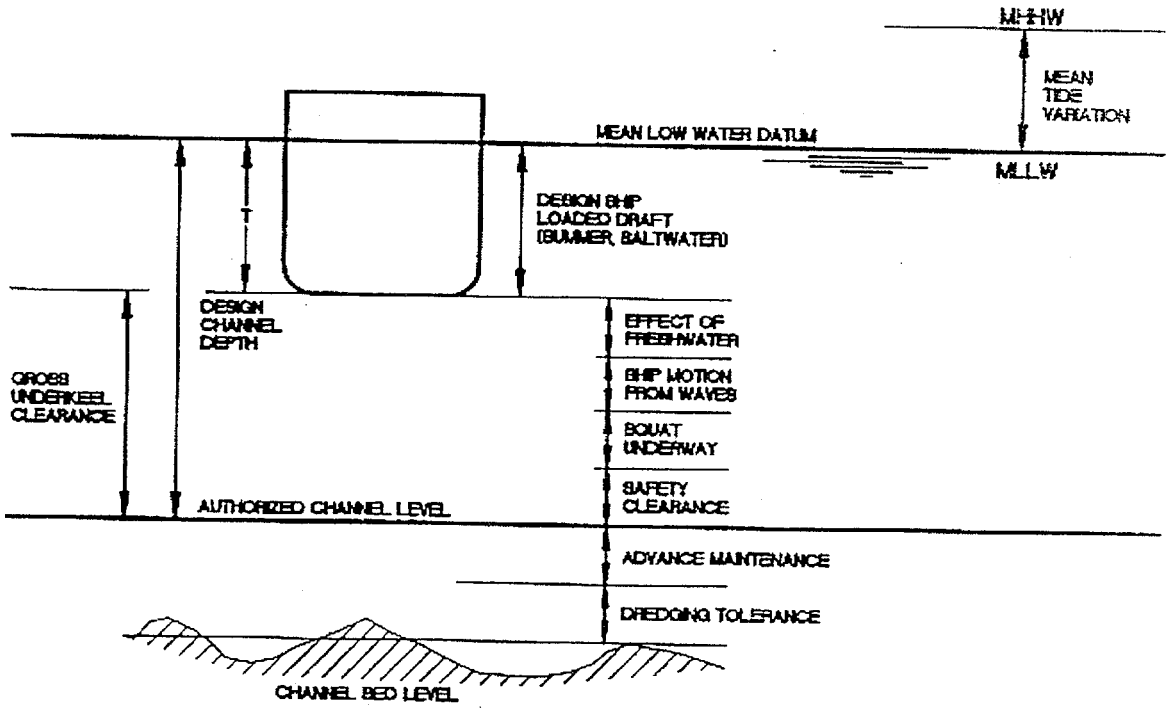
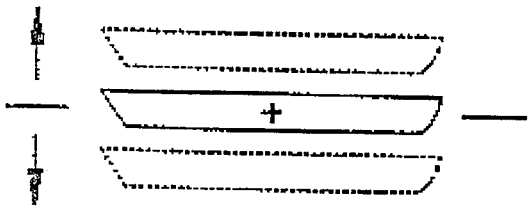
NEW YORK AND NEW JERSEY HARBOR
NAVIGATION STUDY
CHANNEL DESIGN APPENDIX

FIGURE E1
EXISTING NAVIGATION CHANNELS
NEW YORK HARBOR

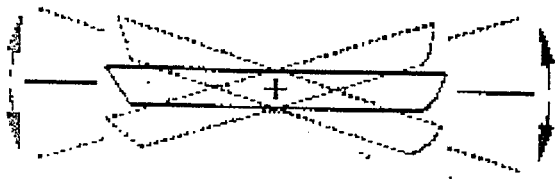


U. S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS NEW YORK, NEW YORK	NEW YORK AND NEW JERSEY HARBOR NAVIGATION STUDY CHANNEL DESIGN APPENDIX	FIGURE E2 CHANNEL DEPTH ALLOWANCES

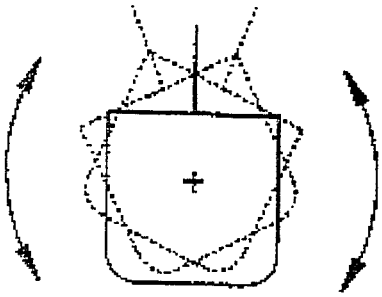
VERTICAL MOTION



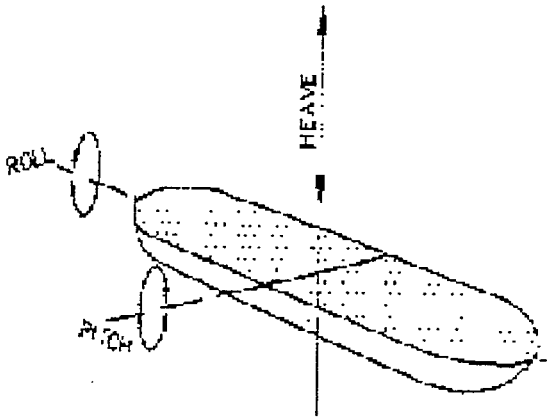
HEAVE



PITCH



ROLL



U. S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS NEW YORK, NEW YORK	NEW YORK AND NEW JERSEY HARBOR NAVIGATION STUDY CHANNEL DESIGN APPENDIX	FIGURE E3 VERTICAL SHIP MOTION

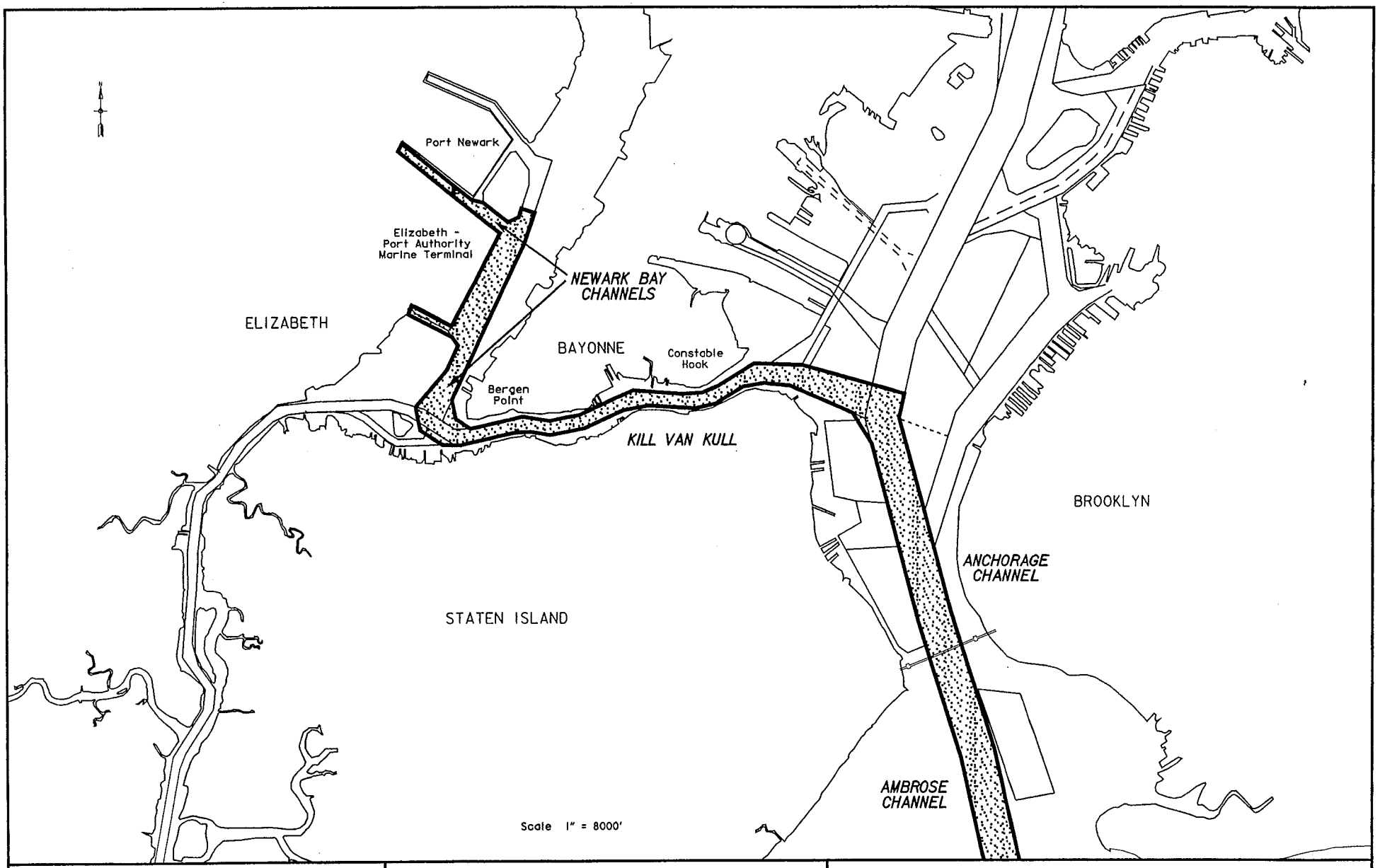


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FIGURE E4
PATHWAY 1 IMPROVEMENTS
KILL VAN KULL, NEWARK BAY

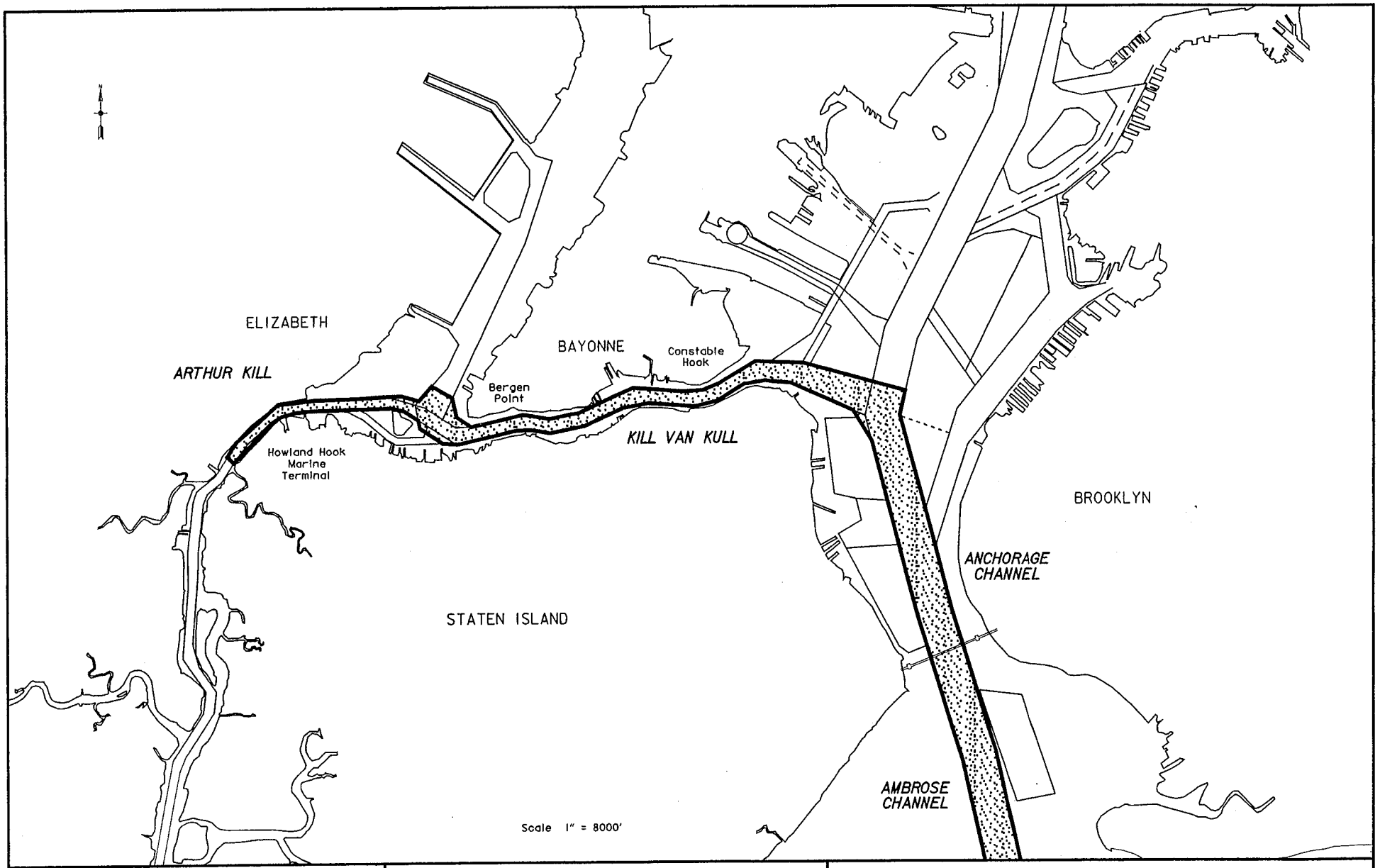

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FIGURE E5
PATHWAY 2 IMPROVEMENTS
KILL VAN KULL, ARTHUR KILL TO HOWLAND HOOK

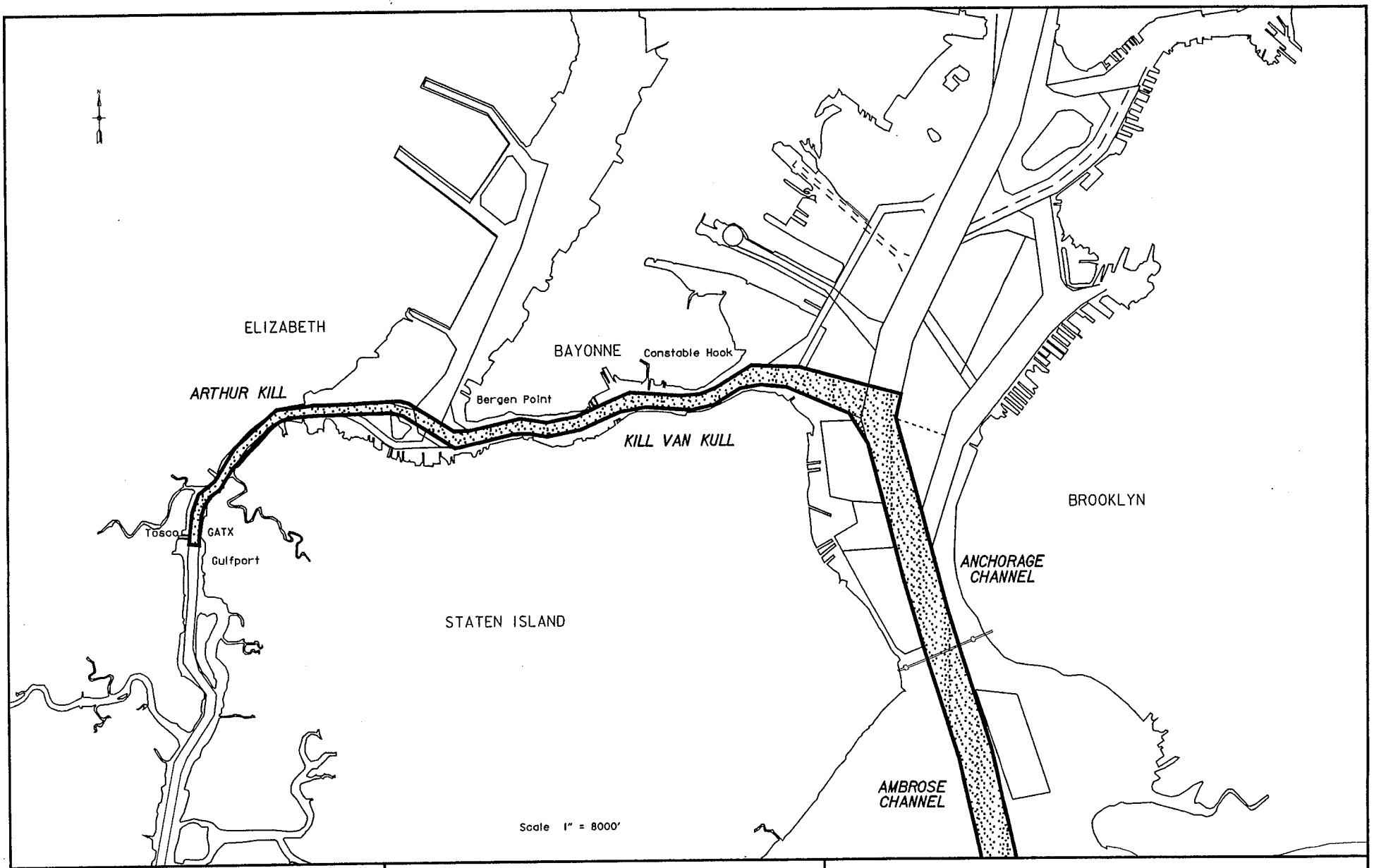

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FIGURE E6
PATHWAY 3 IMPROVEMENTS
KULL VAN KULL, ARTHUR KILL TO GULFPORT

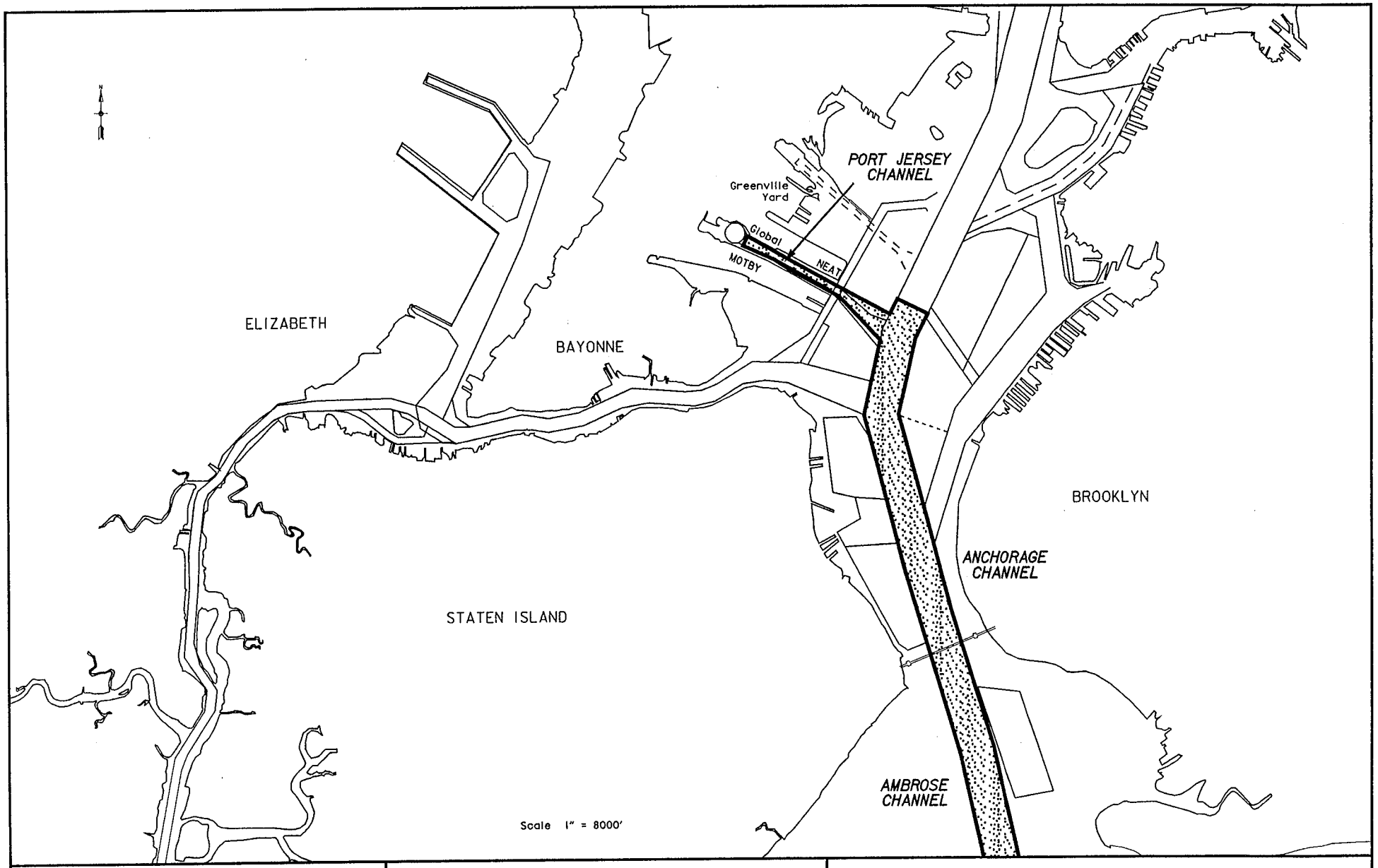

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FIGURE E7
PATHWAY 4 IMPROVEMENTS
PORT JERSEY CHANNEL

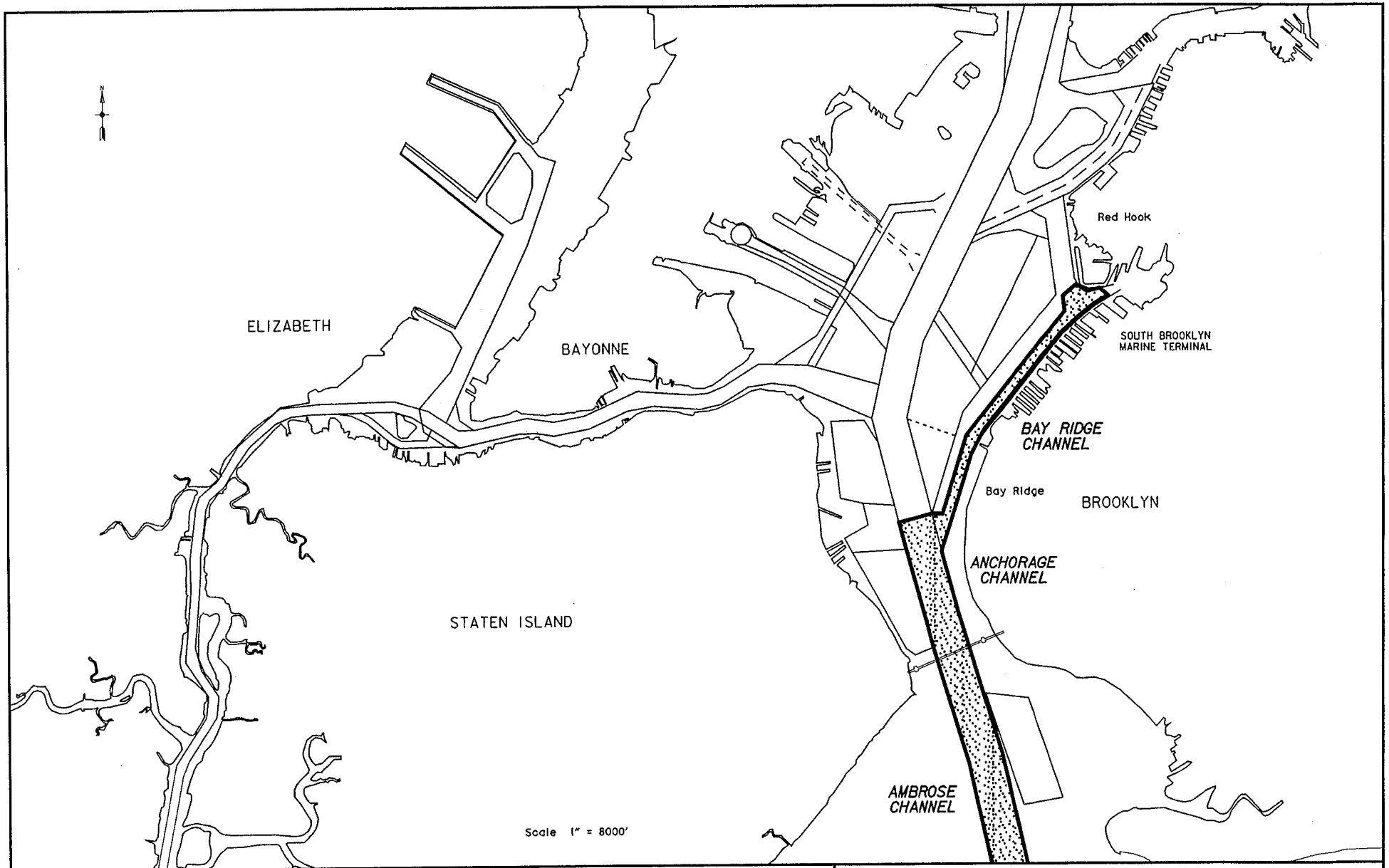

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FIGURE E8
PATHWAY 5 IMPROVEMENTS
BAY RIDGE CHANNEL

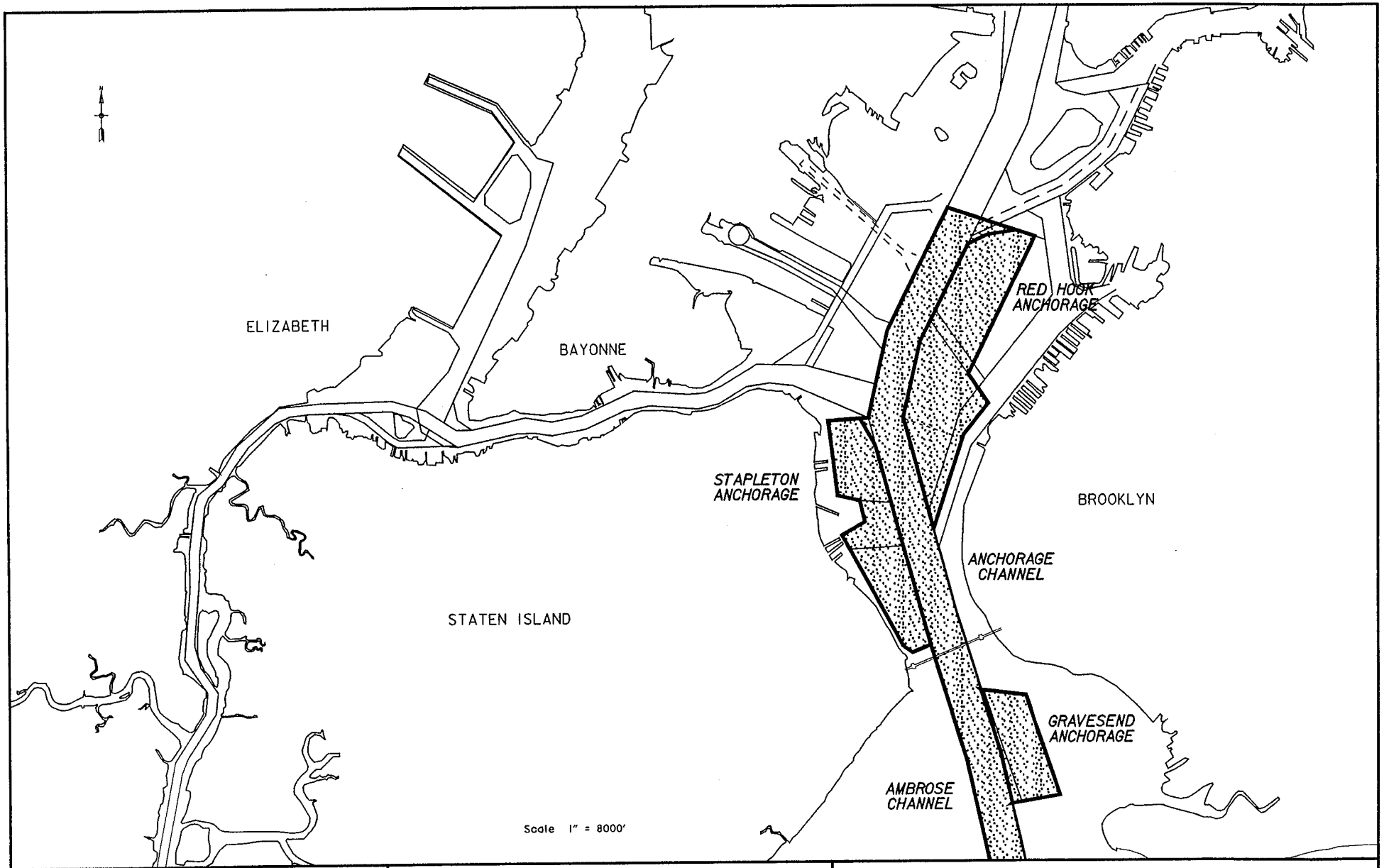

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FIGURE E9
PATHWAYS 6 & 7 IMPROVEMENTS
RED HOOK, STAPLETON AND GRAVESEND ANCHORAGES

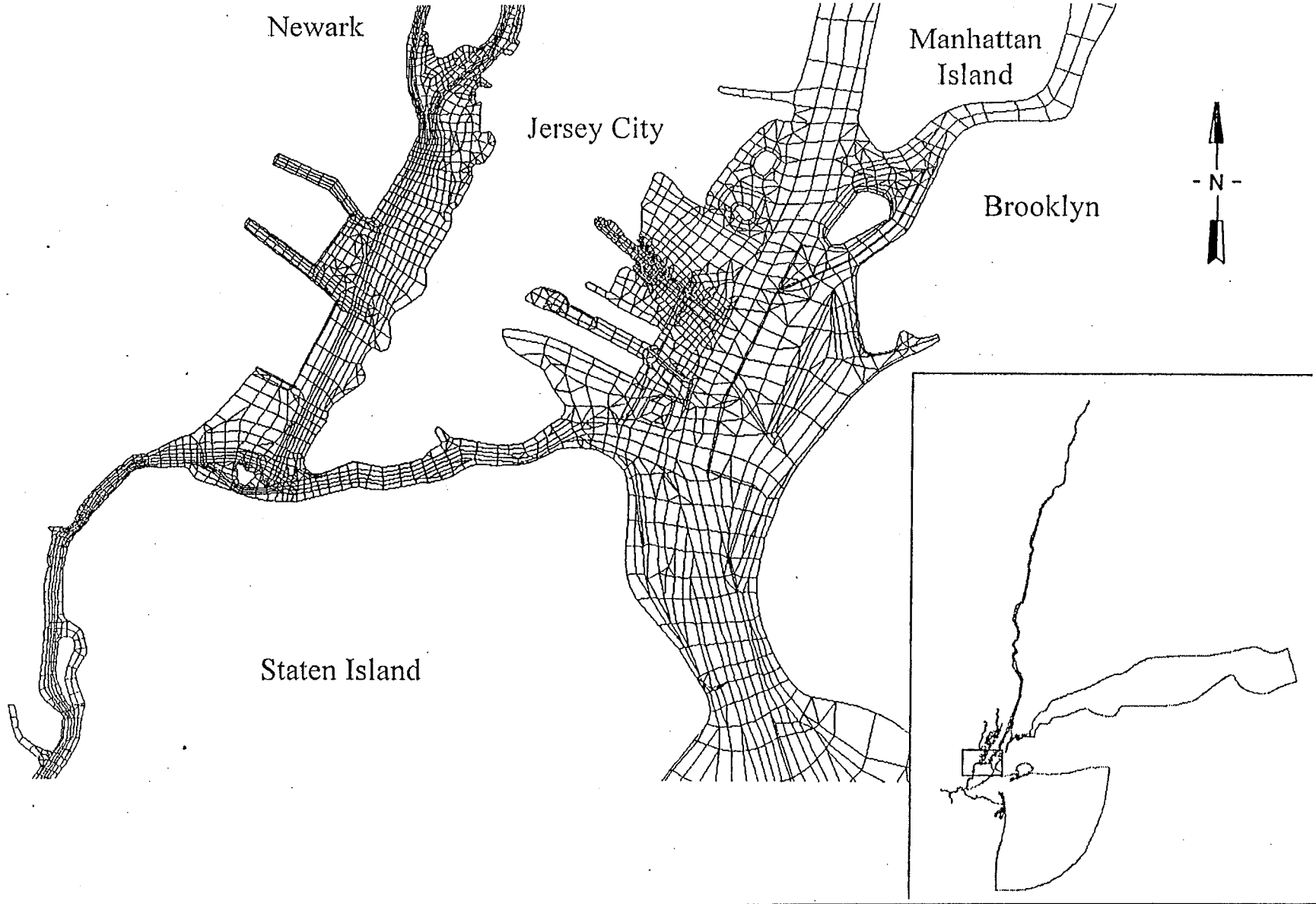

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FIGURE E10A
HYDRODYNAMIC MODEL MESH
UPPER BAY, NEWARK BAY AND THE KILLS

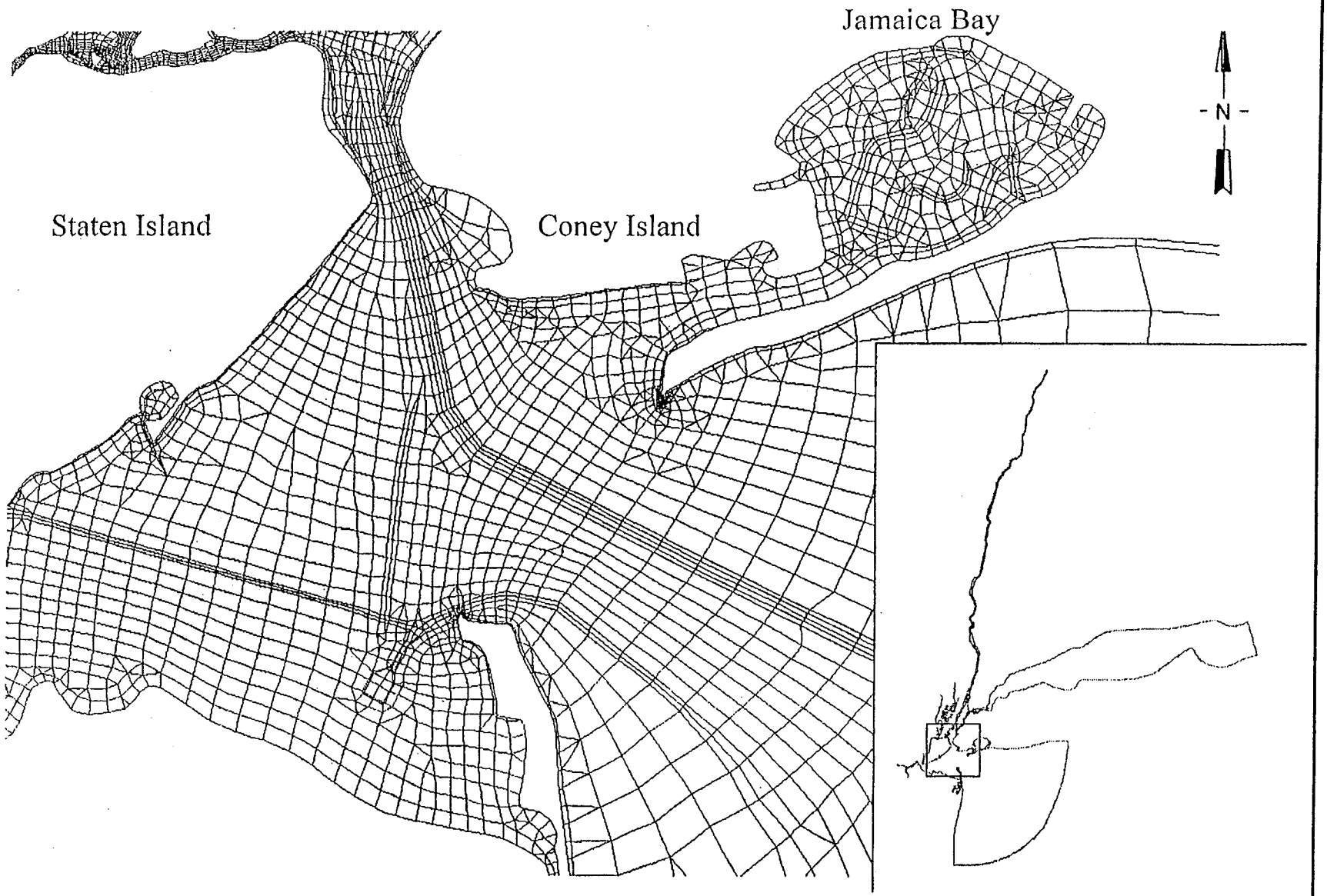

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FIGURE E10B
HYDRODYNAMIC MODEL MESH
LOWER BAY, RARITAN BAY AND JAMAICA BAY

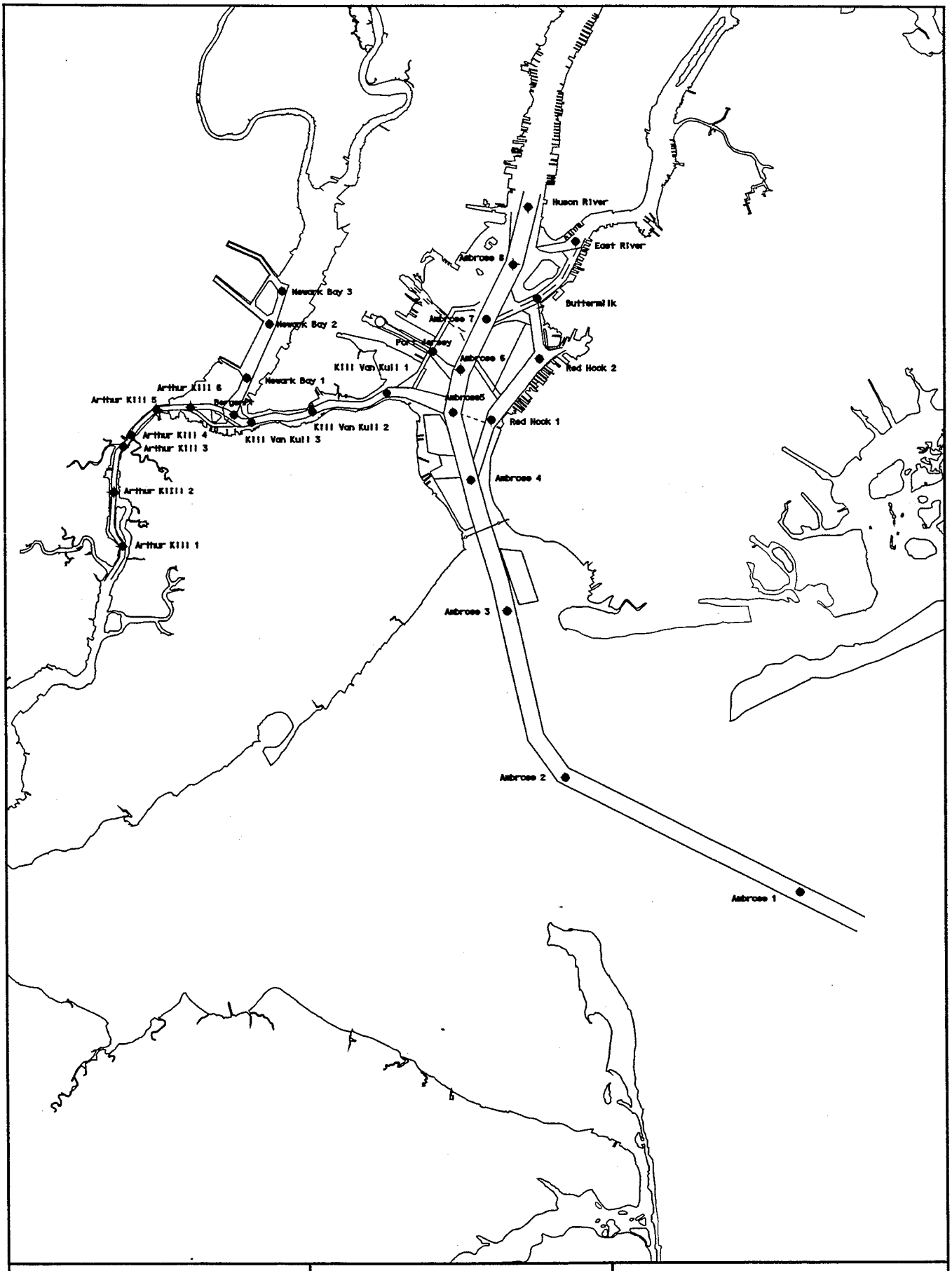

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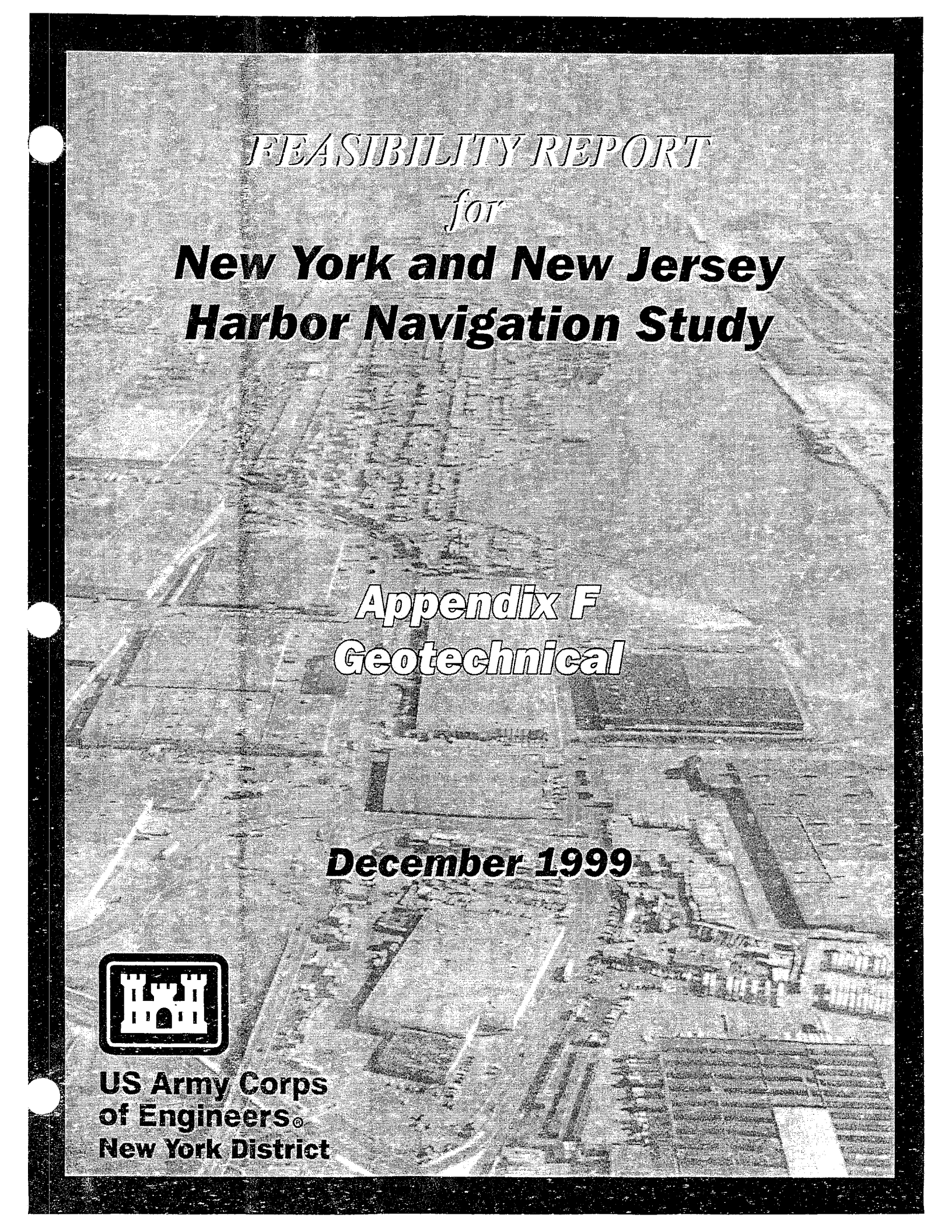
FIGURE E11
HYDRODYNAMIC MODEL
SUMMARY GAGE LOCATIONS



FEASIBILITY REPORT

for

New York and New Jersey Harbor Navigation Study

Appendix F
Geotechnical

December 1999

US Army Corps
of Engineers®
New York District

NEW YORK HARBOR NAVIGATION STUDY

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INTRODUCTION

F1. The channels within the Port of New York and New Jersey are too shallow to allow passage of deep draft and other fully loaded vessels. In order to meet the needs of these larger vessels the channels within the "Port" will require deepening. The New York Harbor Navigation Feasibility Study is an evaluation and screening of potential alternatives for channel deepening and related improvements throughout the Port of New York and New Jersey. The study includes Ambrose, Anchorage, Bay Ridge, Red Hook, Buttermilk, Claremont, Port Jersey, Kill Van Kull, Arthur Kill, Newark Bay, Elizabeth, South Elizabeth and Port Newark Channels as well as the anchorage areas at Stapleton, Red Hook Flats and Gravesend Bay (Figure 1). In order to facilitate the formulation and analyses of alternatives, the study area was divided into pathways (routes) to existing facilities and proposed facilities (Figure 2).

OBJECTIVES

F2. To evaluate the economics of deepening the channels a number of factors will need to be determined. These factors include the physical nature of the material to be removed, how much material will be removed, the best method of removal, where to dispose of the dredged material, and what effects the project will have on nearby property. In order to answer these questions a relatively detailed knowledge of the subsurface is required. Some of the objectives of this appendix are:

- Map the top of bedrock and delineate where it will occur along the proposed paths so that volumetric calculations can be performed
- Map the thickness of contaminated material throughout the port and calculate volumes.
- Construct other maps such as Top of Pleistocene and Percent Sand to help define the dredgeability and disposal options for the of the various channels
- Construct profiles and cross sections to illustrate the aerial distribution of the various soil and rock types that will be encountered along each channel. Based on the profiles and cross sections define similar stratigraphic reaches where soil and rock properties are relatively constant and a specific coarse of action such as blasting or dredging with a specific type of dredge is indicated.
- Define the characteristics (soil or rock classification, density, unit weight, compressive strength etc) of various soil and rock types to be encountered along each channel so that dredgeability analysis and slope stability analysis can be performed.
- Determine which dredging equipment that might be best suited for each stratigraphic reach using available computer programs and dredging records.
- Determine the stability of the channel side slopes

- Evaluate the potential affects that blasting may have on nearby structures.

GEOTECHNICAL INVESTIGATIONS

Review and Inventory of Existing Subsurface Data

F3. A review of previous Corps of Engineer reports and dredging contracts was conducted to determine the location of existing subsurface information. Other public agencies and private sources were contacted to determine the availability of additional subsurface data. The process of spotting the data was complicated by the fact that maps and borings were in different coordinate systems (latitude-longitude, NJ State Plane and NY Long Island Lambert State Plane). All of the data was converted to NJ State Plane NAD 83 using the computer program CORECON and was plotted on a Regional Subsurface Index Map (Figure 3). At the time of this report approximately eight hundred and thirteen (813) borings had been located.

Design and Implementation of Boring Plan

F4. The distribution, depth, and quality of the available data was reviewed to determine the need for additional subsurface. The review determined that some of the channels (i.e. Kill Van Kull, Arthur Kill, Newark Bay and Port Jersey) would require very little additional data whereas other channels (i.e. Anchorage, Ambrose, Bay Ridge, and Red Hook) were essentially unexplored. In those channels that were essentially unexplored a 1000' X 1000' grid (one boring per 1,000,000 square feet) was employed to select boring or vibracore locations. In channels where there was existing data, locations were selected in areas where there was less than adequate coverage. NOAA charts, construction drawings, and permits were employed to plot the location of utilities and tunnels. As a rule of thumb no locations were selected closer than 250 feet from utility and tunnel alignments. In order to develop the most accurate profiles and cross-sections many locations were selected along the centerline or perpendicular to the centerline of the Channels. Five hundred and thirty (530) new locations were defined and are shown on the Regional Subsurface Index Map (Figure 3 and 3A).

F5. Due to the lack of jack-up or spud barges capable of acquiring SPT borings in water deeper than fifty feet (50'), vibracores were acquired at approximately one hundred and thirty (130) "deep water" locations. All of the deep-water locations occurred in Ambrose Channel where one hundred vibracores were acquired or in the Anchorage Channel where thirty (30) vibracores were obtained. In order to accomplish the work on schedule it was necessary to employ both the COE Drill Ship "Explorer" and a private drilling contractor.

Subsurface Data Acquisition and Testing

F6. Standard Penetration Test (SPT) methods were employed to collect continuous soil samples at approximately 400 locations throughout the Port of New York and New Jersey. Representative soil and rock samples were selected for testing from both SPT borings and vibracores. Samples were selected and tested with the two major objectives:

- to define the geotechnical properties of the soil necessary for slope stability analysis, dredging analysis and blasting analysis.
- to investigate possible "low cost" techniques to determine the thickness of the contaminated interval

F7. Geotechnical testing included grain size distribution, moisture content, unit weight, specific gravity, liquid and plastic limits. Multiple undisturbed (Shelby Tube) samples were recovered from each of the major Silt and Clay strata. Triaxial tests were performed on the undisturbed samples to determine shear strength, cohesion and other factors necessary for slope stability.

F8. Rock cores were recovered in those areas where shallow (<65'from MLW) bedrock was encountered. Cores were described in detail and rock quality (RQD) was determined. Point load tests were conducted on representative core samples.

F9. Testing that was conducted with the objective of determining the thickness of the contaminated interval included ultra violet fluorescence, photo ionization, total petroleum hydrocarbons and moisture content.

BORING LOG DATA BASE

F10. Boring log identification, coordinates, elevation, strata (soil) descriptions and strata breaks were entered into electronic data libraries using the computer program "INSITU". Once the data is entered into electronic libraries the information on an individual log can be printed out as a boring log or the information on numerous logs can be displayed in the form of soil profiles or cross-sections. All 530 of the new borings and 751 pre-existing borings have been entered into electronic boring libraries. However, the program does not display all of the information in the preferred format so some editing is required on each boring. All 1281 borings have been edited, printed and catalogued in paper and electronic formats. The boring logs are available for review at the Corps of Engineers New York District.

REGIONAL GEOLOGY

STRATIGRAPHY AND PHYSIOGRAPHY

F11. The near surface stratigraphy in the study area can be grouped into three major units: Bedrock, Pleistocene Sediments and Holocene (Recent) Sediments. The aerial extent, thickness and volume of these units are significant factors to be considered in the economics of deepening the channels within the Port.

BEDROCK LITHOLOGY and TOP OF ROCK CONTOUR MAP

F12. A Top of Rock Contour (Structure) Map was constructed to delineate where rock will be encountered when the channels are deepened (Figure 4 and 5). Figures 4 shows the location and type of rocks that will be encountered if the channels are deepened to fifty-feet (-50' MLW). The location and type of rock that will be encountered if the channels are deepened to sixty feet (-60 MLW) is shown on Figure 5. The Top of Rock Contour (Structure) Map was employed to determine the volume of rock that will require removal. The location and rock volumes are required for blasting analysis, and cost analysis.

F13. Metamorphic rocks (Serpentinite, Gneiss, and Schist) were identified in the eastern portion of Kill Van Kull and in Port Jersey. These metamorphics are considered to be part of the Manhattan Prong of the New England Uplift (Cambrian). Diabase, an igneous rock, was identified in western Kill Van Kull and Newark Bay. Sedimentary rocks (Shale and Sandstone) were identified in Arthur Kill, Newark Bay, Elizabeth and South Elizabeth Channels. The Diabase, Sandstone and Shale are members of the Brunswick Formation (Jurassic) of the Newark Basin Physiographic Province. Bedrock was not encountered above the projected project depths (-50' MLW and –60' MLW) in the Upper Bay channels (Anchorage, Bay Ridge, Port Jersey and Claremont) and anchorages (Red Hook Flats and Stapleton). However, bedrock (Sandstone and Schist) is just below the projected dredge depth of fifty-feet below mean low water (-50 MLW) in Port Jersey and should be better delineated before dredging begins. Poorly consolidated sandstone and shale of the Atlantic Coastal Plain Physiographic Province (Tertiary-Cretaceous) underlies Ambrose Channel and Gravesend anchorage but were not encountered within the depth of investigation (-75 MLW).

PLEISTOCENE SEDIMENTS

F14. The bedrock complex is overlain by Pleistocene glacial sediments that range in size from silt and clay to large cobbles and boulders. In most cases glaciation subdued the terrain by leveling the higher peaks and filling the valleys with glacial till (ground moraine). However, in some cases, low relief, elongated hills were formed by debris pushed in front (terminal moraine) or to the sides (lateral moraines) of the advancing glacier. A terminal moraine exists along the south edge of Staten Island up to the Narrows, and then appears again in the Bay Ridge section of Brooklyn. The terminal moraine continues out on Long Island to Nassau County where it

splits into two separate terminal moraines that continue out to Montauk Point and Orient Point. The southern terminal moraine is known as the Ronkonkoma and the northern as the Harbor Hill. Adjacent to the Narrows, the Harbor Hill terminal moraine overlies the Ronkonkoma.

F15. Southeast of the terminal moraine are outwash deposits of sand and gravel that extend under Lower New York Bay. These fluvial deposits are the result of ice melt water washing soils out beyond the terminal moraine. Behind the terminal moraine is a ground surface moraine deposit consisting of an unsorted mixture of sand, silt, clay, gravel, cobbles and boulders. These materials were picked up by the advancing ice and dropped as the ice melted. Scattered within this ground moraine are fluvial deposits, such as eskers and kames, which were deposited by concentrated ice melt water that flowed in and under the ice.

F16. As the glacier receded, the terminal moraine became a natural dam that impounded the glacier melt water and formed a number of large lakes. Varved silts and clays were deposited within these lakes. These varved deposits which overly ground moraines are sometimes as thick as one hundred feet (100'). Sands were deposited on top of the varved silt and clay when the lakes became shallow. Eventually the terminal moraine was breached and the glacial lakes were drained. Subsequent to the draining of these glacial lakes, outwash plains composed of alluvial sand deposits were formed along the perimeter of the lakebeds.

F17. A Top of Pleistocene Contour (Structure) Map was constructed (Figure 6). The map was employed to define areas where the dense (more difficult to dredge) Pleistocene Sediments will be encountered. It should be noted that Pleistocene sediments are normally red to brown, rarely contain shells and are relatively dense when compared to Holocene (Recent) sediments, which are normally gray to black and frequently contain shells. Although there are significant differences between Pleistocene and Holocene (Recent) sediments it is not always easy to define the top of the Pleistocene.

F18. The Pleistocene Structure Map indicates that no Pleistocene sediments will be encountered above the proposed dredge elevations in Ambrose Channel, Anchorage Channel, Gravesend Anchorage or Red Hook Flats Anchorage. A relatively small portion (less than 25%) of the sediments to be removed from Bay Ridge Channel and Stapleton Anchorage will be Pleistocene. Approximately fifty percent (50%) of the sediments in the Claremont Channel are Pleistocene. The sediments to be removed from Port Jersey, Kill van Kull, Arthur Kill, Newark bay, Elizabeth and South Elizabeth Channels will be essentially all (greater than 90%) Pleistocene.

F19. The Top of Pleistocene Contour Map (Figure 6) can be considered a paleostructure or paleogeographic map. If current estimates are realistic then sea level is rising at rate of 1'-2' per hundred years. Assuming a rate of 1'-2' per hundred years then an elevation of –40' MLW would represent the strand line as it existed 2,000-4,000 years ago (Figure 7). The –100' MLW contour approximates the strand line as it existed 5,000-10,000 years ago. The top of the

Pleistocene normally occurs at an elevation of approximately 20 feet below mean low water (-20' MLW) along the flats adjacent to channels. Based upon a depth of –20' MLW, deposition of marine (estuary) sediments outside of the Hudson River Channel began in the range of 1,000-2,000 years ago. Prior to that time marine sediments were gradually filling the Hudson Channel which (based on borings) is in excess of one hundred and twenty-five feet deep.

HOLOCENE (Recent) SEDIMENTS

F20. During the last 20,000 years sea level has risen as much as three hundred feet (300') and continues to rise at a rate of one to two feet (1'-2') per 100 years. As a result, the project area that was high and dry during the Pleistocene has become a tide-dominated estuary. A blanket of Holocene (Recent) sediments ranging from poorly graded sand, silty sand, slightly organic silt, and occasionally peat has been deposited. The thickness of the Holocene section ranges from a few feet in the flats adjacent to the navigation channels to more than 120' in Red Hook Flats.

F21. The upper portion of the Holocene section often emits a petroleum-like odor and contains man made debris including toxic chemicals and heavy metals. An objective of this study was to estimate the aerial distribution (location and thickness) of the contaminated material so that volumes could be approximated. This was accomplished through the use of isopach (thickness) maps. The thickness of contaminated material above 50 feet and above 60 feet was determined in those borings in which it was detected. The thickness of contaminated interval was estimated in each boring from physical characteristics (moisture content, color, odor, and soil density), scanning methods (UV fluorescence, and photo-ionization) and direct testing (total petroleum hydrocarbons). The estimated thickness was posted next to each boring (plan view) and the values contoured on a two-foot interval. The maps (Figures 8 and 9) show the location and aerial distribution of contaminated sediments that will require removal and disposal as the channels are deepened. The following table summarizes the quantity (cubic yards) of contaminated sediments to be removed from each channel and anchorage. The 2.0' fill column represents the volume of sediment to be removed assuming that channels constructed in rock or hard material will require two feet of safety clearance. These channels will only be maintained if they shoal above project depth thus allowing 2.0' of sediment to accumulate. This shoal material should be contaminated. The 0.0' fill column represents the volume of sediment to be removed without the 2.0 feet of sediment accumulation.

TABLE 1 – QUANTITY OF CONTAMINATED MATERIAL

Cubic yards of contaminated material in place

CHANNEL / ANCHORAGE	CONTAMINATED SEDIMENTS –50' CHANNEL		CONTAMINATED SEDIMENTS –60' CHANNEL	
	0' Fill	2' Fill	0' Fill	2' Fill
AMBROSE CH.	0	NA*	0	
GRAVESEND ANCH.	74,674	NA*	117,683	NA*
ANCHORAGE-BR CH.	56,570	NA*	NA**	
ANCHORAGE-KVK CH	238,969	NA*	1,616,913	NA*
ANCHORAGE-PJ CH	477,737	NA*	NA**	
BAY RIDGE CH.	1,992,659	NA*	NA**	
RED HOOK ANCH.	6,973,734	NA*	11,092,115	NA*
CLAREMONT CH.	1,420,548	NA*	NA**	
PORT JERSEY CH.	311,048	NA*	NA**	
PORT JERSEY PIERHEAD CH	404,171	NA*	NA**	
STAPLETON ANCH.	1,221,051	NA*	2,816,361	NA*
KILL VAN KULL CH.	69,577	2,211,611	208,732	2,350,766
NEWARK BAY CH.	85,106	1,822,148	NA**	
ELIZABETH CH.	42,716	385,394	NA**	
S. ELIZABETH CH.	239,584	360,736	NA**	
ARTHUR KILL – HH CH.	190,683	821,341		
ARTHUR KILL--BW CH.			433,834*	1,265,141*

NA* - existing channel or approved channel depth is interpreted to be in soft material and no over dig for safety purposes is anticipated.

NA - no sixty foot (60') channel is anticipated for this channel**

*** includes Arthur Kill – HH CH. Segment**

PERCENT SAND MAPS (PLEISTOCENE-HOLOCENE)

F22. The percentage of sand and gravel-sized sediments above fifty-feet below mean low water (-50 MLW) and above sixty-feet below mean low water (-60' MLW) is shown on Figures 10 and 11. These maps can be used to determine where the dredged material will be predominantly sand and gravel, silt and clay or some combination. The maps should be used in conjunction with the Top of Pleistocene Map (Figure 7), Isopach Maps (Figures 8 and 9), as well as profiles and cross-sections (Figures 12-30) to help define the most suitable contract limits, possible dredge types, and disposal location. All of these factors are employed in the cost analysis.

GEOTECHNICAL ANALYSIS

SOIL PROFILES AND CROSS-SECTIONS

F23. In the following paragraphs the individual channels are described in detail through the use of soil profiles and cross-sections. The profiles were employed to illustrate the aerial extent of the various soil and rock types that will be encountered along the length of the channel. Soils that have similar characteristics (i.e. Silty Sand and Silty Gravel) or that are difficult to differentiate in the field (i.e. Silty Clay or Clayey Silt) were grouped together to define stratigraphic units. Soil color was employed as another factor in determining the stratigraphic units illustrated. Pleistocene sediments are commonly reddish-brown whereas the Holocene sediments are frequently gray, tan or black. Although a stratigraphic unit is, for instance called Holocene Silt and Clay it may contain miner sand or gravel sub-units. The profiles have been used to subdivide the channels into similar reaches where dredging conditions are relatively uniform. Uniform soil and/or rock conditions are a major factor to be considered when dredging contract limits are defined. The location of the profiles and cross-sections is shown on the Subsurface Index Map (Figure and 3A) as well as the Channel Maps and Profiles (Figures 12-22).

F24. Cross sections show the stratigraphy of soil and rock types that occur along the channel side slopes as well as the channel floor. The soil types that occur along the channel side slopes and their properties (i.e. cohesion and shear strength etc) are very significant factors to be considered in determining side slope stability.

DREDGEABILITY ANALYSIS

F25. The WES program DREDGABL was developed to aid the Engineer in determining the suitability of various sediments to dredging. This program allows the Engineer to accurately determine if a given sediment type can be dredged and what dredges are most appropriate for the dredging procedure. The program requires that the specific soil type as described using the Unified Soil Classification System be entered along with several auxiliary items. These include fineness (grain size), consistency (i.e., soft or hard), compactness (density), angularity and plasticity and liquidity indices. For compressible sediments (both Organic and Inorganic Clay and Silt) the consistency, plastic index and liquidity index are needed to perform the analysis. For coarser sediments (Sand and Gravel) the fineness, compactness and angularity are needed. Although the program will allow for the omission of auxiliary items it is more conducive to the obtaining of accurate results if these are included in the evaluation. Additionally, the DREDGABL program will provide information on rock and shale fragments, cemented soils, shells and debris. DREDGABL also allows the operator to create a locality specific database for future use.

F26. The dredgeability analysis that follows for each channel is based on similar reaches as defined from the soil profiles and cross-sections, the DREDGABL program, dredging records,

and practical experience. Table 2 is summary of the general dredging characteristics of the overall dredge types studied. Specific dredges are listed for each channel or anchorage. Before a final dredge type is selected, coordination with other agencies must occur. Some dredge types are not permitted because of environmental concerns, cost or availability. Final selection of the dredge type to be used lies with the Contractor in coordination with the USACE and other agencies.

TABLE 2 - SUMMARY OF DREDGE OPERATING CHARACTERISTICS

DREDGE TYPE	*% SOLIDS IN SLURRY BY WEIGHT*	*TURBIDITY*	*OPEN WATER OPERATION*	*RANGE OF PRODUCTION CU.YD. /HR.*	*DREDGING DEPTH RANGES (FT)*	*WAVE HEIGHT LIMITS (FT)*	*LIMITING CURRENTS*
HOPPER DREDGES	10 to 20	HIGH	YES	500 - 2000	10 to 80	< 7	7 KNOTS
MECHANICAL DREDGES	IN SITU	AVERAGE	YES	30 - 500	0* to 100	< 3	3 KNOTS
PIPELINE DREDGES	10 to 20	AVERAGE	Depends on Type	25 – 10,000	3 to 14	< 3	3 to 7 KNOTS

* Zero draft is used alongside waterway.

F27. Each channel or anchorage has been designated either "soft" or "hard" as a reference to the ease of dredging. The following channels and all anchorages have been designated "soft" because the sediments are relatively loose sands or soft to very soft silts and clays and should be easily dredged: Ambrose, Anchorage, Claremont, and Bay Ridge Channels and Red Hook Flats, Stapleton, and Graves End Anchorages. The following channels have been designated "hard" either because the sediments are dense to very dense or rock is present: Kill Van Kull, Newark Bay, Elizabeth, South Elizabeth, Arthur Kill, and Port Jersey. These channels will require additional efforts during dredging including rock blasting.

CHANNEL SIDE SLOPE STABILITY ANALYSIS

F28. It is necessary to determine the stability of the channel side slopes for the following reasons:

- If there are structures close to the top of the slope and failure occurs, the structural integrity of the structure is diminished and very significant damage may occur.
- If the channel side slopes are not stable (too steep) then failure will result in significant shoaling. Frequent expensive maintenance dredging will be required.

F29. Slope stability analysis was performed using the computer program UTEXAS 3. The program requires input including data such as channel slope profiles, stratigraphy, soil properties, and water properties. The Spencer, Bishop, USACE, and Lowe procedures were used to obtain the lowest factor of safety for the governing cross section of each slope. The analyses were designed to be conservative by selecting the highest point along each cross-section and the deepest projected dredge depth.

F30. The existing channel side slopes in non-rock material were constructed and have been maintained at a 1 (rise) on 3 (run) ratio. These slopes are very similar to those that existed along the natural channel prior to dredging. These side slopes have proven to be stable near critical structures for all types of soils within the channel. Slopes greater than 1 on 3 may not be stable especially for soft soils such organic silts, peat, and loose sands. Excessive sloughing of these types of soils may occur causing more frequent maintenance dredging. In view of these factors a side slope of 1 on 3 is recommended where possible. The results of slope stability based on a 1 on 3 side slope is summarized for each channel evaluated. The results of analyses based on side slopes steeper than 1 on 3 is available at the Corps of Engineers New York District.

F31. The existing channel side slopes in rock areas were constructed at a 1 (rise) on 1 (run) ratio. This slope has proven to be stable, especially near structures. The 1 on 1 side slopes were basically formed from the blasting. The explosives in the blast holes break and push the rock upward in a shape of a 45 degree angle cone. These 1 on 1 side slopes in rock are relatively easy for a contractor to dredge after blasting. In view of these factors a side slope of 1 on 1 is recommended where possible in rock areas. In areas where a steeper slope is required more detailed analysis should be performed. Factors such as the orientation (strike and dip) of fractures and bedding planes should be determined.

F32. The results of slope stability analysis base assuming a 1 on 1 side slope in rock is summarized for each channel evaluated. The results of analyses based on slopes steeper than 1 on 3 is available at the Corps of Engineers New York District.

AMBROSE CHANNEL

STRATIGRAPHY

F33. The near surface stratigraphy of Ambrose Channel is illustrated on Figure 12. The proposed channel depths of fifty-three feet below mean low water (-53 MLW) and 61' below mean low water (-63' MLW) are delineated so that the viewer can focus on the materials that will be removed when the channels are deepened. The profile indicates that the channels can be divided into two similar reaches. Reach 1 is predominantly clean (little or no fines) Sand (SP-SW) with very minor pockets of Silt and Clay. Reach 2 is predominantly silty Sand (SM). Shell fragments are a common component in all of the soil types described.

DREDGEABILITY

F34. For the purpose of this analysis the Ambrose Channel was divided into two reaches. Reach 1 is composed almost entirely of Sands (SP or SW) with little or no Silts and Clays. A fine or fine to medium, poorly graded Sand of loose to medium density is the dominant sediment type. The DREDGABL Program indicates that all the dredge types evaluated can be used to dredge this reach because of the limited amount of Silt and Clay found within the matrix of the Sand. The Silt and Clay found in distinct stratigraphic layers are in small isolated pockets. The overflow of Silt and Clay during dredging will not pose a problem.

F35. A Mechanical Clamshell Dredge with teeth is the most readily available type of dredge in the New York Metro area. A large capacity Clamshell would be well suited for dredging this reach. If the material is suitable for ocean disposal then Pipeline Dredges (i.e. Draghead) would also be a logical choice particularly if the sand can be used at nearby beaches or if a disposal site is located near the channel.

F36. Reach 2 is composed primarily of Sand (SP or SM/SC). However, the amount of Silts and Clays is increasing towards the northernmost end of the reach. The DREDRABL Program indicates that all of the dredge types listed (see attached table) would be suitable for the dredging of this reach. Although the increase in Silt and Clay would not adversely effect the dredgeability of the reach, it will increase the amount of Silt and Clay overflow during the dredging process if either Hopper or Mechanical Dredges are used.

F37. The Mechanical Clamshell Dredge is the most readily available and a Clamshell with a large bucket to cover a wide area would be the best suited for the dredging of this reach. Pipeline Dredges can be used in this reach if a disposal site is located nearby.

SOIL TYPE	*CUTTERHEAD PIPELINE DREDGE*	*BUCKET HOPPER DREDGE*	*BACKHOE MECHANICAL DREDGE*	*CLAMSHELL MECHANICAL DREDGE*	*POWER SHOVEL MECHANICAL DREDGE*
REACH 1 SANDS SP & SW	VERY GOOD TO EASY CUTTING LOW PUMPING ENERGY	FAIR TO EASY DIGGING MUCH OVERFLOW OF FINES	FAIR TO EASY DIGGING MUCH OVERFLOW OF FINES	FAIR DIGGING MUCH OVERFLOW OF FINES	FAIR TO EASY DIGGING MUCH OVERFLOW OF FINES
REACH 2 SANDS SP & SM/SC	VERY GOOD TO EASY CUTTING LOW PUMPING ENERGY	GOOD TO EASY DIGGING VERY LITTLE OVERFLOW OF FINES	GOOD TO EASY DIGGING VERY LITTLE OVERFLOW OF FINES	FAIR DIGGING LITTLE OVERFLOW OF FINES	GOOD TO EASY DIGGING VERY LITTLE OVERFLOW OF FINES

SLOPE STABILITY

F38. The lowest safety factor computed for this channel equals to 1.9. The soil types and profiles for this channel consisted of the following:

MATERIAL	*SYMBOL*	*DEPTH*	*SATURATED UNIT WEIGHT (PCF)*	*ANGLE OF FRICTION (DEGREES)*	*COHESION (PSF)*
SAND	*SP*	*-38 to –150*	*150.0*	*22*	*40.0*

F39. The failure surface for the slope stability occurs entirely within the Sand layer. The failure surface is shown in Figure 13.

ANCHORAGE CHANNEL

STRATIGRAPHY

F40. The stratigraphy of the Anchorage Channel is shown on Figure 14. The proposed channel depths (with over-dredge) of fifty-two feet below mean low water (-52 MLW) and 62' below mean low water (-62' MLW) are delineated so that the viewer can focus on the materials that will be removed when the channels are deepened. The profile indicates that the channel can be divided into two similar reaches. Reach 1 is composed primarily of Holocene (Recent) Silt and Clay and Reach 2 is composed primarily of Holocene (Recent) Sand.

DREDGEABILITY

F41. For the purpose of DREDGABL analysis the Silt and Clay in Reach 1 was classified as either OH or MH, very soft to soft with medium to high plasticity. The Sand in Reach 2 was classified as SP or SM and considered to be fine to medium grained, subangular, and of medium compactness. These criteria were determined from a review of the boring logs in each reach. The Silts and Clays of Reach 1 have excavation characteristics classified as "easy digging" for Hopper and Mechanical Dredges and "well suited" for the Cutterhead Pipeline Dredge. Based upon the results of the DREDGABL analysis, the Sands in Reach 2 have excavation characteristics classified "very good – easy cutting" for the Cutterhead Pipeline Dredge and as either "fair to good" for the Bucket Hopper Dredge and the Backhoe, Clamshell and Power Shovel Mechanical Dredges.

SOIL TYPE	CUTTERHEAD PIPELINE DREDGE	BUCKET HOPPER DREDGE	BACKHOE MECHANICAL DREDGE	CLAMSHELL MECHANICAL DREDGE	POWER SHOVEL MECHANICAL DREDGE
REACH 1 SILTS & CLAYS MH & OH	WELL SUITED LOW CUTTING ENERGY EASY PUMPING	EASY DIGGING MEDIUM TO HIGH OVERFLOW OF FINES	EASY DIGGING SOME TO HIGH SUCTION	EASY DIGGING FINES MAY WASH OUT	EASY DIGGING SOME TO HIGH SUCTION FINES MAY WASH OUT
REACH 2 SANDS SM & SP	VERY GOOD EASY DIGGING LOW PUMPING ENERGY	GOOD TO FAIR DIGGING LITTLE TO MUCH OVERFLOW OF FINES	GOOD TO FAIR DIGGING LITTLE TO MUCH OVERFLOW OF FINES	FAIR DIGGING LITTLE TO APPRECIABLE OVERFLOW OF FINES	GOOD TO FAIR DIGGING LITTLE TO MUCH OVERFLOW OF FINES

F42. In view of contamination, turbidity, overflow, disposal, and availability of dredging equipment an environmentally friendly Clamshell would appear to be the most logical equipment to use to dredge Reach 1. Depending on the results of testing for ocean disposal it might be advantageous to use Pipeline Dredges (i.e. Cutterhead or Draghead) in Reach 2. However, when all factors are considered a large capacity Clamshell may be the dredge of choice.

SLOPE STABILITY

F43. The lowest safety factor for this channel equals to 1.6. The soil profile and properties consist of the following:

MATERIAL	SYMBOL	DEPTH	SATURATED UNIT WEIGHT (PCF)	ANGLE OF FRICTION (DEGREES)	COHESION (PSF)
SAND	SP	-65 to –150	150.0	22	50.0

F44. The failure surface occurs entirely with the SAND Strata. The failure surface is shown in Figure 15.

BAY RIDGE CHANNEL

STRATIGRAPHY

F45. The stratigraphy of the Bay Ridge Channel is shown on Figure 16. The proposed channel depth (with over-dredge) of fifty-two feet below mean low water (-52) is delineated so that the viewer can focus on the materials that will be removed when the channels are deepened. Based on Profile 1-1' the channel can be divided into three similar reaches. The sediments to be dredged from Reach 1 are composed of a layer of black Silt and Clay (ooze) overlying Silty Sand. Stiff, Pleistocene Silt and Clay may be encountered along the north and eastern portions of this Reach. Reach 2 consists of a layer of black Silt and Clay (ooze) overlying soft Gray Silt

and Clay. The sediments to be removed from Reach 3 are predominantly composed of Silty Sand.

DREDGABILITY

F46. For the purpose of DREDGABL Analysis the main focus of Reach 1 is the Sand layer. The Sand in this Reach is described as a fine to medium grained, medium dense to dense Silty Sand and is classified as a SM. Reach 2 is composed almost entirely of very soft to soft Silt and Clay that is classified as OH, MH and CH. Reach 3 is composed primarily of a fine to medium grained, medium dense Silty Sand (SM).

F47. The results from the DREDGABL analysis (detailed in the table below) for Reach 1 indicates that the Cutterhead Pipeline Dredge is capable of dredging this reach the best. Its suitability is classified as "very good – easy cutting". The Bucket Hopper and Backhoe, Clamshell, and Power Shovel Mechanical Dredges were all considered unsuitable with a classification of "poor – difficult digging to hard digging".

F48. According to DREDGABL the Cutterhead Pipeline Dredge was determined to be the "best suited" for dredging the Silts and Clays of Reach 2. However, the Hopper and Mechanical Dredges were considered capable. Their suitability was classified as "easy digging".

F49. Reach 3 is composed of a less dense Silty Sand and based upon the dredging analysis the Cutterhead Pipeline Dredge has the best suitability for this reach with a classification of "very good – easy cutting". The Hopper and Mechanical Dredges were classified as "fair to easy digging".

SOIL TYPE	*CUTTERHEAD PIPELINE DREDGE*	*BUCKET HOPPER DREDGE*	*BACKHOE MECHANICAL DREDGE*	*CLAMSHELL MECHANICAL DREDGE*	*POWER SHOVEL MECHANICAL DREDGE*
REACH 1 SAND SM (DENSE)	VERY GOOD TO EASY CUTTING LOW PUMPING ENERGY	POOR TO DIFFICULT DIGGING MUCH OVERFLOW OF FINES	POOR TO DIFFICULT DIGGING MUCH OVERFLOW OF FINES	HARD DIGGING NEED HEAVY BUCKET MUCH OVERFLOW OF FINES	POOR TODIFFICULT DIGGING MUCH OVERFLOW OF FINES
REACH 2 SILTS & CLAYS OH, MH & CH	WELL SUITED LOW CUTTING ENERGY EASY PUMPING	EASY DIGGING MEDIUM TO HIGH OVERFLOW OF FINES	EASY DIGGING SOME TO HIGH SUCTION	EASY DIGGING FINES MAY WASH OUT	EASY DIGGING SOME TO HIGH SUCTION FINES MAY WASH OUT
REACH 3 SAND SM	VERY GOOD TO EASY CUTTING LOW PUMPING ENERGY	FAIR TO EASY CUTTING MUCH OVERFLOW OF FINES	FAIR TO EASY CUTTING MUCH OVERFLOW OF FINES	FAIR DIGGING APPRECIABLE OVERFLOW OF FINES	FAIR TO EASY CUTTING MUCH OVERFLOW OF FINES

F50. In view of contamination, turbidity, overflow, disposal, and availability of dredging equipment an environmentally friendly Clamshell would appear to be the most logical equipment to use to dredge Reach 1 and 2. A heavy, toothed Clamshell may be required if stiff, dense Pleistocene sediments are encountered. Depending on the results of testing for ocean disposal it might be advantageous to use pipeline dredges (i.e. Cutterhead or Draghead) in Reach 3. In view of the fact that the sediments to be removed from this reach are probably not suitable for ocean disposal a large capacity Clamshell is the most likely dredge.

SLOPE STABILITY

F51. The lowest safety factor for this channel equals to 2.2. The soil properties consist of the following:

MATERIAL	*SYMBOL*	*DEPTH*	*SATURATED UNIT WEIGHT (PCF)*	*ANGLE OF FRICTION (DEGREES)*	*COHESION (PSF)*
SAND	**SM**	**-14 to –150**	**110.0**	**32.0**	**50.0**

F52. The failure surface occurs entirely with the SAND Strata. The failure surface is shown in Figure 17.

RED HOOK FLATS ANCHORAGE

STRATIGRAPHY

F53. The Red Hook Flats Anchorage is located between the Anchorage Channel on the west and the Bay Ridge Channel on the east. The stratigraphy of the Red Hook Flats Anchorage is shown on the east side of Cross Sections A-A' and B-B' (Figure 14). The Red Hook Flats Anchorage is composed almost entirely of very soft to soft Recent Silt and Clay.

DREDGEABILITY

F54. For the purpose of the DREDGABL analysis these Silts and Clays were classified as having medium to high plasticity. Based upon the results of the DREDGABL analysis, the Cutterhead Pipeline Dredge is the well suited for the dredging of this anchorage. However, the Hopper and Mechanical Dredges also selected for comparison can be used as well for the dredging of this anchorage. The results of the analysis are listed below.

SOIL TYPE	*CUTTERHEAD PIPELINE DREDGE*	*BUCKET HOPPER DREDGE*	*BACKHOE MECHANICAL DREDGE*	*CLAMSHELL MECHANICAL DREDGE*	*POWER SHOVEL MECHANICAL DREDGE*
SILTS & CLAYS OH & MH	WELL SUITED LOW CUTTING ENERGY EASY PUMPING	EASY DIGGING MEDIUM TO HIGH OVERFLOW OF FINES	EASY DIGGING SOME TO HIGH SUCTION	EASY DIGGING FINES MAY WASH OUT	EASY DIGGING SOME TO HIGH SUCTION FINES MAY WASH OUT

F55. In view of contamination, turbidity, overflow, disposal, and availability of dredging equipment an environmentally friendly Clamshell would appear to be the most logical dredge to use.

STAPLETON ANCHORAGE

STRATIGRAPHY

F56. The Stapleton Anchorage is located west of the southern portion of the Anchorage Channel adjacent to Staten Island, New York and north of the Verranzano Narrows Bridge. The stratigraphy of the Stapleton Anchorage is illustrated on Cross sections C-C' and D-D' of Figure 14. The cross-sections indicate that Stapleton should be divided into two similar reaches. The northern segment is composed primarily of very soft to soft Silt and Clay (Holocene). The southern segment is mostly a fine to medium grained, moderately dense Silty Sand (Holocene).

DREDGABILITY

F57. The cross-sections indicate that Stapleton should be divided into two similar segments. The northern segment is composed primarily of very soft to soft Recent Silts and Clays with medium to high plasticity. The southern segment is mostly a fine to medium grained Recent Silty Sand with medium density. The Silts and Clays are classified as OH and CH; the Silty Sand as an SM.

F58. According to DREDGABL the northern segment of the Stapleton Anchorage (Silt and Clay OH-CH) can be dredged with all the dredges selected for comparison. In view of contamination, turbidity, overflow, disposal, and availability of dredging equipment an environmentally friendly Clamshell would appear to be the most logical dredge to use. The Cutterhead Pipeline Dredge appears to be the best choice to dredge the southern Segment. However, Hopper and Mechanical Dredges are also quite capable of dredging this segment. The choice of dredge for this segment is dependent on the results of testing for ocean disposal. Listed below are the DREDGABL results of the analysis for each segment and dredge type.

SOIL TYPE	*CUTTERHEAD PIPELINE DREDGE*	*BUCKET HOPPER DREDGE*	*BACKHOE MECHANICAL DREDGE*	*CLAMSHELL MECHANICAL DREDGE*	*POWER SHOVEL MECHANICAL DREDGE*
NORTHERN SEGMENT SILTS & CLAYS OH & MH	WELL SUITED LOW CUTTING ENERGY EASY PUMPING	EASY DIGGING MEDIUM TO HIGH OVERFLOW OF FINES	EASY DIGGING SOME TO HIGH SUCTION	EASY DIGGING FINES MAY WASH OUT	EASY DIGGING SOME TO HIGH SUCTION FINES MAY WASH OUT
SOUTHERN SEGMENT SAND SM	VERY GOOD TO EASY CUTTING LOW PUMPING ENERGY	FAIR TO EASY CUTTING MUCH OVERFLOW OF FINES	FAIR TO EASY CUTTING MUCH OVERFLOW OF FINES	FAIR DIGGING APPRECIABLE OVERFLOW OF FINES	FAIR TO EASY CUTTING MUCH OVERFLOW OF FINES

PORT JERSEY CHANNEL

STRATIGRAPHY

F59. The Port Jersey Channel is located in Bayonne, New Jersey between the Military Ocean Terminal on the south and the Global Marine Terminal and the Northeast Automobile Terminal on the north. Figure 18 illustrates the stratigraphy of Port Jersey Channel. The sediments above forty-one feet were cropped off to reflect near future dredging. Port Jersey Channel can be subdivided into two similar reaches. Reach 1 is composed of Pleistocene age sediments composed mostly of a dense to very dense, fine to medium grained, red-brown Silty Sand (SM) with lenses of stiff Silt and Clay and occasional Gravel. Reach 2 is composed of approximately 50% Silts and Clays (OH and MH) and 50% Sand (SP) both of which are Holocene (Recent). There is a nob of stiff Pleistocene Silt and Clay below boring 35 that will be more difficult to dredge.

DREDGABILITY

F60. In Reach 1 the Silty Sand (SM) was analyzed as the other sediments account for only a limited amount of the total volume to be dredged. Based upon the results from the analysis, the Cutterhead Pipeline Dredge is the best suited. The Hopper and Mechanical Dredges used for comparison had suitabilities classified as "poor – difficult digging to hard digging". The table below details the results.

F61. In the DREDGEABL analysis of this Reach 2 the Silts and Clays were classified as very soft to soft and the Sand as being fine to medium grained with medium density. Based upon previous analyses the Recent Silts and Clays can be dredged by all dredges being used for comparison, therefore, only the Sand was used for determining the suitability of the selected

dredge types. All dredge types proved to be suitable for this reach with the Cutterhead Pipeline having the best results. The results are detailed in the table below.

SOIL TYPE	*CUTTERHEAD PIPELINE DREDGE*	*BUCKET HOPPER DREDGE*	*BACKHOE MECHANICAL DREDGE*	*CLAMSHELL MECHANICAL DREDGE*	*POWER SHOVEL MECHANICAL DREDGE*
REACH 1 PLEISTOCENE SAND (DENSE TO VERY DENSE) SM	VERY GOOD TO EASY CUTTING LOW PUMPING ENERGY	POOR TO DIFFICULT DIGGING MUCH OVERFLOW OF FINES	POOR TO DIFFICULT DIGGING MUCH OVERFLOW OF FINES	HARD DIGGING NEED HEAVY BUCKET MUCH OVERFLOW OF FINES	POOR TO DIFFICULT DIGGING MUCH OVERFLOW OF FINES
REACH 2 SAND SP	VERY GOOD TO EASY CUTTING FAIRLY LOW PUMPING ENERGY	GOOD TO EASY DIGGING VERY LITTLE OVERFLOW OF FINES	GOOD TO EASY DIGGING VERY LITTLE OVERFLOW OF FINES	FAIR DIGGING LITTLE OVERFLOW OF FINES	GOOD TO EASY DIGGING VERY LITTLE OVERFLOW OF FINES

F62. In view of dredging records, turbidity, overflow, disposal, and availability of dredging equipment a heavy Clamshell with teeth will probably be required to dredge Reach 1. An environmentally friendly Clamshell would appear to be the most logical dredge to use for Reach 2.

SLOPE STABILITY

F63. The safety factor for this channel equals to 2.1. The soil properties consist of the following:

MATERIAL	*SYMBOL*	*DEPTH*	*SATURATED UNIT WEIGHT (PCF)*	*ANGLE OF FRICTION (DEGREES)*	*COHESION (PSF)*
ORGANIC SILT	OH	-10.0 TO –45.0	90.0	0.0	100.0
PLASTIC SILT	MH	-45.0 TO –50.0	120.0	0.0	500.0
SAND	SP	-50.0 TO –54.0	110.0	32.0	0.0
SANDY SILT	SM-ML	-54.0 TO —	110.0	30.0	100.0

F64. The failure surface goes through the top three layers. The failure surface lies above the bottom Sandy Silt layer. The failure surface is shown in Figure 19.

CLAREMONT CHANNEL

STRATIGRAPHY

F65. The Claremont Channel in located in Jersey City, New Jersey between the Claremont Terminal on the south and Caven Point Army Terminal on the north. The stratigraphy of Claremont Channel is illustrated on Figure 20. Reach 1 is composed of a relatively thick (15') layer of fibrous organic Silt and Clay (Pleistocene) that overlies stiff, red-brown Silt and Clay (Pleistocene). Reach 2 is composed of the fibrous organic Silt and Clay overlying Gray Silt and Clay (Holocene).

DREDGABILITY

F66. Based on previous DREDGABL analyses all of the dredges are capable of removing the black organic Silt and Clay. In view of contamination, turbidity, overflow, disposal, and availability of dredging equipment an environmentally friendly Clamshell would appear to be the most logical dredge to use to remove this type of material. In light of the thickness of this unit it might be prudent to remove this material from the entire channel prior to dredging the deeper sediments.

F67. The analysis of Reach 1 (Stiff Pleistocene Silt and Clay) indicates that the Cutterhead Pipeline Dredge is best suited with the Bucket Hopper and Backhoe and Power Shovel Mechanical Dredges each having a suitability classified as "fair digging". The Clamshell Mechanical Dredge had suitability classified as "hard digging". The analysis of the Reach 2 sediments (Gray Silt and Clay) indicates that all the selected dredge types could be used. Previous dredging would indicate an Environmentally friendly Clamshell. The table below summarizes the results of the DREDGABL analysis.

SOIL TYPE	*CUTTERHEAD PIPELINE DREDGE*	*BUCKET HOPPER DREDGE*	*BACKHOE MECHANICAL DREDGE*	*CLAMSHELL MECHANICAL DREDGE*	*POWER SHOVEL MECHANICAL DREDGE*
REACH 1 PLEISTOCENE SILT (STIFF TO VERY STIFF) ML-CL	WELL SUITED LOW CUTTING ENERGY EASY PUMPING	FAIR DIGGING NO SUCTION HIGH OVERFLOW OF FINES	FAIR DIGGING NO SUCTION FINES MAY WASH OUT	HARD DIGGING NEED HEAVY GRAB BUCKET	FAIR DIGGING NO SUCTION FINES MAY WASH OUT
REACH 2 SILTS AND CLAYS OH & MH	VERY GOOD TO EASY CUTTING FAIRLY LOW PUMPING ENERGY	EASY DIGGING MEDIUM TO HIGH OVERFLOW OF FINES LITTLE SUCTION	EASY DIGGING LITTLE TO SOME SUCTION FINES MAY WASH OUT	EASY DIGGING FINES MAY WASH OUT	EASY DIGGING LITTLE TO SOME SUCTION FINES MAY WASH OUT

SLOPE STABILITY

F68. The lowest safety factor for this channel equals to 1.6. The soil properties consist of the following:

MATERIAL	*SYMBOL*	*DEPTH*	*SATURATED UNIT WEIGHT (PCF)*	*ANGLE OF FRICTION (DEGREES)*	*COHESION (PSF)*
ORGANIC SILT	OH	-10.0 TO -44.0	90.0	0.0	100.0
SILT	ML	-44.0 TO -54.0	110.0	30.0	100.0

F69. The failure surface passes through top Organic Silt layer and the bottom Silt layer. The failure surface is shown in Figure 21.

KILL VAN KULL CHANNEL

STRATIGRAPHY

F70. The Kill Van Kull Channel is located north of Staten Island, New York and south of Bayonne, New Jersey. The channel connects Upper New York Harbor with the Arthur Kill Channel and Newark Bay Complex. The stratigraphy of Kill Van Kull is illustrated on Figure 22. The proposed depths of fifty-two feet below mean low water (-52'MLW) and sixty-two feet below mean low water (-62' MLW) are shown so that the viewer can focus on the sediments to be removed. The sediments above forty-seven feet below mean low water (-47' MLW) were cropped off to reflect near future dredging. Profile 1-1 indicates that the channel can be logically divided into three similar reaches. Reach 1 is the eastern most reach and is composed almost entirely of Serpentinite Rock. This reach will require blasting in order to obtain project depth. Reach 2 located east of the Bayonne Bridge is composed of Pleistocene age Sand. This Sand is red-brown, fine to medium grained and dense to very dense. It is classified as a SP. Reach 3 is the western most reach and is composed of Diabase Rock. This reach will also require blasting to reach project depth.

DREDGEABILITY

F71. Reaches 1 and 3 were not analyzed using the DREDGABL program. The program can not be used to determine the suitability of dredge types for rock areas. Only Reach 2 can be analyzed with DREDGABL. Based upon the results of this analysis, the Cutterhead Pipeline Dredge is the dredge type best suited for dredging this reach. The Bucket Hopper and the Backhoe and Power Shovel Mechanical Dredges were also capable of dredging this reach. The Clamshell Mechanical Dredge's suitability for dredging this reach was classified as "hard digging". DREDGABL results are detailed in the table below.

SOIL TYPE	*CUTTERHEAD PIPELINE DREDGE*	*BUCKET HOPPER DREDGE*	*BACKHOE MECHANICAL DREDGE*	*CLAMSHELL MECHANICAL DREDGE*	*POWER SHOVEL MECHANICAL DREDGE*
REACH 2 PLEISTOCENE SAND (DENSE TO VERY DENSE) SP	WELL SUITED LOW CUTTING ENERGY EASY PUMPING	GOOD TO EASY DIGGING VERY LITTLE OVERFLOW OF FINES	GOOD TO EASY DIGGING VERY LITTLE OVERFLOW OF FINES	HARD DIGGING NEED HEAVY GRAB BUCKET LITTLE OVERFLOW OF FINES	GOOD TO EASY DIGGING VERY LITTLE OVERFLOW OF FINES

SLOPE STABILITY

F72. The lowest safety factor for this channel equals to 2.2. The soil properties consist of the following:

MATERIAL	*SYMBOL*	*DEPTH*	*SATURATED UNIT WEIGHT (PCF)*	*ANGLE OF FRICTION (DEGREES)*	*COHESION (PSF)*
ORGANIC SILT	OH	-7.0 TO -10.0	90.0	0.0	100.0
SAND	SP	-10.0 TO -64.0	110.0	32.0	0.0

F73. The failure surface lies within the Sand layer for this section. The failure surface is shown in Figure 23.

NEWARK BAY CHANNEL

STRATIGRAPHY

F74. Newark Bay is located north of the junction of the Kill Van Kull and Arthur Kill Channels and extends northward to the New Jersey Turnpike Extension Bridge in Jersey City, New Jersey. Figure 24 illustrates the stratigraphy of Newark Bay Channel. The proposed depth of fifty-two feet below mean low water (-52'MLW) is shown so that the viewer can focus on the sediments to be removed. The sediments above forty-seven feet below mean low water (-47' MLW) were cropped off to reflect near future dredging. Profile 1-1' indicates that the channel can be subdivided into two similar reaches. Reach 1 is located just north of the junction of the Kill Van Kull and Arthur Kill Channels. This reach is predominantly composed of a dense to very dense, fine to medium grained, red-brown Silty Sand (SM) that is Pleistocene in age. A significant portion of this reach will consist of rock that will require blasting. Reach 2 continues northward to the bridge and is composed of Pleistocene Silt and Clay. These Silts and Clays are stiff to very stiff and are red-brown in color. They are classified as ML-CL. This reach will also contain pockets of rock that will require blasting.

DREDGEABILITY

F75. The DREDGABL analysis indicated that for both reaches the Cutterhead Pipeline Dredge was best suited for dredging those reaches. The Bucket Hopper Dredge and the Backhoe and Power Shovel Mechanical Dredges had suitabilities ranging from "fair to difficult". The Clamshell Mechanical Dredge had suitability classified as "hard digging". However, dredging records from similar soil conditions indicate that a heavy Clamshell with teeth has been relatively successful. Silty Sand and Gravel (Till) areas around bedrock areas may require a backhoe. Below is a table detailing the results of the DREDGABL analysis.

SOIL TYPE	*CUTTERHEAD PIPELINE DREDGE*	*BUCKET HOPPER DREDGE*	*BACKHOE MECHANICAL DREDGE*	*CLAMSHELL MECHANICAL DREDGE*	*POWER SHOVEL MECHANICAL DREDGE*
REACH 1 PLEISTOCENE SAND (DENSE TO VERY DENSE) SM	WELL SUITED LOW CUTTING ENERGY EASY PUMPING	POOR TO DIFFICULT DIGGING MUCH OVERFLOW OF FINES	POOR TO DIFFICULT DIGGING MUCH OVERFLOW OF FINES	HARD DIGGING NEED HEAVY GRAB BUCKET MUCH OVERFLOW OF FINES	POOR TO DIFFICULT DIGGING MUCH OVERFLOW OF FINES
REACH 2 PLEISTOCENE SILT (STIFF TO VERY STIFF) ML-CL	WELL SUITED LOW CUTTING ENERGY EASY PUMPING	FAIR DIGGING NO SUCTION HIGH OVERFLOW OF FINES	*FAIR DIGGING* NO SUCTION FINES MAY WASH OUT	HARD DIGGING NEED HEAVY GRAB BUCKET	*FAIR DIGGING* NO SUCTION FINES MAY WASH OUT

SLOPE STABILITY

F76. The safety factor for this channel equals to 2.3. The soil properties consist of the following:

MATERIAL	*SYMBOL*	*DEPTH*	*SATURATED UNIT WEIGHT (PCF)*	*ANGLE OF FRICTION (DEGREES)*	*COHESION (PSF)*
ORGANIC SILT	OH	-3.0 TO -10.0	90.0	100.0	0.0
Silty SAND	SM	-10.0 TO -25.0	110.0	32.0	0.0
SILT/CLAY	ML	-25.0 TO -54.0	110.0	30.0	100.0

F77. The failure surface goes through the Silty Sand and Silt/Clay layers. The failure surface is shown in Figure 25.

ELIZABETH CHANNEL

STRATIGRAPHY

F78. The Elizabeth Channel is located on the western side of Newark Bay in Elizabeth, New Jersey between the Elizabeth Port Authority Marine Terminal and Port Newark. The stratigraphy of Elizabeth Channel is shown on Figure 26. The proposed depth of fifty-two feet below mean low water (-52' MLW) is shown so that the viewer can focus on the sediments to be removed. This channel is composed almost entirely of Pleistocene age Silts and Clays (CL-ML). These sediments are stiff to very stiff and red-brown in color. Bedrock will be encountered along a significant portion of the western end of the channel and will require blasting.

DREDGABILITY

F79. The Cutterhead Pipeline Dredge is shown by the DREDGABL analysis to be the best-suited dredge type for dredging this channel. However, turbidity caused by the dredging procedure may eliminate this type of dredge from consideration. The Hopper and Mechanical Dredges selected for this analysis were shown to have suitabilities from "fair to hard digging".

Dredging records from similar soil conditions indicate that a heavy Clamshell with teeth has been relatively successful. The results of the analysis are listed in the table below.

SOIL TYPE	*CUTTERHEAD PIPELINE DREDGE*	*BUCKET HOPPER DREDGE*	*BACKHOE MECHANICAL DREDGE*	*CLAMSHELL MECHANICAL DREDGE*	*POWER SHOVEL MECHANICAL DREDGE*
PLEISTOCENE SILT (STIFF TO VERY STIFF) ML-CL	WELL SUITED LOW CUTTING ENERGY EASY PUMPING	FAIR DIGGING NO SUCTION HIGH OVERFLOW OF FINES	FAIR DIGGING NO SUCTION FINES MAY WASH OUT	HARD DIGGING NEED HEAVY GRAB BUCKET	FAIR DIGGING NO SUCTION FINES MAY WASH OUT

SLOPE STABILITY

F80. The lowest safety factor for this channel equals to 3.4. This channel has the highest safety factor for this project. The soil properties consist of the following:

MATERIAL	*SYMBOL*	*DEPTH*	*SATURATED UNIT WEIGHT (PCF)*	*ANGLE OF FRICTION (DEGREES)*	*COHESION (PSF)*
ORGANIC SILT	**OH**	**-2.0 TO –22.0**	**90.0**	**0.0**	**100.0**
SAND	**SP**	**-22.0 TO –25.0**	**110.0**	**0.0**	**32.0**
SILT	**ML**	**-25.0 TO –54.0**	**110.0**	**30.0**	**100.0**

F81. The failure surface passes through the three layers shown above. The failure surface is Shown in Figure No. 27.

SOUTH ELIZABETH CHANNEL

STRATIGRAPHY

F82. The South Elizabeth Channel is also located on the western side of Newark Bay in Elizabeth, New Jersey. It is south of the Elizabeth Port Authority Marine Terminal. The stratigraphy of South Elizabeth is shown on Figure 28. The proposed depth of fifty-two feet below mean low water (-52' MLW) is shown so that the viewer can focus on the sediments to be removed. This channel is composed primarily of Pleistocene-aged, red-brown, stiff to very stiff Silt and Clay (CL-ML). Bedrock will be encountered along the eastern end of the channel. In fact, bedrock is lurking just below the project depth throughout most of the channel. The planned widening of the channel will include a removal of a relatively thick (10') layer of probably contaminated sediments (See Cross Section A-A').

DREDGEABILITY

F83. The DREDGABL analysis had similar results as in the analysis for the Elizabeth Channel. The Cutterhead Pipeline Dredge is shown to be the best suited for dredging this channel. However, turbidity caused by the dredging procedure may eliminate this type of dredge from consideration. The Hopper and Mechanical Dredges have suitabilities from "fair to hard digging". Dredging records from similar soil conditions indicate that a heavy Clamshell with teeth has been relatively successful. These resulted are tabulated below.

SOIL TYPE	*CUTTERHEAD PIPELINE DREDGE*	*BUCKET HOPPER DREDGE*	*BACKHOE MECHANICAL DREDGE*	*CLAMSHELL MECHANICAL DREDGE*	*POWER SHOVEL MECHANICAL DREDGE*
PLEISTOCENE SILT (STIFF TO VERY STIFF) ML-CL	WELL SUITED LOW CUTTING ENERGY EASY PUMPING	FAIR DIGGING NO SUCTION HIGH OVERFLOW OF FINES	FAIR DIGGING NO SUCTION FINES MAY WASH OUT	HARD DIGGING NEED HEAVY GRAB BUCKET	FAIR DIGGING NO SUCTION FINES MAY WASH OUT

SLOPE STABILITY

F84. The lowest safety factor for this channel equals to 3.4. This channel has the highest safety factor for this project. The soil properties consist of the following:

MATERIAL	SYMBOL	DEPTH	SATURATED UNIT WEIGHT (PCF)	ANGLE OF FRICTION (DEGREES)	COHESION (PSF)
ORGANIC SILT	OH	-10.0 TO -24.0	90.0	0.0	100.0
SILT	ML	-24.0 TO -50.0	110.0	30.0	100.0
SILTY SAND	SM	-50.0 TO -54.0	110.0	32.0	0.0

F85. The failure surface goes the middle Silt layer and at the top of the bottom Silty Sand layer. The failure surface is shown in Figure 29.

ARTHUR KILL CHANNEL

STRATIGRAPHY

F86. The Arthur Kill Channel is located west of the Kill Van Kull Channel between New York and New Jersey extending southward to Gulfport, Staten Island, New York. The stratigraphy of the Arthur Kill is illustrated on Figure 30. The proposed depths of fifty-two feet below mean low water (-52'MLW) and sixty-two feet below mean low water (-62' MLW) are shown so that the viewer can focus on the sediments to be removed. Profile I-I' indicates that the channel can be separated into three similar reaches. Reaches 1 and 3 are composed almost entirely of rock from the Brunswick Formation. Reach 2 is composed thin layer (1'-2') of very soft to soft layer of Holocene (Recent) Silt and Clay overlying a dense to very dense, fine to medium grained, red-brown Silty Sand with Gravel (Pleistocene). If the channel is deepened to sixty-feet below mean low water (-60' MLW) then most of this reach will require blasting.

DREDGEABILITY

F87. Reaches 1 and 3 will require blasting and could not be analyzed with the DREDGABL program. DREDGABL analysis of Reach 2 (Silty Sand and Gravel) indicates that the Cutterhead Pipeline Dredge is best suited for the dredging of this particular reach. The Hopper and Mechanical Dredges used for this comparison had suitabilities ranging from "poor to difficult digging" to "hard digging". Dredging records from similar soil conditions indicate that a heavy Clamshell with teeth has been relatively successful at removing this type of soil. The results of the DREDGEABL analysis are listed below.

SOIL TYPE	CUTTERHEAD PIPELINE DREDGE	BUCKET HOPPER DREDGE	BACKHOE MECHANICAL DREDGE	CLAMSHELL MECHANICAL DREDGE	POWER SHOVEL MECHANICAL DREDGE
REACH 2 PLEISTOCENE SAND (DENSE TO VERY DENSE) SM	WELL SUITED LOW CUTTING ENERGY EASY PUMPING	POOR TO DIFFICULT DIGGING MUCH OVERFLOW OF FINES	POOR TO DIFFICULT DIGGING MUCH OVERFLOW OF FINES	HARD DIGGING NEED HEAVY GRAB BUCKET MUCH OVERFLOW OF FINES	POOR TO DIFFICULT DIGGING MUCH OVERFLOW OF FINES

SLOPE STABILITY

F88. The lowest safety factor computed exists in this channel which equals to 1.2. The soil and rock strata in this channel consists of the following:

MATERIAL	SYMBOL	DEPTH	SATURATED UNIT WEIGHT (PCF)	ANGLE OF FRICTION (DEGREES)	COHESION (PSF)
ORGANIC SILT	OH	-7.0 TO –12.0	90.0	0.0	100.00
PEAT	PT	-12.0 TO –25.0	90.0	0.0	100.00
SANDY SILT	SM-ML	-25.0 TO –50.0	110.0	30.0	100.00
SHALE ROCK		-50.0 TO –66.0	155.0	0.0	3000.00

F89. The top of the failure surface begins in the peat layer and then cut through the Sand Silt layer. The failure surface did not cut into the Shale Bedrock. The failure surface is shown in Figure 31.

BLASTING ANALYSIS SUMMARY

F90. The rock areas of the Kill Van Kull, Arthur Kill, South Elizabeth and Newark Bay Channels will require blasting to reach project depth. The blasting of these channel areas has been analyzed and nearby structures that might be affected has been determined. The complete blasting analysis is available for review at the COE New York District. A short summary of some of the more significant aspects is included in the following paragraphs.

F91. Three types of seismic waves or vibrations are produced as the results of explosions in rock and are classified as compression waves, shear waves or Rayleigh waves. The compression waves radiate from the blast and compress or displace the ground in front of the wave. Shear waves, as known as body waves, travel outward from the blast point through the rock and soil and are perpendicular to the compression wave. The Rayleigh wave is generated by the discontinuity at the ground surface being blasted and is confined to a relatively narrow zone near the water surface. The velocities of the waves and subsequently the effects of these waves are dependent upon rock type, soil type and structural properties of the rock including stratification, jointing, and faults. Additionally, seismic waves from blasting occur at certain frequencies. Typically these frequencies are above 20Hz. Most structures have natural frequencies in the 4Hz to 10 Hz ranges.

F92. Because vibrations have a "form" similar to that of ocean waves, a particle of soil or rock will move much like a floating cork in the ocean as a wave passes, bobbing up and down while translating small distances horizontally. The rate at which the cork displaces in any direction is the particle velocity and is different from the rate of propagation of the wave which passes the cork as it moves through the ocean. The displacement of the cork or, by analogy, a rock or soil particle, occurs at some velocity whose maximum is called the peak particle (PPV). The rate at which the velocity of the cork or, by analogy, a soil or rock particle changes is the acceleration.

F93. The damage to structures is dependent on factors which include: the peak particle velocity (maximum velocity of displacement), frequency of the waves (vibrations) causing that displacement, the dynamic response of the structure (its natural frequency and rigidity), age and condition of the structure, duration of vibrations (waves) and, ground settlement beneath the structure. The closer the wave frequency is to the natural frequency of the structure and the more rapid the peak particle velocity the more likely the structure will be effected by the vibrations produce by the blasting. There are guidelines issued by the States of New Jersey and New York and the City of New York that state the maximum accepted peak particle velocity (PPV) for various types of structures. These velocities (PPV) range from 2.0 in/sec for commercial structures to 0.5 in/sec for historical structures.

F94. Peak particle velocity decreases with distance from the blast location. The relationship between PPV and distance from the blast location was determined from previous blasting in the Port of New York and New Jersey. Based on this relationship contour maps depicting PPV at various distances were constructed. Structures where the PPV exceeded the threshold maximum accepted PPV were noted. In order to reduce the expected PPV at these "critical" structures a blasting plan was developed. This plan consists of two blasting pattern types labeled Type I for typical blasting and Type II for precautionary blasting. All the channels use a combination of the two plans to reach the project depth. When actual construction begins the contractor will be

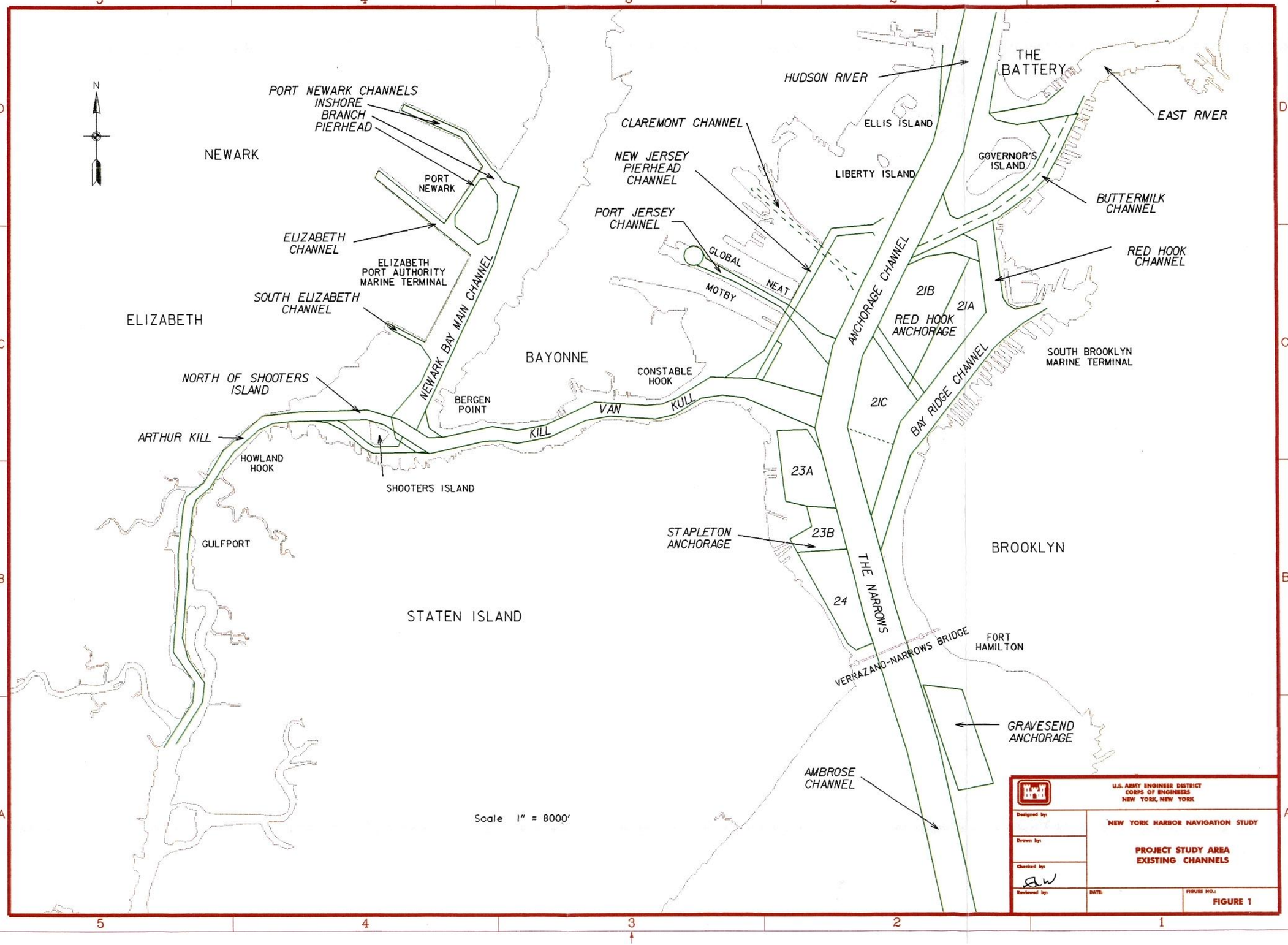
required to produce his own blasting plan, and to perform a test blast program to demonstrate his plan's compliance with local regulations.

F95. The Type I (Typical) blasting plan has two blasting patterns. The first pattern known as the "Confined" blast pattern involves the drilling of three rows of 4.5-inch diameter holes to a selected depth below the project depth. The 4.5-inch diameter hole allows sufficient explosives for rock breakage. These rows are spaced eight feet apart and each row contains thirteen (13) holes spaced eight feet apart. Each row is referred to as a range. The blasting begins with the range (range 1) that is closest to the centerline of the channel. The second blasting pattern is the "Production" pattern and extends from the last range of the "Confined" pattern and is repeated until the edge of the channel is reached. This pattern consists of three rows of 4.5-inch holes drilled to the same selected depth below the project depth as the "Confined" blast pattern holes. These rows are spaced ten (10) feet apart and each row has eleven- (11) holes spaced ten (10) apart. These rows are also referred to as ranges with the range closest to the centerline being denoted first. This blasting plan is used for the channel areas were the peak particle velocity does not exceed the limit of 0.5 in/sec will not effect onshore structures.

F96. The Type II (Precautionary) blasting plan has three blasting patterns. The first pattern involves the drilling and blasting of a relief trench. This relief trench is a zone of broken rock that allows for the attenuation of the seismic waves of subsequent blasts. The blasting pattern for the relief trench consists of two rows spaced eight feet apart each with seventeen (17) 3-inch diameter holes spaced six feet apart drilled to a selected depth below the project depth. The rows in this relief trench are also designated as ranges with range 1 being furthermost from the centerline of the channel and blasting begins with this range proceeds toward the centerline of the channel. Additionally, a drill line of holes spaced along two-foot centers will be drilled four feet from the first range of blast holes toward the channel edge. This line of drill holes serves to attenuate the seismic waves from the blasting of the relief trench. This relief trench pattern is followed by the "Cautious" pattern. This pattern consists of three ranges (rows) spaced eight feet apart with thirteen (13) 3-inch diameter holes in each which are spaced eight feet apart. The blasting in this pattern begins with range 1 and proceeds toward the channel centerline. This pattern is followed by the aforementioned "Production" pattern and it is repeated until the channel centerline is reach.

F97. The Type II blasting plan will be used in all of the South Elizabeth Channel, the area of the Kill Van Kull just east of the Bayonne Bridge between Port Richmond, Staten Island, New York and Port Johnson, Bayonne, New Jersey, and almost the entire southern portion of the Arthur Kill. In addition, to this blasting plan and the Type I plan there are zones of no blasting near the northern portion of the Bayonne Bridge in the Kill Van Kull, and the Goethels Bridge, the Staten Island Railroad Bridge, and various pipelines and utilities that cross the Arthur Kill. Locations of the Type II blasting plan and the no blast zones can be found in a detailed blasting analysis report.

F98. Other areas of concern are the effects of surface water waves and air overpressure waves produced by the blasting. Based upon previously blasting in the Kill Van Kull these waves should not be an issue. The resulting surface water waves were often smaller in amplitude than wind produced waves. The air overpressure waves are only produced when an explosion produces a "gas bubble" with enough amplitude and frequency to cause a problem. Based on previous blasting in the Kill Van Kull, this also should not be a concern. However, it must be noted that there are several churches in the air overpressure impact zone with stained glass windows. Protection of these windows may be necessary.


N
PORT NEWARK CHANNELS
INSHORE
BRANCH
PIERHEAD
NEWARK
PORT NEWARK
ELIZABETH CHANNEL
ELIZABETH PORT AUTHORITY MARINE TERMINAL
SOUTH ELIZABETH CHANNEL
ELIZABETH
NEWARK BAY MAIN CHANNEL
NORTH OF SHOOTERS ISLAND
ARTHUR KILL
HOWLAND HOOK
GULFPORT
SHOOTERS ISLAND
BERGEN POINT
BAYONNE
CONSTABLE HOOK
VAN KULL
KILL
STATEN ISLAND
HUDSON RIVER
CLAREMONT CHANNEL
NEW JERSEY PIERHEAD CHANNEL
PORT JERSEY CHANNEL
GLOBAL
NEAT
MOTBY
ELLIS ISLAND
LIBERTY ISLAND
THE BATTERY
EAST RIVER
GOVERNOR'S ISLAND
BUTTERMILK CHANNEL
RED HOOK CHANNEL
ANCHORAGE CHANNEL
21B
21A
RED HOOK ANCHORAGE
21C
SOUTH BROOKLYN MARINE TERMINAL
BAY RIDGE CHANNEL
23A
23B
24
STAPLETON ANCHORAGE
THE NARROWS
BROOKLYN
FORT HAMILTON
VERRAZANO-NARROWS BRIDGE
GRAVESEND ANCHORAGE
AMBROSE CHANNEL
Scale 1" = 8000'
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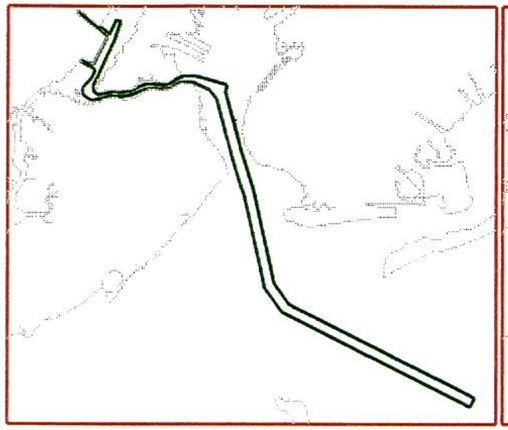
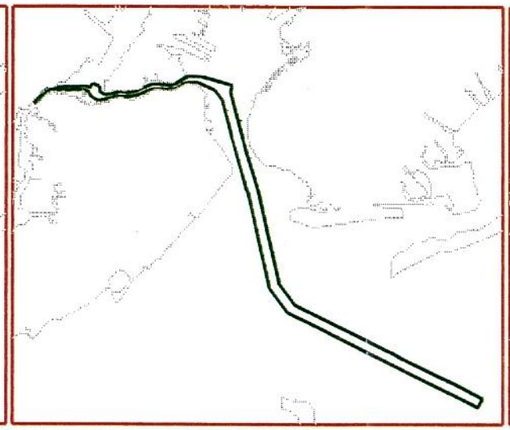
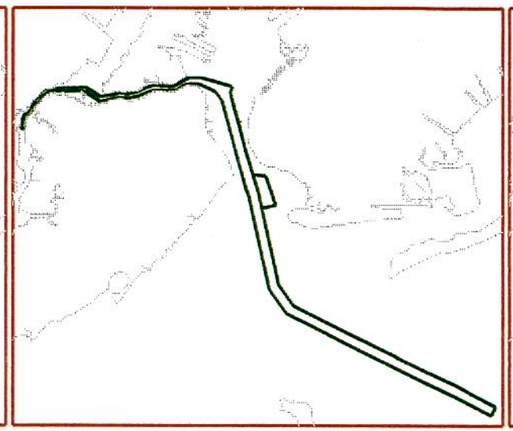
Reviewed by:
NEW YORK HARBOR NAVIGATION STUDY
PROJECT STUDY AREA
EXISTING CHANNELS
DATE:
FIGURE NO.:
FIGURE 1



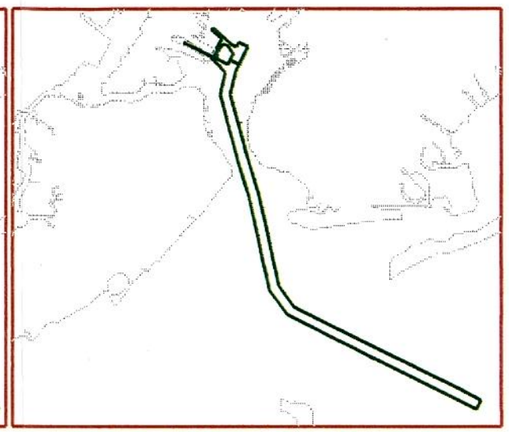
PATHWAY 1 – KILL VAN KULL TO NEWARK BAY TO ELIZABETH AND SOUTH ELIZABETH CHANNELS



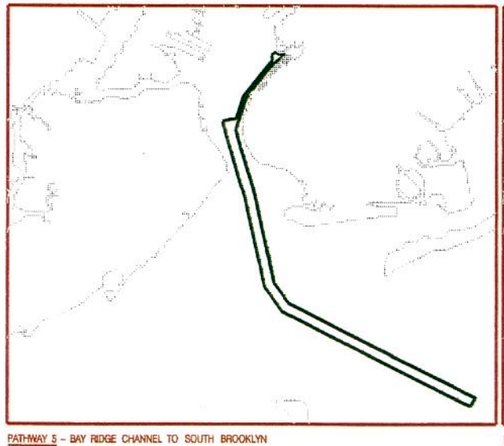
PATHWAY 2 – KILL VAN KULL TO THE ARTHUR KILL TO HOWLAND HOOK



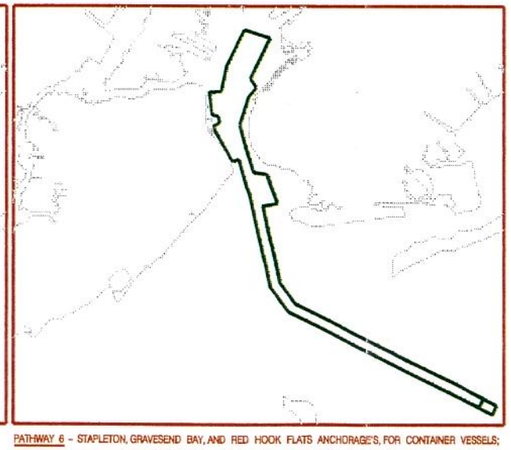
PATHWAY 3 – KILL VAN KULL TO THE ARTHUR KILL TO GULFPORT (AT TANKER DESIGN DEPTH)



PATHWAY 4 – PORT JERSEY CHANNEL TO PORT JERSEY AND THE FORMER MILITARY OCEAN TERMINAL AT BAYONNE (MOTBY)



PATHWAY 5 – BAY RIDGE CHANNEL TO SOUTH BROOKLYN



PATHWAY 6 – STAPLETON, GRAVESEND BAY, AND RED HOOK FLATS ANCHORAGE'S, FOR CONTAINER VESSELS;
PATHWAY 7 – STAPLETON, GRAVESEND BAY, AND RED HOOK FLATS ANCHORAGE'S, FOR TANKERS

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CHANNEL PATHWAYS

DATE:

FIGURE NO.: FIGURE 2

LEGEND

- Existing Borings - Previous Studies, Private Industry, other Public Agencies
- Borings Acquired as Part of Harbor Navigation Study
- Location of Profile or Cross Section
- Location of Slope Stability Analysis

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SUBSURFACE INDEX MAP

DATE:

FIGURE NO.:
FIGURE 3

FIGURE 3

5 4 3 2 1

D C B A

LEGEND

- Existing Borings - Previous Studies, Private Industry, other Public Agencies
- Borings Acquired as Part of Harbor Navigation Study
- Location of Profile or Cross Section
- Location of Slope Stability Analysis - Most Critical Section

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SUBSURFACE INDEX MAP

DATE:

FIGURE NO.:
FIGURE 3A

LEGEND

SERPENTINITE

DIABASE

SHALE

SANDSTONE

SCHIST

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TOP OF ROCK CONTOUR MAP
ROCK AREAS FIFTY - FOOT CHANNEL

SCALE: 1" = 1000'

DATE:

FIGURE NO.: FIGURE 4

LEGEND

SERPENTINITE

DIABASE

SHALE

SANDSTONE

SCHIST

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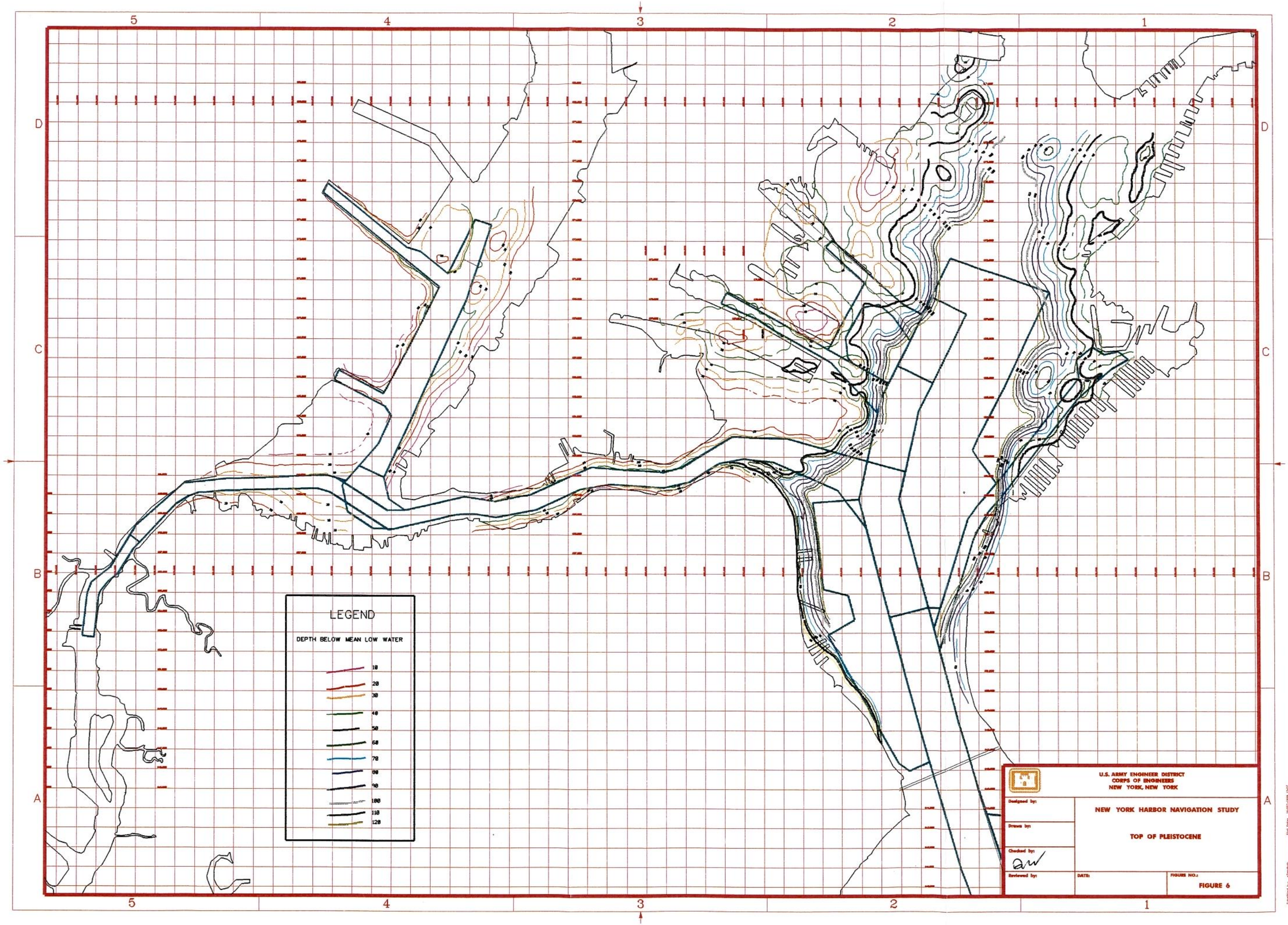
SIXTY-FOOT CHANNEL

TOP OF ROCK CONTOUR MAP
ROCK AREAS - SIXTY FOOT CHANNEL

SCALE: 1" = 1000'

DATE:

FIGURE NO.:
FIGURE 5



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TOP OF PLEISTOCENE

DATE:

FIGURE NO.:
FIGURE 6

PALEO SHORELINE 5000 - 10000 YEARS AGO

PALEO SHORELINE 2000 - 4000 YEARS AGO

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PALEO - SHORELINE
(2000 - 4000 YEARS AGO)
(5000 - 10000 YEARS AGO)

FIGURE NO.:
FIGURE 7

LEGEND

THICKNESS	COLOR/PATTERN
0-2	
2-4	
4-6	
6-8	
8-10	
10-12	
12-15	

GRAVESEND ANCHORAGE

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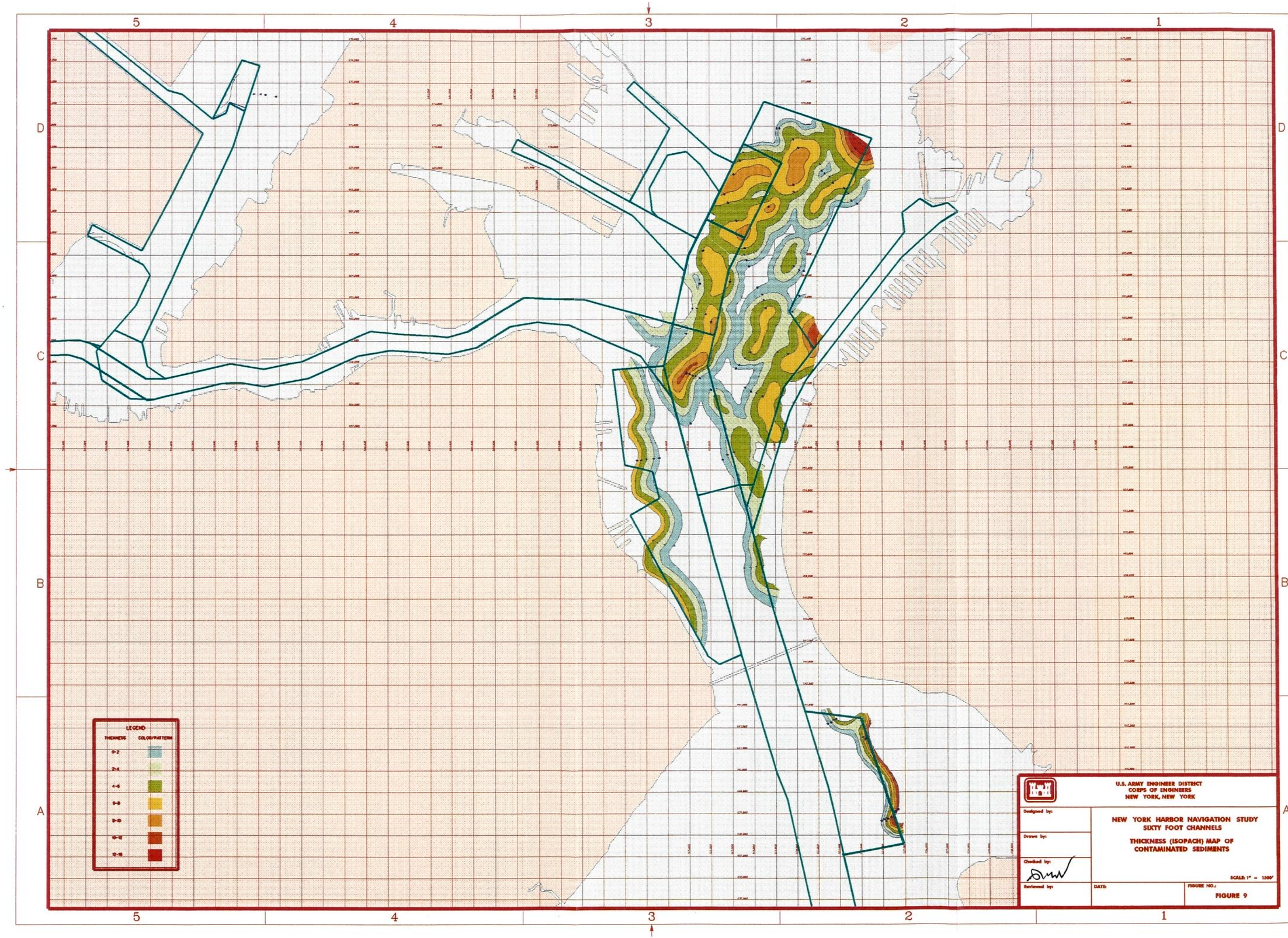
NEW YORK HARBOR NAVIGATION STUDY
FIFTY FOOT CHANNELS

THICKNESS (ISOPACH) MAP OF CONTAMINATED SEDIMENTS

SCALE: 1" = 1500'

DATE:

FIGURE NO.:
FIGURE 8


LEGEND
THICKNESS
COLOR/PATTERN
0-2
2-4
4-6
6-8
8-10
10-12
12-15
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NEW YORK HARBOR NAVIGATION STUDY
SIXTY FOOT CHANNELS
THICKNESS (ISOPACH) MAP OF
CONTAMINATED SEDIMENTS
SCALE: 1" = 1500'
DATE:
FIGURE NO.:
FIGURE 9

5 4 3 2 1

D C B A

LEGEND

% OF SAND	COLOR/PATTERN
0-20%	
20-40%	
40-60%	
60-80%	
80-100%	
100%	

ROCK AREA PATTERNS

SHALE	
SANDSTONE	
DIABASE	
SERPENTINE	
SCHIST	

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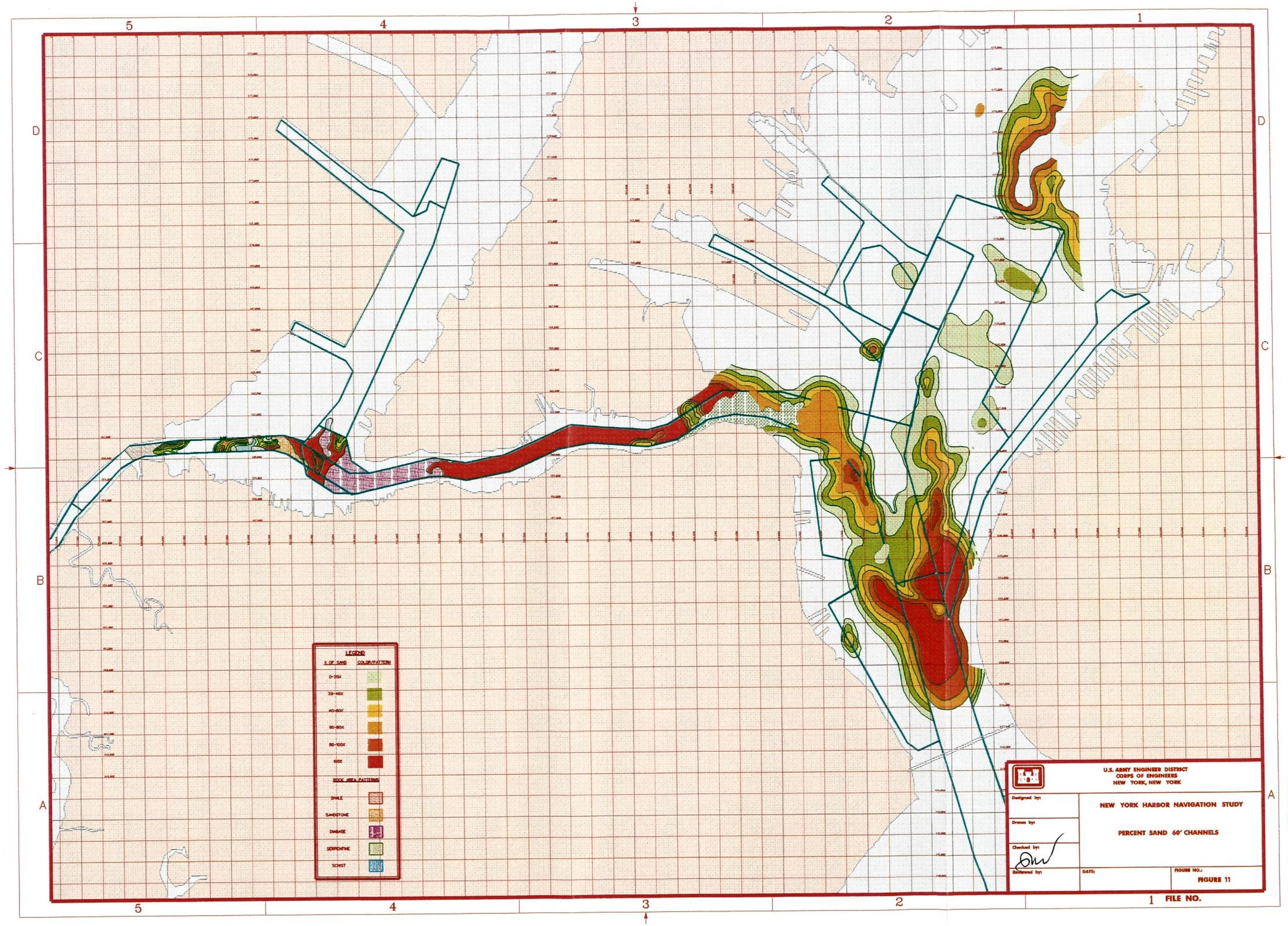
PERCENT SAND 50' CHANNELS

DATE:

FIGURE NO.: FIGURE 10

FILE NO.


LEGEND
% OF SAND
COLOR/PATTERN
0-20%
20-40%
40-60%
60-80%
80-100%
100%
ROCK AREA PATTERNS
SHALE
SANDSTONE
DIABASE
SERPENTINE
SCHIST
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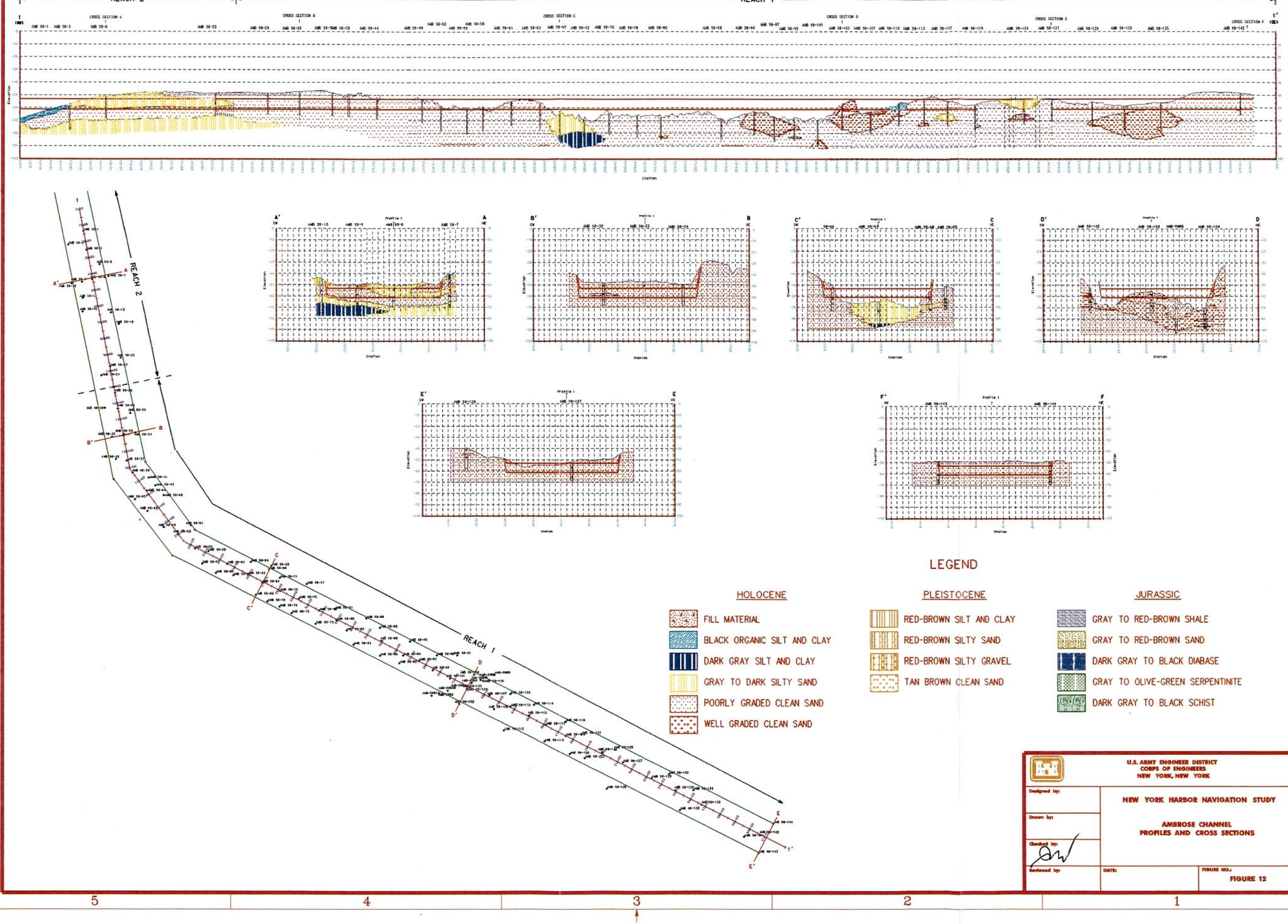
PERCENT SAND 60' CHANNELS
DATE:
FIGURE NO.:
FIGURE 11
FILE NO.


REACH 2
REACH 1
CROSS SECTION A
CROSS SECTION B
CROSS SECTION C
CROSS SECTION D
CROSS SECTION E
CROSS SECTION F
Elevation
Station
REACH 2
REACH 1
LEGEND
HOLOCENE
FILL MATERIAL
BLACK ORGANIC SILT AND CLAY
DARK GRAY SILT AND CLAY
GRAY TO DARK SILTY SAND
POORLY GRADED CLEAN SAND
WELL GRADED CLEAN SAND
PLEISTOCENE
RED-BROWN SILT AND CLAY
RED-BROWN SILTY SAND
RED-BROWN SILTY GRAVEL
TAN BROWN CLEAN SAND
JURASSIC
GRAY TO RED-BROWN SHALE
GRAY TO RED-BROWN SAND
DARK GRAY TO BLACK DIABASE
GRAY TO OLIVE-GREEN SERPENTINITE
DARK GRAY TO BLACK SCHIST
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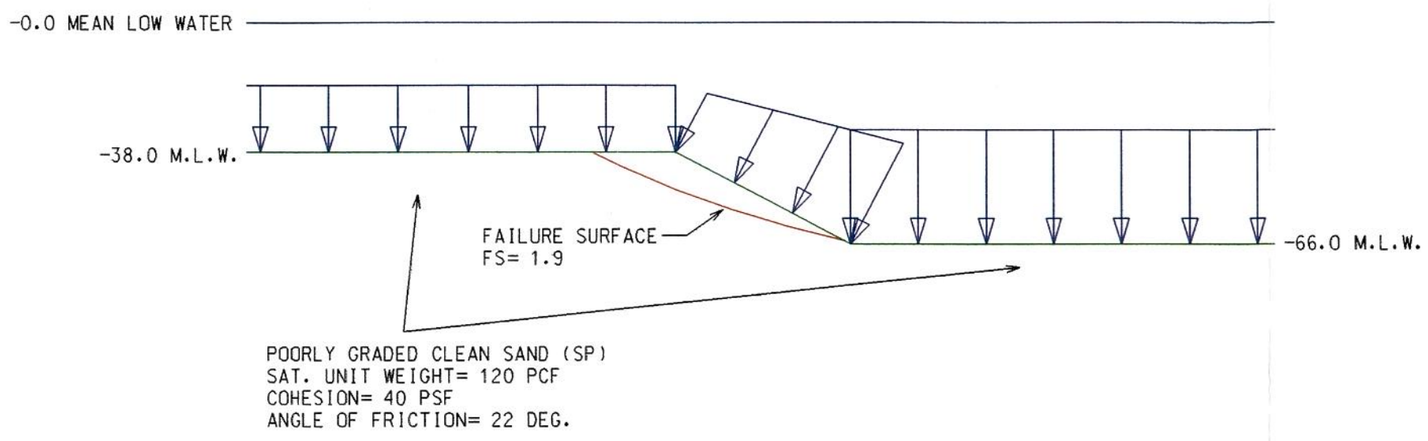
NEW YORK HARBOR NAVIGATION STUDY
AMBROSE CHANNEL
PROFILES AND CROSS SECTIONS
DATE:
FIGURE NO.:
FIGURE 12



AMBROSE NAVIGATION CHANNEL
PROFILE SECTION F
SIDE SLOPE STABILITY ANALYSIS

SCALE: NTS

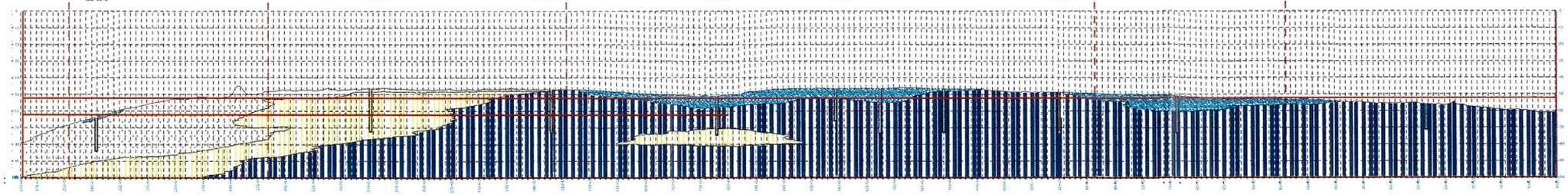
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS NEW YORK, NEW YORK		
Designed by:	NEW YORK HARBOR NAVIGATION STUDY	
Drawn by:	AMBROSE CHANNEL SLOPE STABILITY CROSS SECTIONS	
Checked by:		
Reviewed by:	DATE:	FIGURE NO.: FIGURE 13

REACH 2

REACH 1

1′

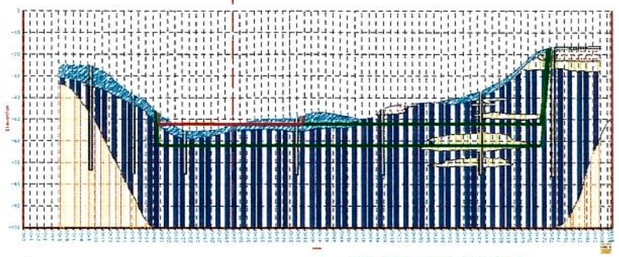
1



A′

A

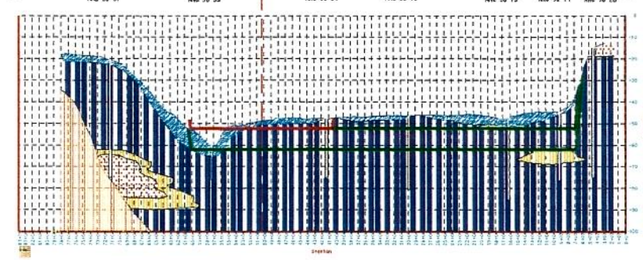
RED HOOK FLATS ANCHORAGE



B′

B

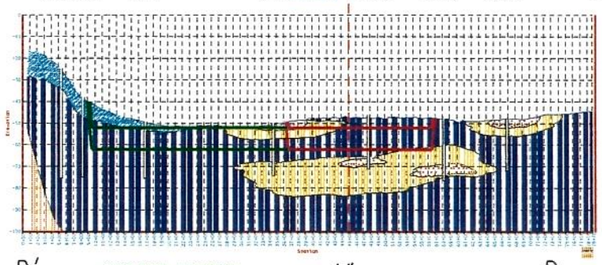
RED HOOK FLATS ANCHORAGE



C′

C

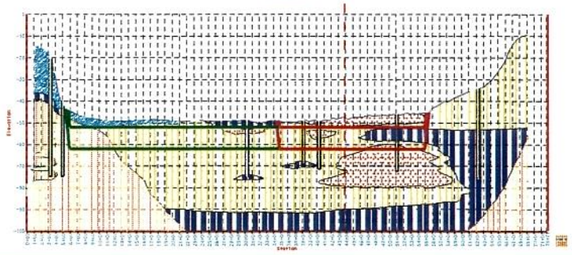
STAPLETON ANCHORAGE

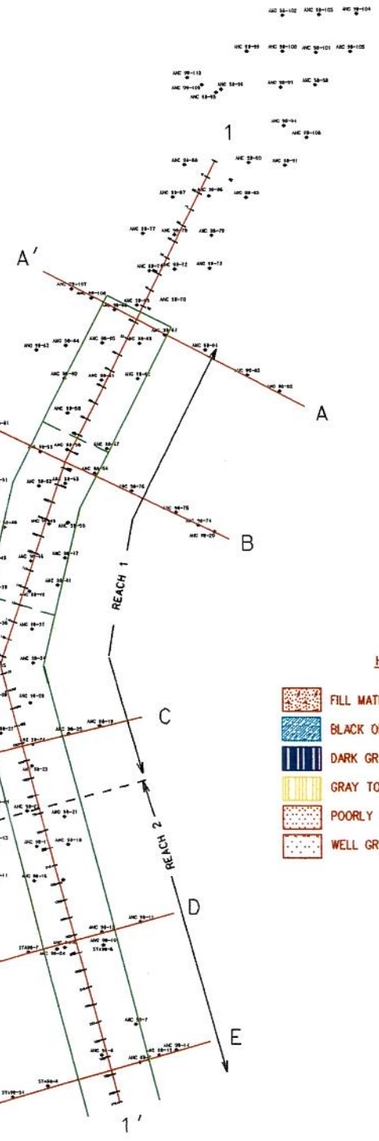


D′

D

STAPLETON ANCHORAGE

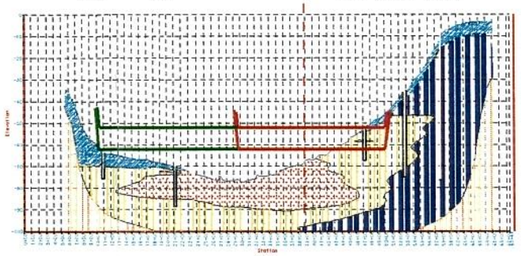




E′

E

STAPLETON ANCHORAGE



LEGEND

HOLOCENE

- FILL MATERIAL
- BLACK ORGANIC SILT AND CLAY
- DARK GRAY SILT AND CLAY
- GRAY TO DARK SILTY SAND
- POORLY GRADED CLEAN SAND
- WELL GRADED CLEAN SAND

PLEISTOCENE

- RED-BROWN SILT AND CLAY
- RED-BROWN SILTY SAND
- RED-BROWN SILTY GRAVEL
- TAN BROWN CLEAN SAND

JURASSIC

- GRAY TO RED-BROWN SHALE
- GRAY TO RED-BROWN SAND
- DARK GRAY TO BLACK DIABASE
- GRAY TO OLIVE-GREEN SERPENTINITE
- DARK GRAY TO BLACK SCHIST

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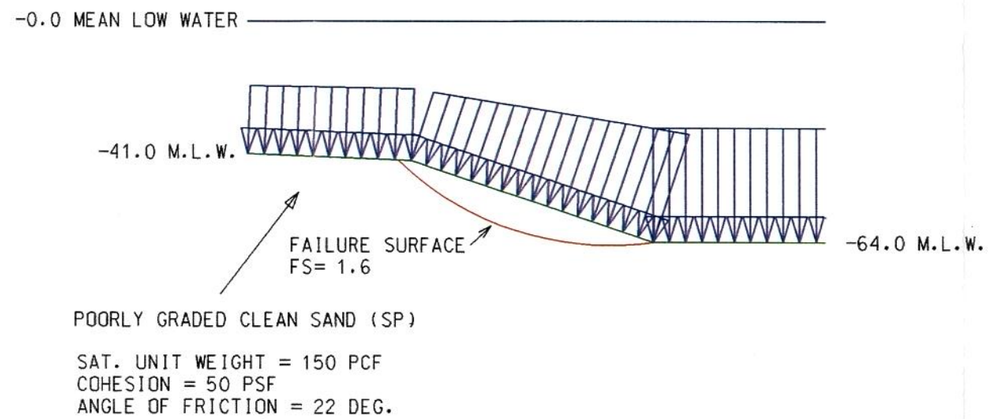
ANCHORAGE CHANNEL
STAPLETON AND REDHOOK FLATS ANCHORAGE
PROFILES AND CROSS SECTIONS

DATE:

FIGURE NO.:
FIGURE 14



ANCHORAGE NAVIGATION CHANNEL
PROFILE SECTION C
SIDE SLOPE STABILITY ANALYSIS

SCALE: NTS

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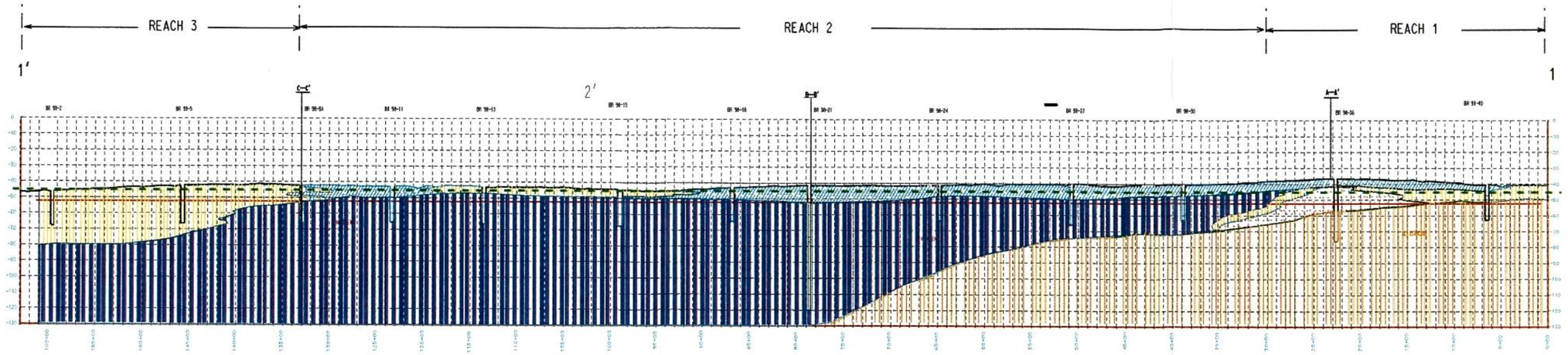
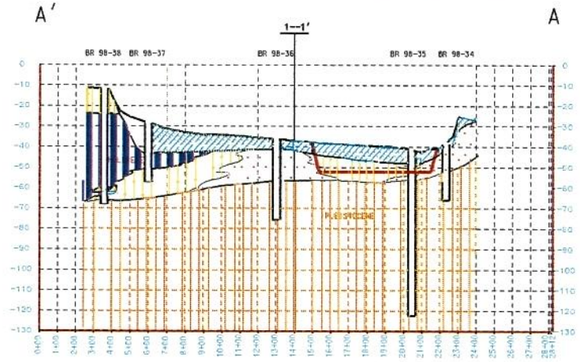
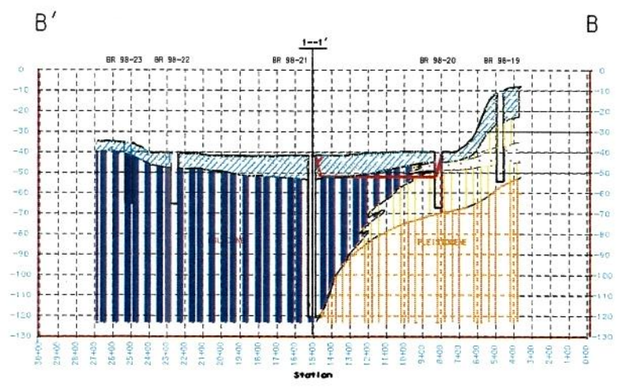
ANCHORAGE CHANNEL
SLOPE STABILITY CROSS SECTIONS

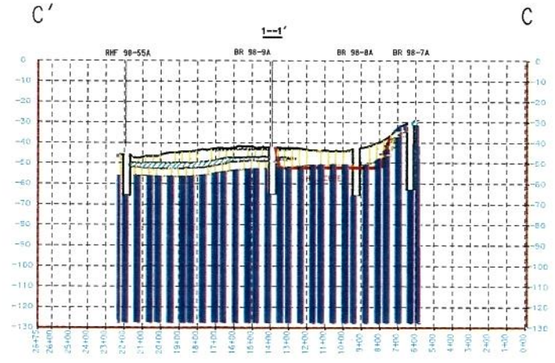
DATE:

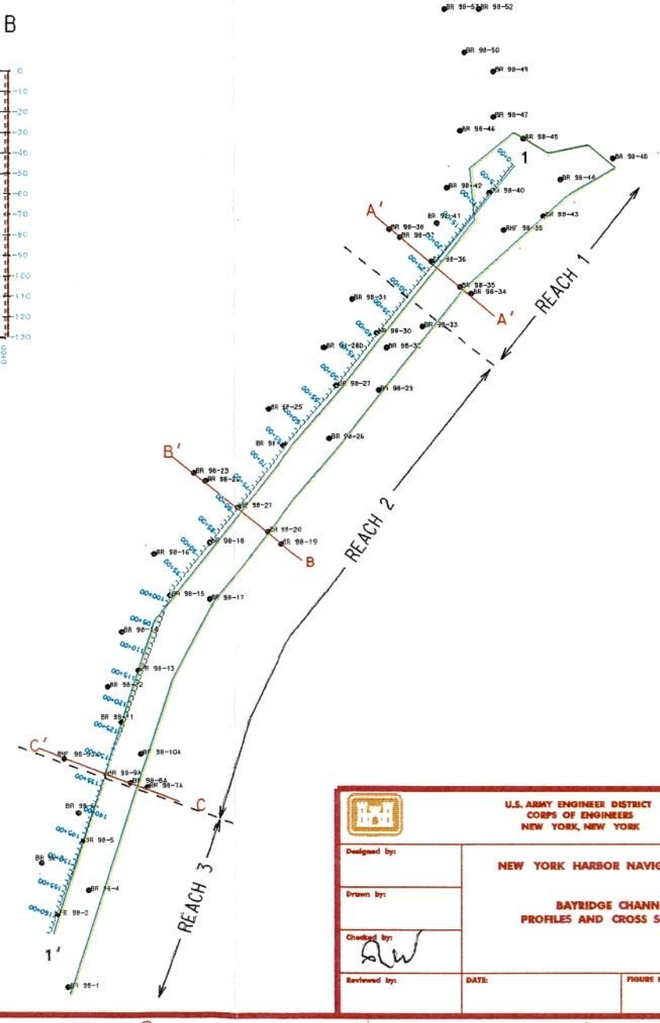
FIGURE NO.:
FIGURE 15











LEGEND

HOLOCENE
- FILL MATERIAL
- BLACK ORGANIC SILT AND CLAY
- DARK GRAY SILT AND CLAY
- GRAY TO DARK SILTY SAND
- POORLY GRADED CLEAN SAND
- WELL GRADED CLEAN SAND

PLEISTOCENE
- RED-BROWN SILT AND CLAY
- RED-BROWN SILTY SAND
- RED-BROWN SILTY GRAVEL
- TAN BROWN CLEAN SAND

JURASSIC
- GRAY TO RED-BROWN SHALE
- GRAY TO RED-BROWN SAND
- DARK GRAY TO BLACK DIABASE
- GRAY TO OLIVE-GREEN SERPENTINITE
- DARK GRAY TO BLACK SCHIST

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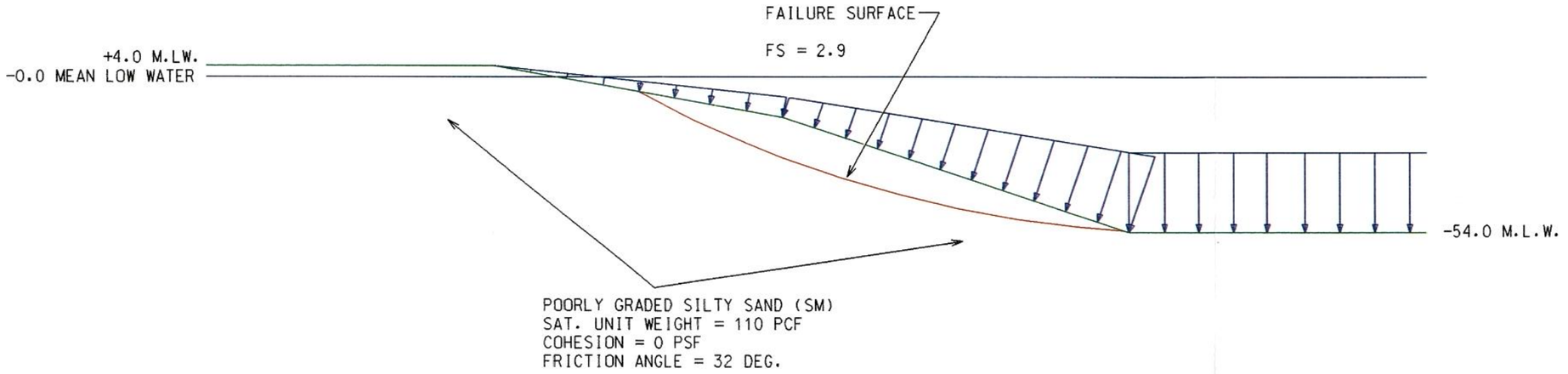
NEW YORK HARBOR NAVIGATION STUDY

BAYRIDGE CHANNEL
PROFILES AND CROSS SECTIONS

DATE:

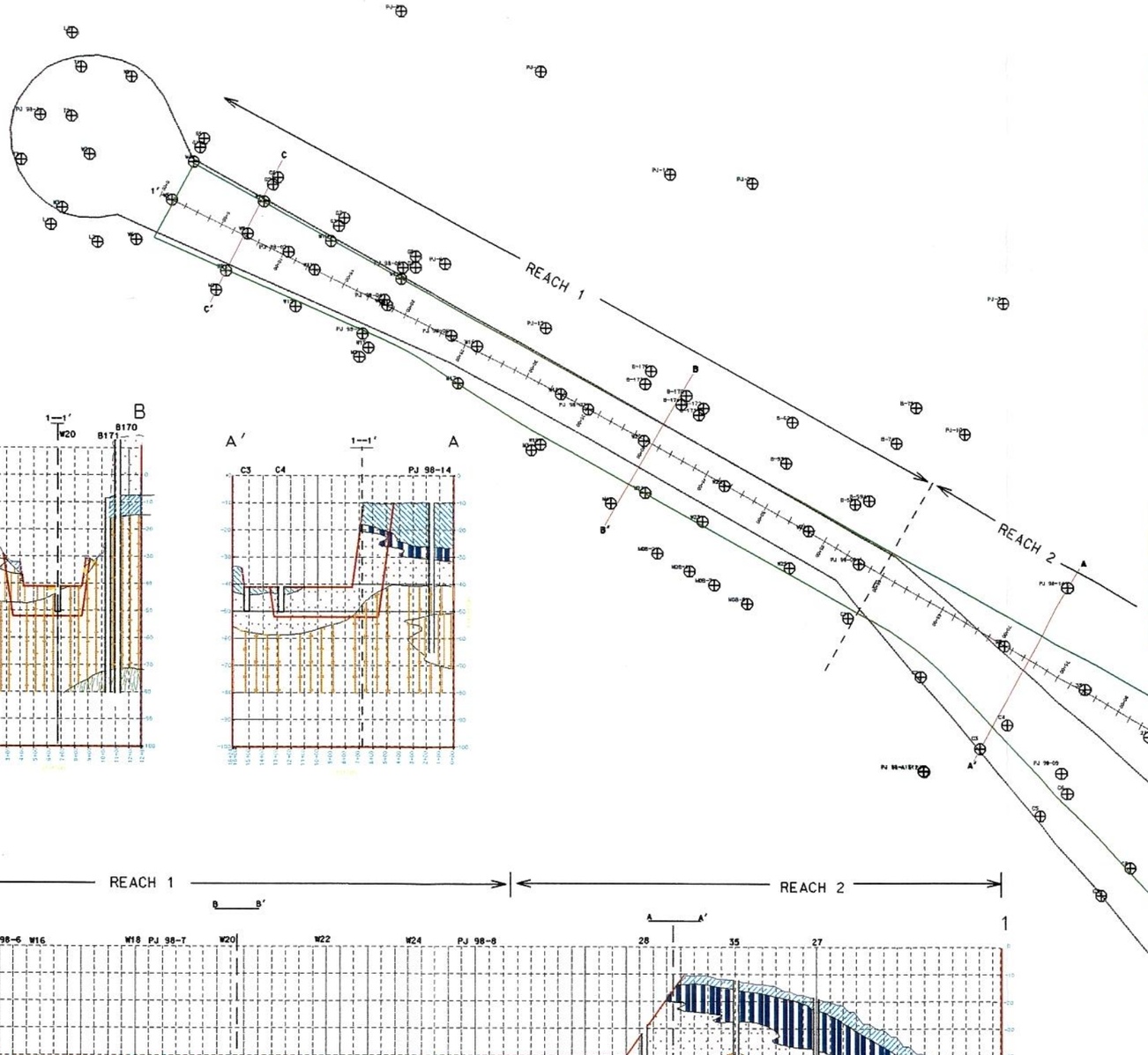
FIGURE NO.:
FIGURE 16



BAY RIDGE NAVIGATION CHANNEL
PROFILE SECTION B
SIDE SLOBE STABILITY ANALYSIS

SCALE: NTS

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS NEW YORK, NEW YORK		
Designed by:	NEW YORK HARBOR NAVIGATION STUDY	
Drawn by:	BAY RIDGE CHANNEL SLOPE STABILITY CROSS SECTIONS	
Checked by: AW		
Reviewed by:	DATE:	FIGURE NO.: FIGURE 17



LEGEND

HOLOCENE

- FILL MATERIAL (GW)
- BLACK ORGANIC SILT AND CLAY (OH)
- DARK GRAY SILT AND CLAY (MH)
- GRAY TO DARK SILTY SAND (SM)
- POORLY GRADED CLEAN SAND (SP)
- WELL GRADED CLEAN SAND (SW)

PLEISTOCENE

- RED-BROWN SILT AND CLAY (ML)
- RED-BROWN SILTY SAND (SM)
- RED-BROWN SILTY GRAVEL (GM)
- TAN BROWN CLEAN SAND (SW)

JURASSIC

- GRAY TO RED-BROWN SHALE
- GRAY TO RED-BROWN SAND
- DARK GRAY TO BLACK DIABASE
- GRAY TO OLIVE-GREEN SERPENTINITE
- DARK GRAY TO BLACK SCHIST

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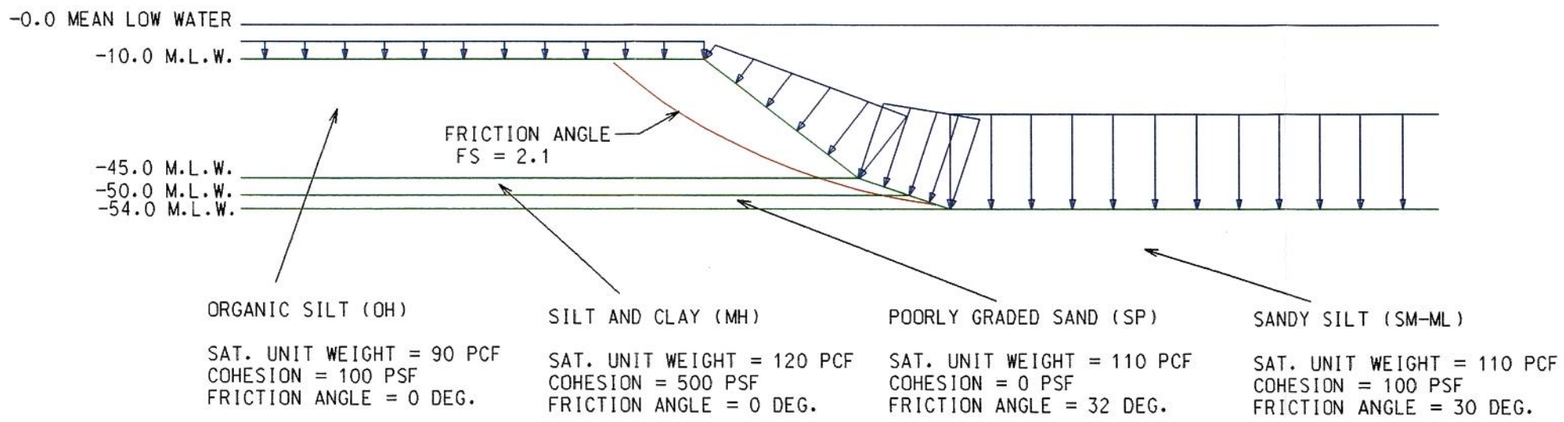
NEW YORK HARBOR NAVIGATION STUDY

PORT JERSEY CHANNEL
PROFILES AND CROSS SECTIONS

DATE:

FIGURE NO.:
FIGURE 18



PORT JERSEY NAVIGATION CHANNEL
PROFILE SECTION A
SIDE SLOPE STABILITY ANALYSIS

SCALE: NTS

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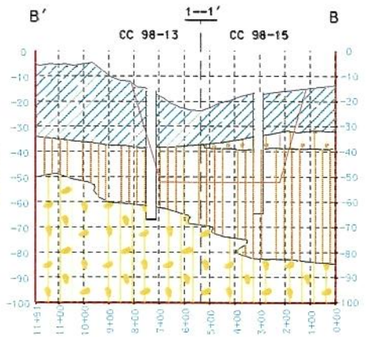
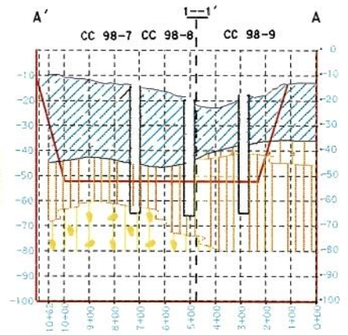
NEW YORK HARBOR NAVIGATION STUDY

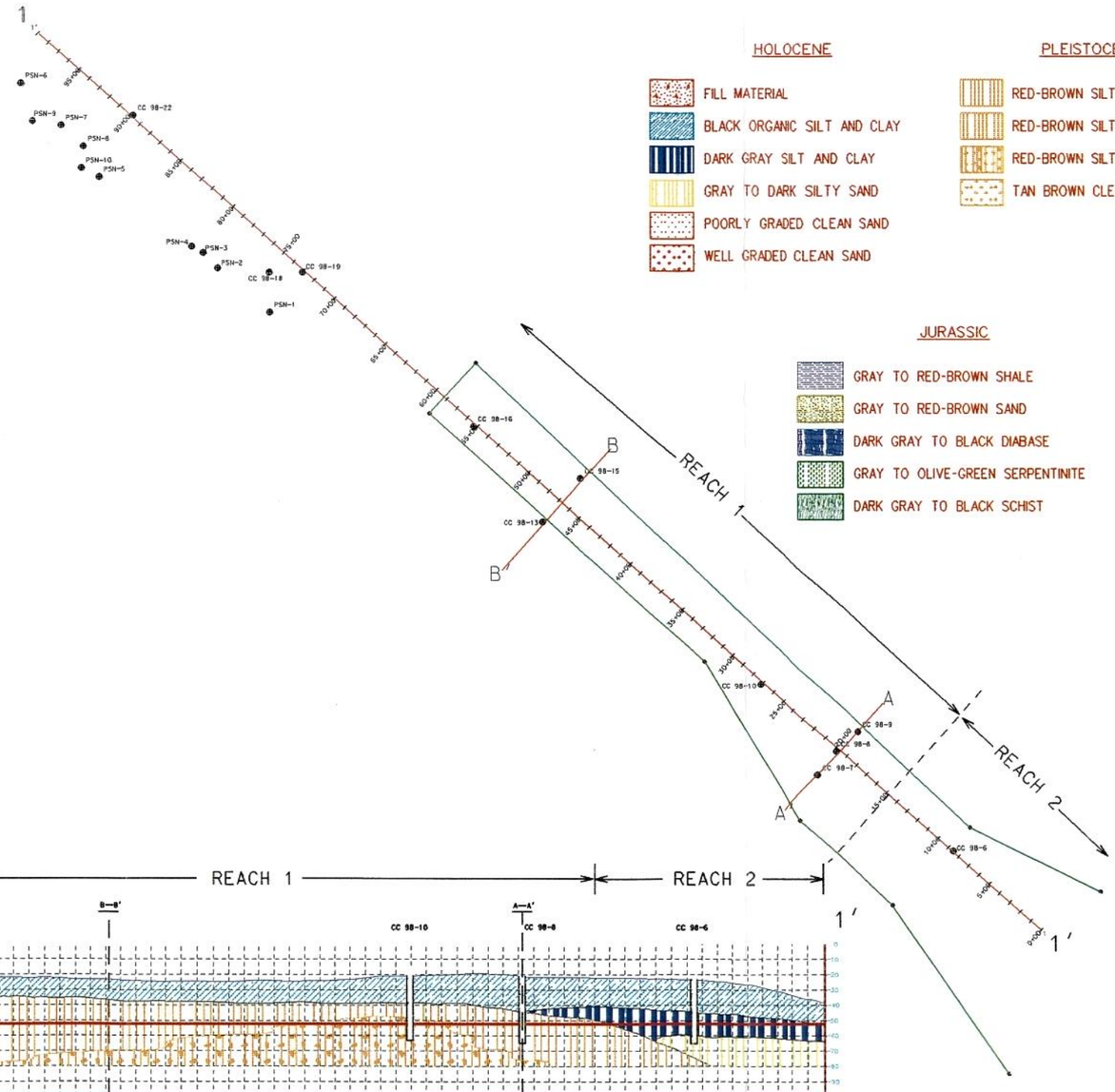
PORT JERSEY CHANNEL
SLOPE STABILITY CROSS SECTIONS

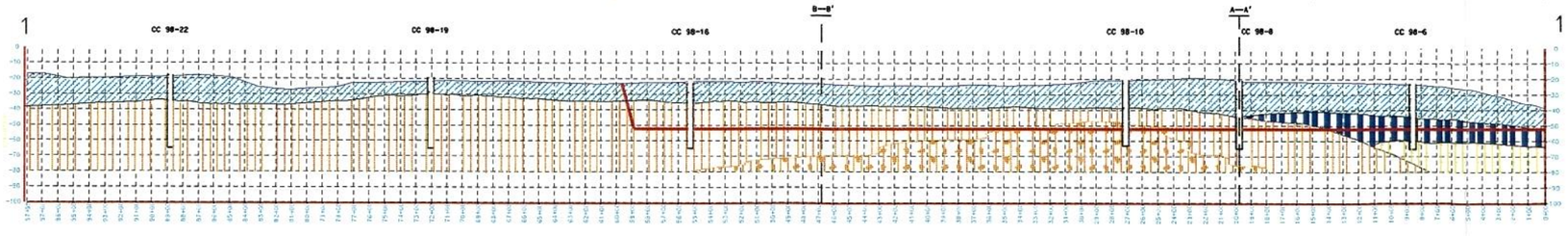
DATE:

FIGURE NO.:
FIGURE 19









LEGEND

HOLOCENE

- FILL MATERIAL
- BLACK ORGANIC SILT AND CLAY
- DARK GRAY SILT AND CLAY
- GRAY TO DARK SILTY SAND
- POORLY GRADED CLEAN SAND
- WELL GRADED CLEAN SAND

PLEISTOCENE

- RED-BROWN SILT AND CLAY
- RED-BROWN SILTY SAND
- RED-BROWN SILTY GRAVEL
- TAN BROWN CLEAN SAND

JURASSIC

- GRAY TO RED-BROWN SHALE
- GRAY TO RED-BROWN SAND
- DARK GRAY TO BLACK DIABASE
- GRAY TO OLIVE-GREEN SERPENTINITE
- DARK GRAY TO BLACK SCHIST

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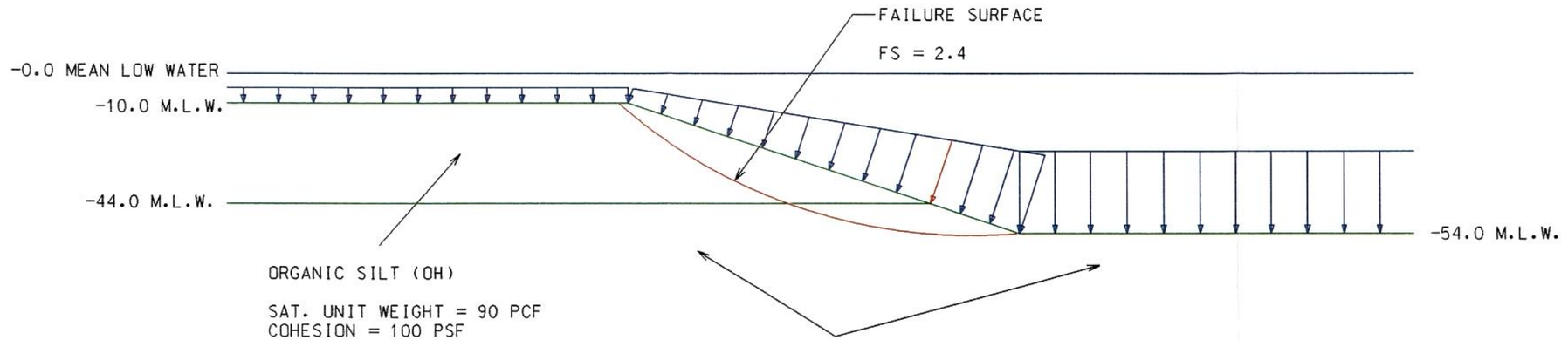
NEW YORK HARBOR NAVIGATION STUDY

CLAREMONT CHANNEL
PROFILES AND CROSS SECTIONS

DATE:

FIGURE NO.:
FIGURE 20



CLAREMONT NAVIGATION CHANNEL
PROFILE SECTION A
SIDE SLOPE STABILITY

SCALE: NTS

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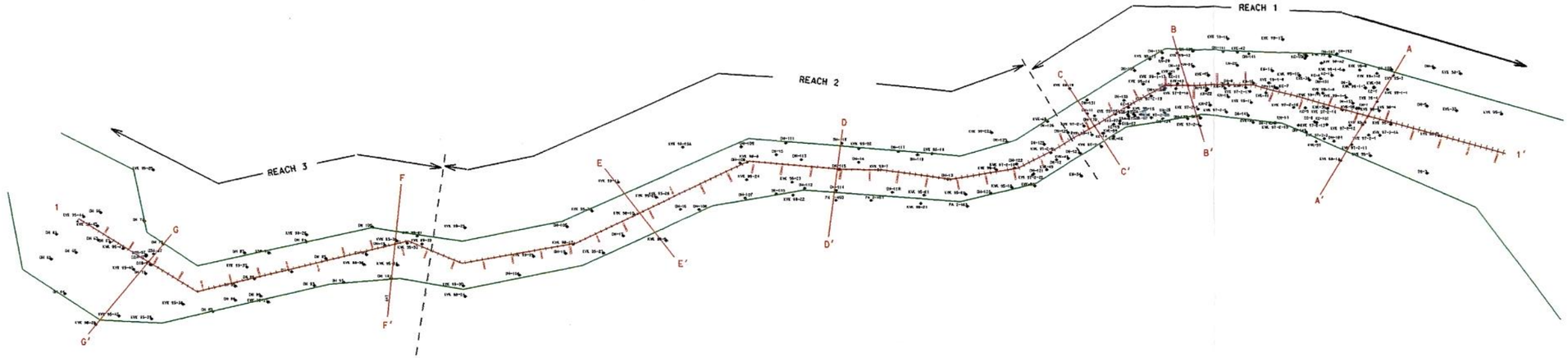
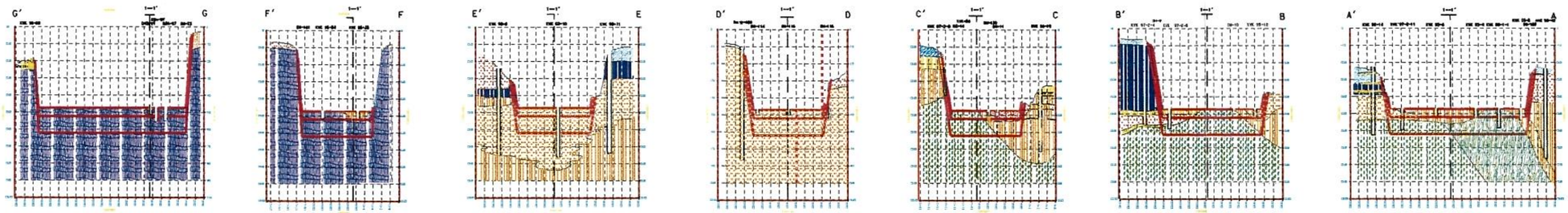
NEW YORK HARBOR NAVIGATION STUDY

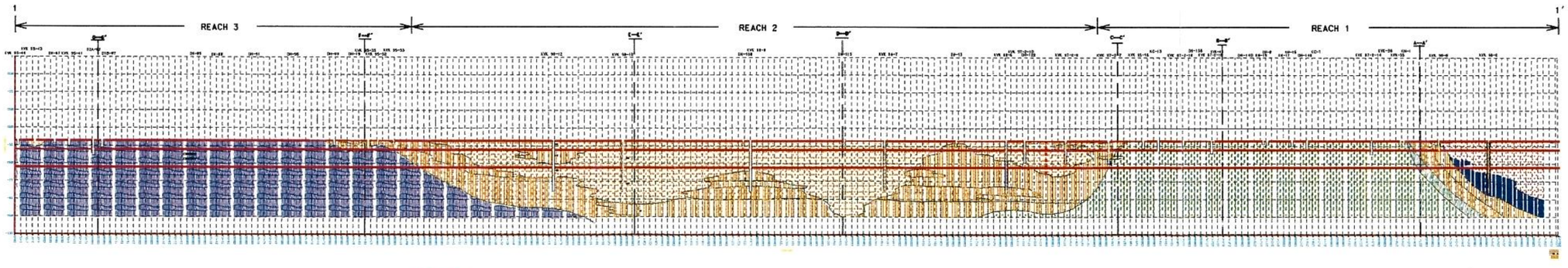
CLAREMONT CHANNEL
SLOPE STABILITY CROSS SECTIONS

DATE:

FIGURE NO.:
FIGURE 21







LEGEND

HOLOCENE

- FILL MATERIAL
- BLACK ORGANIC SILT AND CLAY
- DARK GRAY SILT AND CLAY
- GRAY TO DARK SILTY SAND
- POORLY GRADED CLEAN SAND
- WELL GRADED CLEAN SAND

PLEISTOCENE

- RED-BROWN SILT AND CLAY
- RED-BROWN SILTY SAND
- RED-BROWN SILTY GRAVEL
- TAN BROWN CLEAN SAND

JURASSIC

- GRAY TO RED-BROWN SHALE
- GRAY TO RED-BROWN SAND
- DARK GRAY TO BLACK DIABASE
- GRAY TO OLIVE-GREEN SERPENTINITE
- DARK GRAY TO BLACK SCHIST

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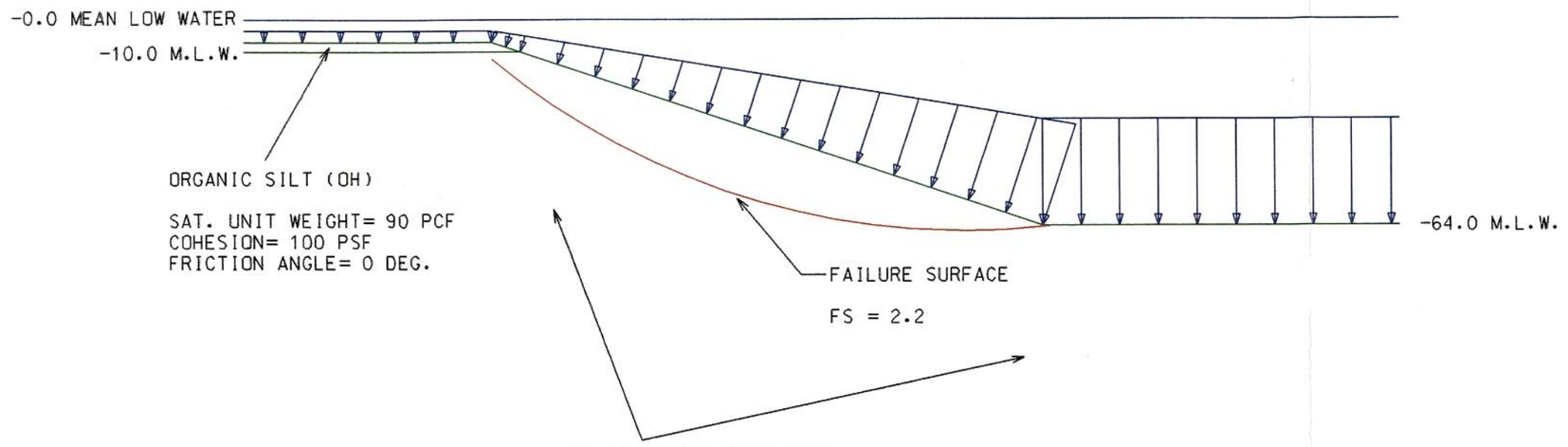
KVK CHANNEL
PROFILES AND CROSS SECTIONS

DATE:

FIGURE NO.:
FIGURE 22



KILL VAN KULL NAVIGATION CHANNEL
PROFILE SECTION D
SIDE STABILITY ANALYSIS

SCALE: NTS

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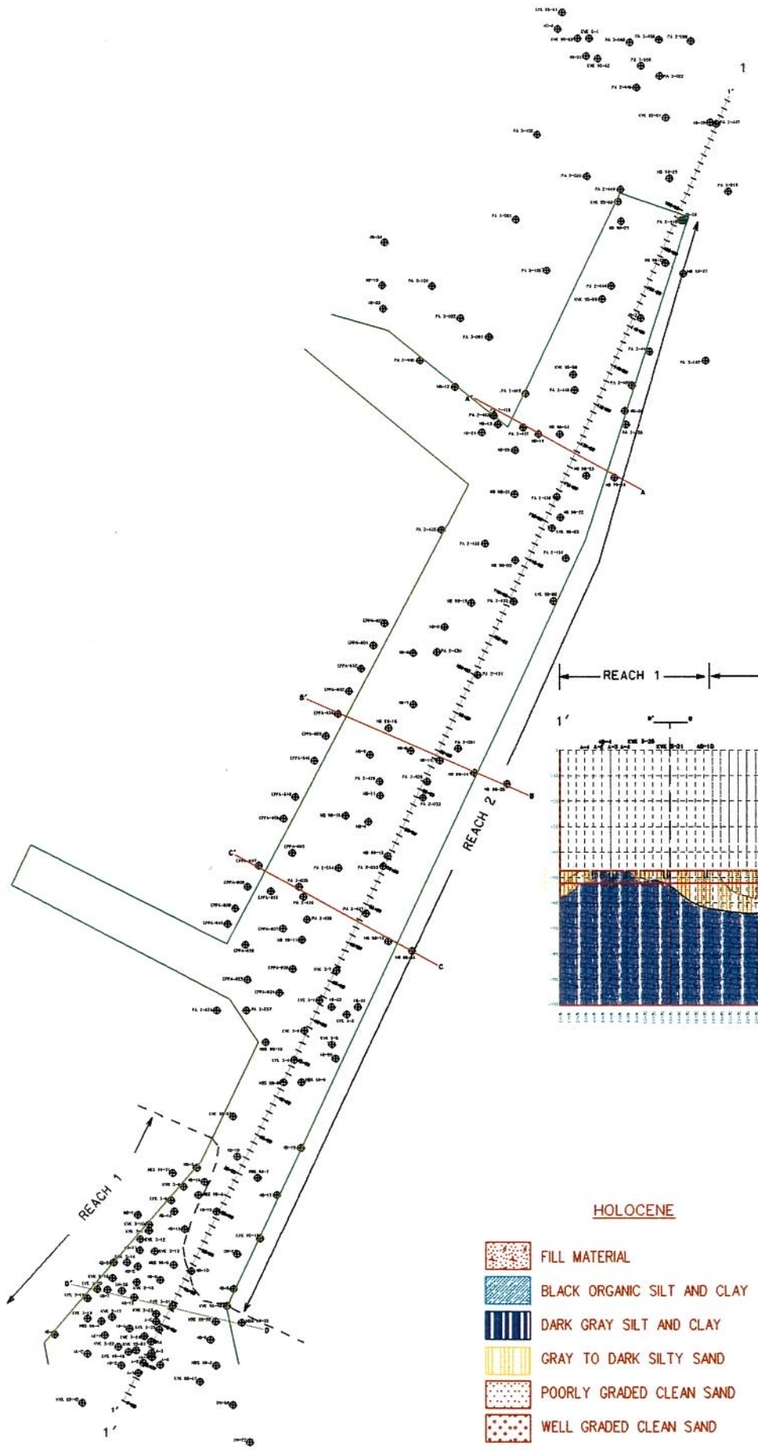
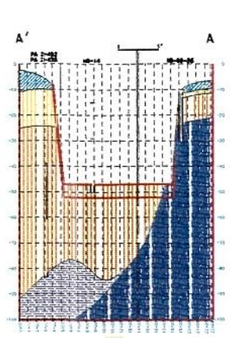
NEW YORK HARBOR NAVIGATION STUDY

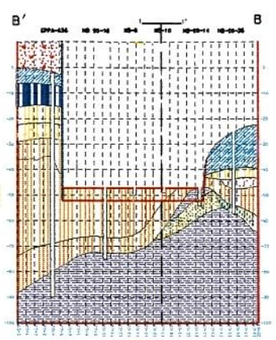
KILL VAN KULL CHANNEL
SLOPE STABILITY CROSS SECTIONS

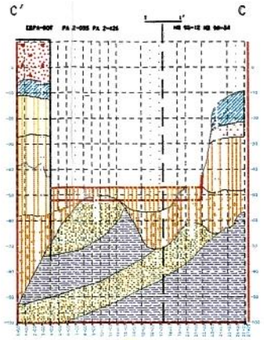
DATE:

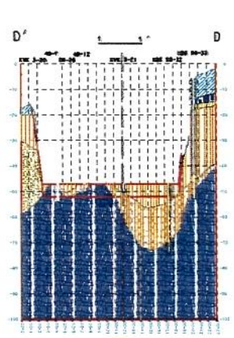
FIGURE NO.:
FIGURE 23

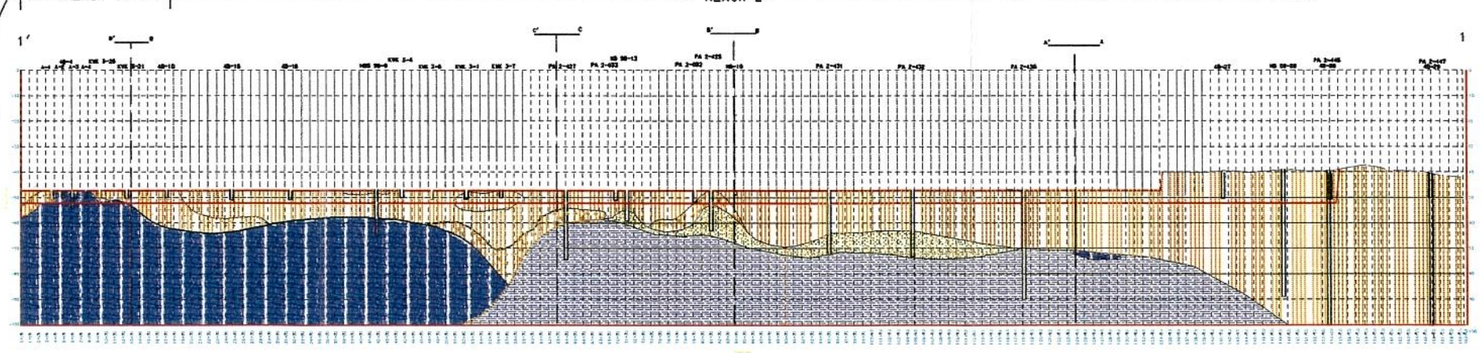












LEGEND

HOLOCENE	PLEISTOCENE	JURASSIC
FILL MATERIAL	RED-BROWN SILT AND CLAY	GRAY TO RED-BROWN SHALE
BLACK ORGANIC SILT AND CLAY	RED-BROWN SILTY SAND	GRAY TO RED-BROWN SAND
DARK GRAY SILT AND CLAY	RED-BROWN SILTY GRAVEL	DARK GRAY TO BLACK DIABASE
GRAY TO DARK SILTY SAND	TAN BROWN CLEAN SAND	GRAY TO OLIVE-GREEN SERPENTINITE
POORLY GRADED CLEAN SAND		DARK GRAY TO BLACK SCHIST
WELL GRADED CLEAN SAND		

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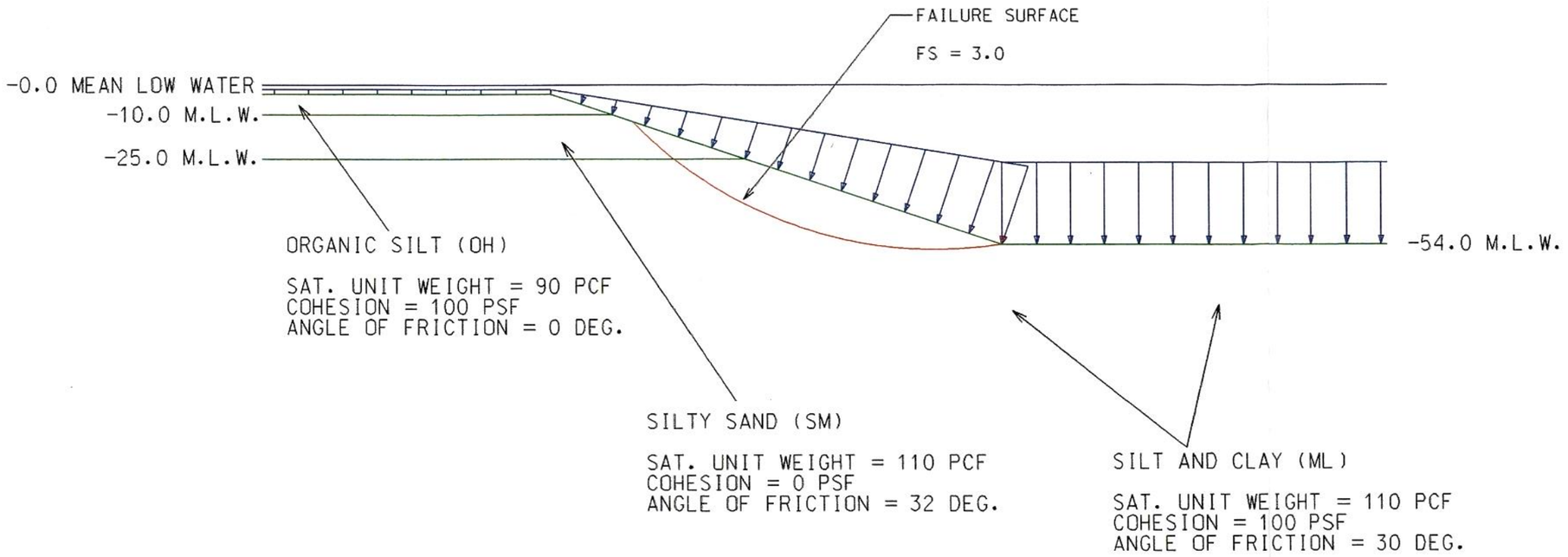
NEWARK BAY CHANNEL
PROFILES AND CROSS SECTIONS

DATE:

FIGURE NO.:
FIGURE 24



NEWARK BAY NAVIGATION CHANNEL
PROFILE SECTION A
SIDE SLOPE STABILITY ANALYSIS

SCALE: NTS

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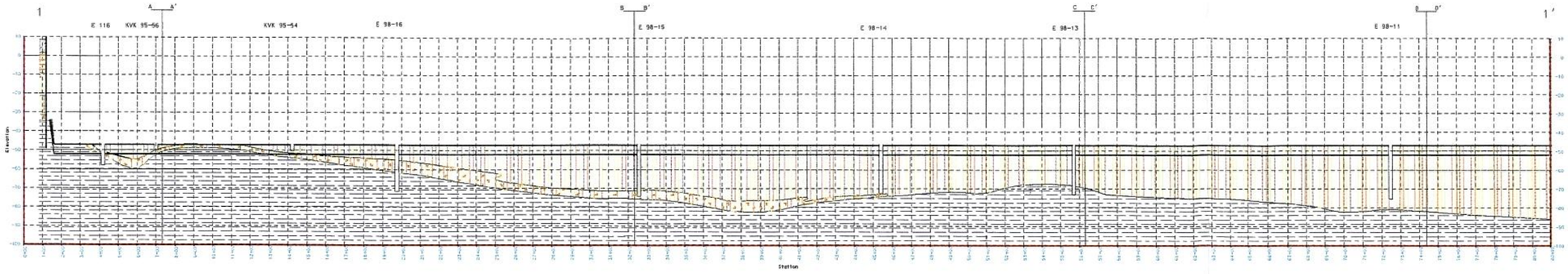
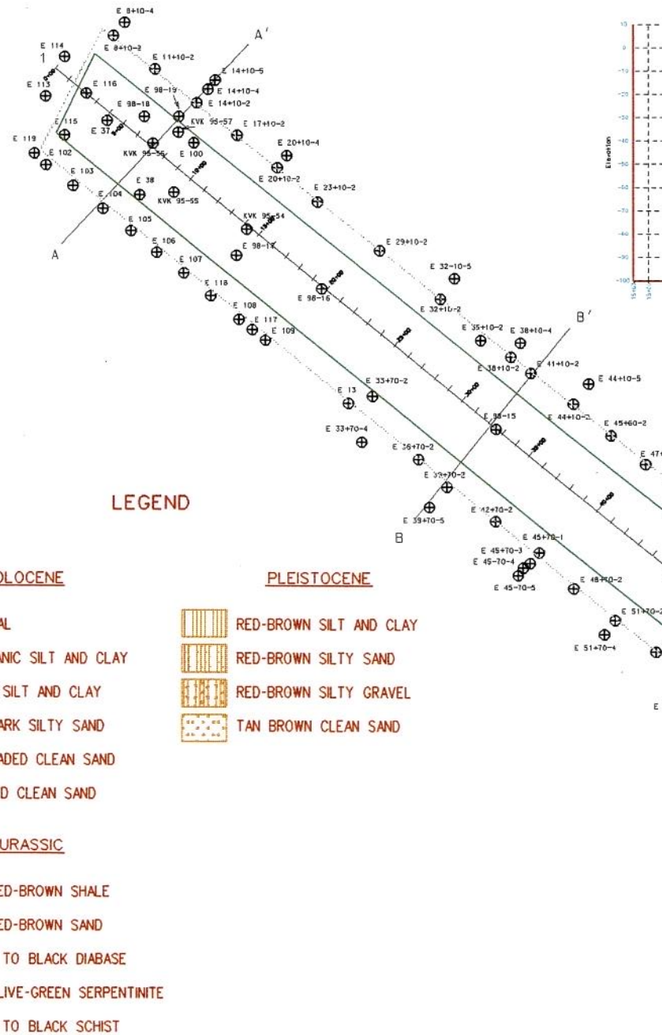
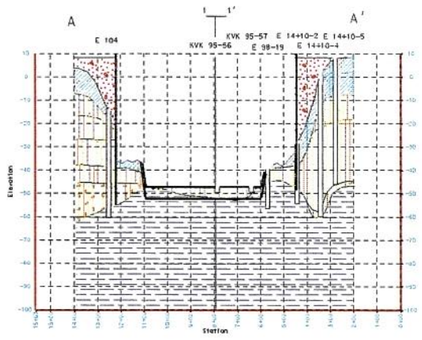
NEWARK BAY CHANNEL
SLOPE STABILITY CROSS SECTIONS

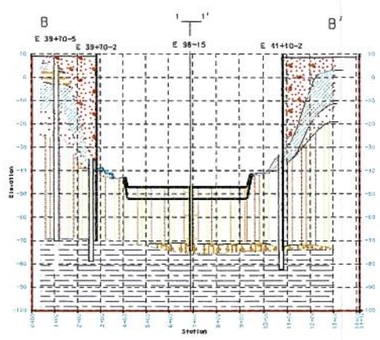
DATE:

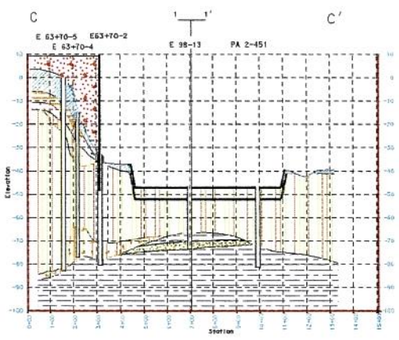
FIGURE NO.:
FIGURE 25

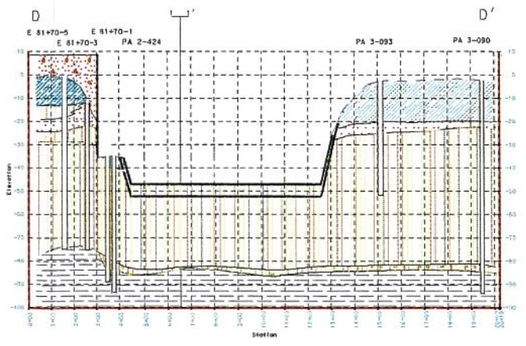












LEGEND

HOLOCENE

- FILL MATERIAL
- BLACK ORGANIC SILT AND CLAY
- DARK GRAY SILT AND CLAY
- GRAY TO DARK SILTY SAND
- POORLY GRADED CLEAN SAND
- WELL GRADED CLEAN SAND

PLEISTOCENE

- RED-BROWN SILT AND CLAY
- RED-BROWN SILTY SAND
- RED-BROWN SILTY GRAVEL
- TAN BROWN CLEAN SAND

JURASSIC

- GRAY TO RED-BROWN SHALE
- GRAY TO RED-BROWN SAND
- DARK GRAY TO BLACK DIABASE
- GRAY TO OLIVE-GREEN SERPENTINITE
- DARK GRAY TO BLACK SCHIST

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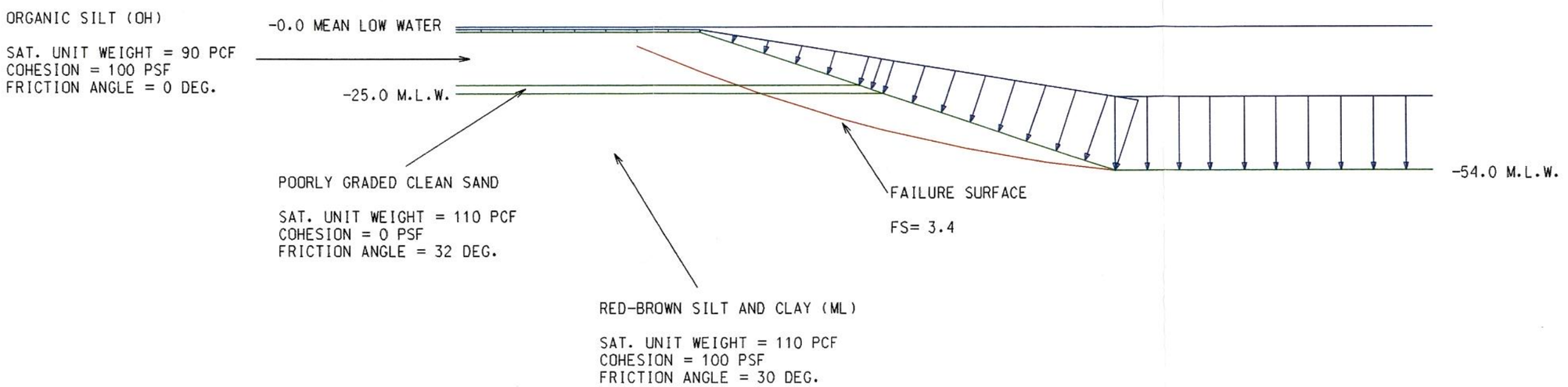
NEW YORK HARBOR NAVIGATION STUDY

ELIZABETH CHANNEL
PROFILES AND CROSS SECTIONS

DATE:

FIGURE NO.:
FIGURE 26



ELIZABETH NAVIGATION CHANNEL
PROFILE SECTION D
SIDE SLOPE STABILITY ANALYSIS

SCALE: NTS

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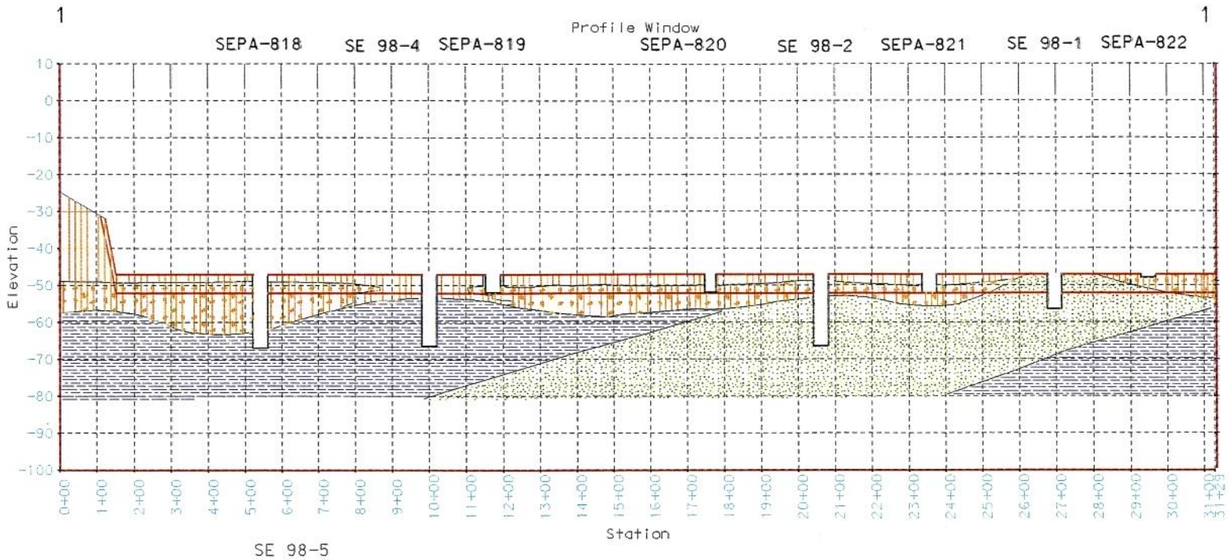
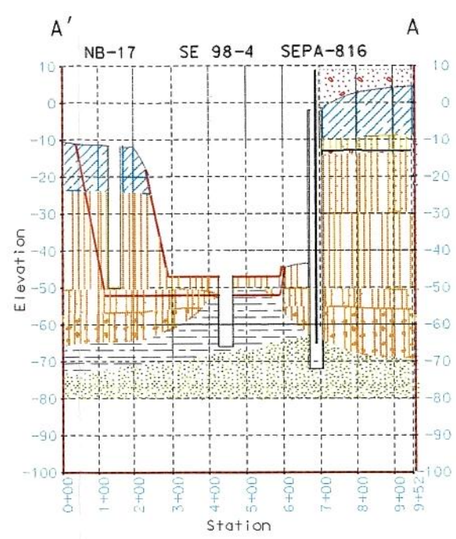
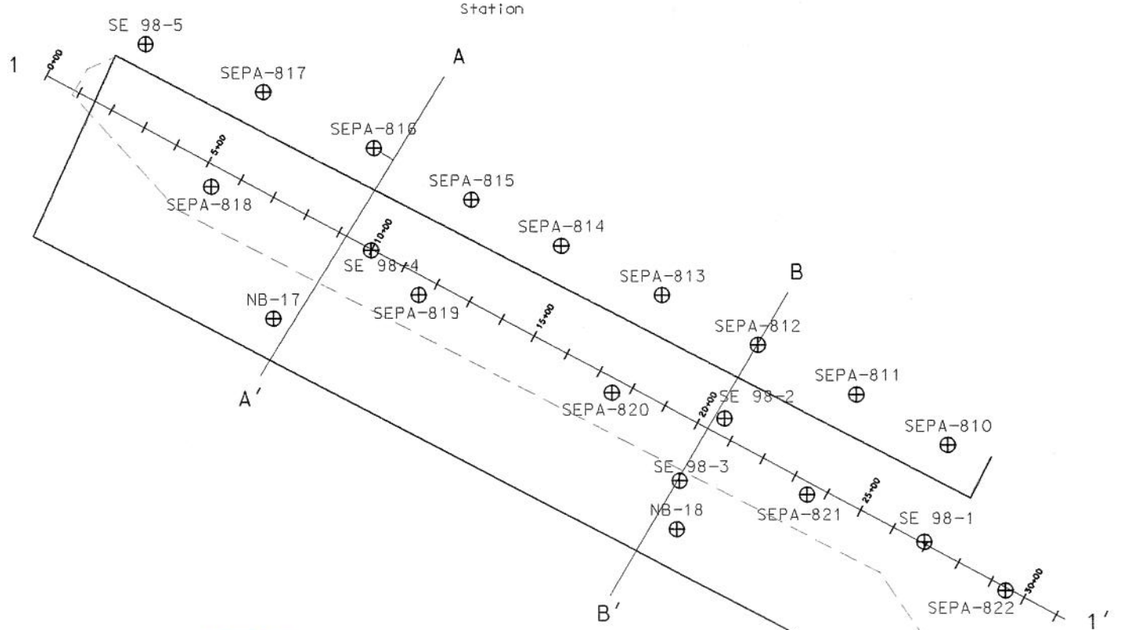
ELIZABETH CHANNEL
SLOPE STABILITY CROSS SECTIONS

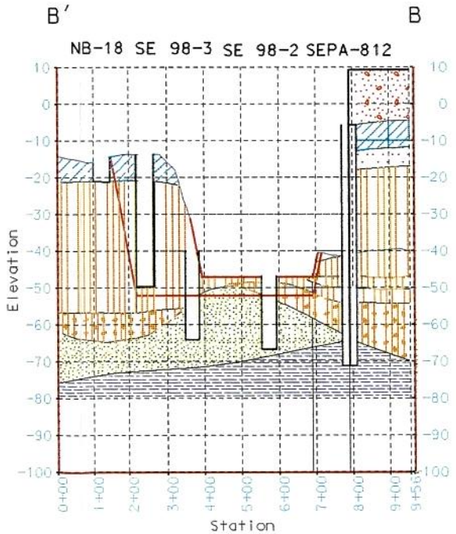
DATE:

FIGURE NO.:
FIGURE 27









LEGEND

HOLOCENE	PLEISTOCENE	JURASSIC
FILL MATERIAL	RED-BROWN SILT AND CLAY	GRAY TO RED-BROWN SHALE
BLACK ORGANIC SILT AND CLAY	RED-BROWN SILTY SAND	GRAY TO RED-BROWN SAND
DARK GRAY SILT AND CLAY	RED-BROWN SILTY GRAVEL	DARK GRAY TO BLACK DIABASE
GRAY TO DARK SILTY SAND	TAN BROWN CLEAN SAND	GRAY TO OLIVE-GREEN SERPENTINITE
POORLY GRADED CLEAN SAND		DARK GRAY TO BLACK SCHIST
WELL GRADED CLEAN SAND		

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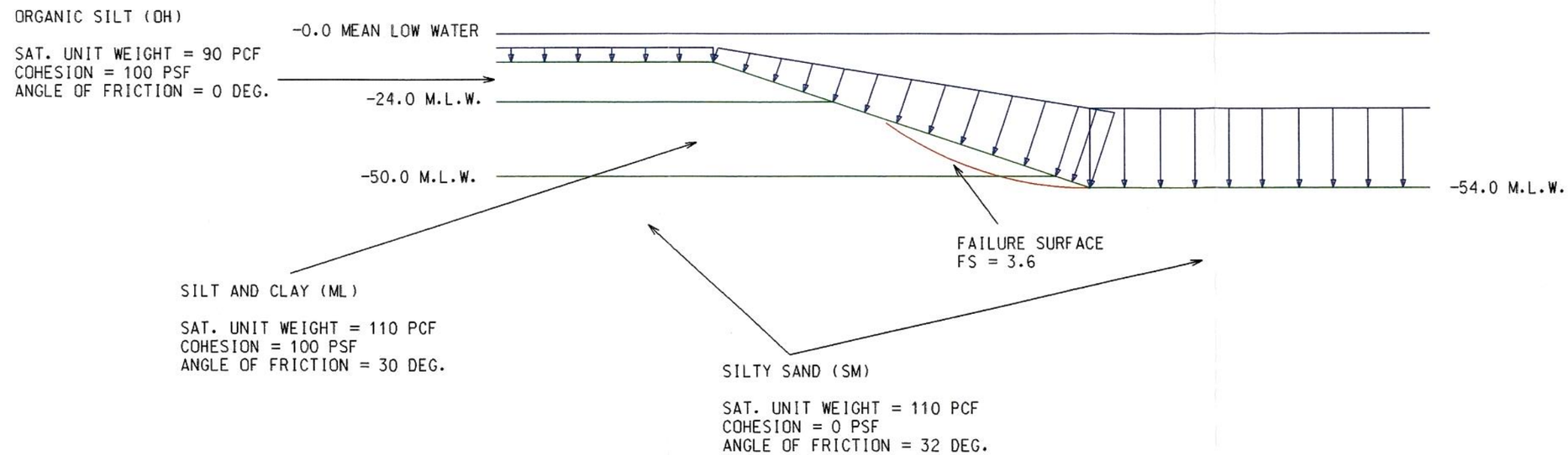
SOUTH ELIZABETH CHANNEL
PROFILES AND CROSS SECTIONS

DATE:

FIGURE NO.:
FIGURE 28



SOUTH ELIZABETH NAVIGATION CHANNEL
PROFILE SECTION F
SIDE SLOPE STABILITY ANALYSIS

SCALE: NTS

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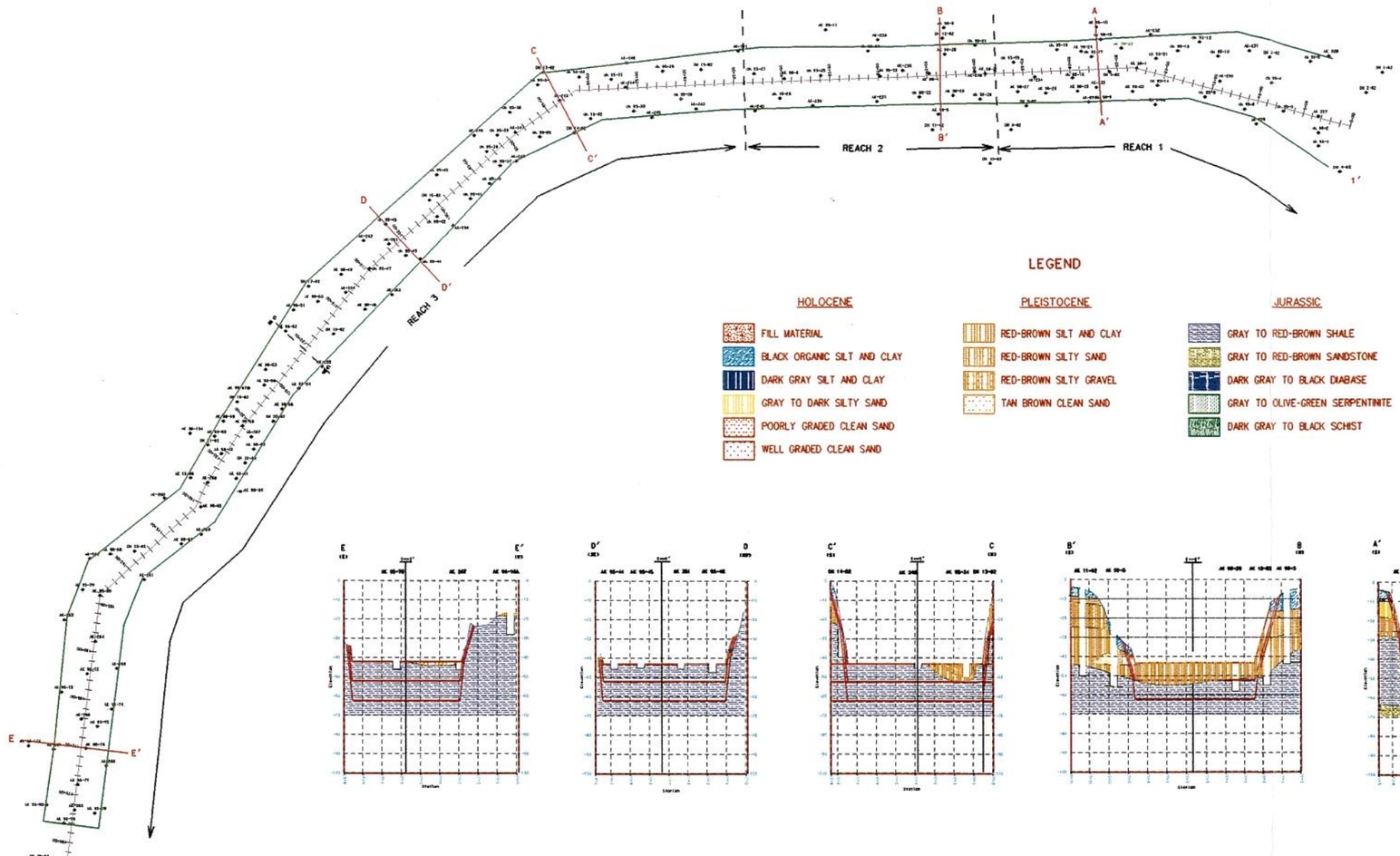
NEW YORK HARBOR NAVIGATION STUDY

SOUTH ELIZABETH CHANNEL
SLOPE STABILITY CROSS SECTIONS

DATE:

FIGURE NO.:
FIGURE 29



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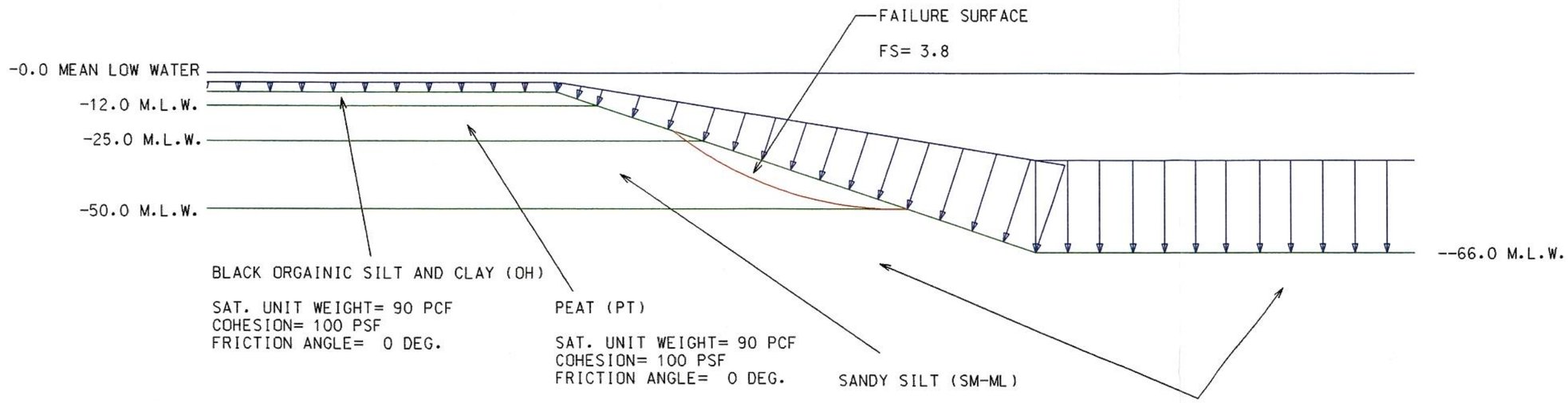
ARTHUR KILL CHANNEL
PROFILES AND CROSS SECTIONS

DATE:

FIGURE NO.:
FIGURE 30



ARTHUR KILL NAVIGATION CHANNEL
PROFILE SECTION B
SIDE SLOPE STABILITY ANALYSIS

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NEW YORK, NEW YORK

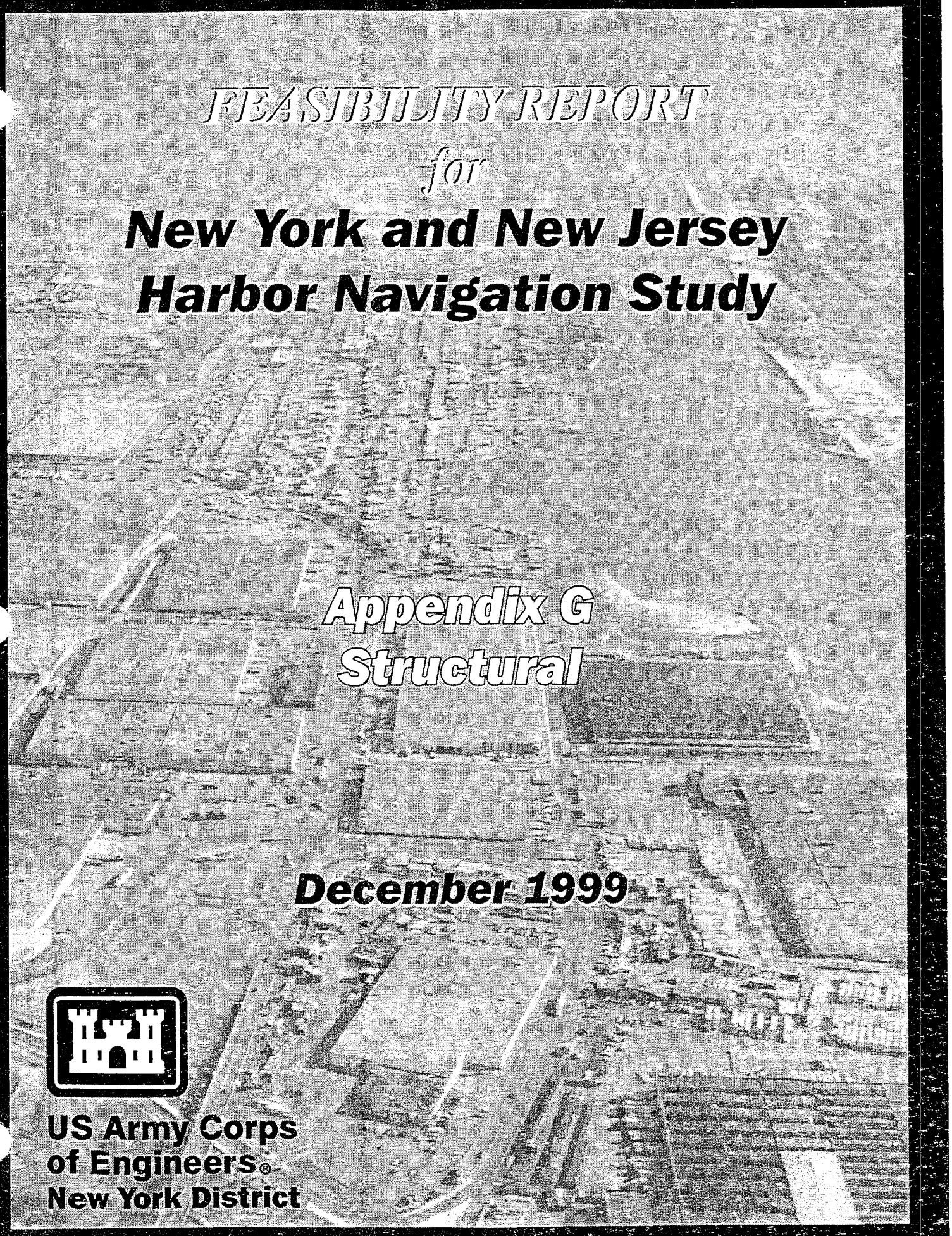
Designed by:
Drawn by:
Checked by:
Reviewed by:

NEW YORK HARBOR NAVIGATION STUDY

ARTHUR KILL CHANNEL
SLOPE STABILITY CROSS SECTIONS

DATE:

FIGURE NO.:
FIGURE 31



FEASIBILITY REPORT

for

New York and New Jersey Harbor Navigation Study

Appendix G
Structural

December 1999

US Army Corps of Engineers®
New York District

NEW YORK AND NEW JERSEY HARBOR NAVIGATION STUDY FEASIBILITY PHASE

Structural

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NY/NJ HARBOR NAVIGATION STUDY
Structural Appendix

G1. PURPOSE

The purpose of this section of the Feasibility Report (FR) is to determine the extent and cost of stabilizing marine structures which have a potential to be impacted by the proposed dredging of Kill Van Kull, Arthur Kill and Newark Bay Channels to either a depth of 50 feet below mean low water or 60 feet below mean low water (see Figure No. 1). Calculations for both the 50 and 60 foot dredge depths included a two foot overdredge. The potentially affected facilities were selected by the Port Authority using channel geometry provided by the Corps of Engineers and a collection of existing subsurface data supplemented by a pilot subsurface boring program performed by the Port Authority's geotechnical consultant, Melick-Tully Associates, Inc. Two Geotechnical Reports were produced by Melick-Tully in support of the structural evaluation of facilities located adjacent to the proposed channel dredging. The reports are entitled, "Geotechnical Evaluation Report, New York and New Jersey Harbor Navigation Study, Feasibility Phase Paths 4 and 5" and "Geotechnical Evaluation Report, New York and New Jersey Harbor Navigation Study, Feasibility Phase Paths 1, 2 and 3 " and have not been included with this submission.

A list of 20 structures were evaluated and each structure was assigned a level of impact, either high or low, based on the data collected from the sources listed above. Structures determined to have a high level of impact were further evaluated to determine a method and cost of stabilization. Facilities determined to have a low level of impact due to the proposed dredging were not evaluated due to the estimated zero cost associated with this action. The goal (stabilization process) is to ensure the continued use of the facilities and their ability to transfer cargo to and from vessels and to ensure the continued use of waterfront structures such as warehouses, highways, and outfall structures.

While the evaluation of the proposed 60 (62) foot dredge depth is include in this report (appendix) the impact of the 60 (62) depth was found not to be economically feasible.

This section of the FR (Structural) evaluates the modifications and construction cost needed to stabilize the existing facilities and their foundations as a result of the proposed dredging projects. The proposed modifications are ***conceptual*** and are not intended to be definitive. The intent of this study was to identify the extent of potential impact, consider a set of relative design parameters, develop a workable solution and determine a budget cost estimate. Detailed analyses and design will be required prior to the performance of any dredging or the construction of any remedial measures.

G2. DESIGN CRITERIA

G2.1. GENERAL

The attached analyses are in accordance with the references listed below:

U.S. Army Corps of Engineers. "The Port of New York, NY and NJ," *Prepared by the Board of Engineers for Rivers and Harbors*," United States Printing Office, Washington: 1978.

U.S. Army Corps of Engineers. *"The Port of New York, NY and NJ and Ports on Long Island, NY,"* Port Series No. 5, Revised 1988.

U.S. Army Corps of Engineers, Coastal Engineering Research Center. *Shore Protection Manual*, 2 vols., USACE, 1984.

U.S. Army Corps of Engineers, Waterways Experiment Station. *"Theoretical Manual for Design of Cellular Sheet Pile Structures (Cofferdams and Retaining Structures"*, USACE, 1987.

U.S. Army Corps of Engineers (ACOE) manual "Design of Sheet Pile Walls." EM 1110-2-2504. 31 March 1994.

U.S. Army Corps of Engineers (ACOE) manual "Design of Sheet Pile Cellular Structures." EM 1110-2-2503. 29 September 1989.

United States Steel, *"Steel Sheet Piling Design Manual, "*USS, 1975.

U.S. Navy. *Design Manual - Foundations and Earth Structure*, 3 vols., NAVFAC,DM-7.2, Washington, D.C, 1982.

G2.2. DESIGN PARAMETERS

Typical design data used in the analysis are as follow, values taken from Army Corps of Engineers, Technical Support Documents, Structural Design, Arthur Kill/Howland Hook Marine Terminal - Final LRR, December 1997.

Concrete	unit weight	150 pcf
	compressive strength	3000psi
Cell Fill (Sand)	moist unit weight	120 pcf
	internal friction angle	32 deg
	cohesion	0 deg

Cell Fill (Rock)	unit weight	100 pcf
	internal friction angle	35 deg
	cohesion	0 deg
Silty Sand	moist unit weight	130 pcf
	internal friction angle	28 deg
	cohesion	300 psf
Sea Water	unit weight	4.4 pcf
Steel Pipe Pile	yield stress, f_y	35,000 psi
Steel Sheet Pile	yield stress, f_y	38,500 psi
Existing Soil	saturated unit weight	130 pcf
	internal friction angle	30 deg

G2.3. OTHER CRITERIA

Dredge slopes used are as follows:

Non-Rock Areas- 3 Horizontal to 1 Vertical
Hard (rock) Areas - 1 Horizontal to 1 Vertical

Design Dredge Depths for calculations depths are:

50' Project Channel Depth - use 52' below MLW

60' Project Channel Depth - use 62' below MLW

G2.4. DESIGN TOOLS

U.S. Army Corps of Engineers. CCELL - Design/Analysis of Sheet Pile Cells

U.S. Army Corps of Engineers. CSHTWALL - Design/Analysis of Sheet Pile Walls

G2.5. DRAWINGS

G2.5.1 General - A site visit was made to each of the facilities by water, land or both. Where possible, the owner was contacted and a request for design/construction drawings was made. As a result of the site visit and request, the following documents were recovered:

City of Elizabeth Waterfront Development, *Breakwater and Boat Slip System*, Musial/Guerra, 4 Drawings, August 1983.

City of Elizabeth Waterfront Development, *Proposed Steel Bulkhead, Boat Ramp, Dock, Dredging and Marina, Ft. of East Jersey Street*, Musial/Guerra, 3 Drawings, 1982.

New York City Development Corporation, *Rehabilitation of the Arthur Kill Lift Bridge Fender System,* CTE Engineers, 11 Drawings, 1996.

Atlantic Salt Inc., *Existing Site Plan*, Bourne Consulting Engineering, 3 Drawings, 1997.

Drawings or other construction documents were not available for the Corey Warehouse Building or Richmond Terrace Road.

G3. FACILITIES

G3.1. KILL VAN KULL

G3.1.1 Atlantic Salt Company Stockpile

General - The original facility reportedly consisted of 550 feet of timber bulkhead. The bulkhead has since been stabilized with a rip rap revetment. No construction drawings were available for this site; a recent site survey and sounding plan were made available by the owner. Based on information provided by the geotechnical consultant, the presence of bedrock does not appear to be a construction consideration at this site.

At the time of inspection, a 40 foot ± high salt pile was stored approximately 15 feet from the edge of rip rap embankment (see Paragraph G7. , Photo Nos. 1 and 2).

The top of the rip rap embankment is located approximately 145 feet from the edge of channel, see Figure G-1 for site location.

Impacts - The toe of the proposed 3H:1V dredge slope is located approximately 145 feet from the existing rip rap slope. The limited information recovered for this structure indicates that there will be little to no impact for the 50-foot dredge depth.

The proposed 3H:1V slope for the proposed 60-foot dredge slope intersects the existing rip rap slope. Given the amount of dredge material to be removed from the existing slope and the volume of material stored upland of the embankment, consideration should be given to the evaluation of the stability of the dredge slope (see geotechnical appendix for evaluation).

Design Solution - As a result of the limited impact at the proposed 50-foot dredge depth, the recommended modifications to the existing rip rap slope include adding additional rip rap/redressing the slope to a 1.5H:1V slope (see Figure No. G-2).

Impacts at the 60-foot dredge depth will require additional stabilization. The solution evaluated consists of a cantilevered sheet pile bulkhead. The proposed bulkhead would be positioned outboard of the existing rip rap slope with a top of wall elevation at about MLW. Placing the bulkhead at this location and outboard of the existing rip rap slope both simplifies the construction (limited rip rap conflicts) and reduces the required size/capacity of the proposed system. The bulkhead would have a freestanding height of 10 feet. Design calculations require a sheet length of approximately 40 feet. The design solution did not consider any benefit from the reported existing timber bulkhead or potential pile supported decking (see Figure No. G-3). Design computations are located in Section VIII of this report.

G3.1.2. Staten Island Richmond Terrace Road

General - This portion of shoreline is located along the Staten Island side of the Kill Van Kull Channel approximately 2,100 feet west of the Atlantic Salt facility. It presently consists of a heavy rip rap slope with a significant number of deteriorated piles and pier ruins (see Paragraph G7. , Photo

Nos. 3 and 4).

An abandoned railroad line is located inboard of the rip rap embankment.

The top of the embankment is located approximately 145 feet from the edge of channel; see Figure G-1 for site location. No plans were available for this site.

Impacts - The existing rip rap embankment is located approximately 150 feet from the edge of the channel. The conditions at Richmond Terrace are similar to those at the Atlantic Salt Company storage area. The proposed 3H:1V slope for the 50-foot dredge channel would have little to no impact on the existing rip rap embankment. While there is a significant amount of material to be removed for the 60-foot dredge channel, there is no large surcharge behind the existing embankment. Due to the fact that the existing timber ruins are not presently being utilized, no impacts to the timber pile foundation piles were considered as part of this analysis.

Design Solution - Limited impact at the proposed 50-foot dredge depth for this location requires a stabilization solution similar to that selected for the Atlantic Salt Stock Pile area. Recommended modifications to the existing rip rap slope include adding additional stone materials and redressing the existing slope to 1.5H on 1V (see Figure No.G-4). Construction cost for this location will be increased due to the amount of debris and pier ruins located along the shoreline.

Impacts at the 60-foot dredge depth will require the addition of an anchored steel sheet pile bulkhead. The proposed bulkhead is to be located inboard of the existing bulkhead line due to the significant amount of pier/bulkhead ruins including what appears to be batter piles which may have been used to support a timber bulkhead/cut-off wall. The top of wall is approximately 3 feet above MLLW and requires a 40- foot sheet length with 2.25 inch diameter tie rods at 13-foot center-to-center spacing. The deadman requires 10-foot sheet pile lengths (see Figure No. G-5). Because their extent is unknown, no consideration was given to existing pile-supported or retaining structures which may exist beneath the rip rap embankment. Design computations are located in Paragraph G6. of this report.

G3.2 ARTHUR KILL CHANNEL

G.3.2.1 Proctor and Gamble

General - The Proctor and Gamble site is located along the east side of the Arthur Kill channel approximately 1.1 miles above the Goethals Bridge. The original timber pile, timber deck structures includes two piers that are connected via a timber bulkhead. The facility is presently abandoned and in ruins and does not appear to have any capacity. See Figure G-6 for site location.

Impacts - The two structures are located between 50' and 125' from the edge of the channel. Based on the cross section provided in the Geotechnical Evaluation Report for this project, the timber foundation piles for Pier No. 2 are impacted by the 3H on1V side slope for the proposed 50 foot and 60 foot channels. Note, that due to the deteriorated/abandoned condition of the facility, there appears to be no or very limited financial impact to the site. No further consideration is provided for this site.

G3.2.2 City of Elizabeth Marina

General - The marina is located on the New Jersey side of the channel approximately 4,500 feet north of Goethals Bridge. The marina consists of a steel sheet pile bulkhead with concrete floating docks. The floating docks are anchored in place with timber guide piles approximately 40 feet long.

The marina is protected from channel wakes by a timber pile supported wave screen. The wave screen is located approximately 40 feet from the Arthur Kill channel and parallel to shore. The wave screen is constructed of two rows of timber piles framed together with timber cross bracing and an additional batter pile. Vertical timber boards (wave fence) extend from 6 feet below mean low water to the top of the breakwater (elev. +12 MLW) on both sides of the pile supported structure (see Paragraph G7. , Photo No.7).

The marina also includes a 50-foot x 195-foot fixed timber pile and timber deck wharf structure located on the north side of the marina basin. The front row of foundation piles for the wharf is located approximately 20 feet from the edge of the channel. The deck of the wharf is at elevation 9.5 MLW. A wave screen (vertical boards) is also attached to the outboard row of timber foundation piles for the wharf (see Paragraph G7. , Photo No. 8).

See Figure G-6 for site location. Plans of the wave screen and public pier were made available by the owner.

Impacts - The two structures are located between 20 feet and 40 feet from the edge of the channel and both the Wave Screen and Public Pier are affected by both the proposed 50-foot and 60-foot dredge depths. In addition, both timber pile structures have shallow soil embedment, and reportedly the piles were driven to refusal. The proposed combined 1H:1V rock slope and 3H:1V soil slope will eliminate all soil embedment from each of the structures.

Design Solution - The proposed solution for both the wave screen and the public pier facilities consists of demolition of portions of both facilities and following dredging of the channel, replace the timber pile foundations with new steel pipe piles socketed into rock. The proposed replacement would included the attachment of a timber wave screen and replacement of the timber deck with concrete (see Figure No. G-7 and G-8).

G3.2.3. Arthur Kill Lift Bridge

General - The 535 foot clear span vertical lift railroad bridge is currently not operational but is scheduled to be reactivated in the very near future. The foundation system consist of two 68-foot by 62- foot reinforced concrete spread footings, each set on a 23-foot thick tremie concrete pad that is keyed into rock approximately 9 feet. There is limited clearance between the horizontal bridge/rail bed and the top of the bridge pier foundation. The main east and west bridge piers are located at the edge of the existing channel; see Figure G-2 for site location and Photo Nos. 9 and 10 located in Paragraph G7. Plans dated June 1996 were recovered from the New York Redevelopment Corp. The plans which were for the rehabilitation of the bridge abutment fender system provide details of the abutment foundations.

Impacts - Based on plans recovered during the data collection phase of the project, the edge of the proposed (and existing) channel is located at the face of the existing bridge protection cell. In addition, the bottom of the existing bridge pier foundations are located at approximately elevation -48, which is above the proposed channel elevations of -50 feet and -60 feet.

Compliance with the Army Corps of Engineers proposed 1H:1V rock side slopes will require narrowing of the channel by a minimum of 24 feet at the 50 foot dredge condition and 36 feet at the 60-foot dredge depth.

Design Solution - There are two proposed solutions for the main bridge piers. The first is to realign and reduce the clear width between piers from 535 feet to approximately 467 feet (50-foot channel) and 487 feet (60-foot channel), a similar solution was used at the Goethals Bridge. The reduced channel width would allow a 12-foot rock shelf to be left in place outboard of the existing concrete tremie pier foundation and a 1H:1V slope from the shelf to the proposed 50-foot or 60-foot dredge depth (see Figure Nos.G-9 and G-10).The second design solution would be significantly more expensive, but allow almost the full width (total 20-foot width reduction) of the channel to remain as is. The solution consists of drilled shafts installed to depths of approximately 20 feet below the implemented dredge depth. This would place the drilled shaft tips at approximate elevations of -72 to -82 MLW. The work could be performed by barge mobilized equipment working without headroom restriction. The drilled shaft diameters would be in the range of 6 feet with a 3 to 4 foot clear space between units to take advantage of the rock strength and bridging effects. Six foot diameter was chosen as a median diameter range which could be constructed efficiently by most drilled shaft contractors. Drilled shafts would be constructed by drilling and, seating, a 6 inch over-diameter steel casing into the bedrock and drilling the shaft in-the-dry. The drilled shaft spacing and tip elevations would be dependent upon the localized bedrock type and characteristics. The shafts would be cut off at or slightly above the post dredge mudline so that they do not further reduce the proposed channel width at the bridge structure (see Figure No. G-11).

Due to the close proximity of the structures, we have assumed that additional precautions be taken during the dredging of this portion of the channel. These precautions include line drilling and pre- and post-blast surveys of the structure.

G3.2.4. Joseph Cory Furniture Warehouse

General - The formerly Bayway Terminal facility consists of a five-story structure located along the south side Goethals Bridge inlet/slip. The five-story building includes a wharf structure on both the channel and inlet sides (see Paragraph G7. , Photo No. 11).

The wharf structure foundations include timber and steel piles. The wharf appears to be a relieving platform structure with a reported stone block and timber cutoff wall (see Paragraph G7. , Photo No. 12). The southern end of the wharf has been modified to include a short section of steel sheet pile bulkhead.
No plans were recovered for this structure. It is assumed, but not confirmed, that the five story building includes a pile foundation system.

Impacts - No plans were recovered during the data collection phase of the project for this structure. Based on the Corps of Engineers channel plans, the existing structure is located approximately 90 feet from the edge of the channel. Subsurface data collected from different sources indicated rock at varying elevations.

Additional geotechnical data collection will confirm the subsurface conditions at this location and the elevation of the rock. The confirmation of high rock elevations may eliminate the need to provide stabilization of the existing structure.

Design Solution - Both the proposed 50 foot and 60 foot dredge depths will require some type of structural stabilization for the existing warehouse facility. The proposed solution for this location consists of adding a row of steel sheet pile cells approximately 30 feet in diameter between the existing facility and the edge of the channel. The cells and the area between the existing structure and the new cells would be backfilled with crushed stone (see Figure No. G-12). Due to the close proximity of the structures, we have assumed that additional precautions be used during the dredging of this portion of the channel. The precautions would include line drilling and pre- and post-blast surveys of the structure.

G4. EFFECTS OF BLASTING ON STRUCTURES

G4.1. GENERAL

Based on available information, the following facilities will require special construction procedures for the excavation of rock from the channel and side slopes. Those structures are:

City of Elizabeth Marina and Public Pier

Arthur Kill Lift Bridge

Corey Warehouse

The use of blasting in and around these structures will require the implementation of a program of special controls and surveys to limit the effects of rock removal with the use of explosives. The program should include:

1. An inventory of geologic literature and surficial bedrock drilling, sampling and testing in order to understand the local bedrock geology including bedding, fracture and discontinuity locations and orientations. This type of program will be used to determine rock strengths, moduli and fracture characteristics, and estimate ground vibration intensities for various blast design configurations.

2. Inventory of structures in and around the blast area in order to assess the level of ground vibration which can be tolerated and record the pre-blast site conditions.

3. Evaluate electrical potentials along the blast site to access the safe use of electronic detonators to include evaluation of extraneous electricity (lightning, electrostatic induction, electromagnetic induction, stray ground currents and radio transmissions).

4. Develop clear concise specifications which, in addition to the items listed above, provides a description of what is expected of the contractor and what will be provided by the engineer including QA/QC and safety guidelines.

5. Provide the contractor with a plan for both a pre-and post-condition survey and a continuous vibration monitoring program.

G5. CONCEPTUAL CONSTRUCTION COST

G5.1 GENERAL

Conceptual construction cost for the recommended structural modifications listed above have been developed base on similar projects and discussions with marine contractors. All costs are September 1998 dollars and do not include the cost of engineering design, permits, environmental impact statements, surveys, bid advertising or any type of administrational cost. No contingencies have been added to this construction cost estimate.

Special cost for monitoring of sensitive facilities during blasting have been added to the cost of the structural modifications. No cost has been added for modifications to the dredging process which may be required (line drilling, pre-splitting or controlled blasting, bubble curtains etc.) to reduce the effects of blasting on the structures.

No costs have been provided for the rock shelf option for the Arthur Kill Lift Bridge. This option requires that the typical 1H:1V rock slope used for dredging the channel in rock be used at this location, with the exception that the top of rock slope be offset 12 feet from the edge of the concrete foundation.

The following page is a summary of construction costs by facility, followed by a breakdown of construction cost development.

G6. COMPUTATIONS

Note: Corps Dock No. refers to the numbering system used by the Army Corps of Engineers in there report, "The Port of New York and New Jersey and Ports on Long Island, NY," Port Series No. 5, Revised 1988.

HARBOR NAVIGATION STUDY

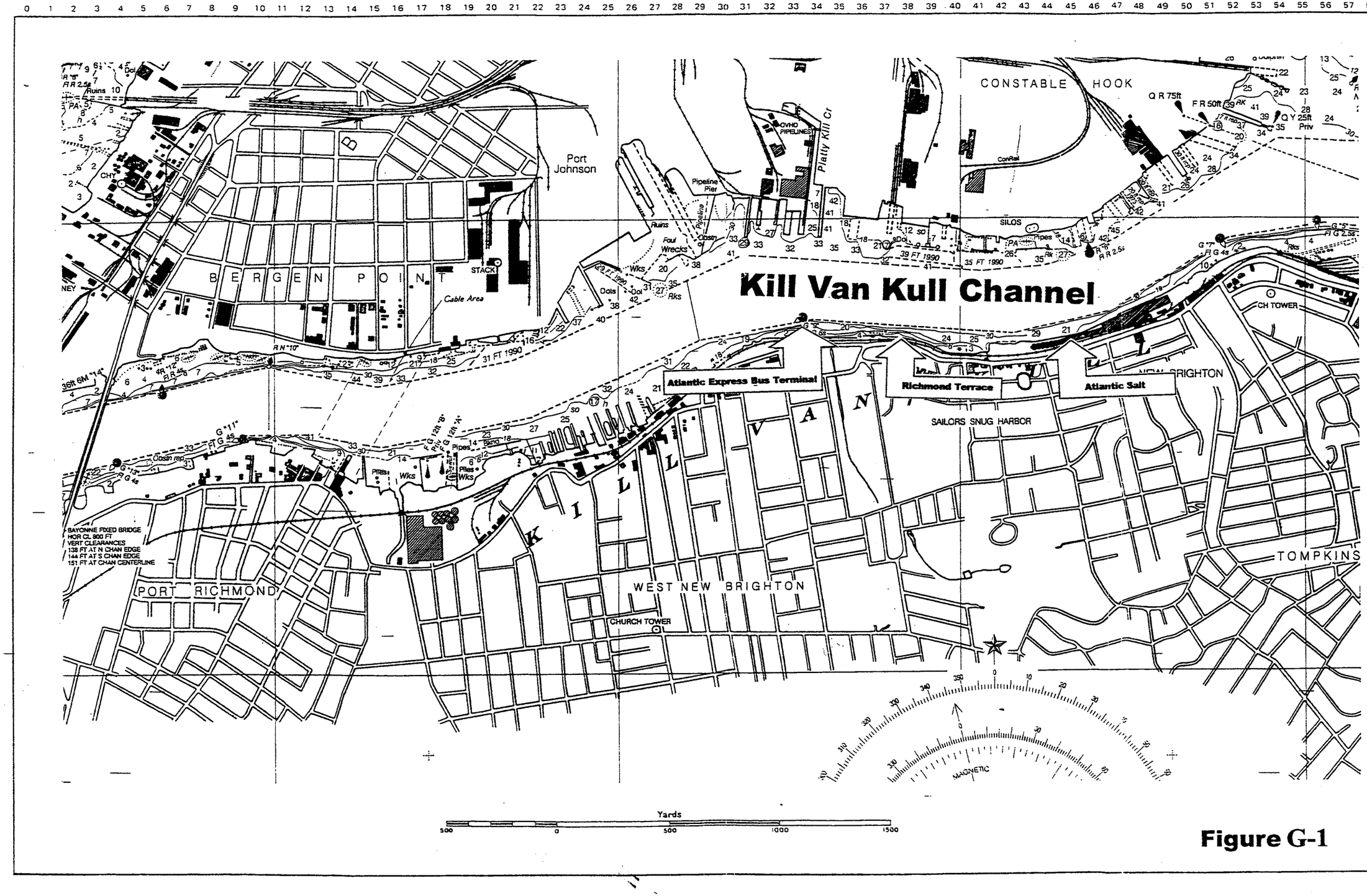
Job _____ Sheet No. _____

Kill Van Kull Channel Location Map

_____ Date _____

By _____ Checked _____ Job No. _____

MAGUIRE GROUP



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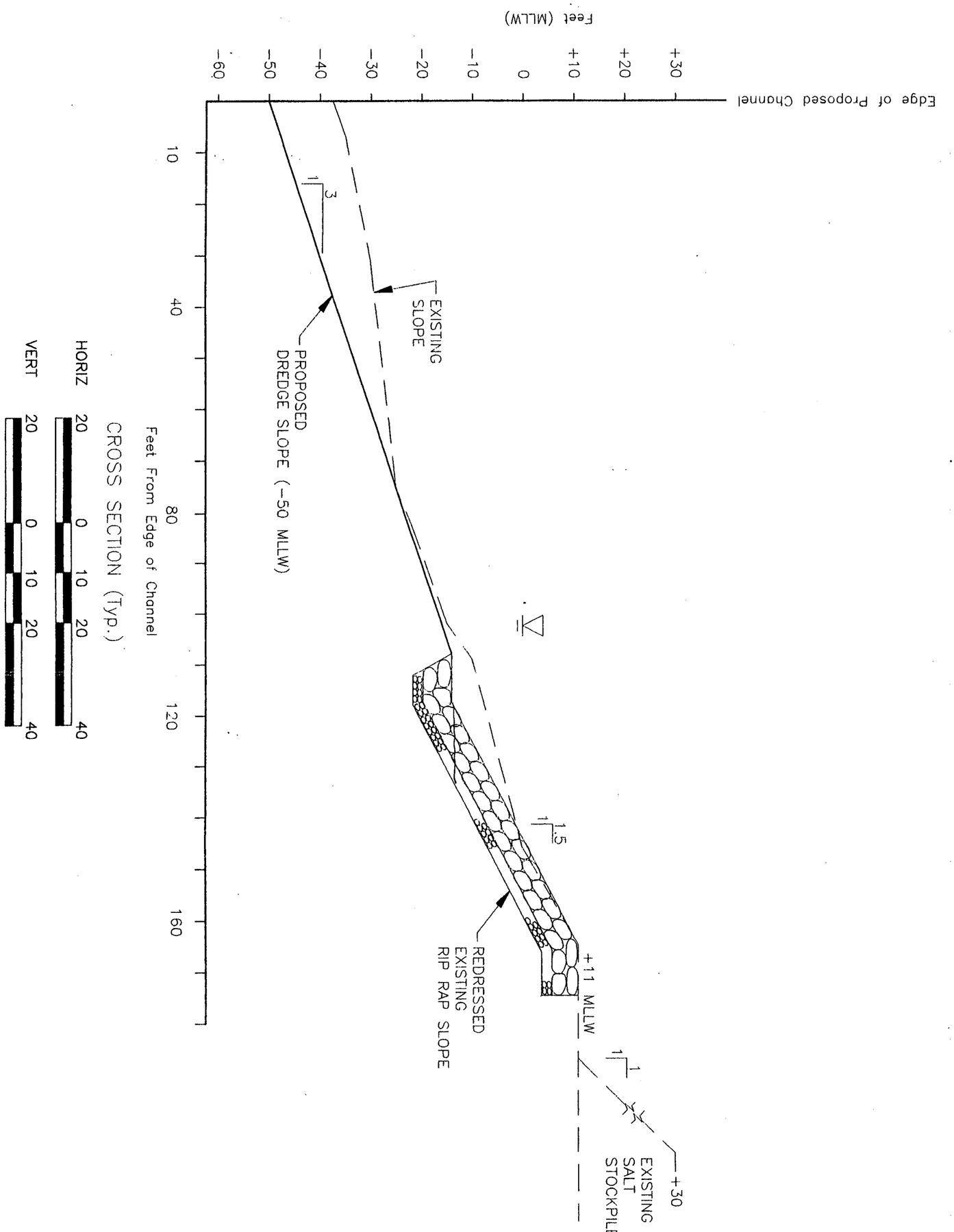
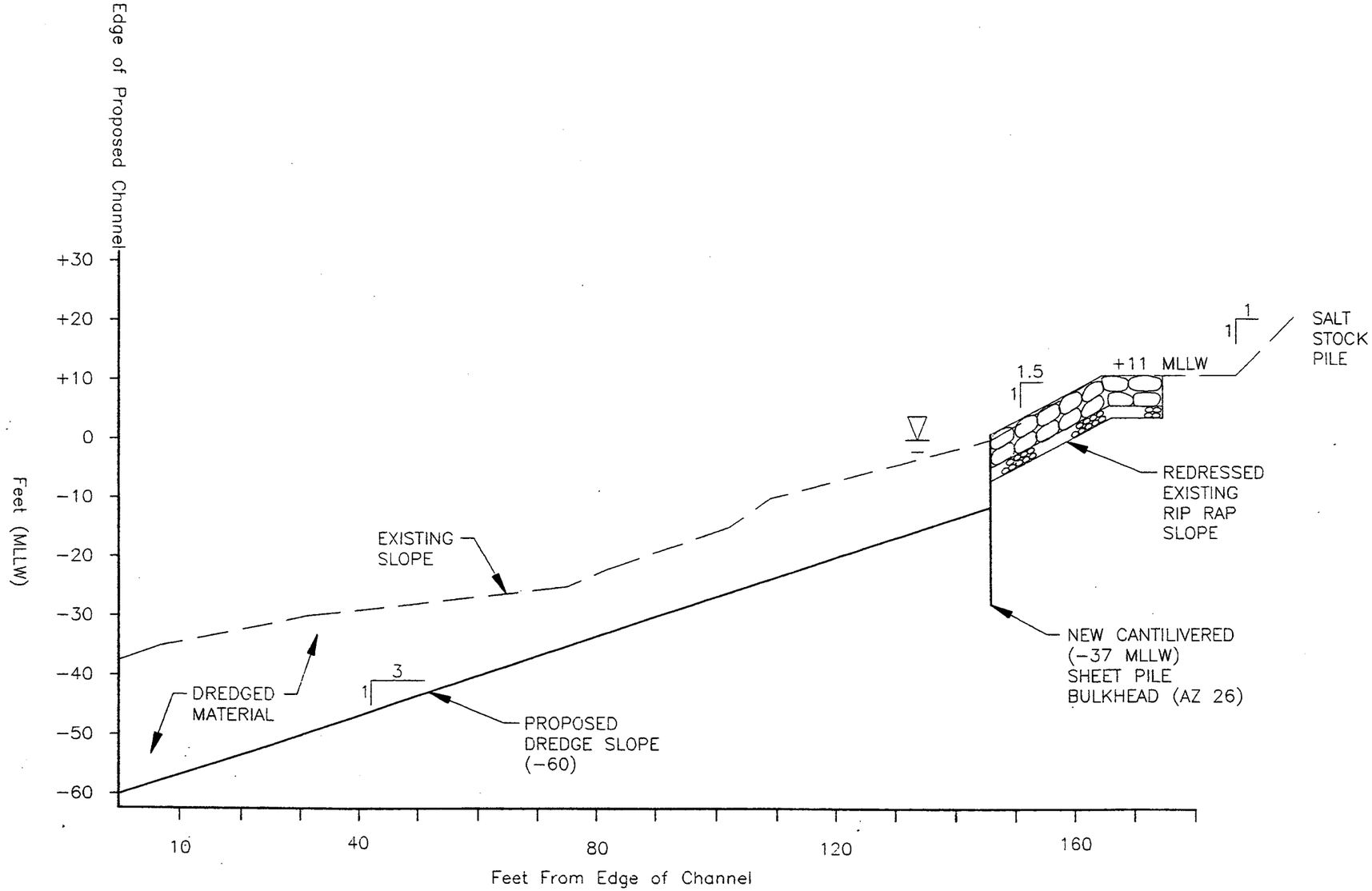


THE PORT AUTHORITY OF NY & NJ HARBOR NAVIGATION STUDY	Maguire Group Inc. Engineers/Planners 3000 Hadley Road South Plainfield, New Jersey 07080	FEASIBILITY PHASE MGI PROJECT NO. 14803
ATLANTIC SALT STOCK PILE		Date: OCT. 1998 Figure No. G-2



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FEASIBILITY PHASE

MGI PROJECT NO. 14803

Date: OCT. 1998 Figure No. G-3

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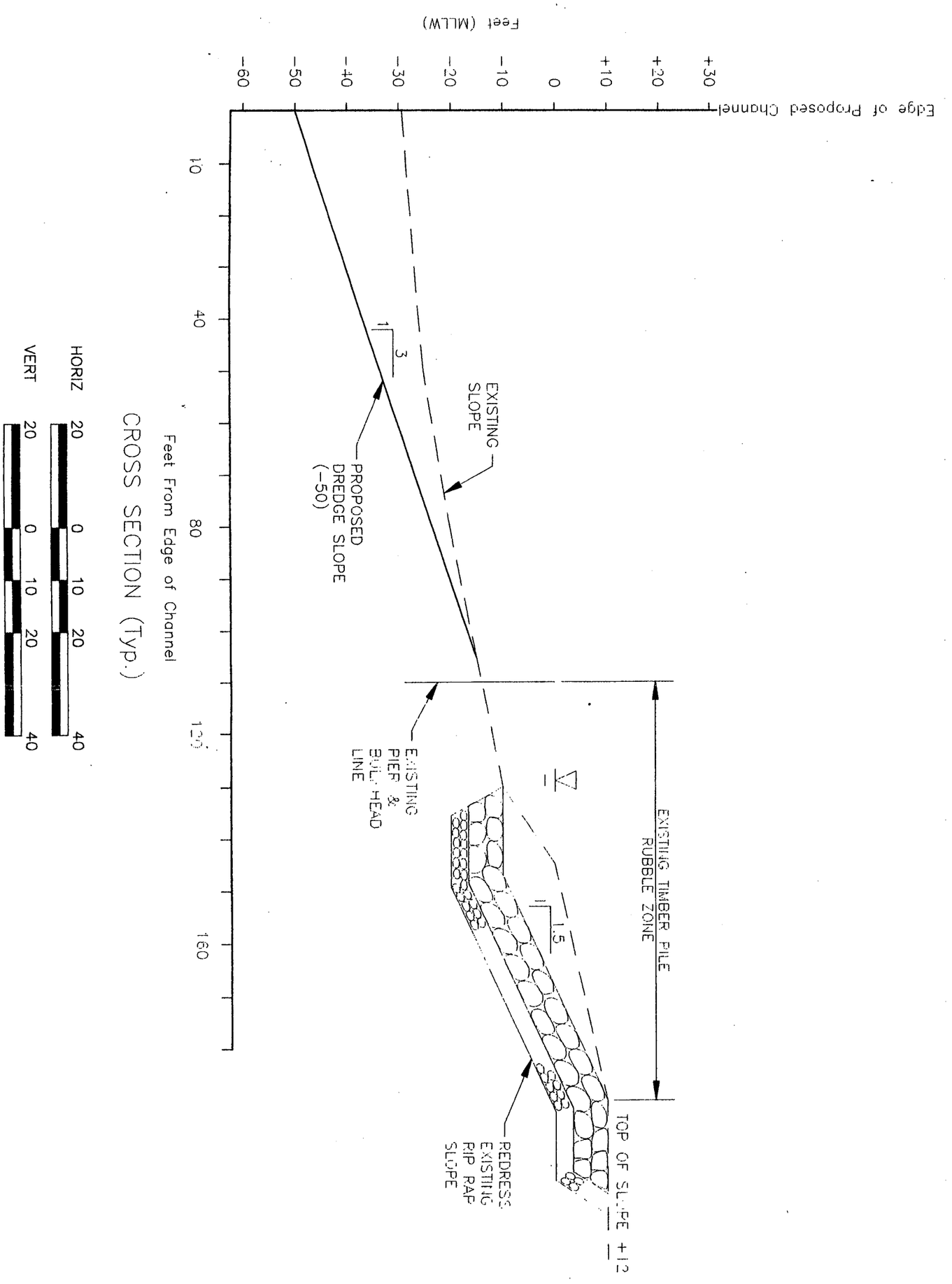
South Plainfield, New Jersey 07080

THE PORT AUTHORITY OF NY & NJ

HARBOR NAVIGATION STUDY

ATLANTIC SALT STOCK PILE



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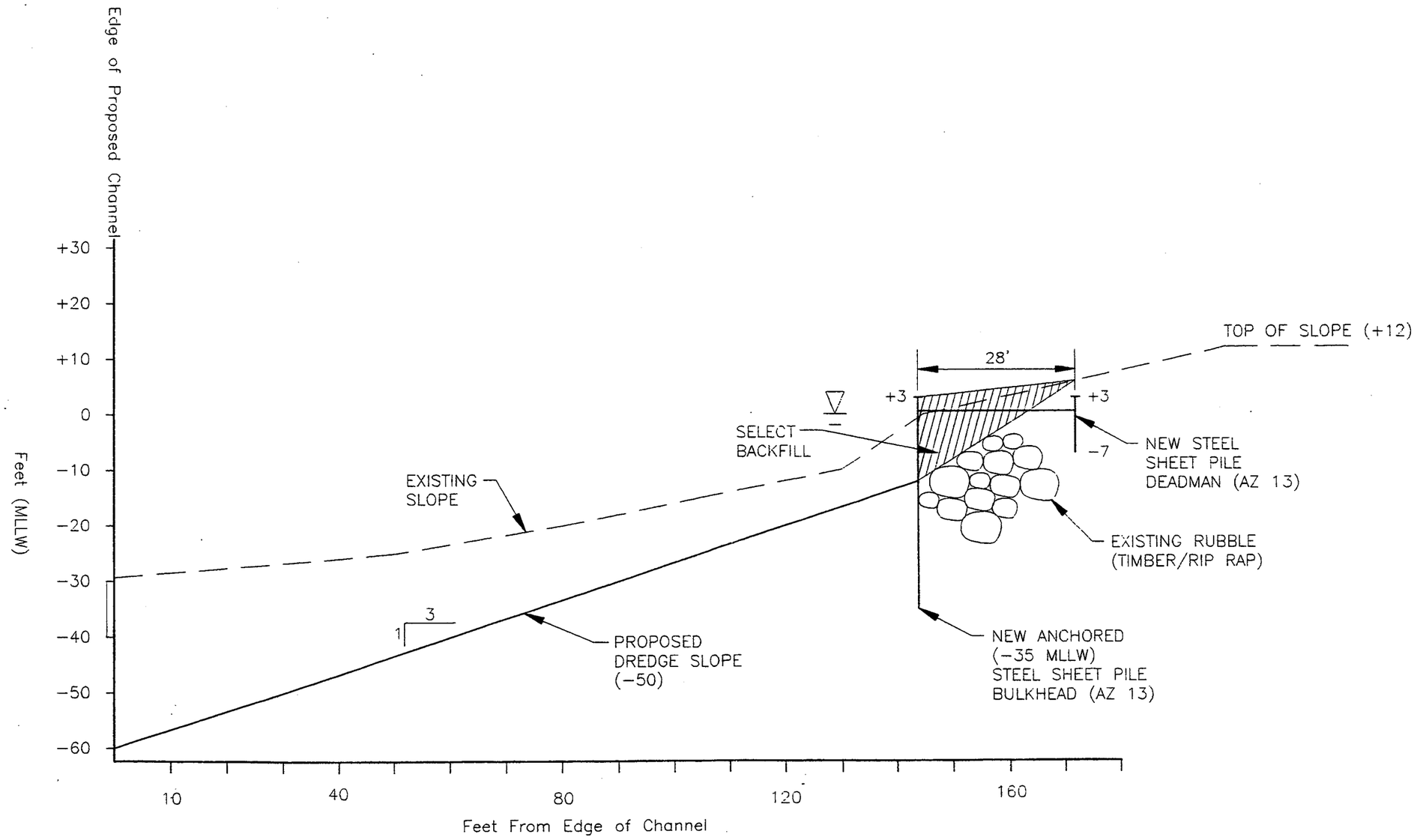
RICHMOND TERRACE		Date: OCT. 1998 Figure No. G-4



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FEASIBILITY PHASE

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Date: OCT. 1998 Figure No. 6-5

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HARBOR NAVIGATION STUDY

RICHMOND TERRACE

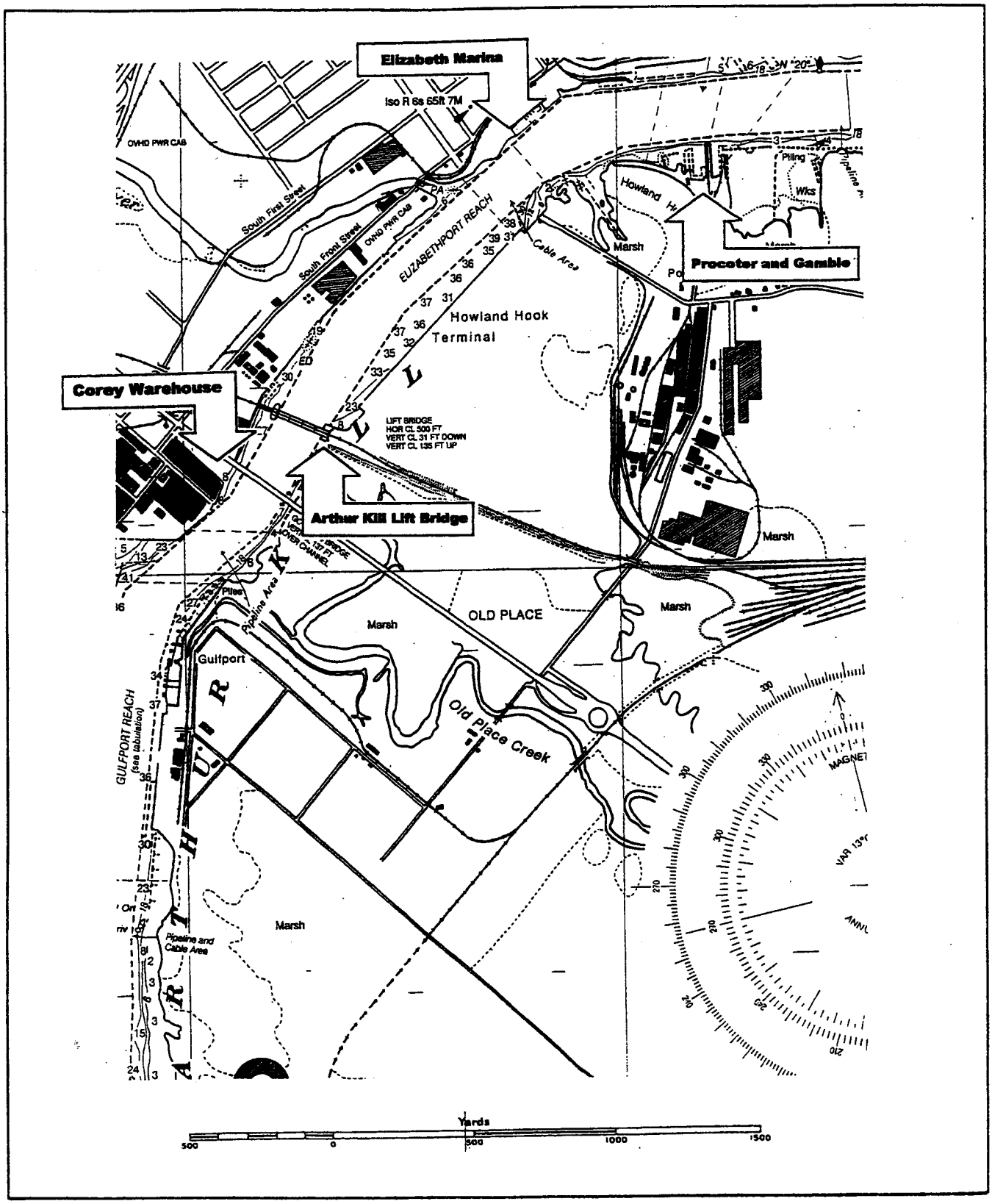
MAGUIRE GROUP

Project **HARBOR NAVIGATION STUDY** Acc. No. _____

Subject **Arthur Kill Channel Location Map** Sheet No. _____ of _____

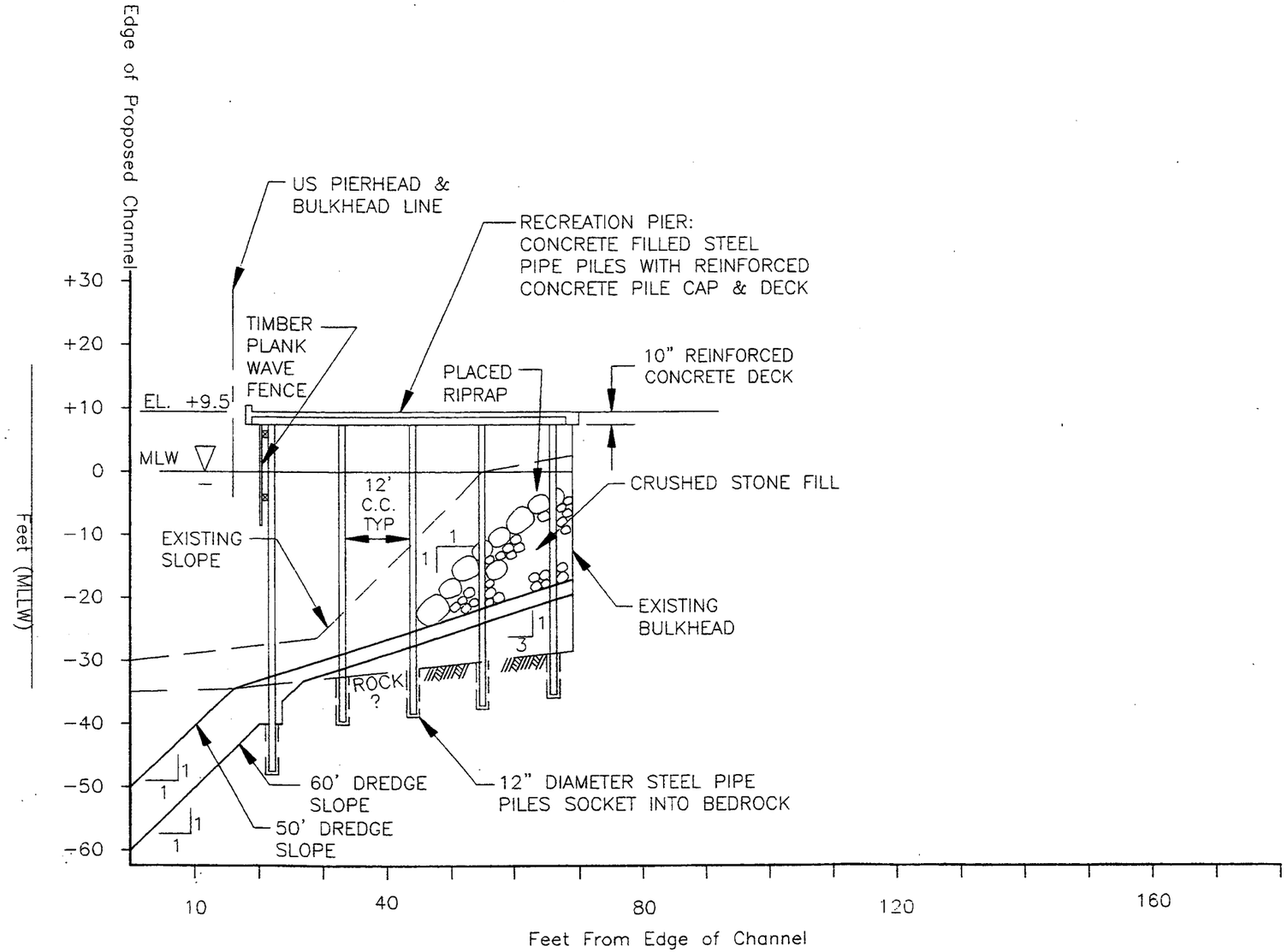
Date _____ 19 _____

Comp. _____ Check _____ Cont. No. _____



5–87

Figure G-6



CROSS SECTION (Typ.)

HORIZ 20 0 10 20 40

VERT 20 0 10 20 40

FEASIBILITY PHASE

MGI PROJECT NO. 14803

Date: OCT. 1998 Figure No. G-7

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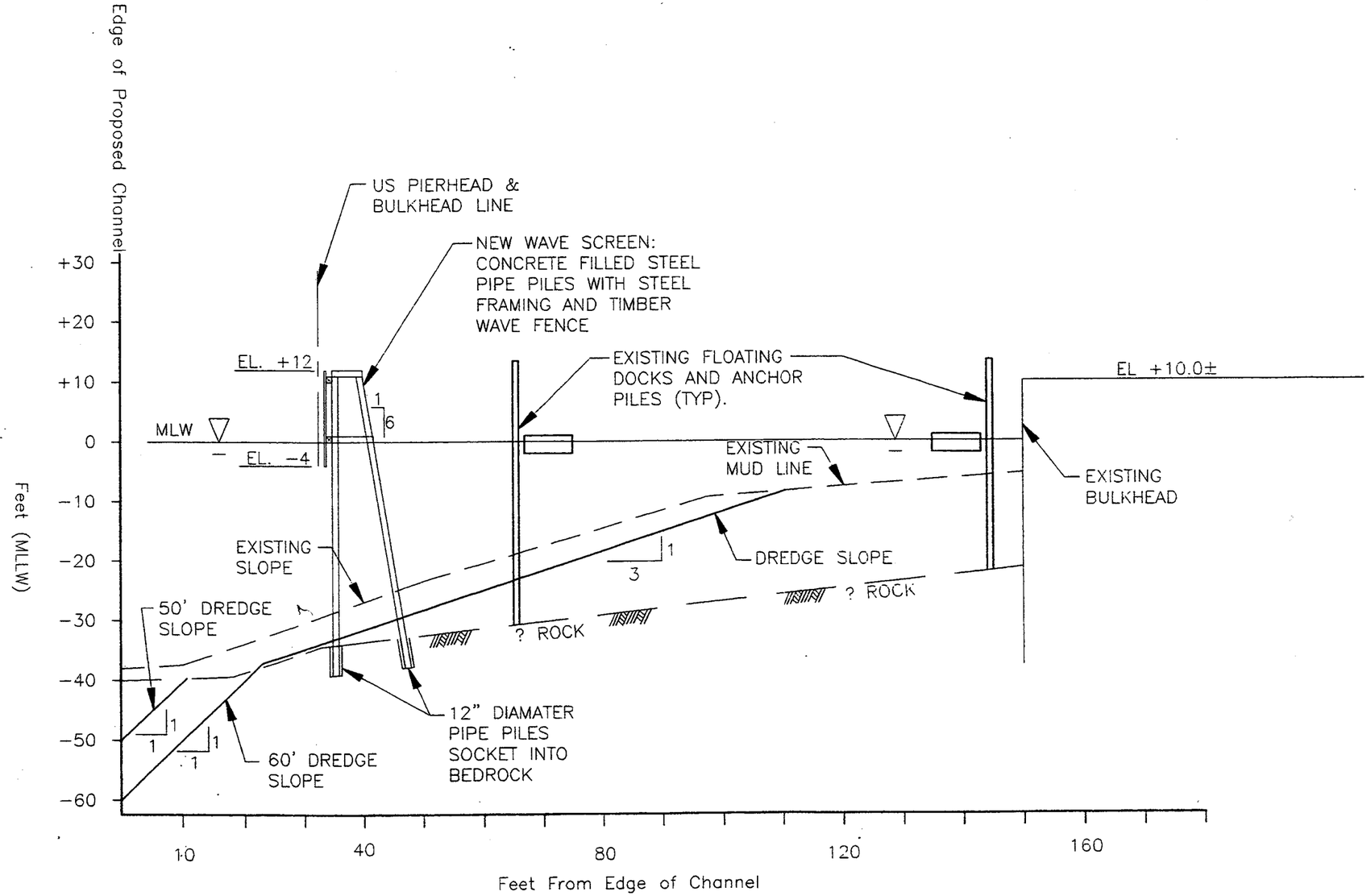
HARBOR NAVIGATION STUDY

ELIZABETH CITY MARINA
PUBLIC RECREATION PIER



CROSS SECTION (Typ.)

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VERT 20 0 10 20 40

FEASIBILITY PHASE

MGI PROJECT NO. 14803

Date: OCT. 1998 Figure No. C-8

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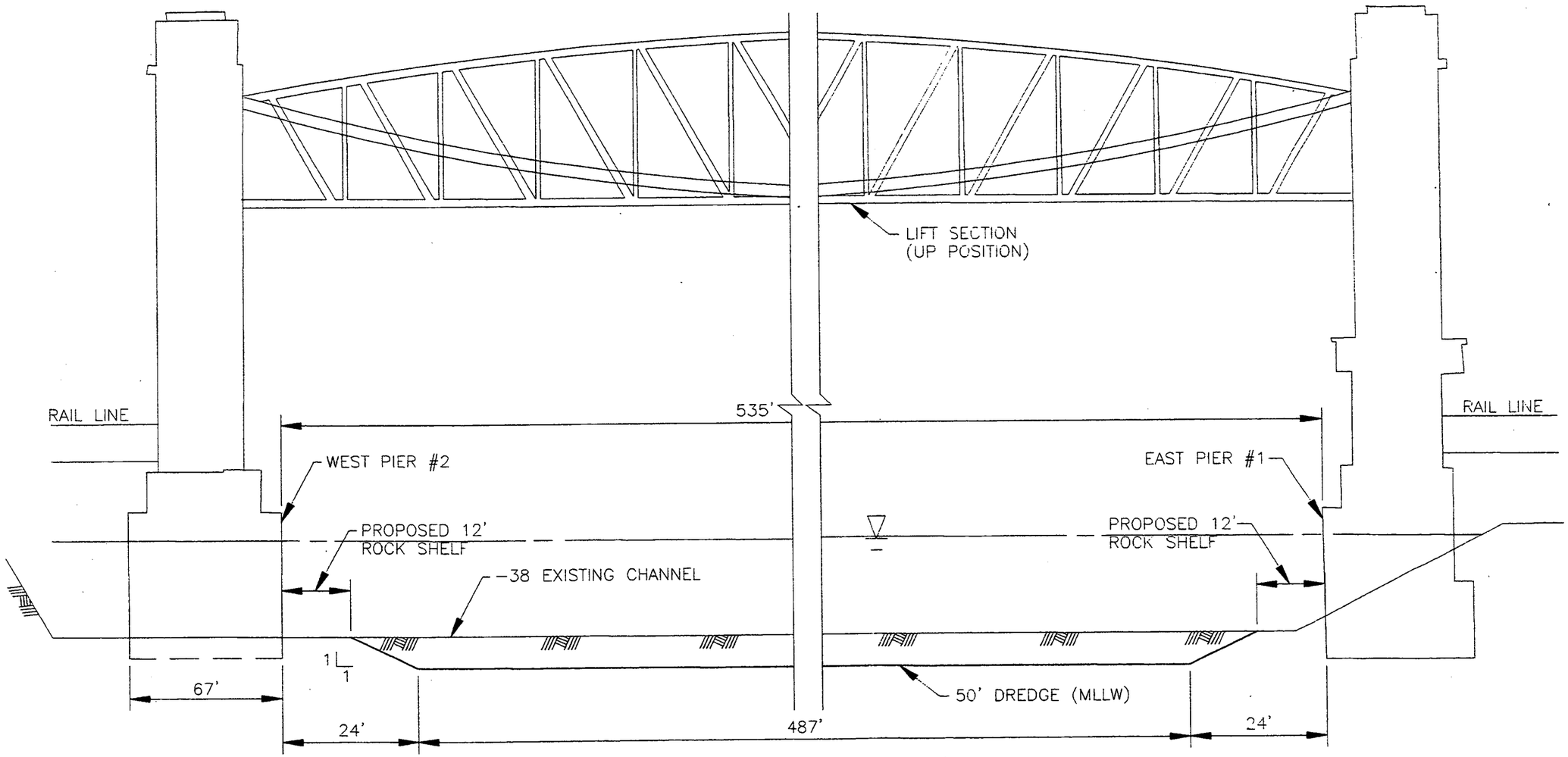
HARBOR NAVIGATION STUDY

ELIZABETH CITY MARINA
WAVE SCREEN



TYPICAL SECTION
-50' CHANNEL

FEASIBILITY PHASE

MGI PROJECT NO. 14803

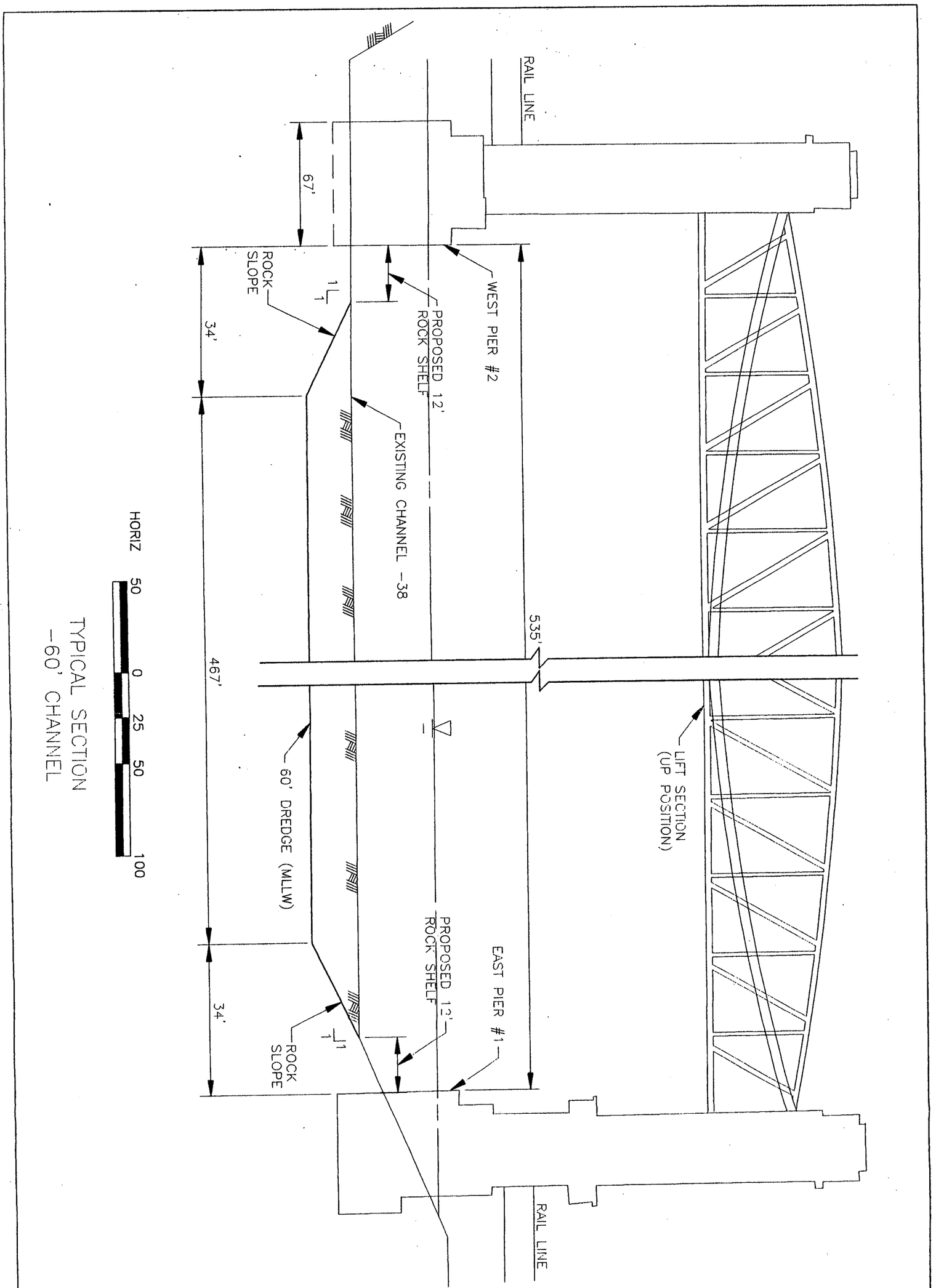
Date: OCT. 1998

Figure No. G-9

Maguire Group Inc.
Engineers/Planners
3000 Hadley Road
South Plainfield, New Jersey 07080

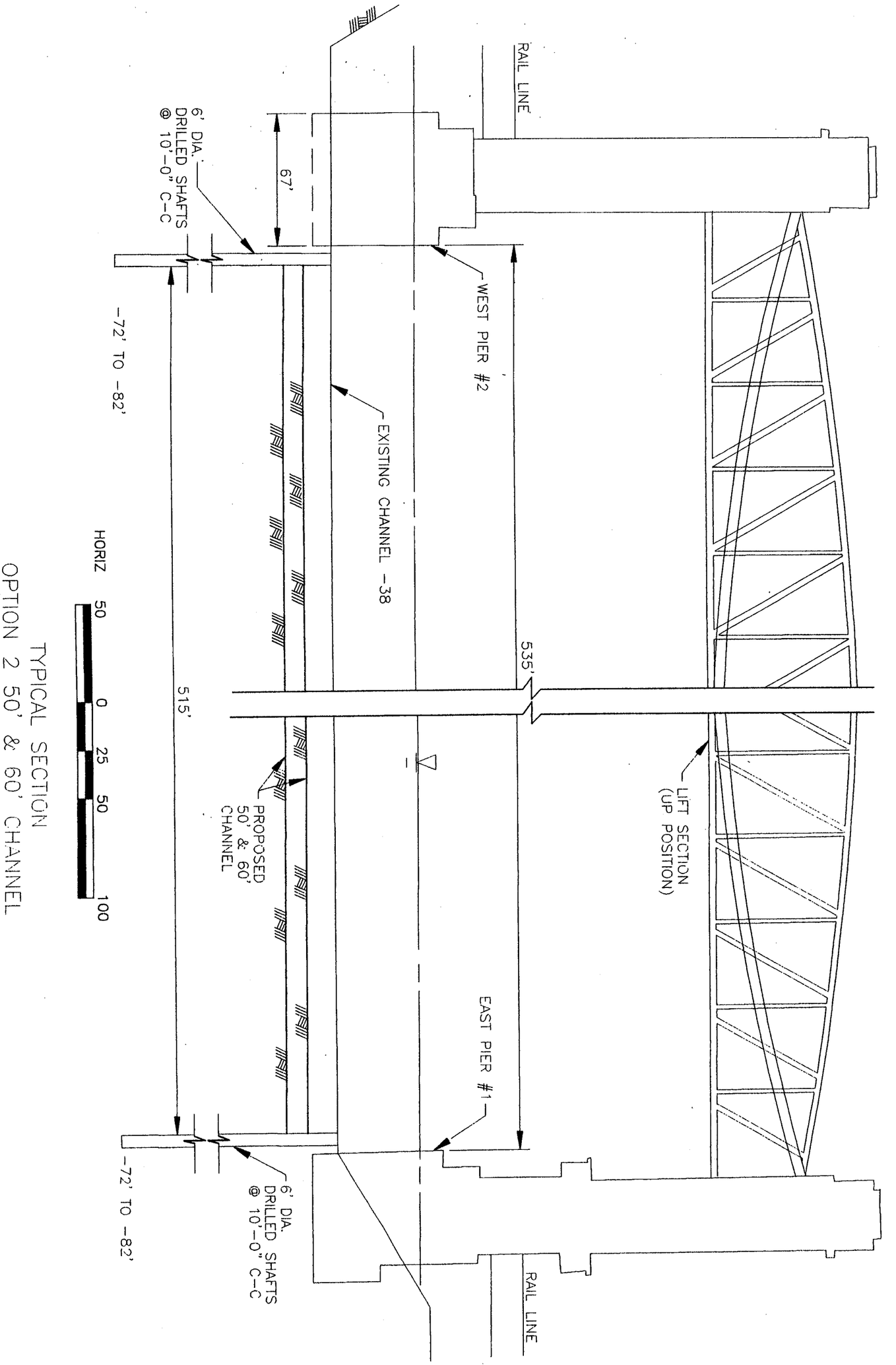
THE PORT AUTHORITY OF NY & NJ
HARBOR NAVIGATION STUDY

ARTHUR KILL LIFT BRIDGE
WITH ROCK SHELF



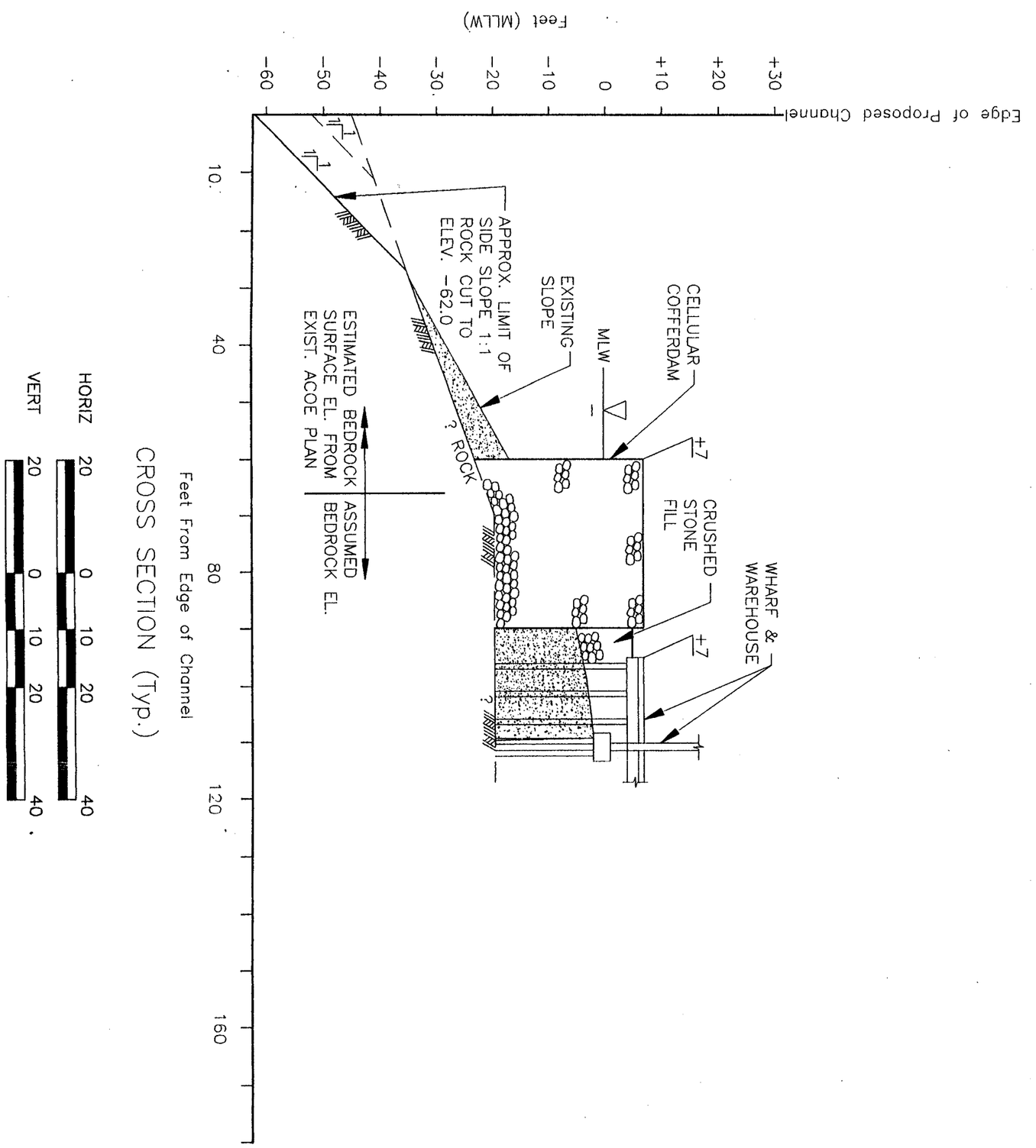
TYPICAL SECTION
-60' CHANNEL

THE PORT AUTHORITY OF NY & NJ HARBOR NAVIGATION STUDY	Maguire Group Inc. Engineers/Planners 3000 Hadley Road South Plainfield, New Jersey 07080	FEASIBILITY PHASE MGI PROJECT NO. 14803
ARTHUR KILL LIFT BRIDGE WITH ROCK SHELF		Date: OCT. 1998 Figure No. G-10



TYPICAL SECTION
OPTION 2 50' & 60' CHANNEL

THE PORT AUTHORITY OF NY & NJ HARBOR NAVIGATION STUDY	Maguire Group Inc. Engineers/Planners 3000 Hadley Road South Plainfield, New Jersey 07080	FEASIBILITY PHASE MGI PROJECT NO. 14803
ARTHUR KILL LIFT BRIDGE WITH CAISSONS		Date: OCT. 1998 Figure No. G-11



THE PORT AUTHORITY OF NY & NJ HARBOR NAVIGATION STUDY	Maguire Group Inc. Engineers/Planners 3000 Hadley Road South Plainfield, New Jersey 07080	FEASIBILITY PHASE MGI PROJECT NO. 14803
CORY WAREHOUSE		Date: OCT. 1998 Figure No. G-12

BUDGET COST ESTIMATE

MAGUIRE GROUP INC.

PROJECT: HARBOR NAVIGATION STUDY **JOB No: 14803**

SUBJECT: FEASIBILITY PHASE **DATE: October 1998**

ITEM No.	DESCRIPTION	QUANTITY		COST	
		UNIT	AMOUNT	UNIT	TOTAL
	50' DREDGE CHANNEL				
1	Atlantic Salt Stockpile (redress slope)	LF	1,050.00	$975.00	$1,023,750.00
2	Richmond Terrace	LF	1,450.00	$1,835.00	$2,660,750.00
3	Elizabeth Marina				
	Demolition	LS	1.00	$247,300.00	$247,300.00
	Wave Screen	LF	415.00	$2,920.00	$1,211,800.00
	Public Pier	SF	7,650.00	$107.00	$818,550.00
4	Arthur Kill Lift Bridge				
	Rock Shelf	LF		No Additional Cost	
	Drilled Shaft	EA	50.00	$82,920.00	$4,146,000.00
	Pre/Post Blast Survey	EA	2.00		
	Line Drilling and Blasting	LF	440.00	$455.00	$200,200.00
5	Corey Warehouse	LF	225.00	$4,045.00	$910,125.00
	Pre/Post Blast Survey	EA	2.00	$5,000.00	$10,000.00
	Line Drilling and Blasting	LF	225.00	$455.00	$102,375.00
				SHEET TOTAL	**$11,330,850.00**

BUDGET COST ESTIMATE

MAGUIRE GROUP INC.

PROJECT: HARBOR NAVIGATION STUDY

JOB No: 14803

SUBJECT: FEASIBILITY PHASE

DATE: October 1998

ITEM No.	DESCRIPTION	QUANTITY		COST	
		UNIT	AMOUNT	UNIT	TOTAL
	60' DREDGE CHANNEL				
1	Atlantic Salt Company Stockpile Area	LF	1,050.00	$1,840.00	$1,932,000.00
2	Staten Island 'Richmond Terrace	LF	1,450.00		
3	Elizabeth Marina				
	Demolition	LS	1.00	$247,300.00	$247,300.00
	Wave Screen	LF	415.00	$3,140.00	$1,303,100.00
	Public Pier	SF	7,650.00	$118.00	$902,700.00
4	Arthur Kill Lift Bridge				
	Rock Shelf	LF		No Additional Charge	
	Drill Shafts	EA	50.00	$97,520.00	$4,876,000.00
	Pre/Post Blast Survey	EA	2.00	$30,000.00	$60,000.00
	Line Drilling and Blasting	LF	440.00	$815.00	$358,600.00
5	Corey Warehouse	LF	225.00	$4,500.00	$1,012,500.00
	Pre/Post Blast Survey	EA	2.00	$5,000.00	$10,000.00
	Line Drilling and Blasting	LF	225.00	$815.00	$183,375.00
				SHEET TOTAL	**$10,885,575.00**

Atlantic Salt

MAGUIRE GROUP

Project NAV. STUDY
Subject ATLANTIC SALT 50' Dredge BUDGET COST EST.
Comp. hgt Check
Acc. No.
Sheet No. 1 of
Date 7 1998
Cont. No.

Redress & Supplement Existing Rip Rap Slope

Stone work @ $65/cy

Proposed EW Slope 15 cy/LF

$15 \frac{cy}{LF} \times \$65/cy = \$975/LF$

Atlantic Salt

MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.
Subject CONCEPTUAL COST ESTIMATE Sheet No. of
ATLANTIC SALT 60' Date Aug 1998
Comp. LBT Check Cont. No.

60' DREDGE

Based on AZ 26 sheets @ 82 lbs/LF & width = 24.8"

Sheet Length = 37' + 1' driving = 38'

MATERIAL COST

$38' \times 82 \frac{lbs}{ft} \times \frac{\$850/ton}{2000 \frac{lbs}{ton}} = \$1,325/sheet$

Coating

$\$6.5/LF \times 37' = \$240.5/sheet$

SUBT $1566/sheet ÷ 2.067 Lay length/sheet =

COST/Ft of Wall $757.40/LF

Installation @ 50' production/day & $216/LF

CREW/EQUIP. = $4320/day

$973/LF

USE 1,000/LF

AZ sheet pile sections

Date: February 14, 1996

Sections	Geometrical dimensions				Physical properties				Bending Moment Capacities (at allowable working stress = 0.667 * nominal yield strength)					
	Width (in) (mm)	Height (in) (mm)	Web thickness (in) (mm)	Flange thickness (in) (mm)	Section modulus (in3 / ft) (cm3 / m)	Moment of Inertia (in4 / ft) (cm4 / m)	Weight per single (lb / ft) (kg / m)	Weight per wall (lb / ft2) (kg / m2)	A 328 (270) (kips*ft / ft) (kNm / m)	A572 Gr 42 (290) (kips*ft / ft) (kNm / m)	A572 Gr 50 (345) (kips*ft / ft) (kNm / m)	A572 Gr 55 (380) (kips*ft / ft) (kNm / m)	A572 Gr 60 (414) (kips*ft / ft) (kNm / m)	A572 Gr 65 (448) (kips*ft / ft) (kNm / m)
AZ 13 rd .04" (-1.0 mm)	26.38 670	11.89 302	0.335 8.5	0.335 8.5	22.3 1201	132.8 18140	44.42 66.1	20.22 98.7	48.42 216	52.15 232	62.08 276	68.29 304	74.50 332	80.71 359
AZ 13 rd .02" (-0.5 mm)	26.38 670	11.91 302.5	0.354 9.0	0.354 9.0	23.4 1257	139.2 19010	46.63 69.4	21.22 103.6	50.68 226	54.58 243	64.98 289	71.48 319	77.97 347	84.47 376
AZ 13	26.38 670	11.93 303	0.375 9.5	0.375 9.5	24.2 1300	144.3 19700	48.38 72.0	21.92 107.0	52.42 234	56.45 251	67.20 299	73.92 329	80.64 359	87.36 388
AZ 13 ru .02" (+0.5 mm)	26.38 670	11.95 303.5	0.394 10.0	0.394 10.0	25.0 1343	149.2 20380	50.26 74.8	22.86 111.6	54.15 242	58.32 260	69.42 309	76.37 340	83.31 371	90.25 401
AZ 13 ru .04" (+1.0 mm)	26.38 670	11.97 304	0.413 10.5	0.413 10.5	26.1 1401	156.0 21300	52.62 78.3	23.94 116.9	56.49 252	60.83 271	72.42 322	79.66 355	86.91 387	94.15 419
AZ 18 rd .04" (-1.0 mm)	24.805 630	14.92 379	0.335 8.5	0.335 8.5	31.0 1666	231.3 31580	45.96 68.4	22.24 108.6	67.17 300	72.34 322	86.12 383	94.73 422	103.34 460	111.96 498
AZ 18 rd .02" (-0.5 mm)	24.805 630	14.94 379.5	0.354 9.0	0.354 9.0	32.5 1748	242.9 33170	48.25 71.8	23.35 114.0	70.48 315	75.90 338	90.36 402	99.39 443	108.43 483	117.47 522
AZ 18	24.805 630	14.96 380	0.375 9.5	0.375 9.5	33.5 1800	250.4 34200	49.99 74.4	24.17 118.0	72.58 324	78.16 348	93.05 414	102.35 456	111.66 497	120.96 538
AZ 18 ru .02" (+0.5 mm)	24.805 630	14.98 380.5	0.394 10.0	0.394 10.0	34.6 1858	258.9 35350	52.01 77.4	25.15 122.8	74.91 335	80.68 359	96.04 428	105.65 471	115.25 513	124.86 555
AZ 18 ru .04" (+1.0 mm)	24.805 630	15.00 381	0.413 10.5	0.413 10.5	36.1 1941	270.8 36980	54.43 81.0	26.34 128.6	78.26 350	84.28 375	100.34 447	110.37 492	120.40 536	130.44 580
AZ 26 rd .04" (-1.0 mm)	24.805 630	16.77 426	0.441 11.2	0.472 12.0	45.6 2453	382.6 52250	61.49 91.5	29.74 145.2	98.91 442	106.51 474	126.80 564	139.48 622	152.16 677	164.84 733
AZ 26 rd .02" (-0.5 mm)	24.805 630	16.79 426.5	0.461 11.7	0.492 12.5	47.2 2538	396.3 54120	63.84 95.0	30.89 150.8	102.33 457	110.20 491	131.20 584	144.32 643	157.43 701	170.55 758
AZ 26	24.805 630	16.81 427	0.480 12.2	0.512 13.0	48.4 2600	406.5 55510	65.72 97.8	31.75 155.0	104.83 468	112.90 503	134.40 598	147.84 659	161.28 718	174.72 777
AZ 26 ru .02" (+0.5 mm)	24.805 630	16.83 427.5	0.500 12.7	0.531 13.5	49.6 2665	417.1 56960	67.67 100.7	32.75 159.9	107.45 480	115.72 515	137.76 613	151.54 675	165.31 736	179.09 796
AZ 26 ru .04" (+1.0 mm)	24.805 630	16.85 428	0.520 13.2	0.551 14.0	51.2 2754	431.6 58940	70.15 104.4	33.94 165.7	111.04 496	119.58 533	142.36 634	156.60 698	170.83 760	185.07 823
AZ 36 rd .04" (-1.0 mm)	24.805 630	18.07 459	0.512 13.0	0.669 17.0	63.8 3429	576.3 78700	77.61 115.5	37.54 183.3	138.26 618	148.89 663	177.25 789	194.98 869	212.70 947	230.43 1025
AZ 36 rd .02" (-0.5 mm)	24.805 630	18.09 459.5	0.531 13.5	0.689 17.5	65.4 3515	591.3 80750	79.83 118.8	38.63 188.6	141.73 633	152.63 680	181.70 809	199.87 891	218.04 971	236.21 1050
AZ 36	24.805 630	18.11 460	0.551 14.0	0.709 18.0	67.0 3600	606.3 82800	82.11 122.2	39.73 194.0	145.15 648	156.32 696	186.09 828	204.70 912	223.31 994	241.92 1076
AZ 36 ru .02" (+0.5 mm)	24.805 630	18.13 460.5	0.571 14.5	0.728 18.5	68.6 3689	622.0 84940	84.47 125.7	40.86 199.5	148.74 664	160.18 714	190.69 849	209.76 935	228.83 1019	247.90 1102
AZ 36 ru .04" (+1.0 mm)	24.805 630	18.15 461	0.591 15.0	0.748 19.0	70.3 3778	637.7 87080	86.75 129.1	41.97 204.9	152.33 680	164.05 731	195.29 869	214.82 958	234.35 1043	253.88 1129

MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.
Subject CONCEPTUAL COST ESTIMATE Sheet No. 1 of
ATLANTIC SALT Date AUG 19 95
Comp. LBT Check Cont. No.

RIP RAP & DEBRIS
REMOVAL

10 CY/LF X $15/CY = $150/LF

BARGE & CRANE SKELL $4320/day = $90/LF
50 T/day Production

$240/CY

BACKFILL NEW BULKHEAD

15' X 10' (stacked up) / 27 = 5.5 CY/LF

Select Fill $45/CY * 5.5 CY/LF = $250/LF

Redress R & Cap (Top of Bulkhead to top of Slope $350/LF

Total $1,840/LF

Richmond Terrace Road

MAGUIRE GROUP

Project NAVIGATION STUDY Acc. No.
Subject Richmond Terrace Sheet No. of
BUDGET COST ESTIMATE Date 7 19 91
Comp. LGT Check Cont. No.

C 50' DREDG DEPTH

Remove Timber Pile Debris

10 piles/bent @ 10' cc = 1 pile/LF @ $80 ea = $80/LF
(ESTIMATED)

Proposed 2V/1 slope

$\frac{81' \times 9'}{27}$ = 27 cy/LF @ $65 LF $1,755/LF

$1,835

Richmond Terrace

MAGUIRE GROUP

Project NAVIGATION STUDY
Subject RICHMOND TERRACE
COST ESTIMATE
Comp. LBT Check

Acc. No.
Sheet No. 1 of 2
Date 7 1998
Cont. No.

Dredge depth = -60'

TOP OF Wall 103

Bottom of Wall 65 38'

AZ-13 Sheet pile (Assume)

Tie Rods @ 13.2' CL and 2¼ w/upset 2 3/4"

Wale 2-C 12x30

Cap 15x50

DEADMAN AZ 13 L=103-93 = 10'+1 "CONTINUOS" = 11'

MOB/DEMOB $\frac{\$60,000}{1450} = 42/LF$

MATERIAL COST

BULLHEAD SHEETING

$49 \frac{lbs}{LF} \times \frac{((103-65)+1)}{2,000 \frac{lbs}{ton}} \times \$850/ton = \$812/pile$ (39')

Coatings

$39' \times 6.5/LF = \$253.5/pile$

DEADMAN SHEETING

$49 \times \frac{11}{2000} \times 850 = \$229/pile$

SUBT = $1337/LF

MAGUIRE GROUP

Project NAVIGATION STUDY
Subject CONCEPTUAL COST ESTIMATE
RICHMOND TERRACE
Comp. LBT
Check
Acc. No.
Sheet No. of
Date Aug 1998
Cont. No.

60' CHANNEL

CAP $\frac{50 \text{ lbs}}{\text{LF}} \times 2.50/\text{lb} = \$125/\text{LF}$

Channels (Wale)

$4 \times 30 \frac{\text{lbs}}{\text{ft}} \times 2.50 = \$300/\text{LF}$

Tie Rods

$13.50 \frac{\text{lb}}{\text{ft}} \times 28' \times \$3.50/\text{lb} = 1.325 \text{ ea}$

EXCAVATION
[illegible]

[illegible] $\times \$8.00$ [illegible]

$\frac{\text{[illegible]}}{\text{[illegible]}}$ $\$1549/\text{ea} \div 13.2' \text{ c-c} = \$120/\text{LF}$

Production
10'/day $\$43.00/\text{day}$ $\$432/\text{LF}$

REMOVE RIP RAP

$\frac{5' \times 8'}{27} \times \$15/\text{cy} = \$25/\text{LF}$

MIS. FILL $\frac{\frac{50 \times 5}{2}}{27} \times \$20/\text{cy} = \$95/\text{LF}$

TOTAL = 2,434./LF

Corey Warehouse

MAGUIRE GROUP

Project NAVIGATION STUDY Acc. No.
Subject CONCEPTUAL COST ESTIMATE Sheet No. of
CORPUS WAREHOUSE Date Aug 19 96
Comp. LCT Check Cont. No.

50 & 60 Dredge Depths

30' dia Steel Sheet Pile Cells

Top of Cell = +6 (steel)
Ag Sheet Length = 28'
6 full cells 5 partial

MOB/DEMOB 40,000

MATERIALS

(13 x 2) + (13 x 2) = 52

2 + 19 = 38

$[(6 * 52) + (5 * 38)] * 50.9 \frac{lb}{ft} \times \frac{\$}{2000} \frac{850}{Ton} * 28'$

$28 * 502 * \frac{50.90}{2000} \times 850 =$ $304,066

T's $12 * 28' * \frac{850}{2000} \times 57 \frac{lb}{ft}$ $8,140

DRIVING TEMPLATES $60,000

CELL DREDGES

$\frac{672}{27} * 2' \times 6 \text{ cells} \times \frac{\$}{CY} 20/cy =$ $5980

$\frac{247}{27} * 2 \times 5 * 20/cy$ $1830

Cell Installation 408 tons * 1,100/ton $448,800

SUBT $868,816

MAGUIRE GROUP

Project NAVIGATION STUDY
Subject CORBY WAREHOUSE
COST ESTIMATE 50 & 60'
Comp. LBX Check
Acc. No.
Sheet No. of
Date Sept 1998
Cont. No.

CELL Fill

$6 * \frac{672}{27} \times 23' * \$3.50 = 12,000$

$5 * \frac{247}{12} * 23 * 3.50 = 3700$

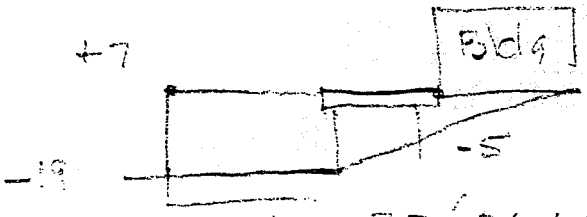
$\boxed{\$15,700}$

Concrete Cap

$33' \frac{\text{WIDE}}{27} * 215' L * 11' = 263$ cy

@ \$350 cy = $\boxed{\$91,972}$

Back Fill (CELLS TO Bldg)



$A = 33\left(\frac{26+11}{2}\right) = 610$ □

$CELL_s$ L = 215'

$215' \frac{\times 610}{27} = 4,861$ cy

$4861 * 3.50^* = \boxed{\$17,013}$

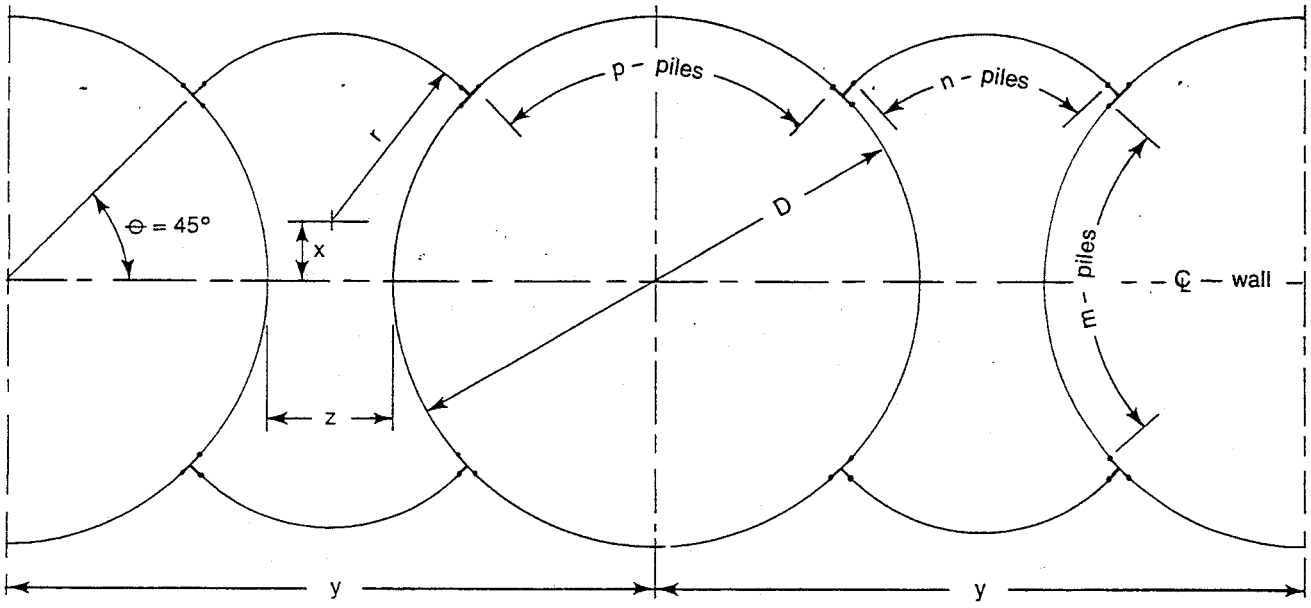
COATINGS \$2.00/SF $\boxed{\$7,355}$

TWO CLOSER STRUCTURES @ \$5,000 ea $\boxed{\$10,000}$

*quality dredge material

TOTAL \$1,010,860
@ \$4,500/LF

Cellular Layout Using PS27.5 and/or PS31
Circular Type With 90° T Connections

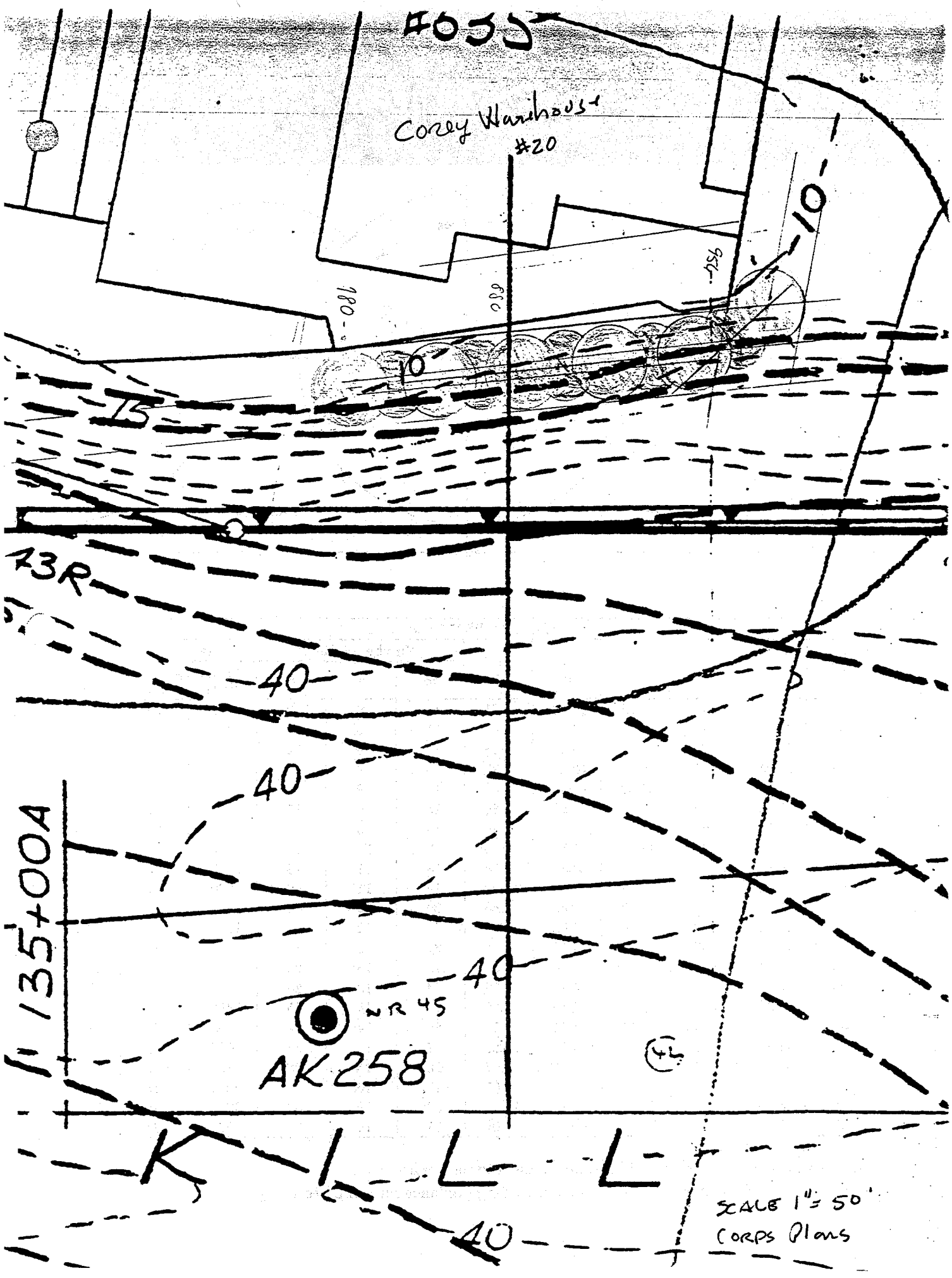


SECTION PS27.5 and PS31											
*Number of Piles in Cell	D ft	z ft	y ft	r ft	x ft	Number of Piles			Area, sq ft		Average Width ft
						m	n	p	Within circle	Between circles	
44	22.98	8.10	31.08	10.49	.71	10	9	10	415	228	20.7
48	25.07	7.49	32.56	10.49	1.45	11	9	11	493	236	22.4
52	27.16	6.88	34.04	10.49	2.18	12	9	12	579	242	24.1
56	29.25	6.27	35.52	10.49	2.92	13	9	13	672	247	25.9
60	31.34	5.66	37.00	10.49	3.66	14	9	14	771	251	27.6
64	33.43	6.52	39.95	11.53	3.66	15	10	15	877	302	29.5
68	35.52	5.91	41.43	11.53	4.40	16	10	16	990	305	31.3
72	37.61	5.30	42.91	11.53	5.14	17	10	17	1110	308	33.1
76	39.69	6.16	45.85	12.58	5.14	18	11	18	1237	365	34.9
80	41.78	5.55	47.33	12.58	5.88	19	11	19	1370	367	36.7
84	43.87	6.42	50.29	13.62	5.88	20	12	20	1511	429	38.6
88	45.96	5.80	51.76	13.62	6.62	21	12	21	1658	430	40.4
92	48.05	6.67	54.72	14.66	6.62	22	13	22	1812	498	42.2
96	50.14	6.06	56.20	14.66	7.35	23	13	23	1974	499	44.0
100	52.23	5.45	57.68	14.66	8.09	24	13	24	2141	499	45.8
104	54.32	6.31	60.63	15.71	8.09	25	14	25	2316	573	47.7
108	56.41	5.70	62.11	15.71	8.83	26	14	26	2498	573	49.5
112	58.50	6.57	65.07	16.75	8.83	27	15	27	2686	652	51.3
116	60.59	5.95	66.54	16.75	9.57	28	15	28	2881	651	53.1
120	62.68	6.82	69.50	17.80	9.57	29	16	29	3084	736	55.0
124	64.76	6.21	70.97	17.80	10.31	30	16	30	3293	735	56.8
128	66.85	5.59	72.44	17.80	11.05	31	16	31	3508	733	58.6

*Including four T piles

Average width shown = [area within circle + area between circles] ÷ y.

See page 24 for "Setting and Driving Tips," including guidance for template sizing.



#635
Corey Warehouse
#20
10
10
15
73R
40
40
40
40
135+00A
NR 45
AK258
K I L L
SCALE 1" = 50'
Corps Plans

Elizabeth Marina/Public Pier

MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.
Subject CONCEPTUAL COST ESTIMATE Sheet No. 1 of
ELIZABETH MARINA Date Aug 19 98
Comp. LBT Check Cont. No.

DEMOLITION

Feet of WAVE SCREEN 72 + 301 + 42 = 415'

Square Ft of Wharf = 195 X 50 = 9,750

WAVE SCREEN

88 pile bents w/2 piles/ea

16' wave fence (inside)
18' wave fence (outside)

DEMO METHOD

CRANE/CHAIN SAW TOP & WAVE FENCES

Snip Piles (remainder removed w/ dredge process)

CRANE/EQUIP - $5[illegible]/day ([illegible] 1.35) = $7,400/day

@50'/day demo = 7400 = 148 say $150/LF

Disposal Cost (CREOSOTE PILES)

$200/ton (Tipping) MEANS

150 ton TRANSPORTATION

$350 ton

Elizabeth MARINA

MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.
Subject CONCEPTUAL COST ESTIMATE Sheet No. 2 of
ELIZABETH MARINA Date 19
Comp. LBI Check Cont. No.

WEIGHT (Timber @ 28lbs/cf) WAVE SCREEN

Rbs +12 to -30 = $42' \times \left(\frac{\pi \cdot 7^2}{12}\right)(.95) = 43$ cu.ft.

$43 \times 28 =$ 1,204 lbs

Wavefence

Each $\frac{4''}{12} \times 1'' \times 16' \times 28 \frac{lbs}{f} = 149$ lbs

Front $\frac{4}{12} \times 1 \times 18 \times 28 = 168$ lbs

Bracing

4 units $\frac{6}{12} \times \frac{12}{12} \times 8' \times 28 \frac{lb}{ft^3} = 448$ lbs

2 units $\frac{4}{12} \times \frac{12}{12} \times 12' \times 28 = 224$

2,193 lbs ÷ 2000 = 1.1 $\frac{tons}{LF}$

Total Lengths = $415' \times 1.1 \frac{tons}{Ft} = 457$ tons

MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.
Subject CONCEPTUAL COST ESTIMATE Sheet No. 3 of
ELIZABETH MARINA Date 19
Comp. LEX Check Cont. No.

Wharf 195 X 51 $\frac{51}{5.5}$ = 9 + 1 piles/bent

195 ÷ 9' = 22 pile bents

10 piles bent X 22 = 220 piles

220 piles @ 1200 lbs each = 264,000 lbs

Lock 150 X 51 X $\frac{4''}{12}$ X 28 $\frac{lbs}{ft^3}$ = 71,400 lbs

Cross bracing

$\frac{448'}{7}$ X 51 = 3,264 lbs

228 X 9 = 2,052 lbs

5,316 $\frac{lbs}{bent}$ X 18 bents = 95,688 lbs

OUTSIDE WAVE fence 25,200

168 $\frac{lbs}{LF}$ X 150

456,288 lbs or

228 tons

MAGUIRE GROUP

Project NAVIGATION STUDY
Subject COST ESTIMATE
ELIZABETH MARINA
Comp. LPT Check

Acc. No.
Sheet No. of
Date Sept 19 92
Cont. No.

DEMOLITION Wharf & Wave Screen

Wave Screen DEMO

DEMO $150/LF * 415 $62,250

DISPOSAL $350/ton * 457 tons - 159,950

$222,200

WHARF DEMO 9,750 SF

CREW & EQUIP. @ $7,400/day

RATE 2500 SF/day = 4 days - $29,600

DISPOSAL @ $350/ton * 228 tons $79,800

$109,400

TOTAL MARINA DEMO = $331,600

MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.
Subject COST ESTIMATE 50' & 60' dredge Sheet No. of
ELIZABETH MARINA Date Sept 19 98
Comp. LBH Check Cont. No.

NEW CONSTRUCTION

Wharf 51' x 150' 12' x 12' piles Grid

5 piles per bent * 13 BENTS = 65 piles

@ 50' dredge

65 * $125/LF * [50' dredge + 9' cutoff + 5' socket]

$520,000

@ 60' dredge

65 * 125 * [60 + 9 + 5] = $601,250

DECK - 10' CONC.

$\frac{10}{12} \times \frac{51' \times 150'}{27} =$ 236 cy

Pile caps & beams

13 bents $\times$ 2' x 2' beams x 5' long = 98.2 cy

334 cy

334 cy @ $\frac{600}{cy}$ = $200,533

$50,000

Misc Railings, lights

$250,533

MAGUIRE GROUP

Project HABOR NAVIGATION STUDY Acc. No.
Subject CONCEPTUAL COST ESTIMATE Sheet No. of
ELIZABETH MARINA Date AUG 19 98
Comp. LBT Check Cont. No.

50') NEW TIMBER WAVE SCREEN (TIMBER ONLY)

+12 to -6 = 18 x (3/12 boards) x $4.50/BF = $243/LF (3BF/Ft)

Bracing 3 x (6x12) @ $4.50/BF $81/LF

Mis Bolts ... hardware 25/LF $25/LF

$349/LF

150' Wharf w/ Wave SCREEN = $52,350

50' Total Wharf = $822,883

60' TOTAL Wharf = $904,133

MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.
Subject CONCEPTUAL COST ESTIMATES Sheet No. of
ELIZABETH MARINA 50' & 60' Channel Date 8/ 1998
Comp. LET Check Cont. No.

WAVE SCREEN 10 bents

2 pils/bent 66' Vert pile 70' battered @50'
76' " " 80' " @60

Pile + Rock Anchor

ANCHORS $8000 ea $8,000

Pipe pile @ $90/LF * 66 = 5940

$13,940 ea @50'

Battered pile use 125/LF * 70 = $8750

$22,690

415' ÷ 10 + 1 = 43 Bents X $22,690 = $975,670

Steel bracing 420 lbs $.5/lb * 43 bents $90,300

TIMBER FENCE @ 350/LF * 415 $145,250

@50' $1,211,220

@60' dredge depth

pipe piles $90 * 76 = $6,840

$125/ft * 80' = 10,000

Anchors @ 8000

$24,840 * 43 = 1,068,120
90,300
145,250

@60' = $1,303,670

Arthur Kill Lift Bridge

MAGUIRE GROUP

Project NAVIGATION STUDY
Subject CONCEPTUAL COST ESTIMATE
ARTHUR KILL LIFT BRIDGE
Comp. LST
Check
Acc. No.
Sheet No. of
Date AUG 1998
Cont. No.

50' DREDGE

50 shaft units (25 each pier)

L= -40 to -72 = 32'

Production MOB/DEMOB $60,000

1 shaft/wk (5 days)

BARGE/DRILL/CREW/tug/
$7000/day x 5 days x 50 units 1,750,000

Shaft $1460/L = x 32 x 50 ea = 2,336,000

$4,146,000

÷50 = 82,920 ea

5–87

ARTUR KILL LIFT BRIDGE

MAGUIRE GROUP

Project NAVIGATION STUDY Acc. No.
Subject CONCEPTUAL COST ESTIMATES Sheet No. of
ARTHUR KILL LIFT BRIDGE Date Aug 19 98
Comp. LBX Check Cont. No.

60' DREDGE

50 shafts 25 each / pier
L = -40 to -82 = 42'

MOB / DEMOB $ 60,000

Production = 1 shaft/wk (5 days)

Barge / tug / crew DRILL @ $7,000/day

50 ea * 5 days * 7000/day = 1,750,000

Shaft (MEANS) = $1,016/LF * NY Factor 1.34

1,016 * 1.34 = $1300/LF

ADD $100/LF "OVERWATER Premium"

$1400/LF * 50 each * 42' each = 3,066,000

4,876,000

÷ 50 = $97,520 ea

MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.
Subject CONCEPTUAL COST ESTIMATE Sheet No. of
ARTHURKILL LIFT BRIDGE Date AUG 19 98
Comp. LBT Check Cont. No.

PRE DRILLING

50' Dredge

$60,000

MOB/DEMOB

Line drill -42 to -52 = 10'/hole

Barge & Crew $4500/day

daily output 350'/day $\frac{\$4500}{350}$ $12.90/LF

$12.90/LF X 10'/hole = $129/hole [Equip]

2½" dia holes @ $4.00/LF X 10' = $40/hole

Hole spacing 18"

L.F. of Protection 440' (Both Piers)

# of holes $\frac{440}{1.5}$ + 2 = 662 holes

Equip	662 holes * $129.00	85,398
Drill	662 holes * $40/hole	26,480
Blast (every other hole)	$\frac{662}{2}$ * $25.00/hole =	8,275
Safety TEAM @	$1500/day * $\frac{662 \times 10}{350}$	28,375
		$208,528

÷ 440 = $475/LF*

USE AT COREY WAREHOUSE 50' CHANNEL

MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY
Subject CONCEPTUAL COST ESTIMATE
ARTHUR KILL LIFT BRIDGE
Comp. LBT Check

Acc. No.
Sheet No. of
Date AUG 19 98
Cont. No.

60' DREDGE CHANNEL

PREDRILLING

MOB/DEMOB $60,000

Line drill depth

-42 to -62 = 20'

[illegible] $4500/day

OUTPUT 350'/day 4500 ÷ 350 = 12.90/LF

[illegible] X 20' = $258/hole

[illegible] = $80/hole

[illegible]

[illegible] 170,796

[illegible] 52,960

[illegible] 50/[illegible] = 16,555

Safety Team

1500/day x 662 holes x 20'/hole 56,745
350'/day

357,056

÷ 440 = $815/LF*

*USE A COKY WAREHOUSE 60' channel

SECTION VIII COMPUTATIONS

Note Corps Dock No. refers to the numbering system used by the Army Corps of Engineers in there report, "The Port of New York and New Jersey and Ports on Long Island, NY," Port Series No. 5, Revised 1988.

CORPS DOCK NO. 648
NAME: Atlantic Salt Company Stockpile
CHANNEL: Kill Van Kull

FACILITY NO. 9 - ATLANTIC SALT COMPANY

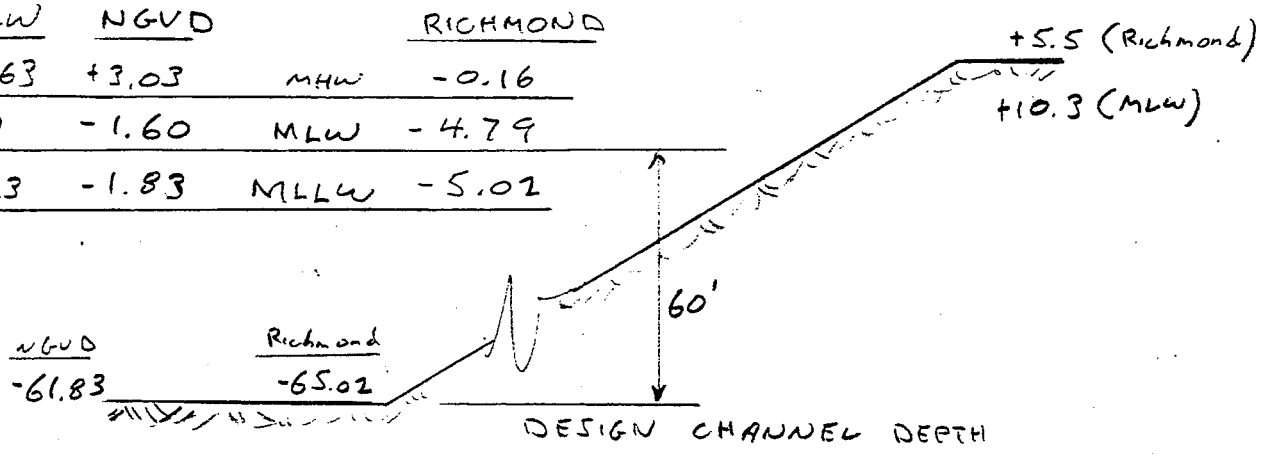
The impacted portion of the facility is an area of fill utilized to stockpile salt. The slope along the waterfront of the fill area consists of riprap and miscellaneous debris and appears to be partially supported by a stone block wall. The stones may be part of an old gravity retaining wall or possibly a relieving platform. Recent hydrographic surveys indicate that the slope runs uninterupted from a point roughly ten feet above low tide, down to the present channel dredge depth of -40.0, MLW datum.

The impact of dredging the existing channel to a 50 foot depth, (52 feet with the allowable overdredge), appears to be minimal. With the design side slope of 3:1, there will be no change in the slope along the shore. The portion of the slope in and just below the tidal zone can be dressed with riprap.

A 60 foot deep channel, (62 feet with the allowable overdredge), will require a vertical cut in the existing bottom, near the shore, to accomodate the 3:1 channel side slope.

- Investigate a cantilever bulkhead.
- Locate the bulkhead at the mean low water line to minimize the height of the cantilever, to anticipate driving outboard of obstructions in the channel bank such as debris, riprap and abandoned piles, and to reduce the lateral earth pressure induced by the stockpile surcharge
- Existing bottom conditions taken from EXISTING SITE PLAN, ATLANTIC SALT, INC., by Bourne Consulting Engineering, 4-25-97
- Existing grade at the top of the slope is +5.5, Borough of Richmond Datum. The datum shift is shown below:

MLW	NGVD		RICHMOND
+4.63	+3.03	MHW	-0.16
0	-1.60	MLW	-4.79
-0.23	-1.83	MLLW	-5.02



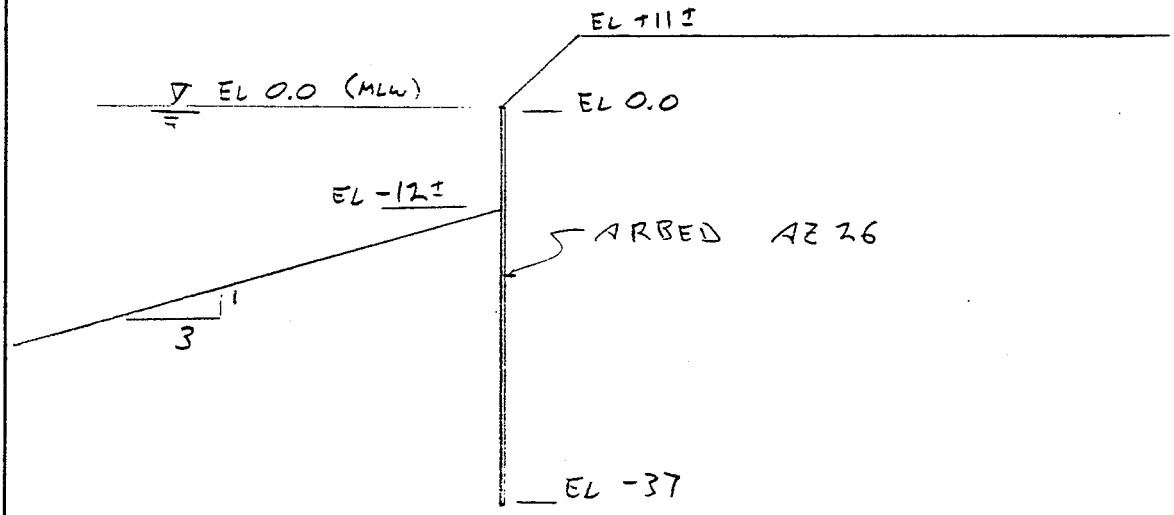
POTENTIAL SOLUTION:

INSTALL A SHEET PILE BULKHEAD AT THE TOE OF THE EXISTING CHANNEL BANK, INTERUPTING THE DREDGE SLOPE

BULKHEAD PARAMETERS:

A325 STEEL

ARBED AZ 26 OR EQUIVALENT
MIN LENGTH 37'



DESIGN CALCULATIONS FOLLOW:

ASSUMED SOIL PROPERTIES:

From Melick-Tully and Associates, 6-5-98 mtg w/ PANYNJ

one soil type

$\gamma_{sat} = 130$ pcf

$\phi = 30°$

Calculated values:

$K_a = 0.333$

$K_p = 3.0$

$K_o = 0.5$

A typical section illustrating existing and potential channel slopes is shown on the following page

Elevations are shifted to MLW Datum

FROM 5.20.98, THE BANK ALONG THE FRONT OF THE SALT PILE APPEARS TO BE SUPPORTED (AT LEAST PARTIALLY) BY A STONE BLOCK WALL (POSSIBLY A GRAVITY WALL REMNANT OR RELIEVING PLATFORM)

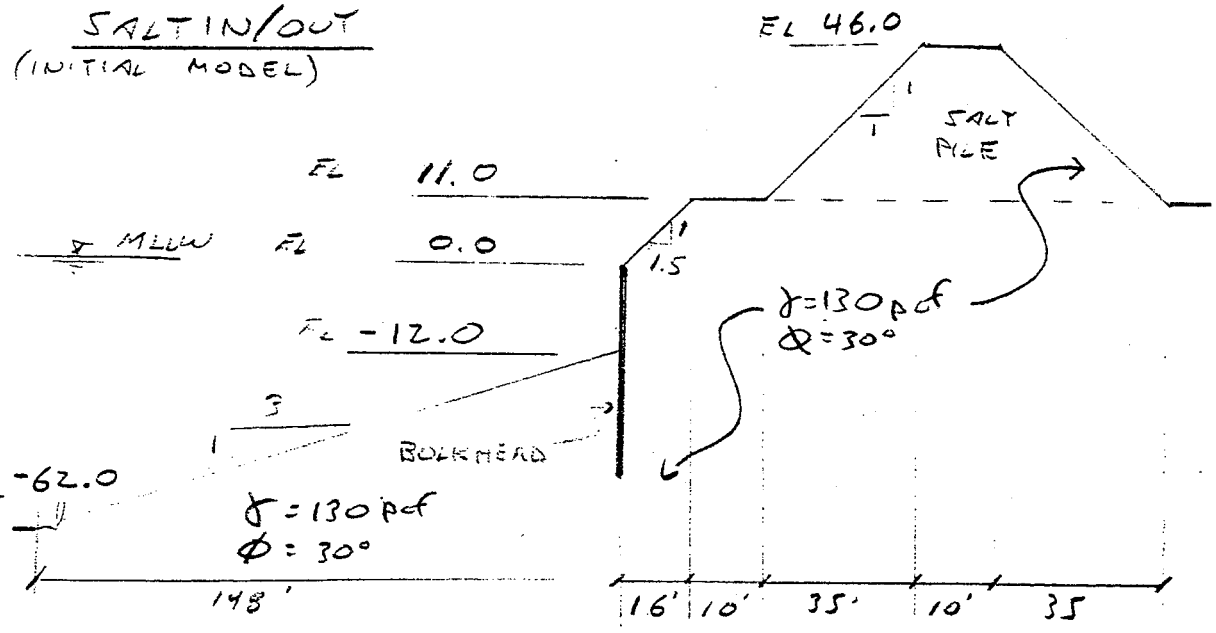
ASSUME THAT THE BULKHEAD WOULD BE INSTALLED OUTBOARD OF THIS WALL, AT THE TOE OF THE BANK

INVESTIGATE A BULKHEAD USING THE ACOE PROGRAM CWALSHT, X0031

CONSIDER A CANTILEVERED BULKHEAD

- SET THE TOP OF SLOPE AT ELEV +11.0 FOR COMPUTER RUN; TOP OF WALL @ ELEV. 0.0
- ASSUME BEDROCK SURFACE IS BELOW BULKHEAD TIP ELEVATION
- ASSUME 35' HIGH SALT PILE (BASED ON INTERPRETATION OF 5-20-98 SITE PHOTOS)

SALT IN/OUT
(INITIAL MODEL)



MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.
Subject PANYNJ - KVK Sheet No. of
ATLANTIC SALT - # 9 Date 19
Comp. DOF Check Cont. No.

A series of 3 runs will be made to establish the maximum presumptive loading on the bulkhead.

In the first run, SALT1IN/OUT, the ground elevation behind the bulkhead will be modelled to include the shape of the salt pile. The salt will conservatively be considered to have the same properties as the soil.

In the second run, SALT2IN/OUT, the ground surface will be assumed to be level at elevation 11.0 and the salt will be modelled as a triangular surcharge.

In the third run, SALT3IN/OUT, the ground surface will be assumed to be level at elevation 11.0 and a uniform surcharge of 325 psf will be applied to approximate the operation of heavy equipment.

A summary of the CWALSHT results is presented below:

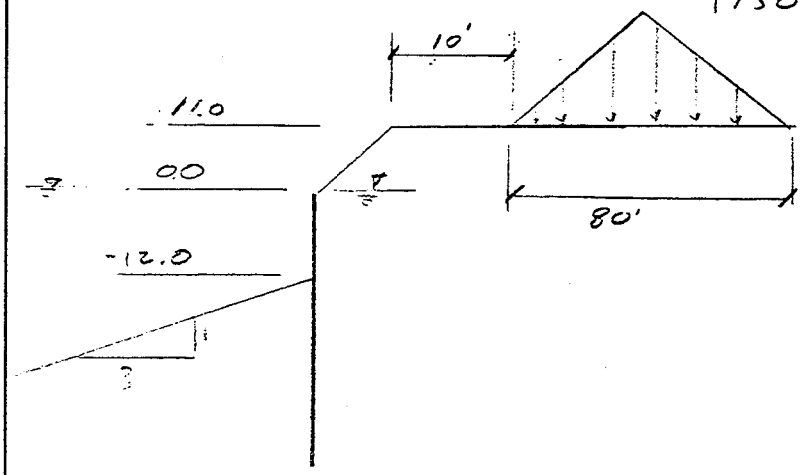
RUN	SALT 1	SALT 2	SALT 3
BULKHEAD TIP EL.	-27.85	-27.86	-31.88
PENETRATION	15.85	15.86	19.88
TOTAL LENGTH (FT)	27.85	27.86	31.88
MAX MOMENT (*)	38.3	38.3	74.53
ELEV.	-20.92	-20.92	-23.03
MAX DEFL. (**) /(E·I)	1.5056E+10	1.5057E+10	3.926E+10

* MOMENTS ARE IN FOOT KIPS

** DEFLECTIONS ARE VALUES IN LB/IN^3 AND MUST BE DIVIDED BY THE PILE E·I ($LB \cdot IN^2$) TO GET ACTUAL DEFLECTION IN INCHES

X0031 CWALSHT MODELS

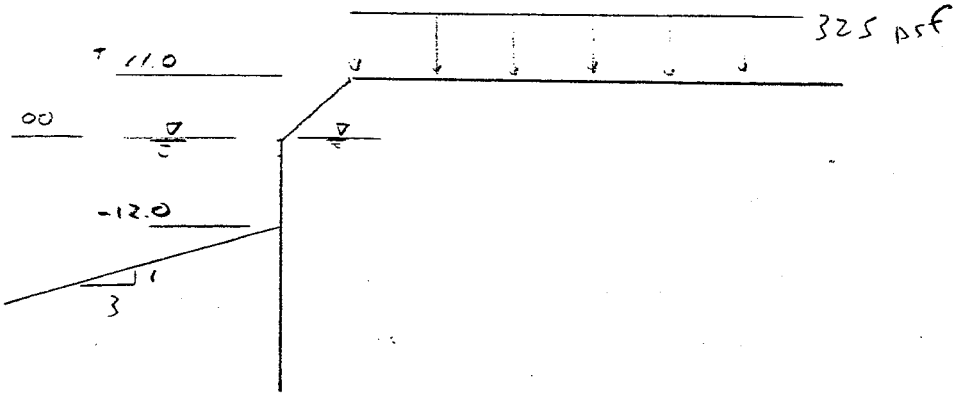
SALT2IN/OUT: MODEL ONLY SALT PILE AS SURCHARGE



SALT3IN/OUT: CONSIDER UNIFORM SURCHARGE

AASHTO SURCHARGE OF 2 FEET OF SOIL ≈ 260 psf ; increase by 25% TO ACCOUNT FOR HEAVY EQUIPMENT

1.25 (260) = 325 psf



SHEETING DESIGN:

325 psf surcharge governs

$M_{max} = 74.53$ ft-k

w/ A328 Sheeting $F_y = 39$ ksi

$F_s = 0.65(39) = 25$ ksi

$S_{req'd} = 74.53(12)/25 = 35.77$ in^3

Select **Arbed AZ 26** $S = 48.4$ in^3/lf of wall

wt. = 31.8 psf

$I = 406.5$ in^4

$\Delta = 1.506(10)^{10}/406.5(29)(10)^6 = 1.28"$

(3" w/ surcharge)

Sheet length:

19.88' penetration req'd

Increase minimum required by 25%

$19.88(1.25) = 25'$

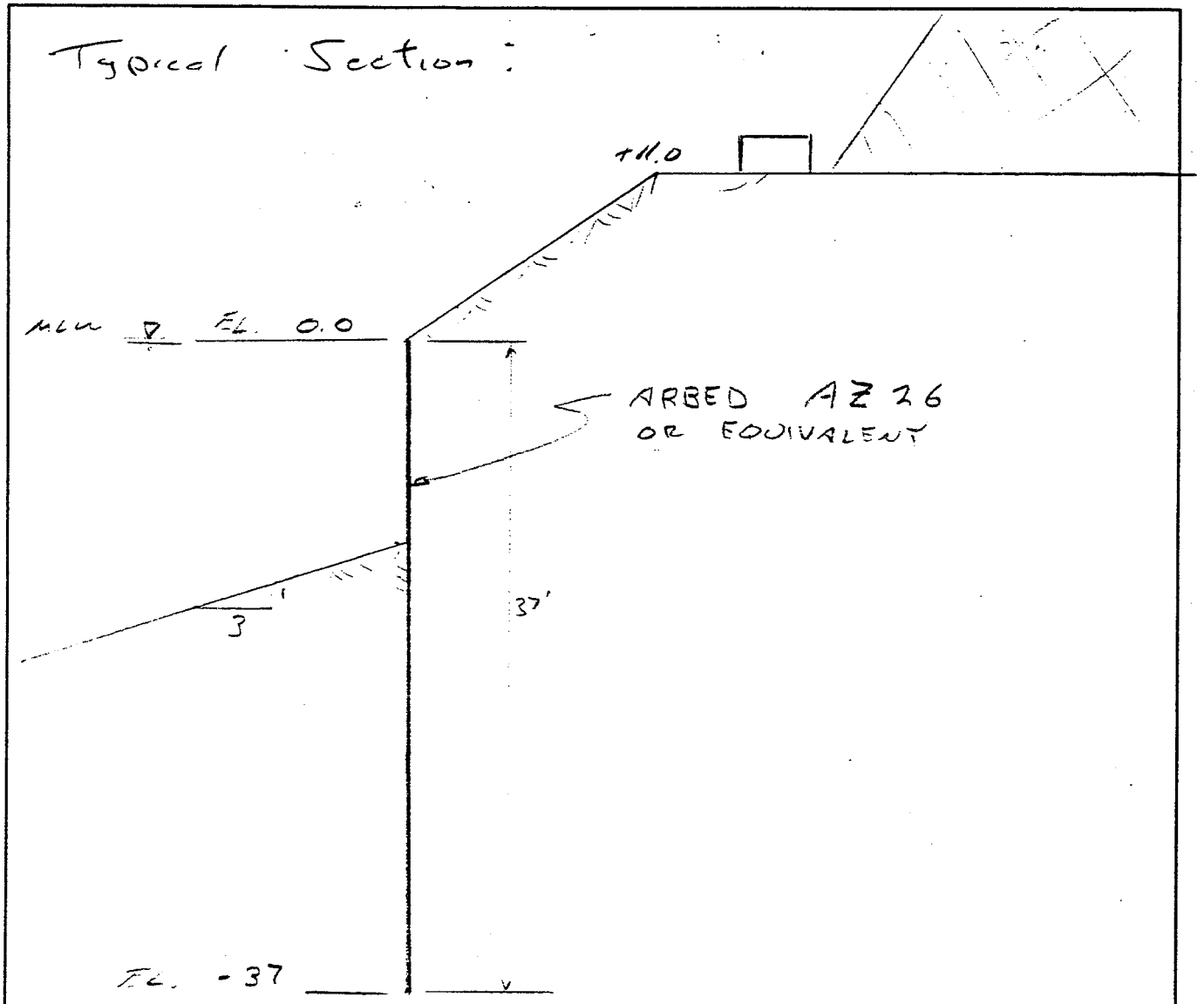
∴ Recommended Tip Elev. $= -25$

$\Rightarrow$ Sheet Length $= 25' + 12' = 37'$

MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.
Subject PANYNJ - KILL VAN KULL Sheet No. of
SITE # 9 Date 19
Comp. DOF Check Cont. No.

Typical Section:



MAGUIRE GROUP

Project _____ Acc. No. _____

Subject _____ Sheet No. _____ of _____

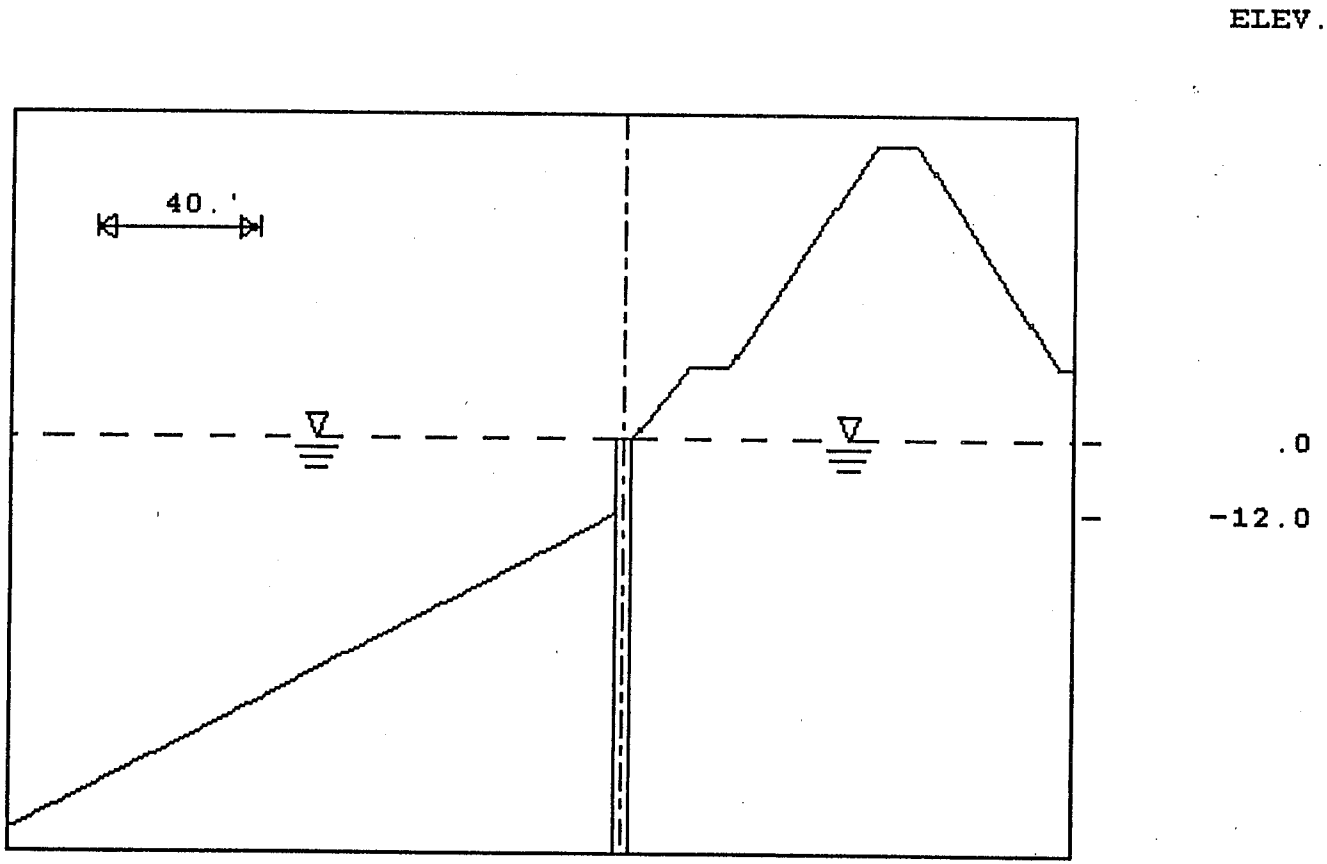
_____ Date _____ 19 _____

Comp. _____ Check _____ Cont. No. _____

CWALSHT RUNS

'HARBOR NAVIGATION STUDY PORT AUTHORITY OF NY & NJ

'"SALT1IN" ATLANTIC SALT - FACILITY #9

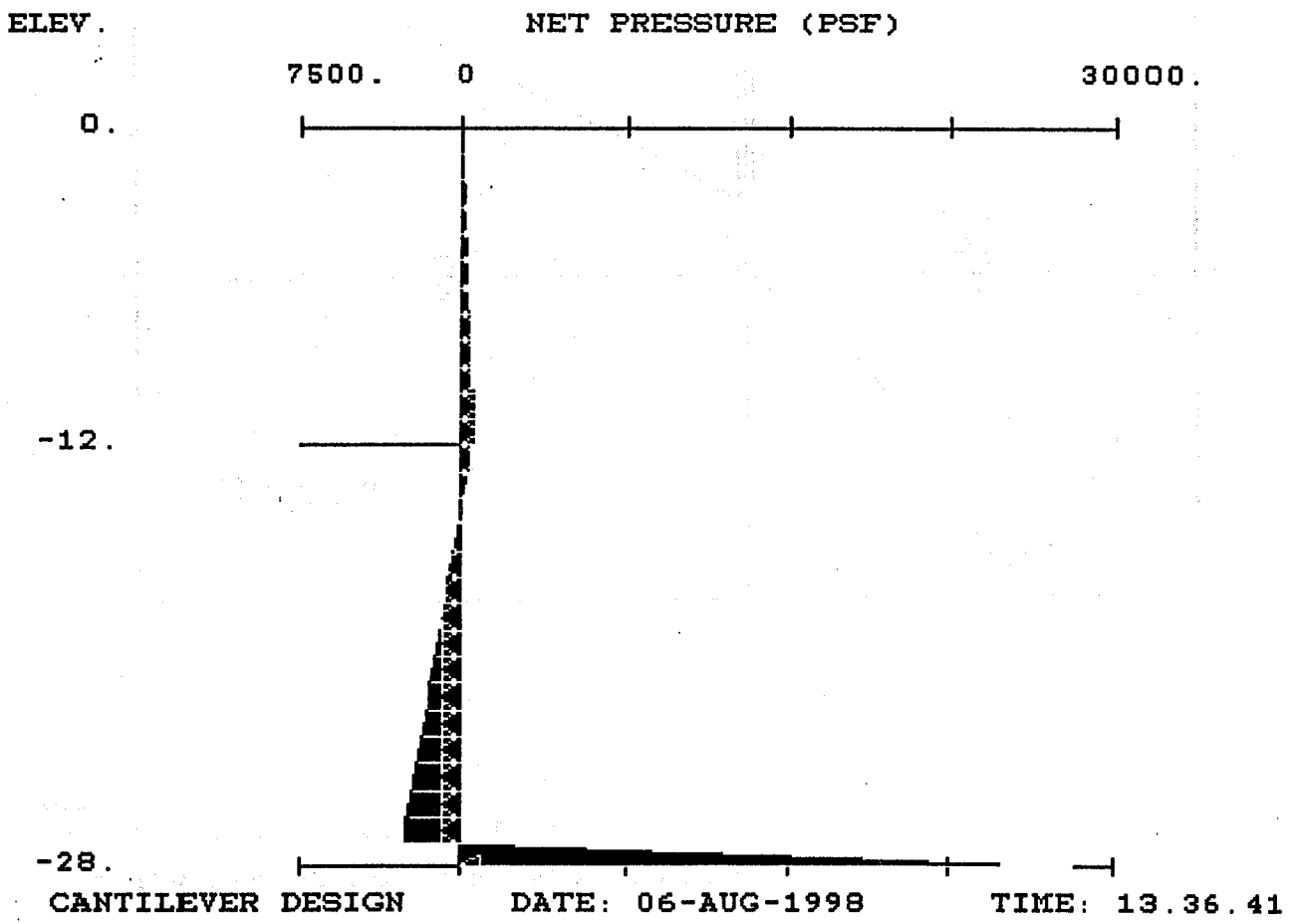


***** INPUT GEOMETRY *****

DATE: 06-AUG-1998 TIME: 13.20.58

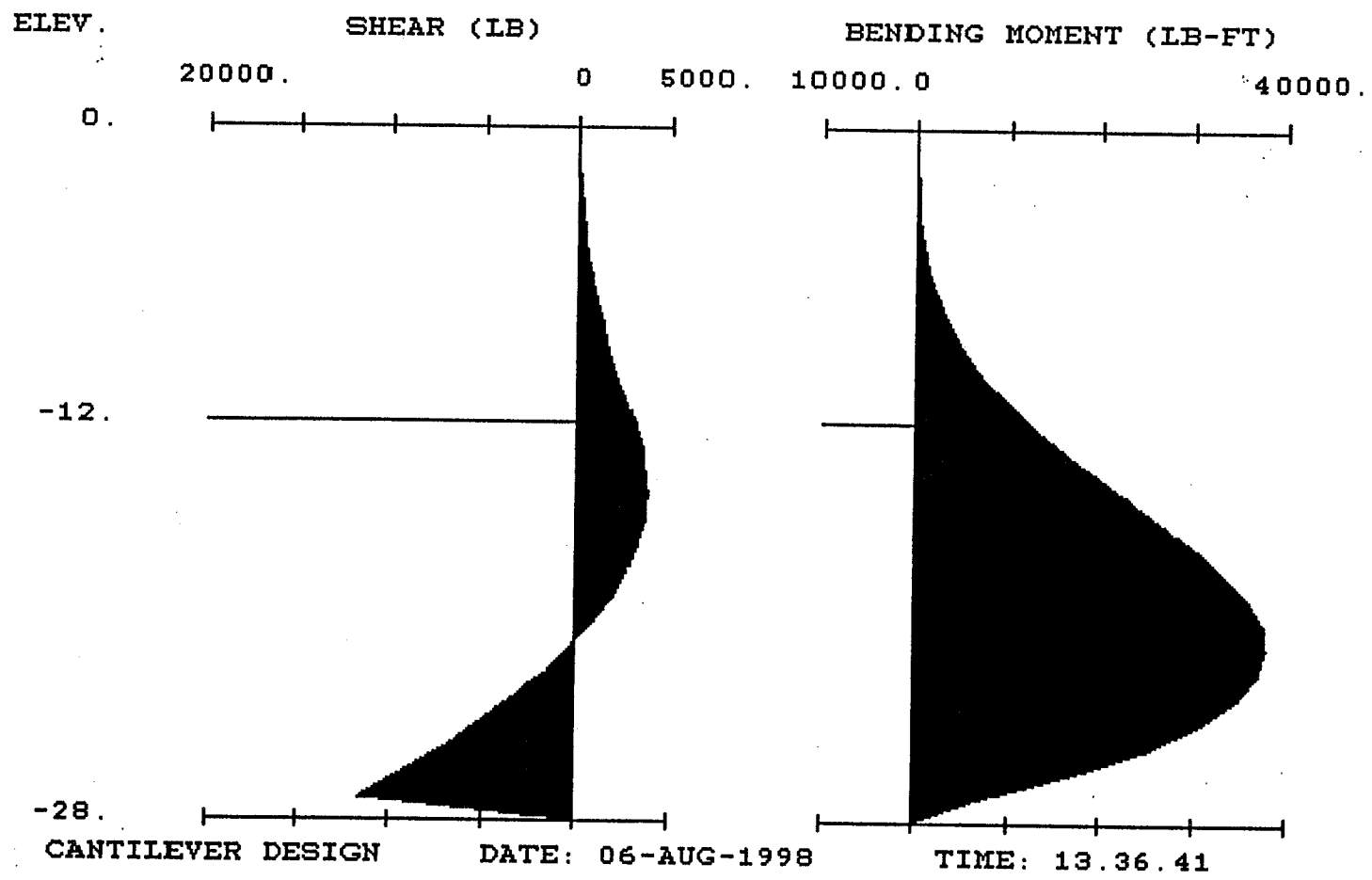
'HARBOR NAVIGATION STUDY PORT AUTHORITY OF NY & NJ

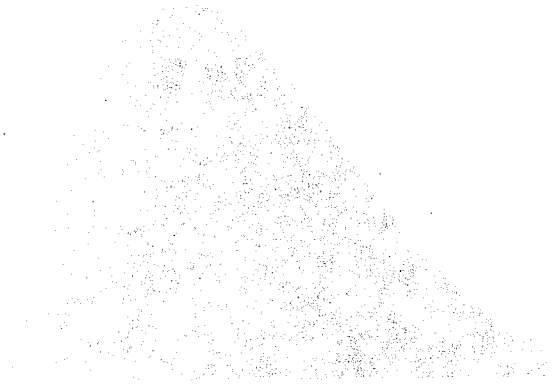
'"SALT1IN" ATLANTIC SALT - FACILITY #9



'HARBOR NAVIGATION STUDY PORT AUTHORITY OF NY & NJ

'"SALT1IN" ATLANTIC SALT - FACILITY #9







PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 06-AUG-1998 TIME: 13.20.30

INPUT DATA

I.--HEADING:
'HARBOR NAVIGATION STUDY PORT AUTHORITY OF NY & NJ
'"SALT1IN" ATLANTIC SALT - FACILITY #9
'60 FOOT CHANNEL / CANTILEVER BULKHEAD / 35 FOOT SALT PILE
'MLW DATUM / LATERAL EARTH PRESSURE ONLY

II.--CONTROL
CANTILEVER WALL DESIGN

LEVEL 1 FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
LEVEL 1 FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

III.--WALL DATA
ELEVATION AT TOP OF WALL = .00 (FT)

IV.--SURFACE POINT DATA

IV.A--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	.00
16.00	11.00
26.00	11.00
61.00	46.00
71.00	46.00
106.00	11.00

IV.B-- LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	-12.00
148.00	-62.00

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE LAYER DATA
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> ACT.	<-FACTOR-> PASS.
130.00	128.00	30.00	.0	15.00	.0			DEF	DEF

V.B.-- LEFTSIDE LAYER DATA

LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> ACT.	<-FACTOR-> PASS.
130.00	128.00	30.00	.0	15.00	.0			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)

RIGHTSIDE ELEVATION = .00 (FT)

LEFTSIDE ELEVATION = .00 (FT)

NO SEEPAGE

VII.--SURFACE LOADS

NONE

VIII.--HORIZONTAL LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 06-AUG-1998 TIME: 13.32.03

SOIL PRESSURES FOR
CANTILEVER WALL DESIGN

I.--HEADING

'HARBOR NAVIGATION STUDY PORT AUTHORITY OF NY & NJ
'"SALT1IN" ATLANTIC SALT - FACILITY #9
'60 FOOT CHANNEL / CANTILEVER BULKHEAD / 35 FOOT SALT PILE
'MLW DATUM / LATERAL EARTH PRESSURE ONLY

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

	<-LEFTSIDE PRESSURES->		<---NET PRESSURES----> (SOIL PLUS WATER)		<RIGHTSIDE PRESSURES->	
ELEV. (FT)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
.00	.00	.00	.000	.000	.00	.00
-1.00	.00	.00	43.372	11724.405	43.37	11724.41
-2.00	.00	.00	86.745	2504.006	86.74	2504.01
-3.00	.00	.00	130.117	52654.651	130.12	52654.65
-4.00	.00	.00	173.490	113553.792	173.49	113553.79
-5.00	.00	.00	216.862	69991.417	216.86	69991.42
-6.00	.00	.00	260.235	25295.197	260.23	25295.20
-7.00	.00	.00	303.607	30092.768	303.61	30092.77
-8.00	.00	.00	346.980	30007.964	346.98	30007.96
-9.00	.00	.00	390.352	29923.160	390.35	29923.16
-10.00	.00	.00	433.725	29838.356	433.72	29838.36
-11.00	.00	.00	477.097	29753.552	477.10	29753.55
-12.00	.00	.00	520.470	29668.748	520.47	29668.75
-13.00	233.08	15.94	330.759	29568.002	563.84	29583.94
-14.00	466.17	31.89	141.048	29467.255	607.21	29499.14
-14.74	639.68	43.75	.000	29392.258	639.68	29436.01
-14.87	669.46	45.79	-24.214	29379.383	645.25	29425.17
-15.00	699.25	47.83	-48.428	29366.508	650.82	29414.34
-16.00	932.33	63.77	-239.280	29265.762	693.05	29329.53
-17.00	1165.42	79.71	-438.412	29165.015	727.01	29244.73
-18.00	1398.50	95.66	-648.697	29064.268	749.80	29159.93
-19.00	1631.59	111.60	-863.115	28963.521	768.47	29075.12
-20.00	1864.67	127.54	-1077.163	28862.775	787.51	28990.32
-21.00	2097.75	143.49	-1291.194	28762.028	806.56	28905.51
-22.00	2330.84	159.43	-1505.225	28661.281	825.61	28820.71
-23.00	2563.92	175.37	-1719.256	28560.534	844.66	28735.91
-24.00	2797.00	191.31	-1933.287	28459.788	863.72	28651.10
-25.00	3030.09	207.26	-2147.318	28359.041	882.77	28566.30
-26.00	3263.17	223.20	-2361.350	28258.294	901.82	28481.49
-27.00	3496.25	239.14	-2575.381	28157.547	920.87	28396.69
-28.00	3729.34	255.09	-2789.412	28056.801	939.93	28311.89
-29.00	3962.42	271.03	-3003.443	27956.054	958.98	28227.08
-30.00	4195.51	286.97	-3217.474	27855.307	978.03	28142.28
-31.00	4428.59	302.91	-3431.505	27754.561	997.08	28057.48
-32.00	4661.67	318.86	-3645.708	27653.814	1015.96	27972.67
-33.00	4894.76	334.80	-3859.718	27553.067	1035.04	27887.87
-34.00	5127.84	350.74	-4061.410	27452.320	1066.43	27803.06
-35.00	5360.92	366.69	-4238.671	27351.574	1122.25	27718.26
-36.00	5594.01	382.63	-4402.616	27250.827	1191.39	27633.46
-37.00	5827.09	398.57	-4565.947	27150.080	1261.14	27548.65
-38.00	6060.17	414.52	-4729.503	27049.333	1330.67	27463.85
-39.00	6293.26	430.46	-4893.059	26948.587	1400.20	27379.04
-40.00	6526.34	446.40	-5056.615	26847.840	1469.73	27294.24
-41.00	6759.42	462.34	-5220.171	26747.093	1539.25	27209.44
-42.00	6992.51	478.29	-5383.727	26646.346	1608.78	27124.63
-43.00	7225.59	494.23	-5547.282	26545.600	1678.31	27039.83
-44.00	7458.68	510.17	-5710.838	26444.853	1747.84	26955.03
-45.00	7691.76	526.12	-5874.394	26344.106	1817.37	26870.22
-46.00	7924.84	542.06	-6037.950	26243.360	1886.89	26785.42

-47.00	8157.93	558.00	-6201.506	26142.613	1956.42	26700.61
-48.00	8391.01	573.94	-6365.062	26041.224	2025.95	26615.17
-49.00	8624.09	589.89	-6528.618	25934.890	2095.48	26524.78

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 06-AUG-1998 TIME: 13.36.41

SUMMARY OF RESULTS FOR
CANTILEVER WALL DESIGN

I.--HEADING

'HARBOR NAVIGATION STUDY PORT AUTHORITY OF NY & NJ
'"SALT1IN" ATLANTIC SALT - FACILITY #9
'60 FOOT CHANNEL / CANTILEVER BULKHEAD / 35 FOOT SALT PILE
'MLW DATUM / LATERAL EARTH PRESSURE ONLY

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

WALL BOTTOM ELEV. (FT) : -27.85
PENETRATION (FT) : 15.85

MAX. BEND. MOMENT (LB-FT) : 38284.
AT ELEVATION (FT) : -20.92

MAX. SCALED DEFL. (LB-IN3): 1.5056E+10
AT ELEVATION (FT) : .00

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF
ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA
IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 06-AUG-1998 TIME: 13.36.41

COMPLETE RESULTS FOR
CANTILEVER WALL DESIGN

I.--HEADING

'HARBOR NAVIGATION STUDY PORT AUTHORITY OF NY & NJ
'"SALT1IN" ATLANTIC SALT - FACILITY #9
'60 FOOT CHANNEL / CANTILEVER BULKHEAD / 35 FOOT SALT PILE
'MLW DATUM / LATERAL EARTH PRESSURE ONLY

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
.00	0.	0.	1.5056E+10	.00
-1.00	7.	22.	1.4262E+10	43.37
-2.00	58.	87.	1.3469E+10	86.74
-3.00	195.	195.	1.2675E+10	130.12
-4.00	463.	347.	1.1882E+10	173.49
-5.00	904.	542.	1.1090E+10	216.86
-6.00	1561.	781.	1.0299E+10	260.23
-7.00	2479.	1063.	9.5115E+09	303.61
-8.00	3701.	1388.	8.7279E+09	346.98
-9.00	5270.	1757.	7.9508E+09	390.35
-10.00	7229.	2169.	7.1828E+09	433.72
-11.00	9621.	2624.	6.4274E+09	477.10
-12.00	12491.	3123.	5.6887E+09	520.47
-13.00	15843.	3548.	4.9716E+09	330.76
-14.00	19525.	3784.	4.2820E+09	141.05
-14.74	22368.	3837.	3.7902E+09	.00
-14.87	22858.	3835.	3.7078E+09	-24.21
-15.00	23348.	3831.	3.6261E+09	-48.43
-16.00	27123.	3687.	3.0106E+09	-239.28
-17.00	30657.	3348.	2.4418E+09	-438.41
-18.00	33750.	2804.	1.9260E+09	-648.70
-19.00	36195.	2048.	1.4685E+09	-863.11
-20.00	37776.	1078.	1.0733E+09	-1077.16
-21.00	38280.	-106.	7.4330E+08	-1291.19
-22.00	37493.	-1504.	4.7923E+08	-1505.23
-23.00	35201.	-3116.	2.7974E+08	-1719.26
-24.00	31189.	-4943.	1.4082E+08	-1933.29
-25.00	25244.	-6983.	5.5520E+07	-2147.32
-26.00	17152.	-9237.	1.3533E+07	-2361.35
-26.94	7341.	-11564.	1.0677E+06	-2563.56
-27.00	6699.	-11654.	8.4458E+05	-698.22
-27.85	0.	0.	0.0000E+00	28071.77

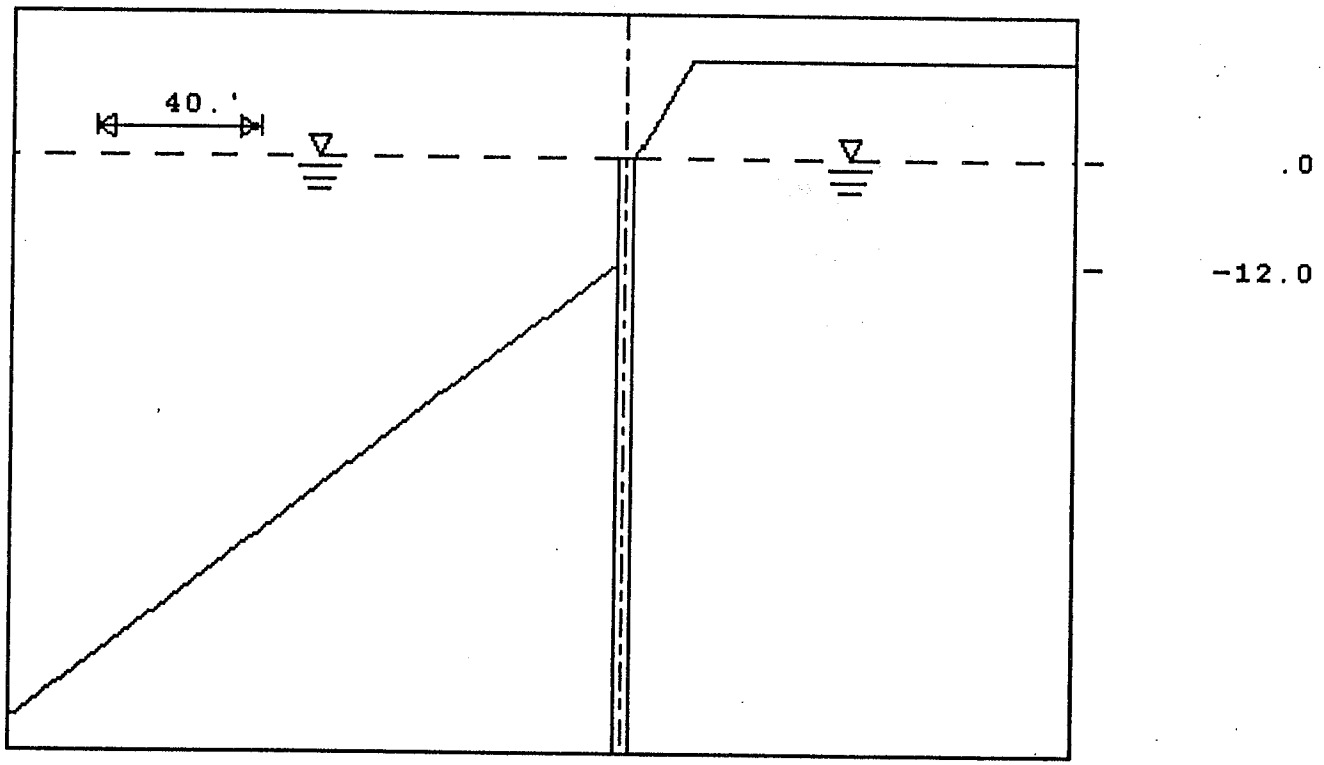
(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

III.--SOIL PRESSURES

ELEVATION	< LEFTSIDE PRESSURE (PSF)>		<RIGHTSIDE PRESSURE (PSF)>	
(FT)	PASSIVE	ACTIVE	ACTIVE	PASSIVE
.00	0.	0.	0.	0.
-1.00	0.	0.	43.	11724.
-2.00	0.	0.	87.	2504.
-3.00	0.	0.	130.	52655.
-4.00	0.	0.	173.	113554.
-5.00	0.	0.	217.	69991.
-6.00	0.	0.	260.	25295.
-7.00	0.	0.	304.	30093.
-8.00	0.	0.	347.	30008.
-9.00	0.	0.	390.	29923.
-10.00	0.	0.	434.	29838.
-11.00	0.	0.	477.	29754.
-12.00	0.	0.	520.	29669.
-13.00	233.	16.	564.	29584.
-14.00	466.	32.	607.	29499.
-14.74	640.	44.	640.	29436.
-14.87	669.	46.	645.	29425.
-15.00	699.	48.	651.	29414.
-16.00	932.	64.	693.	29330.
-17.00	1165.	80.	727.	29245.
-18.00	1399.	96.	750.	29160.
-19.00	1632.	112.	768.	29075.
-20.00	1865.	128.	788.	28990.
-21.00	2098.	143.	807.	28906.
-22.00	2331.	159.	826.	28821.
-23.00	2564.	175.	845.	28736.
-24.00	2797.	191.	864.	28651.
-25.00	3030.	207.	883.	28566.
-26.00	3263.	223.	902.	28481.
-26.94	3483.	238.	920.	28401.
-27.00	3496.	239.	921.	28397.
-27.85	3729.	255.	940.	28312.
-29.00	3962.	271.	959.	28227.

'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ

'"SALT2IN", FACILITY NO 9 - ATLANTIC SALT

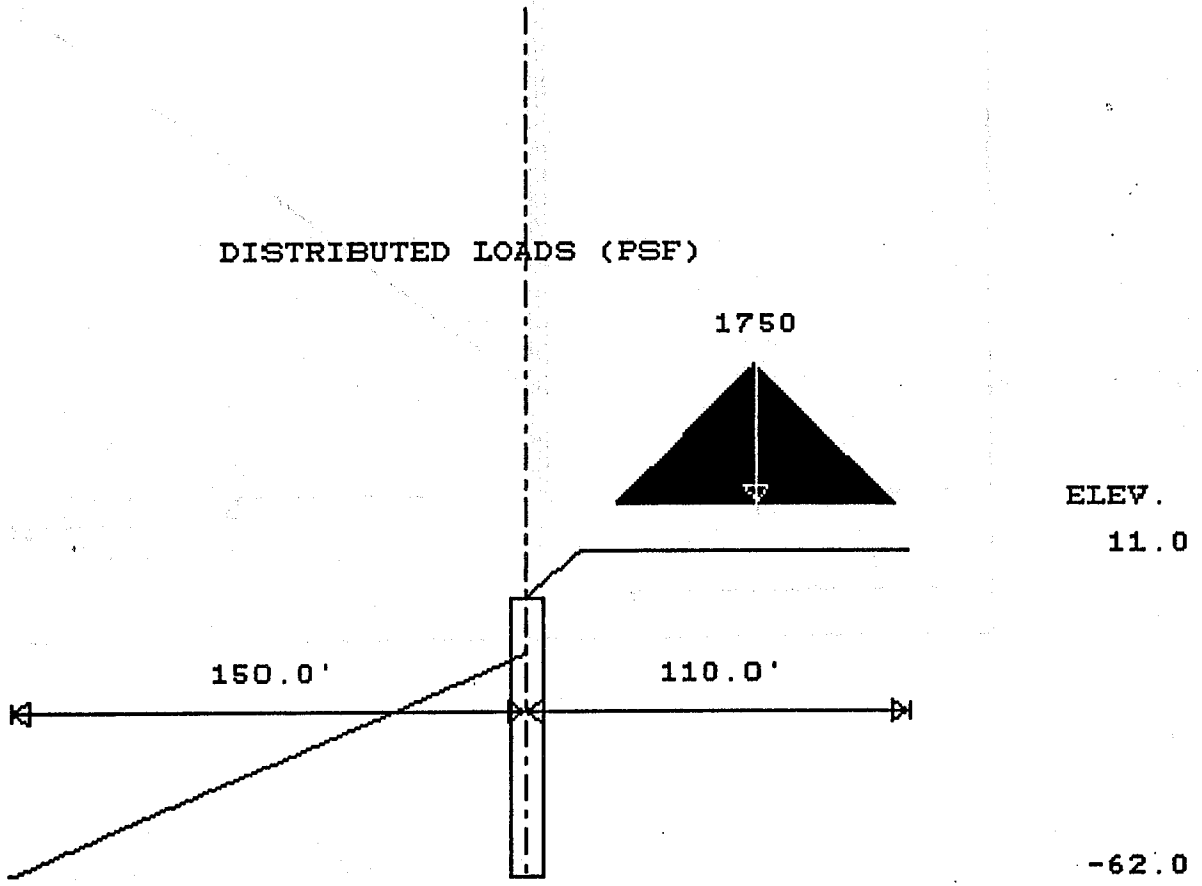


***** INPUT GEOMETRY *****

DATE: 07-AUG-1998 TIME: 09.14.29

'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ

'"SALT2IN", FACILITY NO 9 - ATLANTIC SALT

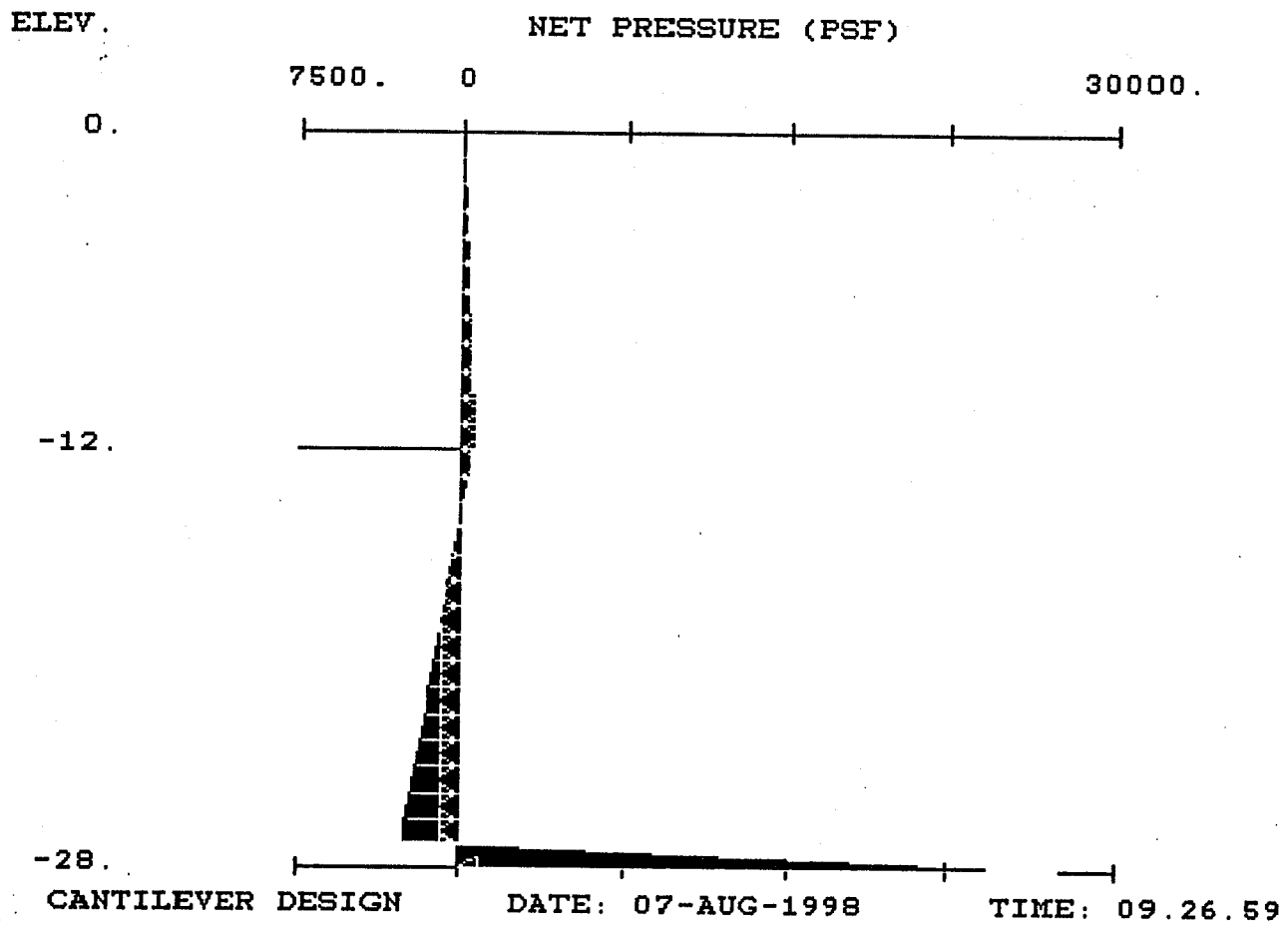


***** SURFACE LOADS *****

DATE: 07-AUG-1998 TIME: 09.16.24

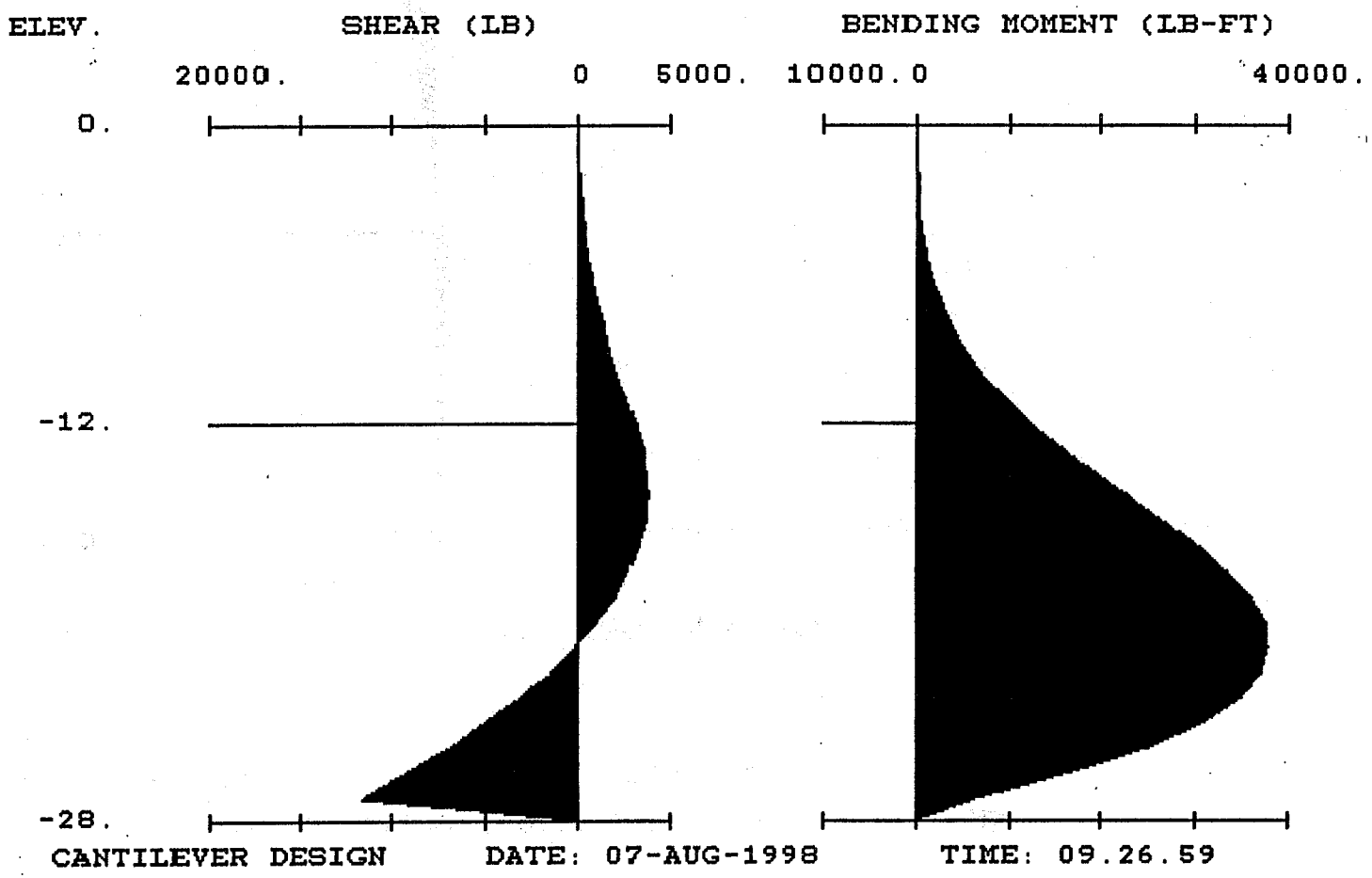
'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ

'"SALT2IN", FACILITY NO 9 - ATLANTIC SALT



'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ

'"SALT2IN", FACILITY NO 9 - ATLANTIC SALT



PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 07-AUG-1998 TIME: 09.14.12

INPUT DATA

I.--HEADING:
'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ
'"SALT2IN", FACILITY NO 9 - ATLANTIC SALT
'CANTILEVER BULKHEAD / 60 FOOT CHANNEL PLUS 2' OVERDREDGE
'MODEL 35 FOOT SALT PILE AS TRIANGULAR SURCHARGE

II.--CONTROL
CANTILEVER WALL DESIGN

LEVEL 1 FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
LEVEL 1 FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

III.--WALL DATA
ELEVATION AT TOP OF WALL = .00 (FT)

IV.--SURFACE POINT DATA

IV.A--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	.00
16.00	11.00
30.00	11.00

IV.B-- LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	-12.00
148.00	-62.00

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE LAYER DATA
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = DEFAULT

SAT.	MOIST	ANGLE OF INTERNAL	COH-	ANGLE OF WALL	ADH-	<--BOTTOM-->	<-SAFETY-> <-FACTOR->

WGHT. (PCF)	WGHT. (PCF)	FRICTION (DEG)	ESION (PSF)	FRICTION (DEG)	ESION (PSF)	ELEV. (FT)	SLOPE (FT/FT)	ACT.	PASS.
130.00	128.00	30.00	.0	15.00	.0			DEF	DEF

V.B.-- LEFTSIDE LAYER DATA

LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
130.00	128.00	30.00	.0	15.00	.0			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)

RIGHTSIDE ELEVATION = .00 (FT)

LEFTSIDE ELEVATION = .00 (FT)

NO SEEPAGE

VII.--SURFACE LOADS

VII.A.--RIGHTSIDE SURFACE LOADS

VII.A.1.--SURFACE LINE LOADS

NONE

VII.A.2.--SURFACE DISTRIBUTED LOADS

<----DIST. FROM WALL----> START (FT)	PEAK (FT)	END (FT)	TRIANGULAR PEAK LOAD (PSF)
26.00	66.00	106.00	1750.00

VII.B.-- LEFTSIDE SURFACE LOADS

NONE

VIII.--HORIZONTAL LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 07-AUG-1998 TIME: 09.20.44

¤ SOIL PRESSURES FOR ¤
¤ CANTILEVER WALL DESIGN ¤

I.--HEADING

'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ
'"SALT2IN", FACILITY NO 9 - ATLANTIC SALT
'CANTILEVER BULKHEAD / 60 FOOT CHANNEL PLUS 2' OVERDREDGE
'MODEL 35 FOOT SALT PILE AS TRIANGULAR SURCHARGE

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

	<-LEFTSIDE PRESSURES->		<---NET PRESSURES----> (SOIL PLUS WATER)		<RIGHTSIDE PRESSURES->	
ELEV. (FT)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
.00	.00	.00	.000	.000	.00	.00
-1.00	.00	.00	43.372	11724.405	43.37	11724.41
-2.00	.00	.00	86.745	8040.646	86.74	8040.65
-3.00	.00	.00	130.117	8990.075	130.12	8990.08
-4.00	.00	.00	173.490	9467.008	173.49	9467.01
-5.00	.00	.00	216.862	10149.400	216.86	10149.40
-6.00	.00	.00	260.235	10940.900	260.23	10940.90
-7.00	.00	.00	303.607	11736.311	303.61	11736.31
-8.00	.00	.00	346.980	12529.991	346.98	12529.99
-9.00	.00	.00	390.352	13323.670	390.35	13323.67
-10.00	.00	.00	433.725	14117.350	433.72	14117.35
-11.00	.00	.00	477.097	14911.030	477.10	14911.03
-12.00	.00	.00	520.470	15704.709	520.47	15704.71
-13.00	233.08	15.94	330.759	16482.446	563.84	16498.39
-14.00	466.17	31.89	141.048	17260.183	607.21	17292.07
-14.74	639.68	43.75	.000	17839.139	639.68	17882.89
-14.87	669.46	45.79	-24.214	17938.529	645.25	17984.32
-15.00	699.25	47.83	-48.428	18037.920	650.82	18085.75
-16.00	932.33	63.77	-239.280	18815.657	693.05	18879.43
-17.00	1165.42	79.71	-438.412	19593.393	727.01	19673.11
-18.00	1398.50	95.66	-648.697	20371.130	749.80	20466.79
-19.00	1631.59	111.60	-863.115	21148.867	768.47	21260.47
-20.00	1864.67	127.54	-1077.163	21926.604	787.51	22054.15
-21.00	2097.75	143.49	-1291.194	22704.341	806.56	22847.83
-22.00	2330.84	159.43	-1505.225	23482.077	825.61	23641.51
-23.00	2563.92	175.37	-1719.256	24259.814	844.66	24435.19
-24.00	2797.00	191.31	-1933.287	25037.551	863.72	25228.87
-25.00	3030.09	207.26	-2147.318	25817.355	882.77	26024.61
-26.00	3263.17	223.20	-2361.350	26600.214	901.82	26823.41
-27.00	3496.25	239.14	-2575.381	27193.985	920.87	27433.13
-28.00	3729.34	255.09	-2789.412	27379.736	939.93	27634.82
-29.00	3962.42	271.03	-3003.443	27323.446	958.98	27594.47
-30.00	4195.51	286.97	-3217.474	27247.915	978.03	27534.89
-31.00	4428.59	302.91	-3431.505	27177.239	997.08	27480.15
-32.00	4661.67	318.86	-3645.561	27106.562	1016.11	27425.42
-33.00	4894.76	334.80	-3859.589	27035.886	1035.17	27370.69
-34.00	5127.84	350.74	-4071.837	26965.209	1056.00	27315.95
-35.00	5360.92	366.69	-4280.557	26894.533	1080.37	27261.22

-36.00	5594.01	382.63	-4487.352	26823.856	1106.65	27206.49
-37.00	5827.09	398.57	-4694.059	26753.180	1133.03	27151.75
-38.00	6060.17	414.52	-4900.798	26682.503	1159.38	27097.02
-39.00	6293.26	430.46	-5107.538	26611.827	1185.72	27042.28
-40.00	6526.34	446.40	-5314.277	26541.150	1212.06	26987.55
-41.00	6759.42	462.34	-5521.017	26470.473	1238.41	26932.82
-42.00	6992.51	478.29	-5727.756	26399.797	1264.75	26878.08
-43.00	7225.59	494.23	-5934.495	26329.120	1291.10	26823.35
-44.00	7458.68	510.17	-6141.235	26258.444	1317.44	26768.62
-45.00	7691.76	526.12	-6347.974	26187.767	1343.79	26713.88
-46.00	7924.84	542.06	-6554.714	26117.091	1370.13	26659.15
-47.00	8157.93	558.00	-6761.453	26046.414	1396.47	26604.42
-48.00	8391.01	573.94	-6968.192	25975.138	1422.82	26549.08
-49.00	8624.09	589.89	-7174.932	25899.245	1449.16	26489.13

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 07-AUG-1998 TIME: 09.26.59

è ë £
¤ SUMMARY OF RESULTS FOR ¤
¤ CANTILEVER WALL DESIGN ¤
à ë ¥

I.--HEADING

'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ
'"SALT2IN", FACILITY NO 9 - ATLANTIC SALT
'CANTILEVER BULKHEAD / 60 FOOT CHANNEL PLUS 2' OVERDREDGE
'MODEL 35 FOOT SALT PILE AS TRIANGULAR SURCHARGE

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

WALL BOTTOM ELEV. (FT) : -27.86
PENETRATION (FT) : 15.86

MAX. BEND. MOMENT (LB-FT) : 38284.
AT ELEVATION (FT) : -20.92

MAX. SCALED DEFL. (LB-IN3): 1.5057E+10
AT ELEVATION (FT) : .00

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF
ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA
IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 07-AUG-1998 TIME: 09.26.59

COMPLETE RESULTS FOR
CANTILEVER WALL DESIGN

I.--HEADING

'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ
'"SALT2IN", FACILITY NO 9 - ATLANTIC SALT
'CANTILEVER BULKHEAD / 60 FOOT CHANNEL PLUS 2' OVERDREDGE
'MODEL 35 FOOT SALT PILE AS TRIANGULAR SURCHARGE

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
.00	0.	0.	1.5057E+10	.00
-1.00	7.	22.	1.4263E+10	43.37
-2.00	58.	87.	1.3469E+10	86.74
-3.00	195.	195.	1.2676E+10	130.12
-4.00	463.	347.	1.1883E+10	173.49
-5.00	904.	542.	1.1091E+10	216.86
-6.00	1561.	781.	1.0300E+10	260.23
-7.00	2479.	1063.	9.5121E+09	303.61
-8.00	3701.	1388.	8.7285E+09	346.98
-9.00	5270.	1757.	7.9513E+09	390.35
-10.00	7229.	2169.	7.1833E+09	433.72
-11.00	9621.	2624.	6.4279E+09	477.10
-12.00	12491.	3123.	5.6891E+09	520.47
-13.00	15843.	3548.	4.9720E+09	330.76
-14.00	19525.	3784.	4.2824E+09	141.05
-14.74	22368.	3837.	3.7905E+09	.00
-14.87	22858.	3835.	3.7082E+09	-24.21
-15.00	23348.	3831.	3.6264E+09	-48.43
-16.00	27123.	3687.	3.0109E+09	-239.28
-17.00	30657.	3348.	2.4421E+09	-438.41
-18.00	33750.	2804.	1.9263E+09	-648.70
-19.00	36195.	2048.	1.4687E+09	-863.11
-20.00	37776.	1078.	1.0735E+09	-1077.16
-21.00	38280.	-106.	7.4348E+08	-1291.19
-22.00	37493.	-1504.	4.7938E+08	-1505.23
-23.00	35201.	-3116.	2.7986E+08	-1719.26
-24.00	31189.	-4943.	1.4092E+08	-1933.29
-25.00	25244.	-6983.	5.5588E+07	-2147.32

-26.00	17152.	-9237.	1.3574E+07	-2361.35
-26.93	7512.	-11526.	1.1495E+06	-2560.38
-27.00	6700.	-11626.	8.5790E+05	-306.01
-27.86	0.	0.	0.0000E+00	27353.67

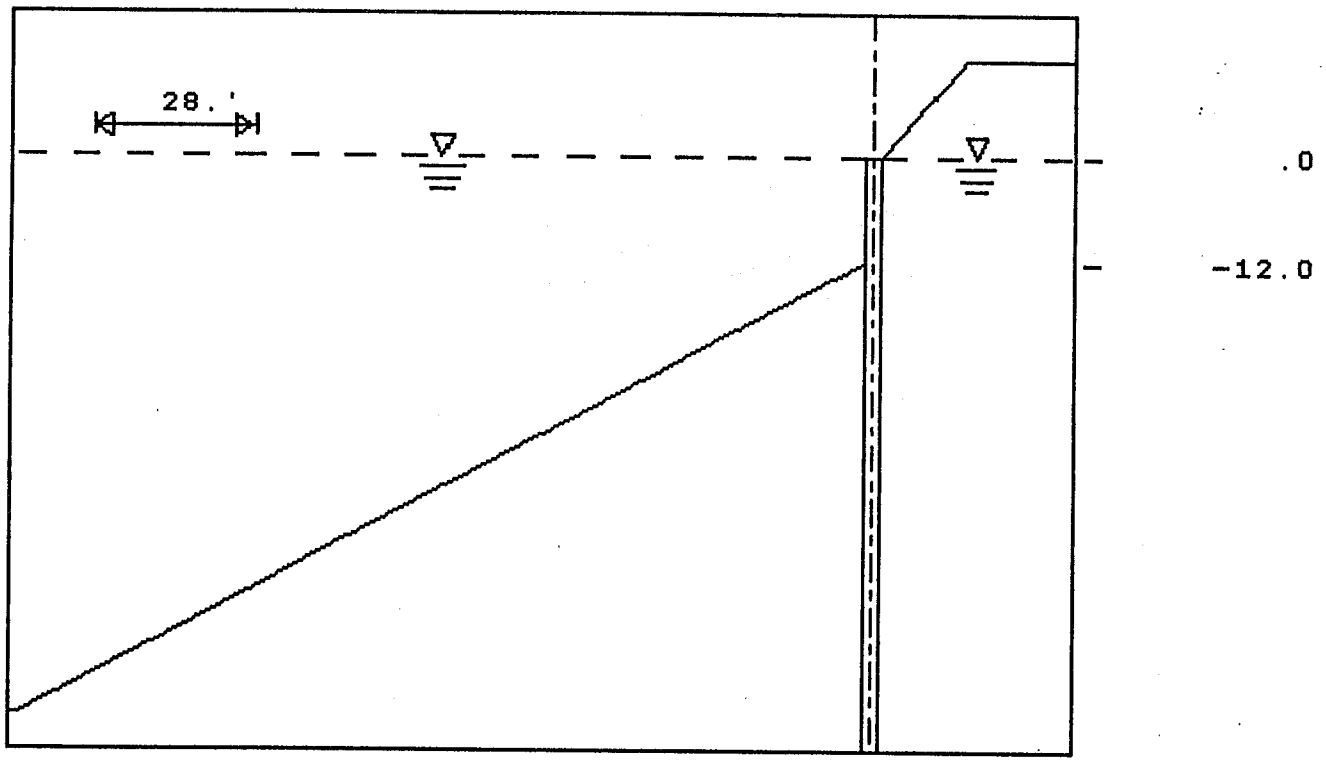
(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

III.--SOIL PRESSURES

ELEVATION	< LEFTSIDE PRESSURE (PSF)>		<RIGHTSIDE PRESSURE (PSF)>	
(FT)	PASSIVE	ACTIVE	ACTIVE	PASSIVE
.00	0.	0.	0.	0.
-1.00	0.	0.	43.	11724.
-2.00	0.	0.	87.	8041.
-3.00	0.	0.	130.	8990.
-4.00	0.	0.	173.	9467.
-5.00	0.	0.	217.	10149.
-6.00	0.	0.	260.	10941.
-7.00	0.	0.	304.	11736.
-8.00	0.	0.	347.	12530.
-9.00	0.	0.	390.	13324.
-10.00	0.	0.	434.	14117.
-11.00	0.	0.	477.	14911.
-12.00	0.	0.	520.	15705.
-13.00	233.	16.	564.	16498.
-14.00	466.	32.	607.	17292.
-14.74	640.	44.	640.	17883.
-14.87	669.	46.	645.	17984.
-15.00	699.	48.	651.	18086.
-16.00	932.	64.	693.	18879.
-17.00	1165.	80.	727.	19673.
-18.00	1399.	96.	750.	20467.
-19.00	1632.	112.	768.	21260.
-20.00	1865.	128.	788.	22054.
-21.00	2098.	143.	807.	22848.
-22.00	2331.	159.	826.	23642.
-23.00	2564.	175.	845.	24435.
-24.00	2797.	191.	864.	25229.
-25.00	3030.	207.	883.	26025.
-26.00	3263.	223.	902.	26823.
-26.93	3480.	238.	920.	27390.
-27.00	3496.	239.	921.	27433.
-27.86	3729.	255.	940.	27635.
-29.00	3962.	271.	959.	27594.

'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ

' "SALT3IN", FACILITY NO 9 - ATLANTIC SALT

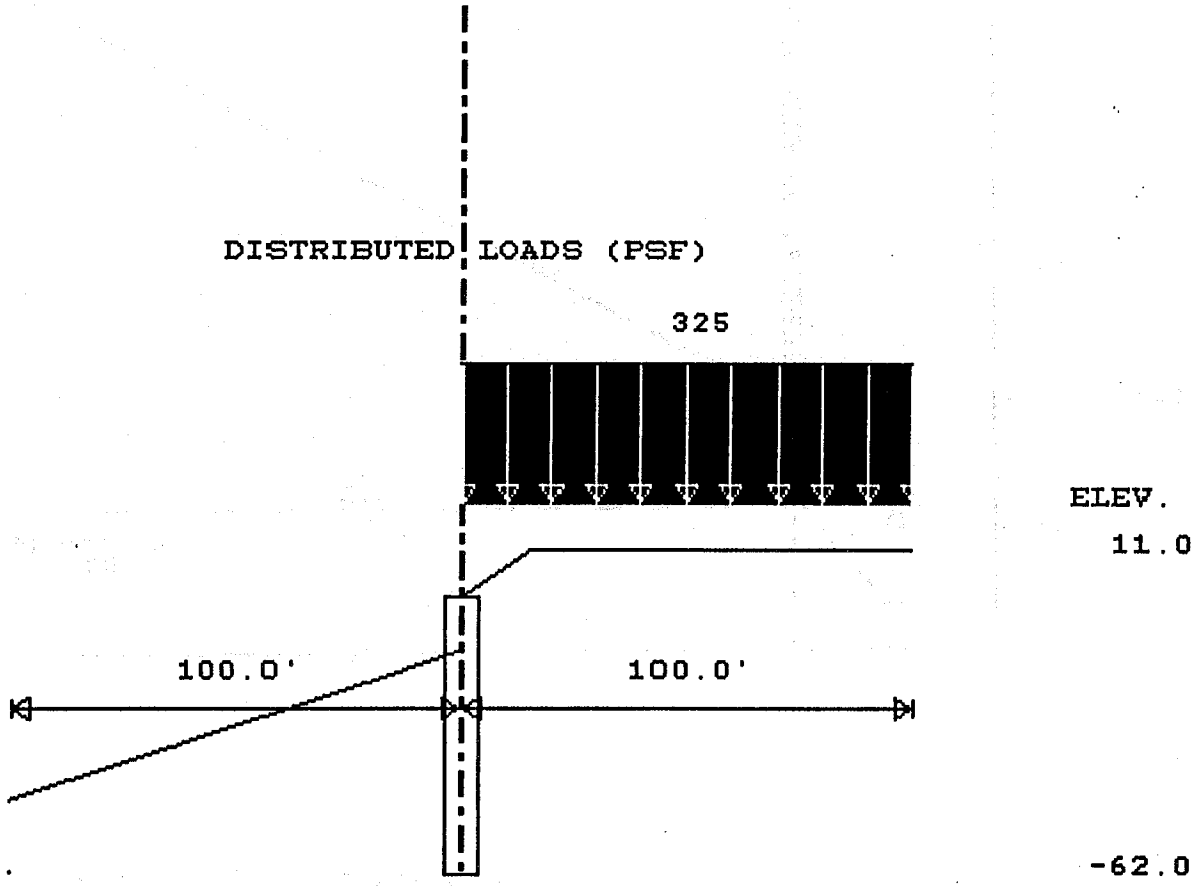


***** INPUT GEOMETRY *****

DATE: 07-AUG-1998 TIME: 10.22.18

'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ

' "SALT3IN", FACILITY NO 9 - ATLANTIC SALT

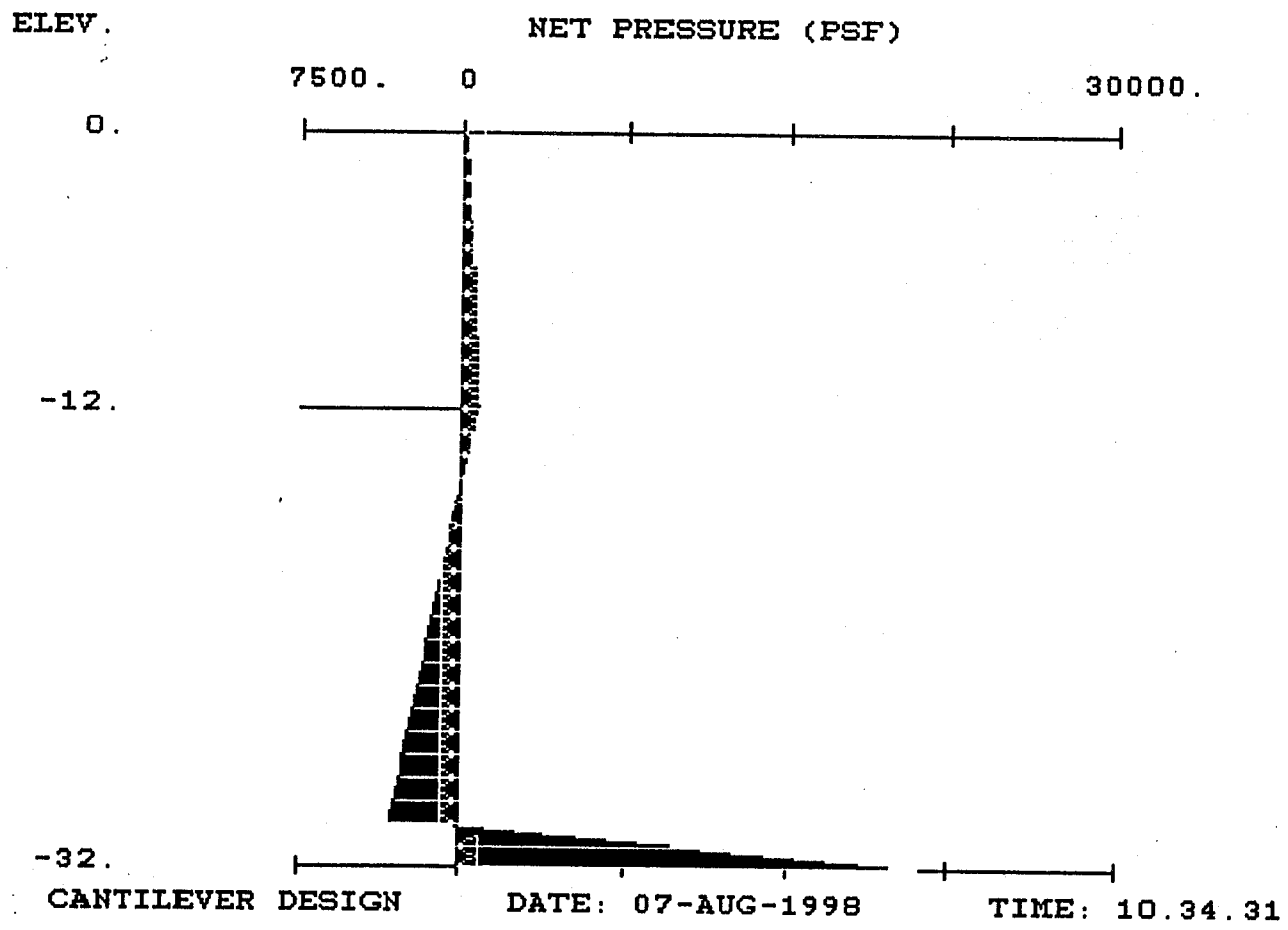


***** SURFACE LOADS *****

DATE: 07-AUG-1998 TIME: 10.27.42

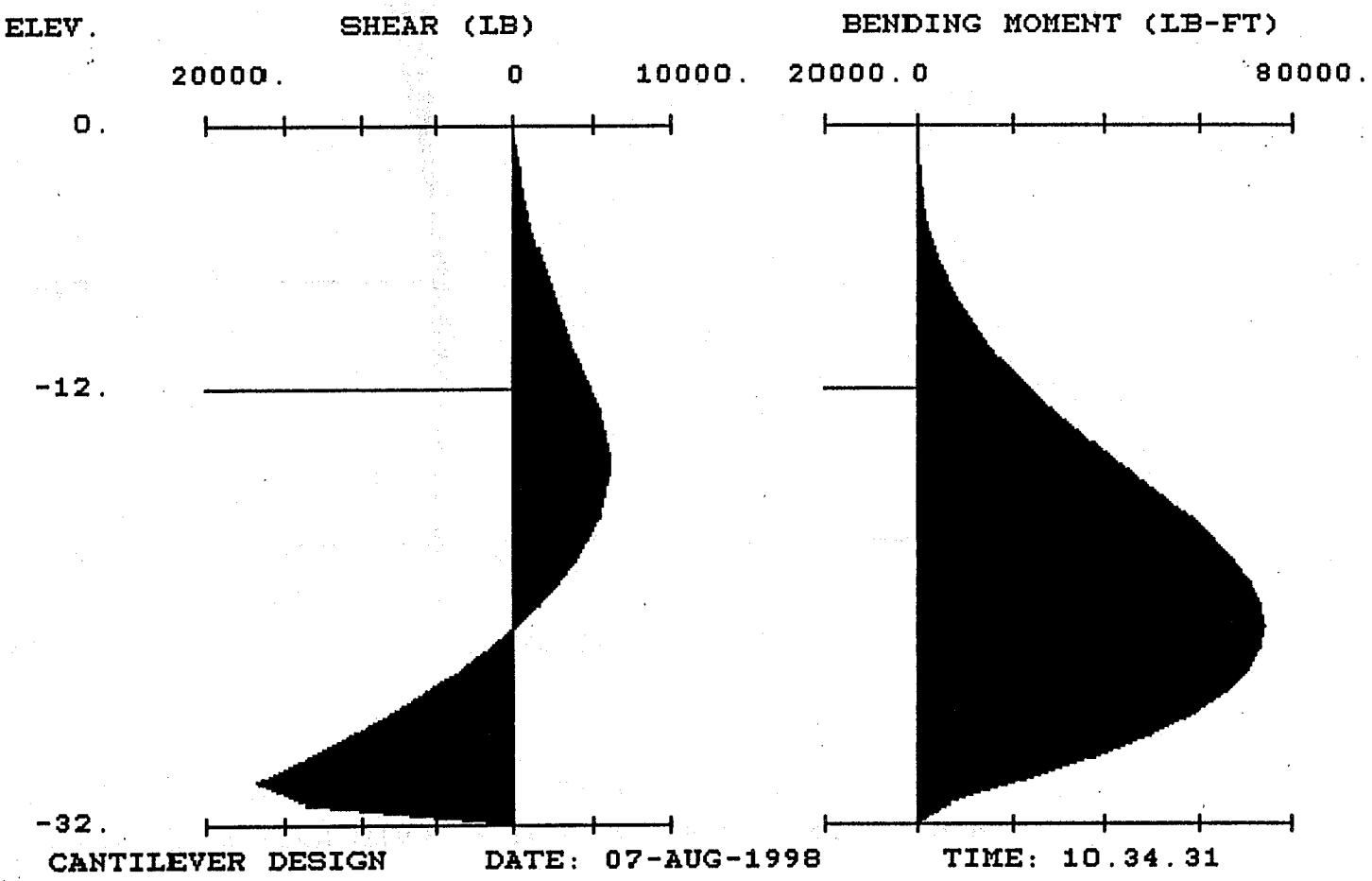
'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ

' "SALT3IN", FACILITY NO 9 - ATLANTIC SALT



'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ

' "SALT3IN", FACILITY NO 9 - ATLANTIC SALT



PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 07-AUG-1998 TIME: 10.21.59

INPUT DATA

I.--HEADING:
'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ
' "SALT3IN", FACILITY NO 9 - ATLANTIC SALT
'60 FOOT CHANNEL PLUS 2' OVERDREDGE/ CANTILEVER BULKHEAD
'UNIFORM SURCHARGE 325 PSF

II.--CONTROL
CANTILEVER WALL DESIGN

LEVEL 1 FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
LEVEL 1 FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

III.--WALL DATA
ELEVATION AT TOP OF WALL = .00 (FT)

IV.--SURFACE POINT DATA

IV.A--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	.00
16.00	11.00
30.00	11.00

IV.B-- LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	-12.00
148.00	-62.00

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE LAYER DATA
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = DEFAULT

SAT.	MOIST	ANGLE OF INTERNAL	COH-	ANGLE OF WALL	ADH-	<--BOTTOM-->	<-SAFETY-> <-FACTOR->

WGHT. (PCF)	WGHT. (PCF)	FRICTION (DEG)	ESION (PSF)	FRICTION (DEG)	ESION (PSF)	ELEV. (FT)	SLOPE (FT/FT)	ACT.	PASS.
130.00	128.00	30.00	.0	15.00	.0			DEF	DEF

V.B.-- LEFTSIDE LAYER DATA

LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = DEFAULT

		ANGLE OF		ANGLE OF				<-SAFETY->	
SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	INTERNAL FRICTION (DEG)	COH-ESION (PSF)	WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-FACTOR-> ACT.	PASS.
130.00	128.00	30.00	.0	15.00	.0			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)

RIGHTSIDE ELEVATION = .00 (FT)

LEFTSIDE ELEVATION = .00 (FT)

NO SEEPAGE

VII.--SURFACE LOADS

VII.A.--RIGHTSIDE SURFACE LOADS

VII.A.1.--SURFACE LINE LOADS

NONE

VII.A.2.--SURFACE DISTRIBUTED LOADS

UNIFORM LOAD = 325.00 (PSF)

VII.B.-- LEFTSIDE SURFACE LOADS

NONE

VIII.--HORIZONTAL LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 07-AUG-1998 TIME: 10.30.10

SOIL PRESSURES FOR
CANTILEVER WALL DESIGN

I.--HEADING

'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ
' "SALT3IN", FACILITY NO 9 - ATLANTIC SALT
'60 FOOT CHANNEL PLUS 2' OVERDREDGE/ CANTILEVER BULKHEAD
'UNIFORM SURCHARGE 325 PSF

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

	<-LEFTSIDE PRESSURES->		<---NET PRESSURES----> (SOIL PLUS WATER)		<RIGHTSIDE PRESSURES->	
ELEV. (FT)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
.00	.00	.00	104.460	2081.324	104.46	2081.32
-1.00	.00	.00	198.942	23550.341	198.94	23550.34
-2.00	.00	.00	242.314	8193.845	242.31	8193.85
-3.00	.00	.00	285.687	10809.885	285.69	10809.89
-4.00	.00	.00	329.059	11179.358	329.06	11179.36
-5.00	.00	.00	372.432	11548.831	372.43	11548.83
-6.00	.00	.00	415.804	11918.304	415.80	11918.30
-7.00	.00	.00	459.177	12287.777	459.18	12287.78
-8.00	.00	.00	502.549	12657.250	502.55	12657.25
-9.00	.00	.00	545.922	13026.723	545.92	13026.72
-10.00	.00	.00	589.294	13396.196	589.29	13396.20
-11.00	.00	.00	632.667	13765.669	632.67	13765.67
-12.00	.00	.00	676.039	14135.142	676.04	14135.14
-13.00	233.08	15.94	486.328	14488.673	719.41	14504.62
-14.00	466.17	31.89	296.617	14842.203	762.78	14874.09
-15.00	699.25	47.83	108.660	15195.733	807.91	15243.56
-15.54	824.26	56.38	.000	15385.348	824.26	15441.73
-15.77	878.30	60.08	-46.967	15467.305	831.33	15527.38
-16.00	932.33	63.77	-93.933	15549.263	838.40	15613.03
-17.00	1165.42	79.71	-323.693	15902.793	841.73	15982.51
-18.00	1398.50	95.66	-553.522	16256.323	844.98	16351.98
-19.00	1631.59	111.60	-769.706	16609.853	861.88	16721.45
-20.00	1864.67	127.54	-983.344	16963.384	881.33	17090.93
-21.00	2097.75	143.49	-1197.375	17316.914	900.38	17460.40
-22.00	2330.84	159.43	-1411.406	17670.444	919.43	17829.87
-23.00	2563.92	175.37	-1625.437	18023.974	938.48	18199.35
-24.00	2797.00	191.31	-1839.468	18377.504	957.54	18568.82
-25.00	3030.09	207.26	-2053.499	18731.034	976.59	18938.29
-26.00	3263.17	223.20	-2267.530	19084.564	995.64	19307.76
-27.00	3496.25	239.14	-2481.561	19438.095	1014.69	19677.24
-28.00	3729.34	255.09	-2695.592	19791.625	1033.75	20046.71
-29.00	3962.42	271.03	-2909.623	20145.155	1052.80	20416.18
-30.00	4195.51	286.97	-3123.654	20498.685	1071.85	20785.66
-31.00	4428.59	302.91	-3337.685	20852.215	1090.90	21155.13
-32.00	4661.67	318.86	-3551.716	21205.745	1109.96	21524.60
-33.00	4894.76	334.80	-3765.747	21559.275	1129.01	21894.08
-34.00	5127.84	350.74	-3979.779	21912.806	1148.06	22263.55
-35.00	5360.92	366.69	-4193.810	22266.336	1167.11	22633.02
-36.00	5594.01	382.63	-4407.841	22619.866	1186.17	23002.50
-37.00	5827.09	398.57	-4621.872	22973.396	1205.22	23371.97
-38.00	6060.17	414.52	-4835.903	23326.926	1224.27	23741.44
-39.00	6293.26	430.46	-5049.934	23680.456	1243.32	24110.91

-40.00	6526.34	446.40	-5263.965	24033.986	1262.38	24480.39
-41.00	6759.42	462.34	-5477.996	24387.517	1281.43	24849.86
-42.00	6992.51	478.29	-5692.027	24741.047	1300.48	25219.33
-43.00	7225.59	494.23	-5906.058	25094.577	1319.53	25588.81
-44.00	7458.68	510.17	-6120.089	25448.107	1338.59	25958.28
-45.00	7691.76	526.12	-6334.120	25801.637	1357.64	26327.75
-46.00	7924.84	542.06	-6548.151	26155.167	1376.69	26697.23
-47.00	8157.93	558.00	-6762.182	26508.697	1395.74	27066.70
-48.00	8391.01	573.94	-6976.213	26862.228	1414.80	27436.17
-49.00	8624.09	589.89	-7190.244	27215.758	1433.85	27805.64

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 07-AUG-1998 TIME: 10.34.31

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¤ SUMMARY OF RESULTS FOR ¤
¤ CANTILEVER WALL DESIGN ¤
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I.--HEADING

'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ
' "SALT3IN", FACILITY NO 9 - ATLANTIC SALT
'60 FOOT CHANNEL PLUS 2' OVERDREDGE/ CANTILEVER BULKHEAD
'UNIFORM SURCHARGE 325 PSF

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

WALL BOTTOM ELEV. (FT) : -31.88
PENETRATION (FT) : 19.88

MAX. BEND. MOMENT (LB-FT) : 74534.
AT ELEVATION (FT) : -23.03

MAX. SCALED DEFL. (LB-IN3): 3.9261E+10
AT ELEVATION (FT) : .00

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF
ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA
IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 07-AUG-1998 TIME: 10.34.31

COMPLETE RESULTS FOR
CANTILEVER WALL DESIGN

I.--HEADING

'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ
' "SALT3IN", FACILITY NO 9 - ATLANTIC SALT
'60 FOOT CHANNEL PLUS 2' OVERDREDGE/ CANTILEVER BULKHEAD
'UNIFORM SURCHARGE 325 PSF

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
.00	0.	0.	3.9261E+10	104.46
-1.00	68.	152.	3.7372E+10	198.94
-2.00	326.	372.	3.5483E+10	242.31
-3.00	827.	636.	3.3595E+10	285.69
-4.00	1613.	944.	3.1708E+10	329.06
-5.00	2729.	1294.	2.9824E+10	372.43
-6.00	4217.	1689.	2.7945E+10	415.80
-7.00	6121.	2126.	2.6073E+10	459.18
-8.00	8483.	2607.	2.4212E+10	502.55
-9.00	11349.	3131.	2.2365E+10	545.92
-10.00	14760.	3699.	2.0538E+10	589.29
-11.00	18761.	4310.	1.8737E+10	632.67
-12.00	23394.	4964.	1.6968E+10	676.04
-13.00	28665.	5545.	1.5240E+10	486.33
-14.00	34421.	5937.	1.3562E+10	296.62
-15.00	40475.	6139.	1.1943E+10	108.66
-15.54	43778.	6169.	1.1102E+10	.00
-15.77	45208.	6163.	1.0746E+10	-46.97
-16.00	46635.	6147.	1.0393E+10	-93.93
-17.00	52697.	5938.	8.9248E+09	-323.69
-18.00	58434.	5499.	7.5473E+09	-553.52
-19.00	63621.	4838.	6.2706E+09	-769.71
-20.00	68038.	3961.	5.1038E+09	-983.34
-21.00	71472.	2871.	4.0544E+09	-1197.37
-22.00	73709.	1566.	3.1284E+09	-1411.41
-23.00	74534.	48.	2.3295E+09	-1625.44
-24.00	73733.	-1684.	1.6592E+09	-1839.47
-25.00	71093.	-3631.	1.1160E+09	-2053.50
-26.00	66400.	-5791.	6.9534E+08	-2267.53
-27.00	59439.	-8166.	3.8912E+08	-2481.56
-28.00	49997.	-10755.	1.8525E+08	-2695.59
-29.00	37859.	-13557.	6.7391E+07	-2909.62

-30.00	22811.	-16574.	1.4532E+07	-3123.65
-30.03	22320.	-16666.	1.3704E+07	-3129.98
-31.00	6674.	-13515.	8.0671E+05	9623.88
-31.88	0.	0.	0.0000E+00	21162.61

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

III.--SOIL PRESSURES

ELEVATION	< LEFTSIDE PRESSURE (PSF)>		<RIGHTSIDE PRESSURE (PSF)>	
(FT)	PASSIVE	ACTIVE	ACTIVE	PASSIVE
.00	0.	0.	104.	2081.
-1.00	0.	0.	199.	23550.
-2.00	0.	0.	242.	8194.
-3.00	0.	0.	286.	10810.
-4.00	0.	0.	329.	11179.
-5.00	0.	0.	372.	11549.
-6.00	0.	0.	416.	11918.
-7.00	0.	0.	459.	12288.
-8.00	0.	0.	503.	12657.
-9.00	0.	0.	546.	13027.
-10.00	0.	0.	589.	13396.
-11.00	0.	0.	633.	13766.
-12.00	0.	0.	676.	14135.
-13.00	233.	16.	719.	14505.
-14.00	466.	32.	763.	14874.
-15.00	699.	48.	808.	15244.
-15.54	824.	56.	824.	15442.
-15.77	878.	60.	831.	15527.
-16.00	932.	64.	838.	15613.
-17.00	1165.	80.	842.	15983.
-18.00	1399.	96.	845.	16352.
-19.00	1632.	112.	862.	16721.
-20.00	1865.	128.	881.	17091.
-21.00	2098.	143.	900.	17460.
-22.00	2331.	159.	919.	17830.
-23.00	2564.	175.	938.	18199.
-24.00	2797.	191.	958.	18569.
-25.00	3030.	207.	977.	18938.
-26.00	3263.	223.	996.	19308.
-27.00	3496.	239.	1015.	19677.
-28.00	3729.	255.	1034.	20047.
-29.00	3962.	271.	1053.	20416.
-30.00	4196.	287.	1072.	20786.
-30.03	4202.	287.	1072.	20797.
-31.00	4429.	303.	1091.	21155.
-31.88	4662.	319.	1110.	21525.
-33.00	4895.	335.	1129.	21894.

CORPS DOCK NO. n/a
NAME: Staten Island Richmond Terrace Road
CHANNEL: Kill Van Kull

FACILITY NO. 10 - RICHMOND TERRACE ROAD

The shoreline along Richmond Terrace Road consists of a riprap embankment and the remains of a timber pile supported bulkhead/wharf. The structural remains include numerous outboard batters. At the top of and along the embankment runs an (apparently) abandoned railroad line. Tracks are in disrepair and are undermined in several locations. Beyond, (inland), of the RR is Richmond Terrace Road. The roadway is estimated to be 12 feet above MLW.

The impact of dredging the existing channel to a 50 depth will be minimal. The design dredge slope of 3:1 will intersect the existing mudline well below MLW, roughly 30 feet outboard of the low tide line.

A 60 deep channel, (62 feet with the maximum allowable overdredge) with a 3:1 side slope will require a vertical cut in the embankment along the shore.

Potential Solution:

Install an anchored bulkhead in the channel bank. Locate the bulkhead behind the existing timber remains to minimize obstructions to driving.

The exposed face of the wall will be in the 20 foot range. A cantilever wall would be structurally feasible however potential deflection will be unacceptable. Applying only lateral earth pressure, (no surcharge), deflections are calculated to roughly 4" with even the stiffest commercial sheet section available, (Nippon Steel FSPZ45).

MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.
Subject PANYNJ Sheet No. 1 of
STATEN ISLAND RICHMOND TERRACE Date 6 19 98
Comp. DDF Check Cont. No.

CROSS SECTION FOR RICHMOND TERRACE IS A COMPOSITE OF:

- ACOE PLAN — KVK & NEWARK BAY CHANNELS NAVIGATION IMPROVEMENT PROJECT CONTRACT 4A PLAN 106+35K TO STA 141+30K 13 JUNE 1984
- USGS — JERSEY CITY QUADRANGLE
- 5.20.98 SITE VISIT

ASSUMPTIONS:

- BULKHEAD WILL HAVE TO BE IN PLACE BEFORE DREDGING
- LOCATE BULKHEAD AT MID TIDE LEVEL, AT THE MIDDLE OF THE RIPRAP SLOPE AND BEHIND THE POTENTIAL OBSTRUCTIONS OF EXISTING TIMBER BULKHEAD, PILES BATTERS WILL REQUIRE RIPRAP EXCAVATION PRIOR TO INSTALLATION
- NO BEDROCK
- SOILS - GRANULAR $\phi = 30°$ $\gamma_{sat} = 130$ pcf
- SURCHARGE (2' OF SOIL) × 125% = 325 psf (SIMILAR TO AASHTO)
- TOP OF BULKHEAD IS ONLY ≈ 2½' ABOVE MLW ∴ ASSUME NO TIDAL LAG (FREE DRAINING BEHIND BULKHEAD

USE ACOE CWALSHT X0031 PROGRAM

I. INVESTIGATE CANTILEVER BULKHEAD
II. INVESTIGATE ANCHORED BULKHEAD AS REQUIRED

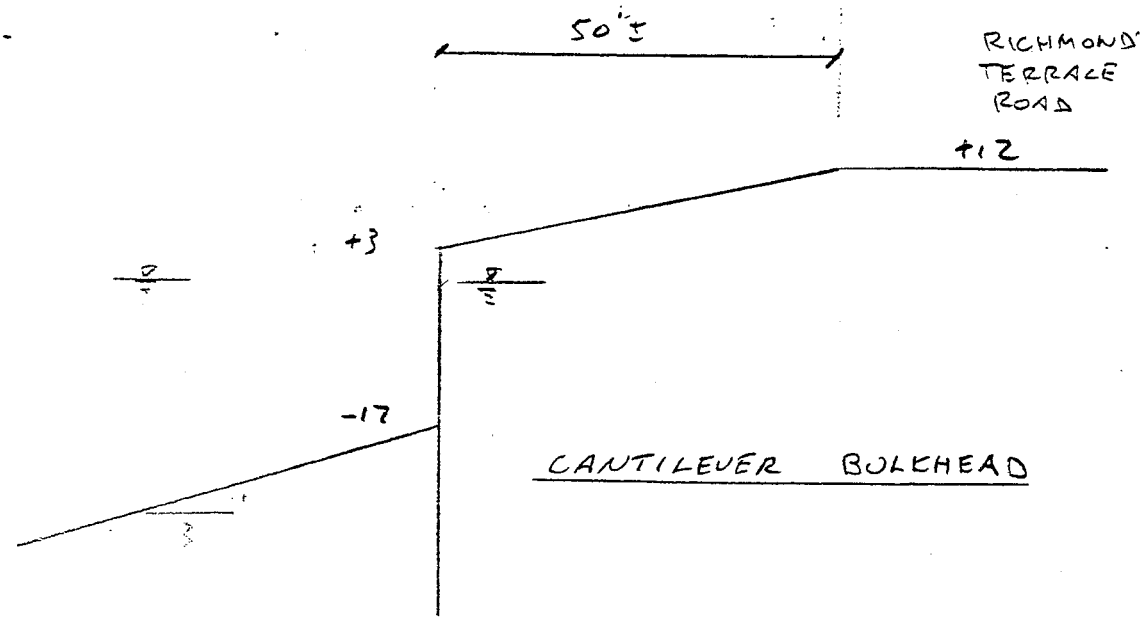
MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.
Subject PA NY CNJ Sheet No. of
SITE #10 RICHMOND TERRACE Date 8 19 98
Comp. DDF Check Cont. No.

- RICHMOND TERRACE : 62' CHANNEL DEPTH

SUMMARY OF CWALSHT RUNS

CASE	INPUT	OUTPUT
CANTILEVER ?25 psf SURCHARGE	TERR1IN	TERR1OUT
CANTILEVER EARTH PRESS ONLY	TERR2IN	TERR2OUT
ANCHORED BULKHEAD	TERR3IN	TERR3OUT



TERRCIN "OUT

EWALSHT RESULTS :

TIP EL	-40.0
PEN (FT)	23.0 FT
M_{MAX} (ft·k)	136.6 f·k
ELEV	-29.0
$\Delta_{MAX} \cdot (EI)$ ($k \cdot in^3$)	1.28 (10)"

A325 sheeting $S_{req'd} = 136.6(12)/25 = 65.6\ in^3$

⇒ ARBED BZ37 $S = 67.9\ in^3$ 47.9 psf

$I = 467.7$

⇒ $\Delta = 1.28(10)^{"}/(29(10)^6)(467.7) = 9.4"$ excessive

THE USE OF GR. 50 SHEETING WOULD ALLOW FOR A LIGHTER SHEET HOWEVER Δ WOULD BE GREATER

INVESTIGATE NO SURCHARGE CONDITION

TERRIN
TERROUT $\Delta = 6.65\,(10)^{10} / E\,(467) = 4.9''$

TO REDUCE Δ, THE OPTIONS ARE A KING PILE SYSTEM (H-Z) OR AN ANCHORED BULKHEAD.

- $I_{(in^4)}$ per l.f. of wall required to reduce Δ to 2".

$$6.65\,(10)^{10} / E\,(I) = 2.0$$

$$I = 1,146\ in^4 \text{ per Ft of wall}$$

∴ CONSIDER AN ANCHORED BULKHEAD

TOP OF WALL @ +3.0
⇒ SET ANCHOR AT MLW
325 psf SURCHARGE

CWALSHT RESULTS (TERRIN OUT)

METHOD	:	FREE EARTH	EQUIV. BEAM	FIXED EARTH
WALL BOTTOM ELEV. (FT)	:	-25.80	-31.04	-30.86
PENETRATION (FT)	:	8.80	14.04	13.86
MAX. BEND. MOMENT (LB-FT)	:	-30206.	-22051.	-22596.
AT ELEVATION (FT)	:	-12.20	-10.76	-10.86
MAX. SCALED DEFL. (LB-IN3)	:	3.3646E+09	-1.6463E+09	2.2722E+09
AT ELEVATION (FT)	:	-13.00	-31.04	-12.00
ANCHOR FORCE (LB)	:	4970.	4260.	4310.

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

WALL SECTION:

$S_{req'd} = 22.6(12)/25 = 10.85\ in^3$

⇒ ARBED AZ13 $S = 24.2$ 21.42 psf wall

$I = 144.3$

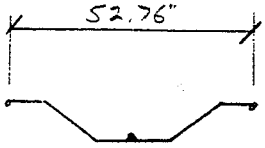
$\Delta = 0.54"$

also

⇒ HOESCH H116 $S = 22.3\ in^3$ 23.8 psf wall

$I = 109.9\ in^4$

USING AZ13



Req'd Pen = 13.83 $13.83 \times 1.25 = 17.3' \approx 18'$

⇒ sheet length: 38'

ANCHOR SPACING: 3 pair = 13.14'/2 pair = 8.8'

ANCHOR FORCE: 4.31 KLF

INCREASE BY 30% FOR SIZING TIEBACKS

$4.31(1.3) = 5.6$ KLF

TIE ROD:

@ 3 pair $5.6(13.19)/.6(36) = 3.4\ in^2$

requires 2 1/4" upset to 2 3/4" $A = 3.975\ in^2$

@ 2 pair $2.28\ in^2$ req'd:

1 3/4" upset to 2 1/4" $A = 2.4\ in^2$

WALE

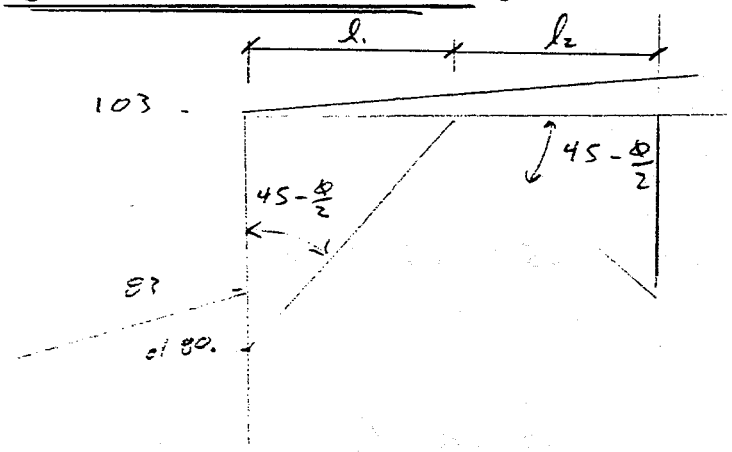
3 pair $M \approx \frac{wl^2}{10}$ $5.6\,(13.19)^2/10 = 97.43^{1.1k}$, $S_{reqd} = 54.1\,in^3$

2 pair $43.4^{1.1k}$ $S_{reqd} = 24.1\,in^3$

3 pair 2 channels C 12×30

2 pair " " C 10×15.3

DEADMAN LOCATION:



$45 - \Phi/2 = 30°$

$\frac{l_1}{23} = \tan 30°$ $l_1 = 13.3'$

RESISTANCE AT DEADMAN = $P_p - P_a$

$= \gamma \frac{d}{2}^2 K_p - \gamma \frac{d}{2}^2 K_a = \frac{\gamma d^2}{2}(K_p - K_a)$

$K_p = \tan^2\left(45 + \frac{30}{2}\right)$ $K_a = \tan^2\left(45 - \frac{30}{2}\right)$

$K_p - K_a = 3.0 - 0.333 = 2.67$

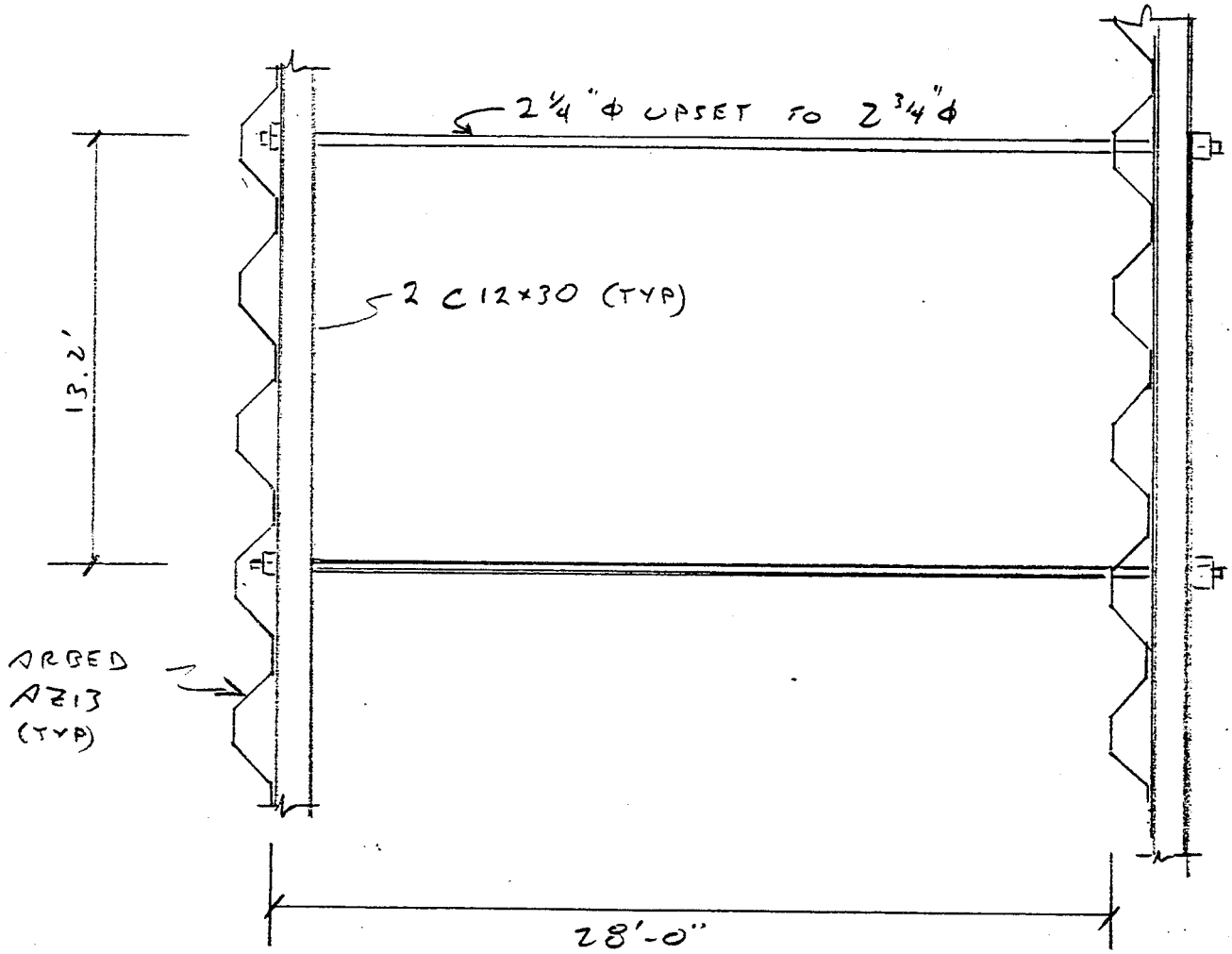
CONSERVATIVELY USE $\gamma_t = 130 - 64 = 66$ pcf

$\approx$ 5.6 klf

$$5.6 = .066 \frac{(d)^2}{2} (2.67) = \quad d = 8'$$

$$8/l_2 = \tan 45 - \frac{\phi}{2} \qquad l_2 = 14'$$

$\therefore$ SET DEADMAN 13.3' + 14' $\approx$ 28' BEHIND BULKHEAD



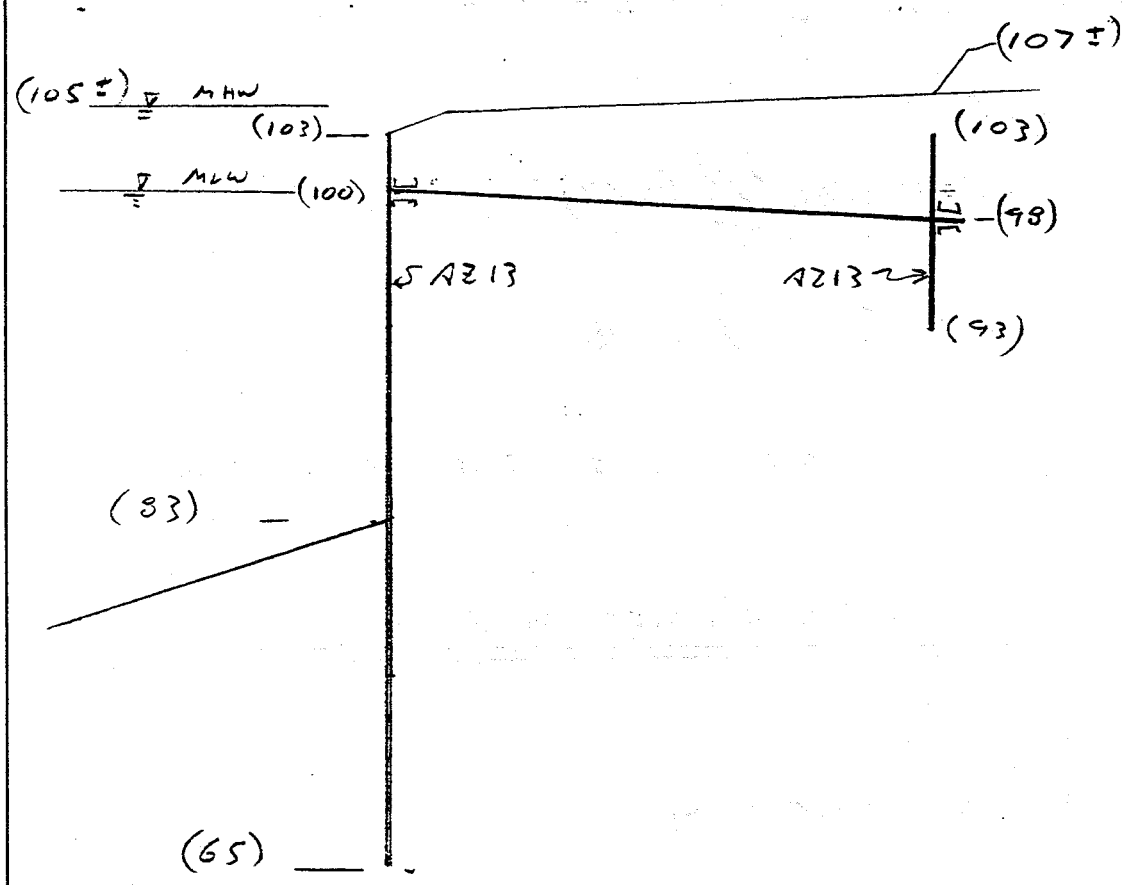
MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.

Subject PANYNJ Sheet No. 7 of

S. I. RICHMOND TERRACE Date 19

Comp. DOF Check Cont. No.



MAGUIRE GROUP

Project NAVIGATION STUDY Acc. No.

Subject RICHMOND TERRACE SITE 10 Sheet No. of

Date 19

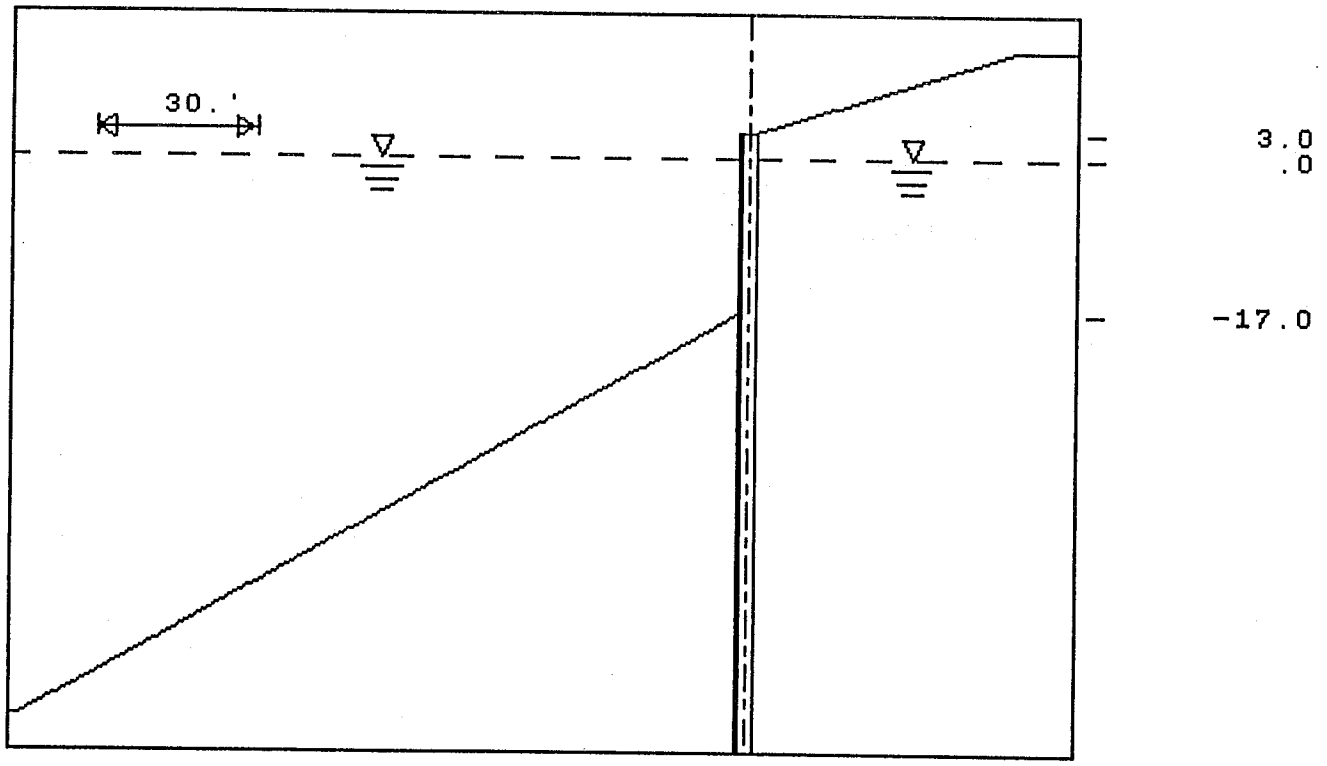
Comp. Check Cont. No.

RICHMOND TERRACE

CWALSHT RUNS

'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ

'FACILITY NO 10 - STATEN ISLAND RICHMOND TERRACE

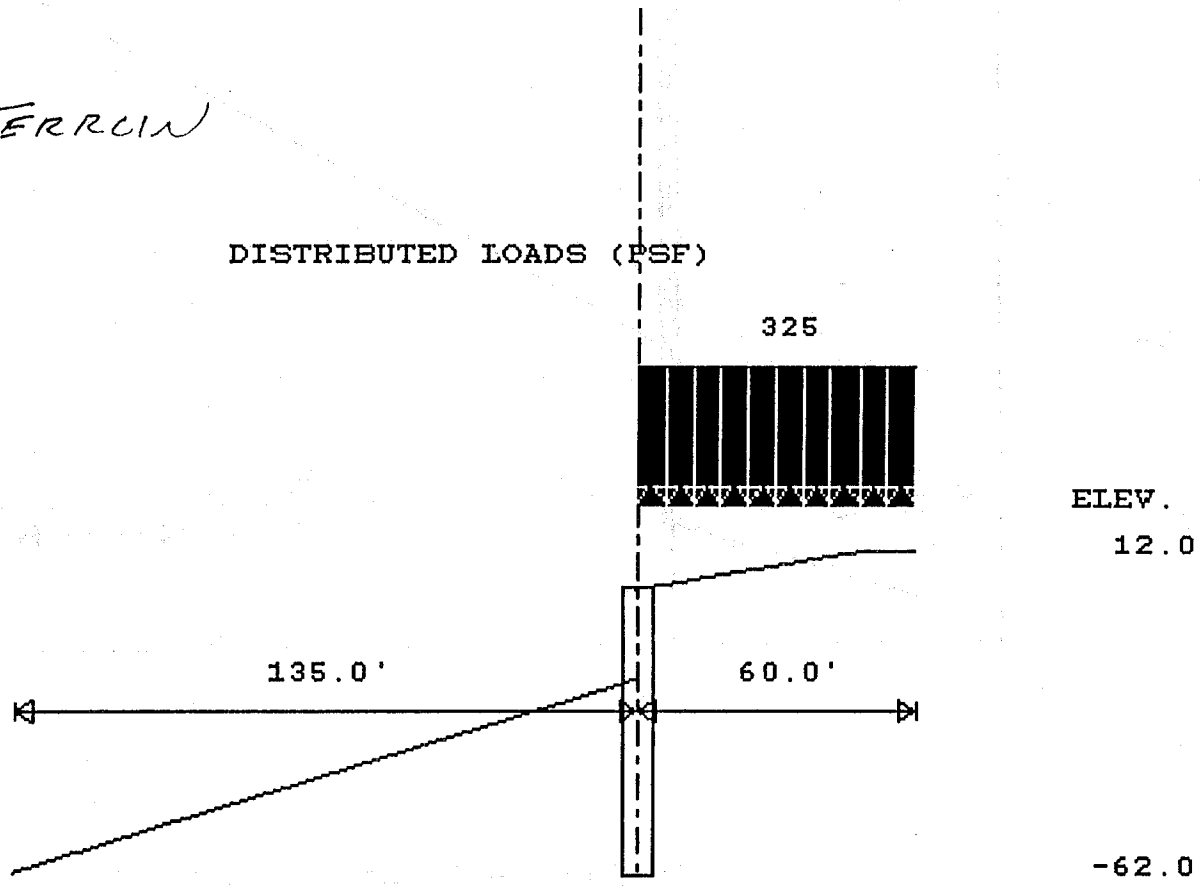


***** INPUT GEOMETRY *****

DATE: 08-AUG-1998 TIME: 11.43.58

'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ
'FACILITY NO 10 - STATEN ISLAND RICHMOND TERRACE

TERRCIN

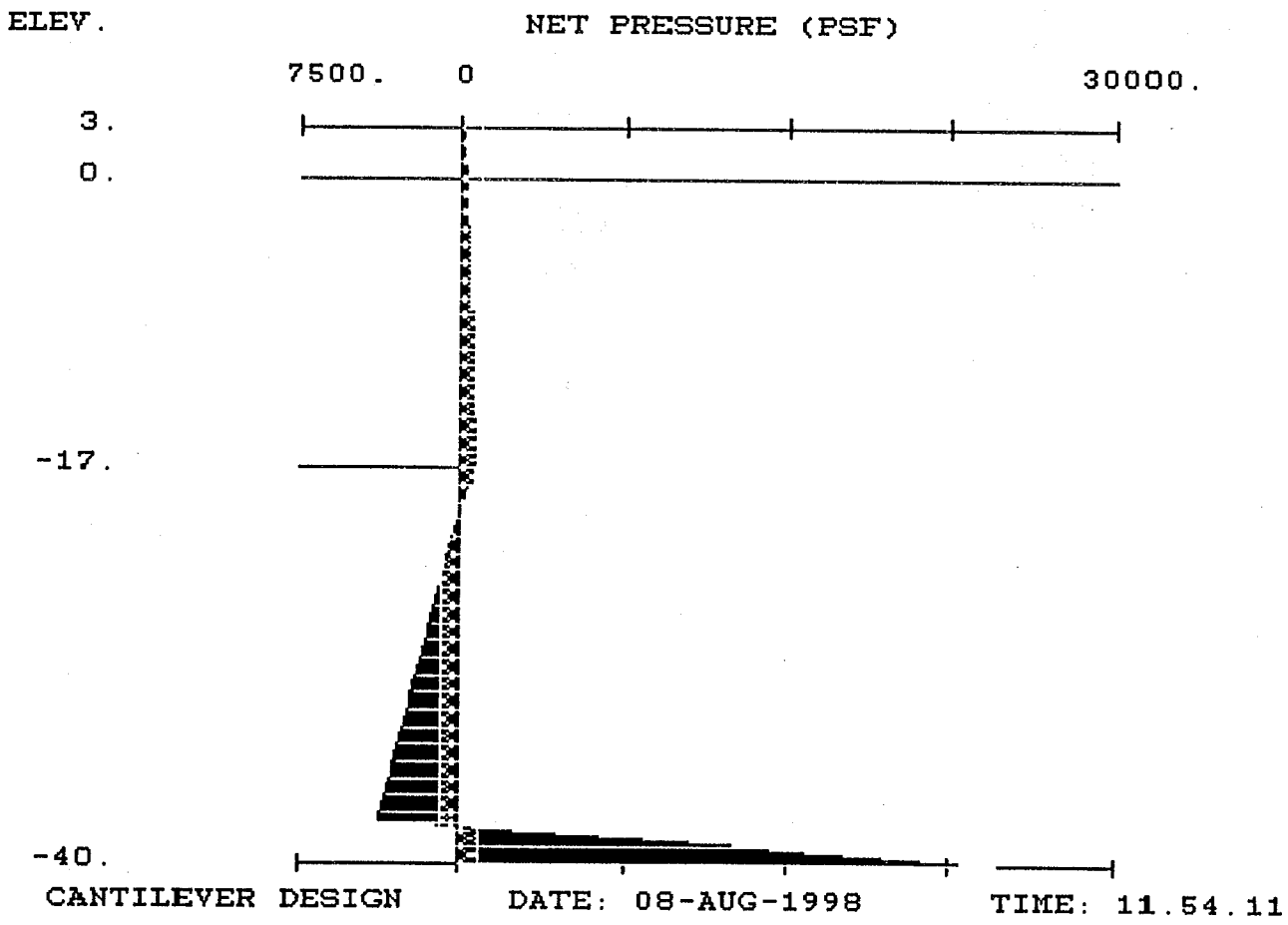


***** SURFACE LOADS *****

DATE: 08-AUG-1998 TIME: 11.45.26

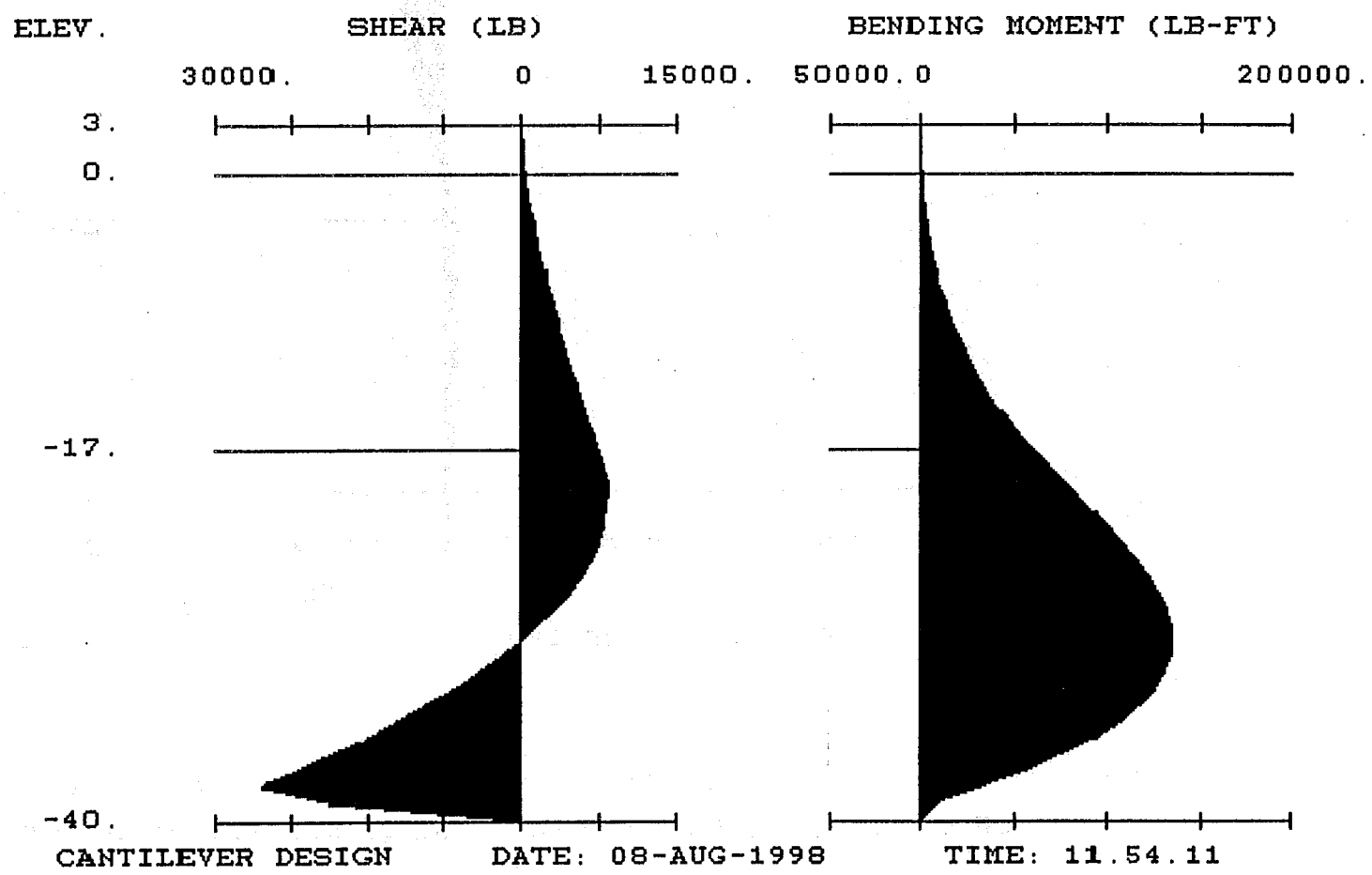
'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ

'FACILITY NO 10 - STATEN ISLAND RICHMOND TERRACE



'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ

'FACILITY NO 10 - STATEN ISLAND RICHMOND TERRACE



PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 08-AUG-1998 TIME: 11.43.40

INPUT DATA

I.--HEADING:
'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ
'FACILITY NO 10 - STATEN ISLAND RICHMOND TERRACE
'CANTILEVER BULKHEAD / 60 FOOT CHANNEL
'325 PSF SURCHARGE

II.--CONTROL
CANTILEVER WALL DESIGN

LEVEL 1 FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
LEVEL 1 FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

III.--WALL DATA
ELEVATION AT TOP OF WALL = 3.00 (FT)

IV.--SURFACE POINT DATA

IV.A--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	3.00
50.00	12.00
60.00	12.00

IV.B-- LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	-17.00
135.00	-62.00

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE LAYER DATA
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
130.00	125.00	30.00	.0	15.00	.0			DEF	DEF

V.B.-- LEFTSIDE LAYER DATA

LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
130.00	125.00	30.00	.0	15.00	.0			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)

RIGHTSIDE ELEVATION = .00 (FT)

LEFTSIDE ELEVATION = .00 (FT)

NO SEEPAGE

VII.--SURFACE LOADS

VII.A.--RIGHTSIDE SURFACE LOADS

VII.A.1.--SURFACE LINE LOADS

NONE

VII.A.2.--SURFACE DISTRIBUTED LOADS

UNIFORM LOAD = 325.00 (PSF)

VII.B.-- LEFTSIDE SURFACE LOADS

NONE

VIII.--HORIZONTAL LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 08-AUG-1998 TIME: 11.49.27

SOIL PRESSURES FOR
CANTILEVER WALL DESIGN

I.--HEADING

'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ

'FACILITY NO 10 - STATEN ISLAND RICHMOND TERRACE

'CANTILEVER BULKHEAD / 60 FOOT CHANNEL
'325 PSF SURCHARGE

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

	<-LEFTSIDE PRESSURES->		<---NET PRESSURES----> (SOIL PLUS WATER)		<RIGHTSIDE PRESSURES->	
ELEV. (FT)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
3.00	.00	.00	99.881	1748.638	99.88	1748.64
2.00	.00	.00	145.036	3661.594	145.04	3661.59
1.00	.00	.00	185.239	4677.055	185.24	4677.06
.00	.00	.00	221.117	5608.655	221.12	5608.65
-1.00	.00	.00	248.746	6380.271	248.75	6380.27
-2.00	.00	.00	272.050	7068.026	272.05	7068.03
-3.00	.00	.00	295.220	7753.201	295.22	7753.20
-4.00	.00	.00	318.458	8439.665	318.46	8439.67
-5.00	.00	.00	341.695	9126.130	341.70	9126.13
-6.00	.00	.00	364.933	9812.595	364.93	9812.59
-7.00	.00	.00	388.170	10499.059	388.17	10499.06
-8.00	.00	.00	411.408	11185.524	411.41	11185.52
-9.00	.00	.00	434.645	11871.989	434.65	11871.99
-10.00	.00	.00	457.883	12558.453	457.88	12558.45
-11.00	.00	.00	481.120	13244.918	481.12	13244.92
-12.00	.00	.00	504.358	13931.383	504.36	13931.38
-13.00	.00	.00	527.595	14617.847	527.60	14617.85
-14.00	.00	.00	550.833	15304.312	550.83	15304.31
-15.00	.00	.00	574.070	16009.048	574.07	16009.05
-16.00	.00	.00	597.308	16568.044	597.31	16568.04
-17.00	.00	.00	620.545	16785.908	620.55	16785.91
-18.00	234.24	15.98	409.546	16904.236	643.78	16920.21
-19.00	468.47	31.96	198.547	17195.725	667.02	17227.68
-19.94	688.89	46.99	.000	17536.636	688.89	17583.63
-19.97	695.80	47.46	-6.226	17547.326	689.57	17594.79
-20.00	702.71	47.93	-12.452	17558.017	690.26	17605.95
-21.00	936.95	63.91	-223.451	17911.512	713.49	17975.42
-22.00	1171.18	79.89	-434.450	18265.007	736.73	18344.90
-23.00	1405.42	95.87	-645.449	18618.503	759.97	18714.37
-24.00	1639.66	111.84	-856.448	18971.998	783.21	19083.84
-25.00	1873.89	127.82	-1067.447	19325.494	806.44	19453.31
-26.00	2108.13	143.80	-1278.446	19678.989	829.68	19822.79
-27.00	2342.37	159.78	-1489.445	20032.484	852.92	20192.26
-28.00	2576.60	175.75	-1700.444	20385.980	876.16	20561.73
-29.00	2810.84	191.73	-1911.444	20739.475	899.39	20931.21
-30.00	3045.07	207.71	-2122.443	21092.970	922.63	21300.68
-31.00	3279.31	223.69	-2333.442	21446.466	945.87	21670.15
-32.00	3513.55	239.66	-2544.441	21799.961	969.11	22039.63
-33.00	3747.78	255.64	-2755.440	22153.457	992.34	22409.10
-34.00	3982.02	271.62	-2966.439	22506.952	1015.58	22778.57
-35.00	4216.26	287.60	-3177.438	22860.447	1038.82	23148.05
-36.00	4450.49	303.58	-3388.437	23213.943	1062.06	23517.52
-37.00	4684.73	319.55	-3599.436	23567.438	1085.29	23886.99
-38.00	4918.97	335.53	-3810.435	23920.933	1108.53	24256.46
-39.00	5153.20	351.51	-4021.434	24274.429	1131.77	24625.94
-40.00	5387.44	367.49	-4232.433	24627.924	1155.01	24995.41

-41.00	5621.68	383.46	-4443.432	24981.420	1178.24	25364.88
-42.00	5855.91	399.44	-4654.431	25334.915	1201.48	25734.36
-43.00	6090.15	415.42	-4865.430	25688.410	1224.72	26103.83
-44.00	6324.39	431.40	-5076.429	26041.906	1247.96	26473.30
-45.00	6558.62	447.37	-5287.428	26395.401	1271.19	26842.78
-46.00	6792.86	463.35	-5498.427	26748.896	1294.43	27212.25
-47.00	7027.10	479.33	-5709.426	27102.392	1317.67	27581.72
-48.00	7261.33	495.31	-5920.425	27455.887	1340.91	27951.19
-49.00	7495.57	511.29	-6131.424	27809.383	1364.14	28320.67
-50.00	7729.80	527.26	-6342.424	28162.878	1387.38	28690.14
-51.00	7964.04	543.24	-6553.423	28516.373	1410.62	29059.61
-52.00	8198.28	559.22	-6764.422	28869.869	1433.86	29429.09
-53.00	8432.51	575.20	-6975.421	29223.364	1457.09	29798.56
-54.00	8666.75	591.17	-7186.420	29576.859	1480.33	30168.03
-55.00	8900.99	607.15	-7397.419	29930.355	1503.57	30537.51
-56.00	9135.22	623.13	-7608.418	30283.850	1526.81	30906.98
-57.00	9369.46	639.11	-7819.417	30637.346	1550.04	31276.45
-58.00	9603.70	655.08	-8030.416	30990.841	1573.28	31645.92
-59.00	9837.93	671.06	-8241.415	31344.336	1596.52	32015.40
-60.00	10072.17	687.04	-8452.414	31697.832	1619.76	32384.87
-61.00	10306.41	703.02	-8663.413	32051.327	1642.99	32754.34
-62.00	10540.64	718.99	-8874.412	32404.822	1666.23	33123.82
-63.00	10774.88	734.97	-9085.411	32758.318	1689.47	33493.29
-64.00	11009.12	750.95	-9296.410	33111.813	1712.71	33862.76
-65.00	11243.35	766.93	-9507.409	33465.308	1735.94	34232.24
-66.00	11477.59	782.91	-9718.408	33818.804	1759.18	34601.71
-67.00	11711.83	798.88	-9929.407	34172.299	1782.42	34971.18
-68.00	11946.06	814.86	-10140.406	34525.795	1805.66	35340.66
-69.00	12180.30	830.84	-10351.405	34879.290	1828.89	35710.13
-70.00	12414.54	846.82	-10562.404	35232.785	1852.13	36079.60
-71.00	12648.77	862.79	-10773.404	35586.281	1875.37	36449.07
-72.00	12883.01	878.77	-10984.403	35939.776	1898.61	36818.55
-73.00	13117.24	894.75	-11195.044	36293.271	1922.20	37188.02
-74.00	13351.48	910.73	-11408.741	36646.767	1942.74	37557.49
-75.00	13585.72	926.70	-11627.369	37000.262	1958.35	37926.97
-76.00	13819.95	942.68	-11845.116	37353.758	1974.84	38296.44
-77.00	14054.19	958.66	-12060.346	37707.253	1993.84	38665.91
-78.00	14288.43	974.64	-12275.496	38060.748	2012.93	39035.39

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 08-AUG-1998 TIME: 11.54.11

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¤  SUMMARY OF RESULTS FOR  ¤
¤  CANTILEVER WALL DESIGN  ¤
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I.--HEADING

'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ
'FACILITY NO 10 - STATEN ISLAND RICHMOND TERRACE
'CANTILEVER BULKHEAD / 60 FOOT CHANNEL
'325 PSF SURCHARGE

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

WALL BOTTOM ELEV. (FT)	:	-40.00
PENETRATION (FT)	:	23.00
MAX. BEND. MOMENT (LB-FT)	:	136640.
AT ELEVATION (FT)	:	-28.97
MAX. SCALED DEFL. (LB-IN3):		1.2806E+11
AT ELEVATION (FT)	:	3.00

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 08-AUG-1998 TIME: 11.54.11

COMPLETE RESULTS FOR
CANTILEVER WALL DESIGN

I.--HEADING

'HARBOR NAVIGATION STUDY - PORT AUTHORITY OF NY & NJ
'FACILITY NO 10 - STATEN ISLAND RICHMOND TERRACE
'CANTILEVER BULKHEAD / 60 FOOT CHANNEL
'325 PSF SURCHARGE

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
3.00	0.	0.	1.2806E+11	99.88
2.00	57.	122.	1.2359E+11	145.04
1.00	259.	288.	1.1912E+11	185.24
.00	645.	491.	1.1466E+11	221.12

-1.00	1251.	726.	1.1019E+11	248.75
-2.00	2105.	986.	1.0572E+11	272.05
-3.00	3231.	1270.	1.0126E+11	295.22
-4.00	4652.	1577.	9.6809E+10	318.46
-5.00	6392.	1907.	9.2362E+10	341.70
-6.00	8473.	2260.	8.7927E+10	364.93
-7.00	10920.	2637.	8.3505E+10	388.17
-8.00	13754.	3036.	7.9103E+10	411.41
-9.00	17000.	3459.	7.4725E+10	434.65
-10.00	20681.	3906.	7.0376E+10	457.88
-11.00	24819.	4375.	6.6063E+10	481.12
-12.00	29439.	4868.	6.1793E+10	504.36
-13.00	34563.	5384.	5.7573E+10	527.60
-14.00	40214.	5923.	5.3414E+10	550.83
-15.00	46416.	6485.	4.9324E+10	574.07
-16.00	53193.	7071.	4.5314E+10	597.31
-17.00	60566.	7680.	4.1397E+10	620.55
-18.00	68522.	8195.	3.7584E+10	409.55
-19.00	76886.	8499.	3.3890E+10	198.55
-19.94	84943.	8593.	3.0534E+10	.00
-19.97	85196.	8593.	3.0431E+10	-6.23
-20.00	85450.	8592.	3.0328E+10	-12.45
-21.00	94001.	8474.	2.6914E+10	-223.45
-22.00	102328.	8145.	2.3663E+10	-434.45
-23.00	110221.	7605.	2.0588E+10	-645.45
-24.00	117468.	6854.	1.7704E+10	-856.45
-25.00	123859.	5892.	1.5023E+10	-1067.45
-26.00	129183.	4720.	1.2555E+10	-1278.45
-27.00	133228.	3336.	1.0310E+10	-1489.45
-28.00	135784.	1741.	8.2960E+09	-1700.44
-29.00	136639.	-65.	6.5158E+09	-1911.44
-30.00	135583.	-2082.	4.9716E+09	-2122.44
-31.00	132404.	-4310.	3.6613E+09	-2333.44
-32.00	126892.	-6749.	2.5794E+09	-2544.44
-33.00	118836.	-9399.	1.7165E+09	-2755.44
-34.00	108024.	-12260.	1.0585E+09	-2966.44
-35.00	94245.	-15332.	5.8675E+08	-3177.44
-36.00	77290.	-18615.	2.7740E+08	-3388.44
-37.00	56945.	-22109.	1.0112E+08	-3599.44
-37.65	41745.	-24502.	4.1324E+07	-3737.10
-38.00	33088.	-25071.	2.2722E+07	465.69
-39.00	10265.	-18559.	1.5879E+06	12557.28
-40.00	0.	0.	0.0000E+00	24627.29

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

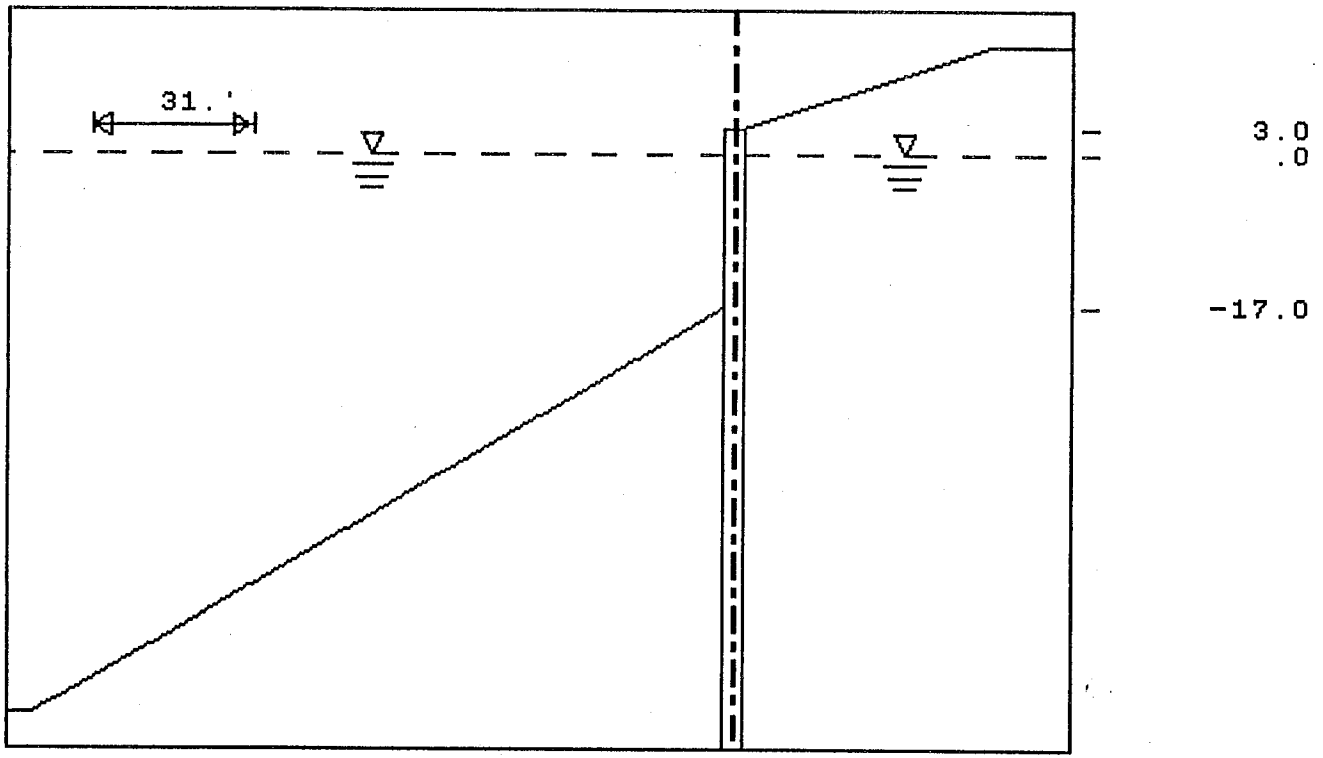
III.--SOIL PRESSURES

ELEVATION	< LEFTSIDE PRESSURE (PSF)>		<RIGHTSIDE PRESSURE (PSF)>	
(FT)	PASSIVE	ACTIVE	ACTIVE	PASSIVE
3.00	0.	0.	100.	1749.
2.00	0.	0.	145.	3662.
1.00	0.	0.	185.	4677.
.00	0.	0.	221.	5609.
-1.00	0.	0.	249.	6380.
-2.00	0.	0.	272.	7068.
-3.00	0.	0.	295.	7753.
-4.00	0.	0.	318.	8440.

-5.00	0.	0.	342.	9126.
-6.00	0.	0.	365.	9813.
-7.00	0.	0.	388.	10499.
-8.00	0.	0.	411.	11186.
-9.00	0.	0.	435.	11872.
-10.00	0.	0.	458.	12558.
-11.00	0.	0.	481.	13245.
-12.00	0.	0.	504.	13931.
-13.00	0.	0.	528.	14618.
-14.00	0.	0.	551.	15304.
-15.00	0.	0.	574.	16009.
-16.00	0.	0.	597.	16568.
-17.00	0.	0.	621.	16786.
-18.00	234.	16.	644.	16920.
-19.00	468.	32.	667.	17228.
-19.94	689.	47.	689.	17584.
-19.97	696.	47.	690.	17595.
-20.00	703.	48.	690.	17606.
-21.00	937.	64.	713.	17975.
-22.00	1171.	80.	737.	18345.
-23.00	1405.	96.	760.	18714.
-24.00	1640.	112.	783.	19084.
-25.00	1874.	128.	806.	19453.
-26.00	2108.	144.	830.	19823.
-27.00	2342.	160.	853.	20192.
-28.00	2577.	176.	876.	20562.
-29.00	2811.	192.	899.	20931.
-30.00	3045.	208.	923.	21301.
-31.00	3279.	224.	946.	21670.
-32.00	3514.	240.	969.	22040.
-33.00	3748.	256.	992.	22409.
-34.00	3982.	272.	1016.	22779.
-35.00	4216.	288.	1039.	23148.
-36.00	4450.	304.	1062.	23518.
-37.00	4685.	320.	1085.	23887.
-37.65	4838.	330.	1100.	24128.
-38.00	4919.	336.	1109.	24256.
-39.00	5153.	352.	1132.	24626.
-40.00	5387.	367.	1155.	24995.
-41.00	5622.	383.	1178.	25365.

'HARBOR NAVIGATION STUDY - PANYNJ
'FACILITY NO 10 - RICHMOND TERRACE

TERRAIN



***** INPUT GEOMETRY *****
DATE: 08-AUG-1998 TIME: 12.12.49

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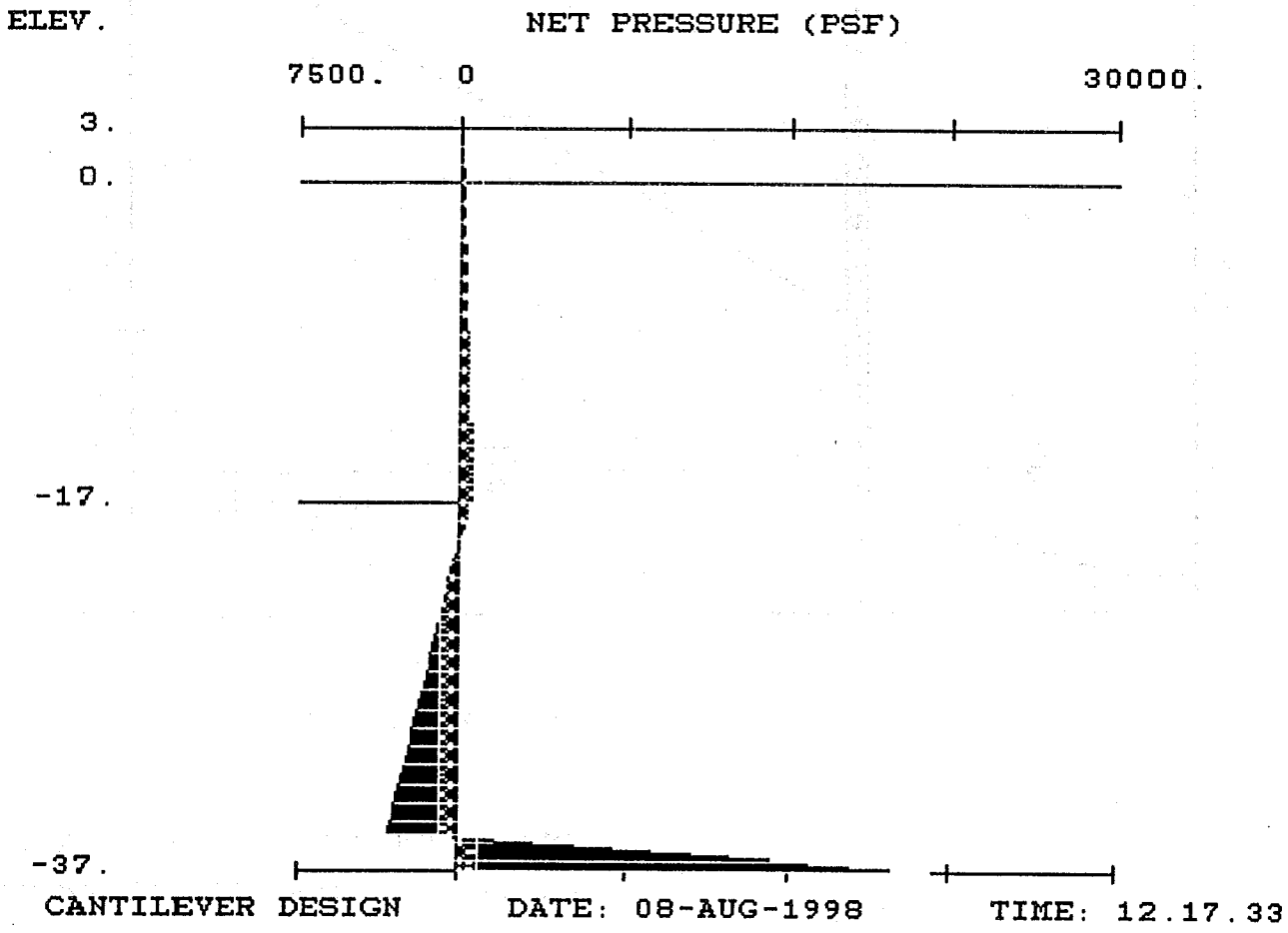
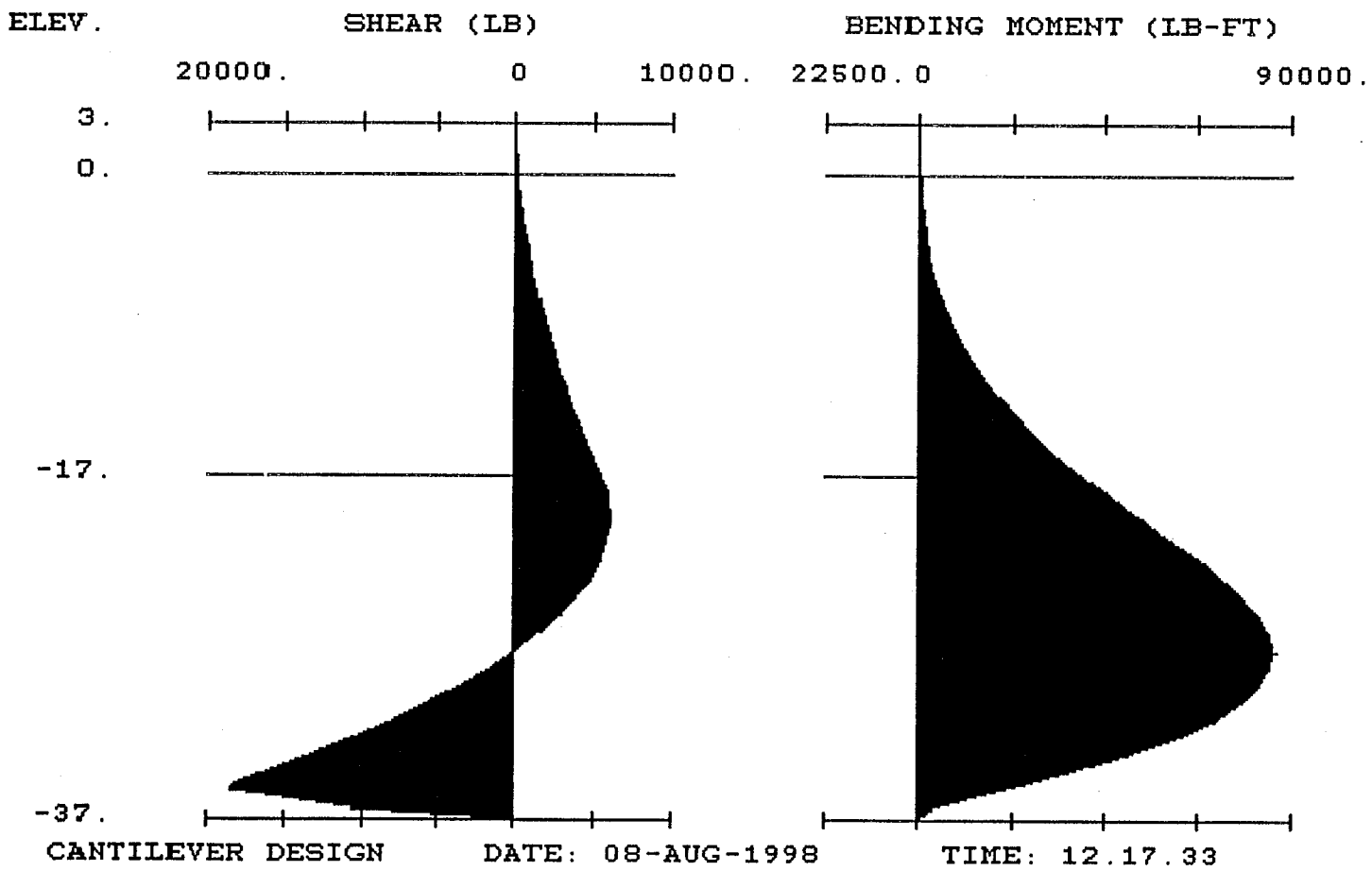
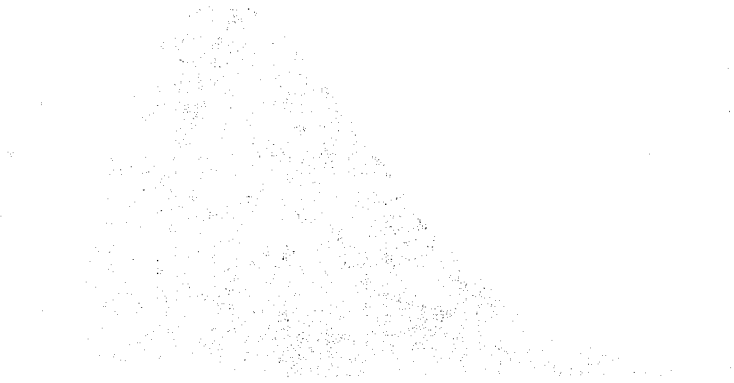
'FACILITY NO 10 - RICHMOND TERRACE



'HARBOR NAVIGATION STUDY - PANYNJ

'FACILITY NO 10 - RICHMOND TERRACE







PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 08-AUG-1998 TIME: 12.12.25

INPUT DATA

I.--HEADING:
'HARBOR NAVIGATION STUDY - PANYNJ
'FACILITY NO 10 - RICHMOND TERRACE
'CANTILEVER 62 FOOT CHANNEL TERR2IN
'NO SURCHARGE

II.--CONTROL
CANTILEVER WALL DESIGN

LEVEL 1 FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
LEVEL 1 FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

III.--WALL DATA
ELEVATION AT TOP OF WALL = 3.00 (FT)

IV.--SURFACE POINT DATA

IV.A--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	3.00
50.00	12.00
60.00	12.00

IV.B-- LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	-17.00
135.00	-62.00

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE LAYER DATA
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = DEFAULT

SAT.	MOIST	ANGLE OF INTERNAL	COH-	ANGLE OF WALL	ADH-	<--BOTTOM-->	<-SAFETY-> <-FACTOR->

WGHT. (PCF)	WGHT. (PCF)	FRICTION (DEG)	ESION (PSF)	FRICTION (DEG)	ESION (PSF)	ELEV. (FT)	SLOPE (FT/FT)	ACT.	PASS.
130.00	125.00	30.00	.0	15.00	.0			DEF	DEF

V.B.-- LEFTSIDE LAYER DATA

LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = DEFAULT

		ANGLE OF		ANGLE OF				<-SAFETY->	
SAT.	MOIST	INTERNAL	COH-	WALL	ADH-	<--BOTTOM-->		<-FACTOR->	
WGHT.	WGHT.	FRICTION	ESION	FRICTION	ESION	ELEV.	SLOPE	ACT.	PASS.
(PCF)	(PCF)	(DEG)	(PSF)	(DEG)	(PSF)	(FT)	(FT/FT)		
130.00	125.00	30.00	.0	15.00	.0			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = .00 (FT)
LEFTSIDE ELEVATION = .00 (FT)
NO SEEPAGE

VII.--SURFACE LOADS

NONE

VIII.--HORIZONTAL LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 08-AUG-1998 TIME: 12.14.16

SOIL PRESSURES FOR
CANTILEVER WALL DESIGN

I.--HEADING

'HARBOR NAVIGATION STUDY - PANYNJ
'FACILITY NO 10 - RICHMOND TERRACE
'CANTILEVER 62 FOOT CHANNEL TERR2IN
'NO SURCHARGE

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

	<-LEFTSIDE PRESSURES->		<---NET PRESSURES----> (SOIL PLUS WATER)		<RIGHTSIDE PRESSURES->	
ELEV. (FT)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
3.00	.00	.00	.000	.000	.00	.00
2.00	.00	.00	40.336	1018.041	40.34	1018.04
1.00	.00	.00	80.539	2033.502	80.54	2033.50
.00	.00	.00	116.417	2965.102	116.42	2965.10
-1.00	.00	.00	144.045	3736.718	144.05	3736.72
-2.00	.00	.00	167.349	4424.473	167.35	4424.47
-3.00	.00	.00	190.520	5109.648	190.52	5109.65
-4.00	.00	.00	213.758	5796.112	213.76	5796.11
-5.00	.00	.00	236.995	6482.577	237.00	6482.58
-6.00	.00	.00	260.233	7169.042	260.23	7169.04
-7.00	.00	.00	283.470	7855.506	283.47	7855.51
-8.00	.00	.00	306.708	8541.971	306.71	8541.97
-9.00	.00	.00	329.945	9228.436	329.95	9228.44
-10.00	.00	.00	353.183	9914.900	353.18	9914.90
-11.00	.00	.00	376.420	10601.365	376.42	10601.36
-12.00	.00	.00	399.658	11287.830	399.66	11287.83
-13.00	.00	.00	422.895	11974.294	422.89	11974.29
-14.00	.00	.00	446.132	12660.759	446.13	12660.76
-15.00	.00	.00	469.370	13349.205	469.37	13349.20
-16.00	.00	.00	492.607	14029.056	492.61	14029.06
-17.00	.00	.00	515.845	14615.865	515.84	14615.87
-18.00	234.24	15.98	304.846	15034.893	539.08	15050.87
-19.00	468.47	31.96	93.847	15385.816	562.32	15417.77
-19.44	572.66	39.06	.000	15542.743	572.66	15581.81
-19.72	637.68	43.50	-58.576	15640.693	579.11	15684.19
-20.00	702.71	47.93	-117.152	15738.642	585.56	15786.57
-21.00	936.95	63.91	-328.151	16092.137	608.79	16156.05
-22.00	1171.18	79.89	-539.150	16445.633	632.03	16525.52
-23.00	1405.42	95.87	-750.149	16799.128	655.27	16894.99
-24.00	1639.66	111.84	-961.148	17152.623	678.51	17264.47
-25.00	1873.89	127.82	-1172.148	17506.119	701.74	17633.94
-26.00	2108.13	143.80	-1383.147	17859.614	724.98	18003.41
-27.00	2342.37	159.78	-1594.146	18213.110	748.22	18372.89
-28.00	2576.60	175.75	-1805.145	18566.605	771.46	18742.36
-29.00	2810.84	191.73	-2016.144	18920.100	794.69	19111.83
-30.00	3045.07	207.71	-2227.143	19273.596	817.93	19481.31
-31.00	3279.31	223.69	-2438.142	19627.091	841.17	19850.78
-32.00	3513.55	239.66	-2649.141	19980.586	864.41	20220.25
-33.00	3747.78	255.64	-2860.140	20334.082	887.64	20589.72
-34.00	3982.02	271.62	-3071.139	20687.577	910.88	20959.20
-35.00	4216.26	287.60	-3282.138	21041.073	934.12	21328.67
-36.00	4450.49	303.58	-3493.137	21394.568	957.36	21698.14
-37.00	4684.73	319.55	-3704.136	21748.063	980.59	22067.62
-38.00	4918.97	335.53	-3915.135	22101.559	1003.83	22437.09
-39.00	5153.20	351.51	-4126.134	22455.054	1027.07	22806.56
-40.00	5387.44	367.49	-4337.133	22808.549	1050.31	23176.04
-41.00	5621.68	383.46	-4548.132	23162.045	1073.54	23545.51
-42.00	5855.91	399.44	-4759.131	23515.540	1096.78	23914.98
-43.00	6090.15	415.42	-4970.130	23869.036	1120.02	24284.45
-44.00	6324.39	431.40	-5181.129	24222.531	1143.26	24653.93
-45.00	6558.62	447.37	-5392.128	24576.026	1166.49	25023.40
-46.00	6792.86	463.35	-5603.128	24929.522	1189.73	25392.87

-47.00	7027.10	479.33	-5814.127	25283.017	1212.97	25762.35
-48.00	7261.33	495.31	-6025.126	25636.512	1236.21	26131.82
-49.00	7495.57	511.29	-6236.125	25990.008	1259.44	26501.29
-50.00	7729.80	527.26	-6447.124	26343.503	1282.68	26870.77
-51.00	7964.04	543.24	-6658.123	26696.998	1305.92	27240.24
-52.00	8198.28	559.22	-6869.122	27050.494	1329.16	27609.71
-53.00	8432.51	575.20	-7080.121	27403.989	1352.39	27979.18
-54.00	8666.75	591.17	-7291.120	27757.485	1375.63	28348.66
-55.00	8900.99	607.15	-7502.119	28110.980	1398.87	28718.13
-56.00	9135.22	623.13	-7713.118	28464.475	1422.11	29087.60
-57.00	9369.46	639.11	-7924.117	28817.971	1445.34	29457.08
-58.00	9603.70	655.08	-8135.116	29171.466	1468.58	29826.55
-59.00	9837.93	671.06	-8346.115	29524.961	1491.82	30196.02
-60.00	10072.17	687.04	-8557.114	29878.457	1515.06	30565.50
-61.00	10306.41	703.02	-8768.113	30231.952	1538.29	30934.97
-62.00	10540.64	718.99	-8979.112	30585.448	1561.53	31304.44
-63.00	10774.88	734.97	-9190.111	30938.943	1584.77	31673.92
-64.00	11009.12	750.95	-9401.110	31292.438	1608.01	32043.39
-65.00	11243.35	766.93	-9612.109	31645.934	1631.24	32412.86
-66.00	11477.59	782.91	-9823.108	31999.429	1654.48	32782.33
-67.00	11711.83	798.88	-10034.108	32352.924	1677.72	33151.81
-68.00	11946.06	814.86	-10245.107	32706.420	1700.96	33521.28
-69.00	12180.30	830.84	-10456.106	33059.915	1724.19	33890.75
-70.00	12414.54	846.82	-10667.105	33413.411	1747.43	34260.23
-71.00	12648.77	862.79	-10878.104	33766.906	1770.67	34629.70
-72.00	12883.01	878.77	-11089.103	34120.401	1793.91	34999.17
-73.00	13117.24	894.75	-11300.049	34473.897	1817.20	35368.65
-74.00	13351.48	910.73	-11511.339	34827.392	1840.14	35738.12
-75.00	13585.72	926.70	-11724.196	35180.887	1861.52	36107.59
-76.00	13819.95	942.68	-11938.874	35534.383	1881.08	36477.06
-77.00	14054.19	958.66	-12154.130	35887.878	1900.06	36846.54
-78.00	14288.43	974.64	-12369.315	36241.374	1919.11	37216.01

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 08-AUG-1998 TIME: 12.17.33

SUMMARY OF RESULTS FOR
CANTILEVER WALL DESIGN

I.--HEADING

'HARBOR NAVIGATION STUDY - PANYNJ
'FACILITY NO 10 - RICHMOND TERRACE
'CANTILEVER 62 FOOT CHANNEL TERR2IN
'NO SURCHARGE

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

WALL BOTTOM ELEV. (FT) : -36.59
PENETRATION (FT) : 19.59

MAX. BEND. MOMENT (LB-FT) : 86197.
AT ELEVATION (FT) : -27.12

MAX. SCALED DEFL. (LB-IN3): 6.6458E+10
AT ELEVATION (FT) : 3.00

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 08-AUG-1998 TIME: 12.17.33

COMPLETE RESULTS FOR
CANTILEVER WALL DESIGN

I.--HEADING

'HARBOR NAVIGATION STUDY - PANYNJ
'FACILITY NO 10 - RICHMOND TERRACE
'CANTILEVER 62 FOOT CHANNEL TERR2IN
'NO SURCHARGE

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
3.00	0.	0.	6.6458E+10	.00
2.00	7.	20.	6.4008E+10	40.34
1.00	54.	81.	6.1559E+10	80.54
.00	181.	179.	5.9109E+10	116.42
-1.00	423.	309.	5.6660E+10	144.05
-2.00	808.	465.	5.4211E+10	167.35
-3.00	1360.	644.	5.1764E+10	190.52
-4.00	2103.	846.	4.9319E+10	213.76
-5.00	3060.	1071.	4.6878E+10	237.00
-6.00	4254.	1320.	4.4443E+10	260.23

-7.00	5708.	1592.	4.2014E+10	283.47
-8.00	7446.	1887.	3.9596E+10	306.71
-9.00	9490.	2205.	3.7190E+10	329.95
-10.00	11864.	2547.	3.4801E+10	353.18
-11.00	14591.	2912.	3.2433E+10	376.42
-12.00	17695.	3300.	3.0089E+10	399.66
-13.00	21199.	3711.	2.7777E+10	422.89
-14.00	25125.	4146.	2.5501E+10	446.13
-15.00	29497.	4603.	2.3268E+10	469.37
-16.00	34339.	5084.	2.1087E+10	492.61
-17.00	39674.	5589.	1.8965E+10	515.84
-18.00	45485.	5999.	1.6912E+10	304.85
-19.00	51601.	6198.	1.4937E+10	93.85
-19.44	54364.	6219.	1.4087E+10	.00
-19.72	56090.	6211.	1.3565E+10	-58.58
-20.00	57811.	6187.	1.3051E+10	-117.15
-21.00	63904.	5964.	1.1266E+10	-328.15
-22.00	69669.	5530.	9.5905E+09	-539.15
-23.00	74894.	4886.	8.0355E+09	-750.15
-24.00	79369.	4030.	6.6098E+09	-961.15
-25.00	82884.	2963.	5.3211E+09	-1172.15
-26.00	85226.	1686.	4.1755E+09	-1383.15
-27.00	86185.	197.	3.1770E+09	-1594.15
-28.00	85549.	-1503.	2.3272E+09	-1805.14
-29.00	83109.	-3413.	1.6249E+09	-2016.14
-30.00	78652.	-5535.	1.0659E+09	-2227.14
-31.00	71969.	-7868.	6.4259E+08	-2438.14
-32.00	62847.	-10411.	3.4325E+08	-2649.14
-33.00	51076.	-13166.	1.5212E+08	-2860.14
-34.00	36445.	-16131.	4.8840E+07	-3071.14
-34.62	25773.	-18089.	1.7906E+07	-3202.79
-35.00	18856.	-18401.	8.0963E+06	1541.82
-36.00	3329.	-10551.	1.7557E+05	14158.45
-36.59	0.	0.	0.0000E+00	21603.16

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

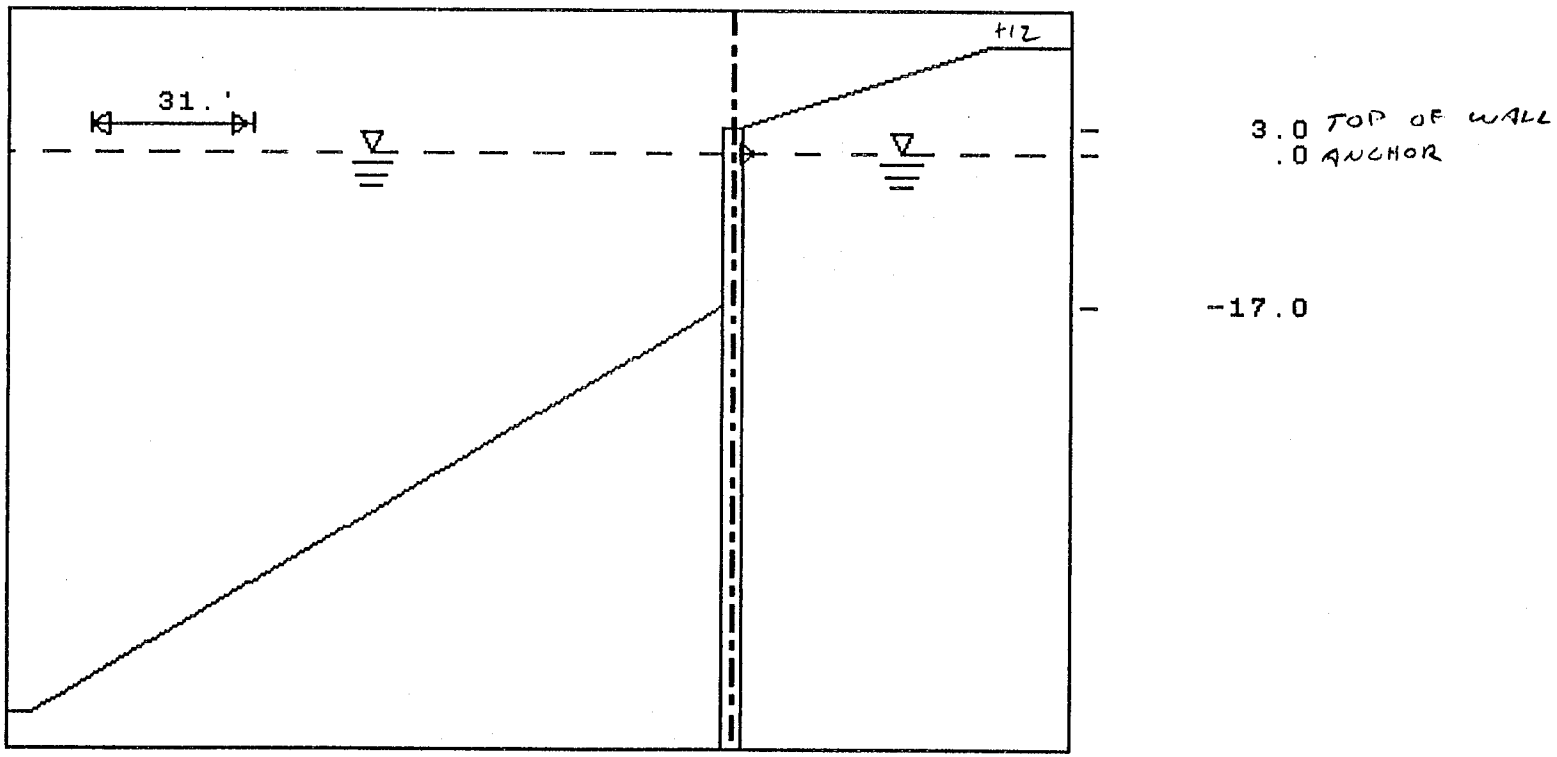
III.--SOIL PRESSURES

ELEVATION	< LEFTSIDE PRESSURE (PSF)>		<RIGHTSIDE PRESSURE (PSF)>	
(FT)	PASSIVE	ACTIVE	ACTIVE	PASSIVE
3.00	0.	0.	0.	0.
2.00	0.	0.	40.	1018.
1.00	0.	0.	81.	2034.
.00	0.	0.	116.	2965.
-1.00	0.	0.	144.	3737.
-2.00	0.	0.	167.	4424.
-3.00	0.	0.	191.	5110.
-4.00	0.	0.	214.	5796.
-5.00	0.	0.	237.	6483.
-6.00	0.	0.	260.	7169.
-7.00	0.	0.	283.	7856.
-8.00	0.	0.	307.	8542.
-9.00	0.	0.	330.	9228.
-10.00	0.	0.	353.	9915.
-11.00	0.	0.	376.	10601.
-12.00	0.	0.	400.	11288.
-13.00	0.	0.	423.	11974.

-14.00	0.	0.	446.	12661.
-15.00	0.	0.	469.	13349.
-16.00	0.	0.	493.	14029.
-17.00	0.	0.	516.	14616.
-18.00	234.	16.	539.	15051.
-19.00	468.	32.	562.	15418.
-19.44	573.	39.	573.	15582.
-19.72	638.	43.	579.	15684.
-20.00	703.	48.	586.	15787.
-21.00	937.	64.	609.	16156.
-22.00	1171.	80.	632.	16526.
-23.00	1405.	96.	655.	16895.
-24.00	1640.	112.	679.	17264.
-25.00	1874.	128.	702.	17634.
-26.00	2108.	144.	725.	18003.
-27.00	2342.	160.	748.	18373.
-28.00	2577.	176.	771.	18742.
-29.00	2811.	192.	795.	19112.
-30.00	3045.	208.	818.	19481.
-31.00	3279.	224.	841.	19851.
-32.00	3514.	240.	864.	20220.
-33.00	3748.	256.	888.	20590.
-34.00	3982.	272.	911.	20959.
-34.62	4128.	282.	925.	21190.
-35.00	4216.	288.	934.	21329.
-36.00	4450.	304.	957.	21698.
-36.59	4685.	320.	981.	22068.
-38.00	4919.	336.	1004.	22437.

'HARBOR NAVIGATION STUDY PANYNJ

'FACILITY NO 10 RICHMOND TERRACE TERR3IN

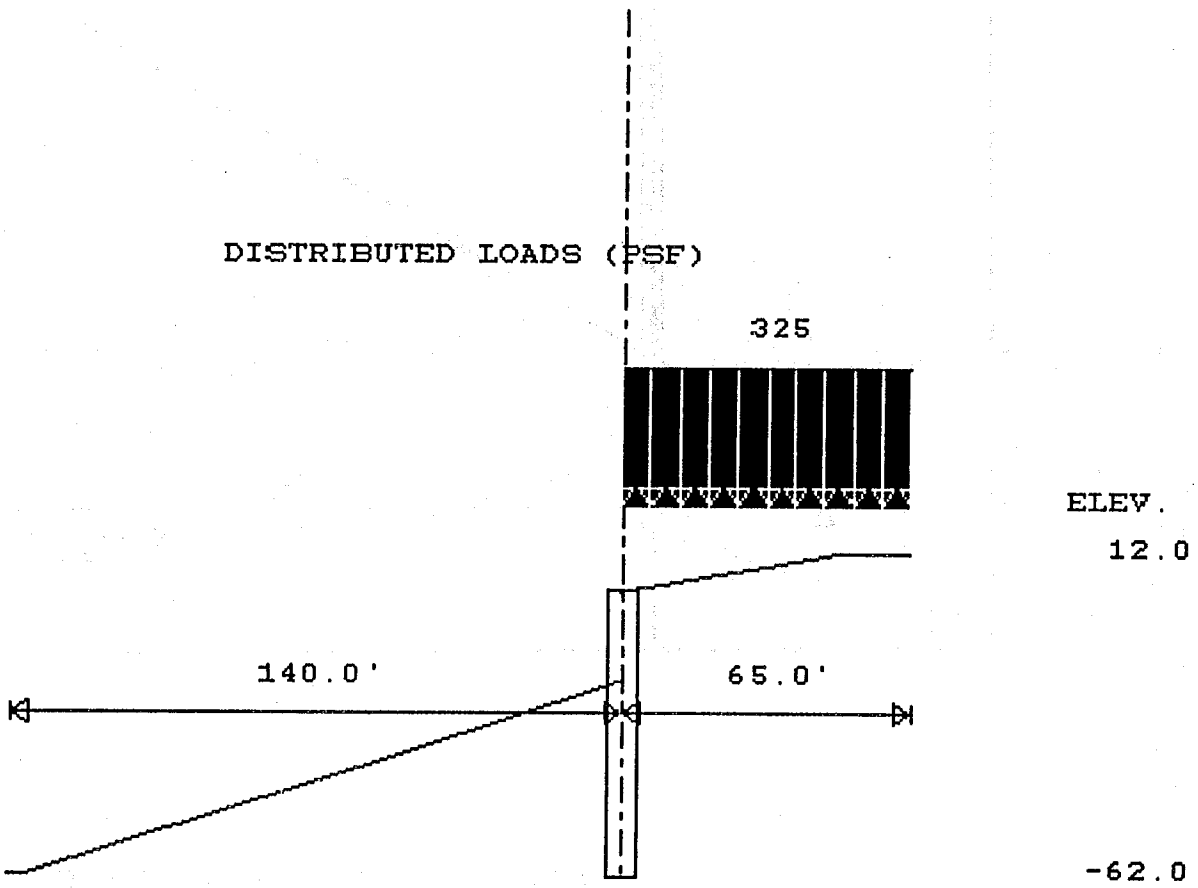


***** INPUT GEOMETRY *****

DATE: 08-AUG-1998 TIME: 12.38.43

'HARBOR NAVIGATION STUDY PANYNJ

'FACILITY NO 10 RICHMOND TERRACE TERR3IN

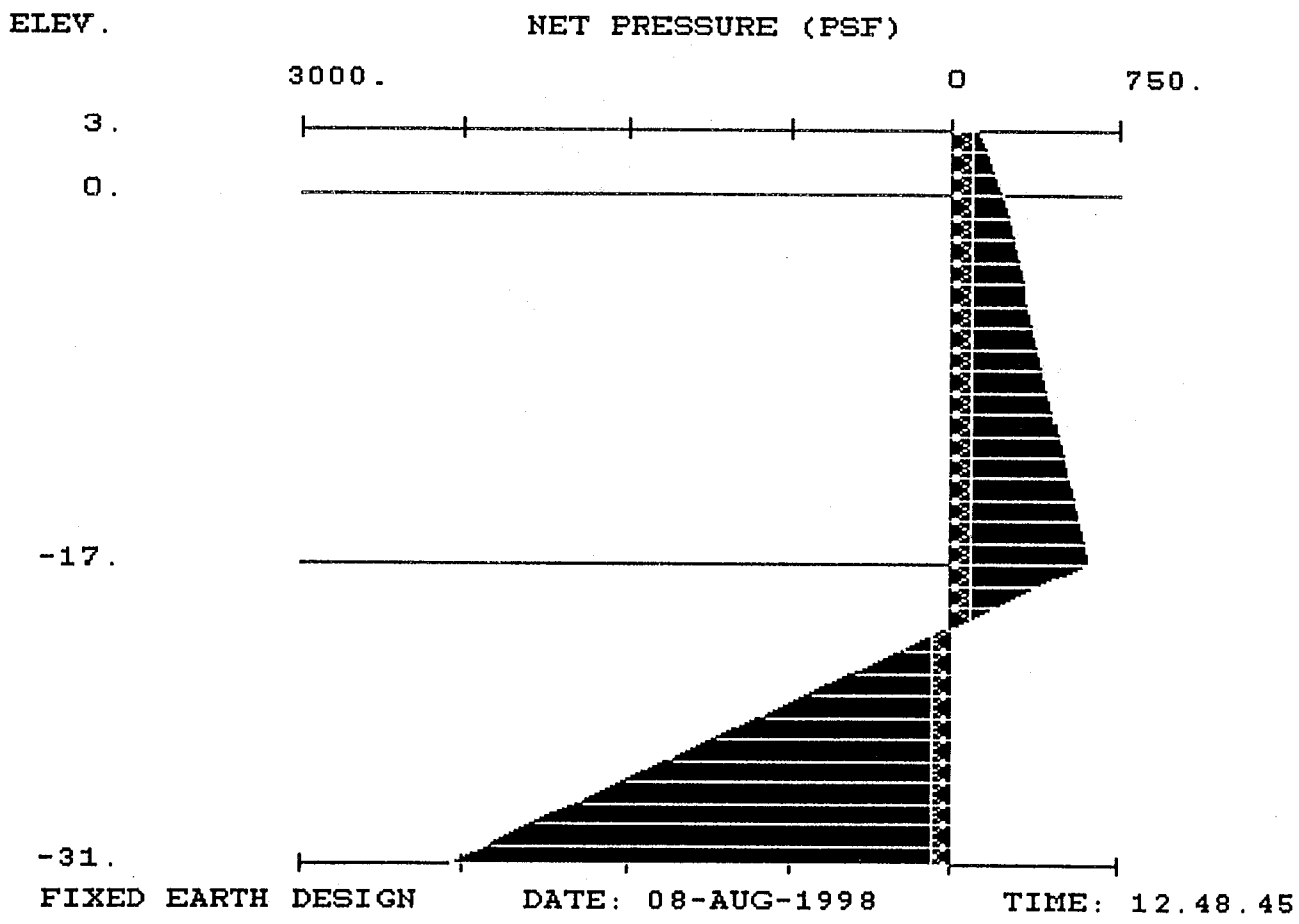


***** SURFACE LOADS *****

DATE: 08-AUG-1998 TIME: 12.43.42

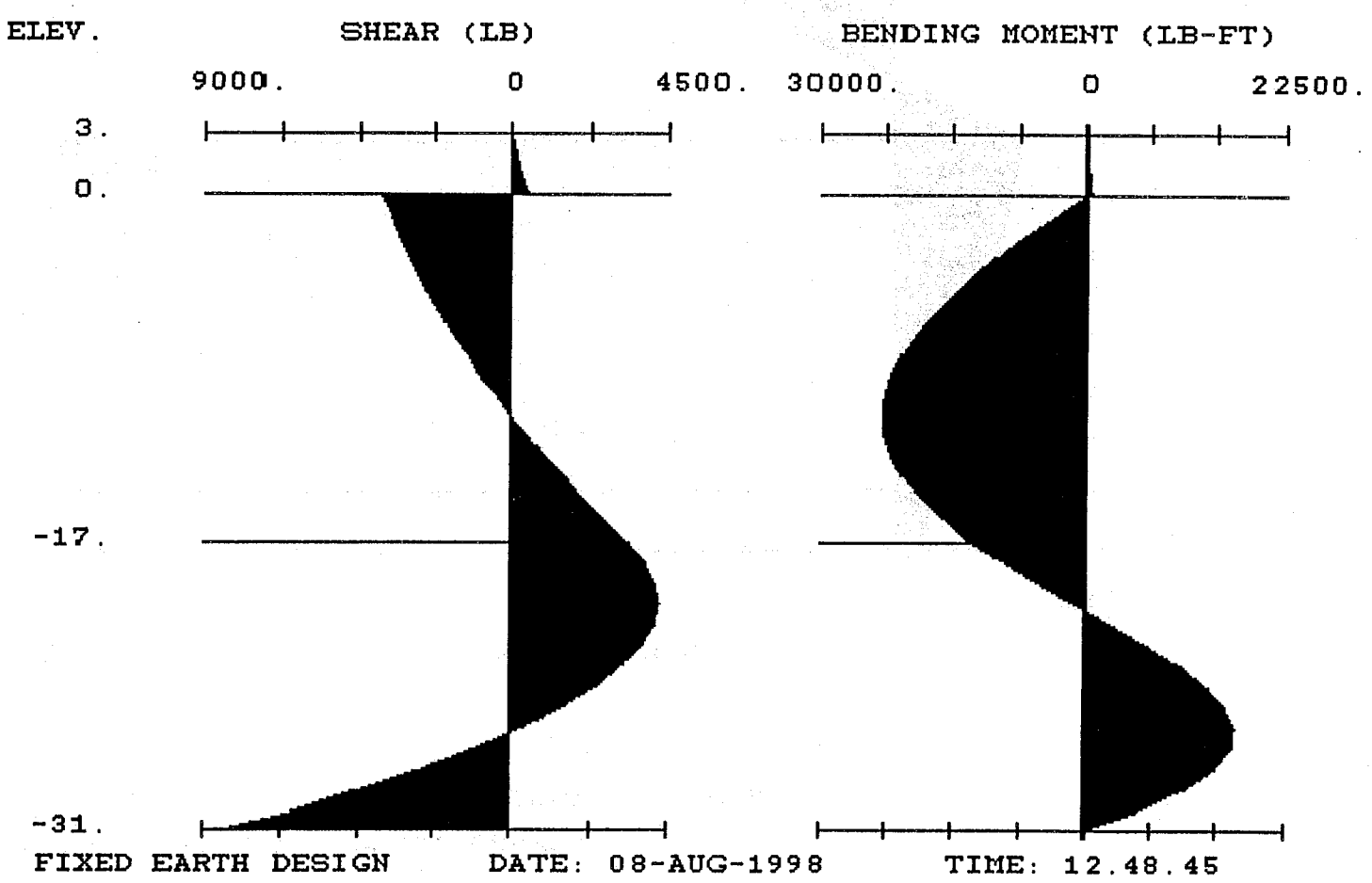
'HARBOR NAVIGATION STUDY PANYNJ

'FACILITY NO 10 RICHMOND TERRACE TERR3IN



'HARBOR NAVIGATION STUDY PANYNJ

'FACILITY NO 10 RICHMOND TERRACE TERR3IN



PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 08-AUG-1998 TIME: 15.08.46

INPUT DATA

I.--HEADING:
'HARBOR NAVIGATION STUDY PANYNJ
'FACILITY NO 10 RICHMOND TERRACE TERR3IN
'ANCHORED BULKHEAD 62 FOOT CHANNEL
'325 PSF SURCHARGE

II.--CONTROL
ANCHORED WALL DESIGN

LEVEL 1 FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
LEVEL 1 FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

III.--WALL DATA
ELEVATION AT TOP OF WALL = 3.00 (FT)
ELEVATION AT ANCHOR = .00 (FT)

IV.--SURFACE POINT DATA

IV.A--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	3.00
50.00	12.00
60.00	12.00

IV.B-- LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	-17.00
135.00	-62.00

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE LAYER DATA
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = DEFAULT

ANGLE OF	ANGLE OF	<-SAFETY->

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	INTERNAL FRICTION (DEG)	COH-ESION (PSF)	WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-FACTOR-> ACT.	PASS.
130.00	125.00	30.00	.0	15.00	.0			DEF	DEF

V.B.-- LEFTSIDE LAYER DATA

LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
130.00	125.00	30.00	.0	15.00	.0			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)

RIGHTSIDE ELEVATION = .00 (FT)

LEFTSIDE ELEVATION = .00 (FT)

NO SEEPAGE

VII.--SURFACE LOADS

VII.A.--RIGHTSIDE SURFACE LOADS

VII.A.1.--SURFACE LINE LOADS

NONE

VII.A.2.--SURFACE DISTRIBUTED LOADS

UNIFORM LOAD = 325.00 (PSF)

VII.B.-- LEFTSIDE SURFACE LOADS

NONE

VIII.--HORIZONTAL LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 08-AUG-1998 TIME: 15.08.58

SOIL PRESSURES FOR
ANCHORED WALL DESIGN

I.--HEADING

'HARBOR NAVIGATION STUDY PANYNJ
'FACILITY NO 10 RICHMOND TERRACE TERR3IN
'ANCHORED BULKHEAD 62 FOOT CHANNEL
'325 PSF SURCHARGE

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

			<---NET PRESSURES---->		
	<-LEFTSIDE PRESSURES->		(SOIL PLUS WATER)	<RIGHTSIDE PRESSURES->	
ELEV.	PASSIVE	ACTIVE	ACTIVE	ACTIVE	PASSIVE
(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
3.00	.00	.00	99.881	99.88	1748.64
2.00	.00	.00	145.036	145.04	3661.59
1.00	.00	.00	185.239	185.24	4677.06
.00	.00	.00	221.117	221.12	5608.65
-1.00	.00	.00	248.746	248.75	6380.27
-2.00	.00	.00	272.050	272.05	7068.03
-3.00	.00	.00	295.220	295.22	7753.20
-4.00	.00	.00	318.458	318.46	8439.67
-5.00	.00	.00	341.695	341.70	9126.13
-6.00	.00	.00	364.933	364.93	9812.59
-7.00	.00	.00	388.170	388.17	10499.06
-8.00	.00	.00	411.408	411.41	11185.52
-9.00	.00	.00	434.645	434.65	11871.99
-10.00	.00	.00	457.883	457.88	12558.45
-11.00	.00	.00	481.120	481.12	13244.92
-12.00	.00	.00	504.358	504.36	13931.38
-13.00	.00	.00	527.595	527.60	14617.85
-14.00	.00	.00	550.833	550.83	15304.31
-15.00	.00	.00	574.070	574.07	16009.05
-16.00	.00	.00	597.308	597.31	16568.04
-17.00	.00	.00	620.545	620.55	16785.91
-18.00	234.24	15.98	409.546	643.78	16920.21
-19.00	468.47	31.96	198.547	667.02	17227.68
-19.94	688.89	46.99	.000	688.89	17583.63
-19.97	695.80	47.46	-6.226	689.57	17594.79
-20.00	702.71	47.93	-12.452	690.26	17605.95
-21.00	936.95	63.91	-223.451	713.49	17975.42
-22.00	1171.18	79.89	-434.450	736.73	18344.90
-23.00	1405.42	95.87	-645.449	759.97	18714.37
-24.00	1639.66	111.84	-856.448	783.21	19083.84
-25.00	1873.89	127.82	-1067.447	806.44	19453.31
-26.00	2108.13	143.80	-1278.446	829.68	19822.79
-27.00	2342.37	159.78	-1489.445	852.92	20192.26
-28.00	2576.60	175.75	-1700.444	876.16	20561.73
-29.00	2810.84	191.73	-1911.444	899.39	20931.21
-30.00	3045.07	207.71	-2122.443	922.63	21300.68
-31.00	3279.31	223.69	-2333.442	945.87	21670.15
-32.00	3513.55	239.66	-2544.441	969.11	22039.63
-33.00	3747.78	255.64	-2755.440	992.34	22409.10
-34.00	3982.02	271.62	-2966.439	1015.58	22778.57
-35.00	4216.26	287.60	-3177.438	1038.82	23148.05

-36.00	4450.49	303.58	-3388.437	1062.06	23517.52
-37.00	4684.73	319.55	-3599.436	1085.29	23886.99
-38.00	4918.97	335.53	-3810.435	1108.53	24256.46
-39.00	5153.20	351.51	-4021.434	1131.77	24625.94
-40.00	5387.44	367.49	-4232.433	1155.01	24995.41
-41.00	5621.68	383.46	-4443.432	1178.24	25364.88
-42.00	5855.91	399.44	-4654.431	1201.48	25734.36
-43.00	6090.15	415.42	-4865.430	1224.72	26103.83
-44.00	6324.39	431.40	-5076.429	1247.96	26473.30
-45.00	6558.62	447.37	-5287.428	1271.19	26842.78
-46.00	6792.86	463.35	-5498.427	1294.43	27212.25
-47.00	7027.10	479			

.33	-5709.426	1317.67	27581.72		
-48.00	7261.33	495.31	-5920.425	1340.91	27951.19
-49.00	7495.57	511.29	-6131.424	1364.14	28320.67
-50.00	7729.80	527.26	-6342.424	1387.38	28690.14
-51.00	7964.04	543.24	-6553.423	1410.62	29059.61
-52.00	8198.28	559.22	-6764.422	1433.86	29429.09
-53.00	8432.51	575.20	-6975.421	1457.09	29798.56
-54.00	8666.75	591.17	-7186.420	1480.33	30168.03
-55.00	8900.99	607.15	-7397.419	1503.57	30537.51
-56.00	9135.22	623.13	-7608.418	1526.81	30906.98
-57.00	9369.46	639.11	-7819.417	1550.04	31276.45
-58.00	9603.70	655.08	-8030.416	1573.28	31645.92
-59.00	9837.93	671.06	-8241.415	1596.52	32015.40
-60.00	10072.17	687.04	-8452.414	1619.76	32384.87
-61.00	10306.41	703.02	-8663.413	1642.99	32754.34
-62.00	10540.64	718.99	-8874.412	1666.23	33123.82
-63.00	10774.88	734.97	-9085.411	1689.47	33493.29
-64.00	11009.12	750.95	-9296.410	1712.71	33862.76
-65.00	11243.35	766.93	-9507.409	1735.94	34232.24
-66.00	11477.59	782.91	-9718.408	1759.18	34601.71
-67.00	11711.83	798.88	-9929.407	1782.42	34971.18
-68.00	11946.06	814.86	-10140.406	1805.66	35340.66
-69.00	12180.30	830.84	-10351.405	1828.89	35710.13
-70.00	12414.54	846.82	-10562.404	1852.13	36079.60
-71.00	12648.77	862.79	-10773.404	1875.37	36449.07
-72.00	12883.01	878.77	-10984.403	1898.61	36818.55
-73.00	13117.24	894.75	-11195.044	1922.20	37188.02
-74.00	13351.48	910.73	-11408.741	1942.74	37557.49
-75.00	13585.72	926.70	-11627.369	1958.35	37926.97
-76.00	13819.95	942.68	-11845.116	1974.84	38296.44
-77.00	14054.19	958.66	-12060.346	1993.84	38665.91
-78.00	14288.43	974.64	-12275.496	2012.93	39035.39

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 08-AUG-1998 TIME: 15.09.17

SUMMARY OF RESULTS FOR
ANCHORED WALL DESIGN

I.--HEADING

'HARBOR NAVIGATION STUDY PANYNJ
'FACILITY NO 10 RICHMOND TERRACE TERR3IN
'ANCHORED BULKHEAD 62 FOOT CHANNEL
'325 PSF SURCHARGE

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

METHOD	:	FREE EARTH	EQUIV. BEAM	FIXED EARTH
WALL BOTTOM ELEV. (FT)	:	-25.80	-31.04	-30.86
PENETRATION (FT)	:	8.80	14.04	13.86
MAX. BEND. MOMENT (LB-FT)	:	-30206.	-22051.	-22596.
AT ELEVATION (FT)	:	-12.20	-10.76	-10.86
MAX. SCALED DEFL. (LB-IN3)	:	3.3646E+09	-1.6463E+09	2.2722E+09
AT ELEVATION (FT)	:	-13.00	-31.04	-12.00
ANCHOR FORCE (LB)	:	4970.	4260.	4310.

(NOTE: PENETRATION FOR EQUIVALENT BEAM METHOD DOES NOT INCLUDE INCREASE PRESCRIBED BY DRAFT EM 1110-2-2906.)

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 08-AUG-1998 TIME: 15.09.17

COMPLETE RESULTS FOR
ANCHORED WALL DESIGN
BY FIXED EARTH METHOD

I.--HEADING

'HARBOR NAVIGATION STUDY PANYNJ
'FACILITY NO 10 RICHMOND TERRACE TERR3IN
'ANCHORED BULKHEAD 62 FOOT CHANNEL
'325 PSF SURCHARGE

II.--RESULTS (ANCHOR FORCE = 4310. (LB))

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)

3.00	0.	0.	-9.1605E+08	99.88
2.00	57.	122.	-6.1094E+08	145.04
1.00	259.	288.	-3.0571E+08	185.24
.00	645.	491.	0.0000E+00	221.12
.00	645.	-3819.	0.0000E+00	221.12
-1.00	-3059.	-3584.	3.0561E+08	248.75
-2.00	-6515.	-3324.	6.0597E+08	272.05
-3.00	-9699.	-3040.	8.9512E+08	295.22
-4.00	-12588.	-2734.	1.1675E+09	318.46
-5.00	-15158.	-2403.	1.4183E+09	341.70
-6.00	-17387.	-2050.	1.6428E+09	364.93
-7.00	-19251.	-1674.	1.8374E+09	388.17
-8.00	-20726.	-1274.	1.9988E+09	411.41
-9.00	-21791.	-851.	2.1244E+09	434.65
-10.00	-22420.	-404.	2.2124E+09	457.88
-11.00	-22592.	65.	2.2618E+09	481.12
-12.00	-22282.	558.	2.2722E+09	504.36
-13.00	-21469.	1074.	2.2441E+09	527.60
-14.00	-20127.	1613.	2.1791E+09	550.83
-15.00	-18235.	2175.	2.0793E+09	574.07
-16.00	-15769.	2761.	1.9481E+09	597.31
-17.00	-12705.	3370.	1.7897E+09	620.55
-18.00	-9060.	3885.	1.6095E+09	409.55
-19.00	-5005.	4189.	1.4137E+09	198.55
-19.94	-1005.	4283.	1.2214E+09	.00
-19.97	-878.	4282.	1.2153E+09	-6.23
-20.00	-752.	4282.	1.2092E+09	-12.45
-21.00	3489.	4164.	1.0035E+09	-223.45
-22.00	7506.	3835.	8.0372E+08	-434.45
-23.00	11089.	3295.	6.1687E+08	-645.45
-24.00	14026.	2544.	4.4910E+08	-856.45
-25.00	16107.	1582.	3.0543E+08	-1067.45
-26.00	17121.	409.	1.8945E+08	-1278.45
-27.00	16856.	-974.	1.0287E+08	-1489.45
-28.00	15101.	-2569.	4.5202E+07	-1700.44
-29.00	11647.	-4375.	1.3384E+07	-1911.44
-30.00	6280.	-6392.	1.4148E+06	-2122.44
-30.86	1.	-8289.	0.0000E+00	-2303.27

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

III.--SOIL PRESSURES

ELEVATION	< LEFTSIDE PRESSURE (PSF)>		<RIGHTSIDE PRESSURE (PSF)>	
(FT)	PASSIVE	ACTIVE	ACTIVE	PASSIVE
3.00	0.	0.	100.	1749.
2.00	0.	0.	145.	3662.
1.00	0.	0.	185.	4677.
.00	0.	0.	221.	5609.
-1.00	0.	0.	249.	6380.
-2.00	0.	0.	272.	7068.
-3.00	0.	0.	295.	7753.
-4.00	0.	0.	318.	8440.
-5.00	0.	0.	342.	9126.
-6.00	0.	0.	365.	9813.
-7.00	0.	0.	388.	10499.
-8.00	0.	0.	411.	11186.
-9.00	0.	0.	435.	11872.

-10.00	0.	0.	458.	12558.
-11.00	0.	0.	481.	13245.
-12.00	0.	0.	504.	13931.
-13.00	0.	0.	528.	14618.
-14.00	0.	0.	551.	15304.
-15.00	0.	0.	574.	16009.
-16.00	0.	0.	597.	16568.
-17.00	0.	0.	621.	16786.
-18.00	234.	16.	644.	16920.
-19.00	468.	32.	667.	17228.
-19.94	689.	47.	689.	17584.
-19.97	696.	47.	690.	17595.
-20.00	703.	48.	690.	17606.
-21.00	937.	64.	713.	17975.
-22.00	1171.	80.	737.	18345.
-23.00	1405.	96.	760.	18714.
-24.00	1640.	112.	783.	19084.
-25.00	1874.	128.	806.	19453.
-26.00	2108.	144.	830.	19823.
-27.00	2342.	160.	853.	20192.
-28.00	2577.	176.	876.	20562.
-29.00	2811.	192.	899.	20931.
-30.00	3045.	208.	923.	21301.
-31.00	3279.	224.	946.	21670.

CORPS DOCK NO. n/a
NAME: City of Elizabeth Marina
CHANNEL: Arthur Kill

FACILITY NO. 3 - CITY OF ELIZABETH MARINA

Affected structures are a timber pile supported wave screen and a timber pile supported public pier. The bedrock surface is high in the area of this site therefore there is little soil for pile embedment. Piles for the existing structure are assumed to be driven 15 to 20 feet to refusal.

The channel side slopes for both the 50 and 60 foot deep channels will extend under both the wave screen and the pier.

Dredging for either channel depth will result in the removal of most of the soils under the structures, leaving little or no material for pile embedment.

Potential Solution:

Remove and reconstruct the existing structures. New piles will be socketed into bedrock therefore concrete filled, steel pipe piles will be used.

The reconstructed wave screen will maintain the geometry of the existing structure, using 12" dia.,(.5" wall), concrete filled steel pipe piles and structural steel framing. The timber screen structure will be replaced in-kind. Some variation in detailing will be required due to the materials to be used.

The public recreation pier will be replaced in the same footprint as the existing structure. The framework of timber piles and cross bracing will be replaced with a rigid frame consisting of pipe piles and reinforced concrete.

The rock cut required for the 60 foot deep channel will extend under the pier. This will require additional rock excavation in the slope to allow for the drilling of a vertical socket for the front row of piles.

The existing the bulkhead behind the pier will remain. Much of the material to be removed under the dredging operations will be replaced with crushed stone and riprap. The stone is to replace the passive resistance which is lost to dredging.

ELIZABETH MARINA

DESIGN DATA:

PILES: A252 SEAMLESS OR STRAIGHT SEAM
Gr. 2 F_y = 35 ksi F_u = 60 ksi

STEEL: A36 F_y = 36 ksi

CONCRETE: f'_c = 3000 psi (pile fill)

TIMBER: SOUTHERN YELLOW PINE No. 2 OR BETTER
C.C.A. TREATED
F_b = 1200 psi
F_c = 90 psi

LOAD CRITERIA: WAVE SCREEN & RECREATIONAL PIER

WIND DRIVEN WAVE:

MAX FETCH: 2 miles

DESIGN WIND: 75 mph fastest mile @ 30' (50yr) ACOE SR-2 1974

DEPTH: 52' min F_{ig} 80-A

WIND PRESSURE: 23 psf F_{ig} 80-B

A

PIER: RECREATIONAL FACILITY/ASSEMBLY AREA

MIN LIVE LOAD: 125 psf

⇒ TO ALLOW FOR EMERGENCY RESCUE VEHICLE ACCESS, DESIGN FOR 200 psf

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Project HARBOR NAVIGATION STUDY
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SOILS:
ASSUME

$\gamma_{sat} = 130$ pcf
$\phi = 30°$
$C = 0$

From
Melnick-Tully & Assoc.

ROCK:
ASSUME

$\gamma = 145$ pcf
$\phi = 45°$
$c = 1000$ psf

$\gamma_{water} = 64.4$ pcf

WAVE LOADING:

Fastest mile wind speed 75 mph

Estimate 1-hour windspeed $U_{t=60_{min}}$

$$t = \frac{3600 \text{ sec/hr.}}{75 \frac{\text{mi}}{\text{hr}}} = 48.0 \text{ sec/mi}$$

$$\therefore U_{t=48} = 75 \text{ mph}$$

From ACOE SPM Fig 3-13.

$$\frac{U_{t=48}}{U_{3,600}} = 1.263 \quad @ \quad t = 48 \text{ sec.}$$

$$\therefore U_{3600} = \frac{75}{1.263} = 59.38 \approx 60 \text{ mph}$$

$$U_A = 0.589 (60)^{1.23} = 90.6$$

From ACOE SPM Fig 3-24, (Deep Water)

w/ $U_A = 90$

Fetch = 2 mi

The maximum wave ht. is 3.75 Ft. T = 3.2 sec

- With a 50 Ft. channel, the wave will not be depth limited.

From ACOE SPM Fig 3-36 (shallow water)

$U_A = 40$

$F = 10{,}500$ ft.

$H_m = 3.5$ ft $\quad T = 3.0$

NEGLECT NARROW FETCH EFFECTS

ESTIMATE FORCE OF NON-BREAKING WAVE ON THE WAVESCREEN

Let $H_i = H_m = 3.5$ ft FOR THIS ANALYSIS

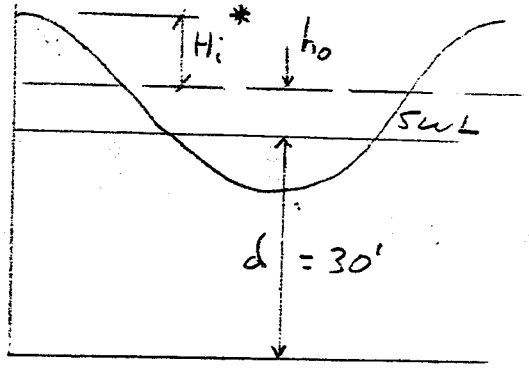
$T = 3.0$ sec

$$\frac{H_i}{gT^2} = \frac{3.5}{32.2\,(3)^2} = 0.0121 \qquad \frac{H_i}{d} \leq 0.117$$

From ACOE SPM, Fig 7-90

$$\frac{H_i}{d} = \frac{3.5}{30} = 0.117$$

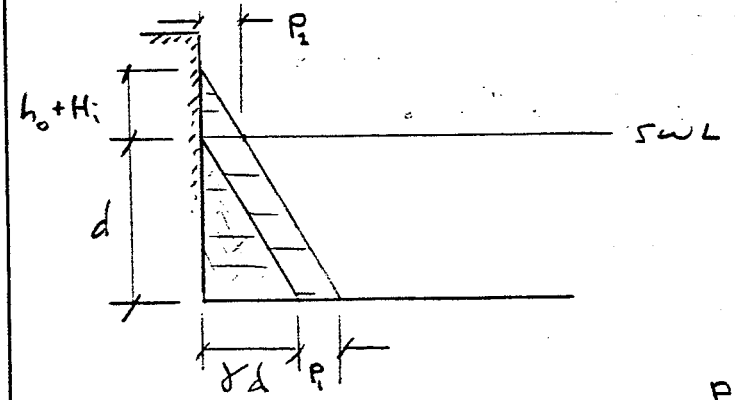
$$\frac{h_o}{H_i} = 0.23 \quad \therefore \quad h_o = .23(3.5) = 0.805$$



[* χ = reflection coeff @ wall (screen) ≈ 1.0

$\therefore \left(\frac{1+\chi}{2}\right) H_i = H_i$]

- Pressure distribution @ vertical wall (wave crest)



$d = 30'$

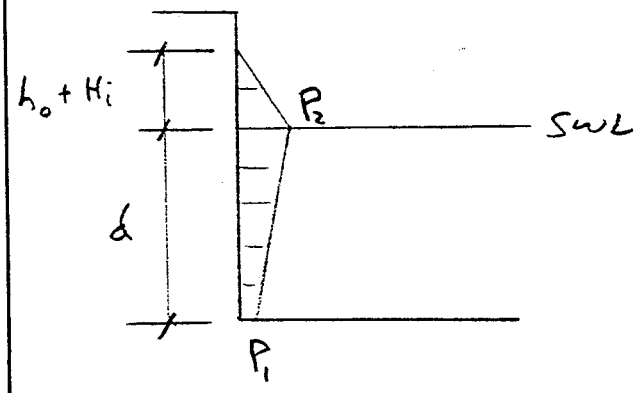
$H_i + h_0 = 3.5 + .80 = 4.3'$

γd = hydrostatic pressure

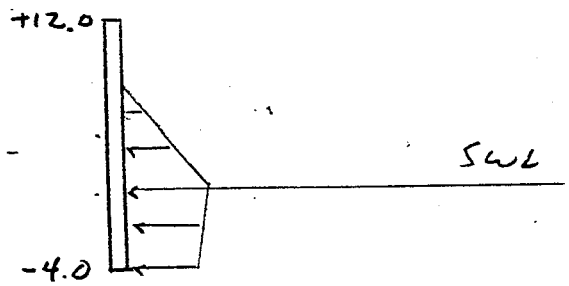
$$P_1 = \left(\frac{1+\chi}{2}\right) \frac{\gamma H_i}{\cosh\left(\frac{2\pi d}{L}\right)}$$

1

where hydrostatic is balanced on both sides of the wall:



Approximation for Wave Screen:



$L_o = \frac{gT^2}{2\pi} = 46$ ft. deep water wave length

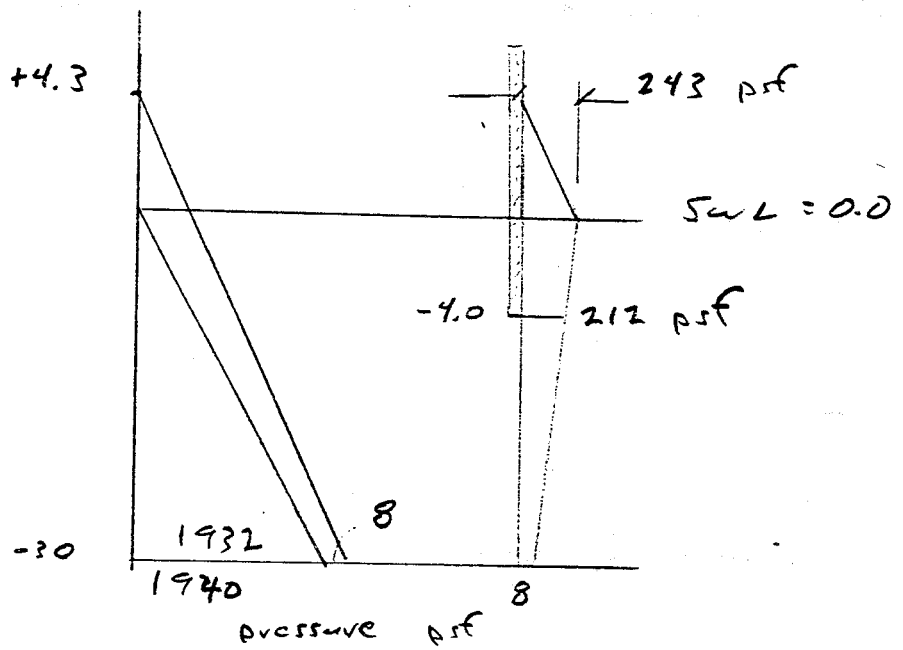
$\frac{d}{L_o} = \frac{30}{46} = 0.65$

From Table C-1, $d/L = .6504 \approx d/L_o > 1/2$

$\therefore L \approx L_o = 46'$ $\cosh 2\pi d/L = 29.77$

$P_1 = 64.4(3.5)/29.77 = 7.58$ psf

$\gamma_d = 64.4(30) = 1,932$ psf

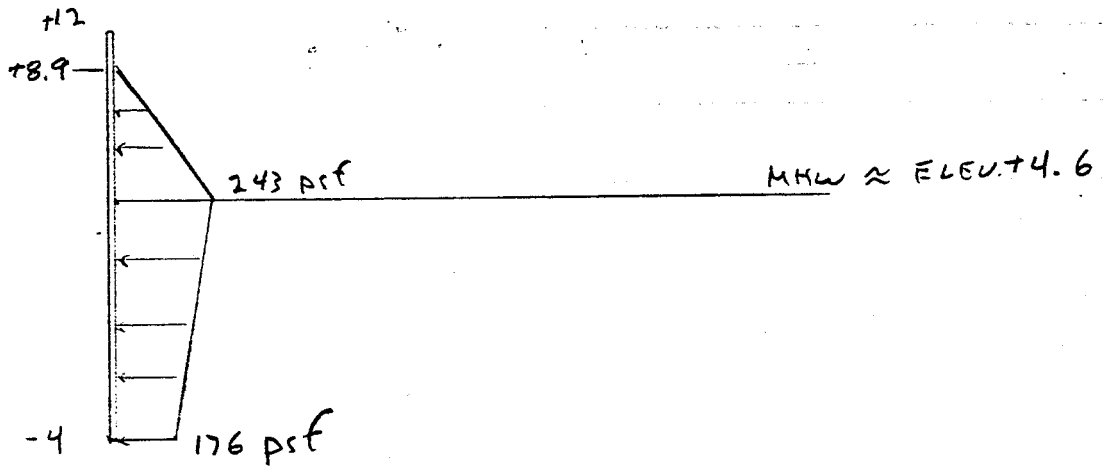


$P = 1433$ lb./L.f. of screen

$243(4.3/2)\left(4 + \frac{4.3}{3}\right) + 212\left(\frac{4^2}{2}\right) + 31\left(\frac{4}{2}\right)\left(\frac{2}{3}\right)(4) = 1433(x)$

$x = 3.28 \Rightarrow$ elev. -0.72

Pressure distribution with SWL & MHW



$P = 176(8.6) + 67(8.6/2) + 243(4.3/2) = 2,324$ #/LF

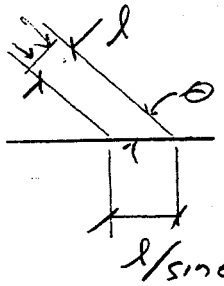
$176\left(\frac{8.6}{2}\right)^2 + 67\left(\frac{8.6^2}{(2)}\frac{(2)}{3}\right) + 243(4.3/2)\left(\frac{4.3}{3} + 8.6\right) = 2324(x)$

$x = 5.93$

$-4 + 5.93 =$ elev. 1.93

⇒ NOTE THAT THE PRESSURES CALCULATED ABOVE ARE FOR A PERPENDICULAR APPROACH LOADING WILL BE REDUCED DUE TO ANGLE OF WAVEFRONT. REDUCTION WILL ONLY BE DUE TO LENGTH OF DISTRIBUTION BECAUSE THIS IS A NON-BREAKING WAVE (HYDROSTATIC ONLY, NO DYNAMIC COMPONENT)

$\frac{P}{\ell}$



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Project HARBOR NAVIGATION STUDY
Subject PANYNJ SITE #3
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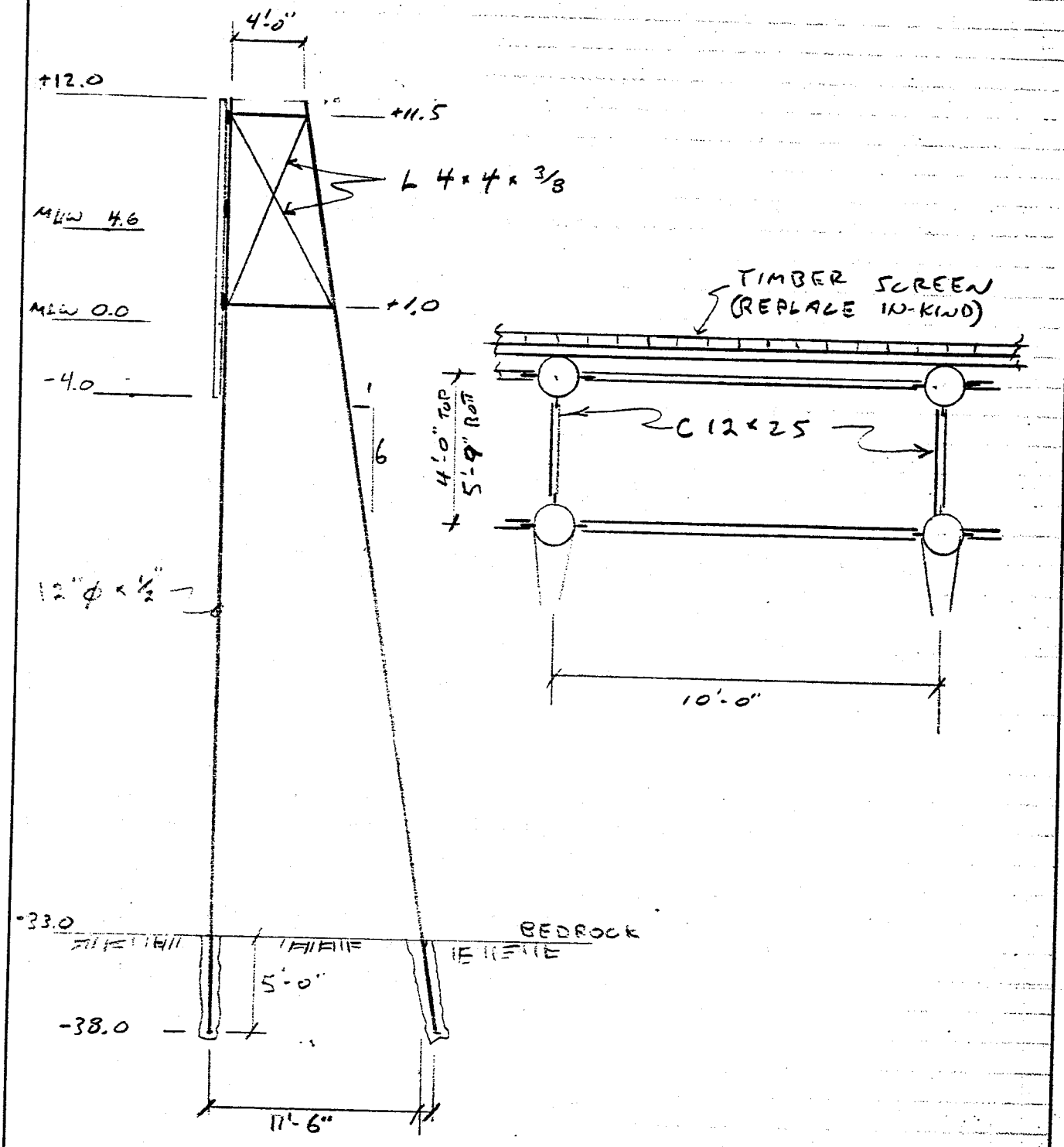
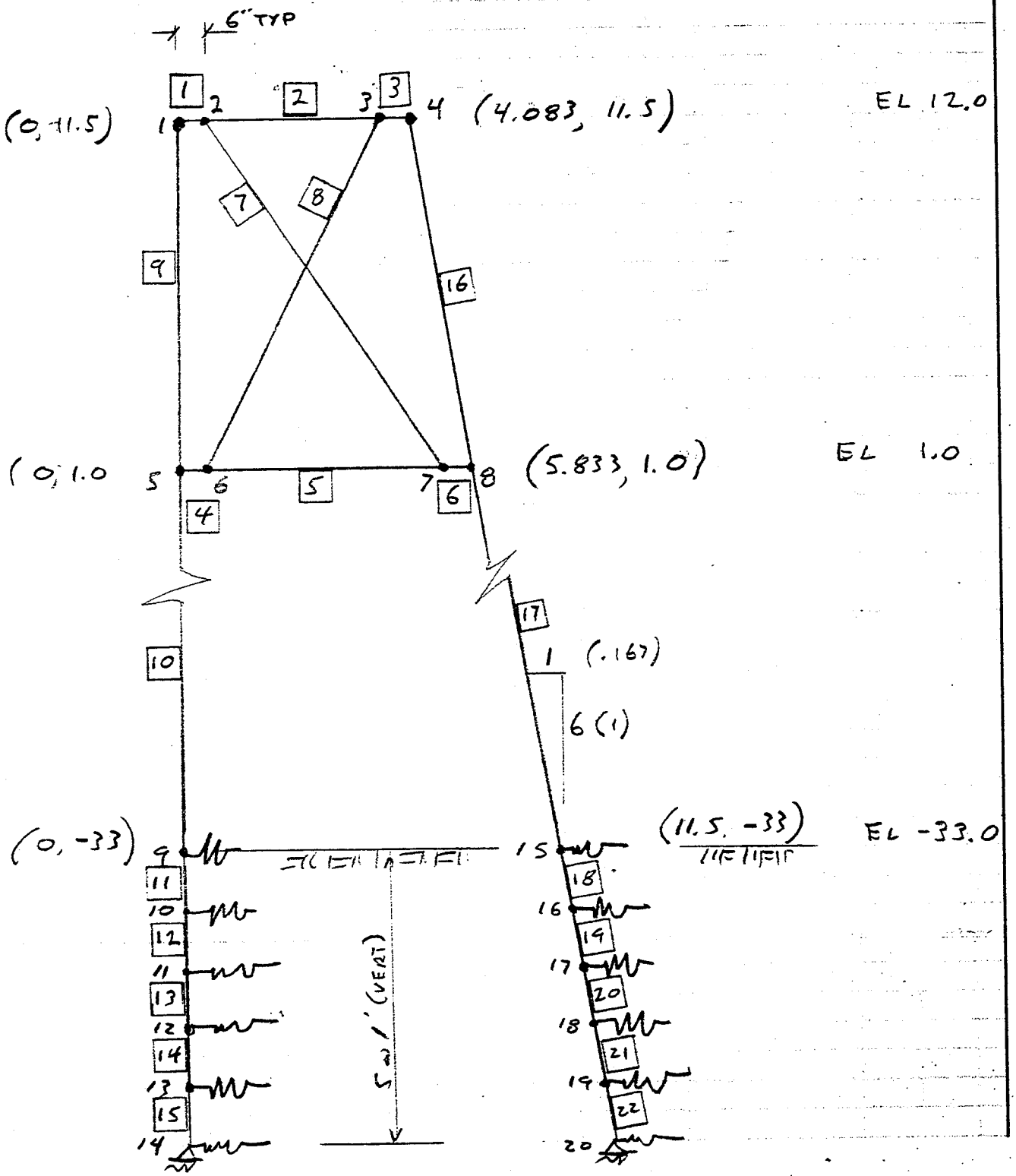
WAVESCREEN GENERAL LAYOUT



- WAVESCREEN: STRUDL MODEL



- MEMBER PROPERTIES:

9 THRU 22: 12" ϕ PIPE ½" wall thickness

$A = 19.2\ in^2$ $I = 362\ in^4$

O.D. = 12 3/4"

2 & 5 HORIZ BRACES - UPPER & LOWER

CHANNEL C 12 × 25

$A = 7.35\ in^2$ $I = 91.2\ in^4$ $t_w = 3/8"$

7 & 8 DIAG. BRACES L 4 × 4 × 3/8

$A = 2.67\ in^2$ $I = 4.36\ in^4$

1, 3, 4, 6 RIGID LINKS BTWN. PILE ϕ & BRACING CONNECTIONS

$A = 100\ in^2$ $I = 10{,}000\ in^4$

ROCK PROPERTIES:

MODEL THE ROCK SOCKETS AS A SERIES OF ELASTIC SPRINGS. TREAT IT AS A STIFF CLAY

LET: $S_u = 1000$ psi

= SPRING CONSTANT = HORIZONTAL SUBGRADE REACTION

$$K_s = 67 \frac{S_u}{B}$$

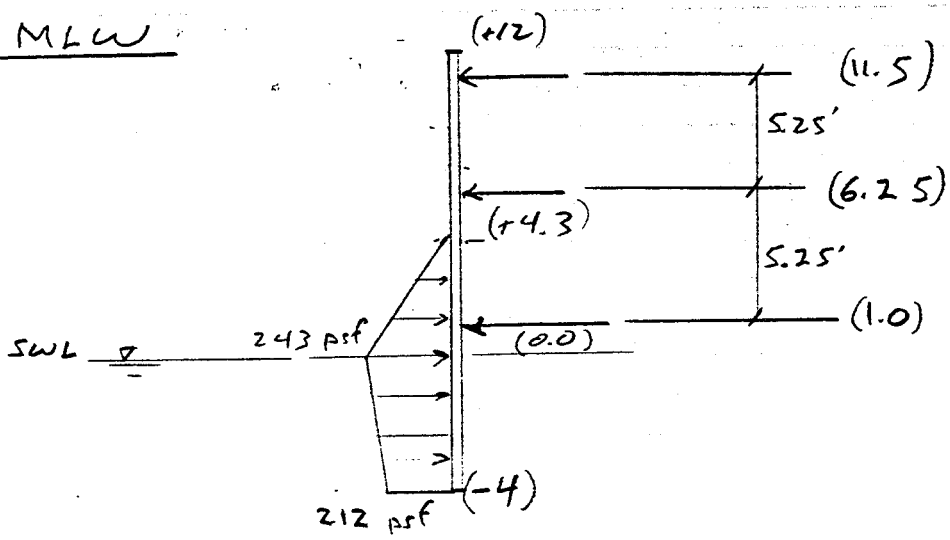
see Prakash & Sharma, "PILE FOUNDATIONS IN ENGINEERING PRACTICE" 4.4.2

$K_s = 67(1000) = 67$ Ksi/in

× 3 pile dia × node spacing = $67(3(12.75))(12") = 30{,}753$ k/in

- LOADING:

@ MLW



$212(4) + 31(4/2) + 243(4.3/2) = 1432.5$ plf of screen

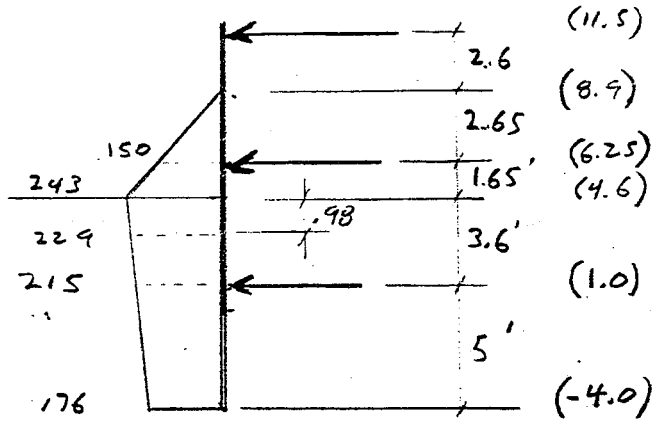
@ 10' pile bent spacing w 10" planks in the screen and 2" gaps between planks

⇒ Assume load goes into lowest support

$1432.5\ (10)\ (10/12) = 11\,937.5 \approx 12^{K}$

@ 45° approach $12 \cdot \sin 45 = 8.5^{K}$

@ MHW



- USING TRIBUTARY LOAD AREAS

LOW SUPPORT:

$[(215+176)/2](5)+[(224+215)/2]\left(\frac{5.25}{2}\right) = 1561$ plf

MIDDLE SUPPORT:

$(224+243)/2\,(.98)+243(4.3/2) = 754$ plf

$1561\,(10)(10/12) = 13^{K} \Rightarrow \times \sin 45^\circ = 9.2^{K}$

$754\,(10)(10/12) = 6.3^{K} \Rightarrow \times \sin 45^\circ = 4.5^{K}$

→ SIZE FRAME MEMBERS

→ Pipe Piles: 12 3/4" O.D. $A = 19.2\ in^2$ $t = 1/2"$

$I = 362\ in^4$ $r = 4.33$

$S = 56.7\ in^3$

From STRUDL 'SITE3W':

(A) $P = 35^K$ $M = 62.7^{'\cdot K}$ $V = 3.9^K$

(B) 32.7^K $77.8^{'\cdot K}$ 4.3

→ @ member 17, node 15 / 8 rock surface

$L = 34'$ Fixed base, semi-rigid @ top, braced against sidesway

let $K = 1.0$

$\frac{KL}{r} = 34(12)/4.33 = 94.22$

see AISC 9th p. 3-16

$\therefore F_a = 13.69$ ksi

(A) $f_a = 35/19.2 = 1.82$ ksi

$f_a/F_a = 1.82/13.69 = 0.133$

$F'_e = 12\pi^2 E/23(K\cdot L/r)^2 = 16.82$

$f_b = 62.7(12)/56.7 = 13.27$

$\frac{f_a}{.6F_y} + \frac{f_b}{F_b} = \frac{1.82}{.6(35)} + \frac{13.21}{.6(35)} = 0.716 < 1.0$ {EQ. H1-2 AISC 9th}

$$\frac{f_a}{F_a} + \frac{C_m \cdot f_b}{\left(1 - \frac{f_a}{F_e'}\right) F_b} \leq 1.0 \qquad \text{[EQ H1-1 : AISC 9th]}$$

Conservatively let $C_m = 1.0$

$$.133 + \frac{13.27}{\left(1 - \frac{1.82}{16.82}\right).6(35)} = 0.842 < 1.0$$

Check (B), memb 17, node 8 $\quad P = 32.7$
$M = 77.8^{1.k}$
$V = 4.3$

EQ H1-2: $f_a = 1.7$
$f_b = 16.47$

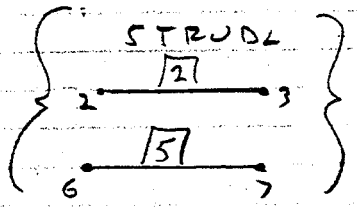
$$\frac{1.7}{.6(35)} + \frac{16.47}{.6(35)} = 0.865 < 1.0$$

EQ H1-1

$$\frac{1.7}{13.64} + \frac{16.47}{\left(1 - \frac{1.7}{16.82}\right).6(35)} = 0.997 < 1.0$$

$\Rightarrow \therefore$ 12" ϕ, $\frac{1}{2}$" wall pipe piles will be adequate

⇒ HORIZONTAL MEMBERS



@ MEMB [5]

P = 7.52 K

M = 40.2 '-K

V = 16.33 K

C 12×25 : L = 4.83'

A = 7.35 in² r = 0.780 in

I = 144 in⁴ t_w = 3/8"

S = 24.1 in³

Set K = 1.0 (cons.)

$Kl/r = 1.0(4.83)(12)/0.78 = 74.31$

F_a = 15.71 ksi. AISC 9th Table C-36 p. 3-16

$f_a = 7.52/7.35 = 1.02$ ksi

$f_a/F_a = 1.02/15.71 = 0.065 < 0.15$

∴ use AISC EQ H1-3

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \leq 1.0$$

$$f_b = \frac{40.2(12)}{24.1} = 20.02$$

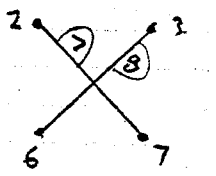
$$\frac{f_b}{F_b} = \frac{20.02}{.6(36)} = 0.927$$

$.065 + 0.927 = 0.992 < 1.0$

⇒ ∴ C 12×25 will be adequate

⇒ DIAGONALS

STRUDL



$P = 11.3^{K}$

L 4 x 4 x 3/8

$A = 2.67\ in^2$ $r = 0.788$

$11.3 / 2.67 = 4.23\ ksi$

$\frac{kl}{r} = (1)(1.0)(11.0)/.788 = 167.5 < 200$ O.K.

$F_a = 5.32$

⇒ ∴ L 4 x 4 x 3/8 will be adequate

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Project _____ Acc. No. _____

Subject ELIZABETH MARINA WAVE SCREEN Sheet No. ____ of ____

Date 9-8 19 90

Comp. _____ Check _____ Cont. No. _____

STRUDL FILE

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OUTPUT: SITE3OUT

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 $ HARBOR NAVIGATION STUDY
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 $ WAVE SCREEN
 $
 JOINT COORDS
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 10 0. -34.
 11 0. -35.
 12 0. -36.
 13 0. -37.
 14 0. -38.
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 9 TO 15 16 TO 22 AX 19.2 IZ 362.
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 $ HORIZ BRACES C12X25
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 $ DIAG L 4X4X.375
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$ WAVE @ MHW
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PRINT DATA
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LIST DISPLACEMENTS
UNIT FEET KIP
LIST REACTIONS FORCES
LIST SECTION FORCES MEMB 9 10 16 17
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FINISH
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Fri Sep 4 08:59:57 1998

HARBOR NAVIGATION STUDY
ELIZABETH CITY MARINA
WAVE SCREEN

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*  RELEASE DATE          VERSION              COMPLETION NO.        *
*  February 1995         9401 PC                 3276               *
*                                                                   *
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**** ACTIVE UNITS -  LENGTH   WEIGHT   ANGLE    TEMPERATURE   TIME
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{   87} > 20 MOM Z KFX 30750.
{   88} > $
{   89} > MATERIAL STEEL ALL
{   90} > $
{   91} > UNIT FEET
{   92} > $
{   93} > $ LOAD CASES
{   94} > $ DL DEAD LOAD
{   95} > $ WAVE @ MHW
{   96} > $
{   97} > $
{   98} > DEAD LOAD 'DL' 'SELF WT.' DIR -Y ALL MEM
{   99} > $
{  100} > LOADING 'WAVE' '3.5 FOOT WAVE AT MHW'
{  101} > JOINT LOADS
{  102} > 5 FORCE X 9.2
{  103} > $
{  104} > MEM LOAD
{  105} > 9 FORCE X GLOB CONC P 4.5 L 5.25
{  106} > LOAD COMB 1 'set' COMB 'DL' 1.0 'WAVE' 1.0
{  107} > LOAD LIST all
{  108} > STIFFNESS ANALYSIS


BANDWIDTH INFORMATION BEFORE RENUMBERING.


THE MAXIMUM BANDWIDTH IS    7 AND OCCURS AT JOINT 15
THE AVERAGE BANDWIDTH IS                      2.000
THE STANDARD DEVIATION OF THE BANDWIDTH IS    1.789
                                             -------
                                              3.789
                                             =======



BANDWIDTH INFORMATION AFTER  RENUMBERING.


THE MAXIMUM BANDWIDTH IS    3 AND OCCURS AT JOINT 7
THE AVERAGE BANDWIDTH IS                      1.300
THE STANDARD DEVIATION OF THE BANDWIDTH IS    0.640
                                             -------
                                              1.940
                                             =======
TIME FOR CONSISTENCY CHECKS FOR     22 MEMBERS      0.06 SECONDS
TIME FOR BANDWIDTH REDUCTION                        0.05 SECONDS
```

```
TIME TO GENERATE      22 ELEMENT STIF. MATRICES      0.05 SECONDS
TIME TO PROCESS        2 MEMBER RELEASES             0.00 SECONDS
TIME TO PROCESS         23 MEMBER LOADS              0.05 SECONDS
TIME TO ASSEMBLE THE STIFFNESS MATRIX                0.06 SECONDS
TIME TO PROCESS       20 JOINTS                      0.05 SECONDS
TIME TO SOLVE WITH     5 PARTITIONS                  0.06 SECONDS
TIME TO PROCESS       20 JOINT DISPLACEMENTS         0.05 SECONDS
TIME TO PROCESS       22 ELEMENT DISTORTIONS         0.06 SECONDS
TIME FOR STATICS CHECK                               0.00 SECONDS
TIME TO GENERATE COMBINED RESULTS                    0.00 SECONDS
{  109} > PRINT DATA
```

```
*****************************************
*  PROBLEM DATA FROM INTERNAL STORAGE   *
*****************************************

JOB ID - SITE3        JOB TITLE - NONE GIVEN

ACTIVE UNITS -  LENGTH       WEIGHT       ANGLE       TEMPERATURE      TIME
                  FEET         KIP          DEG          DEGF           SEC

          ********** STRUCTURAL DATA **********
```

JOINT COORDINATES----------/ STATUS---/

JOINT	X	Y	Z	CONDITION		
1	0.000	11.500	0.000	FREE	ACTIVE	GLOBAL
2	0.500	11.500	0.000	FREE	ACTIVE	GLOBAL
3	3.583	11.500	0.000	FREE	ACTIVE	GLOBAL
4	4.083	11.500	0.000	FREE	ACTIVE	GLOBAL
5	0.000	1.000	0.000	FREE	ACTIVE	GLOBAL
6	0.500	1.000	0.000	FREE	ACTIVE	GLOBAL
7	5.333	1.000	0.000	FREE	ACTIVE	GLOBAL
8	5.833	1.000	0.000	FREE	ACTIVE	GLOBAL
9	0.000	-33.000	0.000	SUPPORT	ACTIVE	GLOBAL
10	0.000	-34.000	0.000	SUPPORT	ACTIVE	GLOBAL
11	0.000	-35.000	0.000	SUPPORT	ACTIVE	GLOBAL
12	0.000	-36.000	0.000	SUPPORT	ACTIVE	GLOBAL
13	0.000	-37.000	0.000	SUPPORT	ACTIVE	GLOBAL
14	0.000	-38.000	0.000	SUPPORT	ACTIVE	GLOBAL
15	11.500	-33.000	0.000	SUPPORT	ACTIVE	GLOBAL
16	11.667	-34.000	0.000	SUPPORT	ACTIVE	GLOBAL
17	11.834	-35.000	0.000	SUPPORT	ACTIVE	GLOBAL
18	12.001	-36.000	0.000	SUPPORT	ACTIVE	GLOBAL
19	12.168	-37.000	0.000	SUPPORT	ACTIVE	GLOBAL
20	12.335	-38.000	0.000	SUPPORT	ACTIVE	GLOBAL

JOINT RELEASES----------/ ELASTIC SUPPORT RELEASES /----------

JOINT	FORCE	MOMENT	THETA 1	THETA 2	THETA 3	KFX	KFY	KFZ	KMX	KMY	KMZ	DAMPING
9	Y	Z	0.000	0.000	0.000	184500.000	0.000	0.000	0.000	0.000	0.000	0.000
10	Y	Z	0.000	0.000	0.000	369000.000	0.000	0.000	0.000	0.000	0.000	0.000
11	Y	Z	0.000	0.000	0.000	369000.000	0.000	0.000	0.000	0.000	0.000	0.000
12	Y	Z	0.000	0.000	0.000	369000.000	0.000	0.000	0.000	0.000	0.000	0.000
13	Y	Z	0.000	0.000	0.000	369000.000	0.000	0.000	0.000	0.000	0.000	0.000
14		Z	0.000	0.000	0.000	369000.000	0.000	0.000	0.000	0.000	0.000	0.000
15	Y	Z	0.000	0.000	0.000	184500.000	0.000	0.000	0.000	0.000	0.000	0.000
16	Y	Z	0.000	0.000	0.000	369000.000	0.000	0.000	0.000	0.000	0.000	0.000
17	Y	Z	0.000	0.000	0.000	369000.000	0.000	0.000	0.000	0.000	0.000	0.000
18	Y	Z	0.000	0.000	0.000	369000.000	0.000	0.000	0.000	0.000	0.000	0.000
19	Y	Z	0.000	0.000	0.000	369000.000	0.000	0.000	0.000	0.000	0.000	0.000

20		Z	0.000	0.000	0.000	369000.000	0.000	0.000	0.000	0.000	0.000	0.000

MEMBER INCIDENCES----------/ LENGTH------/ RELEASES----------/ STATUS--/

MEMBER	START	END	LOCAL COORD.	START FORCE	START MOMENT	END FORCE	END MOMENT			
1	1	2	0.500					ACTIVE	PLANE	FRAME
2	2	3	3.083					ACTIVE	PLANE	FRAME
3	3	4	0.500					ACTIVE	PLANE	FRAME
4	5	6	0.500					ACTIVE	PLANE	FRAME
5	6	7	4.833					ACTIVE	PLANE	FRAME
6	7	8	0.500					ACTIVE	PLANE	FRAME
7	2	7	11.559		Z		Z	ACTIVE	PLANE	FRAME
8	3	6	10.943		Z		Z	ACTIVE	PLANE	FRAME
9	1	5	10.500					ACTIVE	PLANE	FRAME
10	5	9	34.000					ACTIVE	PLANE	FRAME
11	9	10	1.000					ACTIVE	PLANE	FRAME
12	10	11	1.000					ACTIVE	PLANE	FRAME
13	11	12	1.000					ACTIVE	PLANE	FRAME
14	12	13	1.000					ACTIVE	PLANE	FRAME
15	13	14	1.000					ACTIVE	PLANE	FRAME
16	4	8	10.645					ACTIVE	PLANE	FRAME
17	8	15	34.469					ACTIVE	PLANE	FRAME
18	15	16	1.014					ACTIVE	PLANE	FRAME
19	16	17	1.014					ACTIVE	PLANE	FRAME
20	17	18	1.014					ACTIVE	PLANE	FRAME
21	18	19	1.014					ACTIVE	PLANE	FRAME
22	19	20	1.014					ACTIVE	PLANE	FRAME

MEMBER ELASTIC CONNECTIONS ----------

MEMBER	START						/ END					
	KX	KY	KZ	KMX	KMY	KMZ	KX	KY	KZ	KMX	KMY	KMZ

MEMBER NONLINEAR CONNECTIONS----------

MEMBER	START CURVES						/ END CURVES					
	KX	KY	KZ	KMX	KMY	KMZ	KX	KY	KZ	KMX	KMY	KMZ

**** NO SHAPE DATA FOUND FOR MEMBER LIST SPECIFIED

MEMBER PROPERTIES----------/

MEMBER/SEG	TYPE	SEG.L	AX	AY	AZ	IX	IY	IZ	SY	SZ
			YD	ZD	YC	ZC	EY	EZ		
			ID	OD	TH-PIPE	SC				
1	PRISMATIC		0.694	0.000	0.000	0.000	0.000	0.482	0.000	0.000

		0.000	0.000	0.000	0.000	0.000	0.000		
2	PRISMATIC	0.051	0.000	0.000	0.000	0.000	0.004	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
3	PRISMATIC	0.694	0.000	0.000	0.000	0.000	0.482	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
4	PRISMATIC	0.694	0.000	0.000	0.000	0.000	0.482	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
5	PRISMATIC	0.051	0.000	0.000	0.000	0.000	0.004	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
6	PRISMATIC	0.694	0.000	0.000	0.000	0.000	0.482	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
7	PRISMATIC	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
8	PRISMATIC	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
9	PRISMATIC	0.133	0.000	0.000	0.000	0.000	0.017	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
10	PRISMATIC	0.133	0.000	0.000	0.000	0.000	0.017	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
11	PRISMATIC	0.133	0.000	0.000	0.000	0.000	0.017	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
12	PRISMATIC	0.133	0.000	0.000	0.000	0.000	0.017	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
13	PRISMATIC	0.133	0.000	0.000	0.000	0.000	0.017	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
14	PRISMATIC	0.133	0.000	0.000	0.000	0.000	0.017	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
15	PRISMATIC	0.133	0.000	0.000	0.000	0.000	0.017	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
16	PRISMATIC	0.133	0.000	0.000	0.000	0.000	0.017	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
17	PRISMATIC	0.133	0.000	0.000	0.000	0.000	0.017	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
18	PRISMATIC	0.133	0.000	0.000	0.000	0.000	0.017	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
19	PRISMATIC	0.133	0.000	0.000	0.000	0.000	0.017	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
20	PRISMATIC	0.133	0.000	0.000	0.000	0.000	0.017	0.000	0.000

		0.000	0.000	0.000	0.000	0.000	0.000		
21	PRISMATIC	0.133	0.000	0.000	0.000	0.000	0.017	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		
22	PRISMATIC	0.133	0.000	0.000	0.000	0.000	0.017	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000		

MEMBER CONSTANTS----------/

CONSTANT	STANDARD VALUE	DOMAIN	VALUE	MEMBER LIST
E	0.417600E+07	ALL		
G	0.158400E+07	ALL		
DENSITY	0.489542E+00	ALL		
CTE	0.650000E-05	ALL		
BETA	0.000000E+00	ALL		
POISSON	0.300000E+00	ALL		
DAMP STI	0.000000E+00	ALL		
DAMP INE	0.000000E+00	ALL		

********** DESIGN DATA **********

STRUDL DATA SET

PARAMETER DICTIONARY----------/

NAME	TREATMENT	STANDARD	L	W	A	TEMP TIME
CODE	REQUIRED	ALPHA				
TBLNAM	CMPALPHA	QQSTTTBL				
STEELGRD	STANDARD	A36				
FYLD	COMPALWY	QQSTFYLD	-2	1		
PTS	COMPALWY	QQSTFYLD	-2	1		
X	STANDARD	1.00				
XY	STANDARD	1.00				
XZ	STANDARD	1.00				
COMPK	STANDARD	NO				
BAY	STANDARD	COMPUTE				

GAZ	STANDARD	COMPUTE		
GBY	STANDARD	COMPUTE		
GBZ	STANDARD	COMPUTE		
L	COMPUTE	QQSTULEN	1	
LY	COMPUTE	QQSTULEN	1	
LZ	COMPUTE	QQSTULEN	1	
UNLCF	COMPUTE	QQSTULEN	1	
FRLY	STANDARD	1.00		
FRLZ	STANDARD	1.00		
FRL	STANDARD	1.00		
FRUNLCF	STANDARD	1.00		
CB	COMPALWY	QQSTCBIC		
CMY	COMPALWY	QQSTCMYC		
CMZ	COMPALWY	QQSTCMZC		
CM	COMPALWY	QQSTCMRC		
SDSWAYY	STANDARD	YES		
SDSWAYZ	STANDARD	YES		
SDSWAY	STANDARD	YES		
PF	STANDARD	1.00		
A/H	STANDARD	10000.00		
WEBSTIF	STANDARD	NO		
SECNDARY	STANDARD	NO		
DUCTFSTR	STANDARD	1.00		
DUCTFSTA	STANDARD	1.00		
FBLTUP	STANDARD	NO		
CODETOL	STANDARD	0.00		
REDFYLD	STANDARD	1.00		
REDFTS	STANDARD	1.00		
REDE	STANDARD	1.00		
FSB	STANDARD	2.00		
BFAC	STANDARD	1.00		
AXEFF	STANDARD	0.00		
SUMMARY	STANDARD	NO		
MXTRIALS	STANDARD	500.00		
VALUES	STANDARD	1.00		
TRACE	STANDARD	4.00		
PRIDTA	STANDARD	1.00		
FXMIN	STANDARD	0.00		1
FYMIN	STANDARD	0.00		1
FZMIN	STANDARD	0.00		1
FVMIN	STANDARD	0.00		1
MXMIN	STANDARD	0.00	1	1
MYMIN	STANDARD	0.00	1	1
MZMIN	STANDARD	0.00	1	1
MRMIN	STANDARD	0.00	1	1
TYPE	STANDARD	OTHER		
LX	COMPUTE	QQSTULEN	1	
FRLX	STANDARD	1.00		
SLENTEN	STANDARD	COMPUTE		
SLENCOMP	STANDARD	COMPUTE		
CONCNLD	STANDARD	COMPUTE		
RESTRAIN	STANDARD	COMPUTE		
B/TLMT	STANDARD	20.00		
BOLTTYPE	STANDARD	A394		
BOLTSHR	STANDARD	COMPUTE		
DIABOLT	STANDARD	0.05	1	
LEGBOLTD	STANDARD	COMPUTE		

NUMBOLTS	STANDARD	COMPUTE		
HOLESOUT	STANDARD	COMPUTE		
TYPSHEAR	STANDARD	COMPUTE		
BEARNGF	STANDARD	COMPUTE		
HOLE/ROW	STANDARD	12.00		
KL/R	STANDARD	COMPUTE		
BERSURF	STANDARD	COMPUTE		
MINTHK	STANDARD	0.02	1	
MAXTHK	STANDARD	1.00	1	
INCTHK	STANDARD	0.02	1	
MINDIA	STANDARD	0.50	1	
MAXDIA	STANDARD	40.00	1	
INCDIA	STANDARD	0.08	1	
MAXD/T	STANDARD	300.00		
REVSTR	STANDARD	NO		
SYMBRAC	STANDARD	YES		
SFAXTEN	STANDARD	0.60		
SFAXCMP	STANDARD	0.60		
SFSHEAR	STANDARD	0.40		
SFTORSN	STANDARD	0.40		
SFNORMAL	STANDARD	0.60		
FY	STANDARD	5184.00	-2	1
FU	STANDARD	8352.00	-2	1
SY	STANDARD	5184.00	-2	1
SU	STANDARD	8352.00	-2	1
LWARP	COMPALWY	QQSTULEN	1	
XW	STANDARD	0.00	1	
WARP-END	STANDARD	PIN-PIN		
SLEND	STANDARD	0.00	1	
OMEGAZ	COMPALWY	QQSTBMOZ		
OMEGAY	COMPALWY	QQSTBMOY		
OMEGA	STANDARD	1.00		
PHI	STANDARD	0.90		
ULTF	COMPALWY	QQSTULPG	1	
ULBF	COMPALWY	QQSTULPG	1	
FRULTF	STANDARD	1.00		
FRULBF	STANDARD	1.00		
FRLRG	COMPUTE	QQSTULPG		
CFOCRTOL	STANDARD	1.00		
UNITS	STANDARD	CODEUNIT		
PUNCHHOL	STANDARD	0.01	1	
MAXNMBLT	STANDARD	100.00		
INCR	STANDARD	1.00		
FBFAC	STANDARD	0.66		
COMPTEST	STANDARD	1300.00		
SLND	STANDARD	COMPUTE		
LF	STANDARD	1.00		
XBRACE	STANDARD	1.00		
CMC	STANDARD	1.00		
REV	STANDARD	YES		
BASIS	STANDARD	STRESS		
GAMM	STANDARD	1.15		
IPA	STANDARD	0.00	4	
APA	STANDARD	0.00	2	
ICHTK	STANDARD	0.00	1	
INCWT	STANDARD	0.01	1	
FCHTK	STANDARD	0.00	1	

CANTILVR	STANDARD	YES		
KA	STANDARD	COMPUTE		
KB	STANDARD	COMPUTE		
GRPLOAD	STANDARD			
TOLPLANE	STANDARD	10.00		1
PHASE	STANDARD	FIX		
DELH	STANDARD	0.08	1	
SWDP	STANDARD	0.08	1	
Z	STANDARD	0.08	1	
HW	STANDARD	0.08	1	
SF	STANDARD	1.67		
C	STANDARD	1.00		
LW	STANDARD	0.08	1	
SR	STANDARD	-1.00		
PROFAC	STANDARD	1.00		
SECFACY	STANDARD	B		
SECFACZ	STANDARD	A		
WARPCALC	STANDARD	2.00		
KWARP	STANDARD	COMPUTE		
WARPN	STANDARD	2.00		
BUCKLAT	STANDARD	NO		
SFHOOP	STANDARD	2.00		
SFTENS	STANDARD	1.67		
SFCOMP	STANDARD	2.00		
SFBEND	STANDARD	1.00		
RINGD	COMPUTE	QQSTTRNG	1	
SHAPE	STANDARD	COMPUTE		
TENFACT	STANDARD	COMPUTE		
PITCH	STANDARD	0.00	1	
GAGE	STANDARD	0.00	1	
ANETFACT	STANDARD	0.85		
BOLTTENS	STANDARD	COMPUTE		
W/TMAX	STANDARD	25.00		
SHRAREAF	STANDARD	COMPUTE		
APPROACH	STANDARD	EXACT		
Py	COMPALWY	QQSTFYLD	-2	1
REDPy	STANDARD	1.00		
FRLE	STANDARD	1.00		
LE	STANDARD	LY		
my	COMPALWY	QQSTCMYC		
mz	COMPALWY	QQSTCMZC		
n	STANDARD	1.00		
DESTLDZ	STANDARD	YES		
DESTLDY	STANDARD	YES		
COLUMNS	STANDARD	EXACT		
FRLEY	STANDARD	1.00		
FRLEZ	STANDARD	1.00		
UNLCFTF	STANDARD	COMPUTE		
UNLCFBF	STANDARD	COMPUTE		
KX	STANDARD	1.00		
LATTORBU	STANDARD	YES		
FLTORBUK	STANDARD	YES		
ALSTRINC	STANDARD	0.00		
CHECK	STANDARD	3.00		
REVHYDRO	STANDARD	YES		
FRAXMINT	STANDARD	COMPUTE		
FRAXMINC	STANDARD	COMPUTE		

FRSYMIN	STANDARD	COMPUTE
FRSZMIN	STANDARD	COMPUTE
FRZYMIN	STANDARD	COMPUTE
FRZZMIN	STANDARD	COMPUTE

STRUDL DATA SET

CONSTRAINT DICTIONARY----------/

NAME	RETRIEVAL
AX	TABULAR
AY	TABULAR
AZ	TABULAR
IX	TABULAR
IY	TABULAR
IZ	TABULAR
SY	TABULAR
SZ	TABULAR
YD	TABULAR
ZD	TABULAR
FLTK	TABULAR
WBTK	TABULAR
YD/AFL	TABULAR
RY	TABULAR
RZ	TABULAR
COMP	TABULAR
YC	TABULAR
ZC	TABULAR
WEIGHT	TABULAR
ZY	TABULAR
ZZ	TABULAR
INTYD	TABULAR
BF/2TF	TABULAR
D/TW	TABULAR
GRPNUM	TABULAR
LEG1	TABULAR
LEG2	TABULAR
THICK	TABULAR
SPACING	TABULAR
SHAPE	TABULAR
ND	TABULAR
OD	TABULAR
ID	TABULAR
RT	TABULAR
CW	TABULAR

********** LOADING DATA **********

LOADING - DL SELF WT. STATUS - ACTIVE

MEMBER AND ELEMENT LOADS----------/

MEMBER/ELEMENT

L UNIFORM LOAD GLOB FORCE Y FR W -0.340 LA 0.000 LB 1.000

2	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.025	LA	0.000	LB	1.000
3	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.340	LA	0.000	LB	1.000
4	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.340	LA	0.000	LB	1.000
5	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.025	LA	0.000	LB	1.000
6	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.340	LA	0.000	LB	1.000
7	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.009	LA	0.000	LB	1.000
8	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.009	LA	0.000	LB	1.000
9	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.065	LA	0.000	LB	1.000
10	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.065	LA	0.000	LB	1.000
11	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.065	LA	0.000	LB	1.000
12	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.065	LA	0.000	LB	1.000
13	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.065	LA	0.000	LB	1.000
14	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.065	LA	0.000	LB	1.000
15	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.065	LA	0.000	LB	1.000
16	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.065	LA	0.000	LB	1.000
17	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.065	LA	0.000	LB	1.000
18	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.065	LA	0.000	LB	1.000
19	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.065	LA	0.000	LB	1.000
20	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.065	LA	0.000	LB	1.000
21	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.065	LA	0.000	LB	1.000
22	UNIFORM LOAD	GLOB	FORCE	Y	FR	W	-0.065	LA	0.000	LB	1.000

LOADING - WAVE 3.5 FOOT WAVE AT MHW STATUS - ACTIVE

MEMBER AND ELEMENT LOADS----------/

MEMBER/ELEMENT

9	CONCEN. LOAD	GLOB	FORCE	X	P	4.500	L	5.250	

JOINT LOADS----------/

JOINT	STEP	FORCE X	Y	Z	MOMENT X	Y	Z
5		9.200	0.000	0.000	0.000	0.000	0.000

LOADING - 1 set STATUS - ACTIVE

COMBINATION GIVEN - DL 1.000 WAVE 1.000

****
* END OF DATA FROM INTERNAL STORAGE *
****

```
{  110} > OUTPUT DECIMAL 3
{  111} > UNITS INCHES
{  112} > SECT FR NS 1 .5
{  113} > LOAD LIST ALL
{  114} > LIST DISPLACEMENTS
```

****
RESULTS OF LATEST ANALYSES
****

PROBLEM - SITE3 TITLE - NONE GIVEN

ACTIVE UNITS INCH KIP DEG DEGF SEC

--- LOADING - DL SELF WT.

RESULTANT JOINT DISPLACEMENTS SUPPORTS

JOINT		DISPLACEMENT			ROTATION		
		X DISP.	Y DISP.	Z DISP.	X ROT.	Y ROT.	Z ROT.
9	GLOBAL	0.000	0.000				0.001
10	GLOBAL	0.000	0.000				0.000
11	GLOBAL	0.000	0.000				0.000
12	GLOBAL	0.000	0.000				0.000
13	GLOBAL	0.000	0.000				0.000
14	GLOBAL	0.000	0.000				0.000
15	GLOBAL	0.000	0.000				0.002
16	GLOBAL	0.000	0.000				0.000
17	GLOBAL	0.000	0.000				0.000
18	GLOBAL	0.000	0.000				0.000
19	GLOBAL	0.000	0.000				0.000
20	GLOBAL	0.000	0.000				0.000

RESULTANT JOINT DISPLACEMENTS FREE JOINTS

JOINT		DISPLACEMENT			ROTATION		
		X DISP.	Y DISP.	Z DISP.	X ROT.	Y ROT.	Z ROT.
1	GLOBAL	-0.044	-0.003				-0.007
2	GLOBAL	-0.044	-0.004				-0.007
3	GLOBAL	-0.044	-0.008				-0.007
4	GLOBAL	-0.044	-0.009				-0.007
5	GLOBAL	-0.058	-0.003				-0.004
6	GLOBAL	-0.058	-0.003				-0.004
7	GLOBAL	-0.058	-0.011				-0.005
8	GLOBAL	-0.058	-0.011				-0.005

--- LOADING - WAVE 3.5 FOOT WAVE AT MHW

RESULTANT JOINT DISPLACEMENTS SUPPORTS

JOINT		DISPLACEMENT			ROTATION		
		X DISP.	Y DISP.	Z DISP.	X ROT.	Y ROT.	Z ROT.
9	GLOBAL	0.003	0.003				
10	GLOBAL	-0.001	0.003				-0.039
11	GLOBAL	-0.001	0.002				-0.005
12	GLOBAL	0.000	0.001				0.003
13	GLOBAL	0.000	0.001				0.002
14	GLOBAL	0.000	0.000				0.000
15	GLOBAL	0.003	-0.003				0.000
16	GLOBAL	-0.001	-0.003				-0.039
17	GLOBAL	-0.001	-0.002				-0.004
18	GLOBAL	0.000	-0.001				0.004
19	GLOBAL	0.000	-0.001				0.002
20	GLOBAL	0.000	0.000				0.001
							0.001

RESULTANT JOINT DISPLACEMENTS FREE JOINTS

JOINT		DISPLACEMENT			ROTATION		
		X DISP.	Y DISP.	Z DISP.	X ROT.	Y ROT.	Z ROT.
1	GLOBAL	1.499	0.027				
2	GLOBAL	1.499	0.052				0.244
3	GLOBAL	1.499	0.197				0.244
4	GLOBAL	1.499	0.221				0.232
5	GLOBAL	1.962	0.026				0.232
6	GLOBAL	1.962	0.040				0.133
7	GLOBAL	1.960	0.284				0.134
8	GLOBAL	1.960	0.299				0.144
							0.144

--- LOADING - 1 set

RESULTANT JOINT DISPLACEMENTS SUPPORTS

JOINT		DISPLACEMENT			ROTATION		
		X DISP.	Y DISP.	Z DISP.	X ROT.	Y ROT.	Z ROT.
9	GLOBAL	0.003	0.003				
10	GLOBAL	-0.001	0.002				-0.038
11	GLOBAL	-0.001	0.002				-0.005
12	GLOBAL	0.000	0.001				0.003
13	GLOBAL	0.000	0.001				0.002
14	GLOBAL	0.000	0.000				0.000
							0.000

15	GLOBAL	0.003	-0.003					-0.037
16	GLOBAL	-0.001	-0.003					-0.004
17	GLOBAL	-0.001	-0.002					0.003
18	GLOBAL	0.000	-0.002					0.002
19	GLOBAL	0.000	-0.001					0.001
20	GLOBAL	0.000	0.000					0.001

RESULTANT JOINT DISPLACEMENTS FREE JOINTS

JOINT		DISPLACEMENT			ROTATION		
		X DISP.	Y DISP.	Z DISP.	X ROT.	Y ROT.	Z ROT.
1	GLOBAL	1.456	0.024				0.237
2	GLOBAL	1.456	0.049				0.236
3	GLOBAL	1.455	0.189				0.225
4	GLOBAL	1.455	0.212				0.225
5	GLOBAL	1.905	0.023				0.129
6	GLOBAL	1.905	0.037				0.130
7	GLOBAL	1.903	0.274				0.139
8	GLOBAL	1.902	0.288				0.138

```
{  115} > UNIT FEET KIP
{  116} > LIST REACTIONS FORCES
```

****
RESULTS OF LATEST ANALYSES
****

PROBLEM - SITE3 TITLE - NONE GIVEN

ACTIVE UNITS FEET KIP DEG DEGF SEC

--- LOADING - DL SELF WT.

MEMBER FORCES

MEMBER	JOINT	FORCE			MOMENT		
		AXIAL	SHEAR Y	SHEAR Z	TORSIONAL	BENDING Y	BENDING Z
1	1	-0.086	0.300				-0.093
1	2	0.086	-0.130				0.200
2	2	-0.012	-0.083				-0.200
2	3	0.012	0.160				-0.174
3	3	0.101	0.177				0.174
3	4	-0.101	-0.007				-0.128
4	5	0.214	1.067				1.568
4	6	-0.214	-0.897				-1.077
5	6	0.101	0.461				1.077
5	7	-0.101	-0.340				0.857
6	7	0.027	0.448				-0.857
6	8	-0.027	-0.278				1.039
7	2	-0.224	0.022				0.000
7	7	0.129	0.022				0.000
8	3	0.355	0.014				0.000
8	6	-0.451	0.014				0.000
9	1	0.300	0.086				0.093
9	5	-0.985	-0.086				0.812
10	5	2.052	-0.128				-2.380
10	9	-4.271	0.128				-1.969
11	9	4.271	1.345				1.969
11	10	-4.336	-1.345				-0.624
12	10	4.336	0.649				0.624
12	11	-4.402	-0.649				0.025
13	11	4.402	0.058				-0.025
13	12	-4.467	-0.058				0.084
14	12	4.467	-0.058				-0.084
14	13	-4.532	0.058				0.025

15	13	4.532	-0.025	-0.025
15	14	-4.597	0.025	0.000
16	4	0.010	0.101	0.128
16	8	-0.695	0.013	0.337
17	8	0.426	0.059	-1.376
17	15	-2.645	0.311	-2.976
18	15	3.029	1.989	2.976
18	16	-3.094	-1.978	-0.965
19	16	2.929	0.987	0.965
19	17	-2.994	-0.977	0.030
20	17	2.851	0.119	-0.030
20	18	-2.916	-0.108	0.146
21	18	2.892	-0.040	-0.146
21	19	-2.957	0.051	0.099
22	19	2.950	-0.092	-0.099
22	20	-3.015	0.103	0.000

RESULTANT JOINT LOADS SUPPORTS

JOINT		FORCE			MOMENT		
		X FORCE	Y FORCE	Z FORCE	X MOMENT	Y MOMENT	Z MOMENT
9	GLOBAL	1.473	0.000				0.000
10	GLOBAL	-0.695	0.000				0.000
11	GLOBAL	-0.591	0.000				0.000
12	GLOBAL	-0.117	0.000				0.000
13	GLOBAL	0.033	0.000				0.000
14	GLOBAL	0.025	4.597				0.000
15	GLOBAL	2.333	0.000				0.000
16	GLOBAL	-1.004	0.000				0.000
17	GLOBAL	-0.869	0.000				0.000
18	GLOBAL	-0.151	0.000				0.000
19	GLOBAL	-0.042	0.000				0.000
20	GLOBAL	-0.395	2.991				0.000

--- LOADING - WAVE 3.5 FOOT WAVE AT MHW

MEMBER FORCES

MEMBER	JOINT	FORCE			MOMENT		
		AXIAL	SHEAR Y	SHEAR Z	TORSIONAL	BENDING Y	BENDING Z
1	1	5.310	-3.147				8.567
1	2	-5.310	3.147				-10.141
2	2	1.187	5.810				10.141
2	3	-1.187	-5.810				7.771
3	3	-2.096	-5.371				-7.771

3	4	2.096	5.371	5.085
4	5	4.134	-27.972	-55.244
4	6	-4.134	27.972	41.258
5	6	7.417	-16.791	-41.258
5	7	-7.417	16.791	-39.891
6	7	11.539	-25.748	39.891
6	8	-11.539	25.748	-52.765
7	2	9.860	0.000	0.000
7	7	-9.860	0.000	0.000
8	3	-11.653	0.000	0.000
8	6	11.653	0.000	0.000
9	1	-3.147	-5.310	-8.567
9	5	3.147	0.810	-23.561
10	5	-31.119	4.257	78.805
10	9	31.119	-4.257	65.920
11	9	-31.119	-45.032	-65.920
11	10	31.119	45.032	20.888
12	10	-31.119	-21.739	-20.888
12	11	31.119	21.739	-0.851
13	11	-31.119	-1.951	0.851
13	12	31.119	1.951	-2.802
14	12	-31.119	1.949	2.802
14	13	31.119	-1.949	-0.853
15	13	-31.119	0.853	0.853
15	14	31.119	-0.853	0.000
16	4	4.954	-2.951	-5.085
16	8	-4.954	2.951	-26.323
17	8	32.248	4.199	79.089
17	15	-32.248	-4.199	65.634
18	15	24.140	-44.374	-65.634
18	16	-24.140	44.374	20.646
19	16	28.007	-21.215	-20.646
19	17	-28.007	21.215	-0.863
20	17	31.274	-1.656	0.863
20	18	-31.274	1.656	-2.542
21	18	31.934	2.301	2.542
21	19	-31.934	-2.301	-0.209
22	19	31.585	0.206	0.209
22	20	-31.585	-0.206	0.000

RESULTANT JOINT LOADS SUPPORTS

JOINT		FORCE			MOMENT		
		X FORCE	Y FORCE	Z FORCE	X MOMENT	Y MOMENT	Z MOMENT
9	GLOBAL	-49.289	0.000				0.000
10	GLOBAL	23.293	0.000				0.000
11	GLOBAL	19.789	0.000				0.000
12	GLOBAL	3.900	0.000				0.000
13	GLOBAL	-1.097	0.000				0.000
14	GLOBAL	-0.853	-31.119				0.000
15	GLOBAL	-49.235	0.000				0.000
16	GLOBAL	23.480	0.000				0.000
17	GLOBAL	19.830	0.000				0.000
18	GLOBAL	4.011	0.000				0.000

19	GLOBAL	-2.123	0.000				0.000
20	GLOBAL	-5.406	31.119				0.000

--- LOADING - 1 set

MEMBER FORCES

MEMBER	JOINT	FORCE			MOMENT		
		AXIAL	SHEAR Y	SHEAR Z	TORSIONAL	BENDING Y	BENDING Z
1	1	5.224	-2.848				8.474
1	2	-5.224	3.018				-9.940
2	2	1.175	5.727				9.940
2	3	-1.175	-5.650				7.597
3	3	-1.995	-5.195				-7.597
3	4	1.995	5.365				4.957
4	5	4.348	-26.905				-53.676
4	6	-4.348	27.075				40.181
5	6	7.517	-16.330				-40.181
5	7	-7.517	16.451				-39.034
6	7	11.566	-25.300				39.034
6	8	-11.566	25.470				-51.726
7	2	9.636	0.022				0.000
7	7	-9.732	0.022				0.000
8	3	-11.298	0.014				0.000
8	6	11.203	0.014				0.000
9	1	-2.848	-5.224				-8.474
9	5	2.162	0.724				-22.749
10	5	-29.067	4.129				76.425
10	9	26.848	-4.129				63.951
11	9	-26.848	-43.687				-63.951
11	10	26.783	43.687				20.264
12	10	-26.783	-21.090				-20.264
12	11	26.718	21.090				-0.826
13	11	-26.718	-1.892				0.826
13	12	26.652	1.892				-2.718
14	12	-26.652	1.891				2.718
14	13	26.587	-1.891				-0.827
15	13	-26.587	0.827				0.827
15	14	26.522	-0.827				0.000
16	4	4.964	-2.850				-4.957
16	8	-5.649	2.964				-25.986
17	8	32.674	4.257				77.713
17	15	-34.893	-3.887				62.658
18	15	27.169	-42.385				-62.658
18	16	-27.234	42.396				19.680
19	16	30.936	-20.227				-19.680
19	17	-31.002	20.238				-0.833
20	17	34.125	-1.536				0.833

20	18	-34.190	1.547	-2.396
21	18	34.826	2.260	2.396
21	19	-34.891	-2.249	-0.110
22	19	34.535	0.114	0.110
22	20	-34.600	-0.103	0.000

RESULTANT JOINT LOADS SUPPORTS

JOINT		FORCE			MOMENT		
		X FORCE	Y FORCE	Z FORCE	X MOMENT	Y MOMENT	Z MOMENT
9	GLOBAL	-47.816	0.000				0.000
10	GLOBAL	22.598	0.000				0.000
11	GLOBAL	19.198	0.000				0.000
12	GLOBAL	3.783	0.000				0.000
13	GLOBAL	-1.064	0.000				0.000
14	GLOBAL	-0.827	-26.522				0.000
15	GLOBAL	-46.902	0.000				0.000
16	GLOBAL	22.475	0.000				0.000
17	GLOBAL	18.961	0.000				0.000
18	GLOBAL	3.860	0.000				0.000
19	GLOBAL	-2.165	0.000				0.000
20	GLOBAL	-5.801	34.110				0.000

{ 117} > LIST SECTION FORCES MEMB 9 10 16 17

****
RESULTS OF LATEST ANALYSES
****

PROBLEM - SITE3 TITLE - NONE GIVEN

ACTIVE UNITS FEET KIP DEG DEGF SEC

INTERNAL MEMBER RESULTS

MEMBER SECTION FORCES

--- MEMBER 9

LOADING DL SELF WT.

DISTANCE FROM START	FORCE AXIAL	FORCE Y SHEAR	FORCE Z SHEAR	MOMENT TORSION	MOMENT Y BENDING	MOMENT Z BENDING
0.500 FR	-0.6423326	-0.8616079E-01				0.3593081

LOADING WAVE 3.5 FOOT WAVE AT MHW

DISTANCE FROM START	FORCE AXIAL	FORCE Y SHEAR	FORCE Z SHEAR	MOMENT TORSION	MOMENT Y BENDING	MOMENT Z BENDING
0.500 FR	3.147318	5.309806				-19.30948

LOADING 1 set

DISTANCE FROM START	FORCE AXIAL	FORCE Y SHEAR	FORCE Z SHEAR	MOMENT TORSION	MOMENT Y BENDING	MOMENT Z BENDING
0.500 FR	2.504986	5.223646				-18.95017

--- MEMBER 10

LOADING DL SELF WT.

DISTANCE FROM START	FORCE AXIAL	FORCE Y SHEAR	FORCE Z SHEAR	MOMENT TORSION	MOMENT Y BENDING	MOMENT Z BENDING
0.500 FR	-3.161451	0.1278923				0.2053816

LOADING WAVE 3.5 FOOT WAVE AT MHW

DISTANCE FROM START	FORCE AXIAL	FORCE Y SHEAR	FORCE Z SHEAR	MOMENT TORSION	MOMENT Y BENDING	MOMENT Z BENDING
0.500 FR	31.11919	-4.256615				-6.442245

LOADING 1 set

DISTANCE FROM START	FORCE AXIAL	FORCE Y SHEAR	FORCE Z SHEAR	MOMENT TORSION	MOMENT Y BENDING	MOMENT Z BENDING
0.500 FR	27.95774	-4.128722				-6.236864

--- MEMBER 16

LOADING DL SELF WT.

DISTANCE FROM START	FORCE AXIAL	FORCE Y SHEAR	FORCE Z SHEAR	MOMENT TORSION	MOMENT Y BENDING	MOMENT Z BENDING
0.500 FR	-0.3524909	-0.4370601E-01				0.2564035

LOADING WAVE 3.5 FOOT WAVE AT MHW

DISTANCE FROM START	FORCE AXIAL	FORCE Y SHEAR	FORCE Z SHEAR	MOMENT TORSION	MOMENT Y BENDING	MOMENT Z BENDING
0.500 FR	-4.953789	2.950605				-10.61913

LOADING 1 set

DISTANCE FROM START	FORCE AXIAL	FORCE Y SHEAR	FORCE Z SHEAR	MOMENT TORSION	MOMENT Y BENDING	MOMENT Z BENDING
0.500 FR	-5.306280	2.906898				-10.36273

--- MEMBER 17

LOADING DL SELF WT.

DISTANCE FROM START	FORCE AXIAL	FORCE Y SHEAR	FORCE Z SHEAR	MOMENT TORSION	MOMENT Y BENDING	MOMENT Z BENDING
0.500 FR	-1.535392	0.1262571				0.7934864

LOADING WAVE 3.5 FOOT WAVE AT MHW

DISTANCE FROM START	FORCE AXIAL	FORCE Y SHEAR	FORCE Z SHEAR	MOMENT TORSION	MOMENT Y BENDING	MOMENT Z BENDING
0.500 FR	-32.24831	-4.198627				-6.727248

LOADING 1 set

DISTANCE FROM START	FORCE AXIAL	FORCE Y SHEAR	FORCE Z SHEAR	MOMENT TORSION	MOMENT Y BENDING	MOMENT Z BENDING
0.500 FR	-33.78370	-4.072370				-5.933762

```
 {  118} > SAVE 'SITE3'
# File exists and will be overwritten.
 DAM-i-filsave, Sub-system 9401 PC  saved in file .\SITE3.sav.
 {  119} > FINISH
```

---------- RUN-TIME PERFORMANCE SUMMARY ----------

CPU Time 00:00:09.03 Elapsed Time 0 00:00:09 On Fri Sep 4 09:00:04 1998

#Customer #51300101 has unlimited CPU time remaining.

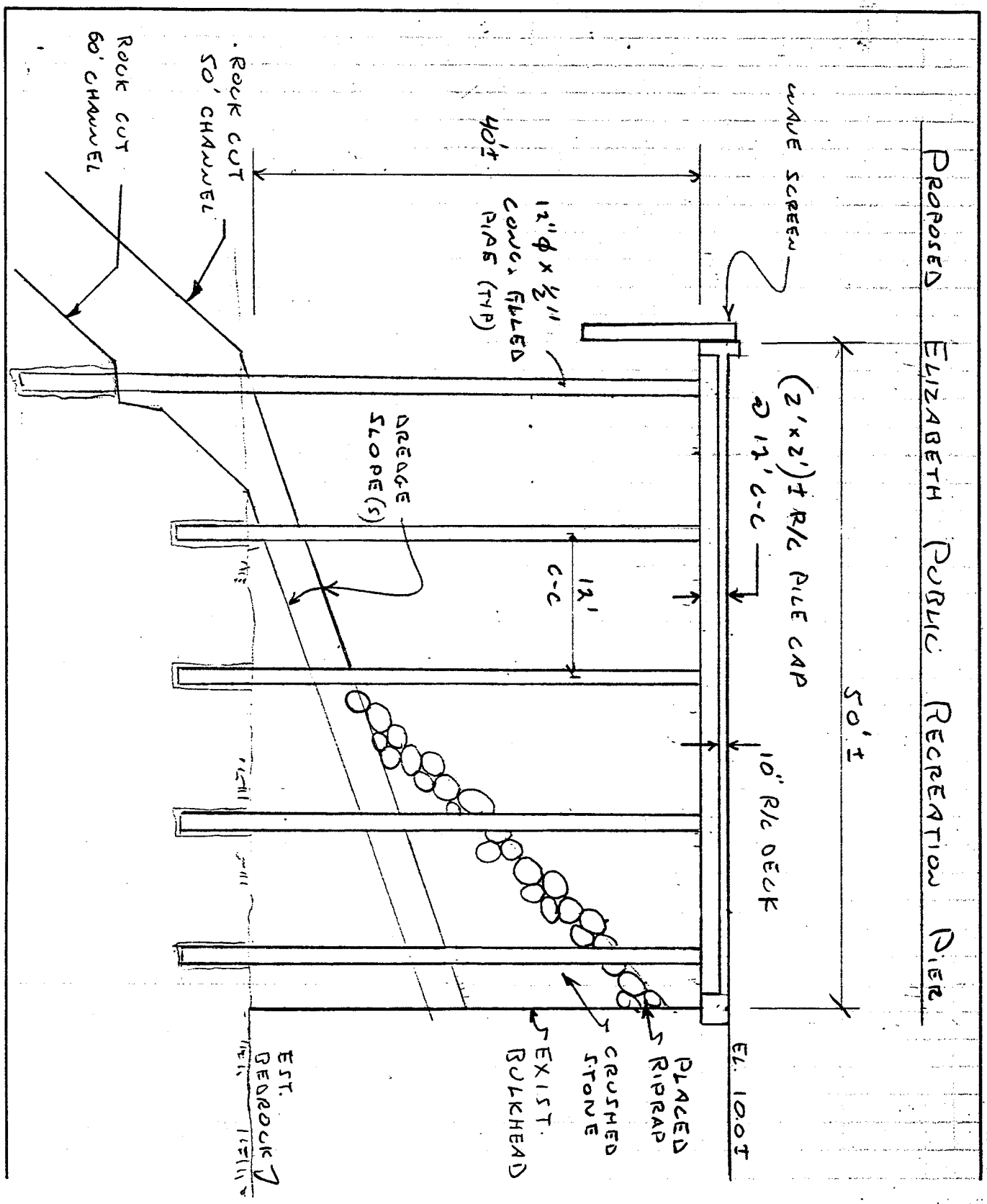
MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.

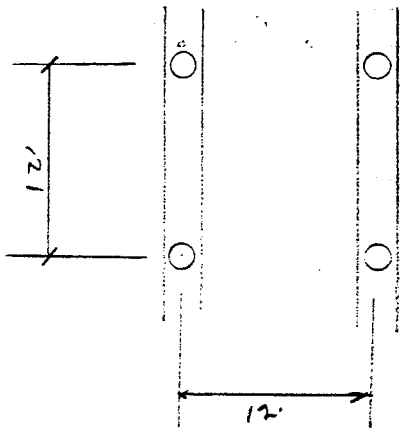
Subject PANYNJ SITE #3 Sheet No. 1 of

ELIZABETH MARINA - PUBLIC PIER Date 9 19 78

Comp. DJF Check Cont. No.



- ASSUME A PILE/BENT GRID OF 12×12



PILE LOADS:

AXIAL: $12(12)(200)/1000 = 28.8^{k}$

LATERAL: from Wave Screen, wave loading is 2.315 klf @ 45° ≈ 1.64 klf

Due to the stiffness of the concrete deck, lateral loading at any location will be distributed to adjacent pile bents. For the analysis of the piles:

- consider that the full wave loading in one span (12)(2.315) is distributed over 4 bents, or 20 piles

  $12(2.315)/20 = 1.389 \approx 1.4$ Kips/pile
- consider the pier as a rigid frame.
- assume the pier is not braced.

- use the same piles as the wave-screen

$$\frac{Kl}{r} = \frac{1.2(40)}{4.33} = 11.085(12) = 133$$

$\therefore$ $F_a = 8.44$ ksi

$f_a = 28.8/19.2 = 1.5$ ksi

$f_a/F_a = 1.5/8.44 = 0.177$

$f_a/.6F_y = 0.072$

$f_b = 1.4(40)(12)/56.7 = 11.85$ ksi

$F_e' = 12\pi^2 E/23(K\cdot L/r)^2 = 8.44$

$$0.072 + \frac{11.85}{.6(35)} = 0.636 < 1.0 \quad [\text{EQ H1-2}]$$

$$0.177 + \frac{(1.0)\,11.85}{\left(1 - \frac{1.5}{8.44}\right).6(35)} = 0.863 < 1.0 \quad [\text{EQ H1-1}]$$

Because the front pile will be anchored in the rock slope of the 60' channel, investigate an unsupported length of 48'

$K\cdot l/r = 159.6$

$F_a = 5.83$

$f_a/F_a = 0.257$

$F_b = 11.85(48/40) = 14.22$

[EQ H1-2] 0.749

[EQ H1-1] $F_e' = 5.86$

$$.257 + \frac{14.22}{\left(1 - \frac{1.5}{5.86}\right).6(35)} = 1.167 > 1.0$$

[A]
Check A252 Gr. 3 $F_y = 45$ ksi

[EQ H1-1] $Kl/r = 159.6$

$F_a = 5.83$ ∴ $0.965 < 1.0$

[B] Check 14" ϕ pipe × .5" wall

$S = 69.1$ $A = 21.1$

$F_b = 11.68$ ksi

⇒ substituting 11.68 for 14.22 in eq H1-1 above yields 1.004 The value will be even lower due to the greater Area and 'r'
∴ 14" pipe × .5" wall will be adequate

DECK & PILE CAP DESIGN

⇒ **Deck:** use 10" min thickness for shear and punching shear to allow for emergency vehicle traffic / 3" conc cover over rebar

@ 200 psf loading, 12 x 12 grid

LL $M_{max} = 0.2(12)^2/10 = 2.88^{1.k} \times 1.7 = 4.9$

DL $\frac{10}{12}(.150)(12)^2/10 = 1.8^{1.k} \times 1.4 = 2.5$

TOTAL $4.68^{1.k}$ $7.4^{1.k}/'$

$$M_d = \phi \rho f_y b d^2 \left(1 - 0.59\rho \frac{f_y}{f_c'}\right)$$

$$(12)(7.4) = 0.9\rho(60)(12")(6.5)^2\left(1 - 0.59\rho\frac{60}{4}\right)$$

$$88.8 = 2737.8\rho - 242,295.3\rho^2$$

$$\rho^2 - .113\rho + .000366 = 0$$

$$\rho = .00334$$

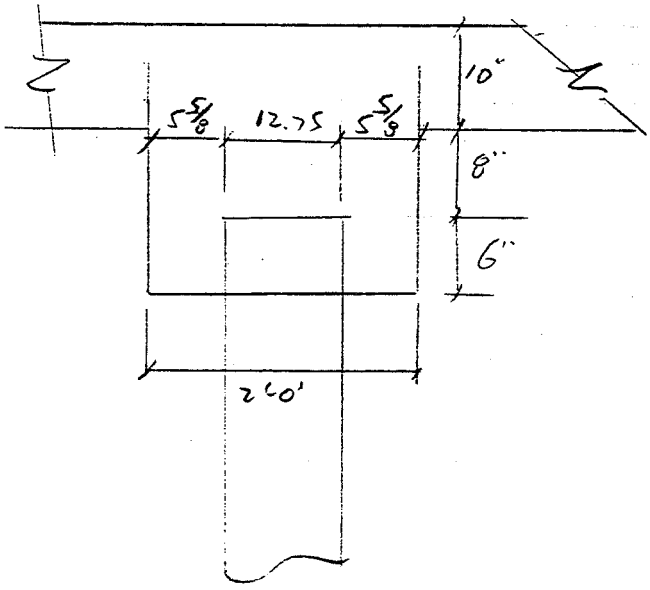
$$\rho_m = 200/f_y = .0033$$

$$A_s = .00334(6.5)(12) = 0.26\ in^2/ft$$

⇒ #5 @ 12" $A_s = 0.31\ in^2/ft$

PILE CAP

Design cap for a rigid connection between the piles and cap beam. The minimum size pile to be used will be a 12.75 O.D.



$d = 24" - 3" - \frac{1}{2}"\text{ stirrup} - \frac{1}{2}" = 20"$

LL $M_{max} = \left[\frac{200}{1000}\text{ksf}(12)\right]\frac{(12)^2}{10} = 34.56^{1.k} \times 1.7 = 58.8^{1.k}$

DL $M_{max} \left[\frac{10}{12}(150)(12') + 2(1.16)(150)\right]\frac{12^2}{10} = 26.61 \times 1.4 = 37.3$

$61.17^{1.k}$ $96.1^{1.k}$

$$96.1(12) = 0.9\rho(60)(24)(20)^2\left(1 - 0.59\rho\frac{60}{4}\right)$$

$$\rho^2 - 0.113\rho + .000251 = 0$$

$$\rho = .00227 \Rightarrow \rho_{min} = .00333$$

$.00333(24)(20) = 1.6\ in^2$

4- #6 bars $A_s = 1.77\ in^2$

Check: reduced pile penetration to 4"

overall cap depth 5_y 4"

$d = 16"$

$\rho = .00359$

$A_s = 1.38\ in^2$

Check shear:

LL $200\left(12 - \frac{16(2)}{12}\right)/2 = 933^{\#} \times 1.7 = 1.6^{k}$

DL $150\left[\left(\frac{16}{12}\right)(12) + \frac{14}{12}(2)\left(12 - \frac{32}{12}\right)\right]/2 = 1.57^{k} \times 1.4 = 2.2^{k}$

3.8^{k}

$(1000)\ 3.8^{k}/24(16) = 9.9\ psi$

∴ Provide #4(@ d/2) stirrups

CORPS DOCK NO. n/a
NAME: Arthur Kill Lift Bridge
CHANNEL: Arthur Kill

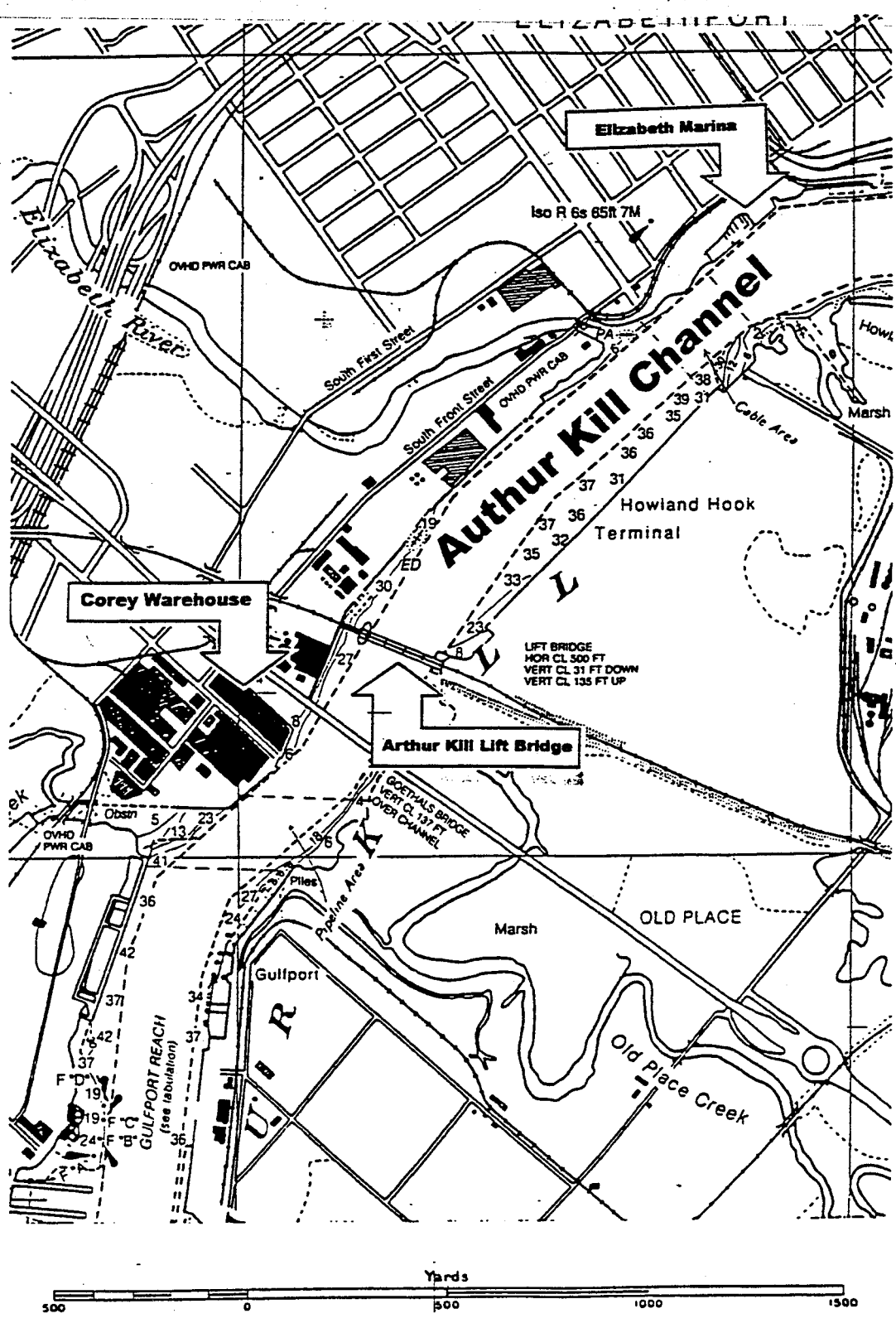
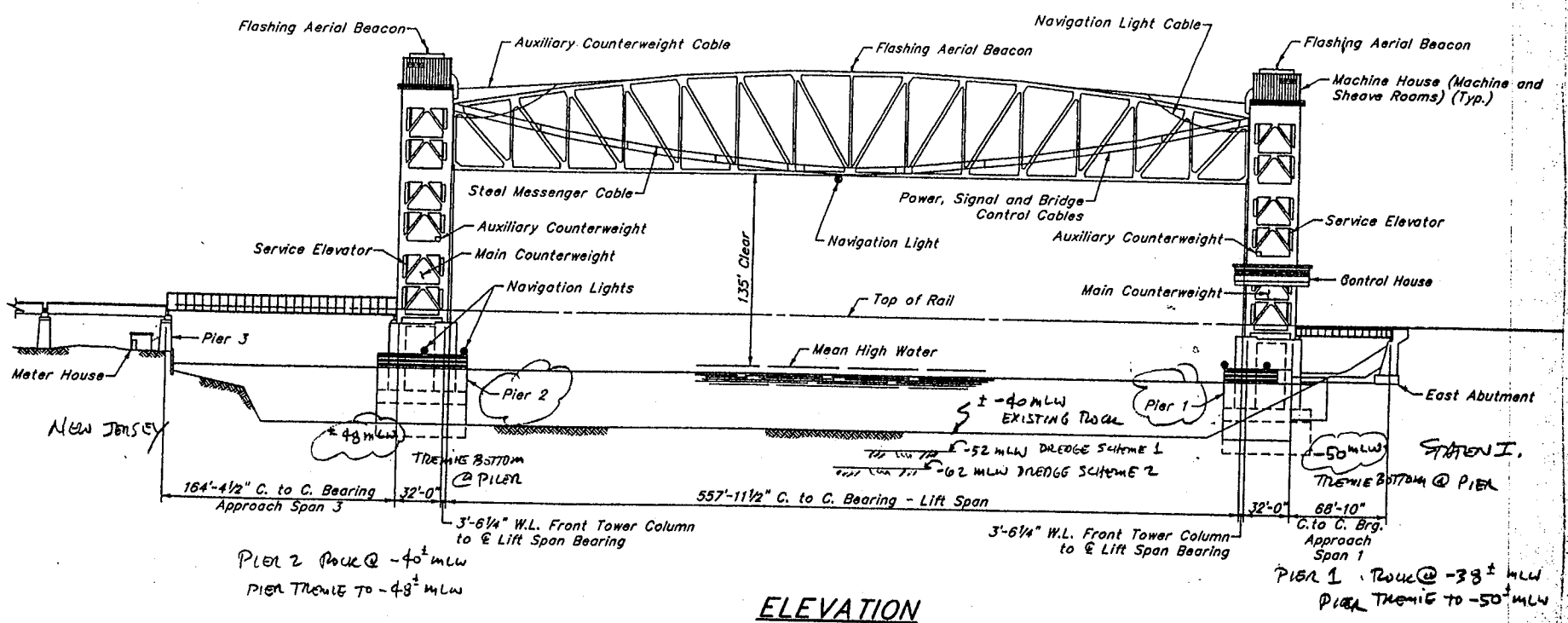

Elizabeth Marina
Iso R 6s 65ft 7M
OVHD PWR CAB
Elizabeth River
South First Street
South Front Street
Authur Kill Channel
Howland Hook
Terminal
Cable Area
Marsh
Corey Warehouse
LIFT BRIDGE
HOR CL 500 FT
VERT CL 31 FT DOWN
VERT CL 135 FT UP
Arthur Kill Lift Bridge
GOETHALS BRIDGE
VERT CL 137 FT
HOVER CHANNEL
Obstn
Piles
Pipeline Area
OLD PLACE
Marsh
Gulfport
GULFPORT REACH
(See tabulation)
Old Place Creek
Yards
500
0
500
1000
1500

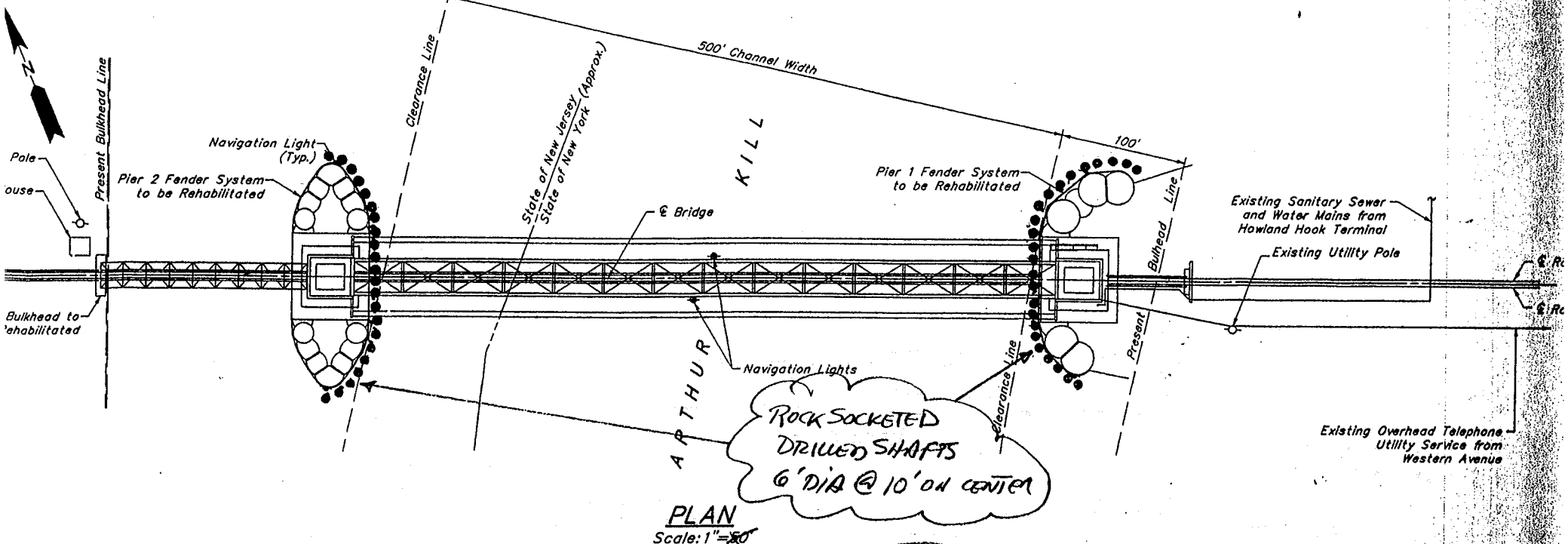
Figure 2



ELEVATION

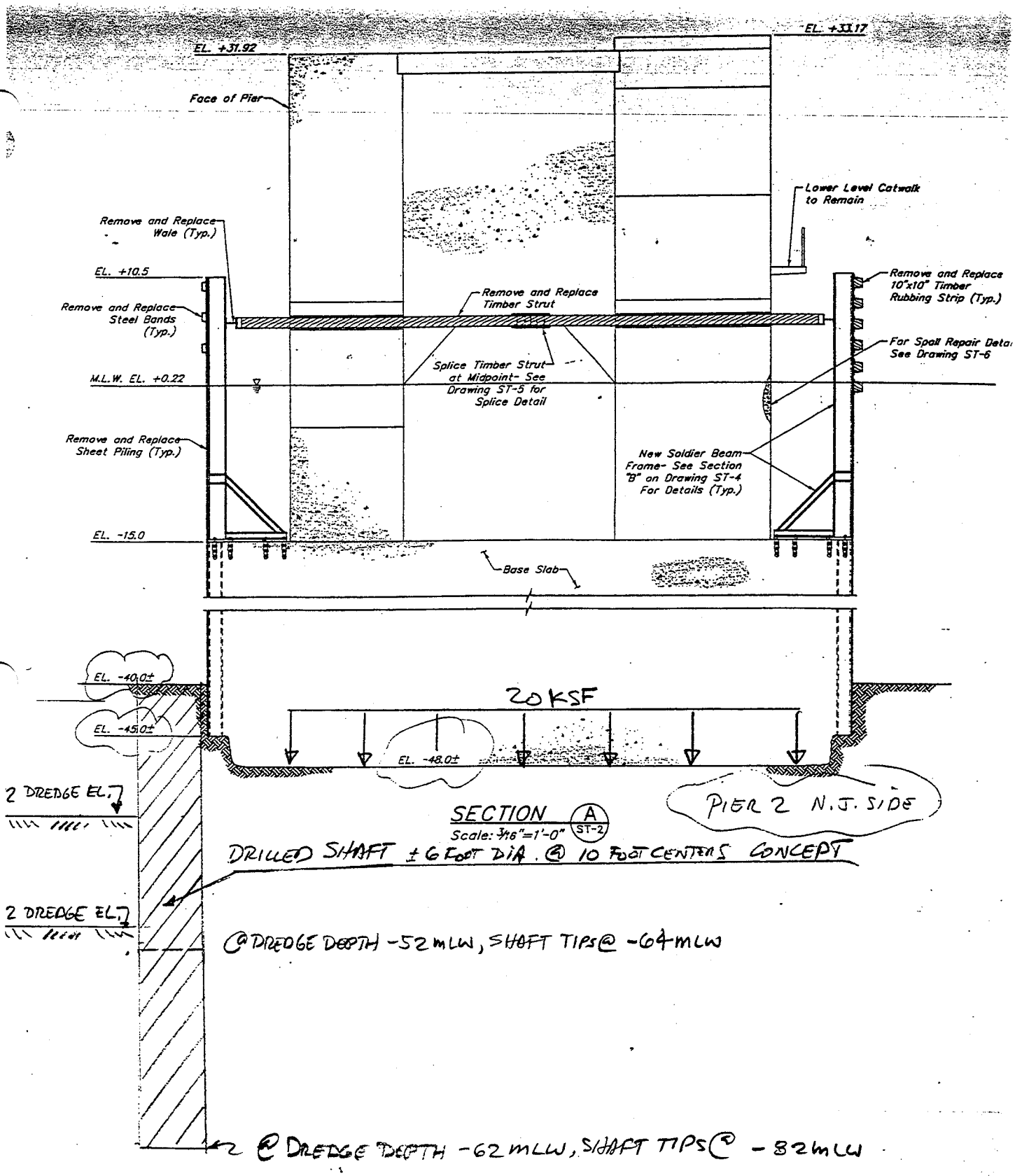
Scale: 1"=~~50~~'

ELEVATION ARTHUR KILL R.R. LIFT BRIDGE



PLAN
Scale: 1"=~~50'~~

PLAN VIEW ARTHUR KILL R.R. LIFT BRIDGE
W/ PROPOSED 500' CHANNEL WIDTH



SECTION (A) (ST-2)

Scale: 3/16"=1'-0"

DRILLED SHAFT ± 6 FOOT DIA. @ 10 FOOT CENTERS CONCEPT

@ DREDGE DEPTH -52 MLW, SHAFT TIPS @ -64 MLW

@ DREDGE DEPTH -62 MLW, SHAFT TIPS @ -82 MLW

MAGUIRE GROUP

Project ARTHUR KILL CHANNEL DREDGING Acc. No. 14803
Subject ARTHUR KILL LIFT BRIDGE Sheet No. ___ of ___
FOUNDATION PROTECTION Date 8-14 19 98
Comp. DMN Check ___ Cont. No. ___

- USACE PROGRAM CWCSHT USED TO MODEL A CONTINUOUS WALL SECTION IMMEDIATELY OUTBOARD OF STRUCTURE FOUNDATION,
- ESTIMATED STRUCTURE CONTACT PRESSURE @ FOUNDATION INVERT ± 20 KSF, UNIFORMLY DISTRIBUTED,
- NO EARTHQUAKE LOADING MODELED,
- ROCK MODELED AS $\phi = 45°$, $\gamma_{SAT} = 145$ lb/ft^3
- FOR MAX MOMENT DETERMINATION ON CONTINUOUS WALL PROGRAM RUN IN CANTILEVER, DESIGN, F.S. = 1 FOR BOTH ACTIVE & PASSIVE PRESSURES, MODE,
- FOR WALL PENETRATION BELOW DREDGE DEPTH PROGRAM RUN IN CANTILEVER, DESIGN, F.S. = 1 ACTIVE, F.S. = 1.5 PASSIVE PRESSURES, MODE,
- TWO DREDGE CONDITIONS MODELED
  - (A.) DREDGE DEPTH @ -52 MLW RESULTING IN A 4 FOOT FOUNDATION UNDERMINING
  - (B) DREDGE DEPTH @ -62 MLW RESULTING IN A 14 FOOT FOUNDATION UNDERMINING

MAGUIRE GROUP

Project ARTHUR KILL CHANNEL DREDGING Acc. No. 14803
Subject ARTHUR KILL LIFT BRIDGE Sheet No. ____ of ____
FOUNDATION PROTECTION Date 8-14 19 98
Comp. DMN Check ____ Cont. No. ____

(A.) DREDGE ELEVATION -52 mLW
+ FOOT FOUNDATION UNDERMINING

MAX. MOMENT GENERATED 40,710 Ft-lb
W/F.S. = 1.0 ACTIVE & PASSIVE PRESSURES

1. CHECK ADEQUACY OF 6 FOOT REINFORCED CONCRETE DRILLED SHAFT SECTION

ACTUAL CASE DRILLED SHAFTS @ 10 FOOT CENTERS
∴ MAX. MOM. = 10(40,710) = 407,100 Ft-lb

ASSUME CONCRETE GOVERNS

$$\sigma = \frac{Mc}{I} = \frac{407{,}100 \text{ Ft-lb} \times 3 \text{ Ft.}}{63.62 \text{ Ft}^4} = 19{,}200 \text{ lb/Ft}^2$$

(133 PSI)

OK

WELL WITHIN CONCRETE WORKING STRESS RANGE

2. CHECK WALL PENETRATION

MAKE RUN WITH ACTIVE PRESSURE FS = 1
PASSIVE PRESSURES FS = 1.5

WALL PENETRATION ± 12 FEET (-64 mLW)

MAX. MOMENT RUN, F.S. = 1.0 ACTIVE & PASSIVE

"A"

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 14-AUG-1998 TIME: 10.35.10

INPUT DATA

I.--HEADING:
'ARTHUR KILL LIFT BRIDGE, Q=20,000PSF, ROCK PHI= 45 DEG, C=0
'BLAST/DREDGE FDN UNDERMINE 4 FT., DRILLED SHAFT 6 FT. DIA
'10 FT. ON CENTER

II.--CONTROL
CANTILEVER WALL DESIGN

LEVEL 1 FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
LEVEL 1 FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

III.--WALL DATA
ELEVATION AT TOP OF WALL = 50.00 (FT)

IV.--SURFACE POINT DATA

IV.A--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	50.00

IV.B-- LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	46.00

4' DIFFERENTIAL HEIGHT

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE LAYER DATA
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = DEFAULT

AT. HT. CF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
.00	145.00	45.00	.0	35.00	.0			DEF	DEF

V.B.-- LEFTSIDE LAYER DATA
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
45.00	145.00	45.00	.0	35.00	.0			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.20 (PCF)
RIGHTSIDE ELEVATION = 100.00 (FT)
LEFTSIDE ELEVATION = 100.00 (FT)
NO SEEPAGE

VII.--SURFACE LOADS

VII.A.--RIGHTSIDE SURFACE LOADS

VII.A.1.--SURFACE LINE LOADS
NONE

VII.A.2.--SURFACE DISTRIBUTED LOADS
UNIFORM LOAD = 20000.00 (PSF)

VII.B.-- LEFTSIDE SURFACE LOADS
NONE

VIII.--HORIZONTAL LOADS
NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 14-AUG-1998 TIME: 10.38.42

SOIL PRESSURES FOR
CANTILEVER WALL DESIGN

I.--HEADING

'ARTHUR KILL LIFT BRIDGE, Q=20,000PSF, ROCK PHI= 45 DEG, C=0
'BLAST/DREDGE FDN UNDERMINE 4 FT., DRILLED SHAFT 6 FT. DIA
'10 FT. ON CENTER

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELASTICITY EQUATIONS FOR SURCHARGE LOADS.

	<-LEFTSIDE PRESSURES->		<---NET PRESSURES----> (SOIL PLUS WATER)		<RIGHTSIDE PRESSURES->	
LEV. FT)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
0.00	.00	.00	2707.001	1644107.407	2707.00	1644107.41
9.00	.00	.00	2717.937	1650749.601	2717.94	1650749.60
8.00	.00	.00	2728.873	1657391.795	2728.87	1657391.80
7.00	.00	.00	2739.810	1664033.989	2739.81	1664033.99
6.00	.00	.00	2750.746	1670676.183	2750.75	1670676.18
5.59	2755.28	4.54	.000	1673426.929	2755.28	1673431.47
5.29	4698.74	7.74	-1940.256	1675367.185	2758.48	1675374.92
5.00	6642.19	10.94	-3880.512	1677307.441	2761.68	1677318.38
4.00	13284.39	21.87	-10511.769	1683938.698	2772.62	1683960.57
3.00	19926.58	32.81	-17143.027	1690569.956	2783.55	1690602.76
2.00	26568.78	43.75	-23774.285	1697201.214	2794.49	1697244.96
1.00	33210.97	54.68	-30405.542	1703832.471	2805.43	1703887.15
0.00	39853.16	65.62	-37036.800	1710463.729	2816.36	1710529.35
9.00	46495.36	76.55	-43668.058	1717094.987	2827.30	1717171.54
8.00	53137.55	87.49	-50299.315	1723726.244	2838.24	1723813.73
7.00	59779.75	98.43	-56930.573	1730357.502	2849.17	1730455.93
6.00	66421.94	109.36	-63561.830	1736988.760	2860.11	1737098.12
5.00	73064.13	120.30	-70193.088	1743620.017	2871.05	1743740.32
4.00	79706.33	131.24	-76824.346	1750251.275	2881.98	1750382.51
3.00	86348.52	142.17	-83455.603	1756882.533	2892.92	1757024.70
2.00	92990.71	153.11	-90086.861	1763513.790	2903.85	1763666.90
1.00	99632.91	164.04	-96718.119	1770145.048	2914.79	1770309.09
0.00	106275.10	174.98	-103349.376	1776776.305	2925.73	1776951.29
9.00	112917.30	185.92	-109980.634	1783407.563	2936.66	1783593.48
8.00	119559.49	196.85	-116611.892	1790038.821	2947.60	1790235.67
7.00	126201.68	207.79	-123243.149	1796670.078	2958.54	1796877.87
6.00	132843.88	218.73	-129874.407	1803301.336	2969.47	1803520.06
5.00	139486.07	229.66	-136505.665	1809932.594	2980.41	1810162.26
4.00	146128.27	240.60	-143136.922	1816563.851	2991.34	1816804.45
3.00	152770.46	251.53	-149768.180	1823195.109	3002.28	1823446.64
2.00	159412.65	262.47	-156399.437	1829826.367	3013.22	1830088.84
1.00	166054.85	273.41	-163030.695	1836457.624	3024.15	1836731.03
0.00	172697.04	284.34	-169661.953	1843088.882	3035.09	1843373.23
9.00	179339.24	295.28	-176293.210	1849720.140	3046.03	1850015.42
8.00	185981.43	306.22	-182924.468	1856351.397	3056.96	1856657.61
7.00	192623.62	317.15	-189555.726	1862982.655	3067.90	1863299.81
6.00	199265.82	328.09	-196186.983	1869613.912	3078.83	1869942.00
5.00	205908.01	339.02	-202818.241	1876245.170	3089.77	1876584.19

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 14-AUG-1998 TIME: 10.40.50

SUMMARY OF RESULTS FOR
CANTILEVER WALL DESIGN

I.--HEADING

'ARTHUR KILL LIFT BRIDGE, Q=20,000PSF, ROCK PHI= 45 DEG, C=0
'BLAST/DREDGE FDN UNDERMINE 4 FT., DRILLED SHAFT 6 FT. DIA
'10 FT. ON CENTER

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS AND THEORY OF ELASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS AND THEORY OF ELASTICITY EQUATIONS FOR SURCHARGE LOADS.

WALL BOTTOM ELEV. (FT)	:	41.53
PENETRATION (FT)	:	4.47
MAX. BEND. MOMENT (LB-FT)	:	40710.
AT ELEVATION (FT)	:	43.72
MAX. SCALED DEFL. (LB-IN3)	:	1.5905E+09
AT ELEVATION (FT)	:	50.00

FOR CONTINUOUS WALL SECTION

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 14-AUG-1998 TIME: 10.40.50

COMPLETE RESULTS FOR
CANTILEVER WALL DESIGN

I.--HEADING

'ARTHUR KILL LIFT BRIDGE, Q=20,000PSF, ROCK PHI= 45 DEG, C=0
'BLAST/DREDGE FDN UNDERMINE 4 FT., DRILLED SHAFT 6 FT. DIA

'10 FT. ON CENTER

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
50.00	0.	0.	1.5905E+09	2707.00
49.00	1355.	2712.	1.3038E+09	2717.94
48.00	5429.	5436.	1.0199E+09	2728.87
47.00	12231.	8170.	7.4569E+08	2739.81
46.00	21773.	10915.	4.9305E+08	2750.75
45.59	26458.	11486.	3.9830E+08	.00
45.29	29791.	11202.	3.3612E+08	-1940.26
45.00	32958.	10351.	2.7834E+08	-3880.51
44.00	40263.	3154.	1.2002E+08	-10511.77
43.00	37057.	-10673.	2.9766E+07	-17143.03
42.00	16707.	-31132.	1.0741E+06	-23774.28
41.58	1399.	-41736.	6.0323E+02	-26568.09
41.53	0.	0.	0.0000E+00	1700325.73

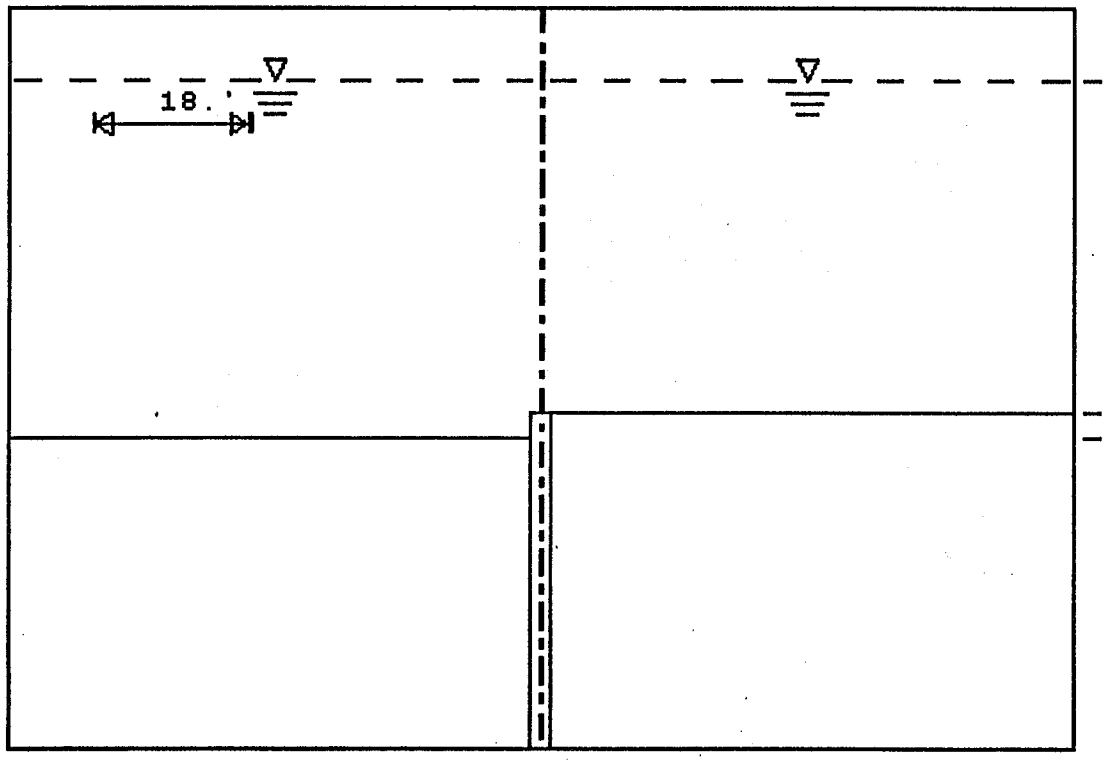
(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

III.--SOIL PRESSURES

ELEVATION	< LEFTSIDE PRESSURE (PSF)>		<RIGHTSIDE PRESSURE (PSF)>	
(FT)	PASSIVE	ACTIVE	ACTIVE	PASSIVE
50.00	0.	0.	2707.	1644107.
49.00	0.	0.	2718.	1650750.
48.00	0.	0.	2729.	1657392.
47.00	0.	0.	2740.	1664034.
46.00	0.	0.	2751.	1670676.
45.59	2755.	5.	2755.	1673431.
45.29	4699.	8.	2758.	1675375.
45.00	6642.	11.	2762.	1677318.
44.00	13284.	22.	2773.	1683961.
43.00	19927.	33.	2784.	1690603.
42.00	26569.	44.	2794.	1697245.
41.58	29367.	48.	2799.	1700043.
41.53	33211.	55.	2805.	1703887.
40.00	39853.	66.	2816.	1710529.

'ARTHUR KILL LIFT BRIDGE, Q=20,000PSF, ROCK PHI= 45 DEG, C=0

'BLAST/DREDGE FDN UNDERMINE 4 FT., DRILLED SHAFT 6 FT. DIA

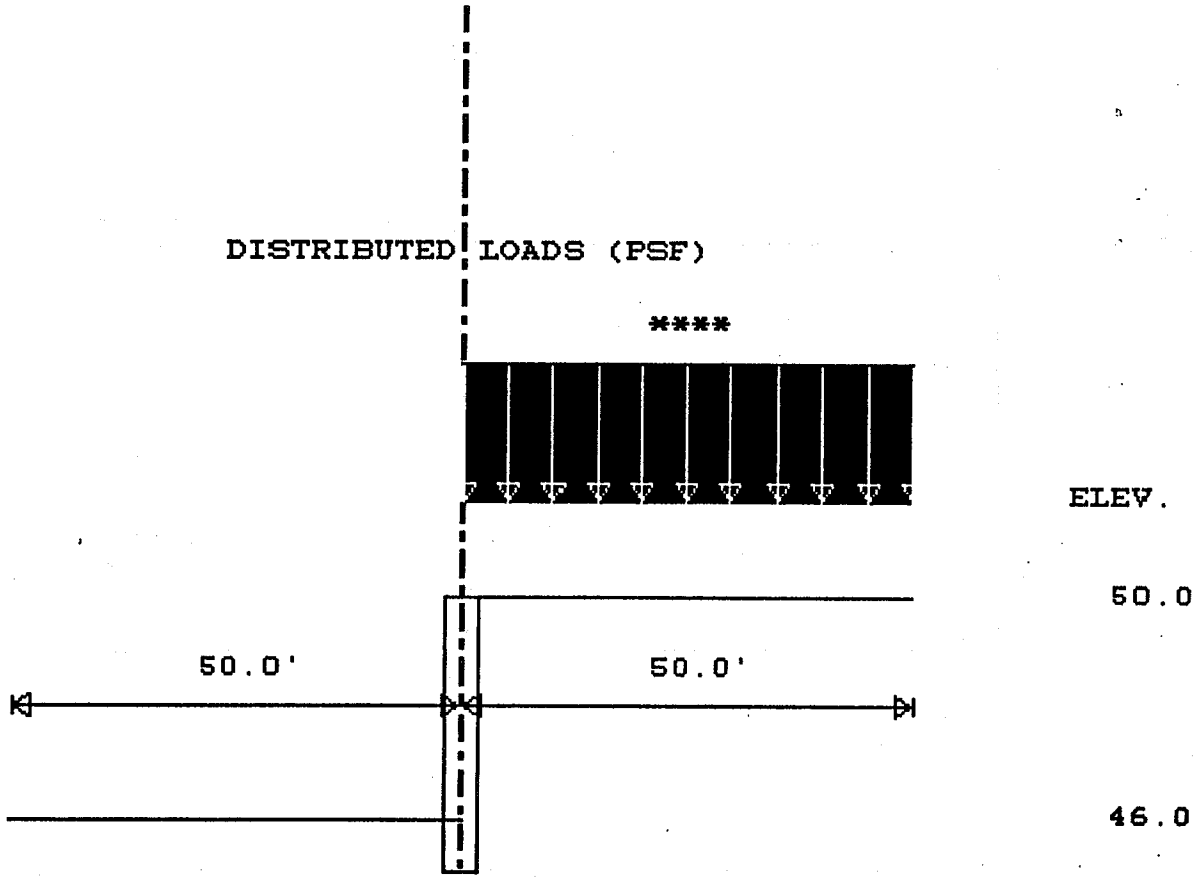


***** INPUT GEOMETRY *****

DATE: 14-AUG-1998 TIME: 10.36.32

'ARTHUR KILL LIFT BRIDGE, Q=20,000PSF, ROCK PHI= 45 DEG, C=0

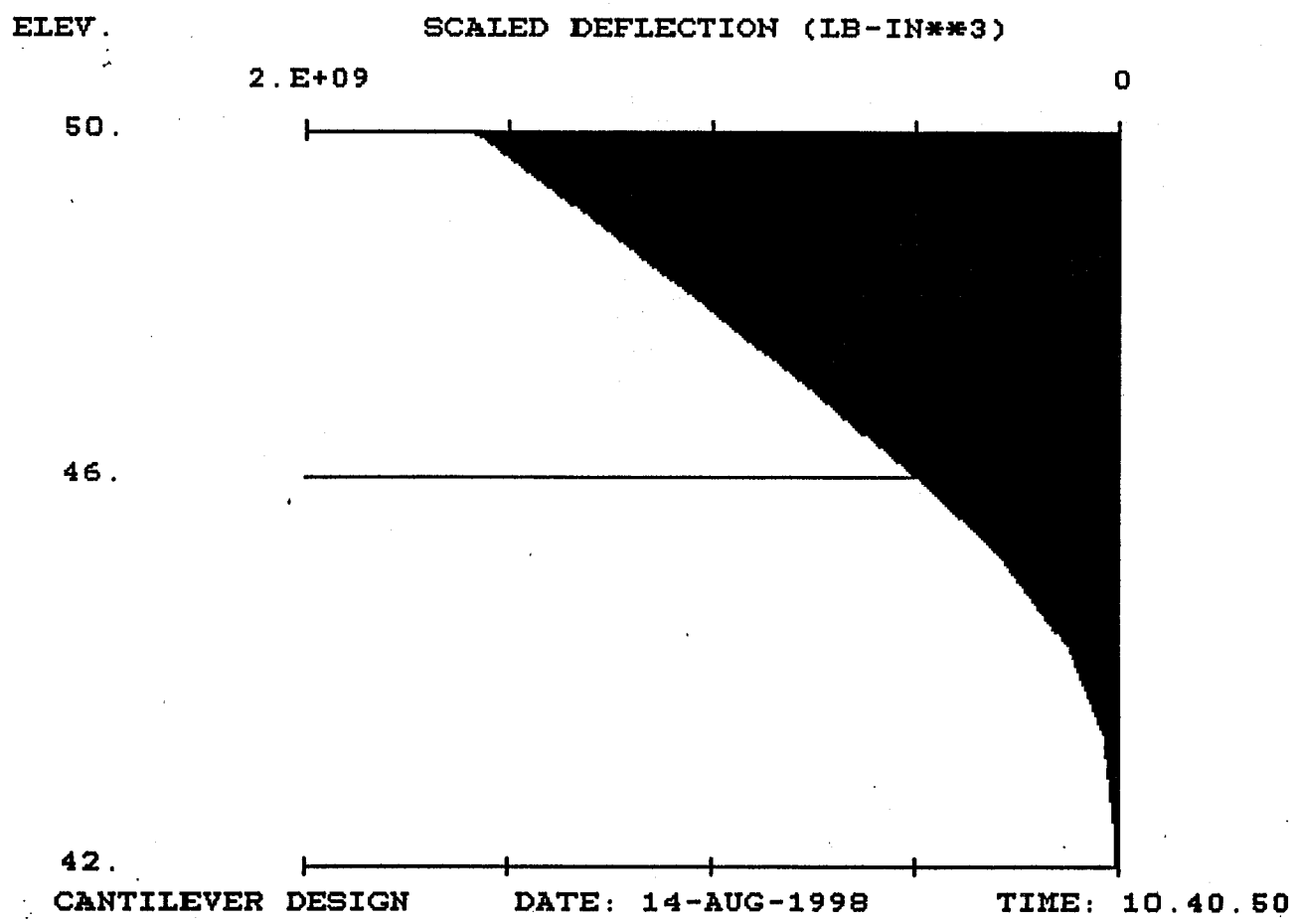
'BLAST/DREDGE FDN UNDERMINE 4 FT., DRILLED SHAFT 6 FT. DIA



***** SURFACE LOADS *****

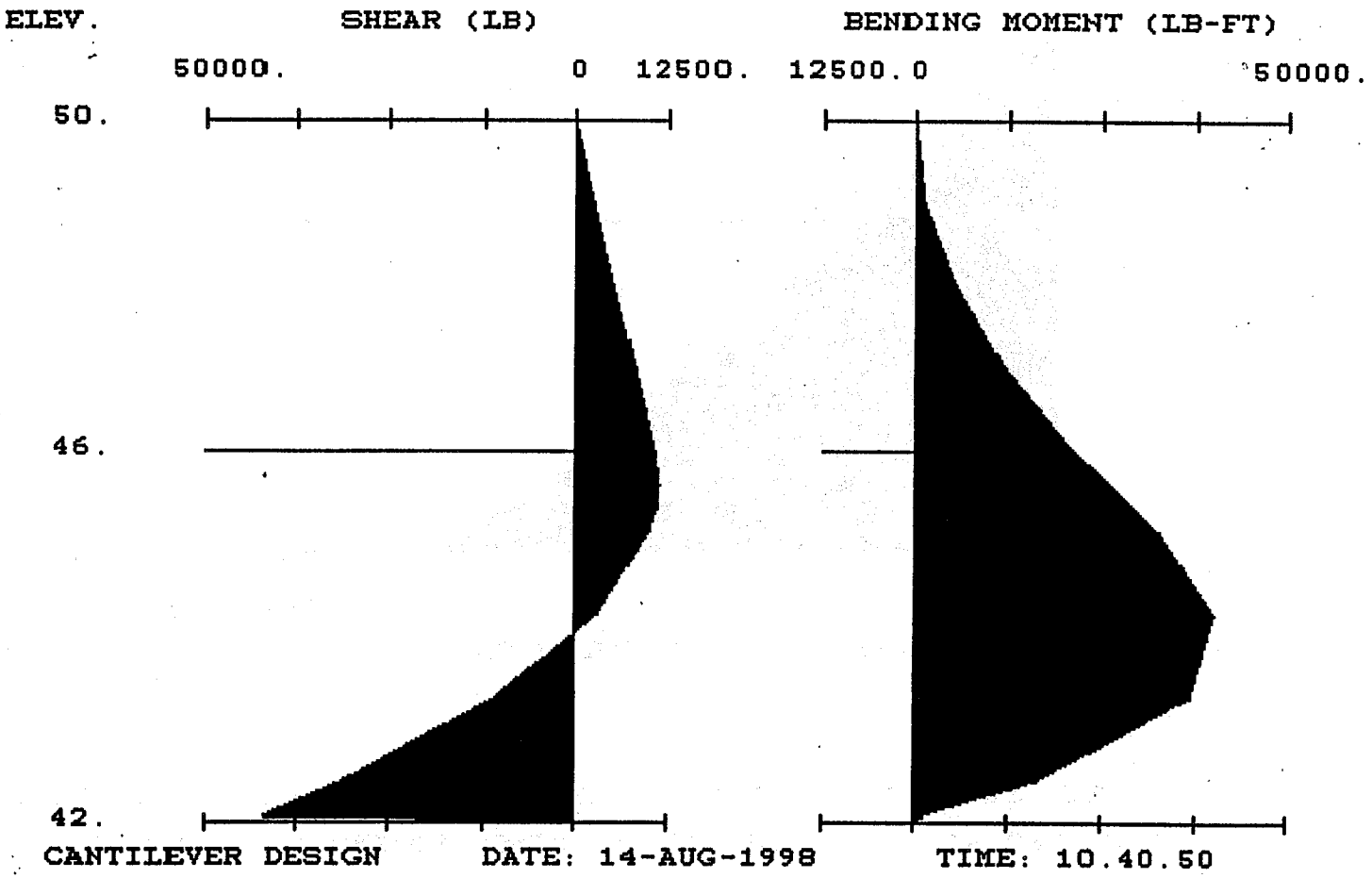
DATE: 14-AUG-1998 TIME: 10.37.45

'ARTHUR KILL LIFT BRIDGE, Q=20,000PSF, ROCK PHI= 45 DEG, C=0
'BLAST/DREDGE FDN UNDERMINE 4 FT., DRILLED SHAFT 6 FT. DIA



'ARTHUR KILL LIFT BRIDGE, Q=20,000PSF, ROCK PHI= 45 DEG, C=0

'BLAST/DREDGE FDN UNDERMINE 4 FT., DRILLED SHAFT 6 FT. DIA



WALL PENETRATION RUN ACTIVE FS = 1.0 PASSIVE FS = 1.5
4 FOOT HEIGHT DIFFERENTIAL

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 14-AUG-1998 TIME: 14.18.19

INPUT DATA

I.--HEADING:
'ARTHUR KILL LIFT BRIDGE, WALL PENETRATION RUN,PASSIVE FS=1.5
'ACTIVE FS=1

II.--CONTROL
CANTILEVER WALL DESIGN

LEVEL 1 FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
LEVEL 1 FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

III.--WALL DATA
ELEVATION AT TOP OF WALL = 50.00 (FT)

IV.--SURFACE POINT DATA

IV.A--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	50.00

IV.B-- LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	46.00

4' DIFFERENTIAL HEIGHT

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE LAYER DATA
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
45.00	145.00	45.00	.0	35.00	.0			1.00	1.50

V.B.-- LEFTSIDE LAYER DATA
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

SAT. GHT. PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH- ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH- ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
5.00	145.00	45.00	.0	35.00	.0			1.00	1.50

VI.--WATER DATA

UNIT WEIGHT = 62.40 (PCF)
RIGHTSIDE ELEVATION = 100.00 (FT)
LEFTSIDE ELEVATION = 100.00 (FT)
NO SEEPAGE

VII.--SURFACE LOADS

VII.A.--RIGHTSIDE SURFACE LOADS

VII.A.1.--SURFACE LINE LOADS
NONE

VII.A.2.--SURFACE DISTRIBUTED LOADS
UNIFORM LOAD = 20000.00 (PSF)

VII.B.-- LEFTSIDE SURFACE LOADS
NONE

VIII.--HORIZONTAL LOADS
NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 14-AUG-1998 TIME: 14.20.24

SUMMARY OF RESULTS FOR
CANTILEVER WALL DESIGN

I.--HEADING

'ARTHUR KILL LIFT BRIDGE, WALL PENETRATION RUN,PASSIVE FS=1.5
'ACTIVE FS=1

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS

AND THEORY OF ELASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELASTICITY EQUATIONS FOR SURCHARGE LOADS.

WALL BOTTOM ELEV. (FT) : 34.65
PENETRATION (FT) : 11.35 ✓ ±12' (-64MLW)

MAX. BEND. MOMENT (LB-FT) : 89561.
AT ELEVATION (FT) : 39.42

MAX. SCALED DEFL. (LB-IN3): 1.1901E+10
AT ELEVATION (FT) : 50.00

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 14-AUG-1998 TIME: 14.20.24

COMPLETE RESULTS FOR
CANTILEVER WALL DESIGN

I.--HEADING

'ARTHUR KILL LIFT BRIDGE, WALL PENETRATION RUN,PASSIVE FS=1.5
'ACTIVE FS=1

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
50.00	0.	0.	1.1901E+10	2707.00
49.00	1355.	2713.	1.0651E+10	2718.18
48.00	5429.	5436.	9.4031E+09	2729.36
47.00	12232.	8171.	8.1653E+09	2740.54
46.00	21775.	10917.	6.9491E+09	2751.72
45.00	33845.	12999.	5.7709E+09	1411.81
44.00	47327.	13741.	4.6514E+09	71.90
43.95	48064.	13743.	4.5935E+09	.00
43.47	54544.	13593.	4.0931E+09	-634.01
43.00	60881.	13143.	3.6137E+09	-1268.01
42.00	73166.	11205.	2.6810E+09	-2607.92
41.00	82844.	7927.	1.8744E+09	-3947.83
40.00	88574.	3309.	1.2104E+09	-5287.74

39.00	89016.	-2648.	6.9860E+08	-6627.65
38.00	82831.	-9946.	3.3971E+08	-7967.56
37.00	68678.	-18583.	1.2280E+08	-9307.47
36.00	45217.	-28561.	2.3234E+07	-10647.39
35.00	11109.	-39878.	2.6606E+05	-11987.30
34.89	6847.	-41147.	7.1759E+04	-12128.26
34.65	0.	0.	0.0000E+00	347753.44

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

III.--SOIL PRESSURES

ELEVATION	< LEFTSIDE PRESSURE (PSF) >		<RIGHTSIDE PRESSURE (PSF) >	
(FT)	PASSIVE	ACTIVE	ACTIVE	PASSIVE
50.00	0.	0.	2707.	327141.
49.00	0.	0.	2718.	328492.
48.00	0.	0.	2729.	329843.
47.00	0.	0.	2741.	331194.
46.00	0.	0.	2752.	332545.
45.00	1351.	11.	2763.	333896.
44.00	2702.	22.	2774.	335247.
43.95	2775.	23.	2775.	335320.
43.47	3414.	28.	2780.	335959.
43.00	4053.	34.	2785.	336598.
42.00	5404.	45.	2796.	337949.
41.00	6755.	56.	2808.	339300.
40.00	8107.	67.	2819.	340651.
39.00	9458.	78.	2830.	342003.
38.00	10809.	89.	2841.	343354.
37.00	12160.	101.	2852.	344705.
36.00	13511.	112.	2864.	346056.
35.00	14862.	123.	2875.	347407.
34.89	15004.	124.	2876.	347549.
34.65	16213.	134.	2886.	348758.
33.00	17564.	145.	2897.	350109.

MAGUIRE GROUP

Project ARTHUR KILL CHANNEL DREDGING Acc. No. 14803
Subject ARTHUR KILL LIFT BRIDGE Sheet No. ___ of ___
FOUNDATION PROTECTION Date 8-16 19 78
Comp. DMN Check ___ Cont. No. ___

(B) DREDGE ELEVATION -62 MLCW

14 FOOT FOUNDATION UNDERMINING

MAX. MOMENT GENERATED 378,463 FT-lb
W/F.S. = 1.0 ACTIVE & PASSIVE PRESSURES

1. CHECK ADEQUACY OF GROUT REINFORCED CONCRETE DRILLED SHAFT SECTION

ACTUAL CASE DRILLED SHAFTS @ 10 FOOT CENTERS

∴ MAX. MOM. = 10(378,463) = 3,784,630 Ft.

ASSUME CONCRETE GOVERNS

$$\sigma = \frac{Mc}{I} = \frac{3{,}784{,}630^{Ft.lb} \times 3^{Ft.}}{63.62^{Ft^4}} = 178{,}464^{lb/Ft^2}$$

(1,240 PSI)

OK

WITHIN CONCRETE WORKING STRESS RANGE

2. CHECK WALL PENETRATION

MAKE RUN WITH ACTIVE PRESSURES FS = 1.0
PASSIVE PRESSURES FS = 1.5

WALL PENETRATION ± 20 FEET (-82 MLCW)

MAX. MOMENT RUN, FS = 1.0 ACTIVE & PASSIVE

"B"

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 14-AUG-1998 TIME: 10.15.30

INPUT DATA

I.--HEADING:
'ARTHUR KILL LIFT BRIDGE, Q=20,000 PSF, ROCK PHI= 45 DEG, C=0
'BLAST/DREDGE FDN UNDERMINE 14 FT, DRILLED SHAFTS 6 FT. DIA
'10 FT. ON CENTER

II.--CONTROL
CANTILEVER WALL DESIGN

LEVEL 1 FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
LEVEL 1 FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

III.--WALL DATA
ELEVATION AT TOP OF WALL = 50.00 (FT)

IV.--SURFACE POINT DATA

IV.A--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	50.00

IV.B-- LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	36.00

14 FOOT HEIGHT DIFFERENTIAL

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE LAYER DATA
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = DEFAULT

AT. HT. CF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
.00	145.00	45.00	.0	35.00	.0			DEF	DEF

V.B.-- LEFTSIDE LAYER DATA
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
45.00	145.00	45.00	.0	35.00	.0			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.20 (PCF)
RIGHTSIDE ELEVATION = 100.00 (FT)
LEFTSIDE ELEVATION = 100.00 (FT)
NO SEEPAGE

VII.--SURFACE LOADS

VII.A.--RIGHTSIDE SURFACE LOADS

VII.A.1.--SURFACE LINE LOADS
NONE

VII.A.2.--SURFACE DISTRIBUTED LOADS
UNIFORM LOAD = 20000.00 (PSF)

VII.B.-- LEFTSIDE SURFACE LOADS
NONE

VIII.--HORIZONTAL LOADS
NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 14-AUG-1998 TIME: 10.20.45

SOIL PRESSURES FOR
CANTILEVER WALL DESIGN

I.--HEADING

'ARTHUR KILL LIFT BRIDGE, Q=20,000 PSF, ROCK PHI= 45 DEG, C=0
'BLAST/DREDGE FDN UNDERMINE 14 FT, DRILLED SHAFTS 6 FT. DIA
'10 FT. ON CENTER

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELASTICITY EQUATIONS FOR SURCHARGE LOADS.

EV.	<-LEFTSIDE PRESSURES-> PASSIVE (PSF)	ACTIVE (PSF)	<---NET PRESSURES----> (SOIL PLUS WATER) ACTIVE (PSF)	PASSIVE (PSF)	<RIGHTSIDE PRESSURES-> ACTIVE (PSF)	PASSIVE (PSF)
')						
.00	.00	.00	2707.001	1644107.407	2707.00	1644107.41
.00	.00	.00	2717.937	1650749.601	2717.94	1650749.60
.00	.00	.00	2728.873	1657391.795	2728.87	1657391.80
.00	.00	.00	2739.810	1664033.989	2739.81	1664033.99
.00	.00	.00	2750.746	1670676.183	2750.75	1670676.18
.00	.00	.00	2761.682	1677318.377	2761.68	1677318.38
.00	.00	.00	2772.619	1683960.571	2772.62	1683960.57
.00	.00	.00	2783.555	1690602.765	2783.55	1690602.76
.00	.00	.00	2794.491	1697244.959	2794.49	1697244.96
.00	.00	.00	2805.427	1703887.153	2805.43	1703887.15
.00	.00	.00	2816.364	1710529.347	2816.36	1710529.35
.00	.00	.00	2827.300	1717171.541	2827.30	1717171.54
.00	.00	.00	2838.236	1723813.735	2838.24	1723813.73
00	.00	.00	2849.173	1730455.928	2849.17	1730455.93
00	.00	.00	2860.109	1737098.122	2860.11	1737098.12
57	2864.83	4.72	.000	1739958.231	2864.83	1739962.95
28	4753.51	7.83	-1885.574	1741843.806	2867.94	1741851.63
00	6642.19	10.94	-3771.149	1743729.380	2871.05	1743740.32
00	13284.39	21.87	-10402.406	1750360.638	2881.98	1750382.51
00	19926.58	32.81	-17033.664	1756991.895	2892.92	1757024.70
00	26568.78	43.75	-23664.922	1763623.153	2903.85	1763666.90
00	33210.97	54.68	-30296.179	1770254.411	2914.79	1770309.09
00	39853.16	65.62	-36927.437	1776885.668	2925.73	1776951.29
00	46495.36	76.55	-43558.695	1783516.926	2936.66	1783593.48
00	53137.55	87.49	-50189.952	1790148.184	2947.60	1790235.67
00	59779.75	98.43	-56821.210	1796779.441	2958.54	1796877.87
00	66421.94	109.36	-63452.468	1803410.699	2969.47	1803520.06
00	73064.13	120.30	-70083.725	1810041.956	2980.41	1810162.26
00	79706.33	131.24	-76714.983	1816673.214	2991.34	1816804.45
00	86348.52	142.17	-83346.241	1823304.472	3002.28	1823446.64
00	92990.71	153.11	-89977.498	1829935.729	3013.22	1830088.84
00	99632.91	164.04	-96608.756	1836566.987	3024.15	1836731.03
00	106275.10	174.98	-103240.013	1843198.245	3035.09	1843373.23
00	112917.30	185.92	-109871.271	1849829.502	3046.03	1850015.42
00	119559.49	196.85	-116502.529	1856460.760	3056.96	1856657.61
00	126201.68	207.79	-123133.786	1863092.018	3067.90	1863299.81
00	132843.88	218.73	-129765.044	1869723.275	3078.83	1869942.00
00	139486.07	229.66	-136396.302	1876354.533	3089.77	1876584.19
00	146128.27	240.60	-143027.559	1882985.791	3100.71	1883226.39
00	152770.46	251.53	-149658.817	1889617.048	3111.64	1889868.58
00	159412.65	262.47	-156290.075	1896248.306	3122.58	1896510.78
00	166054.85	273.41	-162921.332	1902879.563	3133.52	1903152.97
00	172697.04	284.34	-169552.590	1909510.821	3144.45	1909795.16
00	179339.24	295.28	-176183.848	1916142.079	3155.39	1916437.36
00	185981.43	306.22	-182815.105	1922773.336	3166.32	1923079.55
00	192623.62	317.15	-189446.363	1929404.594	3177.26	1929721.75
00	199265.82	328.09	-196077.620	1936035.852	3188.20	1936363.94
00	205908.01	339.02	-202708.878	1942667.109	3199.13	1943006.13
00	212550.21	349.96	-209340.136	1949298.367	3210.07	1949648.33

3.00	219192.40	360.90	-215971.393	1955929.625	3221.01	1956290.52
2.00	225834.59	371.83	-222602.651	1962560.882	3231.94	1962932.72
1.00	232476.79	382.77	-229233.909	1969192.140	3242.88	1969574.91
.00	239118.98	393.71	-235865.166	1975823.398	3253.81	1976217.10
-1.00	245761.18	404.64	-242496.424	1982454.655	3264.75	1982859.30
-2.00	252403.37	415.58	-249127.682	1989085.913	3275.69	1989501.49
-3.00	259045.56	426.52	-255758.939	1995717.170	3286.62	1996143.69
-4.00	265687.76	437.45	-262390.197	2002348.428	3297.56	2002785.88
-5.00	272329.95	448.39	-269021.455	2008979.686	3308.50	2009428.07
-6.00	278972.14	459.32	-275652.712	2015610.943	3319.43	2016070.27
-7.00	285614.34	470.26	-282283.970	2022242.201	3330.37	2022712.46

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 14-AUG-1998 TIME: 10.23.18

SUMMARY OF RESULTS FOR
CANTILEVER WALL DESIGN

I.--HEADING

'ARTHUR KILL LIFT BRIDGE, Q=20,000 PSF, ROCK PHI= 45 DEG, C=0
'BLAST/DREDGE FDN UNDERMINE 14 FT, DRILLED SHAFTS 6 FT. DIA
'10 FT. ON CENTER

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELASTICITY EQUATIONS FOR SURCHARGE LOADS.

WALL BOTTOM ELEV. (FT) : 27.29
PENETRATION (FT) : 8.71

MAX. BEND. MOMENT (LB-FT) : 378463.
AT ELEVATION (FT) : 32.11

For continuous wall section

MAX. SCALED DEFL. (LB-IN3): 1.0164E+11
AT ELEVATION (FT) : 50.00

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF
ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA
IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 14-AUG-1998 TIME: 10.23.18

COMPLETE RESULTS FOR
CANTILEVER WALL DESIGN

I.--HEADING

'ARTHUR KILL LIFT BRIDGE, Q=20,000 PSF, ROCK PHI= 45 DEG, C=0
'BLAST/DREDGE FDN UNDERMINE 14 FT, DRILLED SHAFTS 6 FT. DIA
'10 FT. ON CENTER

II.--RESULTS

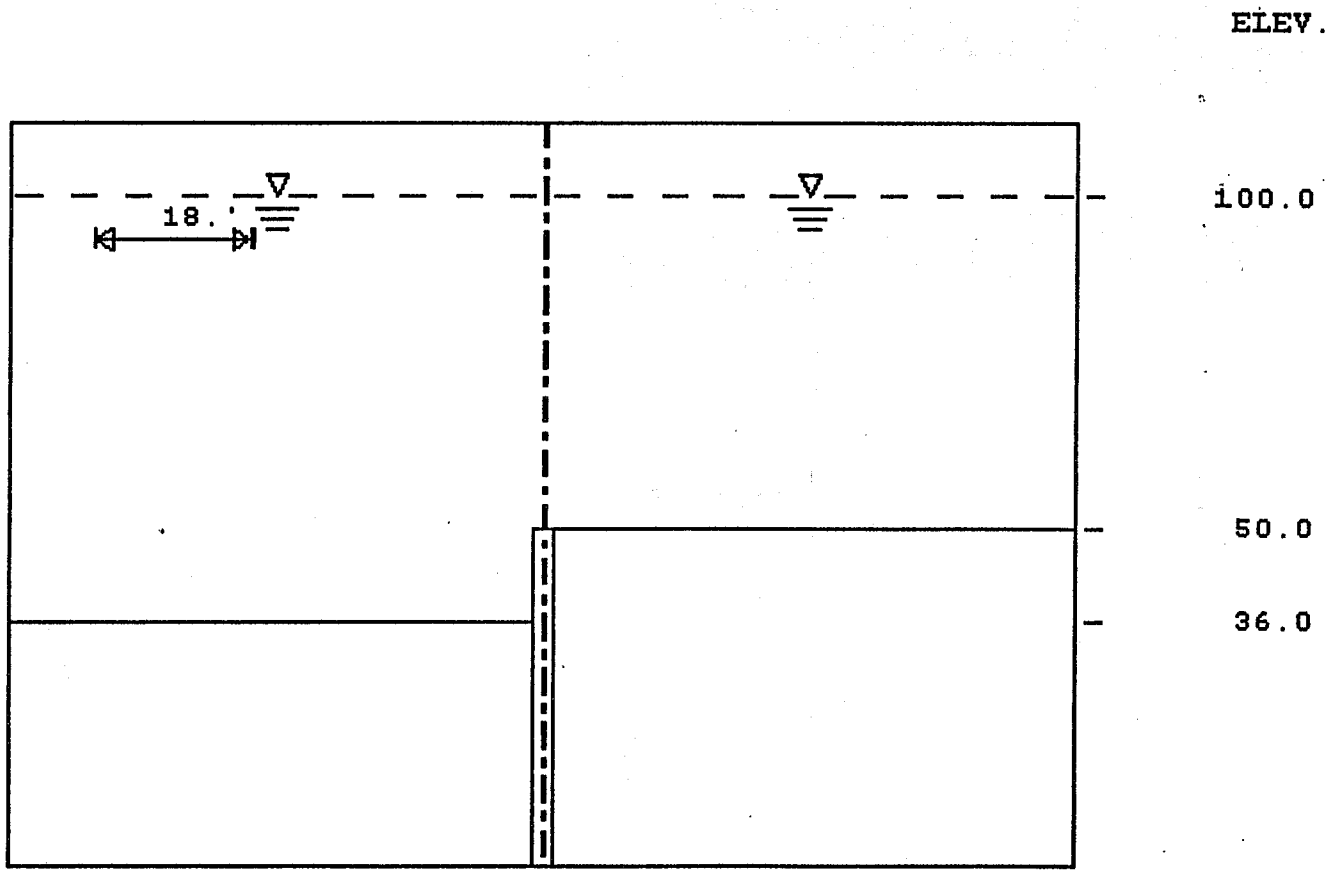
ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
50.00	0.	0.	1.0164E+11	2707.00
49.00	1355.	2712.	9.5055E+10	2717.94
48.00	5429.	5436.	8.8469E+10	2728.87
47.00	12231.	8170.	8.1892E+10	2739.81
46.00	21773.	10915.	7.5337E+10	2750.75
45.00	34065.	13672.	6.8820E+10	2761.68
44.00	49120.	16439.	6.2362E+10	2772.62
43.00	66947.	19217.	5.5990E+10	2783.55
42.00	87557.	22006.	4.9733E+10	2794.49
41.00	110962.	24806.	4.3629E+10	2805.43
40.00	137173.	27617.	3.7716E+10	2816.36
39.00	166200.	30439.	3.2041E+10	2827.30
38.00	198054.	33271.	2.6653E+10	2838.24
37.00	232746.	36115.	2.1608E+10	2849.17
36.00	270288.	38970.	1.6966E+10	2860.11
35.57	287273.	39587.	1.5104E+10	.00
35.28	298504.	39318.	1.3927E+10	-1885.57
35.00	309582.	38514.	1.2791E+10	-3771.15
34.00	345106.	31427.	9.1503E+09	-10402.41
33.00	370227.	17709.	6.1046E+09	-17033.66
32.00	378314.	-2640.	3.6962E+09	-23664.92
31.00	362737.	-29620.	1.9381E+09	-30296.18
30.00	316863.	-63232.	8.0246E+08	-36927.44
29.00	234062.	-103475.	2.0903E+08	-43558.69
28.00	107702.	-150350.	1.3789E+07	-50189.95
27.49	24309.	-176821.	1.7457E+05	-53573.43
27.29	0.	0.	0.0000E+00	1794878.41

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

III.--SOIL PRESSURES

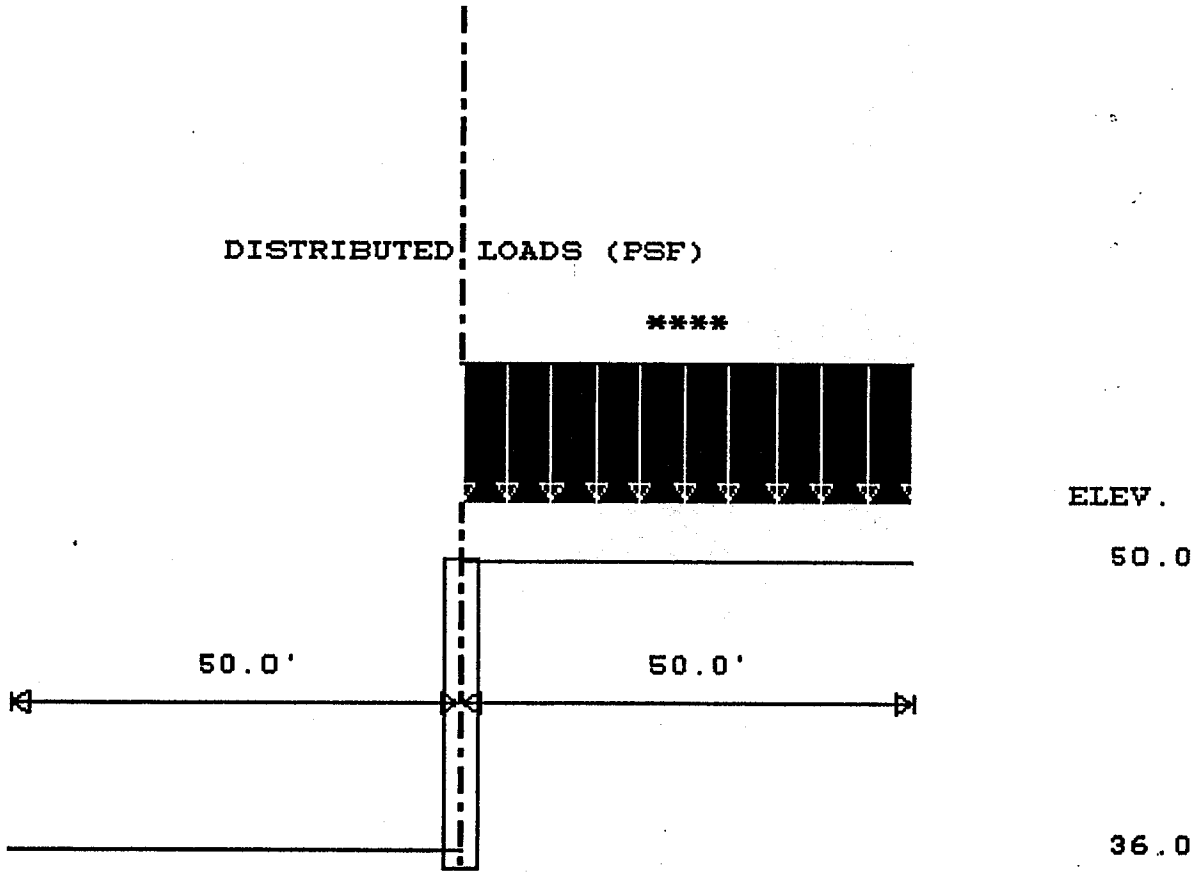
ELEVATION (FT)	< LEFTSIDE PRESSURE (PSF)> PASSIVE	ACTIVE	<RIGHTSIDE PRESSURE (PSF)> ACTIVE	PASSIVE
50.00	0.	0.	2707.	1644107.
49.00	0.	0.	2718.	1650750.
48.00	0.	0.	2729.	1657392.
47.00	0.	0.	2740.	1664034.
46.00	0.	0.	2751.	1670676.
45.00	0.	0.	2762.	1677318.
44.00	0.	0.	2773.	1683961.
43.00	0.	0.	2784.	1690603.
42.00	0.	0.	2794.	1697245.
41.00	0.	0.	2805.	1703887.
40.00	0.	0.	2816.	1710529.
39.00	0.	0.	2827.	1717172.
38.00	0.	0.	2838.	1723814.
37.00	0.	0.	2849.	1730456.
36.00	0.	0.	2860.	1737098.
35.57	2865.	5.	2865.	1739963.
35.28	4754.	8.	2868.	1741852.
35.00	6642.	11.	2871.	1743740.
34.00	13284.	22.	2882.	1750383.
33.00	19927.	33.	2893.	1757025.
32.00	26569.	44.	2904.	1763667.
31.00	33211.	55.	2915.	1770309.
30.00	39853.	66.	2926.	1776951.
29.00	46495.	77.	2937.	1783593.
28.00	53138.	87.	2948.	1790236.
27.49	56527.	93.	2953.	1793625.
27.29	59780.	98.	2959.	1796878.
26.00	66422.	109.	2969.	1803520.

'ARTHUR KILL LIFT BRIDGE, Q=20,000 PSF, ROCK PHI= 45 DEG, C=0
'BLAST/DREDGE FDN UNDERMINE 14 FT, DRILLED SHAFTS 6 FT. DIA



***** INPUT GEOMETRY *****
DATE: 14-AUG-1998 TIME: 10.16.47

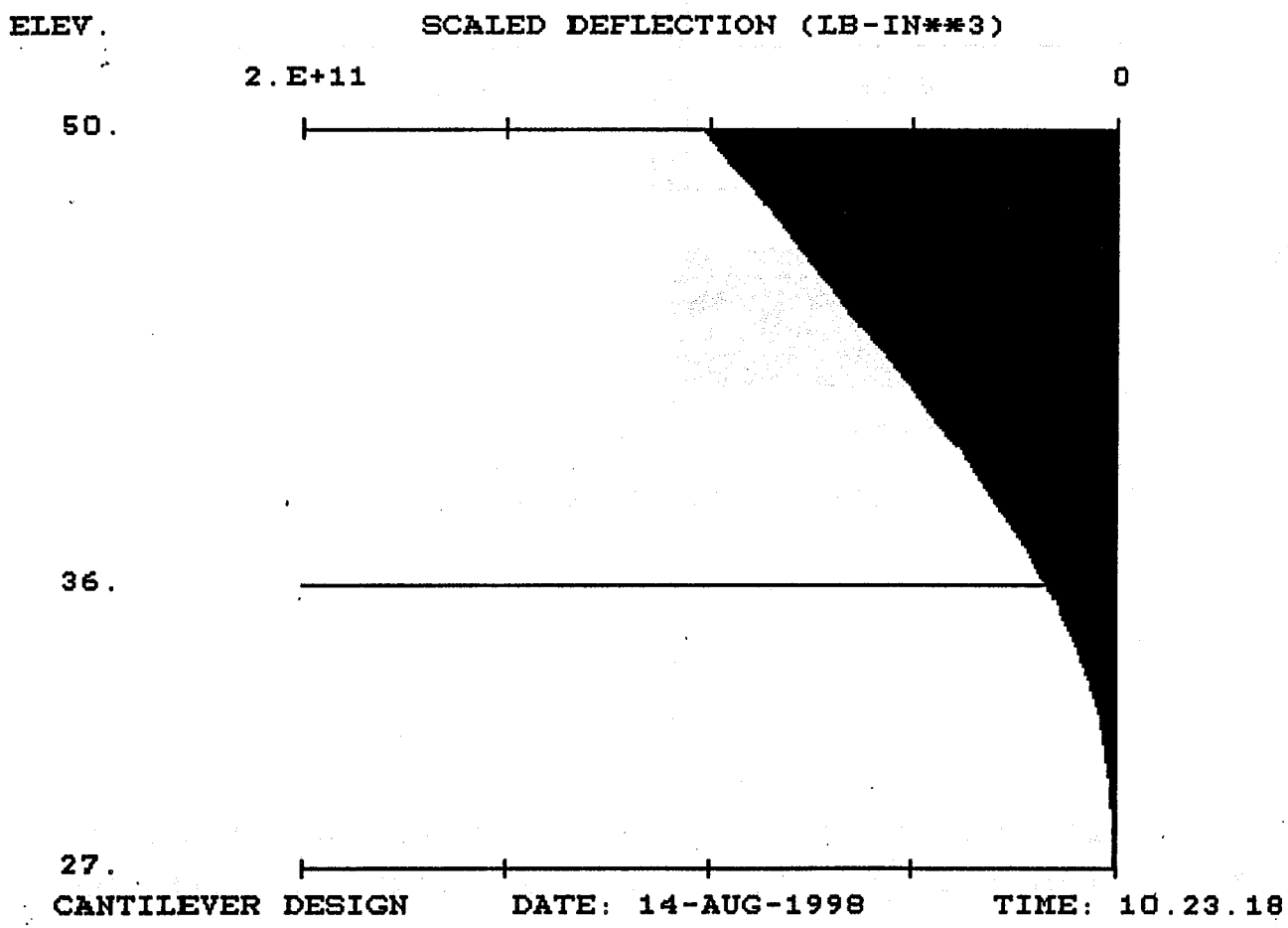
'ARTHUR KILL LIFT BRIDGE, Q=20,000 PSF, ROCK PHI= 45 DEG, C=0
'BLAST/DREDGE FDN UNDERMINE 14 FT, DRILLED SHAFTS 6 FT. DIA



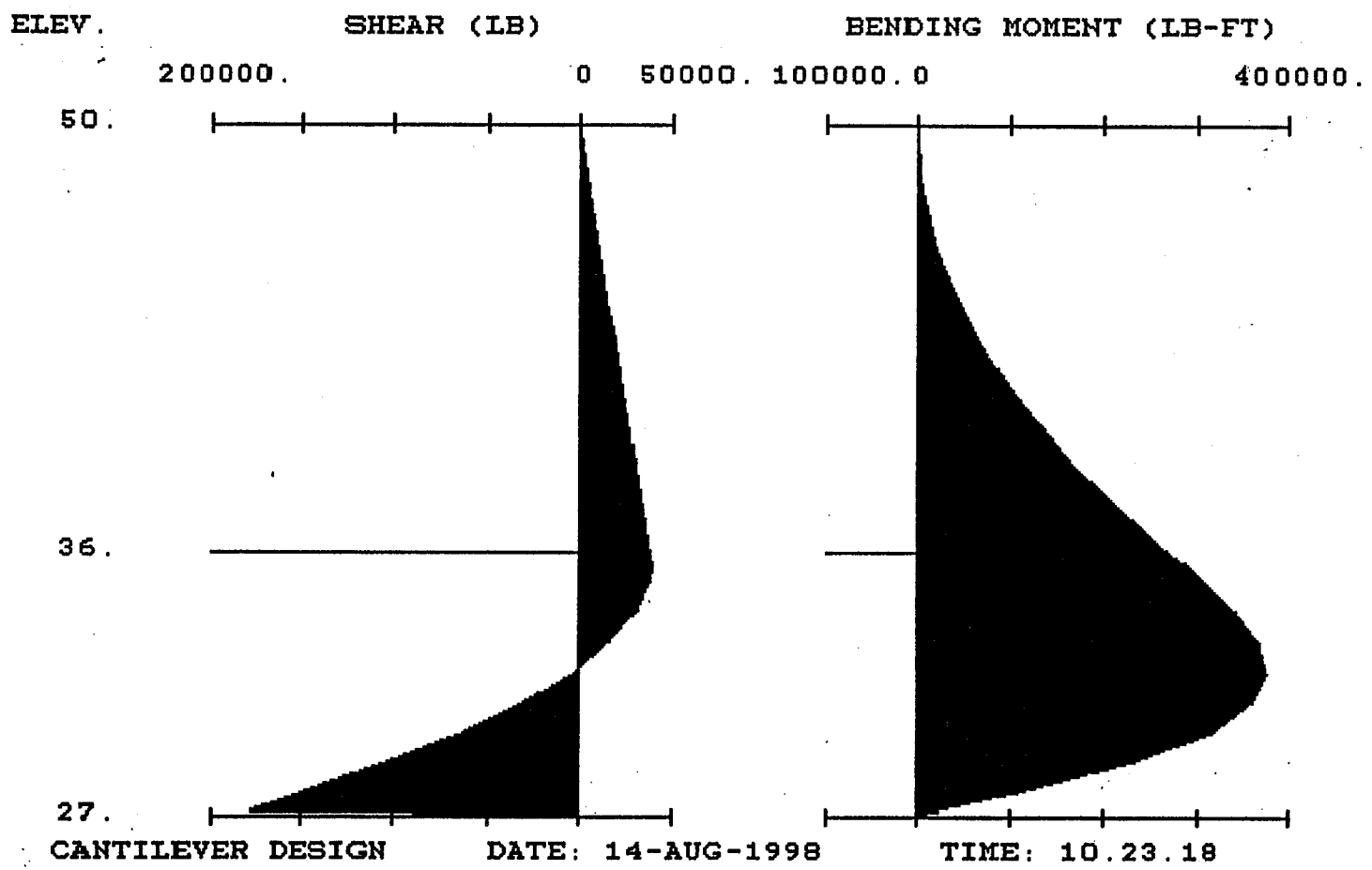
***** SURFACE LOADS *****

DATE: 14-AUG-1998 TIME: 10.19.17

'ARTHUR KILL LIFT BRIDGE, Q=20,000 PSF, ROCK PHI= 45 DEG, C=0
'BLAST/DREDGE FDN UNDERMINE 14 FT, DRILLED SHAFTS 6 FT. DIA



'ARTHUR KILL LIFT BRIDGE, Q=20,000 PSF, ROCK PHI= 45 DEG, C=0
'BLAST/DREDGE FDN UNDERMINE 14 FT, DRILLED SHAFTS 6 FT. DIA



WALL PENETRATION RUN ACTIVE F.S. = 1.0 PASSIVE F.S. = 1.5
14 FOOT HEIGHT DIFFERENTIAL

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 14-AUG-1998 TIME: 14.39.40

INPUT DATA

I.--HEADING:
'ARTHUR KILL LIFT BRIDGE, WALL PENETRATION RUN,PASSIVE FS=1.5
'DREDGE ELEV.= -62 MLW

II.--CONTROL
CANTILEVER WALL DESIGN

LEVEL 1 FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
LEVEL 1 FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

III.--WALL DATA
ELEVATION AT TOP OF WALL = 50.00 (FT)

IV.--SURFACE POINT DATA

IV.A--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	50.00

IV.B-- LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	36.00

14' DIFFERENTIAL HEIGHT

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE LAYER DATA
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
45.00	145.00	45.00	.0	35.00	.0			1.00	1.50

V.B.-- LEFTSIDE LAYER DATA
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
45.00	145.00	45.00	.0	35.00	.0			1.00	1.50

VI.--WATER DATA

UNIT WEIGHT = 62.40 (PCF)
RIGHTSIDE ELEVATION = 100.00 (FT)
LEFTSIDE ELEVATION = 100.00 (FT)
NO SEEPAGE

VII.--SURFACE LOADS

VII.A.--RIGHTSIDE SURFACE LOADS

VII.A.1.--SURFACE LINE LOADS
NONE

VII.A.2.--SURFACE DISTRIBUTED LOADS

UNIFORM LOAD = 20000.00 (PSF)

VII.B.-- LEFTSIDE SURFACE LOADS
NONE

VIII.--HORIZONTAL LOADS
NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 14-AUG-1998 TIME: 14.40.28

SUMMARY OF RESULTS FOR
CANTILEVER WALL DESIGN

I.--HEADING

'ARTHUR KILL LIFT BRIDGE, WALL PENETRATION RUN,PASSIVE FS=1.5
'DREDGE ELEV.= -62 MLW

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS AND THEORY OF ELASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS AND THEORY OF ELASTICITY EQUATIONS FOR SURCHARGE LOADS.

WALL BOTTOM ELEV. (FT) : 16.76
PENETRATION (FT) : 19.24 ± 20' -82 MLW

MAX. BEND. MOMENT (LB-FT) : 580212.
AT ELEVATION (FT) : 25.94

MAX. SCALED DEFL. (LB-IN3): 3.4859E+11
AT ELEVATION (FT) : 50.00

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 14-AUG-1998 TIME: 14.40.28

COMPLETE RESULTS FOR
CANTILEVER WALL DESIGN

I.--HEADING

'ARTHUR KILL LIFT BRIDGE, WALL PENETRATION RUN,PASSIVE FS=1.5
'DREDGE ELEV.= -62 MLW

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
50.00	0.	0.	3.4859E+11	2707.00
49.00	1355.	2713.	3.3229E+11	2718.18
48.00	5429.	5436.	3.1600E+11	2729.36
47.00	12232.	8171.	2.9971E+11	2740.54
46.00	21775.	10917.	2.8345E+11	2751.72
45.00	34070.	13675.	2.6722E+11	2762.90
44.00	49128.	16443.	2.5105E+11	2774.08
43.00	66961.	19223.	2.3497E+11	2785.26
42.00	87578.	22014.	2.1900E+11	2796.44
41.00	110992.	24816.	2.0319E+11	2807.62
40.00	137213.	27629.	1.8757E+11	2818.80
39.00	166254.	30453.	1.7218E+11	2829.98
38.00	198124.	33289.	1.5709E+11	2841.16
37.00	232835.	36136.	1.4233E+11	2852.34
36.00	270399.	38994.	1.2798E+11	2863.52
35.00	310601.	41187.	1.1410E+11	1523.61
34.00	352327.	42041.	1.0075E+11	183.70
33.86	358092.	42053.	9.8968E+10	.00
33.43	376218.	41929.	9.3431E+10	-578.11
33.00	394236.	41555.	8.8014E+10	-1156.21
32.00	434989.	39728.	7.5958E+10	-2496.12
31.00	473246.	36562.	6.4652E+10	-3836.03
30.00	507667.	32056.	5.4164E+10	-5175.94
29.00	536913.	26210.	4.4553E+10	-6515.85
28.00	559642.	19025.	3.5868E+10	-7855.77
27.00	574515.	10499.	2.8149E+10	-9195.68
26.00	580193.	633.	2.1422E+10	-10535.59
25.00	575335.	-10572.	1.5696E+10	-11875.50
24.00	558602.	-23118.	1.0962E+10	-13215.41
23.00	528653.	-37003.	7.1912E+09	-14555.32
22.00	484149.	-52228.	4.3321E+09	-15895.23
21.00	423750.	-68794.	2.3074E+09	-17235.14
20.00	346116.	-86699.	1.0124E+09	-18575.05
19.00	249906.	-105944.	3.1285E+08	-19914.96
18.00	133782.	-126529.	4.2242E+07	-21254.87
17.54	73173.	-136469.	7.8074E+06	-21872.56

17.00	9613.	-74927.	8.4260E+04	250227.86
16.76	0.	0.	0.0000E+00	371836.91

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES.)

III.--SOIL PRESSURES

ELEVATION	< LEFTSIDE PRESSURE (PSF) >		<RIGHTSIDE PRESSURE (PSF) >	
(FT)	PASSIVE	ACTIVE	ACTIVE	PASSIVE
50.00	0.	0.	2707.	327141.
49.00	0.	0.	2718.	328492.
48.00	0.	0.	2729.	329843.
47.00	0.	0.	2741.	331194.
46.00	0.	0.	2752.	332545.
45.00	0.	0.	2763.	333896.
44.00	0.	0.	2774.	335247.
43.00	0.	0.	2785.	336598.
42.00	0.	0.	2796.	337949.
41.00	0.	0.	2808.	339300.
40.00	0.	0.	2819.	340651.
39.00	0.	0.	2830.	342003.
38.00	0.	0.	2841.	343354.
37.00	0.	0.	2852.	344705.
36.00	0.	0.	2864.	346056.
35.00	1351.	11.	2875.	347407.
34.00	2702.	22.	2886.	348758.
33.86	2887.	24.	2887.	348943.
33.43	3470.	29.	2892.	349526.
33.00	4053.	34.	2897.	350109.
32.00	5404.	45.	2908.	351460.
31.00	6755.	56.	2919.	352811.
30.00	8107.	67.	2931.	354162.
29.00	9458.	78.	2942.	355513.
28.00	10809.	89.	2953.	356865.
27.00	12160.	101.	2964.	358216.
26.00	13511.	112.	2975.	359567.
25.00	14862.	123.	2986.	360918.
24.00	16213.	134.	2998.	362269.
23.00	17564.	145.	3009.	363620.
22.00	18915.	157.	3020.	364971.
21.00	20266.	168.	3031.	366322.
20.00	21617.	179.	3042.	367673.
19.00	22969.	190.	3054.	369024.
18.00	24320.	201.	3065.	370375.
17.54	24942.	206.	3070.	370998.
17.00	25671.	212.	3076.	371727.
16.76	27022.	224.	3087.	373078.
15.00	28373.	235.	3098.	374429.

CORPS DOCK NO. 535
NAME: Corey Warehouse
CHANNEL: Arthur Kill

FACILITY NO. 20 - CORY WAREHOUSE (BAYWAY TERMINAL)

In the vicinity of the warehouse, the channel proper is to be dredged in rock. The edge of the rock cut, given a 1:1 side slope, is expected to be roughly 40 feet to 60 feet outboard of the wharf face. Above the bedrock the remainder of the side slope will be at 3:1. Extended, this slope will intercept existing grade at a point within the footprint of the building.

Based on existing borings, the bedrock surface, in the zone of the new channel is assumed to be roughly 20 to 40 feet below MLW.

There are no borings in the vicinity of the warehouse however ACOE plans indicate bedrock rising in the direction of shore.

Assumptions:

- Warehouse and wharf are pile supported.
- There is little soil over the bedrock in the vicinity of the warehouse.
- Bedrock slope is roughly 30%

Potential Solution:

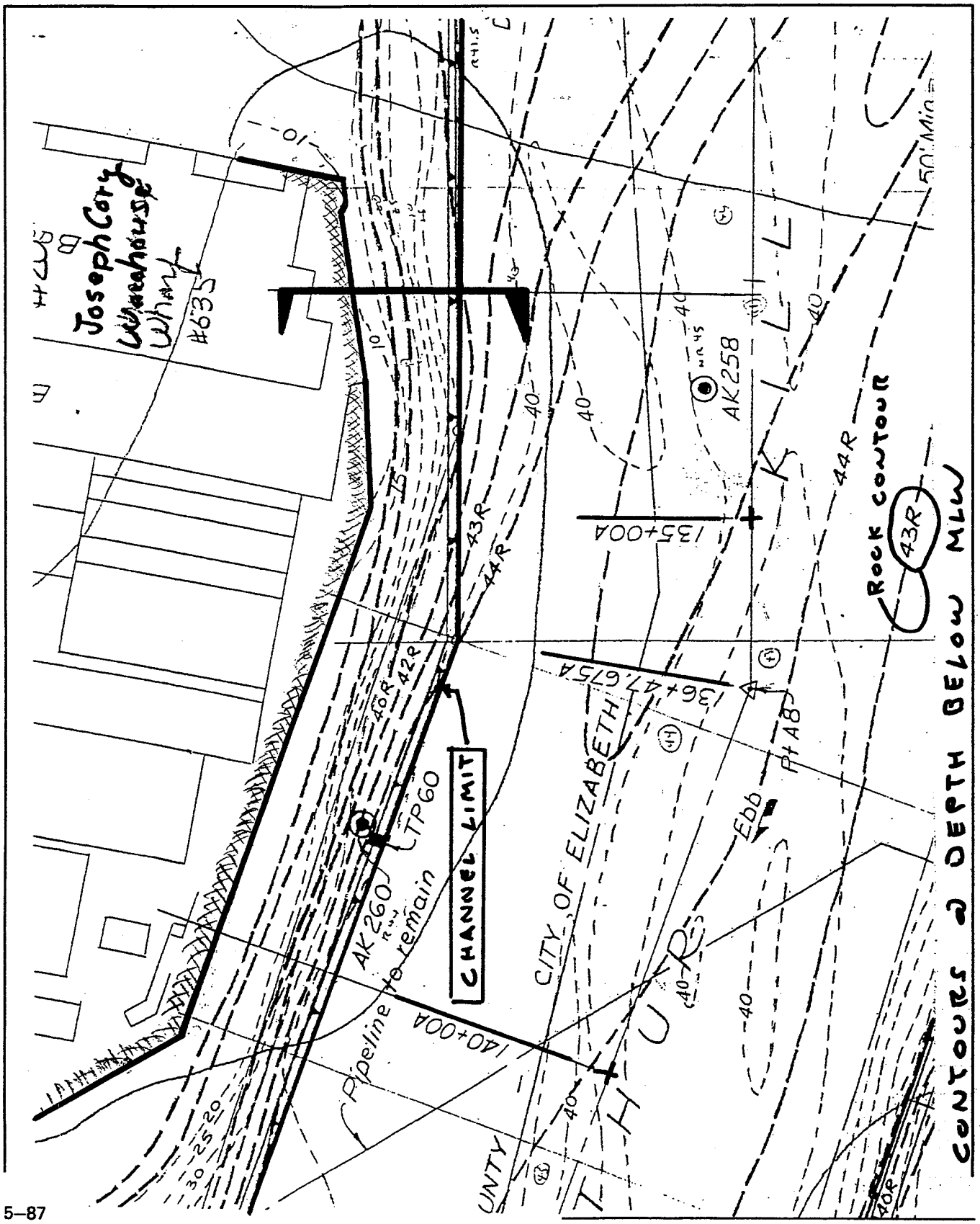
Install cellular cofferdams between the channel and the warehouse to confine the soil mass under the existing structures.

Lateral earth pressure on the cofferdams will not include live loading or surcharges as the shoreside structures are assumed to be pile supported.

Due to the location of the channel cut in the bedrock, conditions for the cofferdam will be virtually the same or both the 62 foot and 52 foot depth.

MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.
Subject PANYNJ SITE #20 Sheet No. of
CORY WAREHOUS Date 19
Comp. JJF Check Cont. No.



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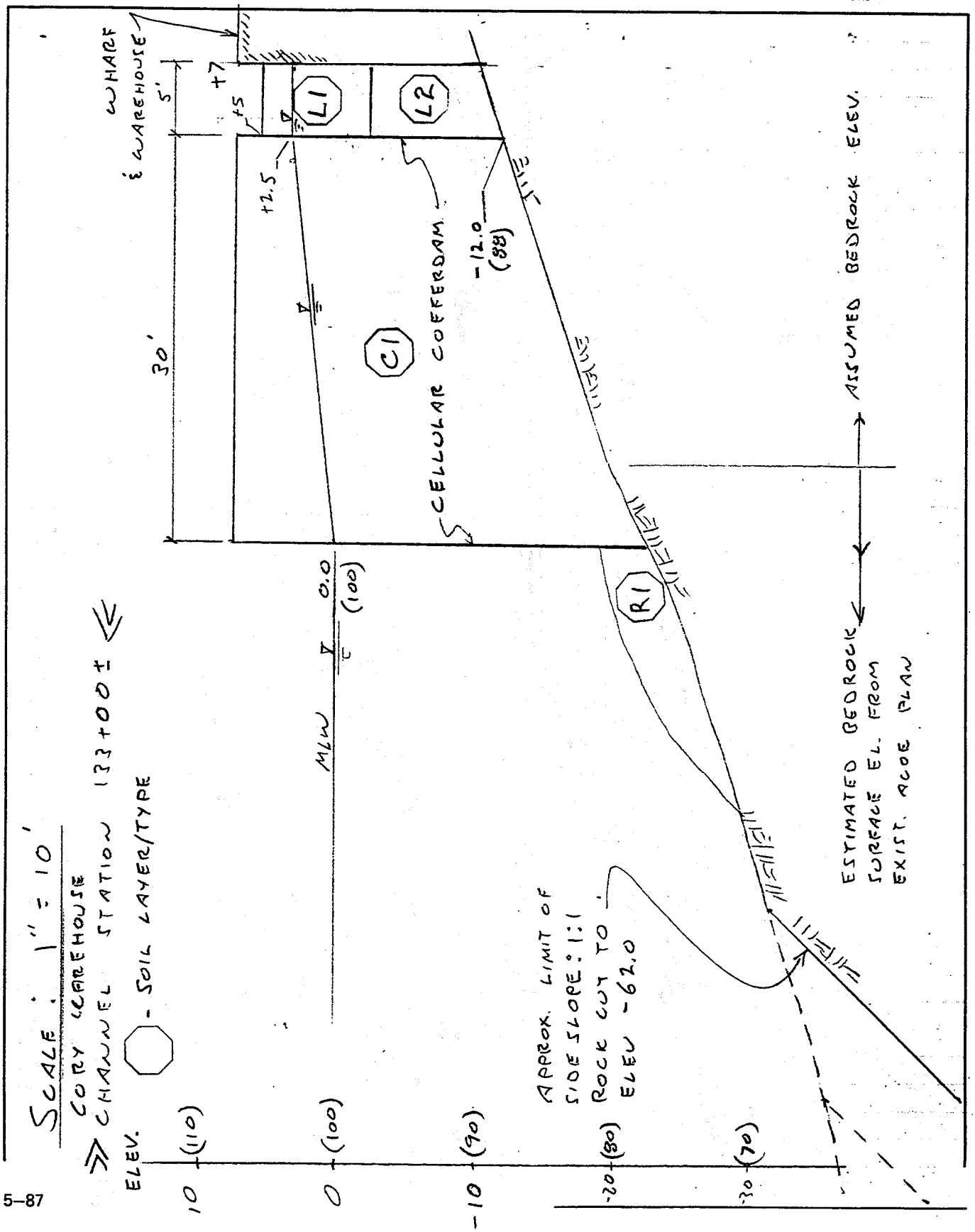
CORY WAREHOUSE — Date 19
Comp. VJ — Check — Cont. No.



MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.
Subject PANYNJ SITE #20 Sheet No. of
CORY WAREHOUSE Date 19
Comp. DOF Check Cont. No.

CELLULAR COFFERDAM ANALYSIS USING ACOE X0040 "EASY CELL"

INPUT ASSUMPTIONS:

- SEE SKETCH FOR GEOMETRY, 30' DIA CELL
- ALLOWABLE INTERLOCK TENSION 16 kips/in
- ULTIMATE BEARING CAPACITY OF ROCK 8 TSF
- COEFF. OF FRICTION BETWEEN CELL FILL & ROCK, μ 0.7
- SOILS & FILL:

EXISTING $\gamma_{sat} = 130$ pcf
$\phi = 30°$

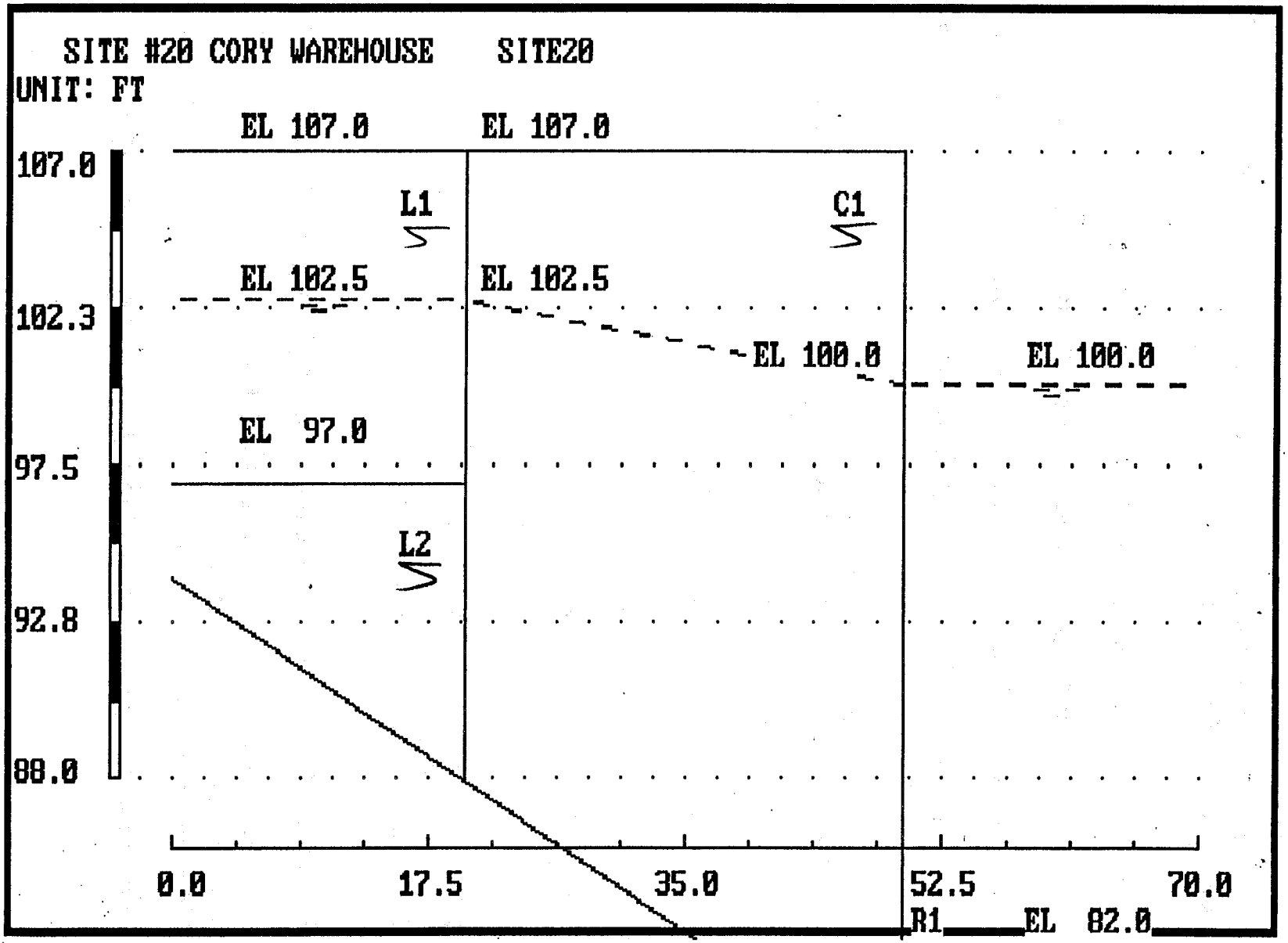
CELL FILL (GRAVEL) $\gamma = 125$ pcf
$\phi = 35°$

BACKFILL BTWN WHARF & CELL (CRUSHED STONE) $\gamma = 135$ pcf
$\phi = 45°$

EARTH PRESSURE COEFFICIENTS; $K_a = 0.27$ $(\phi = 35)$

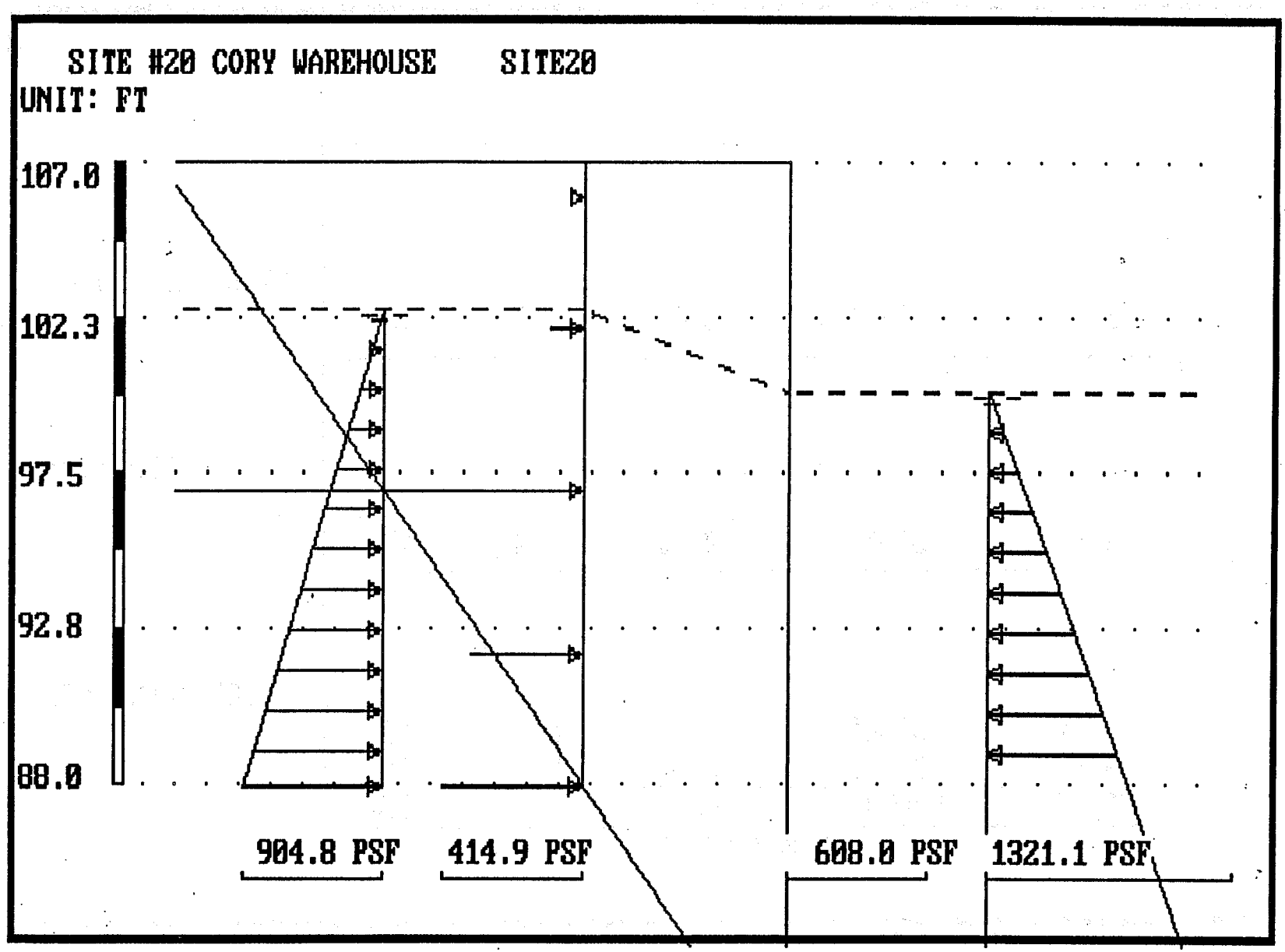
BURSTING $0.43 = (1.6\ K_a)$
INTERLOCK SLIDING 0.43
PENETRATION RESISTANCE 0.43

CENTERPLANE SLIP $\cos^2\phi/2 - \cos^2\phi = 0.50$


SITE #20 CORY WAREHOUSE SITE20
UNIT: FT
EL 107.0
EL 107.0
107.0
L1
C1
EL 102.5
EL 102.5
102.3
EL 100.0
EL 100.0
EL 97.0
97.5
L2
92.8
88.0
0.0
17.5
35.0
52.5
70.0
R1
EL 82.0

SOIL PROPERTIES

	LAYER	C	PHI	GAMMA	DELTA
LEFT_SIDE SOIL:	L1	0.0	45.0	135.0	17.0
	L2	0.0	30.0	130.0	15.0
CELL SOIL:	C1	0.0	35.0	125.0	17.0
RIGHT_SIDE SOIL:	R1	0.0	30.0	130.0	15.0


SITE #20 CORY WAREHOUSE SITE20
UNIT: FT
107.0
102.3
97.5
92.8
88.0
904.8 PSF
414.9 PSF
608.0 PSF
1321.1 PSF

MAGUIRE GROUP

Project HARBOR NAVIGATION STUDY Acc. No.
Subject PANYNJ SITE #20 Sheet No. of
CORY WAREHOUSE Date 19
Comp. DOF Check Cont. No.

CORY WAREHOUSE 30' DIA CELLS
X0040 RESULTS:

SUMMARY OF FACTORS OF SAFETY FOR A CIRCULAR CELL WALL ON ROCK

***** Indicates a very large value

BURSTING	= 26.30
SLIP FAILURE ALONG VERTICAL CENTER-PLANE	= 3.10
HORIZONTAL SHEAR (CUMMING'S METHOD)	= -2.38
PULLOUT OF OUTBOARD SHEETING	= 7.56
BEARING FAILURE OF THE FOUNDATION	= 8.27
SLIDING ON THE BASE	= 3.13

PROGRAM EASY_CCELL - ANALYSIS OF CIRCULAR CELL
COFFERDAMS OR MOORINGS FOUNDED ON ROCK OR SOIL
(SAND OR HARD CLAY) USING CLASSICAL METHODS.
DATE: 12-AUG-1998 TIME: 08.37.38

1. INPUT DATA

1.1.--HEADING

SITE #20 CORY WAREHOUSE SITE20

1.2.--FOUNDATION TYPE,CELL TYPE
FOUNDATION TYPE-ROCK
TYPE-CIRCULAR CELL WALL

1.3.--CELL DESCRIPTION

ELEVATION OF TOP OF CELL	=	107.00 (FT)
ELEVATION OF LEFT-SIDE BOTTOM OF CELL	=	88.00 (FT)
ELEVATION OF RIGHT-SIDE BOTTOM OF CELL	=	78.83 (FT)
EFFECTIVE BASE WIDTH OF CELL	=	30.00 (FT)
SLOPE OF THE ROCK FOUNDATION	=	17.00 (DEG)
THE FRICTION COEFFICIENT BETWEEN FILL AND ROCK	=	.70
CENTER TO CENTER OF CELL	=	20.00 (FT)
ULTIMATE INTERLOCK TENSION	=	192000.00 (LB/FT)
ELEVATION OF DREDGELINE ON INBOARD SIDE	=	.00 (FT)

1.5.--CELL FILL MATERIAL DESCRIPTION

NUMBER OF FILL LAYERS	=	1
ELEVATION OF SURFACE OF CELL FILL	=	107.00 (FT)
ULTIMATE BEARING CAPACITY OF FOUNDATION	=	16000.00 (LB/SQ FT)

CELL FILL MATERIAL LAYER DATA

LAYER NO.	UNIT WEIGHT (LB/CU FT)	INTERNAL FRICTION ANGLE (DEG)	COHESION (LB/SQ FT)	WALL FRICTION ANGLE (DEG)	BOTTOM ELEV AT WALL (FT)
1	125.00	35.00	.00	17.00	.00

COEFFICIENTS OF EARTH PRESSURE FOR CELL MATERIAL

CLKILT = K-VALUE FOR BURSTING
CLKSHC = K-VALUE FOR CENTER-PLANE SHEAR
CLKILR = K-VALUE FOR INTERLOCK SLIDING, PULLOUT, PENETRATION
CLKPEN = K-VALUE FOR PENETRATION RESISTANCE

LAYER NO.	CLKILT	CLKSHC	CLKILR	CLKPEN
1	.430	.500	.430	.430

1.6.--LEFT SIDE SOIL DESCRIPTION

NUMBER OF LEFT SIDE SURFACE POINTS = 1

NUMBER OF LEFT SIDE SOIL LAYERS = 2

LEFT SIDE SURFACE POINT COORDINATES

POINT NO.	ELEVATION (FT)	X-COORD (FT)
1	107.00	.00

LEFT SIDE SOIL LAYER DATA

LAYER NO.	UNIT WEIGHT (LB/CU FT)	INTERNAL FRICTION ANGLE (DEG)	COHESION (LB/SQ FT)	WALL FRICTION ANGLE (DEG)	BOTTOM ELEV AT WALL (FT)	BOTTOM SLOPE (FT/FT)
1	135.00	45.00	.00	17.00	97.00	1: .0
2	130.00	30.00	.00	15.00	*******	1: .0

1.7.--RIGHT SIDE SOIL DESCRIPTION

NUMBER OF RIGHT SIDE SURFACE POINTS = 2

NUMBER OF RIGHT SIDE SOIL LAYERS = 1

RIGHT SIDE SURFACE POINT COORDINATES

POINT NO.	ELEVATION (FT)	X-COORD (FT)
1	82.00	.00
2	77.00	24.00

RIGHT SIDE SOIL LAYER DATA

LAYER NO.	UNIT WEIGHT (LB/CU FT)	INTERNAL FRICTION ANGLE (DEG)	COHESION (LB/SQ FT)	WALL FRICTION ANGLE (DEG)	BOTTOM ELEV AT WALL (FT)	BOTTOM SLOPE (FT/FT)
1	130.00	30.00	.00	15.00	*******	1: .0

1.8.--WATER DATA

ELEVATION OF WATER ON LEFT OUTSIDE CELL = 102.50 (FT)

ELEVATION OF WATER ON RIGHT OUTSIDE CELL = 100.00 (FT)

ELEVATION OF WATER ON LEFT INSIDE CELL = 102.50 (FT)

ELEVATION OF WATER ON RIGHT INSIDE CELL = 100.00 (FT)

UNIT WEIGHT OF WATER = 64.20 (LB/CU FT)

1.9.--SURCHARGE LOADS ON RIGHT SIDE

NUMBER OF CONCENTRATED LOADS = 0

NO DISTRIBUTED LOAD

1.10.--SURCHARGE LOADS ON LEFT SIDE

NUMBER OF CONCENTRATED LOADS = 0

NO DISTRIBUTED LOAD

1.11.-SURCHARGE LOAD ON CELL FILL
NO UNIFORM LOAD

1.12.--HORIZONTAL LOADS ON RIGHT
NUMBER OF HORIZONTAL CONCENTRATED LOADS = 0
NUMBER OF HORIZONTAL PRESSURE POINTS = 0

1.13.--HORIZONTAL LOADS ON LEFT
NUMBER OF HORIZONTAL CONCENTRATED LOADS = 0
NUMBER OF HORIZONTAL PRESSURE POINTS = 0

PROGRAM EASY_CCELL - ANALYSIS OF CIRCULAR CELL
COFFERDAMS OR MOORINGS FOUNDED ON ROCK OR SOIL
(SAND OR HARD CLAY) USING CLASSICAL METHODS.
DATE: 12-AUG-1998 TIME: 08.37.38

2. RESULTS -- FACTORS OF SAFETY

2.1 -- HEADING

SITE #20 CORY WAREHOUSE SITE20

2.2 -- SUMMARY OF FACTORS OF SAFETY FOR A CIRCULAR CELL WALL ON ROCK

***** Indicates a very large value

BURSTING	= 26.30
SLIP FAILURE ALONG VERTICAL CENTER-PLANE	= 3.10
HORIZONTAL SHEAR (CUMMING'S METHOD)	= -2.38
PULLOUT OF OUTBOARD SHEETING	= 7.56
BEARING FAILURE OF THE FOUNDATION	= 8.27
SLIDING ON THE BASE	= 3.13

3. -- SUMMARY OF INTERMEDIATE VALUES OCCURRING IN FACTOR OF SAFETY CALCULATIONS
(NA = not available -- Calculation too complex to print out in compact form)

3.1 -- F.S. -- BURSTING

QUANTITY	VALUE	HOW VALUE WAS OBTAINED
p-max	730.0 LB/SQ FT	SEE SECTION 3.1.1 BELOW
L	10.0 FT	= (CENTER-TO-CENTER DISTANCE)/2
d' (left side)	19.0 FT	NA
x' (left side)	6.3 FT	=(Hfs + d')/3
d' (right side)	3.2 FT	NA
x' (right side)	9.4 FT	=(Hfs + d')/3

3.1.1 -- PRESSURE DISTRIBUTION FOR p-max:
CLKILT IS K-FACTOR FOR p-max

PRESSURE POINT NO.	ELEVATION (FT)	PRESSURE (LB/SQ FT)
1	107.0	.0
2	101.3	309.1
3	101.3	309.1
4	78.8	2334.7

3.2 -- F.S. -- SLIP FAILURE ALONG VERTICAL CENTER-PLANE

QUANTITY	VALUE	HOW VALUE WAS OBTAINED
PwL	6749.0 LB/FT	= RESULTANT WATER PRESS. ON LEFT
HwL	14.5 FT	WATER EL. - CELL TIP EL. ON LEFT
PwR	14388.8 LB/FT	= RESULTANT WATER PRESS. ON RIGHT
HwR	21.2 FT	WATER EL. - CELL TIP EL. ON RIGHT
Pa'	3821.1 LB/FT	WEDGE METHOD OR INPUT
Ha	10.7 FT	WEDGE METHOD OR INPUT
Pp*	964.3 LB/FT	WEDGE METHOD OR INPUT
Pequil	-3818.7 LB/FT	EQUILIBRIUM OF HORIZONTAL FORCES
Pp'	-3818.7 LB/FT	INPUT OR SMALLER OF Pp* AND Pequil
Hp	-3.5 FT	WEDGE METHOD OR INPUT
M	55472.8 FT-LB/FT	SEE SECTION 3.2.1 BELOW
Sm'	8597.5 LB/FT	SEE SECTION 3.2.2 BELOW
Tcw/L	.0 LB/FT	SEE SECTION 3.2.3 BELOW
Sm''	.0 LB/FT	= f * Tcw/L

3.2.1 -- CALCULATION OF M:

M = (1/3)[PwL(HwL) - PwR(HwR)] + Pa'Ha - Pp'Hp + MOMENT DUE TO APPLIED FORCES AND PRESSURES

3.2.2 -- CALCULATION OF Sm'
CLKSHC IS K-FACTOR FOR Pc'

PRESSURE DISTRIBUTION

PRESSURE POINT NUMBER	ELEVATION (FT)	PRESSURE (LB/SQ FT)	RESULTANT (LB/FT)	ANGLE OF INTERNAL FRICTION (DEG)	RESULTANT * TANGENT OF ANGLE (LB/FT)
1	107.0	.0			
			1033.2	35.0	723.5
2	101.3	359.4			
3	101.3	359.4			
			11245.2	35.0	7874.0
4	83.4	901.6			

3.2.3 -- CALCULATION OF Tcw/L

Tcw (left side) governed, values below apply to the left side.

Note: If applied pressures or loads act on the cell, or if water is present outside the cell, on this side then the resultants of these pressures must be subtracted from the resultants in the table below in order to calculate the value of Tcw/L.

PRESSURE DISTRIBUTION FOR PT (= RESULTANT OF SOIL AND WATER PRESSURES INSIDE THE CELL)
CLKILR IS K-FACTOR FOR PT

PRESSURE POINT NO.	ELEVATION (FT)	PRESSURE (LB/SQ FT)	RESULTANT (LB/FT)
1	107.0	.0	
			.0
2	107.0	.0	
3	107.0	.0	
			.0
4	88.0	.0	

RESULTANT OF APPLIED PRESSURES AND LOADS ON RIGHT = .0
RESULTANT OF APPLIED PRESSURES AND LOADS ON LEFT = .0

3.3 F.S. -- HORIZONTAL SHEAR (CUMMING'S METHOD)

QUANTITY	VALUE	HOW VALUE WAS OBTAINED
M	55472.8 FT-LB/FT	SEE SECTION 3.2.1 ABOVE
Tcw/L	.0 LB/FT	SEE SECTION 3.2.3 ABOVE
Mf	.0 FT-LB/FT	= f * b * Tcw/L
Mshear	-132187.7 FT-LB/FT	NA

3.4 F.S. -- PULLOUT OF OUTBOARD SHEETING

QUANTITY	VALUE	HOW VALUE WAS OBTAINED
L	10.0 FT	= (CENTER-TO-CENTER DISTANCE)/2
M	55472.8 FT-LB/FT	SEE SECTION 3.2.1 ABOVE
Pa'TAN(DELTLT)	1059.4 LB/FT	NA
Ps'TAN(DELTC)	3228.4 LB/FT	SEE SECTION 3.4.1 BELOW

3.4.1 -- CALCULATION OF Ps'TAN(DELTC)

CLKILR IS K-FACTOR FOR Ps'

PRESSURE DISTRIBUTION

PRESSURE POINT NUMBER	ELEVATION (FT)	PRESSURE (LB/SQ FT)	RESULTANT (LB/FT)	ANGLE OF WALL FRICTION (DEG)	RESULTANT * TANGENT OF ANGLE (LB/FT)
1	107.0	.0			
			888.6	17.0	271.7
2	101.3	309.1			
3	101.3	309.1			
			9670.9	17.0	2956.7
4	83.4	775.4			

3.5 F.S. -- PENETRATION OF INBOARD SHEETING

NO PENETRATION OF INBOARD SHEETING FOR ROCK FOUNDATION

3.6 F.S. -- BEARING FAILURE OF THE FOUNDATION

QUANTITY	VALUE	HOW VALUE WAS OBTAINED
M	55472.8 FT-LB/FT	SEE SECTION 3.2.1 ABOVE
Weffective	54095.3 LB/FT	= EFFECT. WT. + SURCHARGE
e	1.0 LB/FT	= M/Weffective
Qeffective	1935.5 LB/SQ FT	= Weffective/(b - 2e)

3.7 -- F.S. -- SLIDING INSTABILITY

QUANTITY	VALUE	HOW VALUE WAS OBTAINED
Weffective	54095.3 LB/FT	= EFFECT. WT. + SURCHARGE
PHI	35.0 DEGREES	INPUT
Pp*	964.3 LB/FT	= RESULTANT PASSIVE PRESS. ON RIGHT
F applied-R	.0 LB	= APPLIED LOADS AND PRESS. ON RIGHT
Cohesion	.0 LB/FT	INPUT
B	30.0 FT	= CELL WIDTH
PwL	6749.0 LB/FT	= RESULTANT WATER PRESS. ON LEFT
PwR	14388.8 LB/FT	= RESULTANT WATER PRESS. ON RIGHT
Pa'	3821.1 LB/FT	WEDGE METHOD OR INPUT
F applied-L	.0 LB	= APPLIED LOADS AND PRESS. ON LEFT

G7. FACILITY PHOTOS

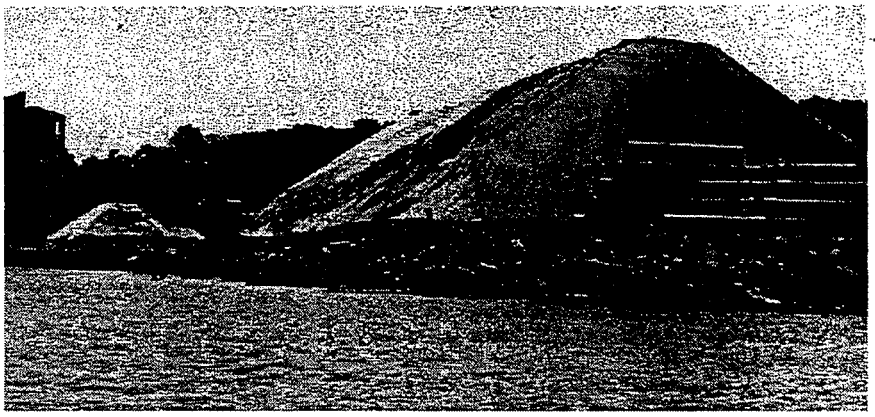


Photo No.1 - Atlantic Salt stock pile looking east.

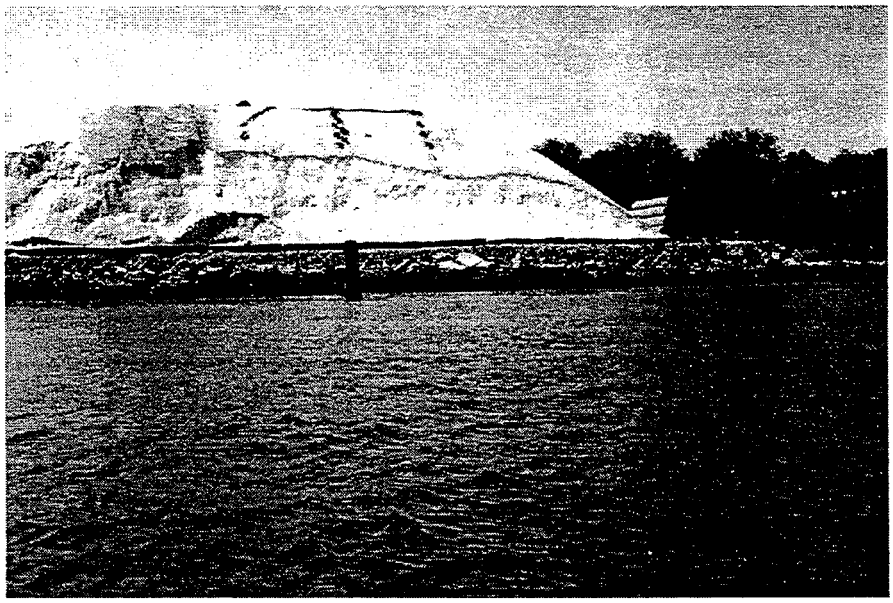
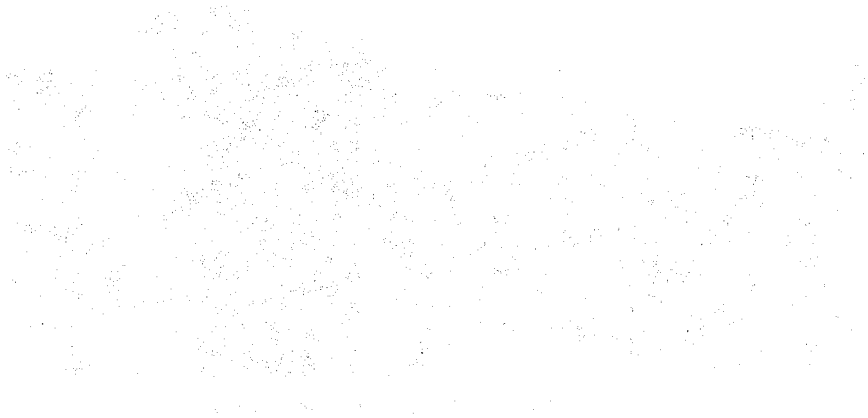


Photo No. 2 Atlantic Salt Stockpile Looking South





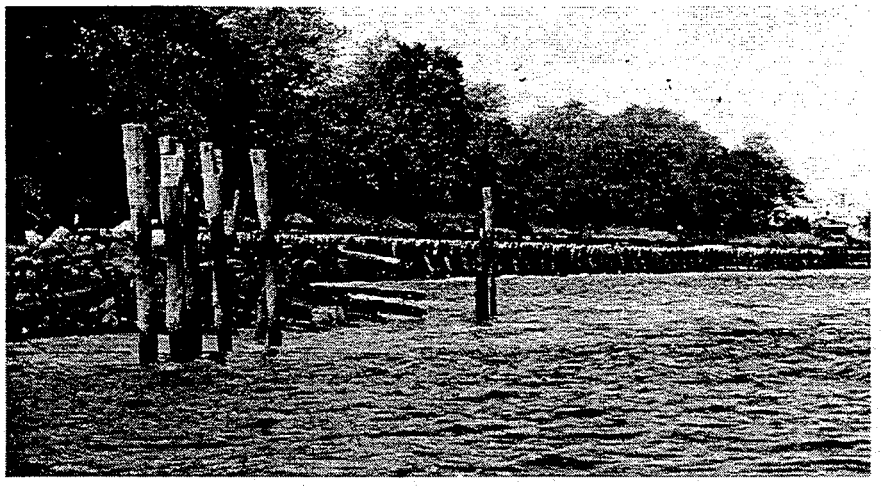


Photo No. 3 Richmond Terrace Road Looking West

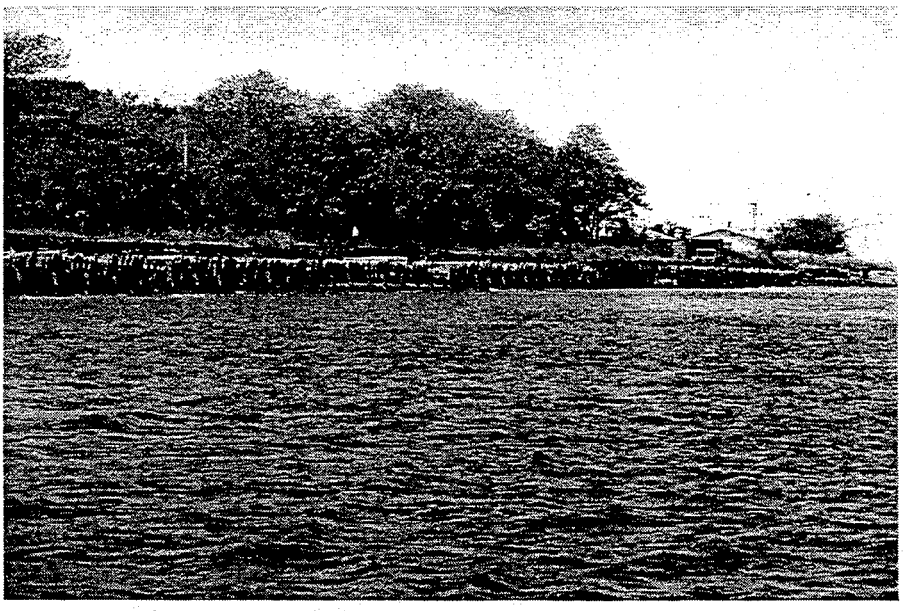


Photo No.4 Richmond Terrace Rd. Looking West

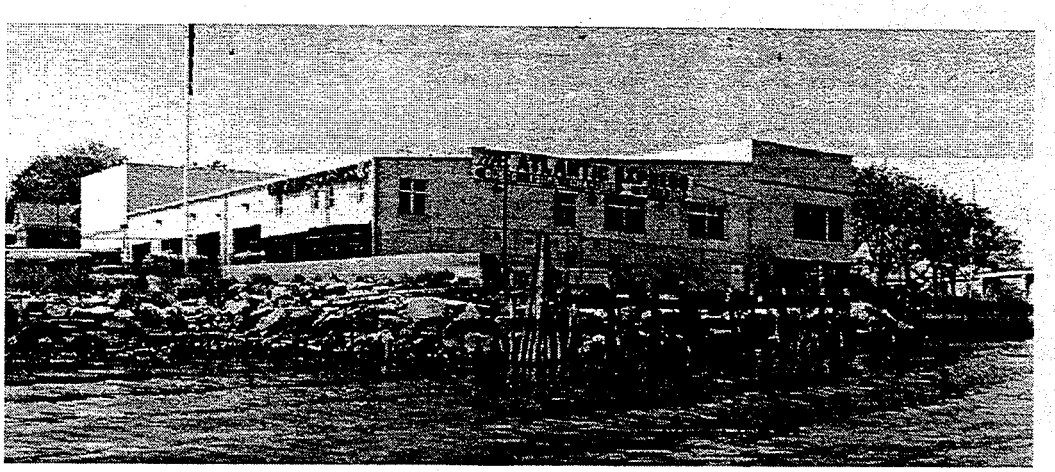


Photo No. 5 Atlantic Bus Terminal

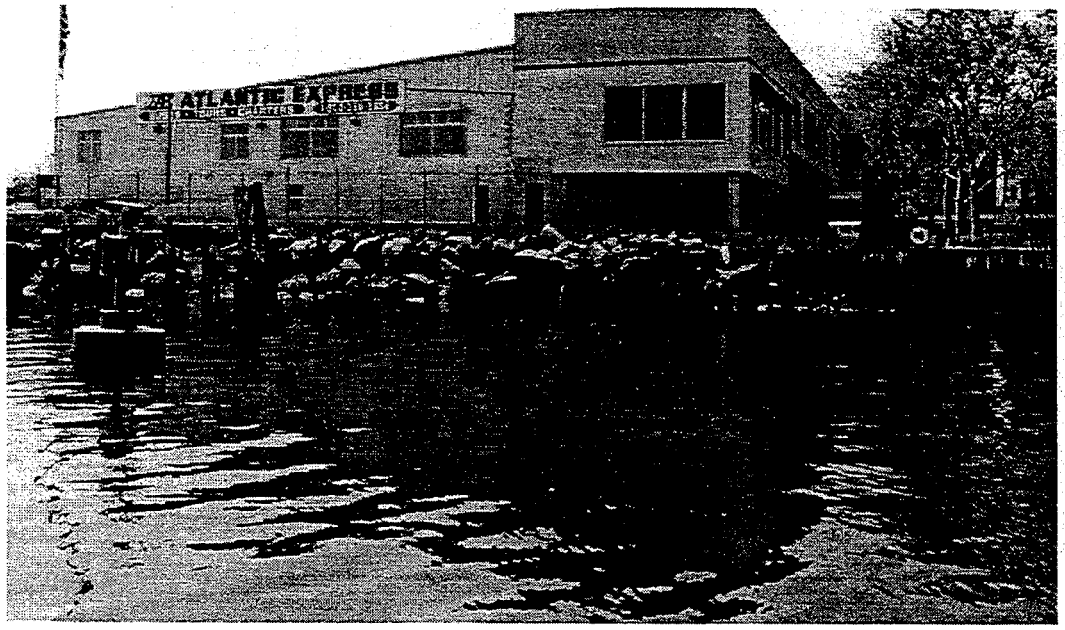


Photo No. 6 Atlantic Bus Terminal Looking Southeast

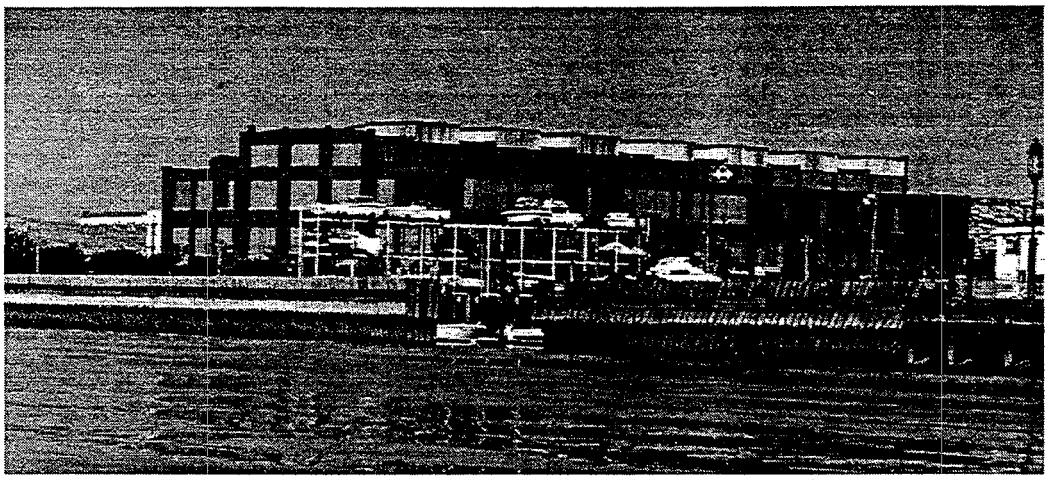


Photo No. 7 City of Elizabeth Marina Looking South

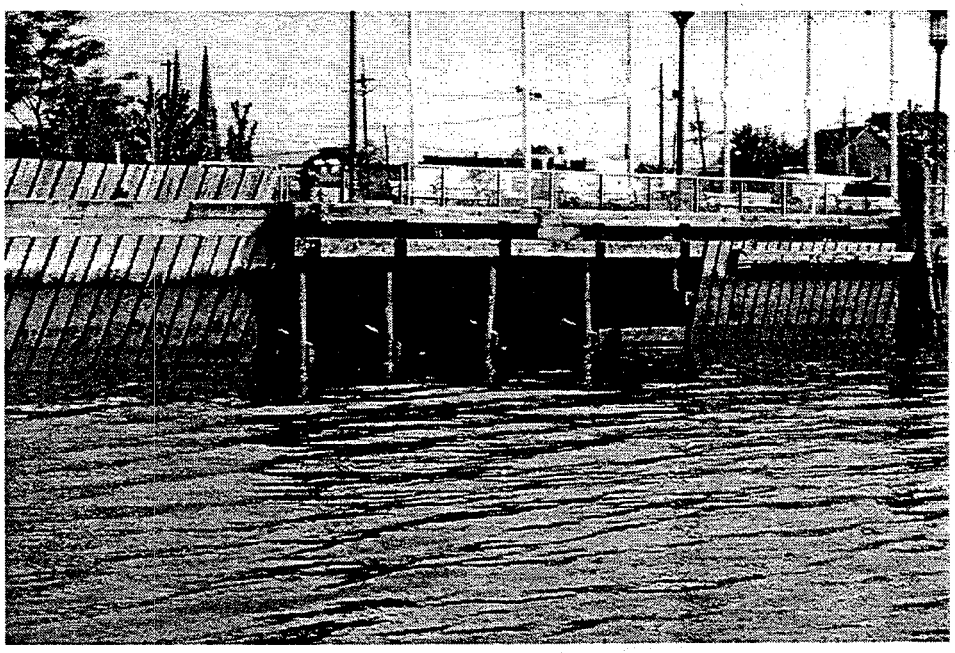


Photo No. 8 City of Elizabeth Public Pier

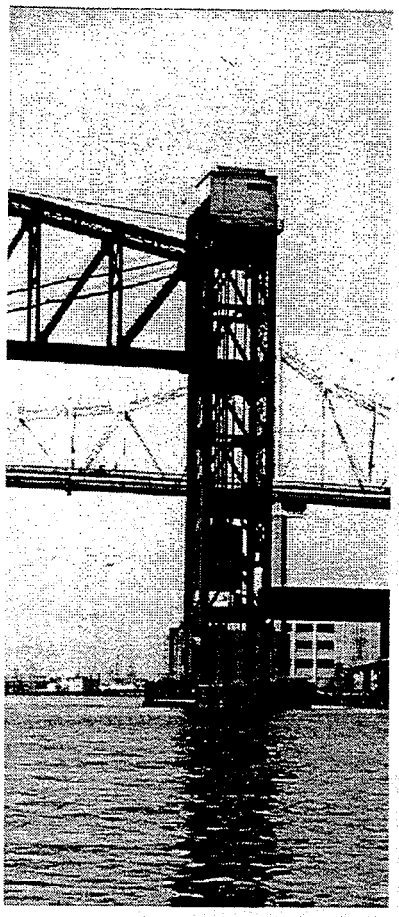


Photo No. 9 East Bridge
Pier Arthur Kill Lift
Bridge Looking North

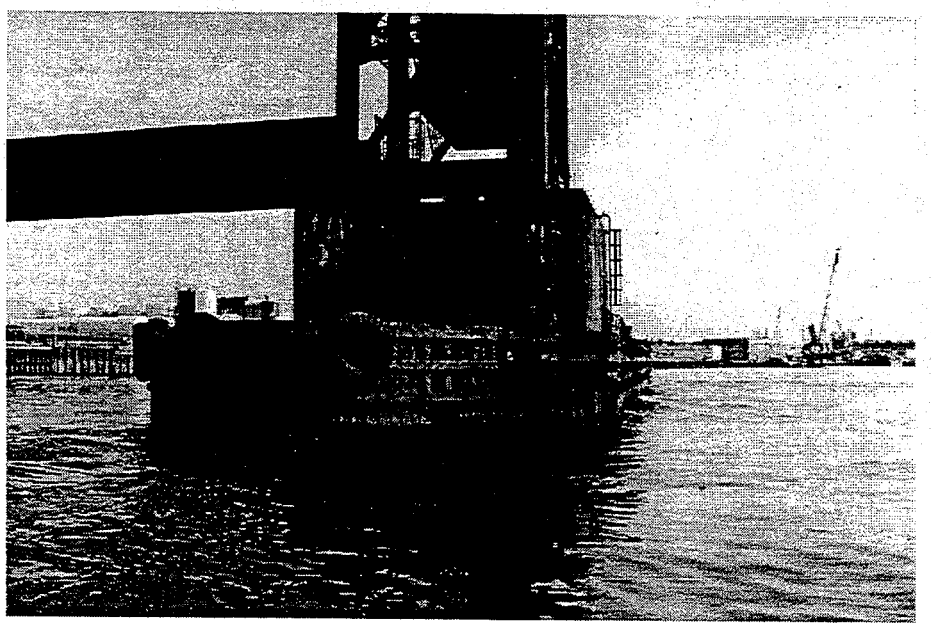


Photo No. 10 East Bridge Pier Looking South

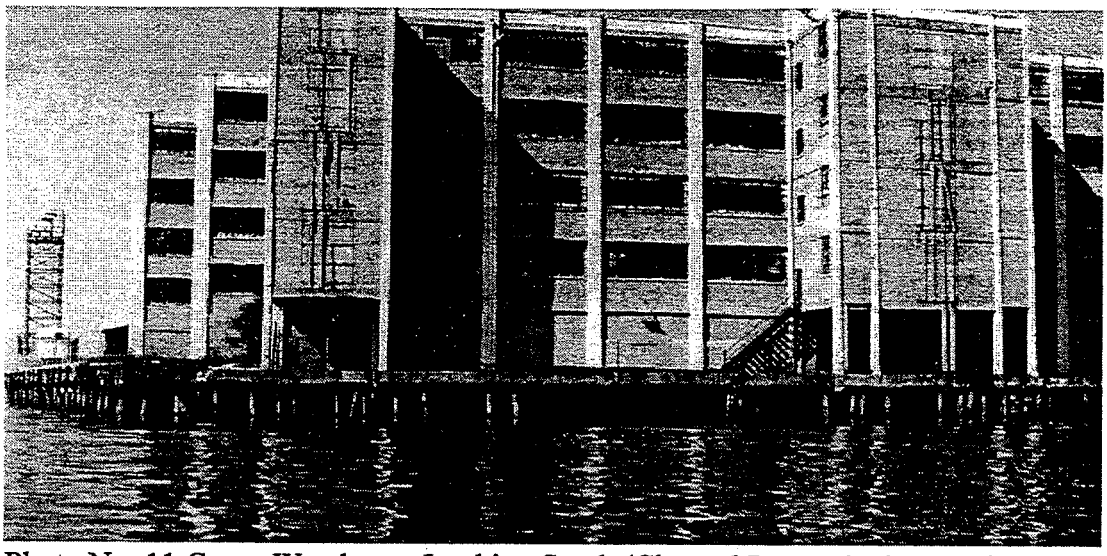


Photo No. 11 Corey Warehouse Looking South (Channel Located Along Left Side of Photo

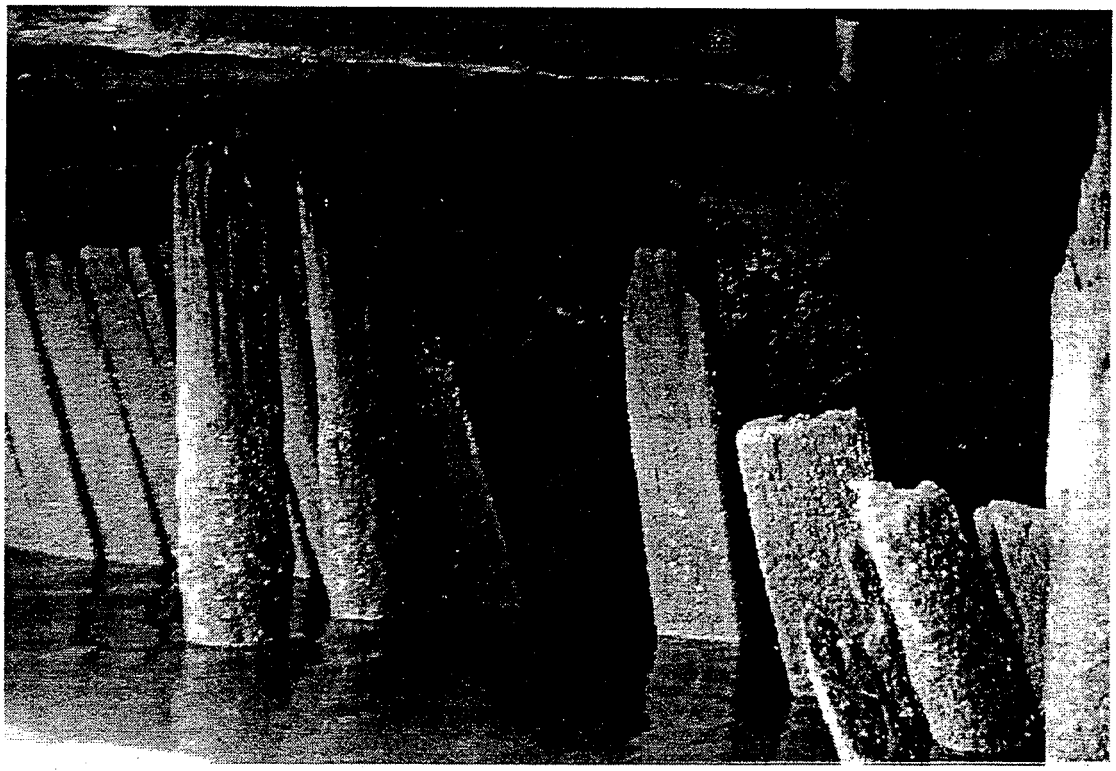
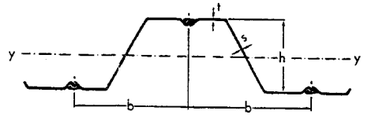


Photo No. 12 Corey Warehouse - North Side Relieving Platform Foundations

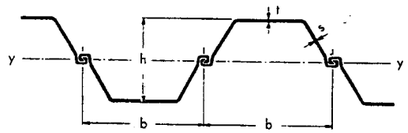
Our range of steel sheet piling.

SEABOARD STEEL CORP.
P. O. Drawer 3408
Sarasota, FL 34230
(941) 355-9773 • (800) 533-2736
FAX: (941) 351-7064

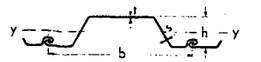
	Section width b	Height h	Back thickness t	Web thickness s	Perimeter P	Sectional Area S. A.	Weight W		Moment of Inertia M. I.	Section Modulus S. M.		Radius of Gyration r
	in.	in.	in.	in.	in./ft. of wall	sq. in./ft. of wall	lbs/l.ft. of single pile	lbs/sq.ft. of wall	in.⁴/ft. of wall	in.³ per single pile	in.³/ft. of wall[1]	in.
HOESCH Sections (Z-Type)												
HOESCH 1200	22.64	10.24	0.375	0.375	31.09	6.43	41.33	**21.91**	108.5	39.96	**21.20**	4.1
HOESCH 1700	22.64	13.78	0.394	0.354	32.41	6.99	44.82	**23.76**	220.4	60.33	**31.99**	5.62
HOESCH 1700 K	22.64	13.78	0.375	0.375	32.41	7.04	45.23	**23.96**	217.8	59.66	**31.62**	5.57
HOESCH 2500	22.64	13.78	0.492	0.375	36.37	9.12	58.73	**31.13**	317.8	86.97	**46.13**	5.87
HOESCH 2500 K	22.64	13.78	0.504	0.394	36.37	9.31	59.88	**31.74**	325.5	89.06	**47.24**	5.83
HOESCH 95[3]	20.67	7.49	0.315	0.315	28.81	5.72	33.52	**19.46**	52.2	22.88	**13.95**	3.03
HOESCH 116[3]	20.67	9.85	0.366	0.354	30.37	6.99	40.92	**23.76**	109.9	36.61	**22.32**	3.98
HOESCH 122[3]	20.67	7.48	0.433	0.421	28.81	7.32	43.1	**24.99**	65.4	29.04	**17.84**	3.00
HOESCH 134	20.67	11.82	0.393	0.374	32.89	8.08	47.33	**27.44**	186.7	51.67	**31.62**	4.81
HOESCH 134 N	20.67	11.82	0.375	0.375	32.89	7.70	45.16	**26.22**	181.3	50.16	**30.69**	4.32
HOESCH 155	20.67	11.82	0.504	0.388	32.05	9.31	54.70	**31.74**	219.7	61.63	**37.20**	4.85
HOESCH 175	20.67	13.39	0.551	0.394	35.89	10.54	61.76	**35.84**	323.7	79.33	**48.36**	5.56
HOESCH 215	20.67	13.39	0.740	0.472	34.93	12.95	75.94	**44.03**	392.2	98.86	**58.59**	5.52
LARSSEN Sections (U-Type)												
LARSSEN 703	27.56	15.75	0.374	0.315	30.13	5.81	45.38	**19.77**	177.2	25.25	**22.51**	5.48
LARSSEN 703 K	27.56	15.75	0.394	0.354	30.13	6.19	48.47	**21.09**	190.0	25.99	**24.18**	5.48
LARSSEN 600	23.64	5.91	0.375	0.375	27.01	5.67	37.90	**19.25**	28.1	6.65	**9.49**	2.23
LARSSEN 600 K	23.64	5.91	0.394	0.394	27.01	5.95	39.93	**20.28**	29.6	7.50	**10.04**	2.21
LARSSEN 601	23.64	12.21	0.295	0.292	30.97	4.63	31.11	**15.77**	84.4	15.31	**13.86**	4.27
LARSSEN 602	23.64	12.21	0.323	0.315	30.97	5.34	35.88	**18.23**	94.3	16.17	**15.44**	4.22
LARSSEN 603	23.64	12.21	0.382	0.323	31.21	6.52	43.55	**22.1**	13[illegible]	20.13	**22.32**	4.58
LARSSEN 603 K	23.64	12.21	0.394	0.354	31.21	6.85	45.76	**23.1**	14[illegible]	20.74	**23.06**	4.55
LARSSEN 604	23.64	14.97	0.414	0.354	33.85	7.47	50.06	**25.40**	224.9	25.93	**30.13**	5.49
LARSSEN 605	23.64	16.55	0.492	0.354	34.81	8.36	56.11	**28.47**	310.3	31.72	**37.57**	6.11
LARSSEN 605 K	23.64	16.55	0.480	0.394	34.81	8.69	58.26	**29.49**	311.6	33.49	**37.76**	5.99
LARSSEN 606	23.64	17.14	0.615	0.362	35.17	9.50	63.44	**32.15**	398.1	36.60	**46.50**	6.49
LARSSEN 606 K	23.64	17.14	0.615	0.394	35.17	9.78	65.52	**33.18**	404.5	37.82	**47.20**	6.44
LARSSEN 607	23.64	17.14	0.847	0.386	35.17	11.48	76.88	**39.12**	509.7	37.21	**59.52**	6.67
LARSSEN 607 K	23.64	17.14	0.847	0.394	35.17	11.53	77.41	**39.32**	512.8	38.43	**59.89**	6.67
LARSSEN 20	19.70	8.67	0.276	0.236	30.01	4.77	26.54	**16.18**	48.3	8.72	**11.16**	3.18
LARSSEN 21	19.70	8.67	0.323	0.315	30.01	5.72	31.92	**19.46**	56.4	9.76	**13.02**	3.14
LARSSEN 22	19.70	13.40	0.394	0.354	33.61	7.32	40.99	**24.99**	155.6	20.50	**23.25**	4.61
LARSSEN 23	19.70	16.55	0.453	0.394	37.81	9.31	52.08	**31.74**	307.6	32.15	**37.20**	5.75
LARSSEN 24	19.70	16.55	0.614	0.394	37.81	10.54	58.80	**35.84**	384.5	33.37	**46.50**	6.03
LARSSEN 25	19.70	16.55	0.787	0.453	37.33	12.37	69.22	**42.19**	467.5	34.28	**56.54**	6.15
LARSSEN 32[3]	17.72	9.85	0.413	0.413	30.01	7.32	36.89	**24.99**	77.6	13.79	**15.81**	3.25
LARSSEN III	15.75	9.73	0.559	0.362	34.21	9.31	41.66	**31.74**	122.1	13.54	**25.11**	3.62
LARSSEN 43	19.70	16.55	0.472	0.472	33.61	10.02	55.80	**34.00**	255.6	29.46	**30.88**	5.04
LARSSEN 430[3]	27.89	29.55	0.472	0.472	47.53	14.13	55.80	**48.13**	1770.8	–	**119.97**	11.19
UNION Straight Web Sections [4]												
FL 409	15.76	3.39	0.355	–	25.81	8.13	36.29	**27.65**	3.7	2.93	**2.23**	0.67
FL 409.5	15.76	3.39	0.375	–	25.81	8.31	37.09	**28.26**	3.7	2.93	**2.23**	0.66
FL 412	15.76	3.39	0.473	–	25.81	9.17	40.99	**31.13**	3.7	2.93	**2.23**	0.63
FL 412.7	15.76	3.39	0.500	–	25.81	9.40	42.07	**31.95**	3.7	2.93	**2.23**	0.62
FL 511	19.70	3.47	0.433	–	30.61	8.13	45.36	**27.65**	2.9	2.93	**1.67**	0.60
FL 512	19.70	3.47	0.473	–	30.61	8.51	47.37	**28.88**	2.9	2.93	**1.67**	0.59
FL 512.7	19.70	3.47	0.500	–	30.61	8.73	48.72	**29.70**	2.9	2.93	**1.67**	0.58
HOESCH Light-weight Sections												
HL 3/6	27.56	5.83	0.236	0.236	29.17	3.97	31.06	**13.52**	22.56	17.51	**7.63**	2.32
HL 3/8	27.56	5.91	0.315	0.315	29.17	5.29	41.34	**18.02**	29.66	23.06	**10.04**	2.36
HOESCH Trench Sheetings												
HKD VI/6	23.64	3.07	0.236	0.236	30.01	3.78	25.21	**12.70**	5.32	6.65	**3.39**	1.18
HKD VI/8	23.64	3.15	0.315	0.315	30.01	5.01	33.61	**17.00**	7.08	8.85	**4.50**	1.18

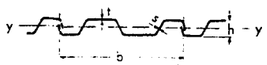


HOESCH sections, LARSSEN sections and UNION straight web sections available in lengths up to approx. 118 ft. on application.









[1] **The section modulus values of the LARSSEN sections require cramping/welding of the prefabricated interlocks to absorb shear forces.**

[2] Wall assembly fabricated from LARSSEN 43 sections. Where quad pile assemblies are supplied, allowance must be made for the weight of the welded seams and reinforcements.

[3] Rolling/delivery on application from 150 nt only.

[4] Minimum interlock tensile strength = 16,000 lbs/l. in. (ultimate load). Higher values (up to 28,000 lbs/l. in.) possible depending on the angle of deviation in the interlocks.

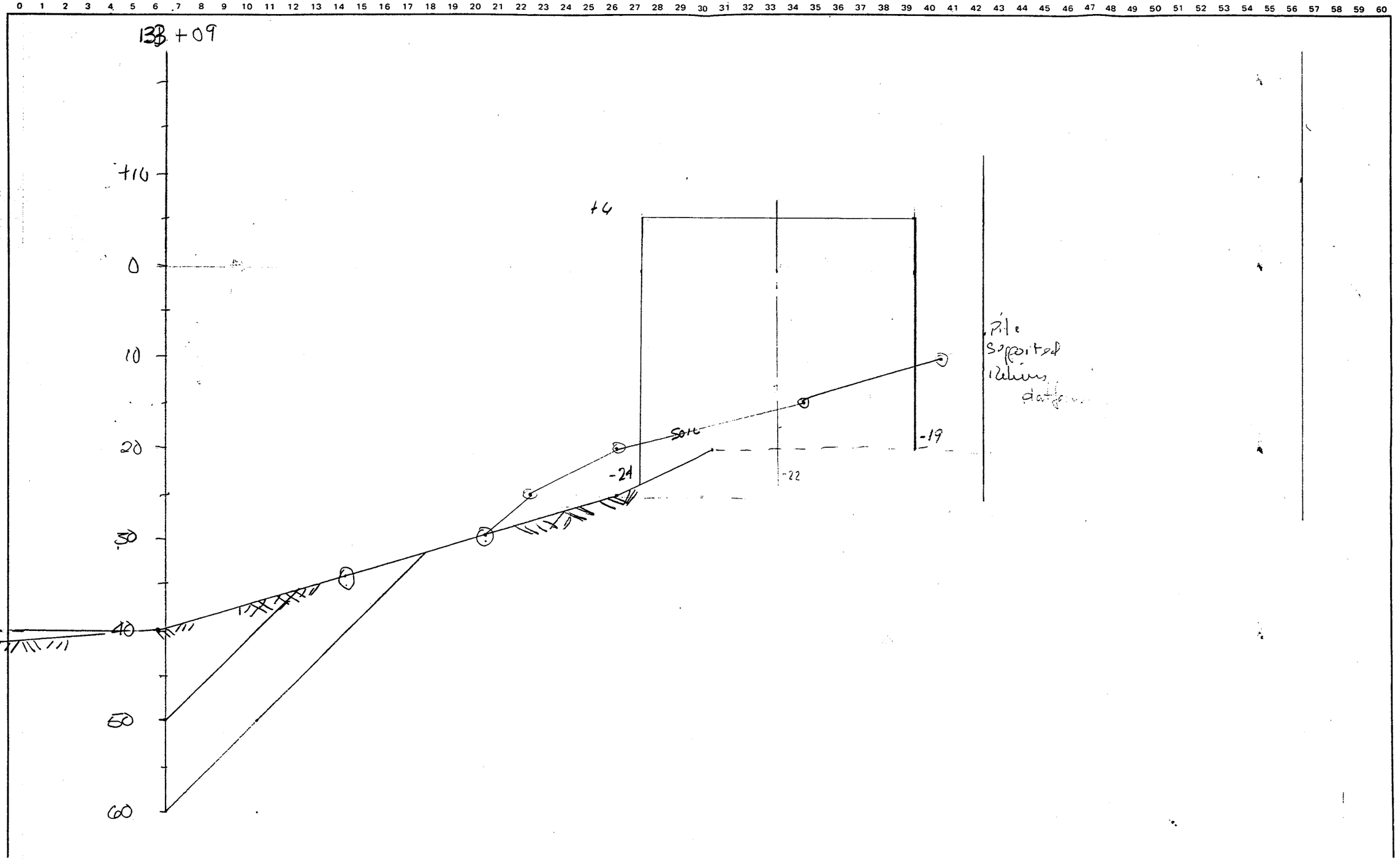
MAGUIRE GROUP

Job Bayway Isem (Coty Warehouse) Sheet No. 320

Date

By Checked Job No.

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60



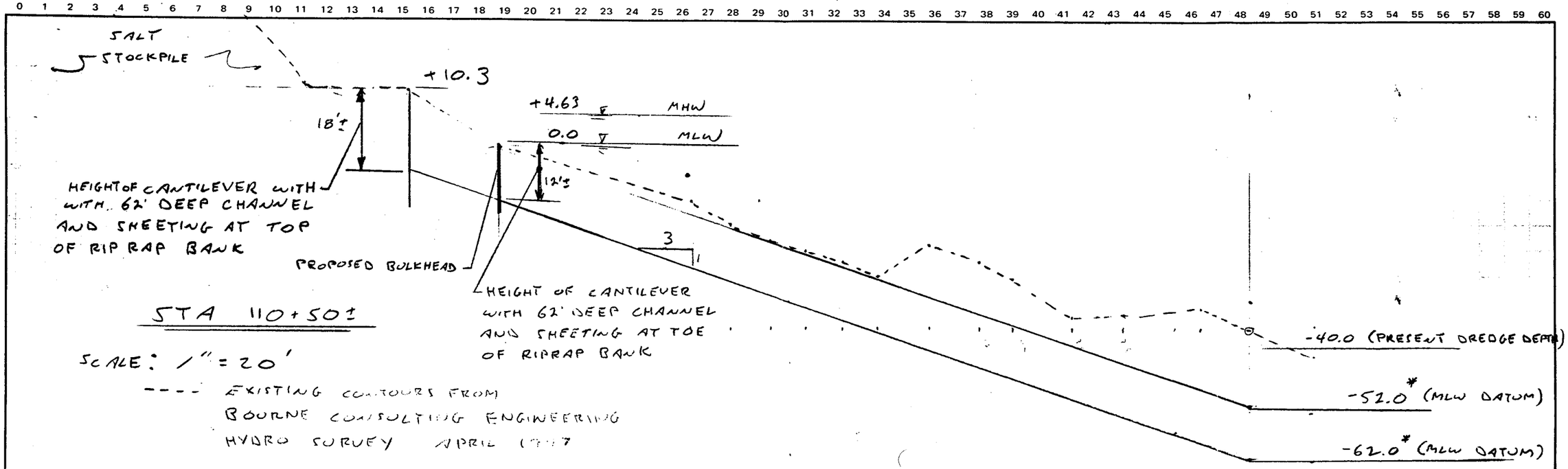
MAGUIRE GROUP

Job HARBOR NAVIGATION STUDY - PANYNJ Sheet No.

KILL VAN KULL - ATLANTIC SALT (#9) Date 6-98

By DAF Checked Job No.

Sheet No. 39



STA 110+50±

SCALE: 1" = 20'

---- EXISTING CONTOURS FROM BOURNE CONSULTING ENGINEERING HYDRO SURVEY APRIL 1997

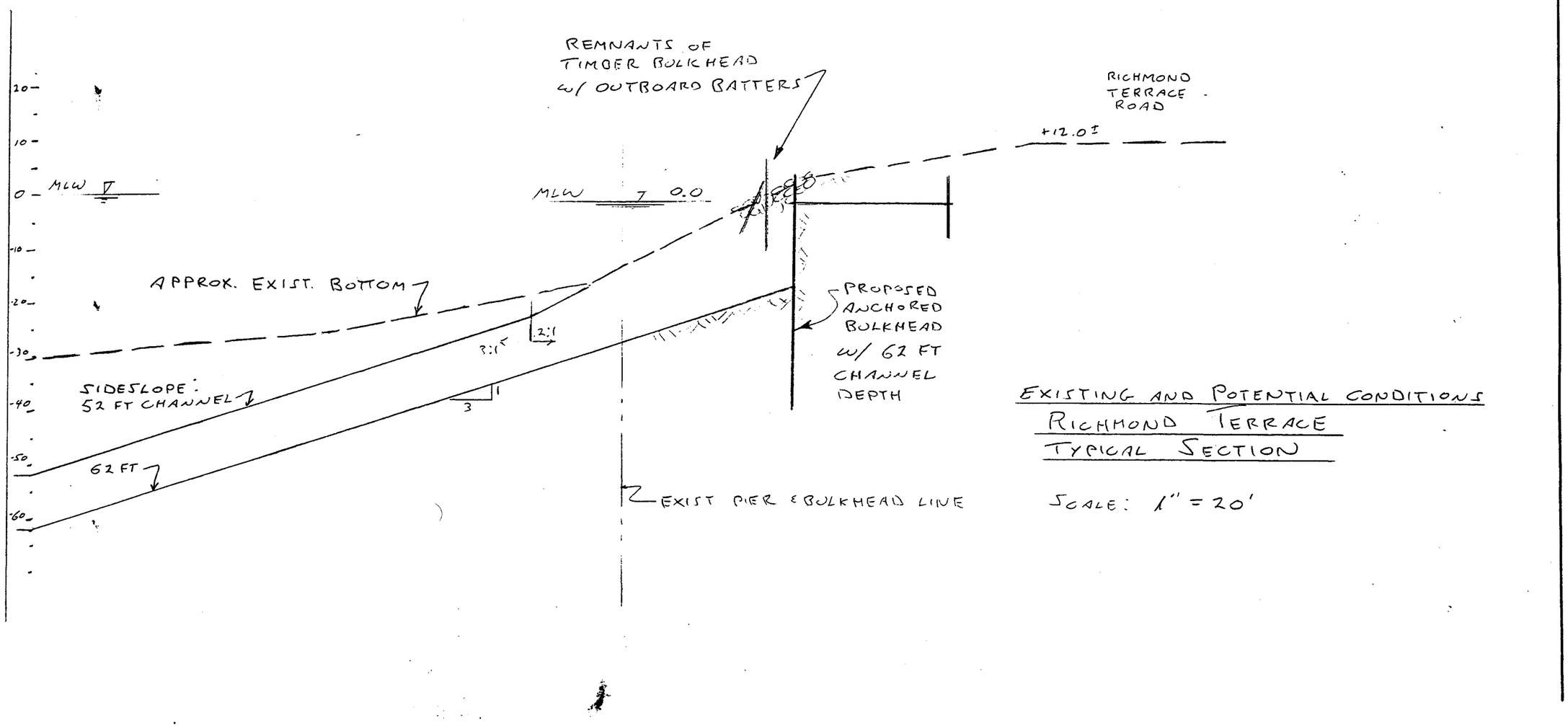
* INCLUDES 2' ALLOWABLE OVERDREDGE

MAGUIRE GROUP

Job HARBOR NAVIGATION STUDY Sheet No. _____

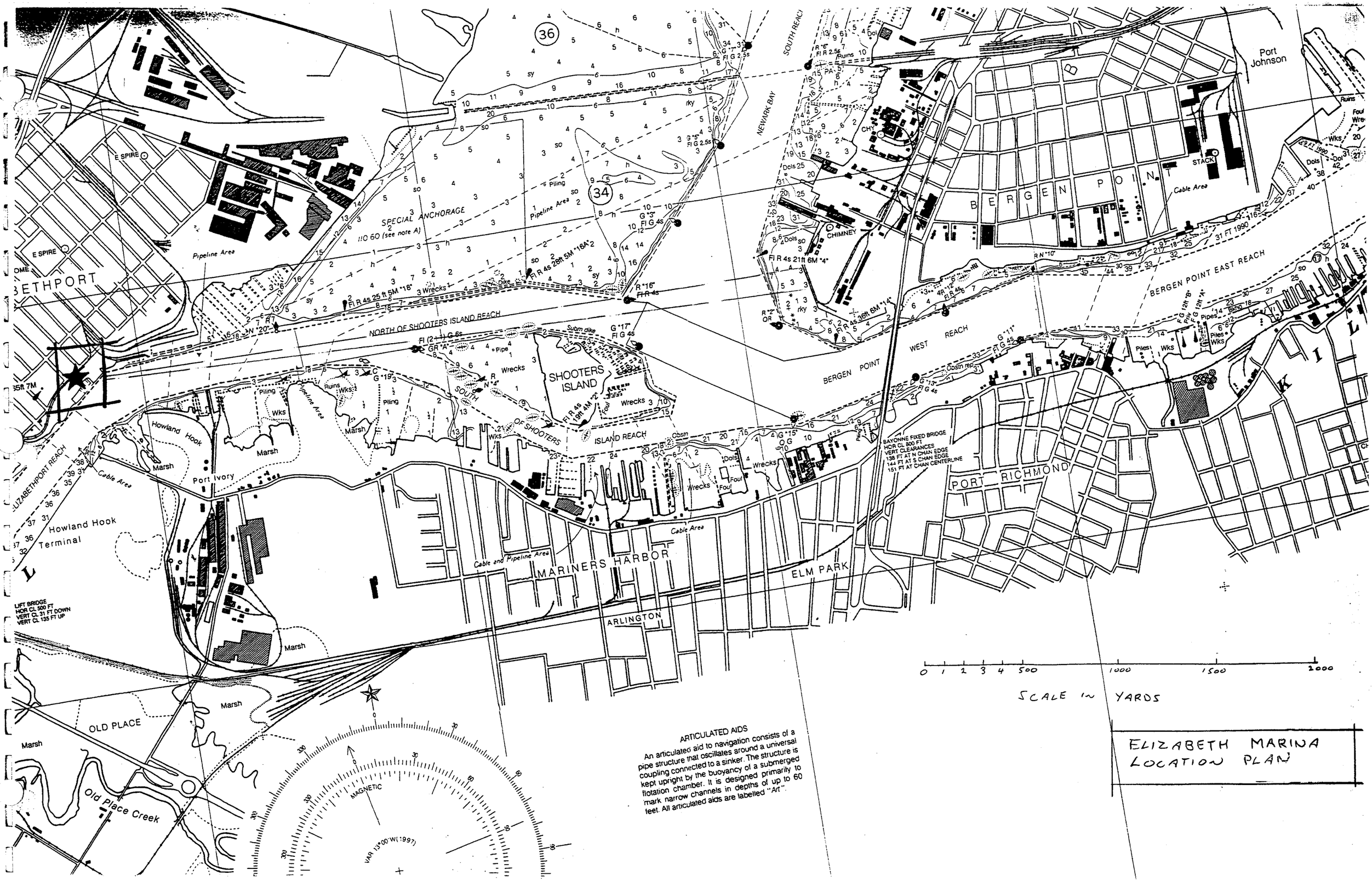
RICHMOND TERRACE - KILL VAN KULL Date 8 - 98

By DJF Checked _____ Job No. 14803



EXISTING AND POTENTIAL CONDITIONS
RICHMOND TERRACE
TYPICAL SECTION

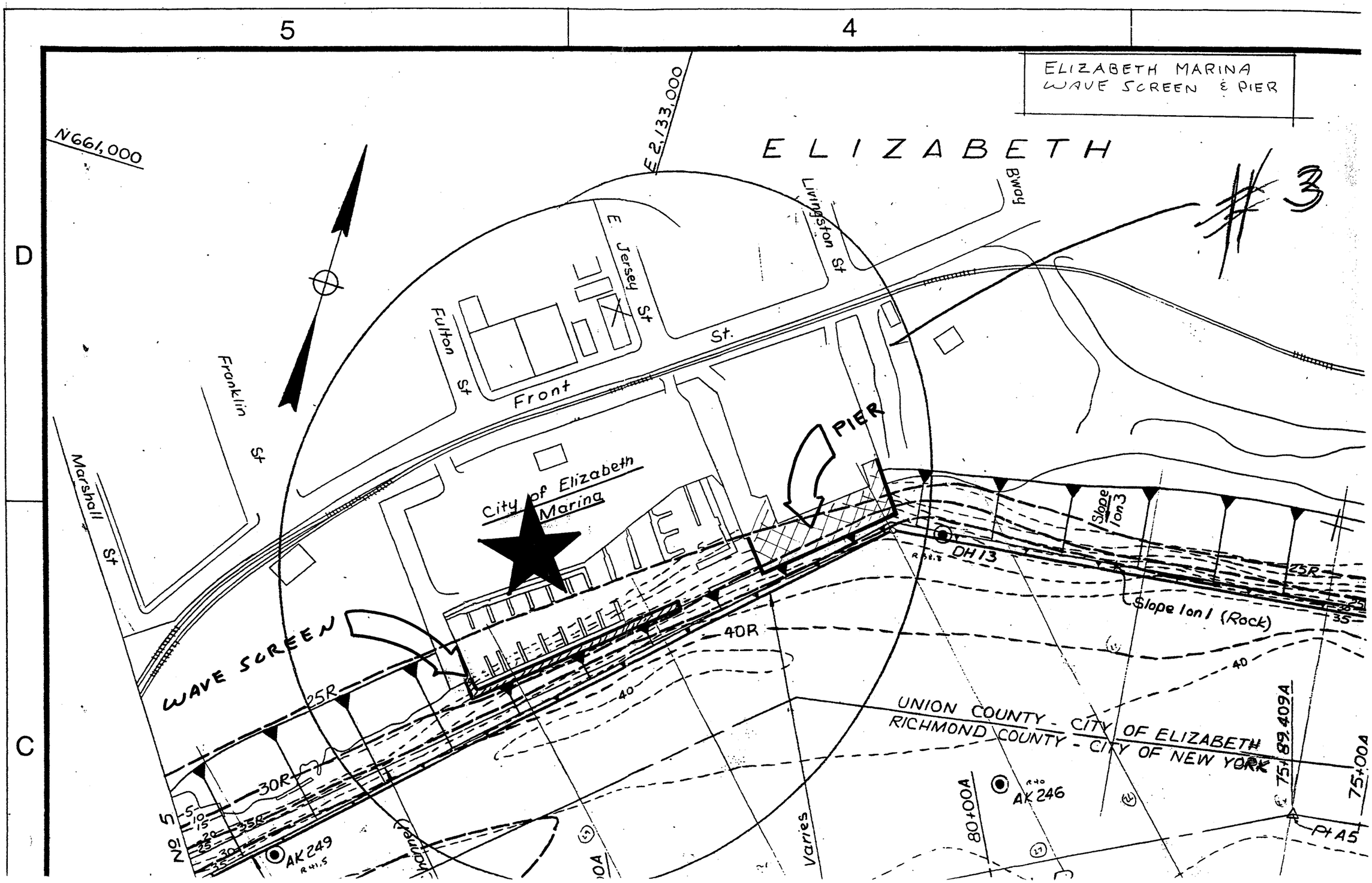
SCALE: 1" = 20'



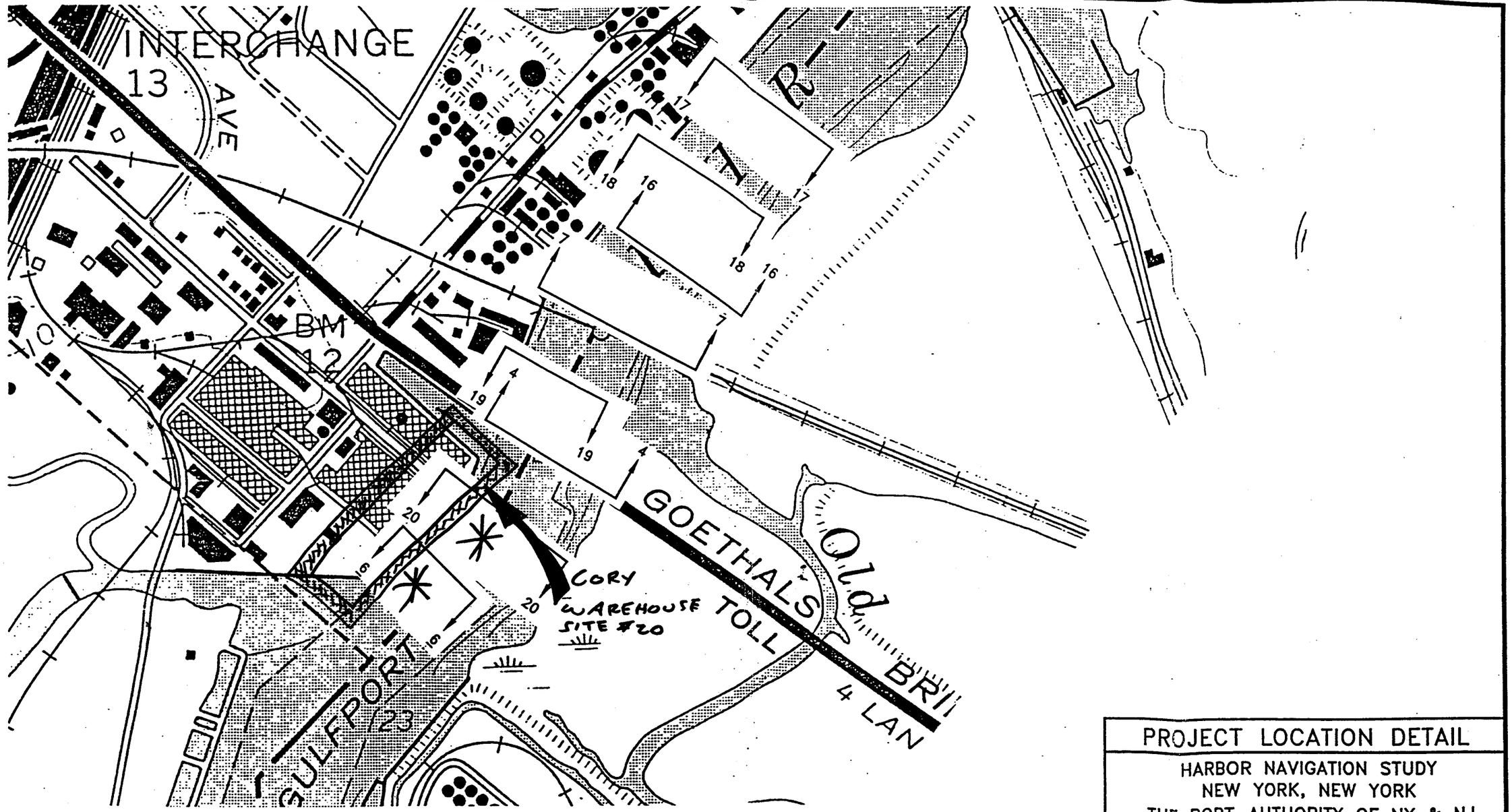
ARTICULATED AIDS

An articulated aid to navigation consists of a pipe structure that oscillates around a universal coupling connected to a sinker. The structure is kept upright by the buoyancy of a submerged flotation chamber. It is designed primarily to mark narrow channels in depths of up to 60 feet. All articulated aids are labelled "Art".

ELIZABETH MARINA LOCATION PLAN



5
4
D
C
ELIZABETH MARINA
WAVE SCREEN & PIER
ELIZABETH
#3
N661,000
E2,133,000
Bway
Livingston St
E Jersey St
Fulton St
Front St.
Franklin St
Marshall St
City of Elizabeth Marina
PIER
WAVE SCREEN
Slope 1 on 3
DH13
25R
Slope 1 on 1 (Rock)
40R
40
UNION COUNTY - CITY OF ELIZABETH
RICHMOND COUNTY - CITY OF NEW YORK
75+89.409A
75+00A
80+00A
AK 246
Pt A5
AK 249
No 5
Varies



NOTES:

1. This drawing is part of Melick–Tully and Associates, P.C. Report No. 3023–019 and should be read together with the report for complete evaluation.

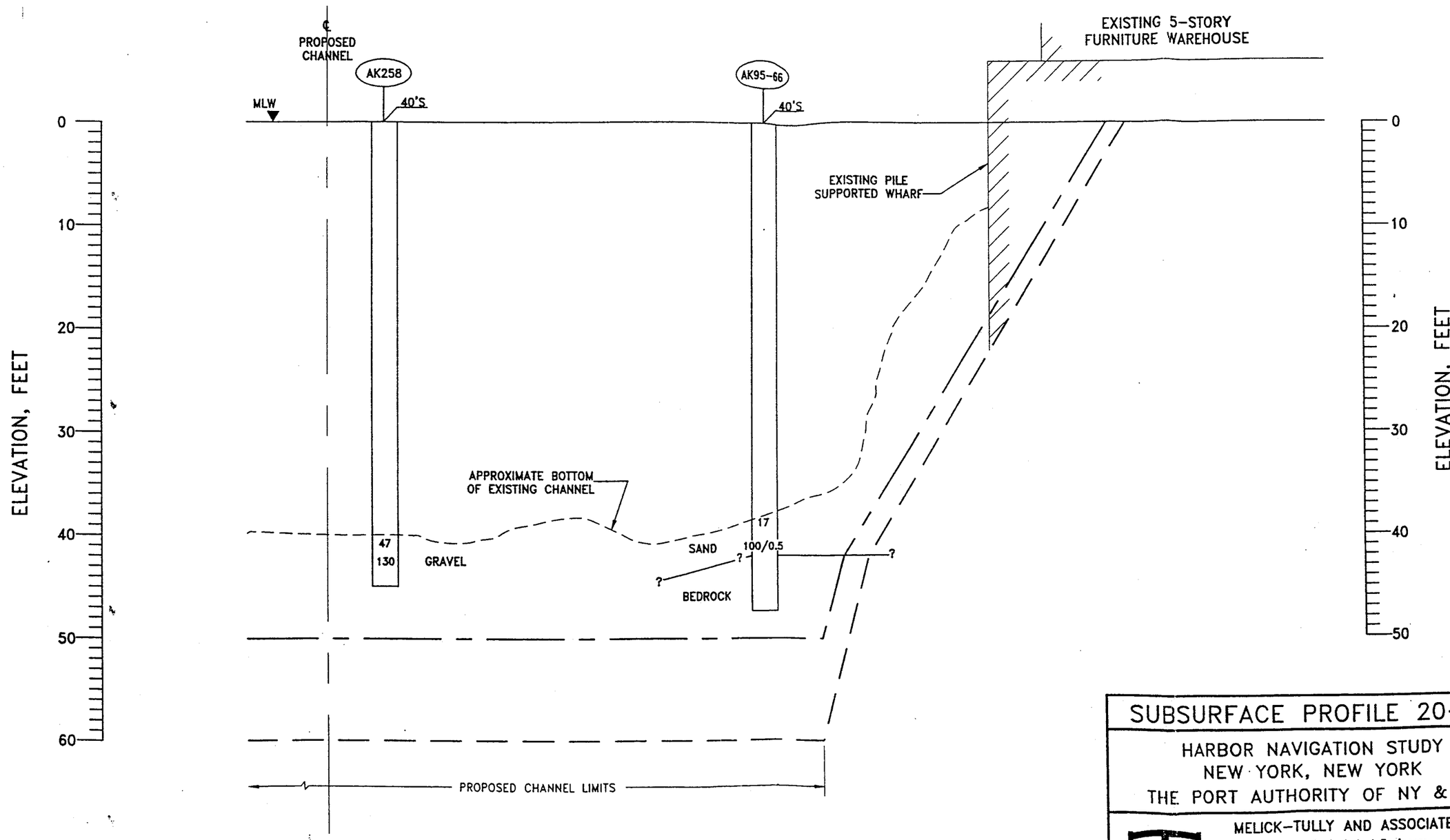
2. General layout was obtained from an USGS Quadrangle Map.

PROJECT LOCATION DETAIL

HARBOR NAVIGATION STUDY
NEW YORK, NEW YORK
THE PORT AUTHORITY OF NY & NJ

MELICK–TULLY AND ASSOCIATES, P.C.
Geotechnical Engineers
& Environmental Consultants
117 Canal Road
South Bound Brook, New Jersey 08880
(732) 356–3400

JOB NO.	FILE NO.			
3023–019	14400			
DR. BY	CHK. BY	DATE	SCALE	PLATE
DJZ	SDT	4/14/98	1"=500'	1B



NOTES:

1. Refer to plate 2A for general notes and key.

SUBSURFACE PROFILE 20-20

HARBOR NAVIGATION STUDY
NEW YORK, NEW YORK
THE PORT AUTHORITY OF NY & NJ

MELICK-TULLY AND ASSOCIATES, P.C.
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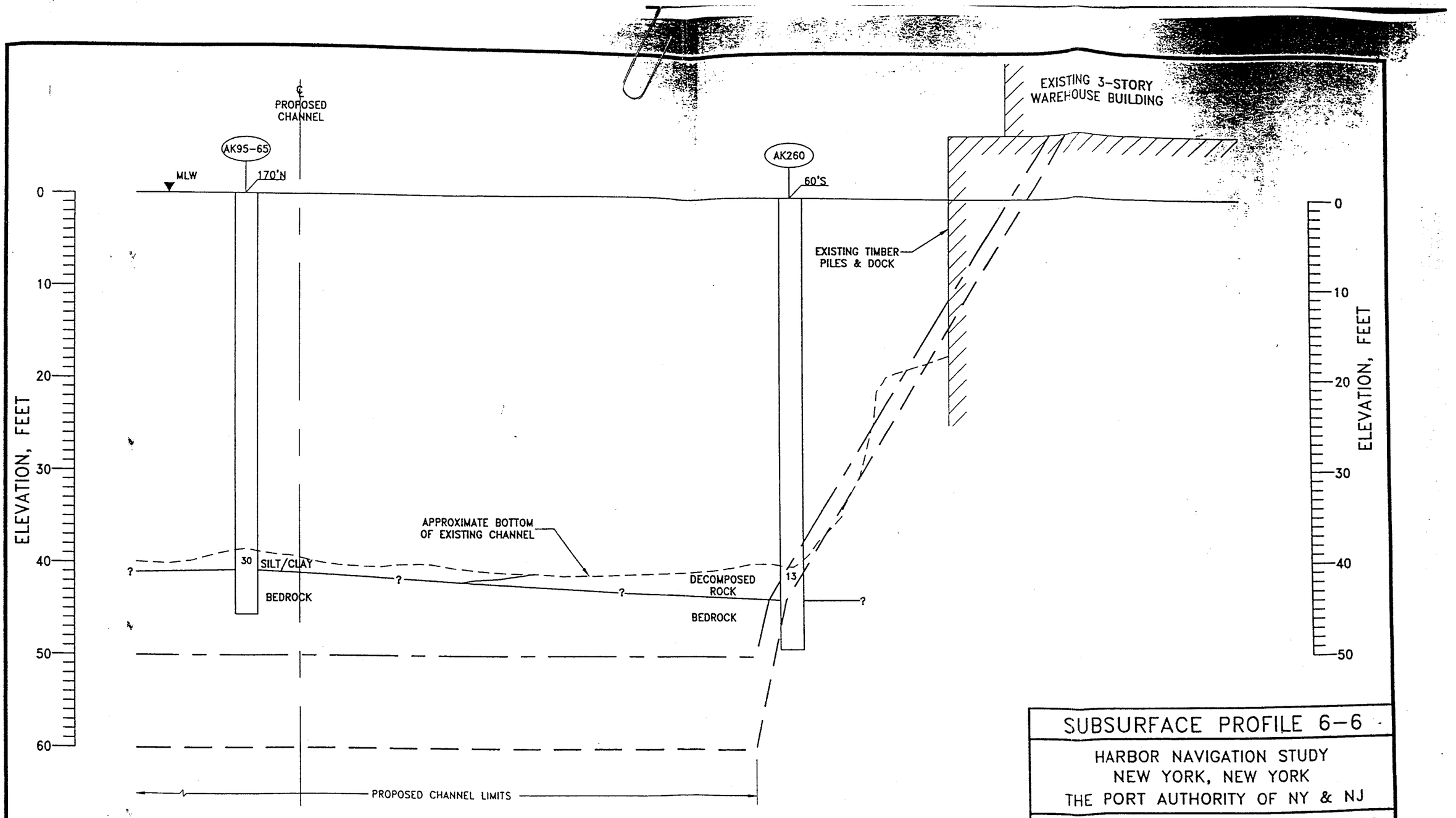
JOB NO.	FILE NO.			
3023-019	14400			
DR. BY	CHK. BY	DATE	SCALE	PLATE
JCB	SDT	4/11/98	AS SHOWN	2W



NOTES:

1. Refer to plate 2A for general notes and key.

SUBSURFACE PROFILE 6-6

HARBOR NAVIGATION STUDY
NEW YORK, NEW YORK
THE PORT AUTHORITY OF NY & NJ

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JOB NO.	FILE NO.			
3023-019	14400			
DR. BY	CHK. BY	DATE	SCALE	PLATE
JCB	SDT	4/11/98	AS SHOWN	21

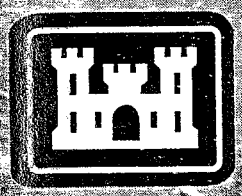
FEASIBILITY REPORT

for

New York and New Jersey Harbor Navigation Study

Appendix H
Costs

December 1999



US Army Corps
of Engineers®
New York District

NEW YORK AND NEW JERSEY HARBOR NAVIGATION STUDY

COST ENGINEERING APPENDIX

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I. INTRODUCTION

General

H1. This appendix documents the development of the estimated cost for the recommended National Economic Development (NED) Plan of the New York and New Jersey Harbor Navigation Improvement Project. In order to evaluate alternatives, channel improvements were identified and preliminary project estimates were prepared and a preliminary plan was formulated and the NED Plan was presented at the Alternatives Formulation Briefing (AFB) in July 1999. This document summarizes the estimates presented during the AFB and includes the MCACES cost estimate for the NED Plan. Detailed economic information is provided in Appendix F "Economic Analysis". The recommended plan of improvement consists of sufficiently deepening, widening, and modifying the alignment (where required) of the channels to accommodate the design vessel, a Maersk K-Class container ship with a maximum draft of 46 feet.

Table 1
Design Depth of Project Channels

Channel	Currently Authorized	Proposed Container
Ambrose	45	53
Anchorage	45	50
Kill Van Kull	45[1]	52
Newark Bay	45[1]	52
Arthur Kill to Howland Hook	41[2]	52
Bay Ridge	40	50
Port Jersey	41[3]	52

1. Channel is currently 40ft. Construction has been initiated on the 45ft channel
2. Channel is currently 35ft. Construction to 41ft has been authorized. Construction is scheduled for FY 00
3. Channel is not a Federal Channel and is not Federally maintained, but deepening of the channel has been authorized. Construction is scheduled for FY 00.

Summary of Alternate Formulation Briefing Estimates

H2. The development of the preliminary project cost estimates for the various channels was conducted utilizing the concept of pathways, wherein each pathway defines the entire ship's transit from deep water to port. In addition, the cost of each channel for its particular path was developed. This was necessary since the formulation process would depend not only upon the cost of pathway, but as subsequent economical analysis was performed, the cost of each channel would be required. Eight (8) pathways, each of which have Ambrose Channel and a portion of

Anchorage Channel in common, were proposed based upon ship destination. These paths were as follows:

- Pathway 2 - Kill Van Kull, Arthur Kill to Howland Hook
- Pathway 3 - Kill Van Kull, Arthur Kill to Gulfport
- Pathway 4 - Port Jersey Channel
- Pathway 5 - Bay Ridge Channel
- Pathway 6 - Red Hook Flats, Stapleton and Gravesend Anchorages for Containerships
- Pathway 7 - Red Hook Flats, Stapleton and Gravesend Anchorages for Tankers
- Pathway 8 – Greenville Yards at Claremont Channel

H3.Final development of the destinations was subsequently modified based upon facilities proposed in the final "Without Project" and "With Project" conditions as contained in the final AFB document.

H4.The channels considered in the alternative screening process to accommodate oil tankers and/ container ships and included in the AFB are shown below in Table 2.

Table 2 Design Depth of Project Channels			
Channel	Currently Authorized	Container	Tanker
Ambrose	45	53	61
Anchorage	45	50	60
Kill Van Kull	45[1]	52	62
Newark Bay	45[1]	52	NA
Arthur Kill to Howland Hook	41[2]	52	62
Arthur Kill to Gulfport	40[2]	NA	62
Bay Ridge	40	50	NA
Port Jersey	41[3]	52	NA
Claremont & NJ Pierhead	*	50	NA
NJ Pierhead	20	50	NA
Red Hook flats Anchorage	35-45	50	60
Gravesend Bay Anchorage	47	50	60
Stapleton Anchorage	45+	50	60

1. Channel is currently 40ft. Construction has been initiated on the 45ft channel
2. Channel is currently 35ft. Construction to 41ft has been authorized. Construction is schedule for FY 00
3. Channel is not a Federal Channel and is not Federally maintained, but deepening of the channel has been authorized. Construction is scheduled for FY 00.

Surveys and Methods

H5. The following summarizes the surveys used and describes how quantities were developed for each channel

Ambrose Channel:

H6. Quantities were based upon March to September 1998 New York District Operation Division (CENAN-OP-S) sweep surveys. A 3-D surface was created from the survey data and 1:3 side slopes were cut from the channel limits to the surface. A Triangular Irregular Network (TIN) was formed from this surface, and volumes calculated for 45, 51, 53, 55, 57, 59, 61, 63 and 65 ft.

Anchorage Channel:

H7. Quantities were based upon March to June 1998 CENAN-OP-S sweep surveys. A 3-D surface was created from the survey data and 1:3 side slopes were cut from the channel limits to the surface. A TIN was formed from this surface, and volumes calculated for 45, 48, 50, 52, 54, 58, 60, 62 and 64 ft.

Kill Van Kull:

H8. Quantities were based upon December 1996 to February 1997 CENAN-OP-S line surveys. A 3-D surface was created from the survey data. Cross sections were generated at 400 ft intervals and at changes in channel direction and size. Volumes calculated for 45, 48, 50, 52, 54, 58, 60, 62 and 64 ft.

Newark Bay, South Elizabeth and Port Elizabeth:

H9. Quantities were based upon July to September 1998 CENAN-OP-S line surveys. A 3-D surface was created from the survey data. For the rock areas cross sections were generated at 400ft intervals and at changes in channel direction and size. For the remainder of Newark Bay a TIN was created and volumes calculated. Volumes calculated for 45, 48, 50, 52 and 54 ft.

Arthur Kill Channel:

H10. Quantities were based upon April to October 1998 CENAN-OP-S sweep surveys. A 3-D surface was created from the survey data. Cross sections were generated at 400ft intervals and at changes in channel direction and size. Volumes calculated for 45, 48, 50, 52, 54, 58, 60, 62 and 64 ft.

Bay Ridge Channel:

H11. Quantities were based upon November to December 1997 CENAN-OP-S line surveys. A 3-D surface was created from the survey data and 1:3 side slopes were cut form the channel limits to the surface. A TIN was formed from this surface, and volumes calculated for 45, 48, 50, 52 and 54 ft.

Port Jersey Channel:

H12. Quantities were based upon a January 1999 Port Authority of NY and NJ survey. A 3-D surface was created from the survey data and 1:3 side slopes were cut from the channel limits to the surface. A TIN was formed from this surface, and volumes calculated for 45, 48, 50, 52 and 54 ft.

Claremont Channel:

H13. Quantities were based upon February 1997 Port Authority of NY and NJ line survey. A 3-D surface was created from the survey data and 1:3 side slopes were cut form the channel limits to the surface. A TIN was formed from this surface, and volumes calculated for 45, 48, 50, 52 and 54 ft.

NJ Pierhead Channel:

H14. Quantities were based upon February-March 1999 CENAN-OP-S sweep survey. A 3-D surface was created from the survey data and 1:3 side slopes were cut form the channel limits to the surface. A TIN was formed from this surface, and volumes calculated for 45, 48, 50, 52 and 54 ft.

Red Hook Flats Anchorage:

H15. Quantities were based upon December 1997 to March 1998 CENAN-OP-S sweep surveys. A 3-D surface was created from the survey data and 1:3 side slopes were cut form the channel limits to the surface. A TIN was formed from this surface, and volumes calculated for 45, 48, 50, 52, 54, 58, 60, 62 and 64 ft.

Gravesend Anchorage:

H16. Quantities were based upon June 1998 CENAN-OP-S line surveys. A 3-D surface was created from the survey data and 1:3 side slopes were cut form the channel limits to the surface. A TIN was formed from this surface, and volumes calculated for 45, 48, 50, 52, 54, 58, 60, 62 and 64 ft.

Stapleton Anchorage:

H17. Quantities were based upon a July 1998 CENAN-OP-S line survey. A 3-D surface was created from the survey data and 1:3 side slopes were cut form the channel limits to the surface. A TIN was formed from this surface, and volumes calculated for 45, 48, 50, 52, 54, 58, 60, 62 and 64 ft.

TABLE 3 AFB Construction Costs for Various Depths ($millions)								
Path		Maintained Channel Depth						
			48 ft	50 ft	52 ft	58 ft	60 ft	62 ft
1	KVK Newark Bay to Port Elizabeth		788	942	1,127			
2	KVK Arthur Kill to Howland Hook		844	977	1,170			
3	KVK Arthur Kill to Gulfport					1,898	2,165	2,468
4	Port Jersey Channel		244	299	355			
5	Bay Ridge Channel		230	263	310			
6	Containers to Anchorage areas		607	721	827			
7	Tankers to Anchorage areas					1,489	1,705	1,943
8	Containers to Greenville yards at Claremont Channel		347	402	446			

Summary Of NED Plan Estimates

H18. Channels included in the NED Plan, their currently authorized and proposed authorized depths were provided in Table 1. The channels and their respective improvements are listed below. For detailed information concerning channel design refer to Appendix E "Channels Design". The Kill Van Kull/Newark Bay Channel 45' plan and the Arthur Kill Channel 41' plan, which are part of the without project condition, will require the removal of utilities. The cost estimates assumes that any utilities removed as part of those projects will, if rebuilt, be located sufficiently deep such that the utilities will not require replacement under this project.

References

H19. This appendix makes use of data from the following appendices and regulations:

- Geotechnical Appendix (Dredgeability and distribution of materials found in the study area. The quantity of material unsuitable for placement in the ocean)

- Channel Design Appendix (Location and size of channels, channel depths, sedimentation rates)
- Structural Appendix (Cost of replacing or reinforcing structures impacted by the Federal Channel)
- Non-Federal costs for berthing areas and associated land side improvements provided by the Local Sponsor
- ER 1110-2-1302 "Civil Works Cost Engineering"

a) Ambrose Channel, deepened to –53 ft MLW, will remain at its present width of 2000 ft and will follow its present alignment. It will be extended 2400ft seaward along its present bearing out to deep water. Ambrose Light Tower is presently being relocated 1.5 nautical miles ESE of its present location. A large mound immediately NW of the present Ambrose Light Tower will be removed to project depth.

b) Anchorage Channel, deepened to –50 MLW, will remain at its present width of 2000 ft, but will be deepened only from the Narrows to a point 1000 ft north of the junction with Port Jersey Channel.

c) Kill Van Kull, deepened to –52 MLW, will remain at its present width of 800 ft and will follow its present alignment.

d) Newark Bay South Reach, and Elizabeth Channel, deepened to –52 MLW, will largely remain at their present width and will follow its present alignment. The one major widening will be in South Elizabeth Channel which will be widened to 500 ft. The berthing areas along the Elizabeth Port Authority Marine Terminal will be widened to 150 ft. Improvements to the Newark Bay Channel will extend 1500 ft north of the Elizabeth Channel to facilitate vessels turning and backing into Port Elizabeth.

e) The Arthur Kill will be deepened to –52 MLW from the junction with the Kill Van Kull to the western limit of the Howland Hook facility, along the alignment of the 41 ft (without project) channel. In addition, the channel will be widened to the north opposite Howland Hook back to include the limits of the 35 ft channel.

f) Port Jersey Channel, deepened to –52 MLW, will be improved to a width of 500 ft between the Global Marine Terminal and MOTBY peninsulas. The entrance flare will be 1500 ft at the junction with Anchorage Channel and taper to 500 ft at the intersection with the NJ Pierhead Channel. The wide flare of the approach channel is necessary due to the fact that vessels inbound on a flood tide will be turning broadside across the current.

g) The existing 1200ft turning basin at the head of Port Jersey Channel is inadequate for the K-class container ship, which has an overall length of 1044 ft. Widening of the existing turning basin is not a practical solution since it would require the construction of sheet pile retaining structures to stabilize existing structures. Without a turning basin, vessels must either back into or out of Port Jersey. In order to facilitate the backing maneuvers, the northern channel limit is straightened, removing a narrow portion of the New Jersey flats. Deepening

Anchorage Channel 1000 ft to the north will permit inbound vessels to bring the bow past Port Jersey Channel, and readily swing the stern around and then backing into the berth.

h) The proposed width of Bay Ridge Channel, deepened to –50 MLW, will be 600 ft, reduced from the current width of 1200 to 1750 ft. The proposed turning basin, with a diameter of 1600 ft, is located opposite the terminal, enabling vessels to back out of or into port.

II. QUANTITIES

Geologic Quantities

H20. Quantities were calculated for the NED Plan for rock, non-rock, and material unsuitable for placement at the HARS (Historic Area Remediation Site) . The material unsuitable for placement at the HARS is hereafter in this report referred to as upland material. The depths for the channels included in this project were based upon the draft of the design vessel, plus appropriate underkeel clearance as described in Appendix E, "Channel Design." This depth is known as the "design depth. Quantities were then calculated for the channels in the NED Plan to the depths identified in Table 1 with channel side slopes of 1V:3H in non-rock, and 1V:1H in rock.

H21. The NED Plan estimated quantities assume that the Ambrose, Anchorage, Bay Ridge and Port Jersey channels were deepened to their currently authorized depths as listed in Table 2. Kill Van Kull and Newark Bay are authorized to –45 ft MLW in soft material and –47 ft MLW in rock and hard materials. However, that 2 ft. of safety clearance, from –45 ft MLW to –47 ft. MLW, will not be maintained and will be allowed to shoal-in creating a soft channel bottom. Arthur Kill is currently authorized to –45 ft MLW subject to a favorable Engineer's Report. However, it is currently constructed to –35 ft MLW. For the purpose of this study Arthur Kill was assumed to be -41ft MLW and –43 ft MLW in rock, which are the depths recommended in the latest favorable report on the Arthur Kill. Again, the 2 ft. of safety clearance, from –41 ft MLW to –43 ft. MLW, will not be maintained and will be allowed to shoal-in creating a soft channel bottom. It was assumed that all the Federal channels are maintained to their current authorized depth, and any O&M material above the authorized depth will be removed independent of this project.

Non-Rock Quantities

H22. For channels where no rock was present, the total quantity was calculated by generating a 3D surface from a survey. A Triangular Irregular Network (TIN) was then generated. The quantity of material between the TIN and the desired channel depth was then calculated using the "INROADS" program.

Rock Quantities

H23. Generating quantities in channels that contain rock beneath non-rock is more complicated. The side slope changes as the rock face rises and falls. For this reason, quantities in these channels were calculated using the average end area method. Cross-sections were generated by computer at 400ft intervals and at any changes in channel direction or size. (Note that rock contours were generated from borings, and are discussed in further detail in the Geotechnical Appendix).

Material Unsuitable for the HARS Quantities

H24. Non-rock quantities must be further divided into material that is suitable for placement at the Historic Area Remediation Site (HARS), and material unsuitable for HARS placement, that is dredged material classified as upland. The upland material requires special treatment for placement in in-channel cells or at upland sites. For the purpose of this document, upland material will be placed at in-channel cells. The volume of the upland material was generated from an isopach map.

H25. An isopach map shows the thickness of a layer, in this case the layer of material requiring in-channel cell placement. Once the area of the channel is identified that contains this material and it's thickness the volume was calculated. This volume was then deducted from the total non-rock quantity.

H26. As chemical and biological testing will not be performed during this phase, the thickness of the upland material interval was estimated based on the presence of hydrocarbons, moisture content and color. The isopach map was generated from information contained on the boring logs and is discussed in further detail in the Geotechnical Appendix.

H27. As discussed above, the Kill Van Kull and the Newark Bay Channels are currently being constructed and the Arthur Kill Channel will begin construction in FY 00. These channels' bottom depth will be constructed in rock or hard material. Therefore, an additional 2 feet of deepening will be required for safety reasons. The estimate of material requiring in-channel cell placement assumes that this additional depth will be permitted to shoal-in with material unsuitable for placement at the HARS. For example, Kill Van Kull will be deepened to 45 ft in soft areas and to 47 ft in rock areas for safety reasons. However, once the rock is removed to 47 ft the bottom is effectively soft, and will therefore only be maintained to 45ft. The rock areas are therefore assumed to have accumulated 2ft of material that will require upland placement.

Pay Quantities

H28. Mechanical dredges cannot completely remove the layer of non-rock from the top of rock in an economical manner. Experience has shown that approximately one foot of material will remain on top of the rock. Therefore, geologic quantities were modified to account for this by treating the one foot of the material that will remain on top of the rock as if it were rock. Therefore, the pay quantity of non-rock will be less than the geologic quantity of non-rock while the pay quantity of rock will be greater than geologic quantity of rock.

Table 4 Pay Quantities (CY)			
Channel	Non-HARS Material	HARS Material	Rock Material
Ambrose	0	8,817,000	0
Anchorage	716,700	2,050,300	0
Kill Van Kull	2,142,000	2,885,300	2,275,600
Newark Bay	2,356,000	4,824,600	892,500
Arthur Kill to Howland Hook	789,000	390,300	2,633,900
Bay Ridge	1,853,600	2,146,400	0
Port Jersey	311,000	3,211,000	0

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III. ASSUMPTIONS

H29. The assumptions used in developing the NED Plan cost estimate have been broken down into the following areas of consideration: environmental, operational, placement, and equipment.

Environmental Considerations

H30. The following environmental assumptions are used in developing the construction cost estimate.

Table 5

Environmental Window Prohibiting Dredging

Channel	From	To
Ambrose	N/A	N/A
Anchorage	N/A	N/A
Kill Van Kull*	Mar 1	Sep 1
Newark Bay	N/A	N/A
Arthur Kill to Howland Hook*	Mar 1	Sep 1
Bay Ridge	N/A	N/A
Port Jersey	N/A	N/A

* The environmental window applies only to the 1000' of channel near Shooters Island.

- In recognition of possible restrictions in State water quality certificates, a no barge overflow condition was assumed when removing material unsuitable for placement at the HARS (upland material).
- Turbidity will be controlled using methods similar to that used in Kill Van Kull Phase I project. The use of all types of dredges will be permitted.
- No regulatory compliance testing will be required during construction for material that is unsuitable for placement at the HARS(upland material).
- There are no restrictions on the transport or handling of dredged material that is unsuitable for placement at the HARS(upland material).

Operational Considerations

H31. The following operational considerations were used in developing the construction cost estimates.

- Mobilization and demobilization were based on the equipment identified below being used for the removal of clean non-rock, material unsuitable for placement at the HARS and rock. It was assumed that 2 calendar months would be required for mobilization and 1 calendar month would be required for demobilization.
- Drilling and blasting operations will be 12 hours per day operating 6 days a week.
- Dredging operations will be 24 hours per day operating 7 days a week.
- A sealed dredging bucket will be used where practicable for the removal of upland material. Hoist speed will be limited to 2 ft/second when dredging upland material (unsuitable for HARS placement) with a sealed bucket.
- Up to1 foot of non rock and upland material (material unsuitable for placement at the HARS) will remain on underlying material.
- Inspections will be required for placement of material at the HARS.

Placement Considerations

H32. The following placement considerations were used in developing the construction cost estimates.

- It is assumed the rock material will be placed at the Sandy Hook and Atlantic Beach Artificial Reefs, which are approximately 25 miles one way.
- It is assumed that clean non-rock material will be utilized for remediation material and will be placed at the HARS. Restrictions based on material characterization, will not apply to this placement at the HARS. The distance to the HARS is approximately 25 miles one way.
- Reference is made to the following: 17 March 99 letter from the Local Sponsor stating that the placement site for upland material (which is unsuitable for placement at the HARS) shall be at in-channel cells located in the lower bay and 25 August 1999 letter from the local sponsor identifying specific dredged material disposal options.

Equipment Considerations

H33. Applicability of available equipment was evaluated. The following summarizes the applicability of equipment and the assumed use of the equipment for this project:

Hopper Dredge - The environmental restriction on barge overflow of upland material (material unsuitable for placement at the HARS), limits the applicability of the hopper dredge for the channels identified in the NED Plan. However, the one exception is Ambrose Channel, which does not contain upland material. The dredged material of Ambrose Channel

is comprised predominantly of clean sand and silty sand. For the purposes of preparing the construction cost estimate a Hopper dredge will be used for Ambrose Channel.

Cutterhead Dredge – Cutterhead dredges have traditionally been environmentally restricted due to turbidity concerns. Two channel contained in the NED Plan could possibly use a Cutterhead dredge, Port Jersey and Kill Van Kull respectively. Within those channels there are areas with dense sand and glacial till. However, because of the turbidity concerns raised in the past, a Cutterhead dredge was not used in the development of the construction cost estimate.

Clamshell Dredge – Clamshell dredges were used extensively during KVK I, by the Port Authority of New York and New Jersey (PANY&NJ) for the Newark Bay Confined Placement Facility and limited dredging of the Port Jersey channel and for O&M dredging. After reviewing the production records from these projects it was concluded that clamshell dredges could be used efficiently in sand, clay, silt, and blasted rock. A sealed clamshell was considered applicable for dredging soft material unsuitable for placement at the HARS and was used in the development of the construction cost estimate for all the channels that contain upland material. In addition, the construction cost estimate utilizes the clamshell dredge for the removal of loose to dense sands, clays and silts for Anchorage, Arthur Kill, Newark Bay and Bay Ridge Channels.

Excavator Dredge – We have reviewed dredging records for the PANYNJ's deepening of the Port Jersey Channel. An Excavator dredge was brought in to remove dense to very dense sand and glacial till that a clamshell dredge was unable not remove. The construction cost estimate utilizes an Excavator dredge for dredging dense to very dense sands, glacial till and blasted rock for Arthur Kill, Kill Van Kull, Newark Bay and Port Jersey Channels.

Dredging Plant Requirements

H34. The dredge type and associated equipment for dredging the various types of material is as follows:

Material Unsuitable for Placement at the HARS (upland material)

- (1) 21 CY Clamshell
- (1) tug boat
- (1) launch
- (4) dump scows

Non-Rock Material (All channels except Ambrose Channel)

- (1) 14 CY Clamshell or (1) 7 CY Excavator (depending upon stiffness)
- (1) tug boat
- (1) launch

- (2) dump scows

Non-Rock Material (Ambrose Channel)

- (2) 3000 CY Hopper per contract
- (1) tug boat
- (1) launch

Rock Material

- (1) 10 CY Excavator Dredge
- (1) tug boat
- (1) launch
- (1) survey tug
- (2) dump scows
- (2) drill boats/contract

Production Rates

H35. Production rates for the dredges varies and depends upon the type of material to be dredged (loose sand, dense sand, soft clay, stiff clay, etc), environmental restrictions, (barge overflow, hoist speed, etc), bucket size, pay face, and cycle time. The production rates were developed using the factors identified above and the Corps of Engineers Dredge Estimating Program (CEDEP). The following table summarizes the production rates used in developing the construction cost estimate

Table 6 Production Rates CY/Month			
Dredge Type	Non-HARS Placement	HARS Placement	Artificial Reef Placement
Sealed Clamshell	181,000 to 230,000		
Hopper		155,000	
Clamshell		46,000 to 170,000	
Excavator		55,000 to 70,000	95,000 to 120,000
Drill/Blast per Barge			353 VLF/day

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IV. COST ESTIMATES

Definitions

H36. Project first cost estimate - Project cost is based on constant dollars. The constant dollar cost estimate is used in project authorizations.

H37. Fully funded cost estimate – Project first cost is based on projected inflation rates. The fully funded estimate is used for appropriation purposes.

H38. Background. The project first cost estimate represents the development of the estimated cost of the project at constant dollars. This is the base cost of the project. However, this cost does not properly represent the actual appropriations needed by the Federal government and Non-Federal sponsor to account for inflation over the period of construction. Cost-sharing partners need to budget to cover the fully funded cost of the project. The fully funded cost is obtained by inflating the project first cost to the mid point of construction using the current inflation factors given in the annual Fiscal Year budget regulation, EC 11-2-177, "Annual Program and Budget Request for Civil Works Activities Corps of Engineers, Fiscal Year 2001," issued each spring. Tables 7, 8 and 9 summarize the project's first cost, the project's annualized first cost and the project's fully funded cost.

Unit Prices

Rock and Non-Rock dredging

H39. The unit prices were developed using the Corps of Engineers Dredge Estimating Program (CEDEP). The unit cost is not directly proportional to each uniform depth increment as can be seen in the estimates included in the AFB report. The CEDEP uses the following inputs:

- The dredgeability and area of the material (from the Geotechnical investigation)
- The volume of the material (discussed earlier in this document)
- Cycle time increases by 2 seconds per foot of dredge depth increment
- Productivity is affected by the ratio of bank height to bucket depth (bank factor) which maximizes when bank height is equal to or greater than bucket depth.
- Operational costs and ownership costs (determined from other dredging projects constructed in NY and other similar areas)
- Operating time, distance to placement , and other similar factors (quantified from the underlying assumptions discussed earlier in this document)

Drilling and Blasting

H40. The cost of drilling and blasting rock was based upon the Corps' experience with rock removal in the Kill Van Kull Phase I project.

Tipping fees

- Material to be placed in the ocean (rock and non-rock material suitable for HARS remediation) do not have a tipping fee in accordance with the DMMP.
- As provided by the Local Sponsor the tipping fee for non-rock material unsuitable for placement at the HARS is $29/cyd. It is our understanding that the local sponsor will continue to pursue the use of upland sites for the placement of dredged material. The local sponsor reserves the right to substitute any sites that may later prove to be more environmentally acceptable, or cost effective, or both. Any costs incurred in excess of the NED unit cost of dredged material as a result of the use of upland sites will be borne by the local sponsor.

Dredging Costs

H41. The cost of excavating the improved channel is based upon the volume of rock, non-rock, and material unsuitable for placement at the HARS and their unit prices. Also included is the cost of mobilizing/demobilizing the equipment and contingencies.

Structural Costs

H42. Federal Costs were included to mitigate the impact to structures due to the deepening of the Federal Channel, and are identified in the Structural Appendix. The cost of mitigating impacts to structures due to berthing area improvements are a non-Federal cost, and were provided by the Local Sponsor.

Mitigation Costs

H43. Mitigation costs were developed by identifying the environmental impacts of each channel's deepening.

H44. Rock material will be placed at artificial reefs. Suitable non-rock material will be placed at the HARS. The remaining material shall be placed in in-channel cells located in the lower bay provided by the Local Sponsor. This alternative will not require real estate acquisition. However, real estate is required for structural improvements and will be included as a Non-Federal Costs.

Non-Federal Costs

H45. Non-Federal costs include berth dredging, structural reinforcement of berths, utility relocations, construction of new facilities and other project costs that are the sole responsibility of the Local Sponsor. The Local Sponsors for this project are the State of New Jersey, the State of New York and the Port Authority of NY and NJ (PANY&NJ). The costs were provided by the PANYNJ who are acting on behalf of the 3 sponsors.

Table 7 First Cost Estimate ($M) General Navigation Features – Cost shared Items			
	Contract Cost	Contingency Cost	Total Cost
Ambrose	114,316	17,147	131,463
Anchorage	78,522	12,818	91,340
Kill Van Kull	431,479	68,030	499,509
Newark Bay	230,376	42,364	272,740
Arthur Kill to Howland Hook	249,068	47,925	296,993
Port Jersey	80,203	12,635	92,838
Bay Ridge	89,722	16,151	105,873
SUBTOTAL	1,273,686	217,070	1,490,756
Account 01	1,700	255	1955
Account 30	41,150	6,173	47,323
Account 31	92,055	13,808	105,863
Total Federal Cost-shared	1,408,591	237306	1,645,897
Newark Bay Channel	53,628	8,044	61,672
Arthur Kill to Howland Hook	14,573	2,186	16,758
Port Jersey Channel	14,625	2,194	16,819
Bay Ridge Channel	3,850	578	4,428
Anchorage Channel	31,010	4,652	35,662
Total Non Federal Cost	117,685	17,653	135,338

Table 8 Annualized Total Investment Cost ($K)			
	Federal Cost	Non-Federal Cost	Total Cost
Ambrose			
Annualized First Cost	11,233	0	11,233
Interest During Construction, Total	14,025	0	14,025
Annualized First Cost – O&M	0	0	0
TOTAL ANNUAL COST	11,233	0	11,233
No O & M cost due to sand mining in Ambrose Ch			
Anchorage			
Annualized First Cost	7,860	2,543	10,403
Interest During Construction, Total	7,882	0	7,882
Annualized First Cost – O&M	0	0	0
TOTAL ANNUAL COST	7,860	2,543	10,403
Kill Van Kull			
Annualized First Cost	54,465	0	54,465
Interest During Construction, Total	211,253	0	211,253
Annualized First Cost – O&M	454	0	454
TOTAL ANNUAL COST	54,919	0	54,919
Newark Bay			
Annualized First Cost	28,329	4,538	32,867
Interest During Construction, Total	99,851	1,962	101,813
Annualized First Cost – O&M	4,781	0	4,781
TOTAL ANNUAL COST	33,110	4,538	37,648

Note: Total annualized cost includes IDC, 01, 30, & 31

Table 8 (Continued) Annualized Total Investment Cost ($K)			
	Federal Cost	Non-Federal Cost	Total Cost
Arthur Kill to Howland Hook			
Annualized First Cost	32,376	1,237	33,613
Interest During Construction, Total	125,123	588	125,711
Annualized First Cost – O&M	(379)	0	(379)
TOTAL ANNUAL COST	31,997	1,237	33,234
Bay Ridge			
Annualized First Cost	9,547	327	9,874
Interest During Construction, Total	16,068	155	16,223
Annualized First Cost – O&M	(225)	0	(225)
TOTAL ANNUAL COST	9,322	327	9,649
Port Jersey			
Annualized First Cost	8,797	1,242	10,039
Interest During Construction, Total	19,736	590	20,326
Annualized First Cost – O&M	(1,232)	0	(1,232)
TOTAL ANNUAL COST	7,565	1,242	8,807
TOTAL PROJECT ANNUAL COST	156,008	9,887	165,895

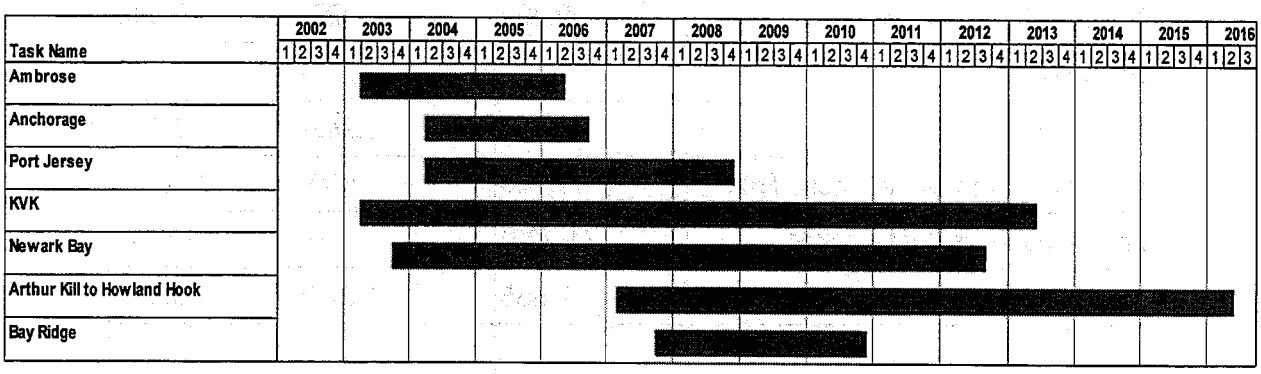
Note: Total annualized cost includes IDC, 01, 30, & 31

Construction Execution and Schedule

H46. Each channel was divided into multiple contracts. Taking into consideration bonding limitations and to maximize competition, contracts are generally between $40 and $80 million. All contracts will be from the without project condition depth to the improved depth, with the contractor responsible for removing all material (silt, sand, clay, rock, etc) within the pay prism. It is assumed that any material above the without project condition depth will have been removed as part of Operations and Maintenance (O&M).

H47. A preliminary construction schedule was developed for the Recommended Plan and is presented below. It is a planning level schedule, used only to provide an assessment of interest during construction (IDC), economic feasibility and cumulative environmental effects, to ensure that the plan will be viable for Congress to authorize it for construction.

H48. The schedule is based on information available to date, predicated on the assumptions listed below. The New York District is working diligently with the Port Authority of New York and New Jersey, to share additional information to refine the schedule. The goals of expediting construction to enable the project to accrue national economic benefits as soon as possible and to satisfy the non-Federal partners' desire for early construction of the overall project, including a fifty foot channel to Port Newark and Elizabeth by the year 2009, is being pursued as a high priority.



H49. The schedule is based upon currently available data and the following assumptions:

- PED phase will be initiated 2nd quarter of FY 00;
- There may be as many as four blast barges working at one time, with a maximum of two per contract;
- There may be as many as three excavators working at one time, with a maximum of one per contract;
- There may be as many as six clamshells working at one time, with a maximum of three per contract;3
- There may be as many as two large (>6,000 CY) hopper dredges, or four medium (4,000-6,000 CY) hopper dredges working at once. There is a maximum of one large or two medium hopper dredges per contract;

- Environmental windows consist only of dredging being prohibited within 1,000 ft of Shooters Island from 1 March to 1 September;
- Adjoining rock contracts will not be dredged at the same time;
- No regulatory compliance testing will be required during construction for material which is unsuitable for placement at the HARS;
- Disposal of material unsuitable for HARS placement will be restricted to no barge. Overflow, use of a sealed bucket where possible, and will be disposed at an in-channel cell;
- No placement restrictions/constraints for material disposed at the HARS;
- Rock material will be disposed of at the Atlantic Beach artificial reef in NY and the Sandy Hook artificial reef in NJ;
- Utility relocations will not impact the schedule

H50. The project schedule will be refined during the PED phase. Upon completion of the ship simulations models and coordination meetings with the pilots and the United States Coast Guard navigational safety concerns will be addressed and the construction sequencing will be revised as required.

* * * TOTAL FEDERAL COST-SHARED SUMMARIES * * *

This Estimate is based on the scope contained in the Feasibility Report dated Sep 1999

Project: NY/NJ Harbor Deepening
Location: New York/New Jersey

District: New York
POC:

Acct. No.	Feature Description	Current MCACES Estimate Prepared: Sep 1999 Effective Pricing Level: Oct 1999 Cost ($K)	Cont. ($K)	Cont (%)	Total ($K)	Authorize/Budget Year: Effective Pricing Level: Cost ($K)	Cont. ($K)	Total ($K)	.....Fully Funded Estimate..... Feature Midpoint	OMB (%)	Cont ($K)	Contr Cost ($K)	Total ($K)
12---	Navigation Ports & Harbors												
	Ambrose Channel	114,315.8	17,147.4	15%	131,463.2				Jun ' 04	21.0%	20,748.4	138,322.1	159,070.5
	Anchorage Channel	78,522.1	12,817.5	16%	91,339.6				Mar ' 05	23.5%	15,829.6	96,974.8	112,804.4
	Kill Van Kull Channel	431,478.6	68,030.2	16%	499,508.8				Jun ' 08	37.0%	93,201.4	591,125.7	684,327.1
	Newark Bay Channel	230,376.4	42,363.5	18%	272,739.9				Dec ' 08	35.0%	57,190.7	311,008.1	368,198.9
	Arthur Kill Channel	249,068.0	47,925.3	19%	296,993.3				Mar '11	50.0%	71,888.0	373,602.0	445,490.0
	Port Jersey Channel	80,202.5	12,635.8	16%	92,838.3				Mar '06	27.5%	16,110.6	102,258.2	118,368.8
	Bay Ridge Channel	89,722.1	16,150.5	18%	105,872.6				Jun '09	42.0%	22,933.7	127,405.4	150,339.1
	Total	1,273,685.5	217,070.2		1,490,755.7						297,902.4	1,740,696.3	2,038,598.7
01---	Lands & Damages	1,700.0	255.0	15%	1,955.0								
30---	Engineering & Design	41,150.0	6,172.5	15%	47,322.5								
31---	Construction Management	92,055.0	13,808.3	15%	105,863.3								
	Total Federal Cost Summary	1,408,590.5	237,306.0		1,645,896.5						297,902.4	1,740,696.3	2,038,598.7

Note: Inflation was developed using EC11-2-177 dtd 31 Mar 1999

Total Federal Costs:	1,121,229.3
Total Non-Federal Costs	917,369.4

NY/NJ Harbor Deepening

Designed By: USACOE NYD Engg Divn
Estimated By: P. Harimohan

Prepared By: P. Harimohan
Checked by: John Chew,PE

Preparation Date: 09/01/99
Effective Date of Pricing: 09/01/99

Sales Tax: 0.00%

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** PROJECT OWNER SUMMARY - Contract (Rounded to 100's) **

		QUANTY	UOM	CONTRACT COST	CONTINGN	ESCALATN	TOTAL COST	UNIT
12	Federal Cost Share Plan			1,408,590,600	237,305,900	0	1,645,896,500	
20	Non Federal Cost			117,685,000	17,652,800	0	135,337,800	
TOTAL NY/NJ Harbor Deepening				1,526,275,600	254,958,700	0	1,781,234,200	

		QUANTY	UOM	CONTRACT COST	CONTINGN	ESCALATN	TOTAL COST	UNIT
12	Federal Cost Share Plan							
12.01	Ambrose Channel	8817000	CY	114,315,800	17,147,400	0	131,463,200	14.91
12.02	Anchorage Channel	2767000	CY	78,522,100	12,817,500	0	91,339,600	33.01
12.03	Kill Van Kull Channel	7303000	CY	431,478,600	68,030,200	0	499,508,800	68.40
12.04	Newark Bay Channel	8073000	CY	230,376,400	42,363,500	0	272,739,900	33.78
12.05	Arthur Kill to Howland Hook	3813000	CY	249,068,000	47,925,300	0	296,993,300	77.89
12.06	Port Jersey Channel	3522000	CY	80,202,500	12,635,800	0	92,838,300	26.36
12.07	Bay Ridge Channel	4000000	CY	89,722,100	16,150,500	0	105,872,700	26.47
12.20	Owner Costs (E & D and S & A)			134,905,000	20,235,800	0	155,140,800	
TOTAL	Federal Cost Share Plan			1,408,590,600	237,305,900	0	1,645,896,500	
20	Non Federal Cost							
20.10	Newark Bay Channel			53,627,500	8,044,100	0	61,671,600	
20.15	Arthur Kill to Howland Hook			14,572,500	2,185,900	0	16,758,400	
20.20	Port Jersey Channel			14,625,000	2,193,800	0	16,818,800	
20.25	Bayridge Channel			3,850,000	577,500	0	4,427,500	
20.30	Anchorage Channel			31,010,000	4,651,500	0	35,661,500	
TOTAL	Non Federal Cost			117,685,000	17,652,800	0	135,337,800	
TOTAL	NY/NJ Harbor Deepening			1,526,275,600	254,958,700	0	1,781,234,200	

	QUANTY	UOM	CONTRACT COST	CONTINGN	ESCALATN	TOTAL COST	UNIT
12 Federal Cost Share Plan							
12.01 Ambrose Channel							
12.01.01 Mob, Demob & Preparatory Work			6,836,600	1,025,500	0	7,862,100	
12.01.17 Hopper Dredging	8817000	CY	107,479,200	16,121,900	0	123,601,100	14.02
TOTAL Ambrose Channel	8817000	CY	114,315,800	17,147,400	0	131,463,200	14.91
12.02 Anchorage Channel							
12.02.01 Mob, Demob & Preparatory Work			6,183,000	927,500	0	7,110,500	
12.02.15 Mechanical Dredging	2766969	CY	51,554,600	7,733,200	0	59,287,800	21.43
12.02.20 Contaminated material disposal	717706	CY	20,784,500	4,156,900	0	24,941,400	34.75
TOTAL Anchorage Channel	2767000	CY	78,522,100	12,817,500	0	91,339,600	33.01
12.03 Kill Van Kull Channel							
12.03.01 Mob, Demob & Preparatory Work			35,013,600	5,252,000	0	40,265,600	
12.03.15 Mechanical Dredging Non-Rock	5027371	CY	105,623,600	15,843,500	0	121,467,200	24.16
12.03.16 Mechanical Dredging Rock	2275629	CY	224,672,900	33,700,900	0	258,373,800	113.54
12.03.20 Contaminated material disposal	2142034	CY	62,119,000	12,423,800	0	74,542,800	34.80
12.03.99 Associated General Items			4,049,500	809,900	0	4,859,400	
TOTAL Kill Van Kull Channel	7303000	CY	431,478,600	68,030,200	0	499,508,800	68.40
12.04 Newark Bay Channel							
12.04.01 Mob, Demob & Preparatory Work			18,933,800	2,840,100	0	21,773,900	
12.04.15 Mechanical Dredging Non-Rock	7180516	CY	55,302,700	8,295,400	0	63,598,100	8.86
12.04.16 Mechanical Dredging Rock	892484	CY	87,766,900	17,553,400	0	105,320,300	118.01
12.04.20 Contaminated material disposal	2355966	CY	68,323,000	13,664,600	0	81,987,600	34.80
12.04.99 Associated General Items			50,000	10,000	0	60,000	
TOTAL Newark Bay Channel	8073000	CY	230,376,400	42,363,500	0	272,739,900	33.78
12.05 Arthur Kill to Howland Hook							
12.05.01 Mob, Demob & Preparatory Work			30,577,300	4,586,600	0	35,163,900	
12.05.15 Mechanical Dredging Non-Rock	1179165	CY	7,189,100	1,078,400	0	8,267,400	7.01
12.05.16 Mechanical Dredging Rock	2933835	CY	184,157,700	36,831,500	0	220,989,300	75.32
12.05.20 Contaminated material disposal	788836	CY	22,876,200	4,575,200	0	27,451,500	34.80
12.05.99 Associated General Items			4,267,700	853,500	0	5,121,200	
TOTAL Arthur Kill to Howland Hook	3813000	CY	249,068,000	47,925,300	0	296,993,300	77.89

		QUANTY	UOM	CONTRACT COST	CONTINGN	ESCALATN	TOTAL COST	UNIT
12.06	Port Jersey Channel							
12.06.01	Mob, Demob & Preparatory Work			2,497,000	374,600	0	2,871,600	
12.06.15	Mechanical Dredging	3522000	CY	65,597,700	9,839,600	0	75,437,300	21.42
12.06.20	Contaminated material disposal	311048	CY	9,020,400	1,804,100	0	10,824,500	34.80
12.06.99	Associated General Items	1.00	CY	3,087,500	617,500	0	3,705,000	3705000
TOTAL	Port Jersey Channel	3522000	CY	80,202,500	12,635,800	0	92,838,300	26.36
12.07	Bay Ridge Channel							
12.07.01	Mob, Demob & Preparatory Work			2,904,000	435,600	0	3,339,600	
12.07.15	Mechanical Dredging	4000000	CY	32,974,100	4,946,100	0	37,920,200	9.48
12.07.20	Contaminated material disposal	1853581	CY	53,753,800	10,750,800	0	64,504,600	34.80
12.07.99	Associated General Items			90,200	18,000	0	108,200	
TOTAL	Bay Ridge Channel	4000000	CY	89,722,100	16,150,500	0	105,872,700	26.47
12.20	Owner Costs (E & D and S & A)							
12.20.01	Lands & Damages			1,700,000	255,000	0	1,955,000	
12.20.05	Planning, Engineering & Design			41,150,000	6,172,500	0	47,322,500	
12.20.10	Construction Management			92,055,000	13,808,300	0	105,863,300	
TOTAL	Owner Costs (E & D and S & A)			134,905,000	20,235,800	0	155,140,800	
TOTAL	Federal Cost Share Plan			1,408,590,600	237,305,900	0	1,645,896,500	
20	Non Federal Cost							
20.10	Newark Bay Channel							
20.10. 2	Construct Berth 52			13,312,500	1,996,900	0	15,309,400	
20.10. 5	Construct Berth 66			7,415,000	1,112,300	0	8,527,300	
20.10.10	Construct Berth 84			7,415,000	1,112,300	0	8,527,300	
20.10.15	Construct Berth 96			7,415,000	1,112,300	0	8,527,300	
20.10.20	Construct Berth 59			7,415,000	1,112,300	0	8,527,300	
20.10.22	Construct Berth 88			7,415,000	1,112,300	0	8,527,300	
20.10.25	Utility Relocation PSEG			3,240,000	486,000	0	3,726,000	
TOTAL	Newark Bay Channel			53,627,500	8,044,100	0	61,671,600	
20.15	Arthur Kill to Howland Hook							
20.15. 5	Construct Berth 1			14,572,500	2,185,900	0	16,758,400	
TOTAL	Arthur Kill to Howland Hook			14,572,500	2,185,900	0	16,758,400	

	QUANTY	UOM	CONTRACT COST	CONTINGN	ESCALATN	TOTAL COST	UNIT
20.20 Port Jersey Channel							
20.20. 5 Port Jersey North Berth Dredging			2,175,000	326,300	0	2,501,300	
20.20.10 Port Jersey Global Terminal			10,275,000	1,541,300	0	11,816,300	
20.20.15 Port Jersey South Berth Dredging			2,175,000	326,300	0	2,501,300	
TOTAL Port Jersey Channel			14,625,000	2,193,800	0	16,818,800	
20.25 Bayridge Channel							
20.25. 5 Dredging Berth 1			1,925,000	288,800	0	2,213,800	
20.25.10 Dredging Berth 2			1,925,000	288,800	0	2,213,800	
TOTAL Bayridge Channel			3,850,000	577,500	0	4,427,500	
20.30 Anchorage Channel							
20.30.10 Utility Reloc - 42" diameter			16,560,000	2,484,000	0	19,044,000	
20.30.5 Utility Reloc - 36" diameter			14,450,000	2,167,500	0	16,617,500	
TOTAL Anchorage Channel			31,010,000	4,651,500	0	35,661,500	
TOTAL Non Federal Cost			117,685,000	17,652,800	0	135,337,800	
TOTAL NY/NJ Harbor Deepening			1,526,275,600	254,958,700	0	1,781,234,200	

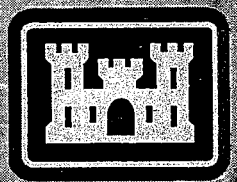
FEASIBILITY REPORT

for

New York and New Jersey Harbor Navigation Study

Appendix I
Real Estate

December 1999



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New York District

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PREAMBLE

Introduction

I1. The New York District, U.S. Army Corps of Engineers has been authorized to conduct a feasibility study to evaluate federal participation in navigation improvements in New York and New Jersey Harbor (the Harbor), specifically, the dredging of the Port of New York and New Jersey and certain of its approach channels to a depth of 50 ft below mean low water (50 ft MLW).

I2. The feasibility study was authorized by Section 435 of the Water Resources Development Act of 1996, which reads:

> *The Secretary shall conduct a comprehensive study of navigation needs at the Port of New York-New Jersey (including the South Brooklyn Marine and Red Hook Container Terminals, Staten Island, and adjacent areas) to address improvements, including deepening of existing channels to depths of 50 feet or greater, that are required to provide economically efficient and environmentally sound navigation to meet current and future requirements.*

Designation

I3. New York and New Jersey Harbor Navigation Feasibility Study.

Project Area

I4. The Port of New York and New Jersey is situated in the vicinity of the City of New York (Boroughs of Brooklyn, Staten Island, Manhattan, Bronx and Queens) in New York State and the vicinities of the Cities of Newark, Elizabeth, Jersey City, Hoboken and Bayonne in the State of New Jersey. The investigation includes the following channels: Ambrose (NY & NJ), Anchorage (between Staten Island and Brooklyn, NY), Bay Ridge (off Brooklyn, NY), Red Hook (off Brooklyn, NY), Buttermilk (off Brooklyn, NY), the Kill Van Kull (between Staten Island, NY and the City of Bayonne, NJ), Claremont (Jersey City, NJ), Port Jersey (City of Bayonne, NJ), Newark Bay, including the Elizabeth Channel and South Elizabeth Channel (Cities of Elizabeth and Newark, NJ), and the Arthur Kill to Gulfport (between Staten Island, NY and the City of Elizabeth, NJ), as well as the anchorage areas at Stapleton (off Staten Island, NY), Red Hook Flats (off Brooklyn, NY), and Gravesend Bay (off Brooklyn, NY).

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PURPOSE

I5. This report is prepared in accordance with the provisions of Corps of Engineers Engineering Regulation (ER) 405-1-12, Chapter 12, Paragraph 12-16. It is intended to serve as an appendix to the New York District's "New York and New Jersey Harbor Navigation Feasibility Study" dated December 1999. The purpose of this Real Estate Plan/Appendix (the Real Estate Plan) is to present the overall plan describing the minimum real estate requirements, costs, and acquisition schedules for the Project.

I6. This Real Estate Plan is tentative in nature and both the final real property acquisition lines and costs are subject to change after approval of the "New York and New Jersey Harbor Navigation Feasibility Study", the decision document to which this Plan is appended.

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COST-SHARING FORMULA

I7. The Water Resources Development Act (WRDA) of 1986 (Public Law 99-662) sets forth the specific provisions for Federal and non-Federal cost sharing on water resources projects. For deep draft navigation projects, the Federal government will provide a maximum contribution of 50% of the total project costs assigned to channel deepening components for depths greater than 45 ft MLW.

I8. The non-Federal partners are required to provide a minimum contribution of 25% of the total project cost. For the channel deepening components of the project, the non-Federal partners share shall consist of a minimum cash contribution of ten percent (10%) of the total costs assigned to channel dredging plus all Lands, Easements, Rights-of-way, and Relocations (LERR's) necessary for project construction. Cash payments are to be made during the construction period at a rate proportional to the Federal expenditures. The non-Federal partners' share of the Pre-construction Engineering and Design (PED) costs are to be repaid during the first year of construction. LERR are to be furnished to the Federal government prior to the advertisement of any construction contract that involves those LERR.

I9. There is no Federal contribution to the non-structural costs, including costs to relocate utilities located within channels identified for deepening; utilities relocations will be funded 50% by the non-Federal partners and 50% by the utility owners. The non-Federal partners will provide 100% of the costs for other project components not identified as General Navigation Features (GNF), including berth deepening and strengthening.

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PROJECT FEATURES

Required Lands, Easements, Rights-of-Way, and Relocations (LERR)

Channel Improvement Easements

I10. The estimated total acreage required for the Project is approximately 25.03 acres, consisting of approximately 23.6 acres in fee and 1.43 acres of perpetual easements (channel improvement easements).

I11. The perpetual easements consists of two parcels of land situated along the shore of the Kill Van Kull north of Richmond Terrace on Staten Island (Richmond County), NY that will be used for the placement of rip-rap to protect the dredged channel from subsidence resulting from erosion of nearby shoreline. The first easement site is approximately 1,050 feet in length by 25 feet in width or 0.60 acre (owned by Atlantic Salt Company). The second easement site is approximately 1,450 feet in length by 25 feet in width or 0.83 acre (owned by the City of New York and administered by its Department of Parks & Recreation).

Environmental Mitigation

I12. The lands required in fee consist of three parcels to be used for environmental mitigation. The first parcel is situated at "Mariners Harbor" along the Kill Van Kull north of Richmond Terrace in Staten Island (Richmond County), New York and comprises approximately 4.60 acres of land subject to tidal ebb and flow owned by the City of New York and administered by its Department of General Services. The second parcel is situated in the Town of Woodbridge, Middlesex County, NJ and comprises the approximately 16-acre "Woodbridge (South)" mitigation site owned privately by William N. Scott, et al. The third site, known as the "South of Goethals Bridge" mitigation site, is situated along the Arthur Kill in the City of Elizabeth, Union County, New Jersey and comprises approximately 3.0 acres of submerged land adjacent to (south of) the right-of-way of the Goethals Bridge.

I13. Access to the two easement sites will be via the waters of the Kill Van Kull, since the placement of the rip-rap will be performed from barges situated directly off-shore. Access to the 4.60 acres to be acquired in fee on Staten Island, NY will be via public roads (Richmond Terrace) and via the waters of the Kill Van Kull. Access to the 16.0 acres to be acquired in fee in Woodbridge, NJ will be via public streets (Woodbridge Road). Access to the 3.0 acres to be acquired in Elizabeth, NJ will be via public streets (South Front Street) and via the waters of the Arthur Kill.

I14. Two of the three non-Federal Partners (the States of New York and New Jersey) will be responsible for obtaining the required real estate interests that are situated in their respective states.

Right-of-Entry for Construction

I15. In addition, a standard Right-of-Entry for Construction will be required for modification of the wave screen and pier at the municipally-owned City of Elizabeth Marina situated along the Arthur Kill in Elizabeth, NJ. The wave screen and pier require replacement due to undermining by the proposed 50 ft. channel, with the work being performed from the water with no access to land required. The replacement of the wave screen and pier will not be subject to operations and maintenance activities after completion of the Project, however, but will instead be the ongoing responsibility of the City of Elizabeth. The New York District will assist the State of New Jersey in obtaining this Right-of-Entry, if required.

Placement Areas

I16. The Project does not require acquisition of real property interests for borrow areas or placement areas. At the request of the non-Federal Partners (the States of New York and New Jersey), rock material will be placed on off-shore artificial reefs (Sandy Hook and Atlantic Beach reef sites). In accordance with federal regulations for ocean placement, materials meeting the standards for ocean placement and suitable for remediation purposes will be placed at the off-shore "Historic Area Remediation Site" ("HARS"). Required permits for these activities will be obtained during the Project's PED stage. Non-rock material deemed unsuitable for placement at the HARS will be placed at in-channel cells to be located in the lower bay. Dredged material will be removed by the construction contractor and placed at these sites. The placement will be accepted for a "tipping fee," which will eliminate the need for real estate acquisition. In lieu of such in-channel cell placement, however, the non-Federal partners have also expressed an interest in pursuing upland placement at privately-owned locations and have identified a number of sites in the State of New Jersey, including the Hunterdon Quarry site, CTI Lehigh Anthracite site, CTI Carteret site, SK Services (Koppers Coke) site, SK Services Port Reading site, OENJ Bayonne site, OENJ Port Reading site, Sayreville National Lead site, Allied Signal Elizabeth site, JCIO Upcycle Decon site, Biogenesis Kearny Decon site, IGT Koppers Decon site and Westinghouse Plasma Arc Decon site. Dredged material will be removed by the construction contractor and placed at these sites. Furthermore, as the placement of such HARS-unsuitable materials into the channel cells represents the "NED costs," the non-Federal partners have agreed to pay any additional costs associated with such upland placement. There is no intent for any Project participants (the States of New York and New Jersey and the Port Authority of New York and New Jersey ("PA") to acquire these sites.



Utility Relocations

I17. There are three "Deep Draft Utility Relocations" required for this Project. These relocations are described and discussed in Section "Facility and Utility Relocations."

I18. A summary of the acreage needed for the Project and the uses thereof is as follows:

TABLE 1 Summary of Acreage	
Fee	**Acres**
Mariners Harbor Mitigation Site, NY	4.60
Woodbridge (South) Mitigation Site, NJ	16.00
South of Goethals Bridge Mitigation Site, NJ	3.00
Total	23.60
Easements (Channel Improvement (Rip-rap))	
Atlantic Salt Co., NY	0.60
NYC Parks (Richmond Terrace), NY	0.83
Total	1.43

I19. Appraisal Information - The highest and best use of the land is as follows:

- Mariners Harbor mitigation site, Staten Island, NY (4.60 acres): Wildlife conservation use (subject to wetlands restrictions on development).
- "Woodbridge (South)" mitigation site, Woodbridge, NJ (16.0 acres): Residential use, subject to wetlands restrictions on development.
- South of Goethals Bridge Mitigation Site, Elizabeth, NJ (3.0 acres): Wildlife conservation use (subject to wetlands restrictions on development – site is totally under water).
- Channel Improvements Easements, Staten Island, NY: Marine industrial use.

I20. A summary of Project LERR "economic" costs based on a December 1999 Gross Appraisal valuation, is as follows:

TABLE 2 Summary of Costs			
(i) Lands and Damages	**Acres**	**Unit Value**	**Total Value**
CHANNEL IMPROVEMENT EASEMENT			
(Rip-rap)	0.83	$4,000/acre	$3,300
(Rip-rap)	0.60	$60,000/acre	$36,000
Sub-Total	**1.43**		**$39,300**
FEE			
Mariners Harbor, SI, NY mitigation site	4.6	$5,000/acre	$23,000
Woodbridge, NJ mitigation site	16.0	$5,000/acre	$80,000
"South of Goethals Bridge" mitigation site, NJ	3.0	$5,000/acre	$15,000
Sub-Total	**23.60**		**$118,000**
Improvements	None	n/a	0
Severance Damages	None	n/a	0
Total – Lands, Improvements & Damages	25.03		$157,300
(ii) Contingencies (20%)			$ 31,460
TOTAL:	**25.03**		**$188,760**

Non-Federal Partner-owned Lands

I21. None of the three non-Federal partners (*i.e.*, the states of New York and New Jersey and the Port Authority of New York and New Jersey) own lands required for the Project.

Estates

I22. There are two "standard estates" to be acquired: Perpetual Channel Improvement Easement; and Fee Simple. The completed texts of these standard estates are included in Exhibit "A".

Existing Federal Project

I23. Insofar as the channels and anchorages comprising the New York and New Jersey Harbor are Federal navigable waterways maintained by the Corps of Engineers, the Project is considered to be an existing Federal project.

Federally-owned Lands

I24. The United States of America owns, in fee, approximately 52 acres of land situated in Jersey City, NJ and administered by the New York District's Operations Division (CENAN-OP) as its Caven Point Marine Base. Approximately 0.50 acre thereon will be used as a New York District Construction Division (CENAN-CO) Field Office for the Project and a temporary office (trailer or "relocatable building") will be placed thereon. The non-Federal partner(s) will not receive LER credit for this land.



Lands within Ordinary or Mean High Water Mark and Navigable Servitude

I25. Insofar as the channels and anchorages comprising the Port of New York and New Jersey that are to be dredged are all Federal channels, the Government will exercise its rights under the doctrine of Navigational Servitude.

Project Maps

I26. Maps labeled Figures 1 and 2 depict the general location of the Project area. Maps labeled Figures 3, 4 (2 SI easements – "Richmond Terrace" and Atlantic Salt Co.), 5 ("Mariners Harbor" SI mitigation area), 6 (Woodbridge NJ mitigation area), 7 (Elizabeth Marina ROE), 8 (Caven Point Marine Base) and 9 ("South of Goethals Bridge" mitigation area) depict the minimum estates required for construction, operation and maintenance of the Project.

Induced Flooding

I27. It is anticipated that no flooding will be induced by the construction, operation or maintenance of the Project.

Baseline Cost Estimates

I28. Baseline Cost Estimates in MCACES format are set forth in Exhibit "B."

PL 91-646 Uniform Relocation Assistance

I29. There are no persons, businesses, farms or not-for-profit entities that will be displaced as a result of the Project. Accordingly, under Title II of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646, as amended) no relocation assistance to such persons, businesses, farms or not-for-profit entities will be required.

Minerals and Timber

I30. There are no present or anticipated mineral activities, or any present or anticipated timber harvesting activities, in the Project area.

Non-Federal Partners' Assessment

I31. There are three (3) non-Federal partners for this project:

- The State of New Jersey (NJ Commerce and Economic Growth Commission, NJMR);
- The State of New York (Empire State Development Corporation, ESDC), assisted by he City of New York; and
- The Port Authority of New York and New Jersey (PANYNJ).

I32. The two States are non-Federal partners for other cost-shared Civil Works projects within their boundaries. They have both the land acquisition experience and the ability to acquire real estate necessary for the Project. These States have clearly demonstrated that they have the capability to perform the real estate requirements of a Project Cooperation Agreement. Both States have quick-take authority.

I33. Three "Assessment of Non-Federal Partner's Real Estate Acquisition Capability" are attached as Exhibits "C-1"; "C-2"; and "C-3". New York District will assist the State of New Jersey in obtaining the required Right-of-Entry for Construction for the improvements/modifications to the wave screen and wharf at the City of Elizabeth Marina in Elizabeth, NJ.

Zoning Ordinances

I34. No application for, or enactment of, any zoning ordinances are proposed in connection with the Project.

Acquisition Schedules

I35. Execution of the Project Cooperation Agreement (PCA) and acquisition of Project LERR is scheduled for FY-2003. The actual commencement of acquisition of Project LERR depends upon the date of PCA execution. Exhibit "D" sets forth the Real Estate Acquisition Milestones and Schedule.

Facility and Utility Relocations

I36. There are three (3) utility lines to be removed for the Project, all of which constitute "Deep Draft Utility Relocations" under the provisions of US Army Corps of Engineers (CECW-AA) Policy Guidance Letter (PGL) No. 44 dated 25 October 1995, "Relocations and Removals at Navigation (Harbor) Projects." Two of these three utilities



(consisting of one 36-inch water line and one 42-inch water line, both owned by the City of New York) cross the Anchorage Channel between Brooklyn (Kings County), NY and Staten Island, NY. These lines cross the Upper Harbor between Brooklyn and Staten Island and cross the Bay Ridge Channel, the southern portion of the Red Hook Flats Anchorage, and Anchorage Channel. The estimated cost of these "deep draft relocations" is $37 million.

I37. In addition, one 12-inch gas pipeline, owned by the Public Service Gas and Electric Company of New Jersey ("PSEG") situated south of South Elizabeth Channel, crosses Newark Bay from Elizabeth, NJ to Bayonne, NJ. The estimated cost of this "deep draft relocation" is $3.24 million.

I38. In accordance with Section 101 (a) (4) of WRDA 86, as amended, and as discussed in Paragraph 4c(1) of PGL 44 ("Deep Draft Utility Relocations"), the respective utility owners are responsible for half of these relocation costs, with the non-Federal partners being responsible for the other half. The actual cost of the utility relocation borne by the non-Federal partner(s) (up to 50 percent of the total cost of the utility relocation) will be creditable against the non-Federal partner(s)' required additional 10 percent payment under Section 101 (a) (2) of WRDA 86, as amended.

I39. In addition, several aids to navigation (floating buoys) will require temporary relocation. The specific buoys to be relocated will be identified during the Project's PED stage. The New York District will notify the Coast Guard in writing of the specific requirements during the PED Phase and will request relocation of these navigation aids in writing upon PCA execution.

I40. No other facilities or utilities will be relocated or removed as a result of the Project. Due to the accelerated schedule for this Project, a Preliminary Attorney's Opinion of Compensability will not be prepared. However, a Final Attorney's Opinion of Compensability will be prepared for each proposed utility relocation and submitted under separate cover prior to the signing of the PCA.

Hazardous, Toxic, or Radiological Waste (HTRW)

I41. As stated in the Project's *Final Environmental Impact Statement*, there are no known HTRW or contaminated lands within the Project area.

Project Support

I42. Affected landowners within the Project area support the project and will benefit from the dredging of the Channel.

Notifications to the Non-Federal Partners

I43. The non-Federal partners will be notified in writing as to the risks involved in proceeding with real estate acquisition. The Partners will be further advised as to the crediting principles and the requirements of Public Law 91-646 applicable to real estate acquisition responsibilities. To facilitate affording of credit for the market value of the LER in a timely manner, the non-Federal partner(s) will be advised by the New York District to submit credit request(s), with supporting documentation, within 180 days after it provided the Government authorization for entry for such LER.

Other Real Estate Issues

I44. After the execution of the PCA, the District will assist the non-Federal partner in obtaining any Federal interests required for the Project, and will monitor the non-Federal partners' performance.

REAL ESTATE PLAN

New York and New Jersey Harbor Navigation Feasibility Study

EXHIBIT "A" – ESTATES

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Channel Improvement Easement

I45. A perpetual and assignable right and easement to construct, operate, and maintain channel improvement work on, over and across the land described in Schedule A (Tract No. __), for the purposes as authorized by the Act of Congress approved _____, 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 and 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.

Fee

I46. The fee simple title to the land described in Schedule A, subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DEPARTMENT OF THE ARMY

Right-of-Entry for Construction

_____ _____

(Project, Installation or Activity) (Tract Number or Other Property Identification)

The undersigned, hereinafter called the "Owner", in consideration of the total compensation to be paid by the UNITED STATES OF AMERICA, hereinafter called the "Government," for all land or easement rights hereinafter described, to be determined by subsequent agreement between the Owner and the Government, or by judicial proceedings, hereby grants to the Government, a permit or right-of-entry upon the following terms and conditions:

1. The Owner hereby grants to the Government an irrevocable right to enter upon the lands hereinafter described at any time within a period of _____ ( ) months from the date of this instrument, in order to erect buildings, or any other type of improvements and to perform construction work of any nature.

2. This permit includes the right of ingress and egress on other lands of the Owner not described below, provided that such ingress and egress is necessary and not otherwise conveniently available to the Government.

3. All tools, equipment, buildings improvements, and other property taken upon or placed upon the land by the Government shall remain the property of the Government and may be removed by the Government at any time within a reasonable period after the expiration of this permit or right-of- entry.

4. The Government shall have the right to patrol and police the lands hereinafter described during the period of this permit or right-of-entry.

5. If aircraft flights over said lands, or entry upon the land by means of helicopter or other type aircraft, are necessary, the Government shall inform the Owner, in advance, of each such flight or entry.

6. In the event that the Government does not acquire title or other necessary interest in said land prior to the expiration of this permit or right-of-entry, or any renewal thereof, the parties agree that, if any action of the Government's employees or agents in

the exercise of this right-of-entry results in damage to the real property, the Government will, at its option, either repair such damage or make an appropriate settlement with the Owner. In no event shall such repair or settlement exceed the fair market value of fee interest of the real property at the time immediately preceding such damage. The Government's liability under this clause may not exceed appropriations available for such payment and nothing contained in this agreement may be considered as implying that Congress will at a later date appropriate funds sufficient to meet deficiencies. The provisions of this clause are without prejudice to any rights the Owner may have to make a claim under applicable laws for any other damages than provided herein. If the Government does acquire such title or other necessary interest, damages would be limited to the decrease in the fair market value of the owner's remainder caused by such damage.

The land affected by this permit or right-of-entry is located in the County of _____ State of _____ , and is described as follows:

(See Exhibit "A")

WITNESS MY HAND AND SEAL this day of , 199

WITNESS:

_____ (SEAL)
SIGNATURE

_____ (SEAL)
SIGNATURE

UNITED STATES OF AMERICA

By: _____

Title: _____

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REAL ESTATE PLAN

New York and New Jersey Harbor Navigation Feasibility Study

EXHIBIT "B" – BASELINE COST ESTIMATES

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	TOTAL PROJECT COSTS	non-Federal	Federal	Contingency (20%)	Project Cost
01	**LANDS AND DAMAGES**	$261,300	$72,300	$66,720	400,320
	(rounded)				**$400,000**
01A	**PROJECT PLANNING**		**58,000**		
01A10	REAL ESTATE SUPPLEMENT/PLAN		32,000		
01A20	PRELIMINARY RE ACQUISITION MAPS		3,000		
01A30	PHYSICAL TAKINGS ANALYSIS		0		
01A40	PRELIMINARY ATTORNEY'S OPINION OF COMPENSABILITY		8,000		
01A50	ALL OTHER RE ANALYSES/DOCUMENTS		15,000		
01B	**ACQUISITIONS**	**157,300**	**6,000**		
01B10	BY GOVERNMENT				
01B20	BY LOCAL PARTNER (LS)	157,300			
01B30	BY GOVT ON BEHALF OF LS				
01B40	REVIEW OF LS		6,000		
01C	**CONDEMNATIONS**	**0**	**0**		
01C10	BY GOVERNMENT				
01C20	BY LS				
01C30	BY GOVT ON BEHALF OF LS				
01C40	REVIEW OF LS				
01D	**INLEASING**	**0**	**0**		
01D10	BY GOVERNMENT				
01D20	BY LS				
01D30	BY GOVT ON BEHALF OF LS				
01D40	REVIEW OF LS				
01E	**APPRAISAL**	**20,000**	**3,000**		
01E10	BY GOVT (IN HOUSE)				
01E20	BY GOVT (CONTRACT)				
01E30	BY LS	20,000			
01E40	BY GOVT ON BEHALF OF LS				

	TOTAL PROJECT COSTS	non-Federal	Federal	Contingency (20%)	Project Cost
01E50	REVIEW OF LS		3,000		
01F	**PL 91-646 ASSISTANCE**	**0**	**0**		
01F10	BY GOVERNMENT				
01F20	BY LS				
01F30	BY GOVT ON BEHALF OF LS				
01F40	REVIEW OF LS				
01G	**TEMPORARY PERMITS/LICENSES/ RIGHTS-OF-ENTRY**	**1,000**	**300**		
01G10	BY GOVERNMENT				
01G20	BY LS	1,000			
01G30	BY GOVT ON BEHALF OF LS				
01G40	REVIEW OF LS		300		
01G50	OTHER				
01G60	DAMAGE CLAIMS				
01H	**AUDITS**	**0**	**0**		
01H10	BY GOVERNMENT				
01H20	BY LS				
01H30	BY GOVT ON BEHALF OF LS				
01H40	REVIEW OF LS				
01J	**ENCROACHMENTS AND TRESPASS**	**0**	**0**		
01J10	BY GOVERNMENT				
01J20	BY LS				
01J30	BY GOVT ON BEHALF OF LS				
01J40	REVIEW OF LS				
01K	**PLACEMENTS**	**0**	**0**		
01K10	BY GOVERNMENT				
01K20	BY LS				
01K30	BY GOVT ON BEHALF OF LS				
01K40	REVIEW OF LS				
01N00	**FACILITY/UTILITY RELOCATIONS**	**80,000**	**2,000**		

	TOTAL PROJECT COSTS	non-Federal	Federal	Contingency (20%)	Project Cost
01Q00	**RESERVED FOR FUTURE HQUSACE USE**	**0**	**0**		
01R	**REAL ESTATE PAYMENTS**	**3,000**	**0**		
01R1	**LAND PAYMENTS**				
01R1A	BY GOVERNMENT				
01R1B	BY LS	3,000			
01R1C	BY GOVT ON BEHALF OF LS		0		
01R1D	REVIEW OF LS				
01R2	**PL 91-646 ASSISTANCE PAYMENTS**	0	0		
01R2A	BY GOVERNMENT				
01R2B	BY LS				
01R2C	BY GOVT ON BEHALF OF LS				
01R2D	REVIEW OF LS				
01R3	**DAMAGE PAYMENTS**	0	0		
01R3A	BY GOVERNMENT				
01R3B	BY LS				
01R3C	BY GOVT ON BEHALF OF LS				
01R3D	REVIEW OF LS				
01R9	**OTHER**				
01T	**LERR CREDITING**	**0**	**3,000**		
01T10	LAND PAYMENTS				
01T20	ADMINISTRATIVE COSTS		3,000		
01T30	PL 91-646 ASSISTANCE				
01T40	ALL OTHER				

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REAL ESTATE PLAN

New York and New Jersey Harbor Navigation Feasibility Study

EXHIBIT "C" – Assessment of Non-Federal Partner's Real Estate Acquisition Capability



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ASSESSMENT OF THE NON-FEDERAL PARTNERS REAL ESTATE ACQUISITION CAPABILITY

State of New Jersey (Commerce and Economic Growth Commission)

I. Legal Authority:

a. Does the partner have legal authority to acquire and hold title to real property for project purposes? YES
b. Does the partner have the power of eminent domain for this project? YES
c. Does the partner have "quick-take" authority for this project? YES
d. Are any of the lands/interests in the land required for the project located outside the partner's political boundary? NO
e. Are any of the lands/interests in the land required for the project owned by an entity whose property the partner cannot condemn? YES

II. Human Resources Requirements:

a. Will the partner's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? NO
b. If the answer to IIa is YES, has a reasonable plan been developed to provide such training? N/A
c. Does the partner's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? YES
d. Is the partner's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? YES
e. Can the partner obtain contractor support, if required, in a timely fashion? YES
f. Will the partner likely request USACE assistance in acquiring real estate? YES

III. Other Project Variables:

a. Will the partner's staff be located within reasonable proximity to the project site? YES
b. Has the partner approved the project/real estate schedule/milestones? YES

IV. Overall Assessment:

a. Has the partner performed satisfactorily on other USACE projects? YES
b. With regard to this project, the partner is anticipated to be: highly capable/ fully capable/ moderately capable/ marginally capable/ insufficiently capable. FULLY CAPABLE

V. Coordination:

a. Has this assessment been coordinated with the partner? YES
b. Does the partner concur with this assessment? YES

State of New York (Empire State Development Corporation)

I. Legal Authority:

a. Does the partner have legal authority to acquire and hold title to real property for project purposes? YES
b. Does the partner have the power of eminent domain for this project? YES
c. Does the partner have "quick-take" authority for this project? YES
d. Are any of the lands/interests in the land required for the project located outside the partner's political boundary? NO
e. Are any of the lands/interests in the land required for the project owned by an entity whose property the partner cannot condemn? YES

II. Human Resources Requirements:

a. Will the partner's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? NO
b. If the answer to IIa is YES, has a reasonable plan been developed to provide such training? N/A
c. Does the partner's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? YES
d. Is the partner's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? YES
e. Can the partner obtain contractor support, if required, in a timely fashion? YES
f. Will the partner likely request USACE assistance in acquiring real estate? YES

III. Other Project Variables:

a. Will the partner's staff be located within reasonable proximity to the project site? YES
b. Has the partner approved the project/real estate schedule/milestones? YES

IV. Overall Assessment:

a. Has the partner performed satisfactorily on other USACE projects? YES
b. With regard to this project, the partner is anticipated to be: highly capable/ fully capable/ moderately capable/ marginally capable/ insufficiently capable. FULLY CAPABLE

V. Coordination:

a. Has this assessment been coordinated with the partner? YES
b. Does the partner concur with this assessment? YES

Port Authority of New York and New Jersey

I. Legal Authority:

a. Does the partner have legal authority to acquire and hold title to real property for project purposes? NO
b. Does the partner have the power of eminent domain for this project? NO
c. Does the partner have "quick-take" authority for this project? NO
d. Are any of the lands/interests in the land required for the project located outside the partner's political boundary? YES
f. Are any of the lands/interests in the land required for the project owned by an entity whose property the partner cannot condemn? YES

II. Human Resources Requirements:

a. Will the partner's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? NO
b. If the answer to IIa is YES, has a reasonable plan been developed to provide such training? N/A
c. Does the partner's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? YES
d. Is the partner's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? NO
e. Can the partner obtain contractor support, if required, in a timely fashion? NO
f. Will the partner likely request USACE assistance in acquiring real estate? YES

III. Other Project Variables:

a. Will the partner's staff be located within reasonable proximity to the project site? YES
b. Has the partner approved the project/real estate schedule/milestones? YES

IV. Overall Assessment:

c. Has the partner performed satisfactorily on other USACE projects? YES
d. With regard to this project, the partner is anticipated to be: highly capable/ fully capable/ moderately capable/ marginally capable/ insufficiently capable. INSUFFICIENTLY CAPABLE

V. Coordination:

a. Has this assessment been coordinated with the partner? YES
b. Does the partner concur with this assessment? YES

REAL ESTATE PLAN

New York and New Jersey Harbor Navigation Feasibility Study

EXHIBIT "D" – Real Estate Acquisition Milestones and Schedules

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Milestones & Schedule for the acquisitions in New Jersey Mitigation Sites

Task	Duration	Start Date	End Date
PCA Execution Accomplished	0		
Start Real Estate Acquisition by n-FS	655		
Start LER Acquisition	535		
(NAN-RE) Formal Transmittal of Final ROW drawings to Acquire LER	10		
(LS) Prepare Mapping and Legal description	60		
(NAN-RE) Review Mapping and Legal description	10		
(LS) Obtain title Evidence	60		
(NAN-RE) Review Title Evidence	15		
(LS) Obtain Tract Appraisal	120		
(NAN-RE) Review Tract Appraisal	20		
(LS) Conduct Negotiations	45		
(NAN-RE) Review Counteroffers	10		
(LS) Perform Closings	60		
(NAN-RE) Review Closings	10		
(LS) Submit Authorization for Entry to Construct	15		
(NAN) Review Authorization for Entry to Construct	10		
(NAN-OC) Review Authorization for Entry to Construct by Office of Counsel	20		
(NAN-RE) Certify LER for Solicitation of Construction Contracts	10		
Construction Award Date	60		
(LS) Prepare and Submit Credit Requests	180		
(NAN-RE) Review and approve Credit to LS	180		
(NAN-RE) Establish Value for Creditable LERR to PM	180		

Schedule dates will be completed so that they are compliant with the Project Management Plan.

Milestones & Schedule for the Acquisitions in New York Mitigation Sites

Task	Duration	Start Date	End Date
PCA Execution Accomplished	0		
Start Real Estate Acquisition/Crediting by n-FS	655		
Start LER Acquisition	535		
(NAN-RE) Formal Transmittal of Final ROW drawings to Acquire LER	10		
(LS) Prepare Mapping and Legal description	60		
(NAN-RE) Review Mapping and Legal description	10		
(LS) Obtain title Evidence	60		
(NAN-RE) Review Title Evidence	15		
(LS) Obtain Tract Appraisal	120		
(NAN-RE) Review Tract Appraisal	20		
(LS) Conduct Negotiations	45		
(NAN-RE) Review Counteroffers	10		
(LS) Perform Closings	60		
(NAN-RE) Review Closings	10		
(LS) Submit Authorization for Entry to Construct	15		
(NAN) Review Authorization for Entry to Construct	10		
(NAN-OC) Review Authorization for Entry to Construct by Office of Counsel	20		
(NAN-RE) Certify LER for Solicitation of Construction Contracts	10		
RTA for Construction Bids	60		
(LS) Prepare and Submit Credit Requests	180		
(NAN-RE) Review and approve Credit to LS	180		
(NAN-RE) Establish Value for Creditable LERR to PM	180		

Schedule dates will be completed so that they are compliant with the Project Management Plan.

REAL ESTATE PLAN

New York and New Jersey Harbor Navigation Feasibility Study

MAPS

Figures 1-9

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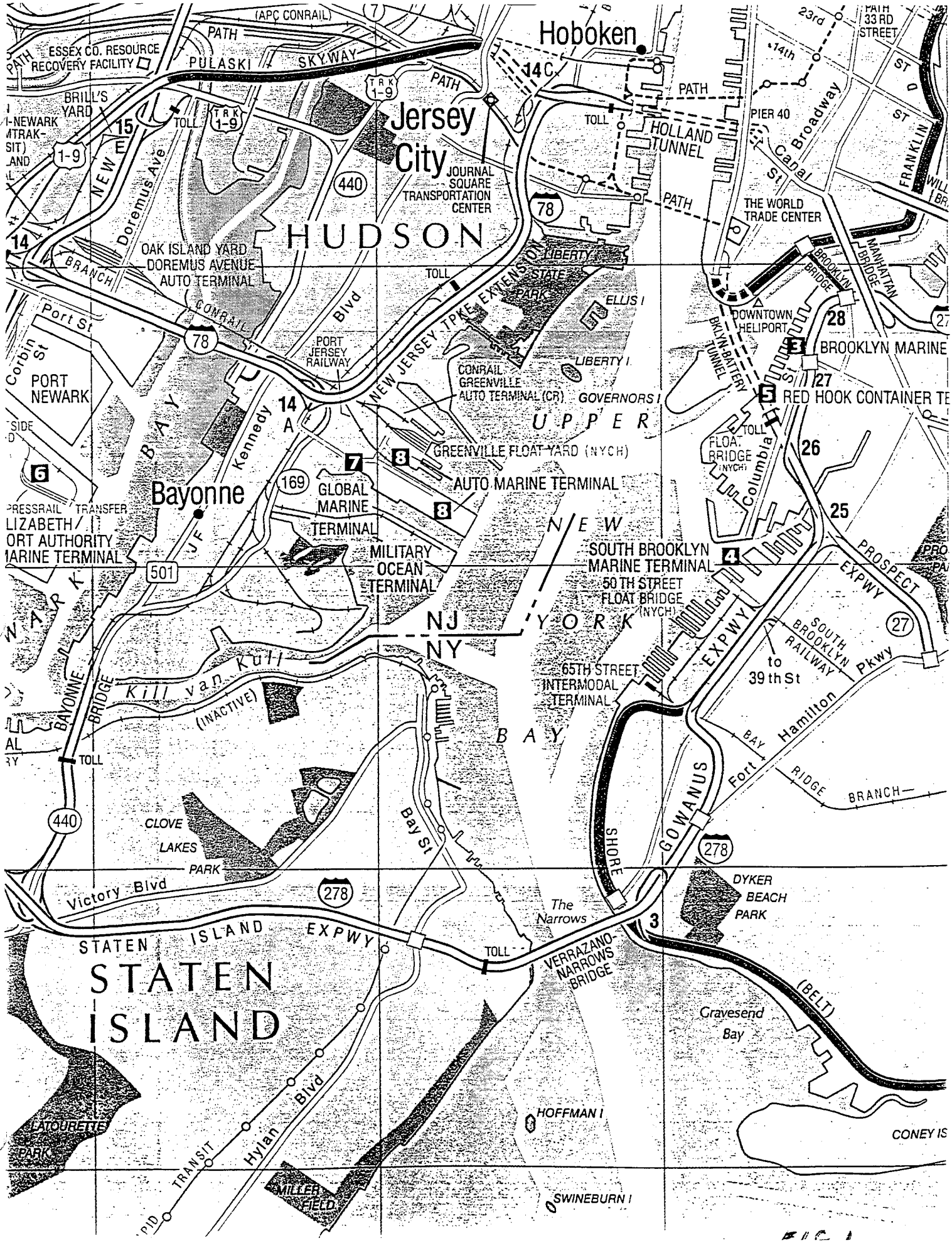
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Jersey City
JOURNAL SQUARE TRANSPORTATION CENTER
HUDSON
PATH
PULASKI SKYWAY
ESSEX CO. RESOURCE RECOVERY FACILITY
BRILL'S YARD
NEWARK
AMTRAK
NJT
LAND
TOLL
TRK 1-9
NEWARK
Doremus Ave
OAK ISLAND YARD
DOREMUS AVENUE AUTO TERMINAL
BRANCH
CONRAIL
Port St
Corbin St
PORT NEWARK
PORT JERSEY RAILWAY
NEW JERSEY TPKE EXTENS
Blvd
Kennedy
BAYONNE
Bayonne
PRESSRAIL TRANSFER
ELIZABETH / PORT AUTHORITY MARINE TERMINAL
GLOBAL MARINE TERMINAL
AUTO MARINE TERMINAL
GREENVILLE FLOAT YARD (NYCH)
CONRAIL GREENVILLE AUTO TERMINAL (CR)
MILITARY OCEAN TERMINAL
SOUTH BROOKLYN MARINE TERMINAL
50 TH STREET FLOAT BRIDGE (NYCH)
65TH STREET INTERMODAL TERMINAL
NJ
NY
NEW YORK
UPPER BAY
Kill van Kull
(INACTIVE)
BAYONNE BRIDGE
CLOVE LAKES PARK
Victory Blvd
STATEN ISLAND EXPWY
STATEN ISLAND
LATOURETTE PARK
Hylan Blvd
MILLER FIELD
SWINEBURN I
HOFFMAN I
The Narrows
VERRAZANO-NARROWS BRIDGE
Gravesend Bay
CONEY IS
DYKER BEACH PARK
GOWANUS
SHORE
Bay St
Fort Hamilton Pkwy
RIDGE BRANCH
SOUTH BROOKLYN RAILWAY
to 39th St
PROSPECT EXPWY
Columbia
FLOAT BRIDGE (NYCH)
BKLYN-BATTERY TUNNEL
BROOKLYN BRIDGE
MANHATTAN BRIDGE
DOWNTOWN HELIPORT
BROOKLYN MARINE
RED HOOK CONTAINER TE
LIBERTY STATE PARK
ELLIS I
LIBERTY I
GOVERNORS I
HOLLAND TUNNEL
PIER 40
THE WORLD TRADE CENTER
Broadway
Canal St
FRANKLIN
14th
23rd
33 RD STREET
14C
440
78
278
501
169
1-9
14
15
26
25
27
28
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7
8

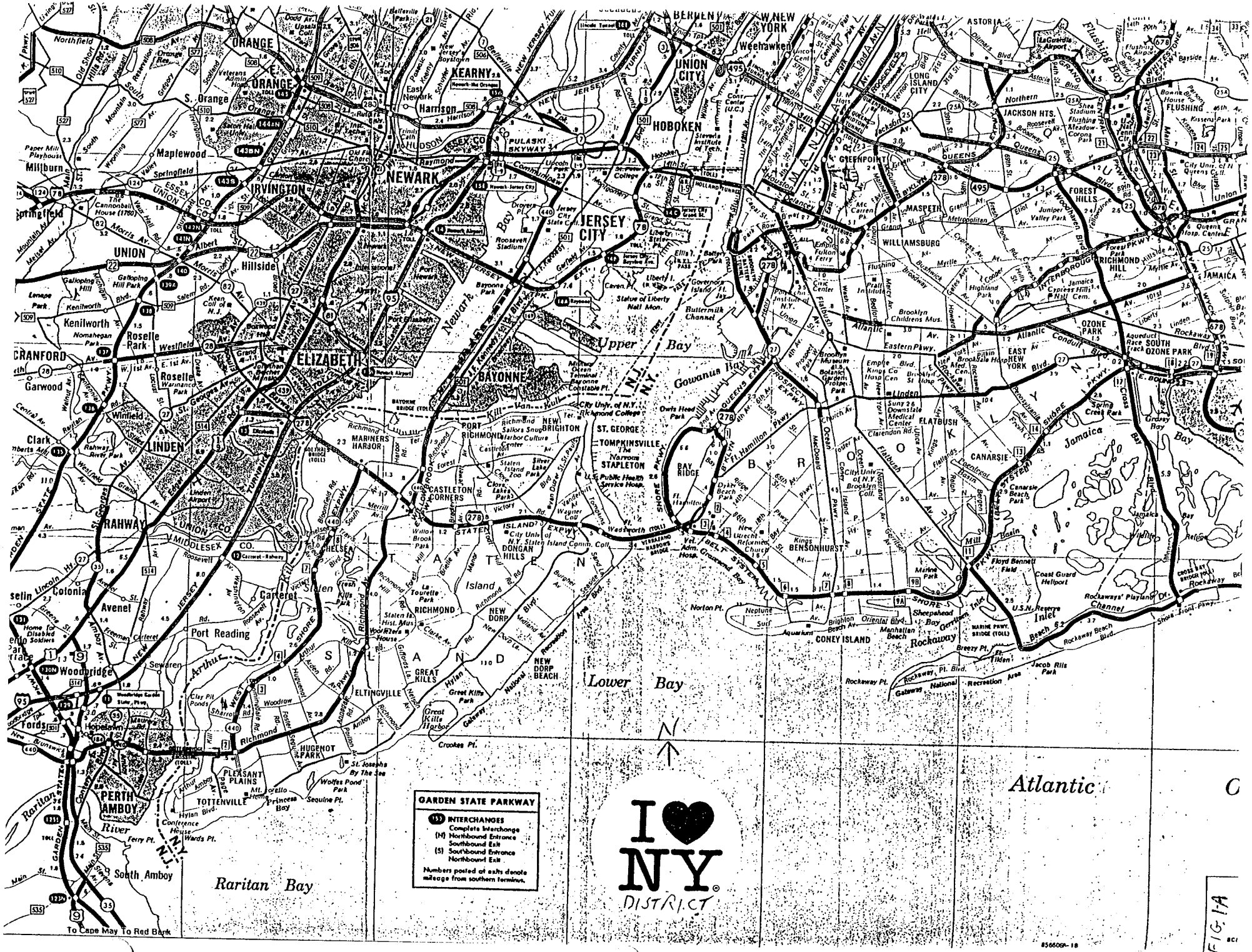
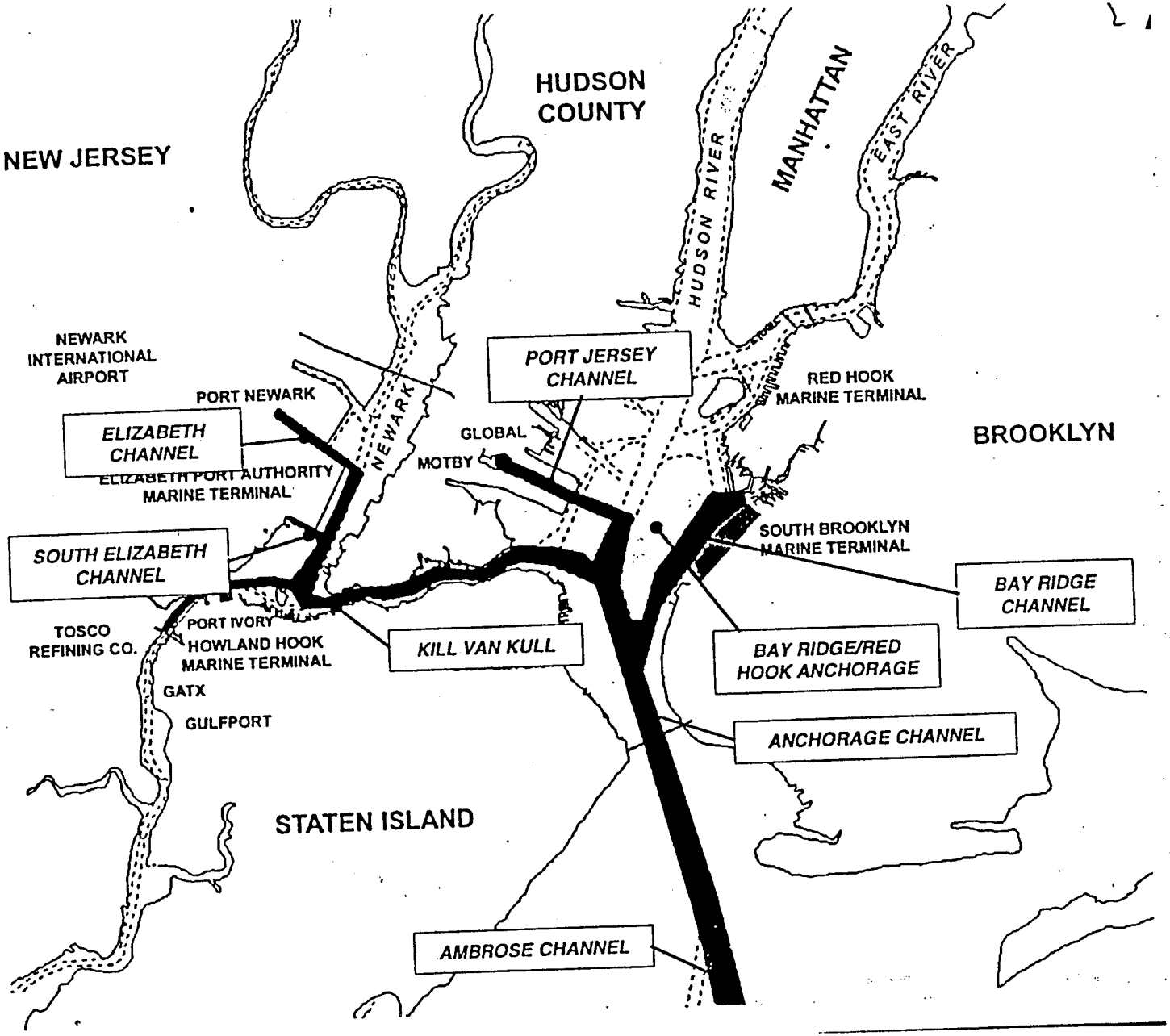
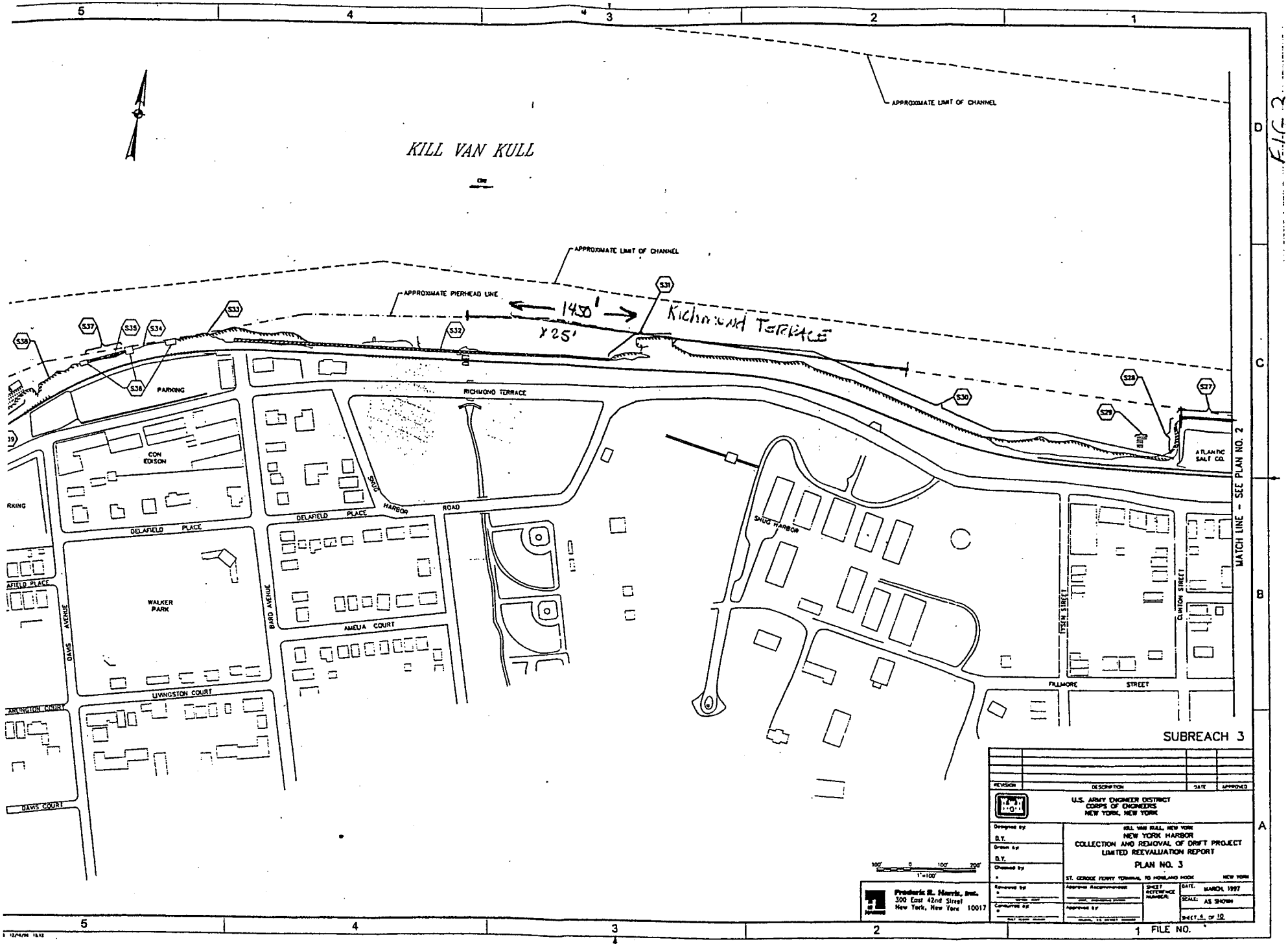

GARDEN STATE PARKWAY
INTERCHANGES
Complete Interchange
(N) Northbound Entrance
Southbound Exit
(S) Southbound Entrance
Northbound Exit
Numbers posted at exits denote mileage from southern terminus.
I ♥ NY DISTRICT
Upper Bay
Lower Bay
Raritan Bay
Atlantic
Jamaica Bay
Gowanus Bay
Newark Bay
Raritan River
ORANGE
KEARNY
NEWARK
IRVINGTON
UNION
ELIZABETH
BAYONNE
JERSEY CITY
HOBOKEN
UNION CITY
WEEHAWKEN
W NEW YORK
BERGEN
LINDEN
RAHWAY
CRANFORD
ROSELLE
PERTH AMBOY
SOUTH AMBOY
STATEN ISLAND
ST. GEORGE
TOMPKINSVILLE
STAPLETON
PORT RICHMOND
NEW BRIGHTON
MARINERS HARBOR
CASTLETON CORNERS
RICHMOND
GREAT KILLS
ELTINGVILLE
HUGENOT PARK
PLEASANT PLAINS
TOTTENVILLE
CARTERET
Port Reading
Woodbridge
Avenel
Colonia
Clark
Garwood
Winfield
Roselle Park
Kenilworth
Hillside
Maplewood
Millburn
Springfield
Harrison
East Newark
S. Orange
E. ORANGE
BROOKLYN
BAY RIDGE
BENSONHURST
CONEY ISLAND
Rockaway
CANARSIE
FLATBUSH
EAST NEW YORK
OZONE PARK
JAMAICA
RICHMOND HILL
FOREST HILLS
WILLIAMSBURG
GREENPOINT
LONG ISLAND CITY
JACKSON HTS.
FLUSHING
ASTORIA
LaGuardia Airport
Newark Airport
Port Elizabeth
Statue of Liberty Nat'l Mon.
Governors Island
Roosevelt Stadium
Bayonne Park
Kill Van Kull
Arthur Kill
Great Kills Harbor
Crooks Pt.
Sandy Hook
Rockaways' Playland
Floyd Bennett Field
Coast Guard Heliport
U.S.N. Reserve
Jacob Riis Park
Rockaway Pt.
Norton Pt.
Neptune
Sheepshead Bay
Gerritsen Inlet
Jamaica Bay
Flushing Bay
Newark Bay
Raritan Bay
Lower Bay
Upper Bay
Gowanus Bay
To Cape May To Red Bank
N
N.J.
N.Y.
856606R-18

FIG. 1-A



The New York & New Jersey Harbor functions as a single unit serving the New York Metropolitan region and its hinterland.



REVISION	DESCRIPTION	DATE	APPROVED

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NEW YORK, NEW YORK

Designed by: D.Y.
Drawn by: D.Y.
Checked by:
Approved by:
Quantities by:

KILL VAN KULL, NEW YORK
NEW YORK HARBOR
COLLECTION AND REMOVAL OF DRIFT PROJECT
LIMITED REEVALUATION REPORT
PLAN NO. 3
ST. GEORGE FERRY TERMINAL TO HOWLAND HOOK, NEW YORK

Approved Recommended:
Approved by:
SHEET REFERENCE NUMBER:
DATE: MARCH 1997
SCALE: AS SHOWN
SHEET 4 OF 10

Frederic R. Harris, Inc.
300 East 42nd Street
New York, New York 10017

100' 0 100' 200'
1"=100'

FILE NO.

Fig 2

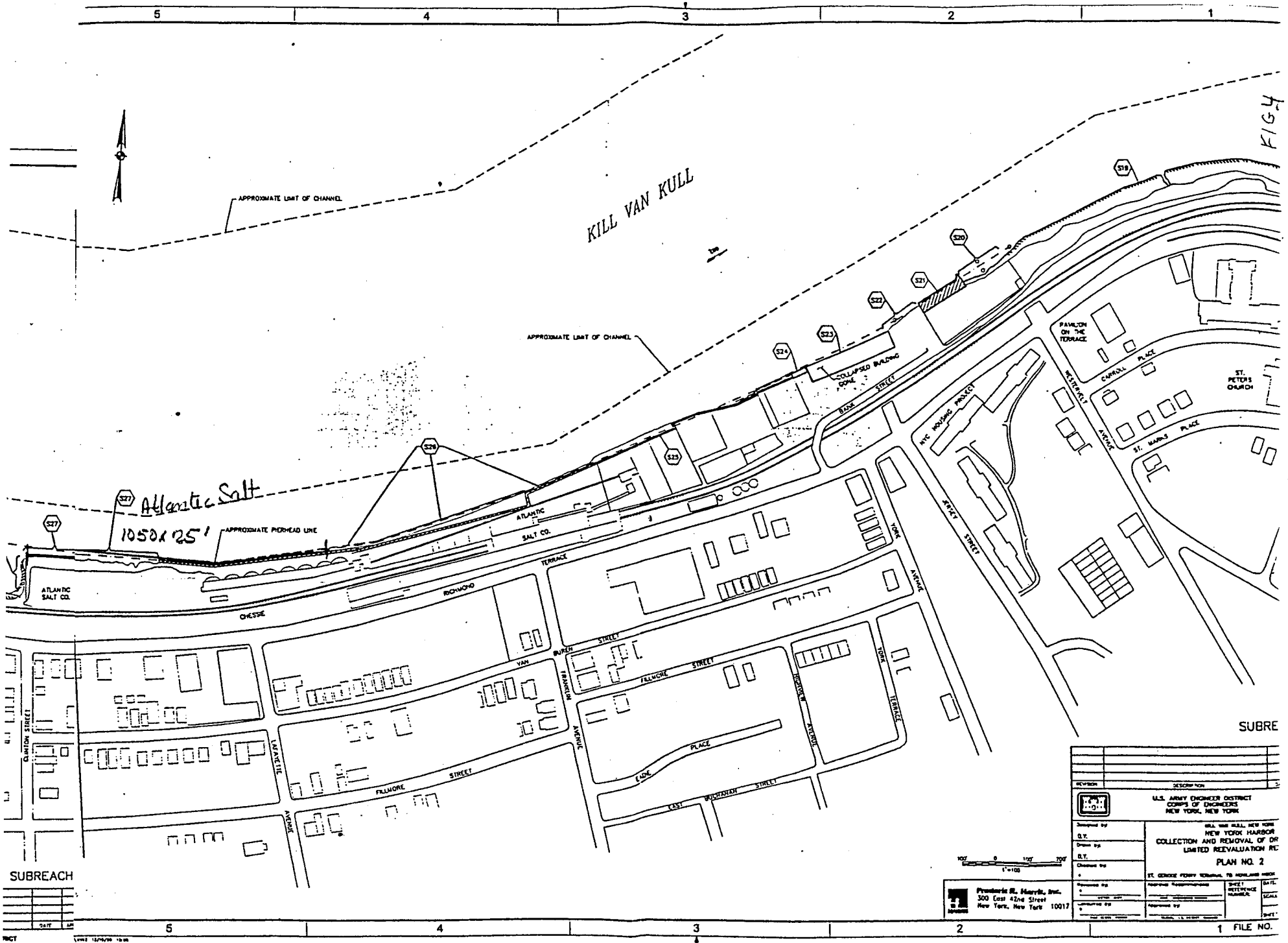
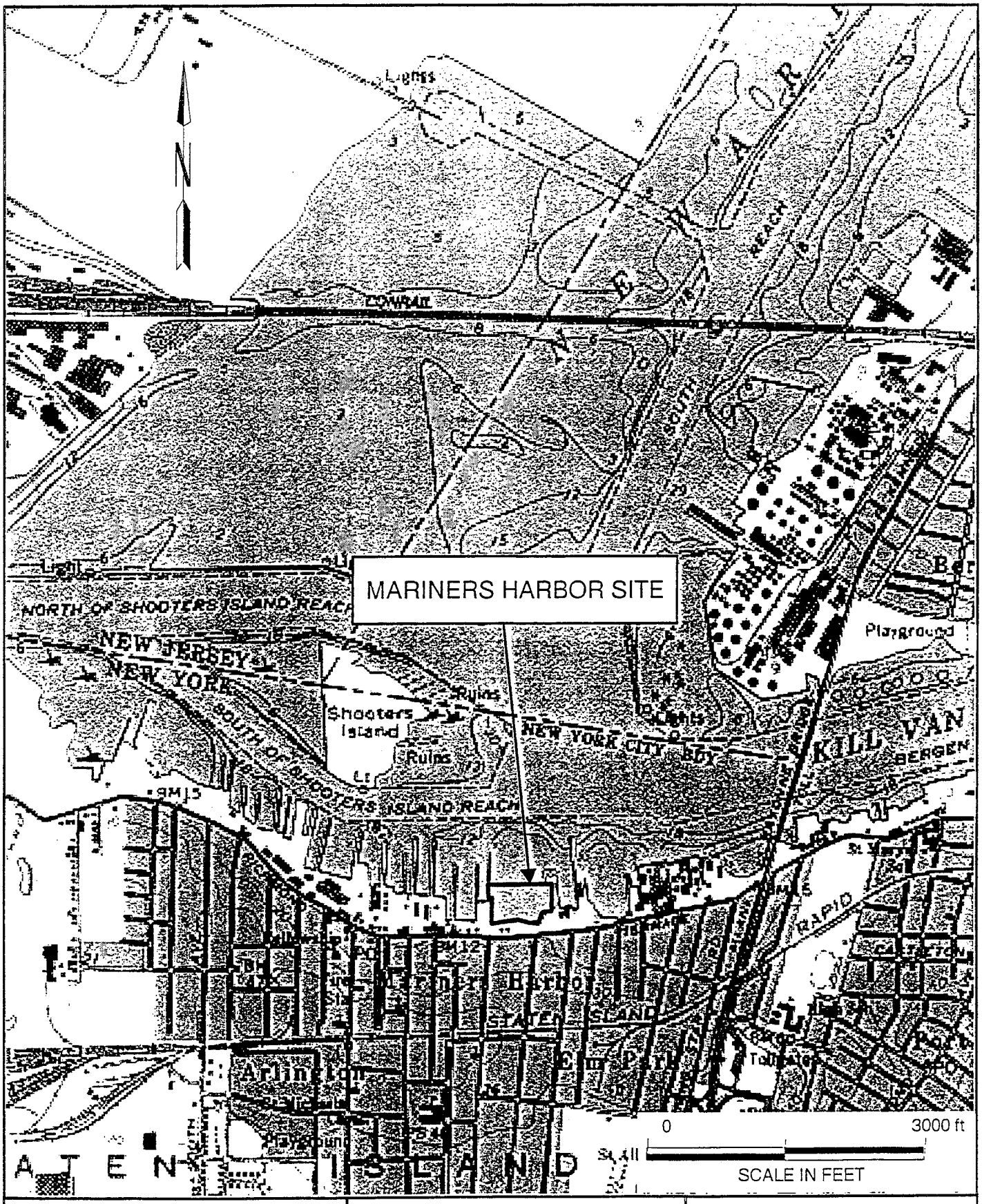
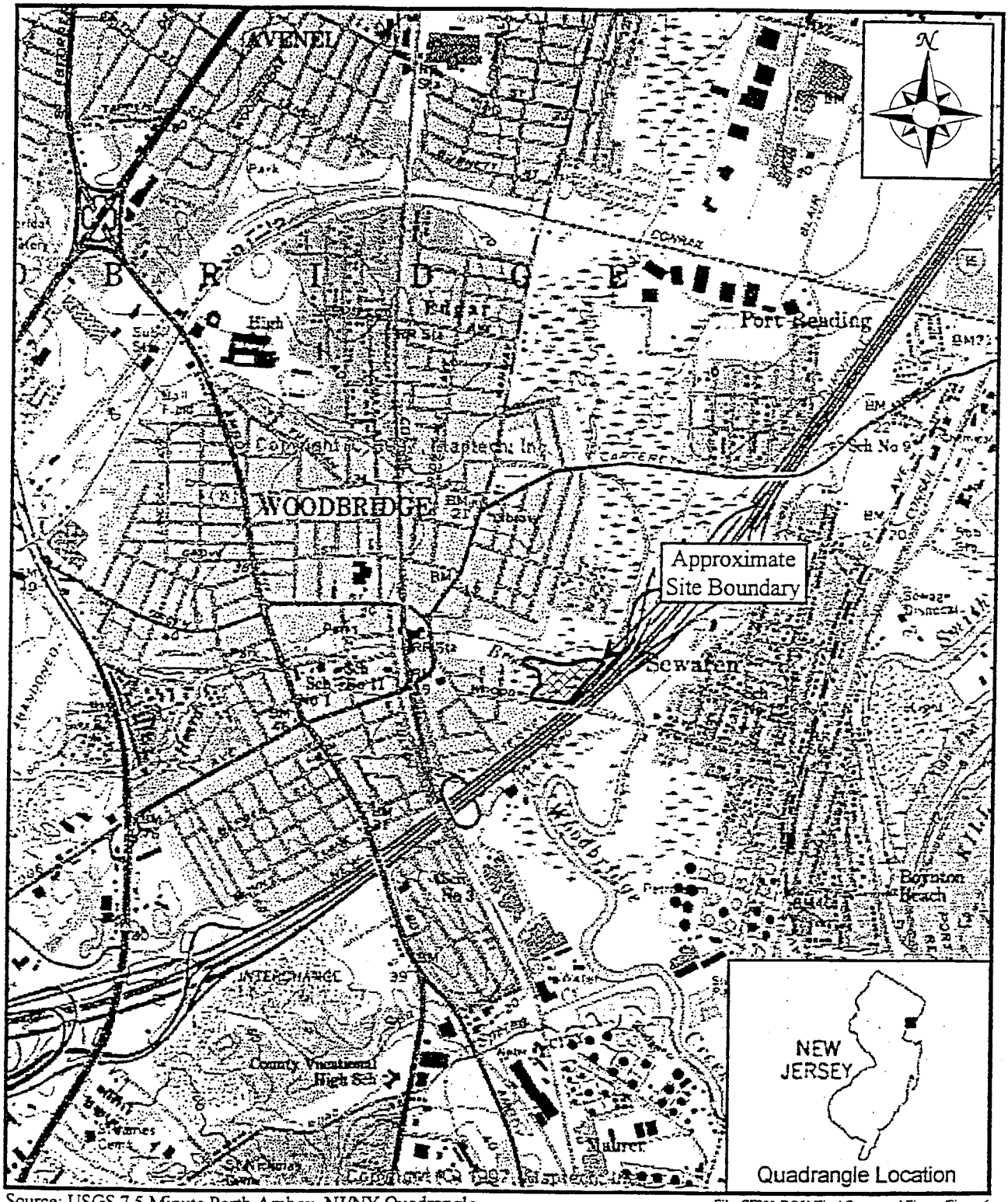

KILL VAN KULL
APPROXIMATE LIMIT OF CHANNEL
APPROXIMATE LIMIT OF CHANNEL
APPROXIMATE PIERHEAD LINE
Atlantic Salt
1050x25'
ATLANTIC SALT CO.
ATLANTIC SALT CO.
COLLAPSED BUILDING ZONE
BANK STREET
PAVILION ON THE TERRACE
CARROLL PLACE
ST. PETER'S CHURCH
ST. MARK'S PLACE
NYC HOUSING PROJECT
JERSEY STREET
YORK AVENUE
RICHMOND TERRACE
CHESSIE
VAN BUREN STREET
FRANKLIN AVENUE
FILLMORE STREET
HUDSON AVENUE
YORK TERRACE
PLACE
EAST BRIGHTMAN STREET
LAFAYETTE AVENUE
CLINTON STREET
S18
S19
S20
S21
S22
S23
S24
S25
S26
S27
SUBREACH
SUBRE
100' 0 100' 200'
1"=100'
Frederic R. Harris, Inc.
300 East 42nd Street
New York, New York 10017
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NEW YORK, NEW YORK
NEW YORK HARBOR
COLLECTION AND REMOVAL OF DR
LIMITED REEVALUATION RE
PLAN NO. 2
FILE NO.

FIG 4



U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS NEW YORK, NEW YORK	**NEW YORK & NEW JERSEY HARBOR NAVIGATION STUDY MITIGATION PLAN**	**FIGURE X** **MARINERS HARBOR SITE**

FIG 5



Source: USGS 7.5 Minute Perth Amboy, NJ/NY Quadrangle

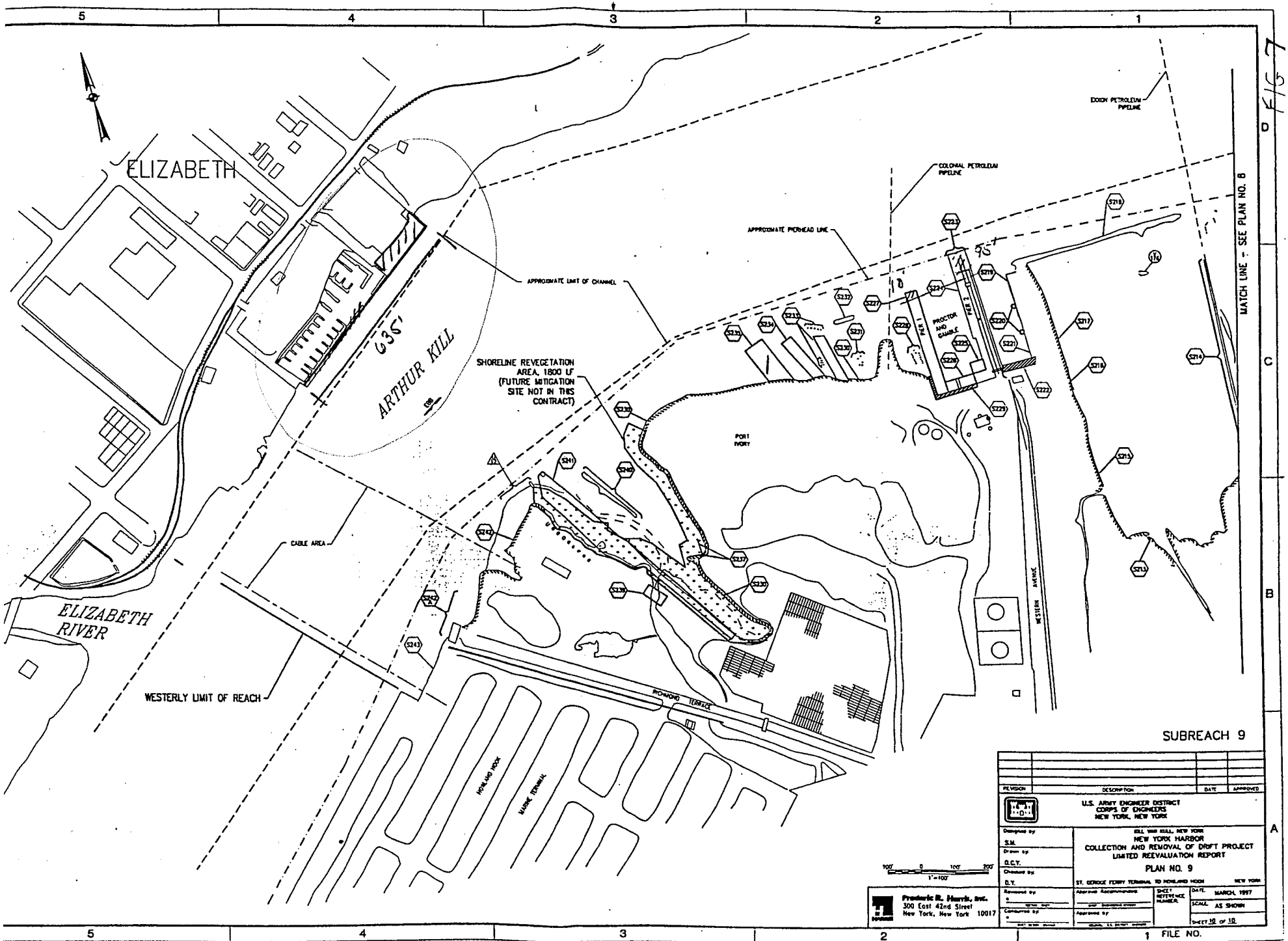
File: CE300-DO51/Final Conceptual Figures/Figure 6

2000 0 2000

1 inch = 2000 feet

FIG 6

Figure 6 Site Location Map - Woodbridge (South) Mitigation Site



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NEW YORK, NEW YORK

Designed by: S.M.
Drawn by: D.C.Y.
Checked by: D.Y.
Reviewed by:
Compared by:
Approved Recommended:
Approved by:

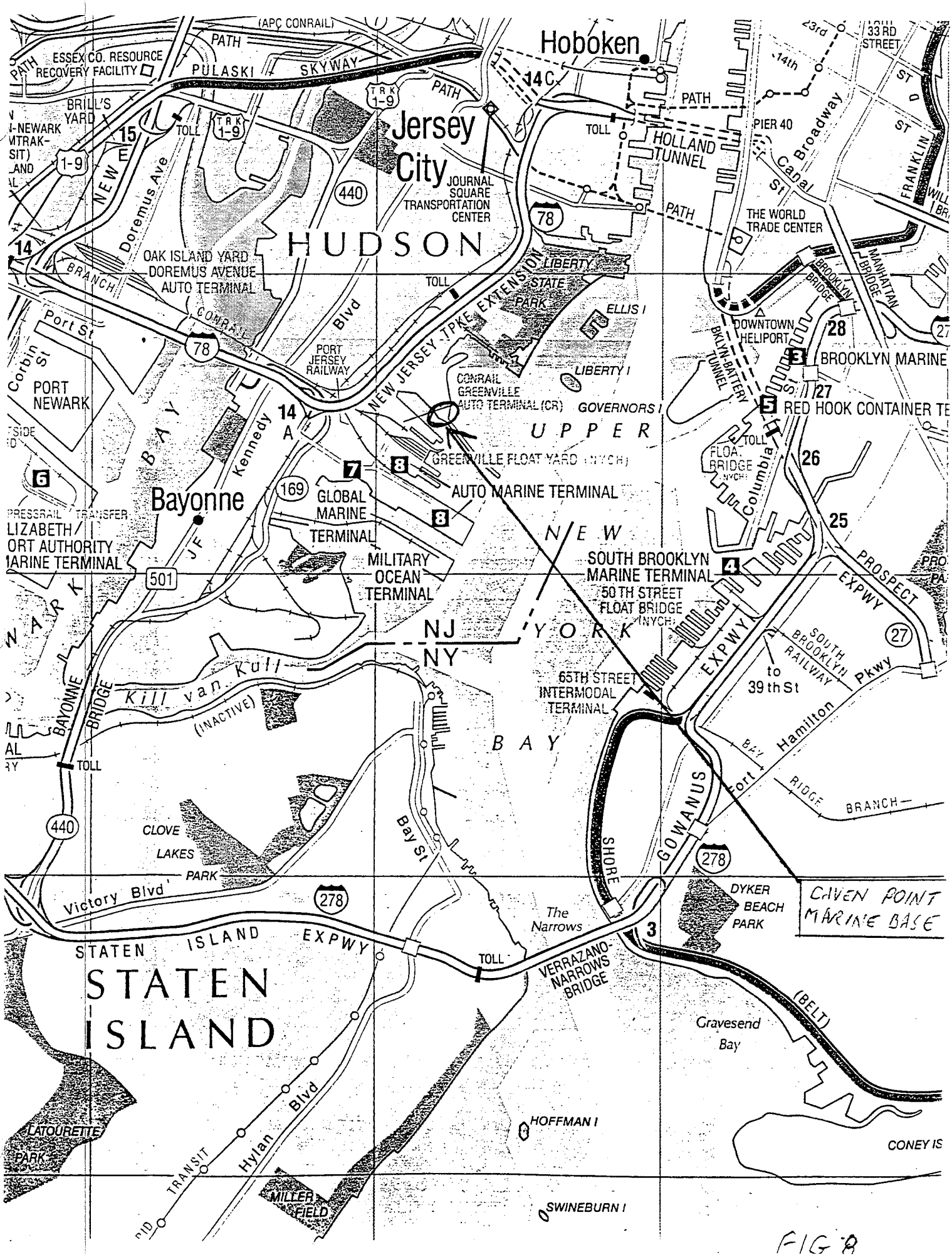
KILL VAN KULL, NEW YORK
NEW YORK HARBOR
COLLECTION AND REMOVAL OF DRIFT PROJECT
LIMITED REEVALUATION REPORT
PLAN NO. 9
ST. GEORGE FERRY TERMINAL TO HOWLAND HOOK NEW YORK

SHEET REFERENCE NUMBER
DATE: MARCH, 1997
SCALE: AS SHOWN
SHEET 10 OF 10

100' 0 100' 200'
1"=100'

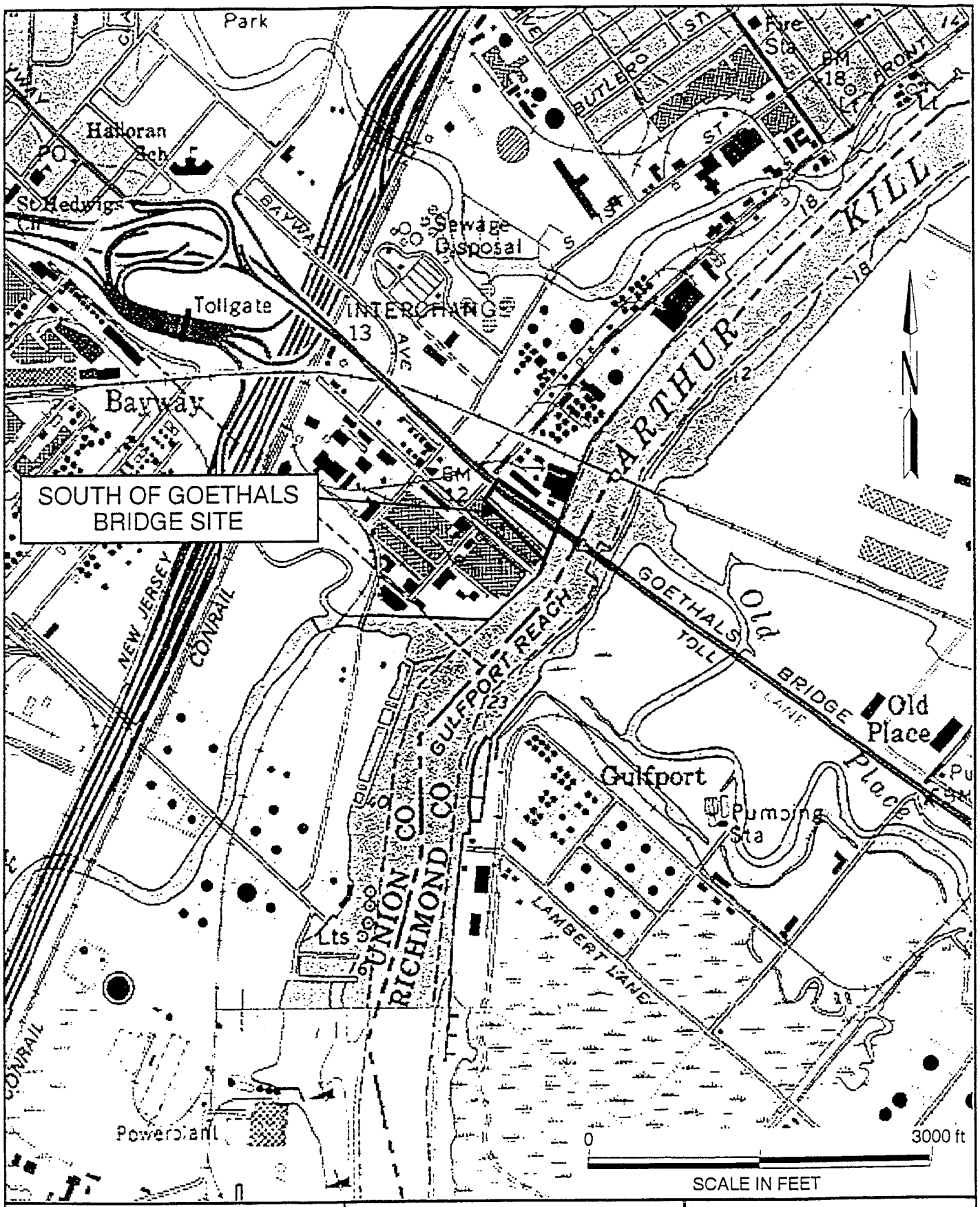
Frederic R. Harris, Inc.
300 East 42nd Street
New York, New York 10017

FILE NO.



Hoboken
Jersey City
HUDSON
Bayonne
STATEN ISLAND
UPPER NEW YORK BAY
NJ
NY
ESSEX CO. RESOURCE RECOVERY FACILITY
PULASKI SKYWAY
PATH
BRILL'S YARD
TOLL
JOURNAL SQUARE TRANSPORTATION CENTER
HOLLAND TUNNEL
PIER 40
THE WORLD TRADE CENTER
OAK ISLAND YARD DOREMUS AVENUE AUTO TERMINAL
Doremus Ave
NEW E
BRANCH
CONRAIL
Port St
Corbin St
PORT NEWARK
PORT JERSEY RAILWAY
NEW JERSEY TPKE EXTENSION
LIBERTY STATE PARK
ELLIS I
LIBERTY I
GOVERNORS I
CONRAIL GREENVILLE AUTO TERMINAL (CR)
GREENVILLE FLOAT YARD (NYCH)
AUTO MARINE TERMINAL
GLOBAL MARINE TERMINAL
MILITARY OCEAN TERMINAL
SOUTH BROOKLYN MARINE TERMINAL
50 TH STREET FLOAT BRIDGE (NYCH)
65TH STREET INTERMODAL TERMINAL
DOWNTOWN HELIPORT
BKLYN-BATTERY TUNNEL
BROOKLYN MARINE
RED HOOK CONTAINER TE
FLOAT BRIDGE (NYCH)
Columbia St
Kennedy
JF
BAY
Kill van Kull
(INACTIVE)
BAYONNE BRIDGE
CLOVE LAKES PARK
Victory Blvd
Bay St
The Narrows
VERRAZANO-NARROWS BRIDGE
GOWANUS
SHORE
EXPWY
PROSPECT EXPWY
SOUTH BROOKLYN RAILWAY
to 39 th St
Fort Hamilton Pkwy
BAY RIDGE BRANCH
DYKER BEACH PARK
CAVEN POINT MARINE BASE
Gravesend Bay
(BELT)
CONEY IS
HOFFMAN I
SWINEBURN I
MILLER FIELD
Hylan Blvd
TRANSIT
LATOURETTE PARK
PRESSRAIL TRANSFER
LIZABETH/ ORT AUTHORITY MARINE TERMINAL
33 RD STREET
FRANKLIN
Broadway
Canal St
MANHATTAN BRIDGE
BROOKLYN BRIDGE

FIG 8



U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NEW YORK, NEW YORK

NEW YORK & NEW JERSEY HARBOR NAVIGATION STUDY MITIGATION PLAN

FIGURE X

SOUTH OF GOETHALS BRIDGE SITE

Fig 9