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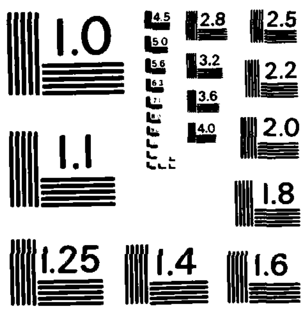

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Stage 2 Report for Reformulation Phase I General Design Memorandum

Cleveland Harbor, Ohio

Volume II, Appendices

US Army Corps of Engineers
Buffalo District

July 1982

Revised February

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This Reformulation Phase I GDM study is to develop a final plan to modify Cleveland Harbor for safe and efficient operation of 1,000-foot vessels in the Lakefront Harbor. The recreational fishing plan recommended in the 1976 Feasibility Report will also be reevaluated. However, as will be discussed in Section II of the Main Report, "Problem Identification," during coordination of the Plan of Study for this study and subsequent correspondence, local interests expressed the need for further modifications to the general navigation features of Cleveland

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Harbor in the interest of commer-'al navigation. These additional modifications include: (1) deepening the Cuya: oga River such that the depth of the navigational channel would be compatible with the Great Lakes System's draft of 25.5 feet (Note: The Cuyahoga River is presently authorized for a 23-foot project depth and can accomodate a vessel loaded to about 21 feet. Thus, vessels are f rced to lighter (reduse their draft) or come into Cleveland Harbor light-loa before proceeding upriver.); (2) modify the Cayuhoga River navigation channel at various locations where undue vessel delays are encountered due to physical restrictions in the channel; and (3) completion of the authorized but uncomplete improvements on the Old River (discussed in greater detail in Section II of the Main Report, "Problem Identification"). Therefore, the original scope of this study was expanded to include formulation, assessment and evaluation (both economic and environmental) of these proposed additional modification plans.

APPENDIX A
GEOTECHNICAL

CLEVELAND HARBOR, OHIO
STAGE 2 REPORT
of
REFORMULATION PHASE I GENERAL DESIGN MEMORANDUM

U.S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, NY 14207

CLEVELAND HARBOR, OH
STAGE 2 REPORT
of
REFORMULATION PHASE I
GENERAL DESIGN MEMORANDUM

APPENDIX A
GEOTECHNICAL

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GEOTECHNICAL

A1. REGIONAL GEOTECHNICAL INFORMATION

A1.1 Physiography.

Cleveland Harbor is located within the Lake Plains section of the Central Lowlands Physiographic Province. The Lake Plains section is characterized by a narrow strip of relatively flat terrain lying along the south shore of Lake Erie. The region is mantled by lake deposits and crossed by beach ridges associated with former glacial lakes. South of the Central Lowlands Province, the glaciated Allegeny Plateau section of the Appalachian Plateaus Province rises gradually to an elevation of about 1,200 feet. The boundary between the two provinces is the Portage Escarpment which crosses the region in an approximately northeast - southwest line. The northwestern edge of the Allegeny Plateau has been deeply dissected by streams that flow across the Portage Escarpment. The Cuyahoga River drains an area of about 810 square miles and enters Lake Erie at Cleveland, OH.

A1.2 Bedrock Geology.

Bedrock underlying northeastern Ohio consists of a thick sequence of Paleozoic age sedimentary strata. The predominant rock types are shale, sandstone and conglomorates of the Devonian, Mississipian and Pennsylvanian Systems (Figure A1). The Upper Devonian rocks in northeastern Ohio consist of shales of the Ohio and Chagrin Formations. These shales are prominently displayed in cliffs along Lake Erie and in the walls of major river valleys. The Ohio and Chagrin Formations represent fine clastic sediments that were deposited in the western portions of the Appalachian Basin, a subsiding shallow sea trough. Most of the accumulated sediments were derived from a narrow belt of mountains that occupied the eastern margin of North America during the Late Devonian. Overlying the Devonian shales are Mississippian age rocks including the Bedford Shale, Berea Sandstone and Cuyahoga Group (shales). Szmuc (1970) describes the Mississippian rock units in northern Ohio as having a composite thickness of about 1,000 feet and consisting of fine to coarse grained clastics that were deposited in the northwestern part of the Appalachian Basin. The most prominent of the Mississippian strata is the Berea Sandstone which attains a maximum thickness cf about 200 feet. The youngest exposed rocks in northern Ohio are a succession of sedimentary sequences including sandstones, shales, limestones, and coals of Pennsylvanian age. In northeastern Ohio, the Pennsylvanian System is about 1,100 feet thick but thickens considerably to the south. Of the various Pennsylvanian age rocks present in northeastern Ohio, the Sharon Conglomorate is probably the best known because of its widespread distribution and exposure.

A1.3 Surficial Geology.

The primary unconsolidated surficial deposits overlying bedrock in northeastern Ohio are of glacial origin, having been deposited either directly by ice sheets, by meltwater streams flowing from retreating ice, or in glacial lakes that were predecessors to present Lake Erie. Localized deposits of alluvium are found filling the major river valleys and were formed by present day streams that flow into Lake Erie.

Three major advances of Wisconsin glacial ice are reported as occurring in northeastern Ohio. They have been classified as the Tazewell, early Cary and late Cary substages (Winslow et. al., 1953). Each of these substages resulted in the deposition of glacial drift in the form of till. Most of the glacial drift at the surface in Cuyahoga County is late Cary in age (Winslow, et. at., 1953). Late Cary till is a silty, clayey, sparingly pebbly boulder clay which mantles bedrock and earlier glacial drift.

As the last of the ice sheets retreated in late Wisconsin time, northward flowing drainage was impounded at the ice front and a series of glacial lakes were formed. Two lake stages have been recognized in northeastern Ohio which have been termed Lakes Whittlesey and Warren. Beach and glaciolacustrine deposits mark the boundaries of these glacial lakes and mantle the region defined as the Lake Plains section of the Central Lowlands Province. Beach deposits of sand and gravel were formed at southern margins of the glacial lakes whereas, glaciolacustrine clays were deposited in deeper waters.

The most recent surficial deposits which overlie glaciolacustrine clays is alluvium which fills the major river valleys. Deposits of alluvium in northern Ohio consist of poorly sorted, poorly bedded silts and sands.

A2. LOCAL GEOTECHNICAL INFORMATION

A2.1 Subsurface Explorations.

No subsurface explorations were performed during this phase or any earlier phase of this study. Beginning in March 1981, a survey was conducted to collect available information on soil and rock in this study area. Subsurface explorations were available from other studies performed by Buffalo District. In addition, information was obtained from public and private offices with interests in the study area. The plan of subsurface explorations is shown on Plates A1 and A2.

a. Corps of Engineers Programs - A total of 72 borings from other studies and projects were used in analyzing subusrface conditions for this Phase I study. These studies and projects include:

Cleveland Harbor, Ohio, 1958 Project Modification, Design Memorandum No. 3, Replacement of Bridge No. 32, U.S. Army Engineer District, Buffalo, September 1965; Cleveland Harbor, OH, 1958 Project Modification, Design Memorandum No. 2, Replacement of Bridge No. 33, U. S. Army Engineer District, Buffalo, December 1961; Cleveland Harbor, OH, East Breakwater Major Rehabilitation, Design Memorandum, U.S. Army Engineer District, Buffalo, February 1979; Cleveland Harbor, OH, Rehabilitation of West Breakwater, Design Analy[illegible]s, U.S. A[illegible]y Engineer District, Buffalo, March 1978; Cleveland Harbor, OH, [illegible] [illegible]fa[illegible] exploration, Contract No. DACW 49-78-B-0030, 26 April 1978; Clevelan[illegible] [illegible]rbo[illegible], OH, Sediment Sampling, Swedish Foil Sampler, Contract No. DACW 49-78-M-0775, July 1978; Cleveland Harbor, OH, Cuyahoga River

Proposed Channel Extension, 9 September 1941, Drawing No. 23-A-19; Cleveland Harbor, OH, Cuyahoga River Improvement, 26 July 1940, Drawings No. 23-A-9, 23-A-10; Cleveland Harbor, OH, Cuyahoga River Improvement, Cut 3-A, 26 April 1939, Drawings No. 23-A-2, 23-A-1; Cleveland Harbor, OH, Cuyahoga River Improvements, 26 January 1940, Drawings No. 23-A-4, 23-A-5, 23-A-6.

b. Programs by Others - A total of 106 borings obtained from public and private offices were used in analyzing subsurface conditions for this report. These offices include: Bessemer and Lake Erie Railroad Company, P.O. Box 750, Greenville, PA, 16125; Norfolk and Western Railway Company, Lake Region, Box 6119, Cleveland, OH 44101; Consolidated Rail Corporation, 15 North, 32nd Street, Philadelphia, PA, 19104; Ohio Department of Transportation, District 12, Box 05188 Newburgh Station, Cleveland, OH 44105; Cuyahoga County Engineer, 1370 Ontario Street, Cleveland, OH 44113; City of Cleveland, Division of Engineering and Construction, Room 518, City Hall, Cleveland, OH 44114; David V. Lewin Corporation, The Arcade, Cleveland, OH 44114.

A2.2 Test Data.

a. Corps of Engineers Program - Field and laboratory testing was performed as outlined below.

(1) Field Testing - Penetration tests were performed in conjuction with most of the subsurface explorations conducted by the Corps of Engineers. In addition, field vane shear tests were performed during subsurface explorations for the Cleveland Harbor, OH, East Breakwater Major Rehabilitation, Design Memorandum. These test results are not presented in this report due to the preliminary nature of this study.

(2) Laboratory Testing - A variety of laboratory tests were run on samples obtained during exploration programs for other studies. A summary of these test results is not given here. Utilization of any laboratory test results is discussed in Section A3.3, Design Parameters.

b. Programs by Others - Penetration tests were performed in conjunction with most of the subsurface explorations obtained from public and private offices. Results of these tests are discussed in Section A3.3, Design Parameters. A limited number of laboratory tests were also performed, but these are not included in this report. Utilization of any laboratory test results is discussed in Section A3.3, Design Parameters.

A2.3 Surficial Geology.

Using available boring information subsurface conditions were investigated for the Outer Harbor, the Cuyahoga River, and the Old River. This was done to determine the soil conditions that would exist for deepening the West Entrance Channel and for any breakwater extensions that were built or modifications that were made at the West Entrance. The soil materials at the West Entrance consist of a thin veneer of sands overlying silts and clays, which become stiffer with depth. These are underlain by glacial till at some depth. The soil materials that would be excavated if the West Basin, East Basin, or East Entrance 'hannel are deepened would generally be silts and clays which are soft in consistency.

Both the Cuyahoga and Old Rivers lie over a buried valley. Three separate strata have been identified in this area. These include the following surficial deposits listed in order of increasing depth:

- Alluvium. These soils generally consist of poorly sorted, poorly bedded silty sand and gravel. Deposition of this material is associated with recent fluvial processess.

- Glaciolacustrine Clay. Soft silts and clays deposited within glacial lakes formed by the impoundment of water at the front of retreating glacial ice.

- Glacial Till. This soil stratum consists of medium stiff to stiff sandy gravelly clay deposited directly by glacial ice. It is likely that material classified as glacial till represents drift deposited by more than one glacial advance.

A2.4 *Bedrock Geology*.

Bedrock underlying Cleveland Harbor consists of deeply buried shale of the Chagrin Formation. The Chagrin Formation has been described by Szmuc (1970) as a soft blue-grey shale inter stratified with a few siltstone layers. Outcrop and well data show that the formation in the vicinity of Cleveland has a total thickness of about 500 feet of which the upper 175 feet is exposed above lake level. South of the harbor the Cleveland Member of the Ohio Shale has been mapped as occurring above the Chagrin Shale. The Cleveland Member is described as a black, fissile bituminous shale, varying from 20 to 50 feet in thickness in the Cleveland area.

Bedrock in the area dips to the south at about 20 feet per mile. The rocks contain few structural features other than small monoclinial folds and minor faults.

The existing Cuyahoga River Valley is underlain by a pre-glacial buried valley which has been cut into the underlying bedrock to a depth of more than 300 feet below sea level. Winslow et. al., (1970) reports that the buried valley underlying the present Cuyahoga River system was formed by a north flowing river and was subsequently filled with a complex and very thick sequence of interbedded sands, silts, clays, and till. The approximate contours on top of rock from existing maps were utilized with available boring data in the development of typical design parameters (depth to bedrock) for the various river deepening alternatives. From this analysis it is concluded that bedrock will not be encountered in any of the project alternatives involving deepening.

A2.5 Sedimentation.

The principal source of sediment which deposits within Cleveland Harbor is delivered by the Cuyahoga River. The Cuyahoga River is approximately 100 miles in overall length and drains a watershed of about 810 square miles. As shown on Figure A2, numerous tributaries feed into the river over its entire length. The major portion of the basin lies within the glaciated

Allegeny Plateau which is underlain by predominantly end and ground moraine. As the river flows north towards Cleveland Harbor, it crosses the Portage Escarpment where it enters the Lake Plains Section of the Central Lowland Province underlain primarily by lacustrine deposits of silt and clay. The lower 5.8 miles of the river is part of the existing Federal navigation project at Cleveland Harbor. River elevations vary from lake elevations at the mouth to an elevation of approximately 1,290 feet at its headwaters. The average rate of fall of the river is 7.1 feet per mile.

A study of erosion and sedimentation within the watershed was conducted as part of the Cuyahoga River Restoration Study. In this study, a 1-year sediment sampling program was conducted on the river by the U.S. Geological Survey. The results of the sediment sampling program indicated that approximately 20,000 tons of suspended sediment passed a gage established at Old Portage, OH, (river mile 40), whereas 235,000 tons was measured at a permanent gage at Independence, OH, (river mile 13.8). The drainage area between these two gages is about 300 square miles and has been described as the most prolific source area of sediment within the watershed (Figure A2). The study identified two primary sources of sediment within this reach of the river. These are: (1) sediment contributed by streambank erosion and (2) sediment contributed by sheet and rill erosion in the upland areas of the watershed. Intensive studies of each of these natural sediment sources was performed. Results of these studies revealed that upland (sheet and rill) erosion contributes significantly (about 50 percent) while streambank erosion is a minor contributor (about 5 percent). Other major sources of sediment within the watershed are discharges of municipal and industrial waste.

A3. GEOTECHNICAL DESIGN

A3.1 General.

Several different alternatives were considered for improvements to the Lakefront Harbor area, Cuyahoga River and Old River. The various alternatives considered are discussed in the Main Report. In the design and analysis of these alternatives, presumptive values were used for the soil properties based on material description, penetration tests and extremely limited laboratory test results. A preliminary construction materials survey was performed in March 1982 to determine possible sources of stone materials.

A3.2 Project Elements.

Four series of improvements are being addressed in this study. These include: improvements to the Lakefront Harbor, improvements to the Old River, deepening the Cuyahoga River and reducing congestion in the Cuyahoga River.

a. Lakefront Harbor - The first series of alternatives addresses improvements to the Lakefront Harbor. This series includes Alternative 1 - "All-Weather" East Entrance Plan, Alternative 2 - "Fair-Weather" West Entrance Plan, Alternative 3 (Options A and B) - "All-Weather" West Entrance Plan and Alternative 4 - Combined "All-Weather" East Entrance and "Fair-Weather" West Entrance Plan. These alternatives are various combinations of breakwater extensions, breakwater modifications, breakwater removal, fishery habitat areas and/or deepening.

b. Old River - This series of alternatives considers improvements to the Old River. Alternative 5 (Option A) includes removing the existing Baltimore and Ohio Railroad Bridge and constructing a new vertical lift railroad bridge, widening and deepening the existing channel and constructing new bulkheads. Alternative 5 (Option B) includes constructing a Baltimore and Ohio Railroad interchange system on the east side of the river, removing the Baltimore and Ohio Railroad Bridge No. 23, widening and deepening the existing channel and constructing new bulkheads.

c. Deepen Cuyahoga River - This series of alternatives considers deepening the Cuyahoga River. Alternative 6 (Option A) includes deepening the navigation channel to 25.5 feet, replacing existing bulkheads along most of the channel, relocating utilities and replacing bridge fenders. Alternative 6 (Option B) is the same as Option A except it includes deepening the navigation channel to 28 feet instead of 25.5 feet.

d. Reduce River Congestion - Many of the railroad bridges cause congestion along the river. This series of alternatives considers replacing some of these bridges and other improvements to various congestion points along the Cuyahoga River. Alternative 7 (Option A) included replacing the Conrail Bridge at the mouth of the river, but this was eliminated from further consideration during initial screening of alternatives. Alternative 7 (Option B) is located near the Detroit-Superior Viaduct at approximately River Mile 1.0 and includes widening the navigation channel, replacing existing bulkheads, constructing new bulkheads and replacing an existing ship unloading building. Alternative 7 (Option C) is located near Columbus Road at approximately River Mile 1.5 and includes replacing both the Columbus Road Bridge and Cleveland Union Terminal Bridge, widening the navigation channel, constructing new bulkheads and relocating a trailer and storage bin. Alternative 7 (Option D) is located near the Inner Belt Freeway at approximately River Mile 3.0 and includes replacing the Norfolk and Western Railroad Bridge, widening the navigation channel, constructing new bulkheads, relocating Western Union telephone pipes, and relocating existing railroad track. Alternative 7 (Option E) is located near West 3rd Street at approximately River Mile 3.6 and includes widening the navigation channel, constructing new bulkheads, and relocating Feldman Mechanical Contractors Building. Alternative 7 (Option F) is located near the Conrail Railroad Bridge at approximately River Mile 4.0 and includes removal of the Conrail Railroad Bridge and center pier by others, widening the navigation channel, replacing existing bulkheads, and relocating Mobil Oil Corporation pipes. Alternative 7 (Option G) is located near Jefferson Avenue at approximately River Mile 4.3 and includes removing the Jefferson Avenue Bridge abutments, widening the navigation channel, replacing existing bulkheads and relocating city of Cleveland power cable.

A3.3 Design Parameters.

Presumptive soil parameters for use in the design of bulkheads along the Cuyahoga and Old Rivers were developed based on boring log descriptions, blow counts, and extremely limited laboratory test results. The recommended design parameters are shown in Table A1. The laboratory test results mentioned above are not included in this report, but were used as a guide along with the references shown in Tables A2, A3, and A4 to arrive at the recommended design parameters.

A3.4 Breakwaters and Foundations.

Due to the preliminary nature of this study and the unlikelihood that Alternatives 2, 3 (Options A and B) and 4, would be carried into Stage 3 study, detailed analyses of the breakwater sections and foundations were not performed. Preliminary analyses showed that the typical section developed for the Breakwater Extensions in Alternatives 2, 3 (Options A and B) and 4 did not require any revisions. A 25-foot berm was added to the typical section developed for the New West Arrowhead Breakwater in Alternatives 2 and 4 to offset additional driving forces (reduced structural stability) resulting from the additional crest width.

A3.5 Sedimentation Analysis.

An analysis of sediment deposition within Cleveland Harbor was performed in order to assess the impacts of the various project alternatives involving deepening on projected annual maintenance dredging requirements.

Cleveland Harbor consists of a Lakefront Harbor area and an Inner Harbor consisting of the lower deep draft section of the Cuyahoga River. The Lakefront Harbor is formed by the East and West Breakwaters and is divided into an East and West Basin. The Inner Harbor includes the improved lower 5.8 miles of the Cuyahoga River and approximately 1 mile of the Old River, the former outlet of the Cuyahoga River. Two entrys to the harbor exist. The west (main) entrance is known as the Lake Approach Entrance Channel and is located between the East and West Arrowhead Breakwaters. The second entrance is located at the east end of the East Basin.

The Corps of Engineers is responsible for dredging Cleveland Harbor to authorized depths as shown on Table A5. The dredging operations have historically been divided into contract dredging of the Cuyahoga and Old Rivers and Government hopper dredging in the Lakefront Harbor. A summary of the dredging volumes at Cleveland Harbor between 1950 and 1979 are shown on Table A6.

The principal source of sediment which deposits in Cleveland Harbor is delivered by the Cuyahoga River. As the river enters the relatively quiet waters of the upper navigation channel, bedload consisting of primarily sand settles out very rapidly due to the decreased transport capacity of the river. As the sediment laden waters moves through the 5.8 miles of navigation channel and into the Lakefront Harbor, progressively finer grained sediments consisting of the river's suspended load, are deposited. Only the finest suspended particles are capable of being transported completely through the harbor into Lake Erie.

At Cleveland Harbor, several factors have contributed to long-term variations in dredging requirements, many of which are independent of the total quantity of sediment actually deposited in a given year. These factors include fluctuations in lake levels, improved methods of measuring dredged quantities, availability of funds for dredging in a particular year, reduction in municipal and industrial waste input in recent years, and others. All of these factors, in combination, complicate any analysis of harbor modifications on predicting future maintenance dredging requirements.

At the present time, there is no known or commonly accepted method of estimating channel dredging requirements at alternative project depths other than by extrapolating historical trends and detailed design level studies based on hydrographic survey (National Waterways Study Report on Engineering Analysis of Waterways Systems, 1981). The second method can provide only a very rough indication of the level of maintenance dredging with increasing project depth. The NWS report presents the following general relationship between dredging volumes and project depth:

$$\left(\frac{D_1}{D_2}\right)^m = \left(\frac{V_1}{V_2}\right)$$

where: D_1 = present project depth

D_2 = alternative project depth

V_1 = present shoaling volume

V_2 = shoaling volume at alternative project depth

m = a variable which usually ranges between 3 and 5.

Generally this relationship has been applied to inland waterways (rivers) having a sand bed and where there is an abundant supply of sediment available for deposition.

It is assumed that as a result of harbor deepening at Cleveland, an increased fraction of sediment load carried by the Cuyahoga River which would normally be carried into Lake Erie will settle out. However, since only the river's suspended load would be effected by deepening, it is assumed that any increases in future dredging requirements would be minor. Following are the projected impacts to annual maintenance dredging requirements as a result of the various project alternatives presented in Appendix J:

a. Alternatives 1, 2, 3A, 3B, and 4 - Lakefront Harbor Improvements - The Lakefront Harbor was deepened in 1965 from 25 feet to present project depths of 27 to 29 feet. Figure A3 presents a plot of annual dredging volumes in the Lakefront Harbor before and after deepening. As shown, annual dredging volumes have actually been decreasing since deepening in 1965. In light of this fact, and since the Lakefront Harbor alternatives will not result in an increase in sediment supplied by the river, it is assumed that there will be no measurable increase in annual maintenance dredging as a result of the proposed deepening alternatives.

b. Alternative 5 - Old River Improvements - Since the Old River channel carries no discrete flow and receives sediment only indirectly from the Cuyahoga River it is assumed that there will be no measureable increase in annual maintenance dredging as a result of deepening.

c. Alternatives 6A and 6B - Deepening Cuyahoga River - It is believed that increasing project depth on the Cuyahoga River navigation channel will result in decreased flow velocities, therefore, an increased fraction of suspended sediment will settle out. The project depth of the Cuyahoga River was increased from 21 feet to 23 feet in 1952, however, the period of record is insufficient to identify significant differences in dredging volumes at the two depths. Therefore, in order to roughly estimate the magnitude of the projected increase, the relationship between dredging volume and project depth presented above was applied using an exponent of one. The estimated increases for each river deepening alternative are shown below:

Alternative	Present Average Annual (1) Dredging Volume at 23 Feet (cu yds)	Estimated Annual Dredging Volume at Alternative Depth (cu yds)	Estimated Increase (cu yds)
6A (25.5 Feet)	469,000	520,000	51,000
6B (28 Feet)	469,000	571,000	102,000

(1) Average Cuyahoga and Old River dredged volume between 1970 and 1979 minus 10 percent for Old River.

A3.6 Construction Materials Survey.

a. General - A materials survey was performed in March 1982 to determine possible sources of construction stone for the various structural alternatives of the Cleveland Harbor Phase I Study. The survey consisted of a file search in which the following were considered: an analysis of the results of quarry investigations, an analysis of laboratory test results, the evaluation of available service records, and the determination of interest in producing required materials on the part of quarry operators.

b. Material Types and Gradations - A number of project alternatives require structural modifications to the existing West Entrance. These alternatives include:

Alternative 1 - "Fair-Weather" West Entrance Plan;

Alternative 3 (Options A and B) - "All-Weather" West Entrance Plan; and Alternative 4 - Combined "All-Weather" East Entrance Plan and "Fair-Weather" West Entrance Plan. Details of these alternatives are presented in the Main Report.

The types of stone materials required for all of the alternatives discussed above are:

Stone Type	Size
Armor Stone	7.0 - 16.0 Tons
Underlayer Stone	0.5 - 2.0 Tons
Bedding and Core Stone	2 - 160 Pounds

c. Specific Gravity of Stone Materials - A specific gravity of 2.48 (155 pcf) was used to compute the stone sizes for the three stone types. A variation in specific gravity equal to $\pm$5 percent (2.36 to 2.60) is acceptable. It will be necessary to redesign stone sizes for any source used having a stone material whose specific gravity is not 2.48 $\pm$ 5 percent.

d. Material Quality.

(1) General - Quality requirements for each material type are discussed below. The bedding stone, armor stone, underlayer, and blanket and core have been subjected to the tests established by the Ohio River Division Laboratories, Cincinnati, OH. Test No. P-9, "Riprap and Breakwater Stone Evaluation," includes a suite of tests to determine stone durability.

(2) Armor, Underlayer and Bedding and Core Stone - The stone to be used for this purpose will be free from significant cracks, seams, and overburden spoil. The sources which are suitable for this must not show significant breakdown in freeze-thaw or wet-dry tests.

e. Material Sources.

(1) General - Armor, underlayer, bedding and core stone can be produced from the indicated sources located on Plate A3 and listed on Plate A4; "Possible Material Sources." It is possible that all the material from these sources is not suitable. The right will be reserved in the specifications to reject materials from certain localized areas, zones, strata, channels, or stockpiles when such materials are deemed unsuitable.

Selective quarrying will be required for the production of armor, bedding, underlayer, and blanket and core. The specifications will require that shale and other undesirable materials will be excluded by adequate processing.

(2) Sources - Nine convenient sources are capable of producing the required material. They are all located within a 100-mile radius of the project and will be transported by barge or truck. It should be noted that although Cleveland Quarries is a viable source, the stone has an unusually low specific gravity (approximately 2.28). The stone, however, is of good quality and has been used in the construction of a number of breakwaters on

the Great Lakes. Material source information for each material type relating number of possible sources and distances from the project site follows:

Armor Stone - 7 sources within a 100-mile radius.

Underlayer Stone - 8 sources within a 100-mile radius.

Bedding and Core Stone - 8 sources within a 100-mile radius.

TABLE A1 - Recommended Design Parameters for Soils*

Soil Types	Parameters: Unit Weight (pcf)	Friction Angle	Cohesion (psf)
Alluvium-Silty Sand and Gravel	125 (saturated)	35°	0
Glaciolacustrine Clay-soft clay	120 (saturated)	0°	500
Glacial Till-medium stiff to stiff sandy gravelly clay	123 (moist)	5°	1450+
Bedrock-shale	162		

+This value is typical, but may be as high as 2000 psf.

*Values are derived from Tables A2, A3, and A4 based on descriptions given on the boring logs, blow counts and extremely limited test data.

TABLE A2

Typical Values of Soil Index Properties

	Part. Size & Gradation: Approx. Size Range (mm) D_{max}	D_{min}	Approx. D_{10} (mm)	Approx. Range Unif. Coef. C_u	Voids: Void Ratio e_{max} (loose)	e_{cr}	e_{min} (dense)	Porosity (%) n_{max} (loose)	n_{min} (dense)	Unit Weight (lb/cu ft): Dry Wt. Min (loose)	100% Mod. AASHO	Max (dense)	Wet Wt. Min (loose)	Max (dense)	Sub. Wt. Min (loose)	Max (dense)
Granular Materials																
1. Uniform Materials																
a. Equal spheres (theoretical values)	—	—	—	1.0	0.92	—	0.35	47.6	26.0	—	—	—	—	—	—	—
b. Standard Ottawa SAND	0.84	0.59	0.67	1.1	0.80	0.75	0.50	44	33	92	—	110	93	131	57	69
c. Clean, uniform SAND (fine or medium)	—	—	—	1.2 to 2.0	1.0	0.80	0.40	50	29	83	115	118	84	136	52	73
d. Uniform, inorganic SILT	0.05	0.005	0.012	1.2 to 2.0	1.1	—	0.40	52	29	80	—	118	81	136	51	73
2. Well-graded Materials																
a. Silty SAND	2.0	0.005	0.02	5 to 10	0.90	—	0.30	47	23	87	122	127	88	142	54	79
b. Clean, fine to coarse SAND	2.0	0.05	0.09	4 to 6	0.95	0.70	0.20	49	17	85	132	138	86	148	53	86
c. Micaceous SAND	—	—	—	—	1.2	—	0.40	55	29	76	—	120	77	138	19	76
d. Silty SAND & GRAVEL	100	0.005	0.02	15 to 300	0.85	—	0.14	46	12	89	—	146‡	90	155‡	56	92
Mixed Soils																
1. Sandy or silty CLAY	2.0	0.001	0.003	10 to 30	1.8	—	0.25	64	20	60	130	135	100	147	38	85
2. Skip-graded silty CLAY with stones or rk. frag.	250	0.001	—	—	1.0	—	0.20	50	17	84	—	140	115	151	53	89
3. Well-graded GRAVEL, SAND, SILT & CLAY mixture	250	0.001	0.002	25 to 1000	0.70	—	0.13	41	11	100	140	148‡	125	156‡	62	94
Clay Soils																
1. CLAY (30 to 50% clay sizes)	0.05	0.5μ	0.001	—	2.4	—	0.50	71	33	50	105	112	94	133	31	71
2. Colloidal CLAY (-0.002 mm. ≥ 50%)	0.01	10Å	—	—	12	—	0.60	92	37	13	90	106	71	124	[illegible]	66
Organic Soils																
1. Organic SILT	—	—	—	—	3.0	—	0.55	75	35	40	—	110	87	131	25	69
2. Organic CLAY (30 to 50% clay sizes)	—	—	—	—	4.4	—	0.70	81	41	30	—	100	81	125	18	62

From: Hough, B.K., Basic Soils Engineering, John Wiley & Sons, New York, 1969.

TABLE A3

Typical Values of Unit Weights, Equivalent Fluid

Classification	Friction Angle φ (deg.)	Density or Consistency	Unit Soil Weight, γ (lb./cu. ft.)	Unit Wt. of Equivalent Fluid, γ_e (lb./cu. ft.) Active Case	Passive Case
Coarse sand or sand and gravel	45 38 32	Compact Firm Loose	140 120 90	24 29 28	820 510 290
Medium sand	40 34 30	Compact Firm Loose	130 110 90	28 31 30	600 390 270
Fine sand	34 30 28	Compact Firm Loose	130 100 85	37 33 31	460 300 280
Fine, silty sand or sandy silt	32 30 28	Compact Firm Loose	130 100 85	40 33 31	420 300 280
Fine, uniform silt	30 28 26	Compact Firm Loose	135 110 85	45 38 33	400 300 220
Clay-silt	20	Medium Soft	120 90	59 44	245 183
Silty clay	15	Medium Soft	120 90	71 53	204 153
Clay	10	Medium Soft	120 90	84 63	170 153
Clay	0	Medium Soft	120 90	120 90	120 90

From: Hough, B.K., Basic Soils Engineering, John Wiley & Sons, New York, 1969.

TABLE A4

Empiral Values for Index Properties of Granular and Cohesive Soils

Empirical values for φ, D_r, and unit weight of granular soils based on the standard penetration number with corrections for depth and for fine saturated sands

Description		Very loose		Loose		Medium		Dense		Very dense	
Relative density D_r*	0		0.15		0.35		0.65		0.85		1.00
Standard penetration no. N			4		10		30		50		
Approx. angle of internal friction φ †	25°-30°		27-32°		30-35°		35-40°		38-43°		
Approx. range of moist unit weight, γ, pcf (kN/m³)		70-100‡ (11-16)		90-115 (14-18)		110-130 (17-20)		110-140 (17-22)		130-150 (20-23)	

* USBR [Gibbs and Holtz (1957)]

† After Meyerhof (1956). φ = 25 + 25D, with more than 5 percent fines and φ = 30 + 25D, with less than 5 percent fines. Use larger values for granular material with 5 percent or less fine sand and silt.

‡ It should be noted that excavated material or material dumped from a truck will weigh 70 to 90 pcf. Material must be quite dense and hard to weigh much over 130 pcf. Values of 105 to 115 pcf for nonsaturated soils are common.

Empirical values for q_u* and consistency of cohesive soils based on the standard penetration number

Consistency		Very soft		Soft		Medium		Stiff		Very stiff		Hard
q_u, ksf	0		0.5		1.0		2.0		4.0		8.0	
N, standard penetration resistance	0		2		4		8		16		32	
γ_{sat}, pcf (kN/m³)		100-120 (16-19)				110-130 (17-20)		120-140 (19-22)				

* These values should be used as a guide only. Local cohesive samples should be tested, and the relationship between N and the unconfined compressive strength q_u established as q_u = kN.

From: Bowles, Joseph E., Foundation Analysis and Design, McGraw Hill Book Company, New York, 1977.

Table A5 - History of Authorized Depth Changes

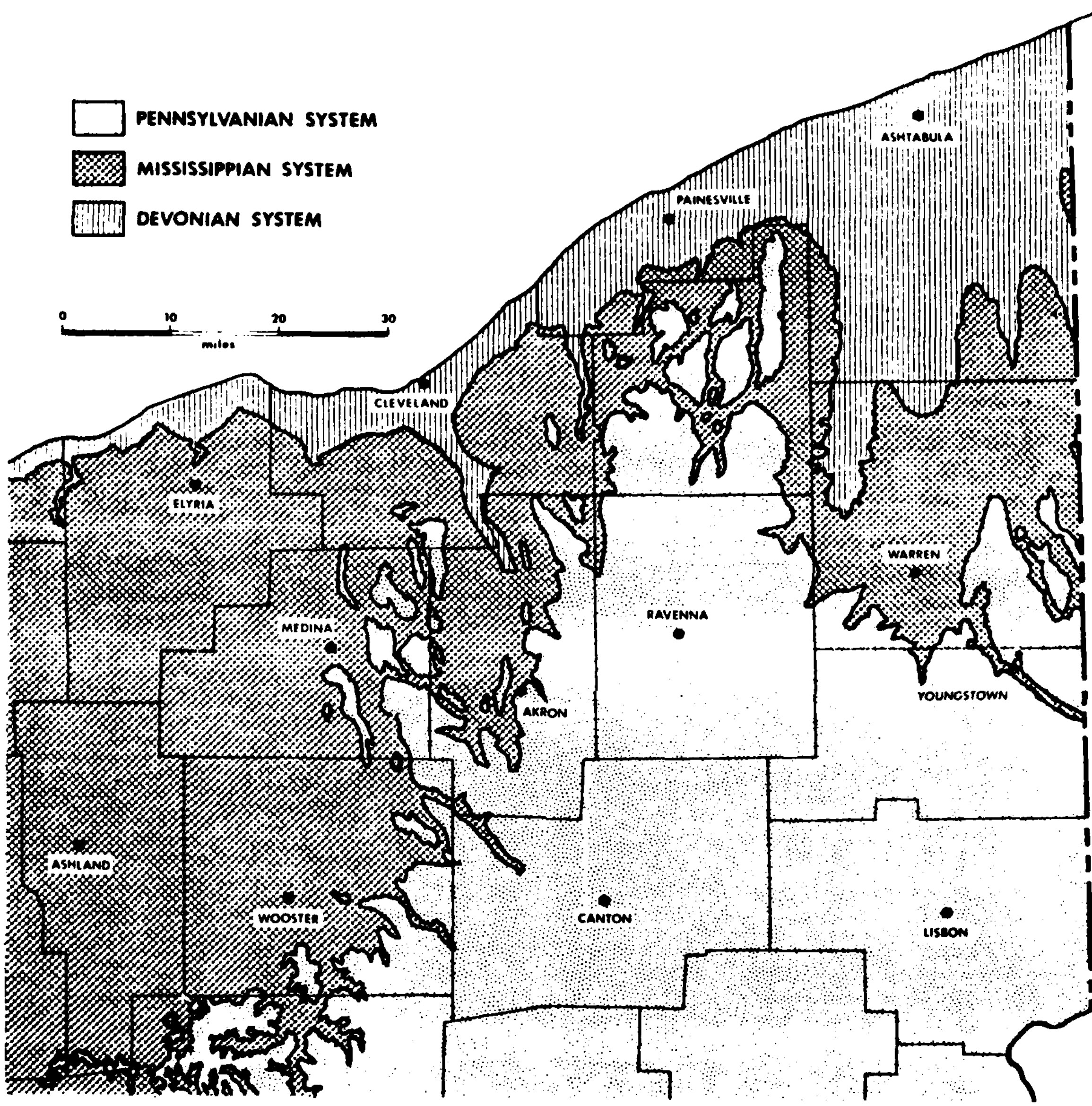
Harbor Element	Authorized Depth Change	Date Authorized	Date Completed
Outer Harbor	a. Outer Harbor and Channel between piers deepened to 19 feet	1902	*
	b. East Channel of East Basin deepened to 25 feet	1958	1965
	c. Lake Approach Channel deepened to 29 feet	1960	1965
	d. Entrance Channel deepened to 28 feet	1960	1965
	e. West Basin deepened to 28 feet	1960	1965
	f. Easterly Dock Channel deepened to 25 feet	1962	1965
Inner Harbor	a. Cuyahoga and Old Rivers deepened to 23 feet	1946	1952
	b. Lower Cuyahoga River, to Old River, deepened to 27 feet	1960	Incomplete
	d. Old River deepened to 27 feet	1966	Incomplete

*Information not available.

Table A6 - Dredged Volume in Cleveland Harbor 1950 to 1979

Year	West Basin, East Basin Entrance Channel and and River Entrance	Cuyahoga and Old Rivers	Advance Maintenance Dredging in Upper Portion of Cuyahoga River to Depth of 26 Feet	Total
1950	177,500	672,700	-	850,200
1951	222,700	598,800	-	821,500
1952	345,500	899,700	-	1,242,200
1953	199,300	448,600	-	647,900
1954	265,300	614,400	-	879,700
1955	158,200	550,800	200,000	909,000
1956	244,300	449,300	196,000	893,600
1957	471,700	573,000	259,000	1,303,700
1958	528,000	495,000	200,000	1,223,000
1959	762,400	615,000	200,000	1,577,400
1960	479,000	734,000	153,500	1,366,500
1961	630,300	557,000	186,000	1,373,300
1962	446,600	524,000	200,000	1,170,600
1963	393,400	508,000	230,000	1,131,400
1964	331,800	534,400	143,000	1,009,200
1965	560,200	495,000	200,000	1,255,200
1966	629,000	539,000	200,000	1,368,000
1967	510,300	525,000	200,000	1,235,300
1968	427,900	377,000	171,000	975,900
1969	233,400	277,700	199,600	710,700
1970	310,000	851,100	75,000	1,236,100
1971	177,900	369,900	187,000	734,800
1972	193,600	400,000	154,300	747,900
1973	-	308,400	-	308,400
1974	88,400	269,600	-	358,000
1975	-	597,100	-	597,100
1976	73,300	705,700	-	779,000
1977	157,900	598,500	-	756,400
1978	166,000	387,300	-	553,300
1979	69,400	720,300	-	789,700

NOTE: Values rounded to nearest 100 cy.
SOURCE: U.S. Army Corps of Engineers Annual Reports

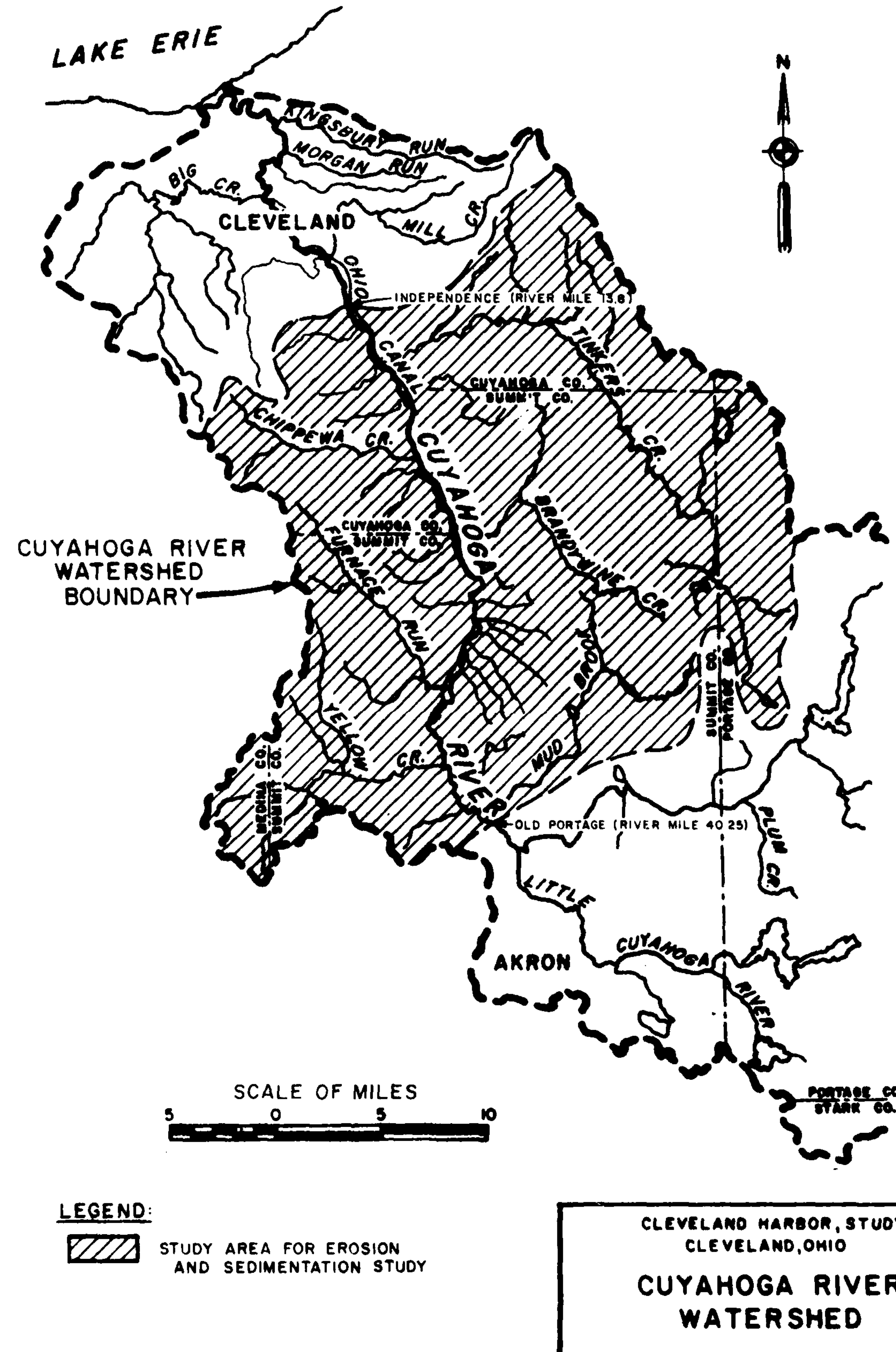


CLEVELAND HARBOR, STUDY
CLEVELAND, OHIO

BEDROCK GEOLOGY OF NORTHEASTERN, OHIO

U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

FIGURE A1

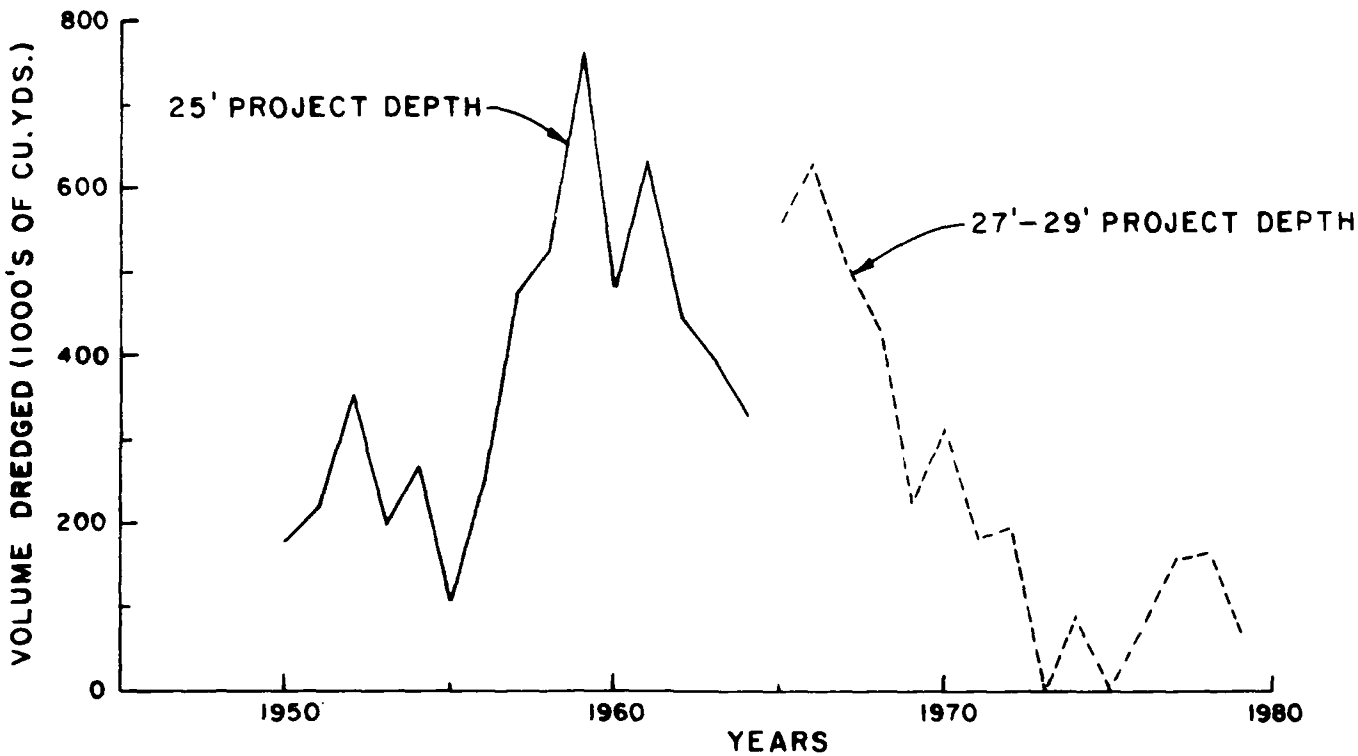


CLEVELAND HARBOR, STUDY
CLEVELAND, OHIO

CUYAHOGA RIVER WATERSHED

U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

FIGURE A2



CLEVELAND HARBOR, STUDY
CLEVELAND, OHIO

DREDGING VOLUMES – CLEVELAND OUTER HARBOR 1950–1979

U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

FIGURE A3

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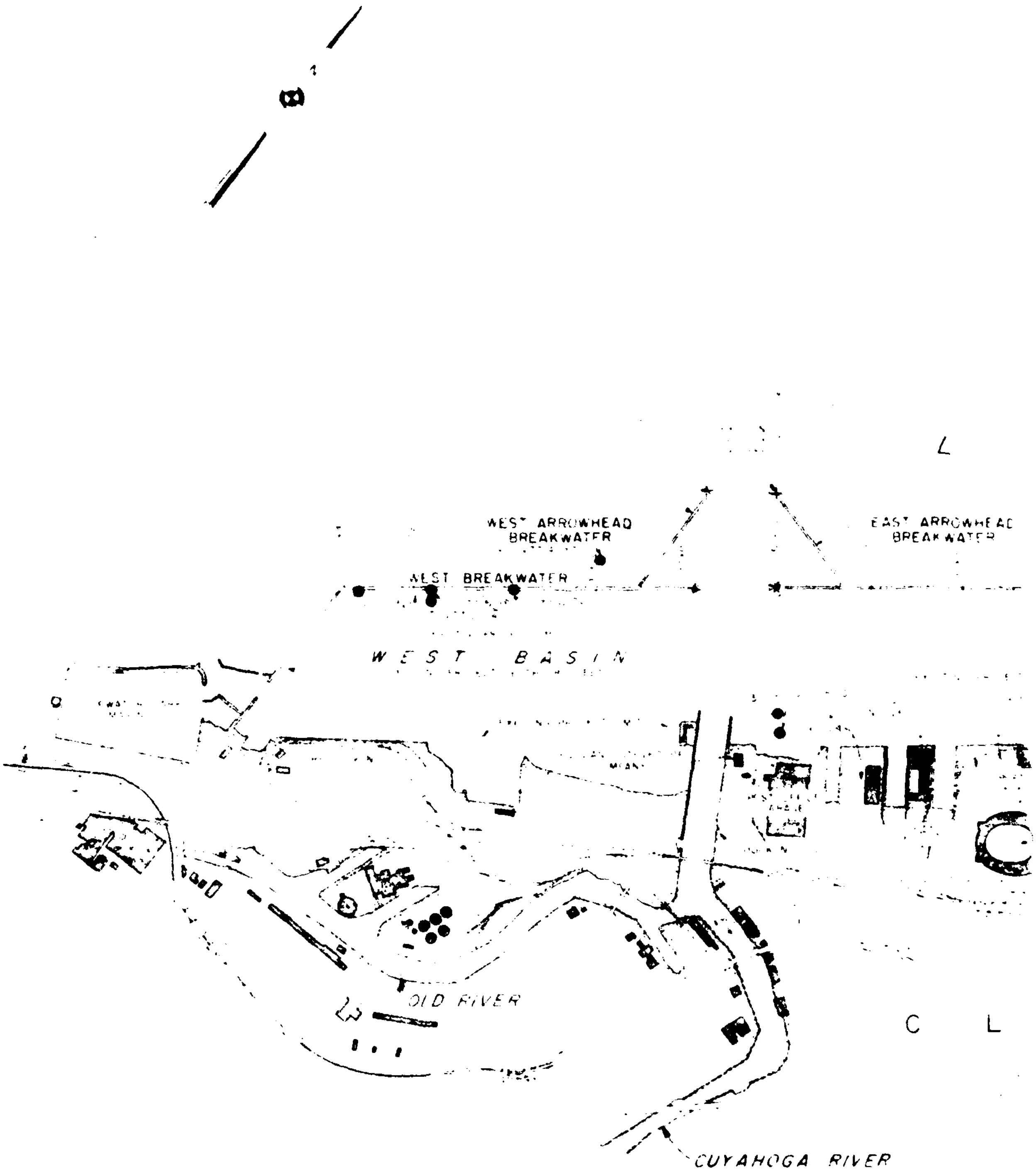
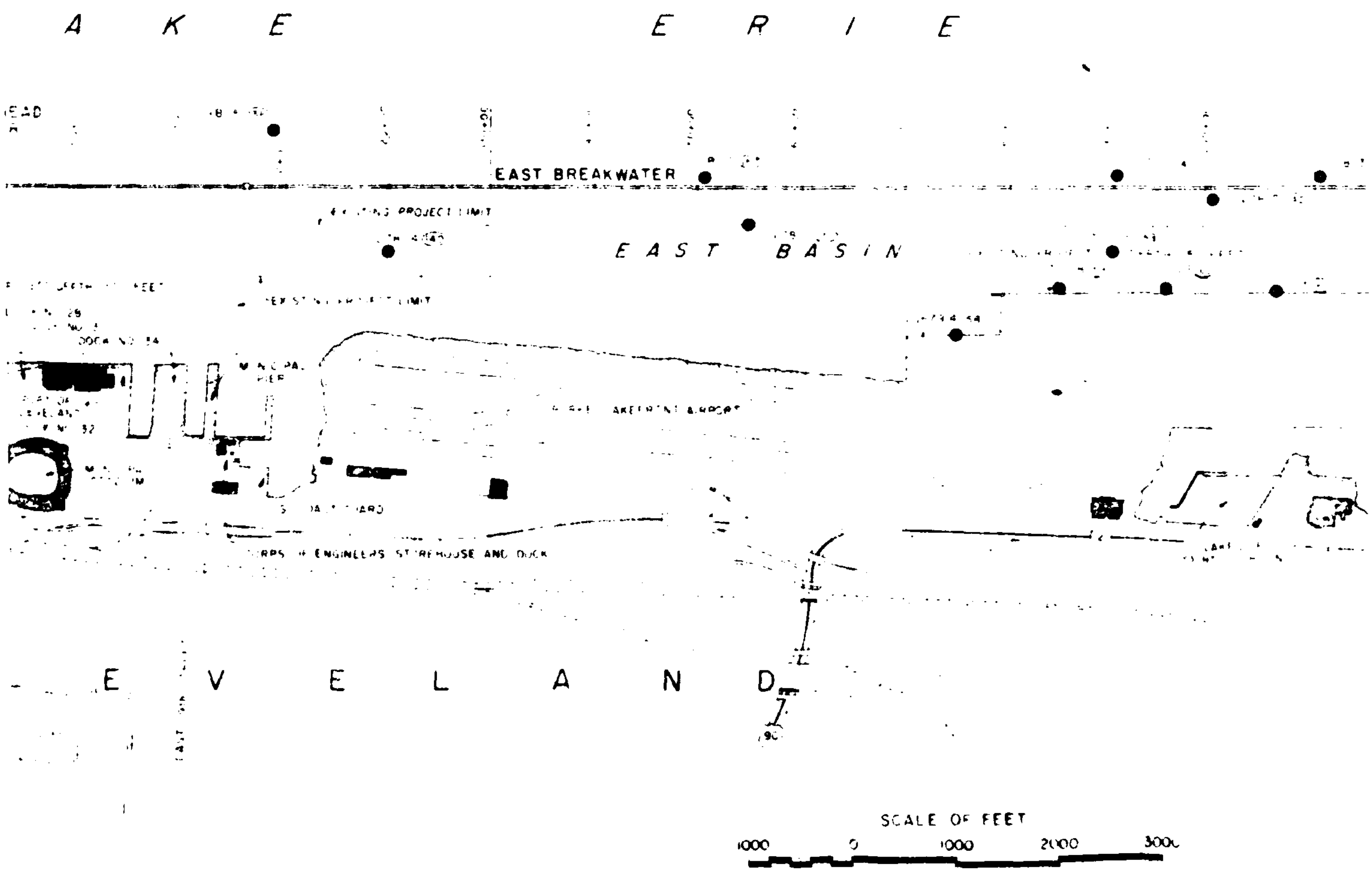
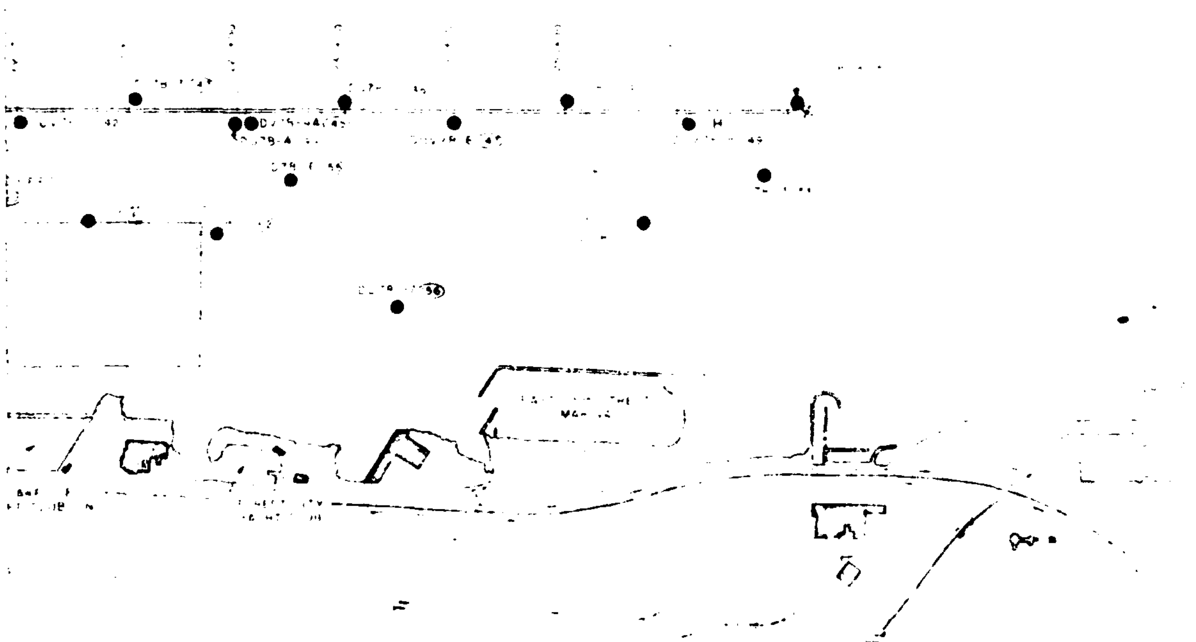

WEST ARROWHEAD BREAKWATER
EAST ARROWHEAD BREAKWATER
WEST BREAKWATER
WEST BASIN
OLD RIVER
CUYAHOGA RIVER



A K E E R I E
EAST BREAKWATER
EAST BASIN
PROJECT LIMIT
DOCK NO. 34
E V E L A N D
SCALE OF FEET
1000 0 1000 2000

2

NOTES

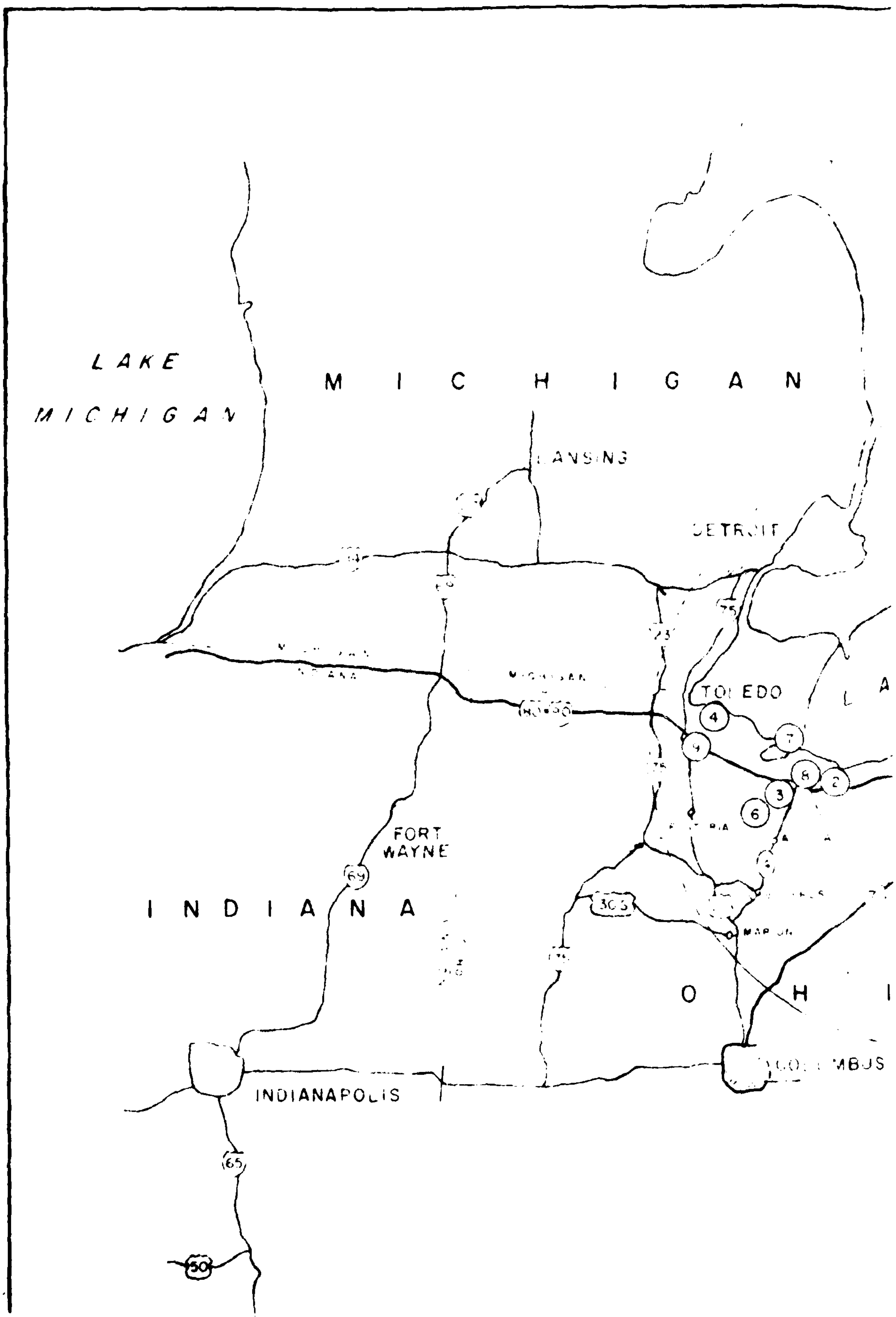


CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

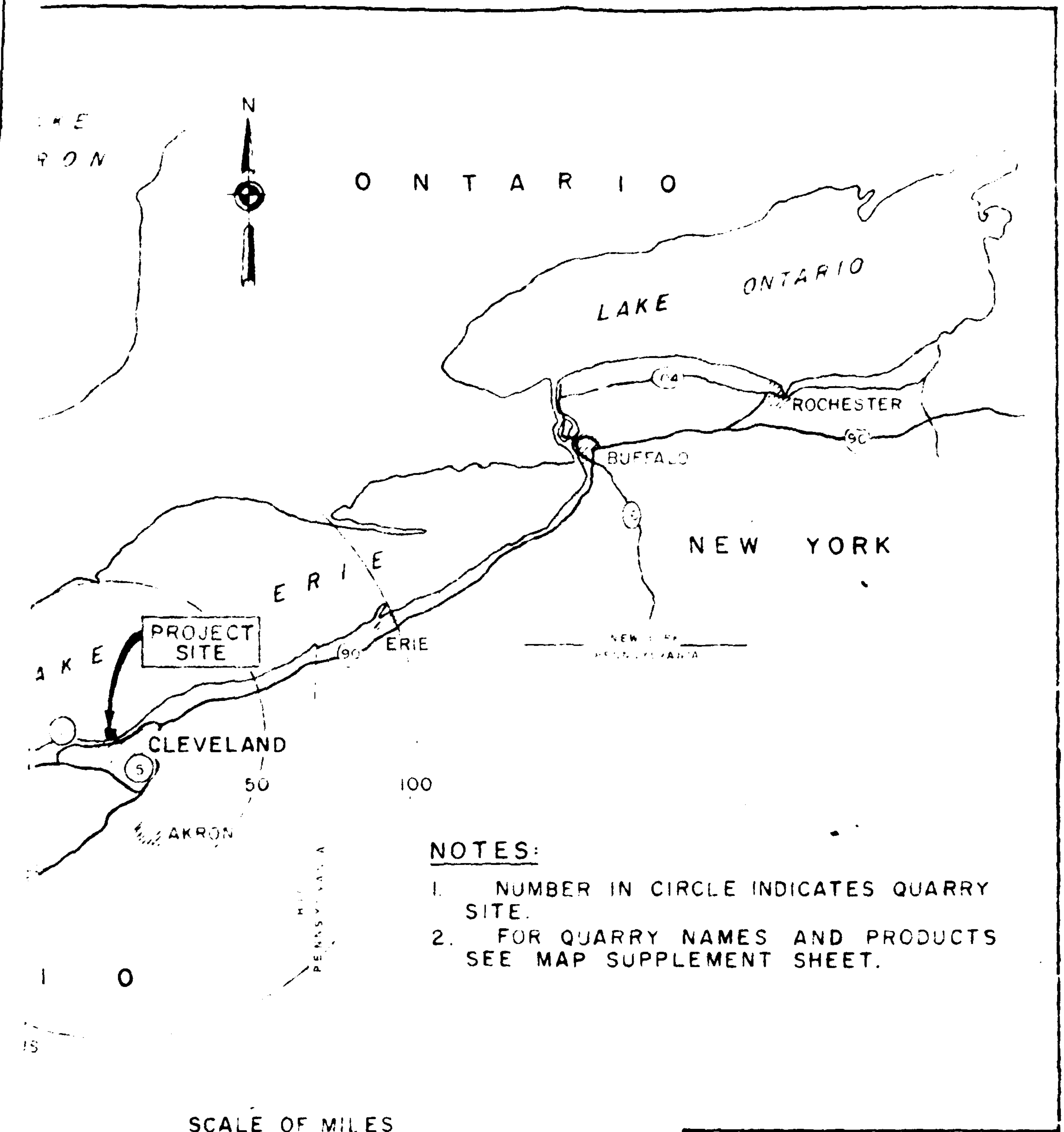
PLAN OF SUBSURFACE EXPLORATIONS

OUTER HARBOR

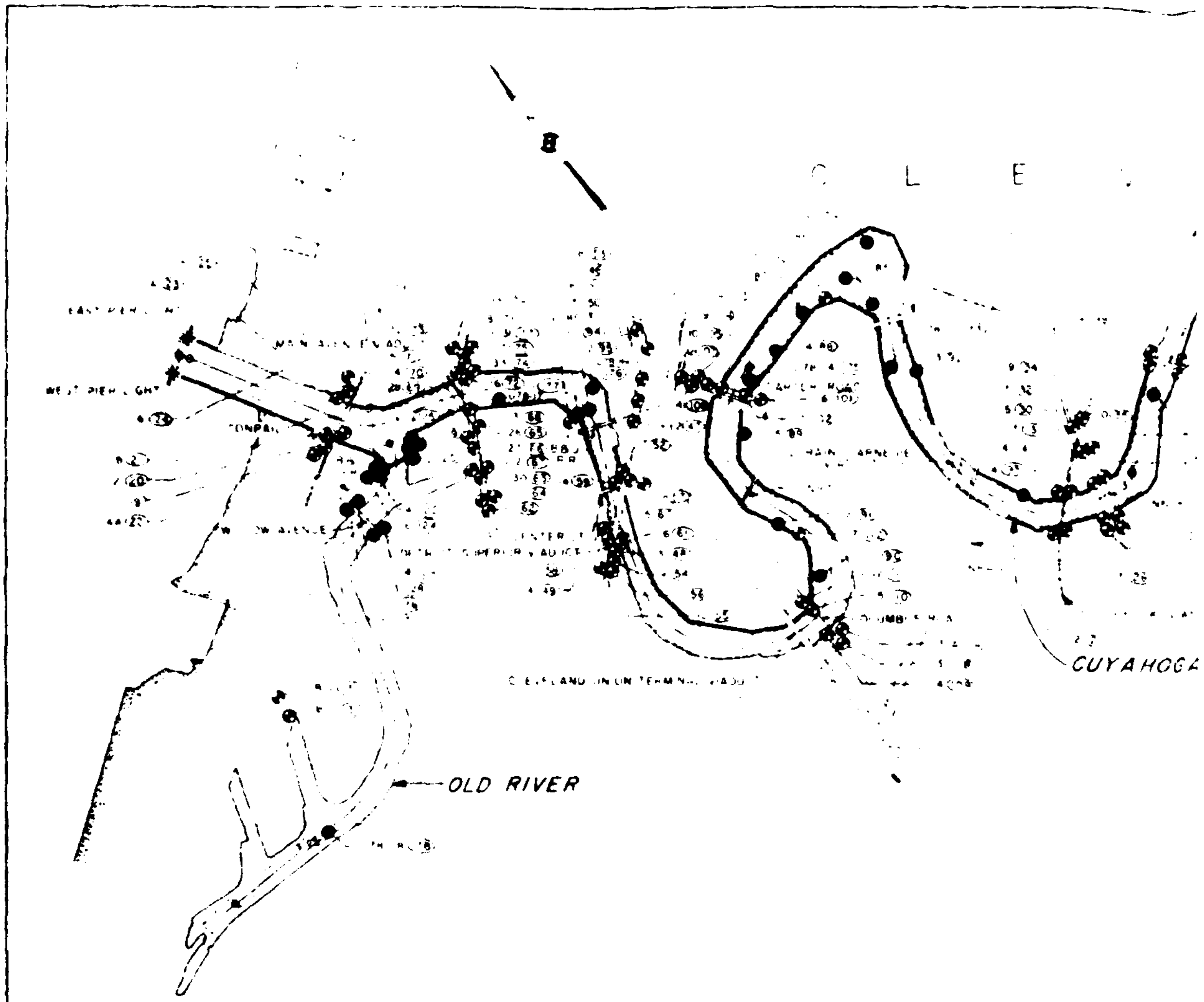
US ARMY ENGINEER DISTRICT BUFFALO

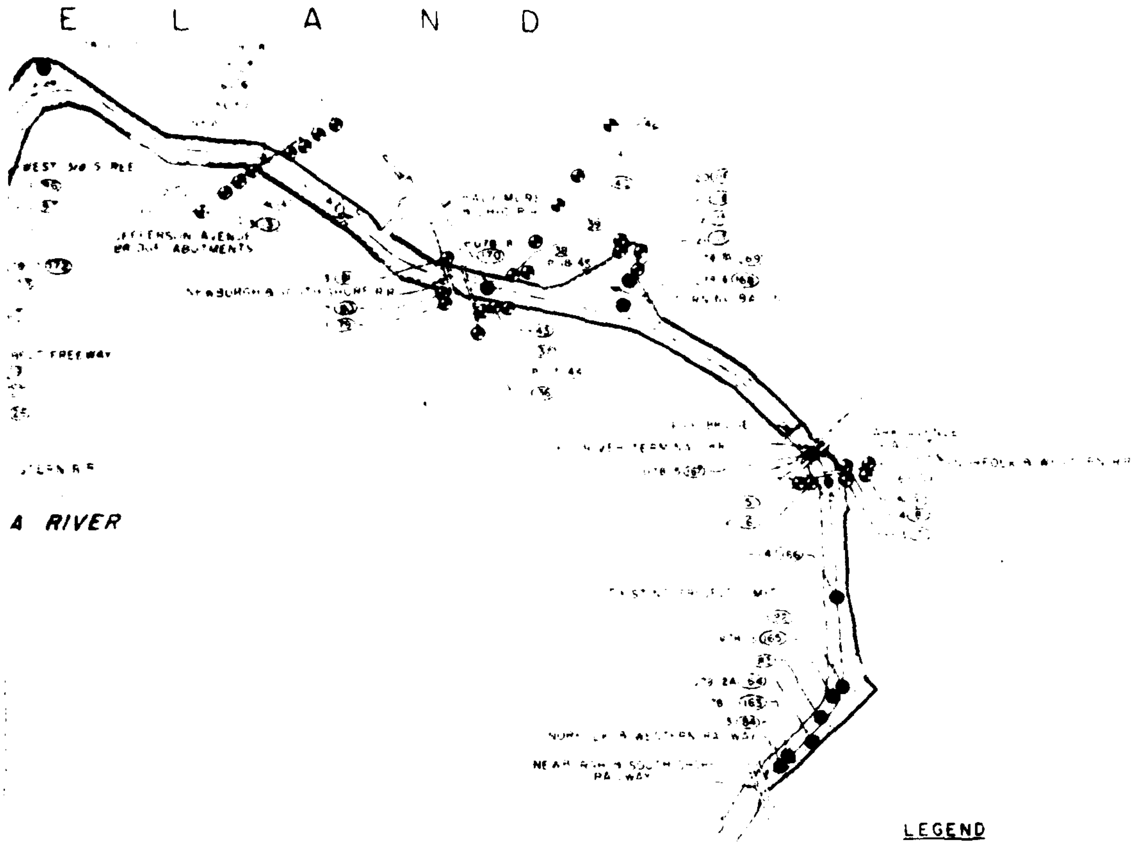


LAKE
MICHIGAN
M I C H I G A N
LANSING
TOLEDO
4
9
7
8
2
3
6
FORT
WAYNE
69
I N D I A N A
303
INDIANAPOLIS
65
50



CLEVELAND HARBOR, STUDY
CLEVELAND, OHIO
LOCATION MAP
POSSIBLE MATERIAL SOURCES
U.S. ARMY ENGINEER DISTRICT, BUFFALO
JULY 1982


OLD RIVER
CUYAHOGA



LEGEND

[illegible] CORPS OF ENGINEERS [illegible]

[illegible] BORINGS BY OTHERS

NOTES

1. FOR PLAN OF SUBSURFACE EXPLORATIONS FOR THE OUTER HARBOR SEE PLATE A
2. ALL ELEVATIONS ARE REFERRED TO LOW WATER DATUM [illegible] ELEVATION 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (I.G.L.D. 1955)
3. BORINGS SHOWN ON THIS SHEET ARE POSITIONED [illegible] ACTUAL LOCATIONS

SCALE OF FEET

1000 0 1000 2000 3000

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

PLAN OF SUBSURFACE EXPLORATIONS

CUYAHOGA RIVER AND OLD RIVER

U.S. ARMY ENGINEER DISTRICT BUFFALO

MAP SUPPLEMENT SHEET
SUMMARY OF POSSIBLE SOURCES FOR CONSTRUCTION MATERIALS

SITE NUMBER	SOURCE	QUARRY OR PIT LOCATION	RADIAL DISTANCE (IN MILES)	ARMOR STONE	UNDERLAYER STONE	BEDDING AND CORE STONE
1.	CLEVELAND QUARRIES	SOUTH AMHERST	25	X	X	
2.	ERIE BLACKTOP INC.	SANDUSKY, OHIO	52	X	X	X
3.	FRANCE STONE CO.	FLAT ROCK, OHIO	66		X	X
4.	E. KRAEMER AND SON, INC.	CLAY CENTER, OHIO	89	X	X	X
5.	BOYAS EXCAVATING	GARFIELD HEIGHTS, OHIO	10	X	X	X
6.	SANDUSKY CRUSHED STONE	PARKERTOWN, OHIO	60			X
7.	STANDARD SLAG CO.	MARBLEHEAD, OHIO	55	X	X	X
8.	WAGNER QUARRIES CO.	SANDUSKY, OHIO	52	X	X	X
9.	WOODVILLE LIME & CHEMICAL	WOODVILLE, OHIO	89	X	X	X

NOTES:

ARMOR STONE: 7.0 - 16.0 TONS

UNDERLAYER STONE: 0.5 - 2.0 TONS

BEDDING AND CORE STONE: 2.0 - 160.0 LBS.

X - INDICATES QUARRY CAPABLE OF PRODUCING STONE INDICATED

CLEVELAND HARBOR, STUDY
CLEVELAND, OHIO

MATERIAL SURVEY
SUMMARY OF SOURCES

U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE A4

APPENDIX B

ECONOMIC EVALUATION

CLEVELAND HARBOR, OHIO

STAGE 2 REPORT
OF
REFORMULATION PHASE I GENERAL DESIGN MEMORANDUM

U. S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, NY 14207

CLEVELAND HARBOR, OHIO
STAGE 2 REPORT
REFORMULATION of PHASE I
GENERAL DESIGN MEMORANDUM

APPENDIX B

ECONOMIC EVALUATION

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TABLES

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FIGURES

TABLE OF CONTENTS (Cont'd)

FIGURES

ECONOMIC EVALUATION
APPENDIX B

B1. ECONOMIC STUDY AREA

a. Physical Description.

Cleveland, OH, is the largest city on the south shore of Lake Erie and the third largest city on the Great Lakes. Located at the mouth of the Cuyahoga River, its early importance as a commercial and industrial port was based on natural assets: a protected harbor, a navigable river, and direct access to the Great Lakes transportation system. The economic vitality of the Cleveland, OH, metropolitan area is still dependent upon these assets.

Briefly, the Port of Cleveland presently consists of an Outer Harbor and an Inner Harbor. The Outer Harbor consists of a 5-mile long breakwall protected lakefront. The Inner Harbor, consists of the lower, deep-draft section of the Cuyahoga River, and the connecting Old River.

The Outer Harbor has two entrances from Lake Erie. The west (main) entrance is through a dredged channel at the west end of the Outer Harbor. This entrance is between the outer ends of two converging breakwaters (east and west arrowhead breakwaters) extending outward from the east and west basin breakwaters. The other entrance is at the east end of the Outer Harbor area between the breakwater and the shore. (See Figure B1)

The Inner Harbor includes about 5.8 miles of the Cuyahoga River and about 1 mile of the Old River, the former outlet of the Cuyahoga River. (See Figure B2)

b. Historical Development.

The iron and steel industries have molded the character of Cleveland, OH, just as the grain merchants and millers molded Buffalo, NY, and the automobile manufacturers formed the patterns of Detroit, MI. The channels and shipways of the Great Lakes and the ports on Lake Erie are the lifeline of the steel industry. Improvements to them with the resultant change in tonnage capacity of the ore fleets have been essential to the survival of the iron and steel industry.

In the mid-19th century the demands of the Civil War, the Reconstruction Period, and the subsequent westward movement of the population required large amounts of iron and steel. This demand for steel quickly outran the resources and capacities of the charcoal furnaces and the bog-iron deposits in Pennsylvania and southeastern Ohio. Consequently, the mines of Michigan and Minnesota experienced long-term development and expansion which has continued to the present day.

Ore in the Lake Superior region had been noted as early as 1850. It was a report of gold in the area that originally brought prospectors to this region. Since little gold was found, ore samples were packed out for

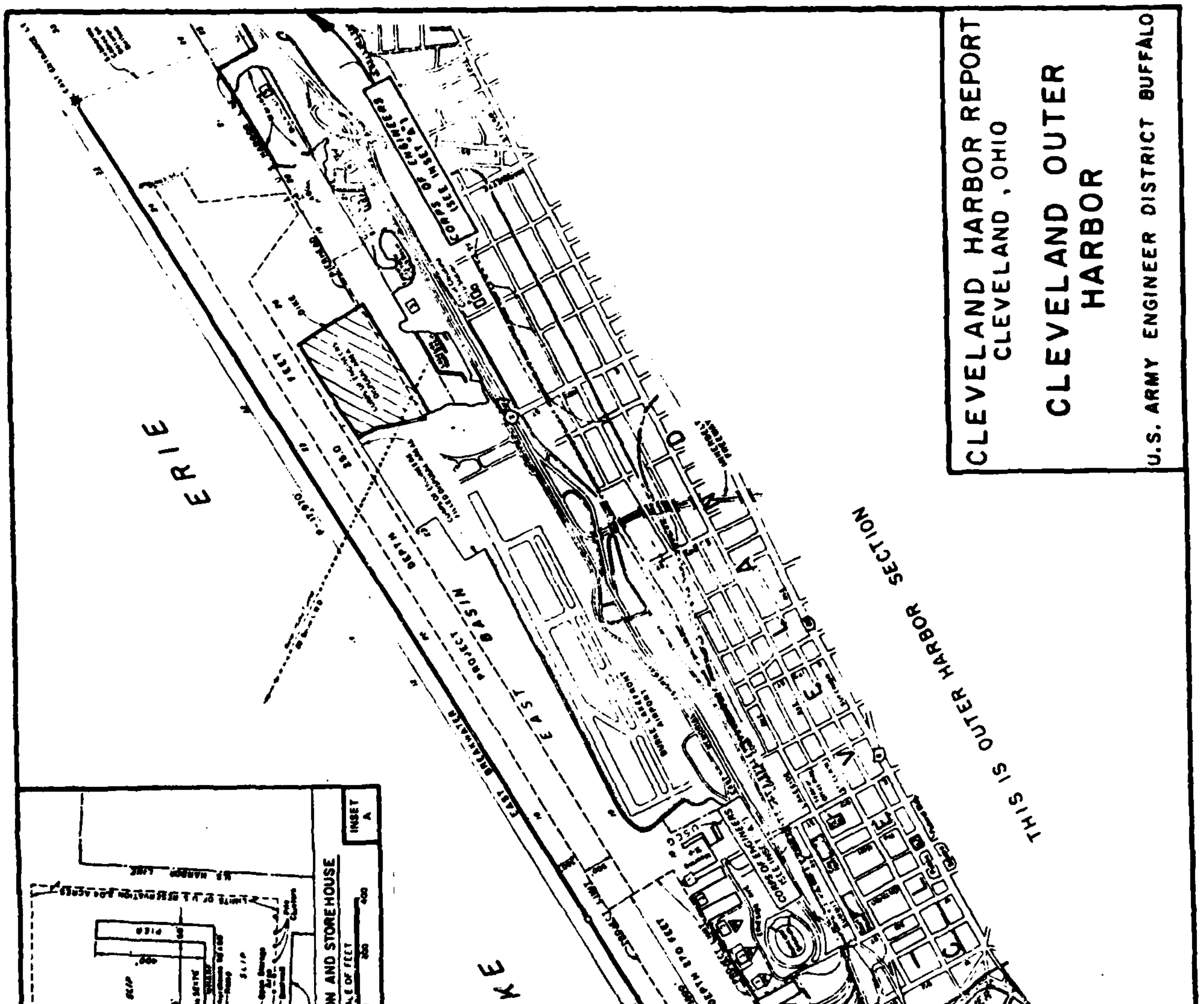
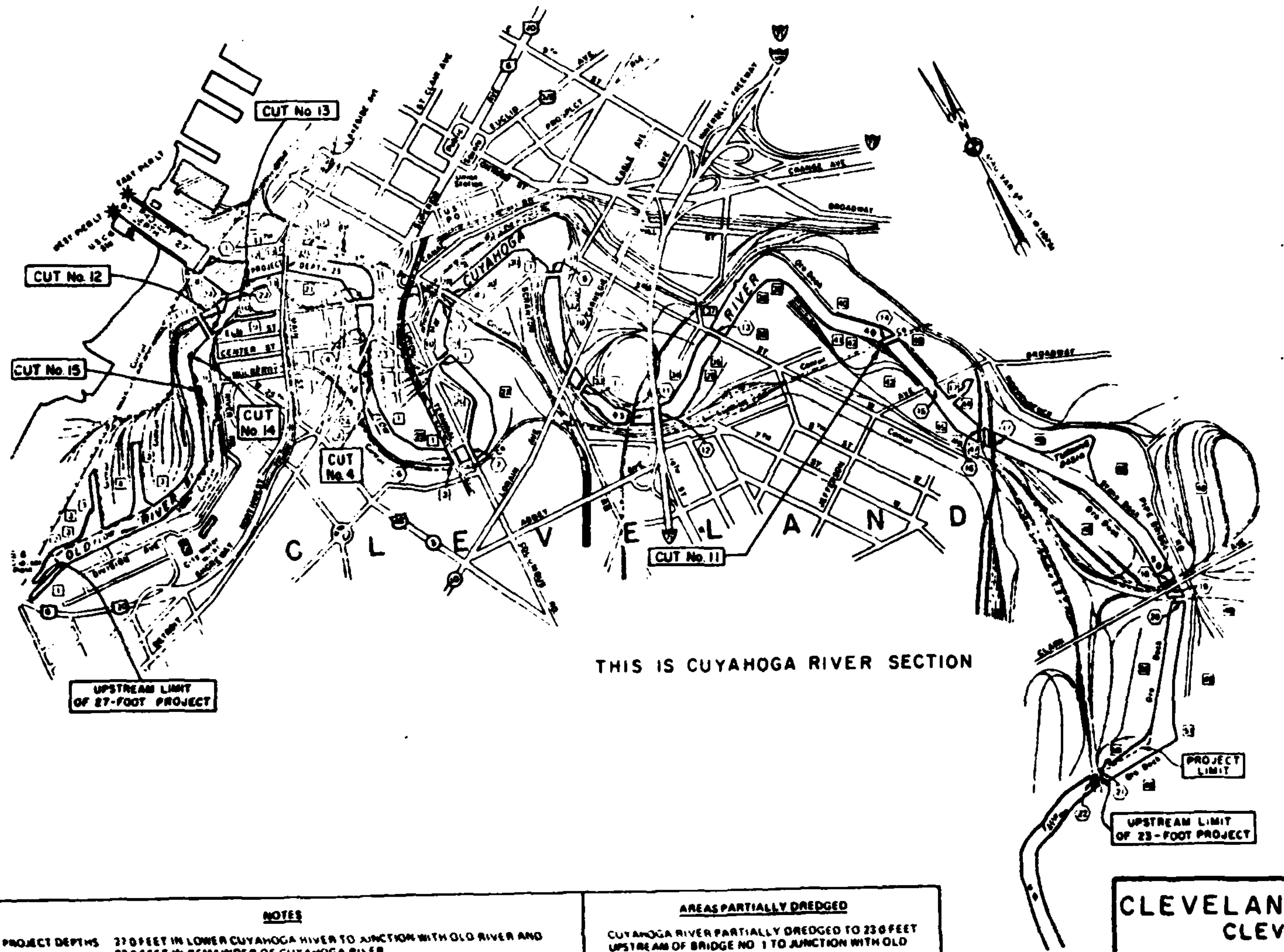

CLEVELAND HARBOR REPORT
CLEVELAND, OHIO
CLEVELAND OUTER HARBOR
U.S. ARMY ENGINEER DISTRICT BUFFALO
LAKE
ERIE
THIS IS OUTER HARBOR SECTION
EAST BASIN
WEST BASIN
CUYAHOGA RIVER
U.S. RESERVATION AND STOREHOUSE
INSET A
INSET B
DISPOSAL AREA

FIGURE B1



INDEX TO BRIDGES

SHOWN THUS (1)

- *1 CONRAIL
- 2 MAIN AVE HIGH LEVEL BRIDGE
- *3 B & O R R BRIDGE
- 4 CENTER ST BRIDGE
- 5 DETROIT SUPERIOR HIGH LEVEL BRIDGE
- 6 UNION TERMINAL R R HIGH LEVEL BRIDGE
- 7 COLUMBUS RD BRIDGE
- 8 CARTER RD BRIDGE
- 9 EAGLE AVE BRIDGE
- 10 LORAIN CARNEGIE HIGH LEVEL BRIDGE
- *11 NORFOLK & WESTERN RAILWAY
- 12 INNERBELT FREEWAY HIGH LEVEL
- 13 W 3rd ST BRIDGE
- **14 CONRAIL
- 15 JEFFERSON AVE BRIDGE SUPERSTRUCTURE REMOVED
- 16 NEWBURG & SOUTH SHORE RAILWAY BRIDGE
- 17 B & O R R BRIDGE
- 18 RIVER TERMINAL R R BRIDGE
- 19 CLARK AVE HIGH LEVEL BRIDGE
- *20 N & W RAILWAY BRIDGE NO 2 (W & L E R R (O))
- 21 N & W RAILWAY BRIDGE NO 3 (W & L E R R (O))
- 22 NEWBURG & SOUTH SHORE RAILWAY BRIDGE
- **23 B & O R R BRIDGE — OLD RIVER
- *24 WILLOW AVE BRIDGE — OLD RIVER

NOTE FEDERAL PARTICIPATION IN REPLACEMENT
*COMPLETED
**AUTHORIZED

NOTES

PROJECT DEPTHS 27.0 FEET IN LOWER CUYAHOGA RIVER TO JUNCTION WITH OLD RIVER AND
23.0 FEET IN REMAINDER OF CUYAHOGA RIVER
18.0 FEET IN TURNING BASIN AT MILE 4.8 ON CUYAHOGA RIVER
27.0 FEET IN OLD RIVER

PROJECT DEPTHS AND SOUNDINGS ARE REFERRED TO LOW WATER DATUM, ELEVATION 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD 1955) (INTERNATIONAL GREAT LAKES DATUM 1955)

MILES ABOVE WEST PIER LIGHT AT OUTER END OF WEST PIER SHOWN THUS 2.0

INDICATES U.S. ROUTES

INDICATES STATE ROUTES

INDICATES INTERSTATE ROUTE

AREAS PARTIALLY DREDGED

CUYAHOGA RIVER PARTIALLY DREDGED TO 23.0 FEET UPSTREAM OF BRIDGE NO. 1 TO JUNCTION WITH OLD RIVER

OLD RIVER PARTIALLY DREDGED TO 23.0 FEET FROM JUNCTION WITH CUYAHOGA RIVER TO OPPOSITE SAND PRODUCTS CORP. DOCK. REMAINDER DREDGED TO 21.0 FEET

CLEVELAND HARBOR REPORT
CLEVELAND, OHIO

CUYAHOGA RIVER

U.S. ARMY ENGINEER DISTRICT BUFFALO

FIGURE B2

inspection and analysis. The Vermilion range in Minnesota was the first to be exploited, followed by the Mesabi and Cuyuna ranges. Ore deposits in Michigan were later identified and commercially developed. By 1978, Minnesota was producing 69 percent of the total national output of iron ore and Michigan 21 percent. A geographic overview of the Great Lakes transportation system and the location of U. S. iron ore deposits is provided in Figure B3.

The ore had little industrial application until it was smelted and processed. The small, mid-century steel producing furnaces had used coal for smelting. Quantity production required enormous amounts of coal. Coal veins lay in quantities equal to the Lake Superior ore fields in the hills of Pennsylvania, West Virginia, Kentucky, and southeastern Ohio. The two primary ingredients for making iron and steel were separated by a thousand miles, but they were joined by the Great Lakes system. The relative distances between each of the critical raw materials was the key to the development of commercial harbors along Lake Erie.

The question became whether it was more efficient to smelt the ore at its source or transport it via the Great Lakes to established furnaces. Both schemes were attempted. The proportion of coal to ore required to make iron and steel at that time was about four to one. Furnaces already in extensive operation near the coal fields were in close proximity to the manufacturers and markets. The procedure finally adopted was to bring the ore to the coal, meeting inevitably on the south shore of Lake Erie.

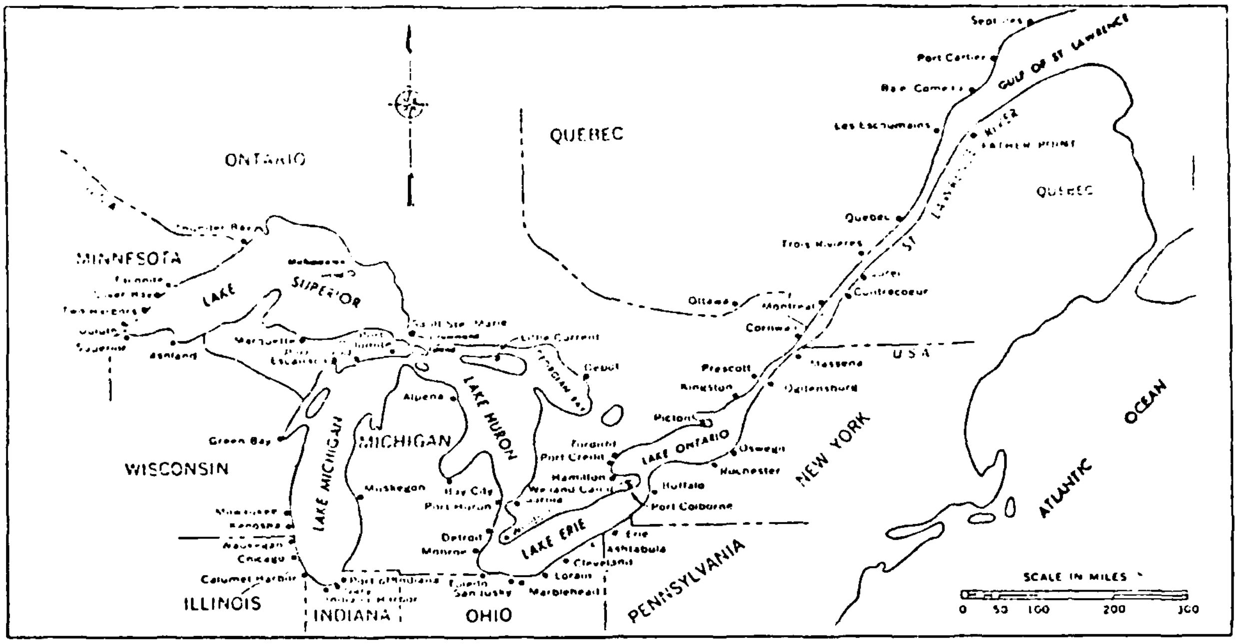
A canal to bypass the St. Mary's Falls at Sault Sainte Marie and the State of Michigan Lock, the first ship lock at Sault Sainte Marie, were constructed in 1855, completing a 9-foot navigable channel from Lake Superior to Lake Erie.

Entrepreneurs from Cleveland saw that the ore for the "steel age" would come from Lake Superior. It would be transported down the lakes and would meet the coal from the Appalachian coal fields somewhere along Lake Erie. These conditions represented a unique opportunity for investors to make Cleveland, OH, the strategic center for controlling the shipping of these basic raw materials.

Cleveland has been actively involved in the receipt and transshipment of iron ore for 125 years. From the day when ore was discovered on the Lake Superior ranges, Cleveland has been in the forefront of mining and shipping. The historical relationship between Cleveland Harbor and other competing harbors along Lake Erie is provided in Table B1.

c. <u>Waterborne Transportation</u>.

The Great Lakes form an efficient and geographically extensive transportation network for the raw material industrial inputs found in the Midwest. Large volumes of dry bulk materials are transported in Great Lakes vessels each year. Raw materials for the U.S. and Canadian steel industry constitute the majority of the commercial activity.



GREAT LAKES – ST LAWRENCE SEAWAY NAVIGATION SYSTEM

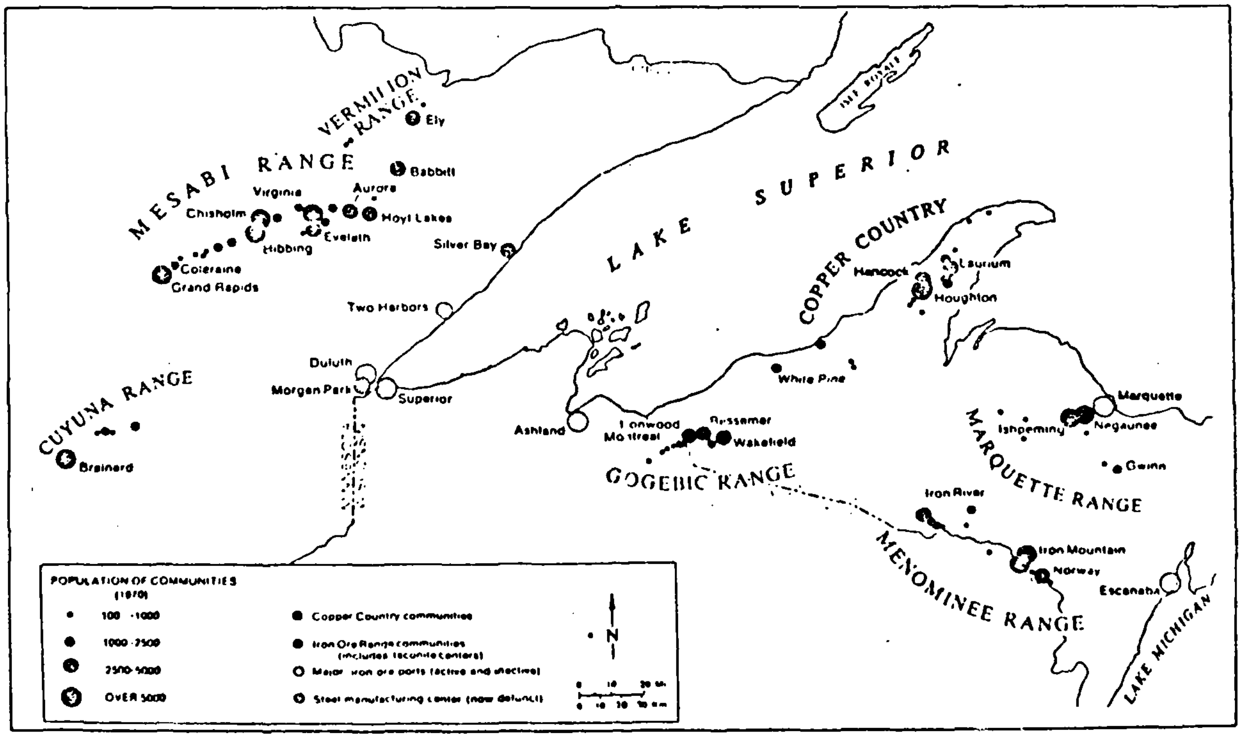


FIGURE B3 LOCATION OF GREAT LAKES IRON ORE DEPOSITS

Table B1 - Historical Iron Ore Receipts for Selected Great Lake Ports
(Tonnages are in Millions of Net Tons)

Year	Buffalo		Conneaut		Ashtabula		Cleveland		Lorain		Huron		Toledo		Detroit		Gary		Burns Harbor		Indiana Waterway		Chicago		Total	
	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%
1965	9.0	11	4.8	6	5.5	7	16.0	20	3.6	4	1.2	1	5.5	7	9.9	12	5.1	6	-	0	9.7	12	10.6	13	80.9	100
1966	9.4	11	7.1	8	5.3	6	17.4	20	3.5	4	1.3	2	4.6	5	10.9	13	9.0	10	-	0	8.6	10	8.6	10	85.9	100
1967	9.1	11	6.9	8	5.2	6	15.0	18	3.0	4	1.5	2	5.0	6	10.5	13	9.6	12	-	0	7.8	10	8.0	10	81.6	100
1968	8.4	10	7.0	8	5.6	6	16.3	19	4.0	5	2.2	3	5.7	7	9.7	11	9.5	11	-	0	11.0	13	7.6	9	87.0	100
1969	8.7	10	6.5	7	6.2	7	17.6	20	4.4	5	2.9	3	5.6	6	9.8	11	9.1	10	0.7	1	8.0	9	9.4	11	88.9	100
1970	8.2	10	7.0	8	5.2	6	16.7	19	3.4	4	2.4	3	5.4	6	10.6	12	8.7	10	1.5	2	7.1	8	9.6	11	85.8	100
1971	5.9	7	6.8	9	4.8	6	14.7	19	3.2	4	2.7	3	5.0	6	10.1	13	6.7	8	2.6	3	7.8	10	8.7	11	79.0	100
1972	4.2	5	6.3	8	4.9	6	17.5	21	4.2	5	2.7	3	6.3	8	9.9	12	7.0	9	3.5	4	6.8	8	8.4	10	81.7	100
1973	7.7	8	7.6	8	5.3	6	18.1	19	5.6	6	2.9	3	6.5	7	11.1	12	8.1	8	4.5	5	10.2	11	8.6	9	96.2	100
1974	5.3	6	7.7	9	5.8	7	15.6	18	4.7	5	2.6	3	5.5	6	10.0	11	8.4	10	4.6	5	9.6	11	8.4	10	88.2	100
1975	3.1	4	9.3	12	3.5	4	13.3	17	4.3	5	1.4	2	4.0	5	9.8	12	8.1	10	4.6	6	10.2	13	7.6	10	79.2	100
1976	7.0	8	8.4	10	5.9	7	13.4	16	4.6	5	1.9	2	4.8	6	9.7	11	7.9	9	4.1	5	9.4	11	8.5	10	85.6	100
1977	4.0	6	5.3	8	5.4	8	10.5	16	3.1	5	1.2	2	3.5	5	7.8	12	6.6	10	3.1	5	8.3	13	5.6	9	64.4	100
1978	4.5	5	7.6	8	6.8	8	13.8	15	5.6	6	1.4	2	5.7	6	9.7	11	6.4	7	5.5	6	13.8	15	9.7	11	90.5	100
Total	94.5	8	98.3	8	75.4	6	215.9	18	57.2	5	28.3	2	73.1	6	139.5	12	110.2	9	34.7	3	128.3	11	119.5	10	1174.9	100
Avg.	6.8	8	7.0	8	5.4	6	15.4	18	4.1	5	2.0	2	5.2	6	10.0	12	7.9	9	2.5	3	9.2	11	8.5	10	83.9	100

SOURCE: Waterborne Commerce of the U. S., Part 3, Great Lakes - Corps of Engineers.

Bulk transportation via the Great Lakes can be accommodated at very competitive prices per ton. However, during the winter period raw materials are transported by alternate transportation networks at much higher average costs per ton. Railroads are frequently the next most competitive mode for movement of the raw materials required by the steel industry.

Table B2 below shows the published all-rail iron ore freight rate to Cleveland Harbor plants from the Mesabi Range in the upper lakes. The Great Lakes water rate assumes an average stockpiling interval of 3 months for an inland iron ore company.

Table B2 - Iron Ore Freight Rates from the Mesabi Range to Cleveland

Description of Movement	Freight Rate/Short Ton
	$
All-Rail, Mesabi Range to Consuming Plant	34.80
Water, Transship to Inland Plant	27.86

SOURCE: Skillings Mining Review.

Total transportation costs for a Great Lakes routing usually involves the cost of related transportation services in addition to the waterborne portion of the origin-destination-commodity movement. These costs usually consist of terminal, storage and related costs plus overland line-haul charges if required. A typical Great Lakes routing and related service costs are provided in Table B3. The cost breakdown shows a wide range of service costs. Not all service costs are applicable in all cases.

d. Problems and Plans.

The fundamental navigation issue in Cleveland is the modification of existing harbor dimensions. This would allow more efficient transportation of cargo through the port. Hazards to navigation are being investigated. Delivery and shipment of bulk commodities are now restricted and the optimum utilization of bulk vessels is not possible.

Most commercial vessels enter and exit Cleveland Harbor through the west entrance between the arrowhead breakwaters. This location is also known as the "Main Entrance" by vessel operators servicing docks within the Federal project limits. The lake approach channel is maintained to a depth of 29 feet LWD and has a width at the lakeward end of 600 feet. This width increases to 750 feet as the spur breakwaters meet the east and west breakwall. The spurs are potential hazards to large vessels, particularly during storm conditions. Channel depth may also be inadequate for vessel clearance under severe pitching and rolling conditions.

Table B3 - Transportation Cost Components - Iron Ore

	Activity	Rate Per Short Ton
		$
1.	Rail haul of taconite which has been beneficiated (pelletized at the mining operation on the Mesabi Range) in a unit train of 180 90-gross ton capacity hopper cars, to Duluth-Superior.	6.26
1a.	Winter ground storage at Duluth-Superior, if required, per month.	0.051
2.	Handling and transfer of pellets to vessel.	0.87
3.	Lake Freight Movement.	7.13 (1)
4.	Dockage.	0.23 (1)
5a.	If vessel is a self-unloader, transfer of ore from dock receiving area into rail cars or to storage and then into rail cars.	1.53
5b.	If vessel is a bulker, transfer from the hold of vessel to rail of vessel.	0.92
5b1.	Transfer from rail of vessel into rail car.	1.02
5b2.	Transfer from rail of vessel into storage yard.	2.22
5b2a.	Storage, per month.	0.71
5b2b.	Transfer from storage into rail car.	1.41
6.	Rail haul to consuming plant.	8.85

(1) Variable by lower lakes destination.

SOURCE: Skillings Mining Review, February 1982.

One plan of improvement for vessel operation at the Lakefront consists of removing part of the east and west spur breakwaters and widening the entrance channel in the vicinity of the spur breakwater removal. This would facilitate entering the west entrance during "fair-weather" conditions. Also, entrance plans were formulated involving constructing additional breakwaters and channels at the west entrance or deepening the east entrance and east basin channel. These plans would allow vessels to enter the Lakefront Harbor under 30-knot winds and 8-foot waves.

The feasibility of reducing vessel congestion on the Cuyahoga River, deepening the Cuyahoga River, and constructing authorized but uncompleted improvements on the Old River were also investigated.

A brief overview of the plans is provided below:

Plan Alternative	Plan Description	Impact on Vessel Operations	Commodities Affected
1. East Entrance Plan	Deepen east entrance approach and entrance channel to 32.0 feet. Deepen east basin channel to 28.0 feet.	Class 10 vessels able to enter the harbor under 30 knot winds and 8-foot waves. Class 5 to Class 10 vessels able to enter harbor at systems draft of 25.5 feet.	Iron ore
2. "Fair-Weather" West Entrance Plan	Remove 300 feet of the west spur breakwater and 200 feet of the east spur breakwater and widen entrance channel in vicinity of the spur breakwater removals. Raise the west arrowhead breakwater to 14 feet above LWD. Add 300-foot breakwater extensions on end of east and west arrowhead breakwaters.	Class 10 vessels able to enter the harbor under 20 knot winds and 4-foot waves.	Iron ore
3. West Entrance Plan	Option A - Add 4,000 feet of breakwater extension to the east arrowhead and 1,000 feet to the west arrowhead breakwater. Deepen approach channel to 32.0 feet.	Class 10 vessels able to enter the harbor under 30 knot winds and 8-foot waves. Class 5 to Class 10 vessels able to enter harbor at systems draft of 25.5 feet.	Iron ore

Plan Alternative	Plan Description	Impact on Vessel Operations	Commodities Affected
	Option B - Add 1,000-foot breakwater extensions to the east and west arrowhead breakwaters. Deepen approach channel to 32 feet. Remove 300 feet of the west spur breakwater and 200 feet of the east spur breakwater.	Class 10 vessels able to enter the harbor under 30 knot winds and 8-foot waves. Class 5 to Class 10 vessels able to enter harbor at systems draft of 25.5 feet.	Iron ore
4. East Entrance and "Fair-Weather" West Entrance Plan	Deepen east entrance approach channel to 32 feet. Deepen east basin channel to 28 feet. Add 300 feet of breakwater to the end of the east and west arrowhead breakwaters. Remove 300 feet of the west spur breakwater and 200 feet of the east spur breakwater and widen entrance channel in vicinity of the spur breakwater removals.	Class 10 vessels able to enter the east entrance under 30-knot winds and 8-foot waves and Class 10 vessels able to enter the harbor's west entrance under 20-knot winds and 4-foot waves. Class 5 to Class 10 vessels able to enter the east entrance loaded to the systems draft of 25.5 feet.	Iron ore
5. Authorized Old River Improvements	Option A - Deepen channel to 28 feet, channel cuts, bulkheading, remove Baltimore and Ohio Railroad Bridge, build a new vertical lift bridge.	Allows Class 7 vessels to enter the Old River. Class 5 to Class 7 vessels able to enter the Old River loaded to systems draft of 25.5 feet.	Salt, sand, stone

Plan Alternative	Plan Description	Impact on Vessel Operations	Commodities Affected
	Option B - Deepen channel to 28 feet, channel cuts bulkheading, remove Baltimore and Ohio Railroad Bridge No. 23, provide connection and interchange system on the east side of the Cuyahoga River.	Allows Class 7 vessels to enter the Old River. Class 5 to Class 7 vessels able to enter the Old River loaded to the systems draft of 25.5 feet.	Salt, sand, stone
6. Deepen Cuyahoga River	Option A - 25.5 Feet - Deepen Cuyahoga River to 25.5 feet, bulkhead replacement, and utility relocations.	Allows deep-draft vessels to enter the Cuyahoga River 2.5 feet deeper than present conditions permit.	Iron ore, limestone
	Option B - 28 Feet - Deepen Cuyahoga River to 28 feet, bulkhead replacement, and utility relocations.	Allows deep-draft vessels to enter the Cuyahoga River loaded to the systems draft of 25.5 feet.	Iron ore, limestone
7. Reduce River Congestion			
Site No. 1	Replace Conrail Bridge No. 1.	Less congestion.	Iron ore, limestone, salt, sand, stone
Site No. 2	Channel cut near Cereal Food Processors dock, bulkhead replacement, replacement of ship unloading building.	Less congestion.	Iron ore, limestone
Site No. 3	Channel cut at river mile 1.5, bulkheading, replacement of Cleveland Union Terminal Bridge and Columbus Road Bridge.	Less congestion, reduced vessel damages.	Iron ore, limestone

Plan Alternative	Plan Description	Impact on Vessel Operations	Commodities Affected
Site No. 4	Channel cuts at river mile 3.0, bulkhead replacement, replace Norfolk and Western Railroad Bridge, relocation of telephone pipes and rail line.	Less congestion, reduced vessel damages.	Iron ore, limestone
Site No. 5	Channel cut at river mile 3.6, bulkhead replacement, building relocation.	Less congestion.	Iron ore, limestone
Site No. 6	Channel cut near Conrail Bridge No. 14 and bulkheading.	Less congestion.	Iron ore, limestone
Site No. 7	Channel cuts near Jefferson Avenue Bridge abutments, bulkheading, utility relocations, removal of bridge abutments.	Less congestion, reduced vessel damages.	Iron ore, limestone

Plans 1, 2, 3 and 4 focus on Outer Harbor improvements. Except for Plan 2, these plans allow vessels currently entering the Outer Harbor at less than maximum carrying capacity to operate at greater drafts. Less trips each year would be required to move the needed annual tonnage. Total transportation costs for commodities serviced by the Outer Harbor is expected to decline.

Modifications to the Outer Harbor also affect a portion of the iron ore consumed at upriver steel plants. Several Class 5 upriver iron ore vessels enter the Outer Harbor at operating drafts over permissible Cuyahoga River drafts. Therefore, some cargo must be "lightered" at a public dock on the east side of the Cuyahoga River. This lightering operation allows these upriver iron ore vessels to take full advantage of the present Outer Harbor channel depths while permitting direct delivery to upriver destinations. Modifications to the Outer Harbor will allow these vessels to carry more tons per trip into the Outer Harbor. These Outer Harbor improvement plans will result in a decrease in the annual trips required to move the annual tonnage. This will cause a decline in vessel activity along the Cuyahoga River.

Alternative 5 consists of deepening the Old River from 23 feet to 28 feet. The depths in the Outer Harbor would be increased to at least 28 feet if Alternative 5 is recommended. An incremental analysis of the benefits and costs for Old River improvements was conducted. Increasing the Old River channel depths would decrease the annual trips per year needed to move the required annual tonnage. This would result in a reduced total transportation cost for the Old River. Larger vessels are also expected to operate on the Old River following the improvement.

Alternative 6 evaluates deepening the Cuyahoga River to 25.5 feet or 28.0 feet from current depths of 23.0 feet. The evaluation of river deepening presumes that the Outer Harbor was modified to depths similar to the Cuyahoga River. These river improvements will increase the operating draft of vessels transporting iron ore and limestone. This plan will decrease transportation costs per ton, reduce the number of trips required to transport iron ore and limestone, and reduce or eliminate the lightering activity on the east side of the Cuyahoga River.

Alternative 7 consists of seven mutually exclusive plans for modifications to the Cuyahoga River. Each improvement is associated with a specific geographical area along the river that physically restricts Class 5 vessel movements. Incremental time delays associated with each site were estimated. These delays may be attributed to either physical obstacles in the river (such as bridge abutments) or inadequate channel widths. Existing annual vessel time delays on the Cuyahoga River were estimated for the base case condition using a computer simulation model. This model was used to determine the reduction in annual Cuyahoga River vessel time delays for each site improvement option by removing the program variable which represents the traffic restriction at that site only. The implementation of any one improvement will result in a reduction in round trip transit times. This results in a decrease in total transit costs.

Economic evaluations were not conducted for several plans (Alternative 2 - "Fair-Weather" West Entrance, Alternative 4 - combined "All-Weather" East Entrance and "Fair-Weather" West Entrance and Alternative 7 - Site No. 1) since these plans were eliminated from further consideration early in Stage 2.

B2. TYPES AND VOLUMES OF COMMODITY FLOW

a. Overview.

The vast majority of waterborne traffic at Cleveland Harbor is domestic and Canadian bulk cargo movements. Table B4 shows the relative importance of iron ore, limestone, sand and gravel, and salt commodity flows. Salt tonnage, although relatively small, is the largest commodity shipped from the harbor. Overseas traffic is not significant, generally comprising less than 4 percent of total harbor tonnage.

Benefits to proposed improvements at the harbor are predominantly related to economies of ship size within the Great Lakes fleet. The analysis will concentrate on iron ore, limestone, sand and gravel, and salt movements. Other commodities at the port of Cleveland include wheat, residual fuel oil, building cement, and primary metal products. They presently move in vessels that are fully utilized under present channel depths and widths within the harbor and are not included in the economic evaluation.

b. Iron Ore.

Iron ore receipts from domestic and Canadian sources constitute 70 to 75 percent of the total annual waterborne traffic in Cleveland. The ore is consumed in two integrated steel mills on the Cuyahoga River or transshipped to inland steel plants in Ohio, Pennsylvania, and West Virginia. The intermediate or finished steel products produced includes bars, sheets, plates, pipes and tubes, and structural shapes. The major sources and eventual areas of distribution for iron ore moving through Cleveland Harbor is presented in Figure B4.

A Lakefront Harbor terminal handles all the transshipped tonnage. Ore is stockpiled at the terminal and railed to inland companies. Another Lakefront Harbor dock is part of a lightering operation which services an upriver steel plant. The Republic Steel Cuyahoga River plant receives all its ore from a transfer facility in Lorain, Ohio, 28 miles west of the harbor.

Location of Docks and Harbor Users

Dock Name	Location
C&P	Lakefront
Dock 20	Lakefront
Jones & Laughlin	Cuyahoga River
Republic	Cuyahoga River

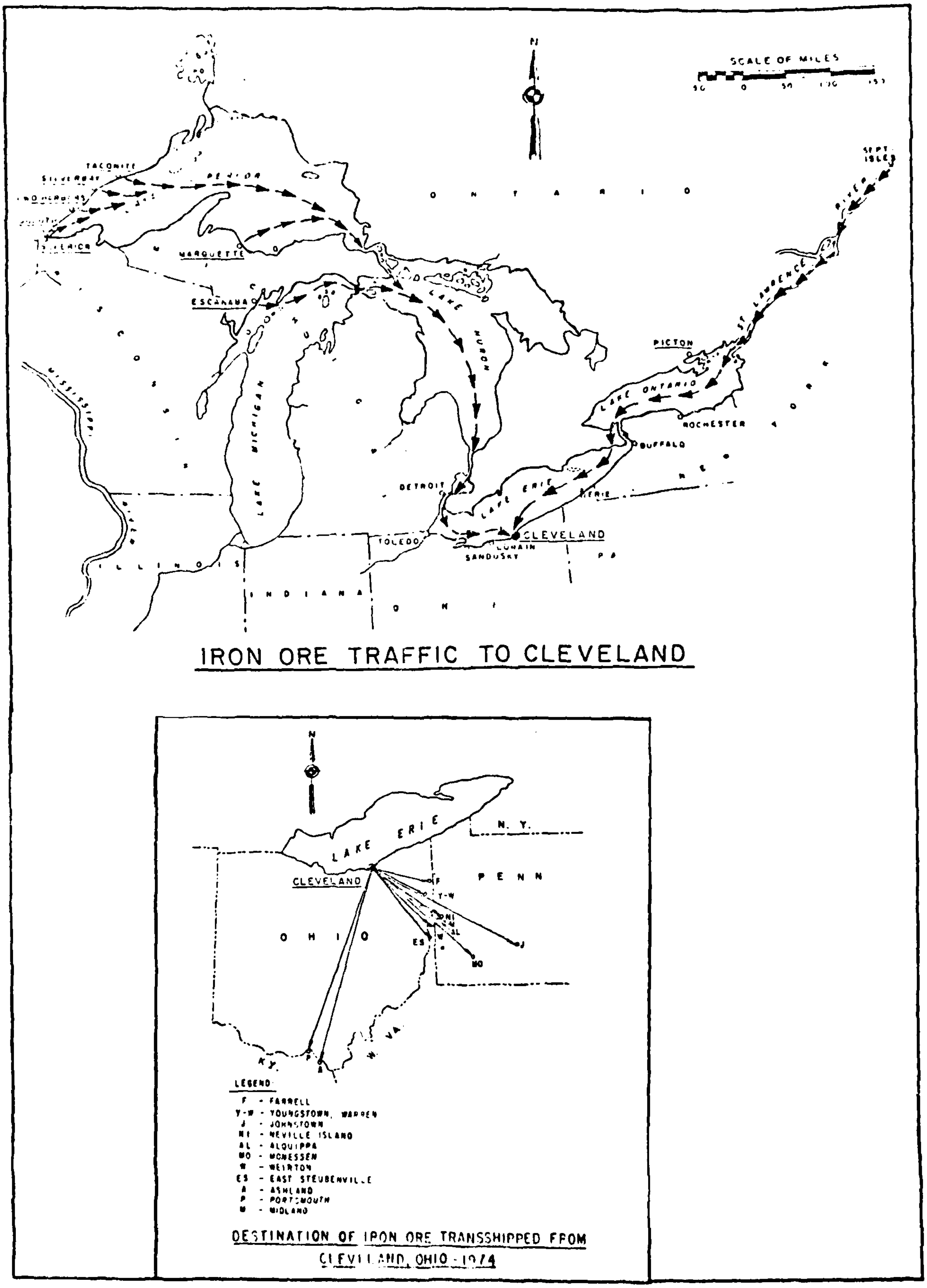
Major Inland Steel Companies	Location
Jones & Laughlin Steel Corp.	Aliquippa, PA
National Steel Corp.	Weirton, WV
Wheeling-Pittsburg Steel Corp.	Steubenville, OH

Table B4 - Selected Commodity Movements at Cleveland Harbor, OH
(Tonnages are in Thousands of Short Tons)

Year	Iron Ore		Limestone		Sand & Gravel		Salt		Selected Commodities: Sub-Total		Harbor Total
	Tonnage	% Total	Tonnage	% Total	Tonnage	% Total	Tonnage	% Total	Tonnage	% Total	
1969	17,593	71.4	2,565	10.4	1,944	7.9	539	2.2	22,641	91.9	24,649
1970	16,649	72.8	2,454	10.7	1,524	6.7	515	2.3	21,142	92.5	22,858
1971	14,694	71.5	2,091	10.2	1,431	7.0	440	2.1	18,656	90.8	20,552
1972	17,450	73.1	2,477	10.4	1,378	5.8	792	3.3	22,097	92.6	23,866
1973	18,080	72.8	2,826	11.4	1,615	6.5	435	1.8	22,956	92.5	24,828
1974	15,635	71.3	2,590	11.8	1,404	6.4	882	4.0	20,511	93.5	21,934
1975	13,263	73.1	1,906	10.5	966	5.3	916	5.0	17,051	94.0	18,145
1976	13,396	73.7	1,935	10.7	823	4.5	740	4.1	16,894	93.0	18,168
1977	10,526	65.4	2,280	14.2	922	5.7	595	3.7	14,323	88.9	16,104
1978	13,770	70.0	2,653	13.5	1,225	6.2	506	2.6	18,154	92.3	19,659
10 Year: Average	15,106	71.7	2,378	11.3	1,323	6.3	636	3.0	19,443	92.3	21,076

SOURCE: Waterborne Commerce Statistics, Part 3, Great Lakes, Corps of Engineers, 1969-1978.

FIGURE B4 CLEVELAND IRON ORE SOURCES AND FINAL DISTRIBUTION AREAS



The iron ore reserves of Minnesota and Michigan are the major source of domestic movements to Cleveland. Canadian ore is mined in Quebec-Labrador mines and railed to deep-water ports along the Gulf of St. Lawrence. The origin ports and historical tonnages for Cleveland iron ore receipts are listed in Table B5.

Iron ore has a low value and is dense relative to other commodities. It is not susceptible to damage and is amenable to efficient bulk handling methods. Because of its low value, transportation decisions regarding ore are extremely price sensitive. Transportation costs comprise a high percentage of the delivered cost of all. The advantage of water transportation is especially significant for bulk commodities such as iron ore.

There is a distinction between crude iron ore and beneficiated iron ore in terms of transportation characteristics. As-mined crude ore has a high moisture content, is low grade in terms of iron content, and is susceptible to freezing. Beneficiated ore, predominantly in pellet form, is low in moisture content. It has more than three times as much of the iron content per ton than crude ore. Pellets do not freeze or cake in cold conditions and are better suited for the most efficient handling techniques. Virtually all of the furnace capacity at Cleveland consists of the basic oxygen variety. Iron content is important because these furnaces require high percentages of high grade ore to steel and scrap in the steel-making process. There are no crude ore receipts at Cleveland. Therefore, the discussion of ore shipments to Cleveland concerns only *high grade* iron bearing pellets.

The efficient transfer of iron ore from the orginating mine to the processing mill depends upon a highly coordinated transportation sequence. This system is comprised of railroads, ships, and dock transfer equipment. The sequence involves moving the crude ore to a beneficiation facility at the mine or origin port. The crude ore or pellets is then moved via rail from the mine site to the origin port. Here the ore is transferred to dry bulk carriers which deliver it to the receiving port.

A portion of the iron ore unloaded at Cleveland Harbor is consumed at the Cuyahoga River steel mills and the remainder is transshipped by rail to the inland users. An overview of the relationship between local and inland iron ore consumption for the period 1969-1978 is provided in Table B6.

There are three major stages in the steel-making process. The first of these stages centers on the blast furnace. The blast furnace uses three basic raw materials: iron ore, coke, and limestone.

Coke provides heat, which releases carbon monoxide and carbon dioxide from the limestone. The carbon monoxide acts on the iron ore so that the iron is separated from the sands and clays and other impurities that are present in the ore. The carbon dioxide can be led off to the coke oven to assist in converting coal to coke. Impurities combine to form a slag. This slag can be used as construction aggregates or a raw material for the cement industry. The iron is led off into pigs, hence the name pig iron. The iron may be used by forges which produce wrought iron, by foundries which make castings; or by a steel converter which produces steel.

Table B5 - Historical Iron Ore Tonnages from Origin Ports to Cleveland
(Tonnages are in Millions of Short Tons)

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	(1) Percent
American Ports											
Duluth, MN	1.3	1.9	1.0	1.5	1.6	1.9	1.3	1.1	0.8	0.9	8.9
Escanaba, MI	1.2	2.1	2.2	2.7	2.4	2.0	2.6	2.7	2.4	2.5	15.1
Marquette, MI	0.6	0.4	0.1	0	0	0	0	0	0	0	-
Presque Isle, MI	2.4	1.4	1.4	1.3	1.4	1.5	1.0	0.9	0.4	1.3	8.6
Silver Bay, MN	5.0	4.1	4.3	5.7	5.6	5.5	3.8	4.9	2.3	4.2	30.0
Superior, WI	2.6	2.0	1.6	2.4	1.9	2.0	1.5	0.7	1.3	1.7	11.7
Taconite, MN	0.7	1.0	0.5	1.2	0.9	0.4	0.4	0.5	2.3	0.4	5.5
Two Harbors, MN	0.2	(2)	0.1	(2)	0.1	0.1	0.1	0.1	0	0.1	0.6
Canadian Ports											
Depot Harbor, Ontario	(2)	0.1	0.1	0.1	0.1	0.1	0.1	(2)	(2)	0.3	0.7
Little Current, Ontario	0.1	0.2	0.2	0.1	0.3	0.3	0.1	0.2	0.1	0.1	1.1
Michipicoten, Ontario	(2)	0	0	0	0	0	0	0	0	0	-
Picton, Ontario	(2)	0	0	0	0	0	0	0	0.3	(2)	0.2
Point Pelee, Ontario	0	0	0.1	0	0	0	0	0	(2)	0	-
Port Arthur, Ontario	0.5	0.1	0.1	0	0.1	0.1	0	0	0	0	0.6
St. Lawrence River above International Boundary	2.7	3.3	3.1	2.4	3.7	1.7	2.3	2.7	2.8	2.2	17.8
Wheatley, Ontario	0	0	0	2/	0	0	0	0	0	0	-
Harbor Total (3)	17.6	16.7	14.7	17.5	18.1	15.6	13.3	13.4	10.5	13.8	

(1) Percentage shown is derived by dividing 10-year average of origin total by 10-year average of harbor total (excluding Marquette, Michipicoten, Point Pelee, and Wheatley).

(2) Less than 50,000 tons.

(3) Total may not equal sum of components due to rounding.

SOURCE: Unpublished Waterborne Commerce Statistics of the United States, Annual Port-to-Port Summary, 1969-1978.

Table B6 - Historical Iron Ore Receipts at Cleveland Harbor
Local Consumption vs. Transshipment
(Tonnages are in Millions of Short Tons)

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
Total Harbor Iron Ore Receipts	17.6	16.7	14.7	17.5	18.1	15.6	13.3	13.4	10.5	13.8
Domestic	14.2	13.0	11.2	14.9	13.9	13.5	10.8	10.4	7.2	11.1
Canadian	3.4	3.7	3.5	2.6	4.2	2.1	2.5	3.0	3.3	2.7
Percent Consumed in Cleveland	37	38	37	38	39	48	43	53	45	51
Domestic	36	35	37	38	39	48	42	52	44	50
Canadian	1	3	(1)	(1)	(1)	(1)	1	1	(2)	1
Percent Transshipped Inland	63	62	63	62	61	52	57	47	55	49
Domestic	44	43	39	47	38	39	39	25	25	31
Canadian	19	19	24	15	23	13	18	22	30	18

(1) Less than 0.5 percent.

(2) A third steel plant on the Cuyahoga River closed on 30 September 1978. One of the existing plants was transshipping tonnage inland (in addition to receiving its own), but now receives all its tonnage from a facility in Lorain and no longer transships any tons.

SOURCE: Unpublished Waterborne Commerce Statistics of the United States, Annual Port to Port Summary, 1969-1978.

Until the invention of the basic oxygen process, there were three types of steel converters in use in the world. The first was invented in 1856 by Henry Bessemer. The Bessemer converter requires an input of hot pig iron. Air is blown through the pig iron to burn off carbon. This technique is a small batch process, with a short conversion time, and poor quality control. A Bessemer converter has low capital and operating costs. A converter lined with dolomite is ideal for removing phosphorus from ores. Phosphoric ores charged into Bessemer converters produce basic or Thomas steel (after the inventor of the phosphorus-removing process). This kind of converter is virtually nonexistent today.

The Open Hearth converter was invented in 1864. Hot and cold pig and scrap iron can all be placed into this converter. It produces large batches of steel and works slowly as air and methane are passed over the metal to provide heat. Advantages of this type of converter include the ability to charge cold scrap metal without prior heating and a high degree of quality control. Approximately 40 percent of the metal moving through an average steel mill is scrap that arises within the plant. This scrap is call circulating scrap.

A third steel converter is the Electric Arc. This converter is used mostly for producing special alloy steels. It uses large amounts of electric power, scrap steel and pig iron. This production of specialty steel also uses alloy metals such as chrome (for resistance to abrasion), vanadium (for flexibility), manganese (for hardness), tungsten (for "high-speed" steels), and molybdenum (for toughness).

The latest entry into the steel-making process is the basic oxygen process (BOP), which was developed in Austria as the Linz-Donawitz (L-D) process. It was introduced to the United States in the early 1950's. It is now the dominant steel-making process in this country. A jet of pure oxygen is injected into the molten metal by a lance of regulated height in a basic refractory-lined converter. Excess carbon, silicon, and other reactive elements are oxidized during the controlled blows. Fluxes are added to form a slag. A "heat" of up to 350 tons of steel can be produced in approximately 45 minutes. Under present practice, the charge consists of about 28 percent scrap with the balance molten pig iron.

Steel moves from the converter to the cogging mill and forging press. Here it is shaped into wheels, axles, etc., or it moves to the finishing mill where plates, sheets, tubes and rails are produced. These products then go to the automotive, construction, container, and engineering industries. These industries constitute the main consumers of the products of the steel industry. Figure B5 presents an overview of the steel-making process, from raw material inputs to finished products.

c. Limestone.

Limestone receipts comprise the second greatest commodity tonnage movement in the harbor. The main use of limestone is as a flux in blast and open-hearth furnaces. Flux helps remove impurities from molten metal. The limestone is crushed, screened, and prepared at the steel-making facilities. Table B7 provides a summary of the relative importance of Great Lakes ports that supply limestone to Cleveland, OH. It also indicates the percent of those receipts consumed by the steel companies.

Stone, like iron ore, is a low-valued product with transportation as the major component of the total cost. Transportation cost minimization becomes critical in determining supply sources. Consequently, virtually all of the limestone moving into Cleveland is consumed locally. Transshipment to inland steel plants is not economical due to the railroad line-haul charge, handling charges, and competition from alternate inland sources.

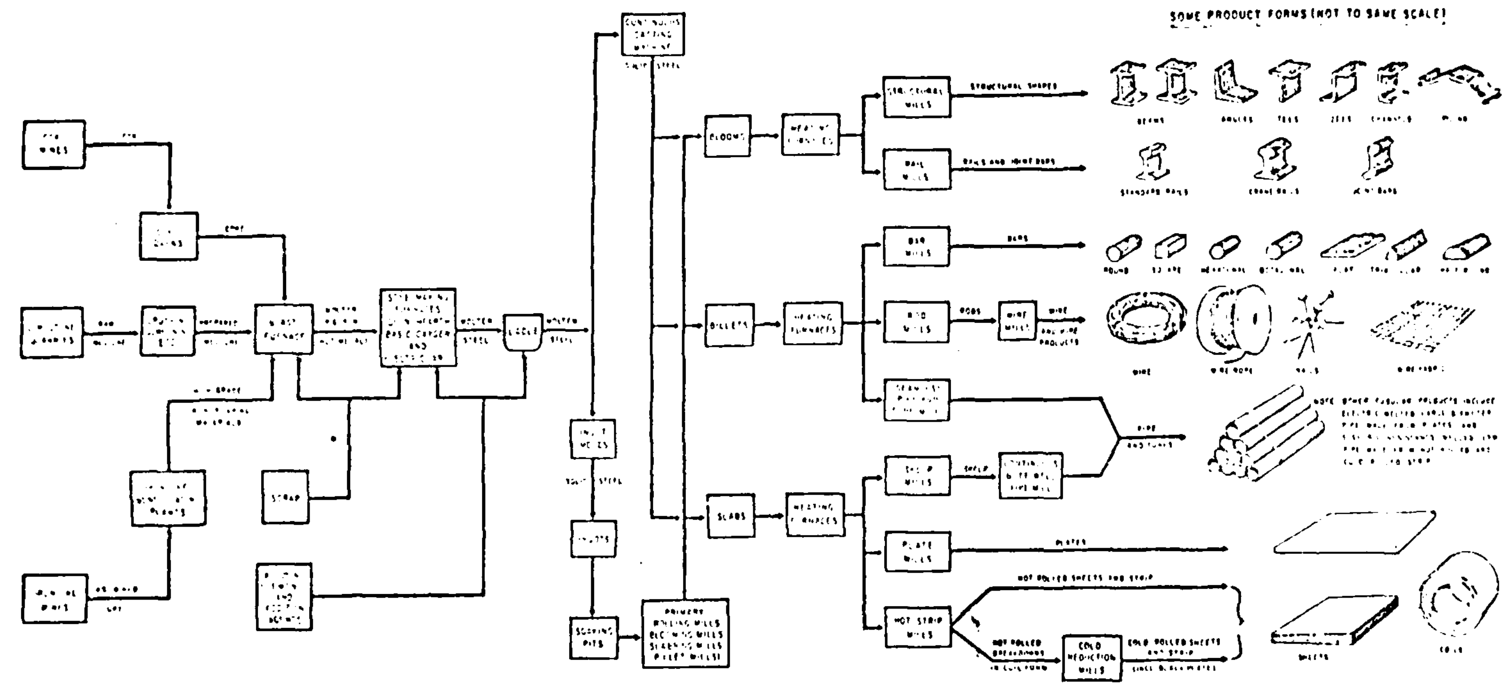


FIGURE B5 - BASIC STEPS IN PRODUCING STEEL PRODUCTS

Limestone is also used in the construction industry. The limestone received by the Old and Cuyahoga River construction supply firms is resold locally.

Table B7 - Historical Limestone Tonnages from Origin Ports to Cleveland Harbor (Tonnages are in Millions of Short Tons)

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	Percent (1)
Calcite, MI	0.15	0.15	0.08	0.11	0.25	0.23	0.09	0.11	0.31	0.43	8.3
Drummond Island, MI	0.02	0.24	0.01	0	0.05	0.06	0.10	0.09	0.19	0.25	4.4
Kelleys Island, OH	0.18	0.13	0.26	0.31	0	0	0	0	0	0	-
Marblehead, OH	0.79	0.53	0.30	0.33	0.80	0.31	0.24	0.28	0.47	0.54	20.0
Port Dolomite, MI	0.10	0.14	0.06	0.19	0.16	0.13	0.10	0.11	0.17	0.20	5.9
Port Inland, MI	0.35	0.40	0.38	0.37	0.40	0.46	0.38	0.33	0.38	0.37	16.7
Stoneport, MI	0.98	1.08	0.99	1.17	1.14	1.39	0.99	1.01	0.77	0.86	45.3
Percent Steel Industry Share	60	75	70	70	60	75	85	85	70	55	
Harbor Total (2)	2.6	2.4	2.1	2.5	2.8	2.6	1.9	1.9	2.3	2.7	

(1) Percentage shown is derived by dividing 10-year average of origin total by 10-year average of harbor total (excluding Kelleys Island).

(2) Totals may not equal sum of components due to rounding.

SOURCE: Unpublished Waterborne Commerce Statistics of the United States, Annual Port-to-Port Summary, 1969-1978.

d. Sand and Gravel.

Sand and gravel movements comprise the third major commodity flow within the Federal project area. This material is used primarily as a filler material in concrete. Sand and gravel is received in the greatest quantities by the construction supply companies located along the Old River and Cuyahoga River. An automobile manufacturer on the Cuyahoga River formerly consumed substantial amounts of sand for use in metal casting. It now receives the commodity by land-based transportation modes.

Table B8 compares the geographic sources for sand and gravel products destined for Cleveland. Canadian movements presently supply over 72 percent of the tonnage movements.

Sand and gravel is a low-value bulk commodity. Inventory costs are a low percentage and transportation costs a high percentage of total delivered costs. Construction materials movement is predominantly local in nature with service being an important factor. The movement of sand and gravel to construction sites is performed by truck hauling firms.

e. Salt.

Ohio ranks fifth in terms of national salt production, accounting for 9 percent of the United States output in 1978. Most of the national salt production is used for the production of chlorine, caustic soda, and soda ash. A substantial amount is used in the northern climes for highway deicing. Salt shipments are the largest commodity movement originating from Cleveland. Table B9 presents Cleveland salt shipment destinations and tonnages for the period 1969-1978. Only one Cleveland dock is involved in the salt traffic. The facilities are located on the Old River.

B3. WATERBORNE COMMERCE PROJECTIONS

a. Overview.

Traffic projections are necessary to conduct the economic evaluation of proposed harbor improvements. For purposes of the National Economic Development (NED) Analysis, the project evaluation period is based on the lesser of (a) the period of time over which the project would serve a useful purpose; or (b) the period of time after which further discounting of beneficial and adverse effects would have no appreciable impact. Traditionally, the evaluation period has been 50 years for general navigation features.

The procedure for constructing traffic projections for the commodity groups identified in the preceding section is to relate the traffic base to an index over time. Assessment of secondary data, surveys of relevant users, shippers, carriers, and port officials, opinions of industry consultants and experts and the historical traffic patterns described earlier form a basis for the projected waterway traffic. Traffic forecasts for individual commodity groups are presented below.

b. Iron Ore.

The major bulk commodity movements on the Great Lakes are associated with the production of iron and steel. Studies concerning input flows to this industry are abundant. Since iron ore receipts are the most important commodity flow at this harbor, the processes of ore production and transportation and steel production were presented. A general description of the steel producing process and the particular origin-destination commodity flows (O/D/C's) that Cleveland steelmakers are currently involved in was discussed in Section B2, Identification of Types and Volumes of Commodity Flow. The physical production capacities of the Cleveland Harbor "hinterland" facilities discussed below will be used to further refine the commodity forecasts. The physical production capabilities presented were aggregated to prevent the disclosure of sensitive information which might pertain to any one individual firm.

(1) Blast Furnaces - The five plants served by Cleveland Harbor possess 24 blast furnaces. These furnaces have a total capacity production of 15.3 million net tons of pig iron per year. Blast furnaces constitute the basic building blocks of the steel-making process. The pig iron they produce is then purified in other furnaces called steel converters.

(2) Steel Converters - Virtually all of the steel-making capacity served by Cleveland Harbor is based on basic oxygen furnaces. One company also operates two electric furnaces. There are no open-hearth operations. The raw steel capacity within the geographic area served by the harbor is 19.4 million net tons.

(3) Finished Products - As mentioned above, all of the plants served are integrated plants. The cogging mills, forging presses, and finishing mills are located in the same industrial complex as the blast furnaces.

Table B8 - Historical Sand and Gravel Tonnages from United States and Canadian Origins to Cleveland Harbor

	Hundred-Thousands of Short Tons										
	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	Percent (1)
American Ports											
East Lake Michigan (Ferrysburg, MI, Ludington, MI and Manistree, MI)	4.72	3.91	3.94	3.82	5.09	2.96	0.40	1.12	1.43	1.54	21.9
East Lake Erie (Fairport, OH and Presque Isle, PA dredge areas)	1.55	1.03	0.67	0.24	0.26	0.40	0.36	0.34	0.36	0.75	4.5
West Lake Erie (Marblehead, OH)	0	0	0	0	0	0.02	0	0.34	0	0	0.3
Canadian Ports											
East Lake Erie (Port Colborne, Ont. and Fort Erie, Ont.)	8.76	6.71	6.56	6.35	7.24	8.39	6.11	4.85	5.76	7.94	51.9
West Lake Erie (Point Pelee dredge area, Leamington, Ont., Wheatley, Ont., and Windsor, Ont.)	4.30	3.57	3.04	3.36	3.23	2.23	2.00	1.50	1.68	1.90	20.3
Lake Ontario and Vicinity	0.02	0.01	0.09	0	0.31	0.05	0	0	0	0	0.4
Total (2)	19.44	15.24	14.31	13.77	16.15	14.04	9.66	8.23	9.22	12.25	

(1) Percentage shown is derived by dividing 10-year average of origin total by 10-year average of harbor total.

(2) Totals may not equal sum of components due to rounding.

SOURCE: Unpublished Waterborne Commerce Statistics of the United States Annual Port to Port Summaries, 19 9-1978.

Table B9 - Historical Bulk Salt Shipments From Cleveland

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	Percent (1)
	Thousands of Short Tons										
American Ports											
Alpena-Bay Shore, MI	8.6	0	0	0	9.6	19.5	0	0	0	0	0.6
Ashtabula, OH	0	0	12.0	0	12.4	0	0	0	0	0	0.4
Bay City-Saginaw-Milwaukee, WI	0	0	0	34.1	24.8	21.8	0	0	0	0	1.3
Buffalo, NY	52.1	69.3	36.9	121.6	63.2	92.8	79.8	0	36.7	23.8	9.1
Duluth, MN	40.5	24.8	16.2	0	13.5	0	0	0	0	0	1.5
Erie, PA	0	117.5	32.2	0	0	46.2	46.8	75.2	123.5	70.9	8.1
Ferrysburg-Grand Haven-Holland, MI	7.8	21.6	0	32.0	12.4	14.4	31.6	11.3	0	0	2.1
Gary, IN	0	0	0	0	5.6	10.0	0	6.0	6.0	8.0	0.6
Gladstone-Marinette, WI	10.1	23.6	36.1	25.3	0	40.9	23.2	38.7	11.5	0	3.3
Green Bay, WI	28.0	24.1	26.2	33.7	14.6	30.0	48.0	24.7	33.6	10.1	4.3
Illinois Waterway	70.3	0	0	40.2	40.0	174.1	206.9	122.3	103.3	71.8	13.0
Manistee, MI	0	0	0	0	9.7	11.2	0	0	0	26.2	0.7
Milwaukee, WI	86.5	129.3	93.4	151.1	44.6	213.2	154.0	150.0	102.7	118.5	20.0
Ogdensburg, NY	0	0	0	0	22.8	13.7	0	24.1	0	0	1.0
St. Ignace, MI	0	0	0	0	0	11.8	0	0	0	0	0.2
St. Joseph, MI	9.0	10.1	0	0	6.4	0	0	0	0	0	0.4
Sheboygan, WI	10.0	13.6	23.3	22.0	10.0	13.7	26.5	27.0	0	0	2.3
Toledo, OH	62.8	39.1	43.2	26.4	48.3	88.1	142.5	103.7	100.5	93.4	11.8
Canadian Ports											
Hamilton, Ont.	0	17.7	0	36.1	0	0	8.9	28.3	0	0	1.4
Midland, Ont.	0	0	0	0	0	0	0	8.1	0	0	0.1
Oshawa, Ont.	0	0	0	28.7	0	0	0	0	0	(3)	0.5
St. Lawrence River above Int. Boundary	83.8	23.9	94.0	206.0	72.2	80.7	113.4	71.7	36.6	69.0	13.4
Thorold, Ont.	0	0	0	5.5	6.8	0	7.2	0	12.2	0	0.5
Toronto, Ont.	69.6	0	30.0	29.1	18.0	0	37.1	48.8	29.0	14.0	4.3
Total (2)	539.0	514.6	440.4	791.8	434.5	882.1	915.8	739.8	595.5	505.8	

(1) Percentage shown is derived by dividing 10-year average of destination total by 10-year average of harbor total.

(2) Totals may not equal sum of components due to rounding.

SOURCE: Unpublished Waterborne Commerce Statistics of the United States Annual Port to Port Summaries, 1969-1978.

Several regional studies were examined to determine the magnitude of future ore movements expected on the Great Lakes in general, and at Cleveland, in particular. Among the analyses reviewed were the Great Lakes/(St Lawrence Seaway Traffic Forecast Study (North Central Division, COE, 1976), the Great Lakes Traffic and Competition Study (Marad, 1980), National Waterways Study Traffic Forecasting Methodology and Demand Projections (IWR, 1980), and OBERS projections for the Cleveland SMSA. These and other studies were then used for Cleveland along with information obtained from harbor users (to develop long-range commodity forecasts).

Annual growth rates for iron ore tonnage, obtained from secondary data, range from 1.4 percent to 2.1 percent. A recent survey of current harbor users reflect lower traffic expectations. The National Waterways Study (NWS) commodity analysis was the most steel district-specific secondary source. This study reflected changing ore beneficiation and steel producing technologies. It contained forecasts which were more compatible with projections obtained from individual dock operators. Therefore, the National Waterway Study was chosen as the basis for ore forecasts. The NWS analysis was subsequently "fine-tuned" to Cleveland Harbor by constraining the projections to reflect current plant steel-making capacities. This was done in light of the fact that no new blast furnace capacity has been added in the last 15 years. This also assumes that new capacity added will consist of electric furnaces which rely primarily upon scrap steel. To determine plant steel-making capacities, liberal assumptions about raw material inputs were made to recognize the possibilities of unforeseen productivity increases. As such, a 1.5:1 ore to pig iron ratio was assumed along with a 1.2:1 BOF input to BOF output ratio. It was also assumed that the BOF charge is 70 percent pig iron and 30 percent scrap. Figure B6 presents the iron ore projections employed in the analysis as "constrained." The original NWS projections are shown as "Unconstrained." Long-term annual iron ore growth rates for the "most probable future" (i.e., constrained by plant capacities) is approximately 1 percent. The NWS forecasts presume a 1.37 percent annual rate of change.

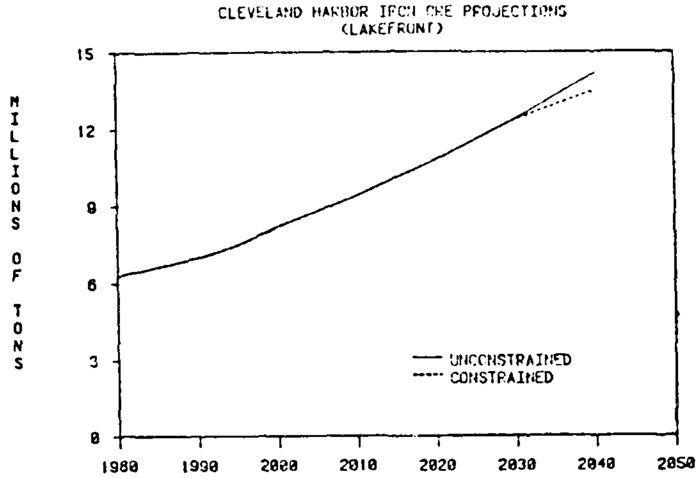
c. Limestone.

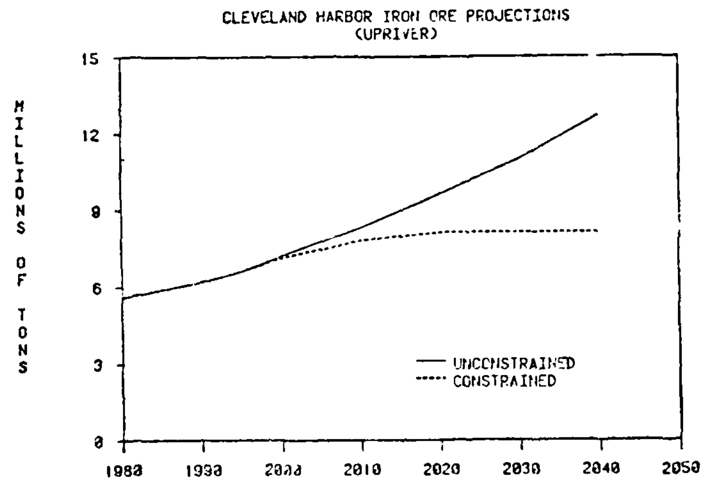
Limestone movements into Cleveland Harbor are heavily linked with iron ore movements. Over 50 percent of this traffic is destined for the steel industry (see Table B7). The consensus of nonsteel limestone receivers is a no-growth scenario. Therefore, limestone receipts of the Cuyahoga River steel plants were projected to increase at the same rate as ore while receipts by nonsteel consumers were held constant. Figure B6 presents the limestone forecasts employed in the analysis. This forecast is labeled constrained.

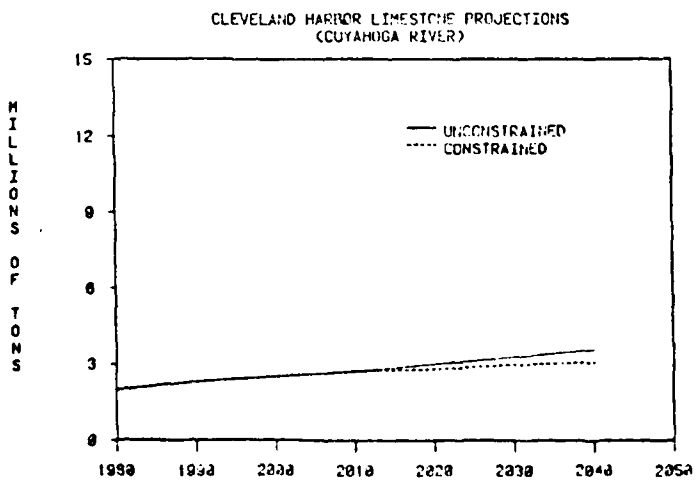
d. Sand and Gravel.

Sand and gravel traffic, received primarily by the construction supply firms, was assumed to be in a no-growth situation. This future scenario is based upon field surveys and coordination with individual dock operators.

FIGURE B6 CLEVELAND HARBOR IRON ORE AND LIMESTONE PROJECTIONS







e. Salt.

National consumption of rock salt for deicing purposes has generally trended upward. However, decreasing occurrences of new highway construction and increasing awareness of environmental damages caused by excessive rock salt applications have contributed to a slow-growth forecast.

f. Traffic Projections.

Table B10 summarizes the major commodity projections for Cleveland Harbor. The economic analysis of all of the alternatives will be based upon the waterborne commerce projections presented in this section.

Because of the multitude of iron ore transshipment facilities currently operating on the south shore of Lake Erie, no project-induced traffic can reasonably be foreseen. Therefore, the growth forecasts shown, constrained only by nonwaterway facilities or waterway facilities not in Cleveland Harbor, will be the basis for the economic evaluation of this report.

Table B10 - Projected Commodity Tonnages - Cleveland Harbor

	Thousands of Short Tons							
		Project Year						
		1	5	10	20	30	40	50
	1980	1990	1995	2000	2010	2020	2030	2040
Outer Harbor Iron Ore	6,300	7,000	7,500	8,200	9,400	10,800	12,400	13,500
Cuyahoga River (1) Iron Ore	5,600	6,200	6,600	7,100	7,800	8,100	8,100	8,100
Total	11,900	13,200	14,100	15,300	17,200	18,900	20,500	21,600
Cuyahoga River (1) Limestone	2,000	2,300	2,400	2,500	2,700	2,800	3,000	3,100
Old River Salt	600	800	1,000	1,000	1,000	1,000	1,000	1,000
Sand and Gravel	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300

(1) Does not include tonnage for recently closed U.S. Steel mill.

B4. TRANSPORTATION COSTS AND FLEET MIX EVALUATION PROCEDURES

The economic benefit from improvements to Cleveland Harbor is the reduction in transportation costs of commercial vessels transporting bulk commodities. Specifically, transportation savings may result from using larger vessels, using existing vessels more efficiently, reducing transit times, and reducing cargo handling and tug assistance costs.

The setting for evaluating possible reductions in transportation costs is defined in terms of a "without-project" condition and alternate "with-project" condition. Briefly, the "without-project" condition is the most likely condition expected to exist over the planning evaluation period in the absence of any plan of improvement. The "with-project" condition is the one expected to occur for alternate plans of improvement. Ideally, there will be as many "with-project" evaluations as there are alternate plans, with benefits attributed to each.

The economic evaluation of alternative plans concentrate on three general parameters: volume of traffic, fleet mix, and unit transportation costs. These variables can be dramatically affected by the physical alteration of the existing Federal harbor. As previously stated, it is assumed that traffic volumes at Cleveland will remain the same under any plan. The major benefit attributable to the harbor improvements are anticipated changes in the physical or financial characteristics of the fleet serving the harbor which lead to reductions in transportation costs.

The process of project sizing for Plans 1, 3A and 3B has been abbreviated in this study. Project sizing would determine the most efficient harbor design that achieves the best balance between expected improvement costs and expected benefits. Engineering and design for each plan of improvement were developed for only one hydrologic (storm) condition. This condition is assumed to occur 100 percent of the time under the "without" and "with-project" scenarios.

Assumptions concerning the fleet mix expected to utilize Cleveland Harbor under both existing and future conditions are as follows: (1) 1,000-foot vessels presently entering Cleveland Harbor were excluded from the "without-project" fleet since it is the opinion of vessel masters that the present west entrance is not suitable for 1,000-foot vessel operation even under ideal weather conditions (see Section II of the Main Report for further discussion of this aspect); (2) Cleveland Harbor improvements will have a highly significant affect on 1,000-foot vessel construction. Therefore, transportation cost savings accruing to alternative improvements, under these assumptions, were used as a surrogate for benefits attributable to "safe and efficient" navigation within Cleveland Harbor.

B5. UNIT TRANSPORTATION COSTS AND VESSEL FLEET COMPOSITION

A key component in evaluating economic impacts of harbor improvements is the potential change in the size, operating characteristics, and resultant cost of vessel operation. The vessel class distribution of the fleets that will be used during the with- and without-project evaluation period are also important study components.

a. Unit Transportation Costs.

A required freight rate analysis was performed to estimate annual transportation costs by commodity. The required freight rate (RFR) is defined as the level of income per ton of cargo necessary to produce an after tax yield of 10 percent on an all-equity investment. The most significant costs which confront the owner/operator of a Great Lakes vessel consist of annual fixed and variable costs associated with operating a given vessel size.

Vessel construction and operating costs developed by the Maritime Administration, U.S. Department of Transportation were used to estimate annual transportation costs. Assumptions on rates of return, economic and engineering life cycles, and the expected length of the navigation season were significant considerations. Annual transportation costs were then divided by the number of tons per season that the vessel could carry, assuming a certain maximum operating draft, vessel operating characteristics, season length and geographic characteristics of the origin or destination ports. These variables were used to estimate the required freight rate by vessel class for a given origin/destination at a given maximum operating draft.

Freight rate differentials resulting from different vessel sizes and/or operating characteristics on a particular trade route can be used to quantify benefits for proposed channel modifications. An overview of the derivation of "required" freight rates is shown in Figure B7.

(1) Required Freight Rate Equation - The required freight rate of a particular vessel operating at a specific draft can be expressed in the following terms:

$$\frac{[a(b) + c\ (d)]}{\left[\left(\frac{c}{2\left[\frac{e}{f} + \frac{g}{h} + i\right]}\right) \times e\right]}$$

where,

a is the construction cost for a specific size/type of vessel,

b is a capital recovery factor,

c is the length of the navigation season,

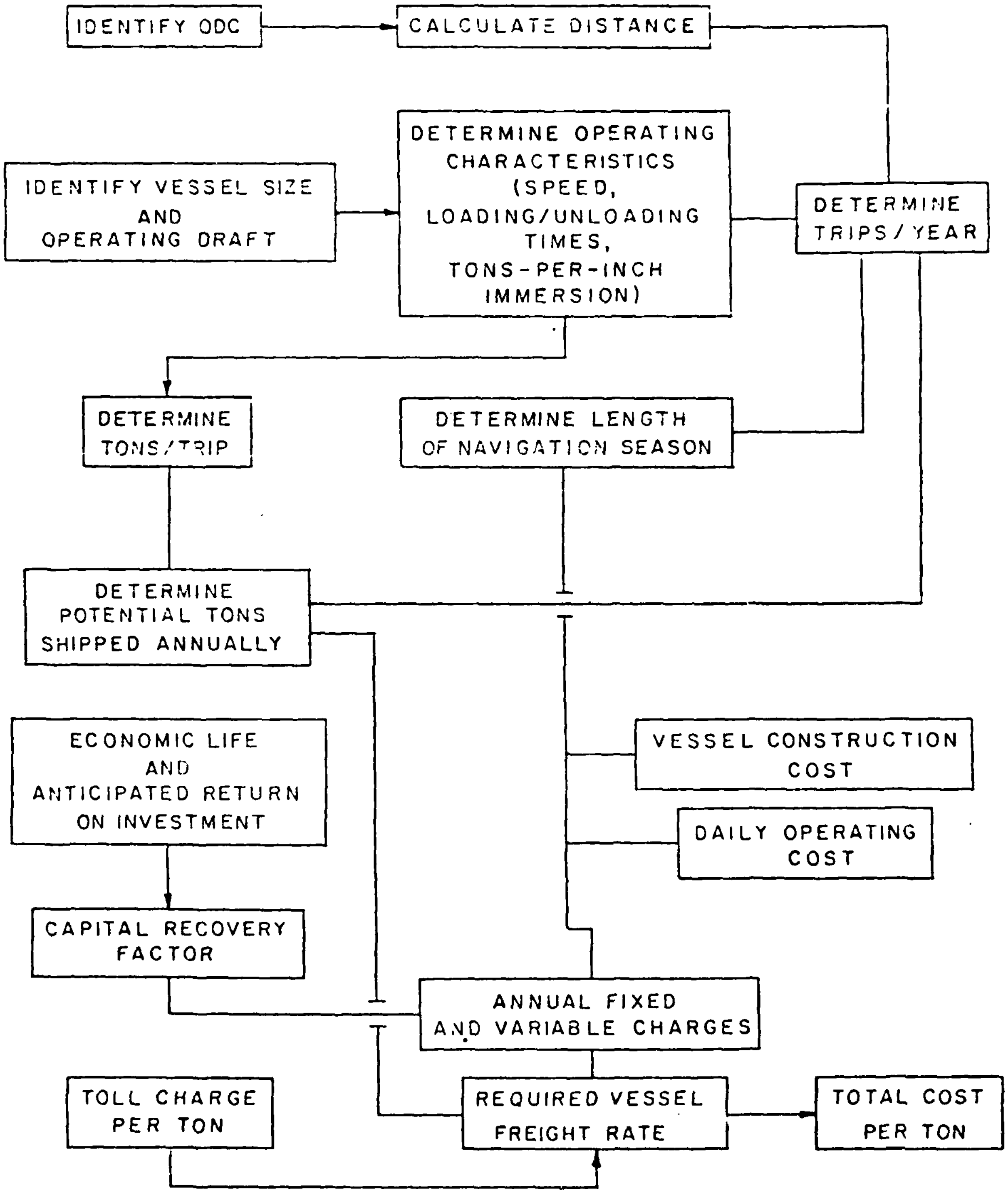


FIGURE B7- PER TON DERIVATION OF VESSEL TRANSPORTATION COSTS d is the daily operating expense of the vessel,

e is the carrying capacity of a specific size of vessel at a particular draft,

f is the unloading/loading rate,

g is the one-way open lake distance between the origin and destination,

h is average open-lake speed, and

i is the time required to traverse locks and harbor maneuvering time.

(2) Vessel Investment Assumptions - The numerator of the required freight rate formula consists of the annual fixed charges and the annual variable costs facing the vessel operator depending on the length of season. These charges change by vessel class, commodity and trade routes.

Variable b, the capital recovery factor, is assumed to be 0.1308. This is based on an expected after-tax yield on investment of 10 percent with a corporate tax rate of 48 percent and a vessel economic life of 50 years. The season length (variable c) assumed was 275 days, or 6,600 hours.

The Maritime Administration vessel classification system was used for evaluating economies of scale existing among vessel sizes within the Great Lakes fleet. Table B11 is a summary of the vessel classification system, which categorizes ships by length, and associated construction and daily operating cost assumptions (variables a and d, respectively).

(3) Vessel Operating Characteristics for Specific Origin-Destination Pairs - The denominator of the required freight rate formula is potential tonnage moved during the navigation season. Required freight rates for each origin-destination trade route reflect geographic factors, i.e., distance, and vessel-specific features, i.e., tons per trip, and average open-lake vessel speeds. Composite vessels by class were developed for each dock's traffic using actual fleet characteristics for the period 1977-1979 based upon waterborne commerce records. Composite vessel sizes presently operating within individual reaches of the harbor are provided in Table B12.

(4) Determination of Maximum Operating Draft - "Static draft," in the case of all vessels, is the distance from the water surface to the lowest point of the vessel's hull under water measured when the vessel is not moving. Maximum operating draft (MOD) is the draft the vessel can safely load to when a design storm condition is occurring. It is derived by integrating characteristics such as the speed and size of the vessel, the depth and width of the channel, and, most importantly, the effects of the design storm condition on vessel movement.

Table B11 - Summary of Vessel Classes and Costs

Vessel Length (feet)	Vessel Class	Construction Costs (1)	Daily Operating Cost (2)
		$	$
400-499	2	17,000,000	8,343
500-549	3	21,000,000	9,775
550-599	4	24,000,000	13,397
600-649	5	30,000,000	14,279
650-699	6	33,000,000	15,377
700-730	7	37,000,000	15,907
731-849	8	41,000,000	13,471
850-949	9	53,000,000	20,729
950-1,099	10	64,000,000	21,519

SOURCE: Letter dated December 1979, Maritime Administration, United States Department of Transportation.

(1) June 1981 prices.

(2) Includes wages, subsistence, stores, supplies, equipment, insurance, maintenance and repair, fuel, tug charges, and lay-up.

Individual vessel movements most critically affecting the depth required at a given static draft is shown in Figure B8. Squat is the combined effect of bodily sinkage and change in trim while a vessel is under way. Roll is the rotation of a vessel around its longitudinal axis which is induced primarily by wave action with a force normal to the port or starboard side of the vessel. The equations to determine each are:

$$S = \frac{V_1^2}{2g} \left[(1.0)\left(\frac{A_1}{A_w}\right)^2 - 0.84 \right] \qquad (a)$$

where:

S = squat at speed V_1 (ft.)

V_1 = ship velocity (ft./sec.) relative to water

A_1 = channel cross sectional area (sq. ft.)

A_w = channel cross sectional area less ship cross sectional area (sq. ft.)

g = 32.2 ft./sec.^{2}

and

$$Y = \frac{B}{2} \text{ Sin } \theta \qquad \text{(b)}$$

where:

Y = depth requirement due to roll (ft.)

B = composite vessel beam (ft.)

θ = roll in degrees

A 2-foot safety bottom clearance is added to the subtotal of equations (a) and (b) to determine required channel depth. The maximum operating draft is determined when static draft and safety clearance under design storm conditions required by a vessel operating within a specified navigation channel equals the available channel depth.

The design storm condition for harbor entrance modification plans (Plans 1, 3A and 3B) is assumed to prevail for 100 percent of the time. The following values are used to reflect vessel movement under design storm conditions: maximum harbor entrance speed of 6 miles per hour (8.8 feet per second), 4° roll for 1,000-foot vessels, and 6° roll for all other vessels.

Because Plans 1, 3A and 3B were formulated for only one storm condition, shippers are assumed to respond to existing conditions by light-loading their vessels. The harbor improvement permits all ships to safely enter the port fully loaded while the design storm condition prevails. This analysis assumes depths presently available within the connecting channels within the GL/SLS are sufficient to allow vessel operation at a maximum draft of 25.5 feet. If the other port in the O/D pair has depths equal to or less than Cleveland, no benefit will accrue towards deepening measures.

(5) Required Freight Rate Calculation - A sample required freight rate calculation is presented in Table B13. The calculation is for an iron ore movement from Duluth-Superior, MN, to the Outer Harbor of Cleveland, OH. The maximum operating draft allowed by existing channel depths in the Outer Harbor is 23 feet. The most critical variable affecting potential tonnage moved, the denominator of the required freight rate equation, is maximum operating draft. Therefore, lake freight transportation costs presented in this appendix show draft as the independent variable. Required freight rates were calculated for the commodities and vessel sizes affected by the project alternatives 1, 3, 5 and 6. These RFR's were calculated for the "without" and "with-project" conditions. These RFR's are presented by alternative and harbor area in Tables B14 to B16.

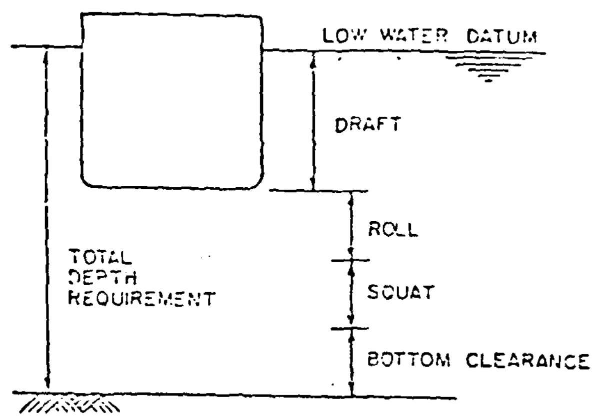
Table B12 - Composite Vessel Characteristics - Cleveland Harbor

Harbor Segment	Vessel	Type of Service	Length (ft)	Beam (ft)	Midsummer Draft (ft-in)	Capacity at MS Draft (NT)	Tons Per Inch of Immersion (NT)
Outer Harbor							
	Class 10	Ore	1,004	105	28-0	66850	237
	Class 8	Ore	794	73	27-9	33450	136
	Class 7	Ore	721	74	28-0	28200	89
	Class 6	Ore	696	70	27-0	26000	108
	Class 5	Ore	620	65	25-9	19350	80
Cuyahoga River*							
	Class 5	Ore	635	68	28-0	26300	86
	Class 5	Ore	631	67	26-5	22700	89
	Class 6	Stone	668	71	27-7	25050	108
	Class 5	Stone	628	66	25-9	20450	95
	Class 5	Stone	622	63	25-3	19800	76
	Class 5	Stone	623	63	25-1	18600	79
	Class 5	Stone	615	63	23-10	17650	71
	Class 5	Stone	620	61	23-6	16200	69
	Class 4	Stone	563	57	21-7	11300	50
	Class 4	Stone	558	56	21-6	12150	48
	Class 4	Stone	556	58	21-4	12800	50
	Class 4	Stone	556	58	21-4	12450	48
Old River*							
	Class 5	Salt	607	60	22-5	14850	62
	Class 4	Salt	558	56	21-6	12050	47
	Class 5	Sand	608	61	22-8	15630	66
	Class 4	Sand	561	56	21-1	12150	47

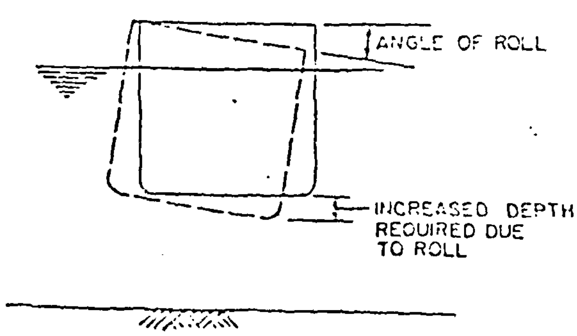
*More than one vessel may be shown for each vessel class since several docks may be serviced by a specific vessel class.

SOURCE: Unpublished Monthly Waterborne Commerce Dock to Dock Data, 1977-1979, and Greenwoods Guide to Great Lakes, 1980.

FIGURE B8 DEFINITION OF DEPTH CRITERIA

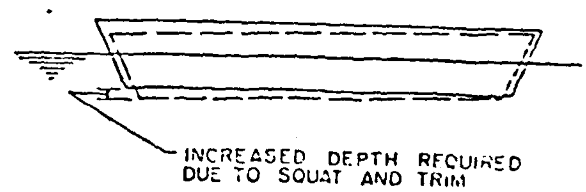


DEFINITION OF TOTAL DEPTH REQUIREMENTS



DEFINITION OF ROLL

The motion of a vessel about its longitudinal axis induced primarily by wave action.



DEFINITION OF SQUAT AND TRIM

SQUAT The combined effect of bodily sinkage and change in trimwhile a vessel is in motion.

TRIM The difference between the draft of a ship forward and that aft.

Table B13 - Required Freight Rate Illustration - Domestic Iron Ore

Commodity: Iron Ore

Harbor Destination: Cleveland Harbor, OH

Harbor Origin: Duluth-Superior, MN

Vessel: Class VII

Vessel Dimensions: 721 feet overall length by 74-foot beam

Vessel Mid-Summer Draft (MSD): 28 feet

Existing Conditions Channel Depth: 28 feet LWD

Maximum Vessel Operating Draft: 23 feet LWD

Vessel Carrying Capacity at MSD: 28,200 net tons

Approximate Capacity Per Inch of Draft: 89 net tons

Carrying Capacity Adjusted to Maximum Vessel Operating Draft:

28 feet - 23 feet = 60 inches

28,200 - (60 X 89) = 22,860

One-Way Open-Lake Distance: 832 miles

Average Speed: 14 mph

Unloading/Loading Rate: 6,000 tons/hour

Length of Navigation Season: 275 days (6,600 hours)

Hours/Round Trip:

Allowance for One-Way Lockage at Soo Locks: 2 Hours

22,860/6000 = 4 hours loading

832/14 = 60 hours in transit

inner harbor maneuvering = 1 hour

(2 + 4 + 60 X 1) 2 = 134 hours/round trip

Maximum Number of Round Trips/Year:

6,600 - 134 = 49

Table B13 - Required Freight Rate Illustration - Domestic Iron Ore (Cont'd)

Potential Annual Tonnage:

22,860 X 49 = 1,120,140

Economic Life of Vessel: 50 years

Initial Investment: $37 million

Capital Recovery Factor for 50 Years: 0.1308

Daily Vessel Operating Cost: $15,907

$$\text{RFR} = \frac{(\$37 \text{ million})(0.1308) + (275)(\$15,907)}{1,120,140} = \$8.23/\text{Net Ton}$$

b. Vessel Fleet Composition.

The future fleet composition of Cleveland Harbor is based upon past trends in vessel sizes and fleet composition illustrated in Table B17. This analysis is complicated by the occasional use of 1,000-foot vessels in the Outer Harbor during recent navigation seasons. Table B18 is a summary of recent Class 10 vessel movements. Shippers have indicated that increasing percent of annual iron ore tonnage received at Cleveland Harbor will be shipped in Class 10 vessels.

The potential safety problem to Class 10 vessels under design storm conditions required two adjustments in the "without-project" fleet: (1) Class 10 vessels will be excluded from the fleet, and (2) the concept of maximum operating draft will preclude the use of fully-loaded vessels. Since no data is available to determine what the fleet composition would be, past trends in fleet composition prevailed under these adjustments. The projected fleet size distribution was based on the current age of the total Great Lakes Fleet, the present composition of the American Fleet (Table B19), specific fleet characteristics obtained from statistics based upon individual dock activity, vessel construction trends over the past 10 years (Table B20), shipper survey responses, and an evaluation of the Great Lakes Fleet conducted by Arctec, Inc. in support of GL/SLS lock capacity studies completed in 1982.

(1) "Without-Project" Fleet Composition - The without-project fleet percent distribution of annual tons moved by vessel class is presented in Table B21. The vessel fleet composition is presented by alternative.

Outer Harbor improvements (Alternatives 1 and 3) would affect the fleet composition used to move iron ore. Class 10 vessels have been excluded from the "without-project" fleet composition for Outer Harbor improvements. Therefore, American Great Lakes shippers are expected to use the next most efficient ship size to carry the bulk of their iron ore.

Table B14 - Required Freight Rates for "Without-Project" Conditions

Alternative/ Reach/Commodity	Vessel Size	Maximum Operating Draft (ft.)	Required Freight Rate ($/ton)
Alternatives 1 & 3			
Lakefront			
Domestic Iron Ore	Class 10	22.5	5.00
	Class 8	23.0	6.65
	Class 7	22.5	7.30
	Class 6	23.0	7.60
	Class 5	23.0	8.85
Canadian Iron Ore	Class 7	22.5	11.85
Cuyahoga River			
Domestic Iron Ore	Class 5	21.0	3.65 (1)
Alternative 5 (2)			
Old River			
Salt	Class 5	21.0	8.20
	Class 4	21.0	8.10
Sand	Class 5	21.0	8.85
	Class 4	21.0	8.90
Stone	Class 5	21.0	5.75
	Class 4	21.0	6.00
Alternative 6 (3)			
Cuyahoga River			
Domestic Iron Ore			
	Class 5	21.0	3.45 (3)
Limestone	Class 6	21.0	7.20
	Class 5	21.0	6.20
	Class 4	21.0	6.25

(1) The required freight rates are composite values to prevent disclosures of individual dock operations. Cuyahoga River unit costs reflect either direct delivery to upriver destinations or lightering at a lakefront dock. Lightered tonnage is presently moved via truck from the river mouth to upriver stockpiles.

(2) Evaluation of deepening the Old River to 28 feet assumes the outer harbor has been deepened to at least a 25.5 maximum operating draft in the without project conditions. The without project maximum operating draft for the Old River is 21 feet.

(3) Evaluation of the Cuyahoga River deepening alternatives assumes that outer harbor deepening to at least 28 feet has already taken place. This allows an additional increase in trip capacity for some Class 5 iron ore vessels using the Cuyahoga River. This incremental tonnage is lightered at the river mouth since river channel depths have not increased.

NOTE: Vessel speeds in the open lake range from 13 to 15 mph, unloading rates range from 3,000 to 10,000 tons per hour, and lock and harbor maneuvering times range from 1 to 24 hours per round trip. Required freight rates are rounded to the nearest nickel.

Table B15 - Required Freight Rates - "With-Project" Conditions - Alternatives 1, 3 and 5

Alternative/ Reach/Commodity	Vessel Type	Maximum Operating Draft (ft.)	Required Freight Rate (1) ($/ton)
Alternatives 1 and 3 - With Outer Harbor Improvements (2)			
Lakefront			
Domestic Iron Ore	Class 10	25.5	4.45
	Class 8	25.5	5.70
	Class 7	25.5	6.50
	Class 6	25.5	6.65
	Class 5	25.5	7.90
Canadian Iron Ore	Class 7	25.5	10.65
Cuyahoga River			
Domestic Iron Ore	Class 5	21.0	3.45 (3)
Alternative 5 - With Outer Harbor Improvements and Authorized Improvements Completed - Option A and B			
Old River			
Salt	Class 7	25.5	5.70 (4)
	Class 5	25.5	7.65
	Class 4	25.5	7.90
Sand	Class 5	25.5	8.10
	Class 4	25.5	8.85
Stone	Class 5	25.5	5.05
	Class 4	25.5	5.90

(1) Required freight rates are rounded to the nearest nickel.

(2) The proposed plan would allow vessels to operate at the maximum GL/SLS system drafts of 25.5 feet LWD in the Outer Harbor.

(3) Increased operating drafts in the Outer Harbor allow an additional increase in trip capacity for some Class 5 iron ore vessels. This incremental tonnage is lightered at the river mouth since river channel depths do not change with Outer Harbor improvements.

(4) The proposed plan would allow vessels to operate at the maximum GL/SLS system draft of 25.5 feet LWD. The maximum sized vessel which could enter the Old River is a Class 7.

Table B16 - Required Freight Rates - "With-Project" Conditions
Alternative 6

Alternative/ Reach/Commodity	Vessel Type	Maximum Operating Draft (ft.)	Required Freight Rate (1) ($/ton)
Alternative 6			
Option A - With Outer Harbor Improvements and Cuyahoga Deepened to 25.5 Feet (2)			
Domestic Iron Ore	Class 5	23.5	3.30 (3)
Limestone	Class 6	23.5	6.20
	Class 5	23.5	5.50
	Class 4	23.5	6.10
Option B - Outer Harbor Improvements and Cuyahoga Deepened to 28 Feet (4)			
Domestic Iron Ore	Class 5	25.5	3.10 (5)
Limestone	Class 6	25.5	5.55
	Class 5	25.5	5.20
	Class 4	25.5	6.10

(1) Required freight rates are rounded to the nearest nickel.

(2) The proposed plan would allow vessels to operate at 23.5 feet with 2.0-foot bottom clearance.

(3) A decrease in the extent of lightering activity at the river mouth is due to increased river depths. This improvement allows a slight reduction in unit costs/ton for direct delivery to upriver stockpiles.

(4) The proposed plan would allow vessels to operate at the maximum GL/SLS system drafts of 25.5 feet at LWD.

(5) All of the iron ore required by upriver steel plants is transported in Class 5 vessels which proceed directly to stockpiles with no lightering at the river mouth.

Table B17 - Historical Tonnage Distribution by Vessel Class

Harbor Segment - Commodity	1973	1975	1977	1979	1980
			(Percent)		
Lakefront (Domestic Iron Ore)					
Class 10	0	0	0	6	5
Class 8	24	19	12	21	20
Class 7	34	62	48	49	50
Class 6	8	13	21	8	10
Class 5	25	6	19	15	15
Class 4	6	0	0	0	0
Class 3	2	1	0	0	0
Class 2	1	0	0	0	0
Cuyahoga River (Domestic Iron Ore)					
Class 5	94	99	95	100	100
Class 4	2	1	3	0	0
Class 3	4	0	2	0	0
Cuyahoga River (Limestone)					
Class 6	1	5	7	8	10
Class 5	59	75	60	63	65
Class 4	40	20	33	29	25
Old River (Salt)					
Class 5	40	74	81	88	75
Class 4	46	22	15	12	20
Old River (Sand)					
Class 5	100	75	84	100	90
Class 4	0	25	16	0	10

SOURCE: Unpublished Monthly Waterborne Commerce Statistics, Dock to Dock, 1973-1979, *Corps of Engineers*.

Table B18 - 1,000-Foot Vessel Entries Into Cleveland Harbor

Vessel	Date	Tons Delivered (NT)	Recorded Draft (ft-in)
GEORGE STINSON	8/13/79	64,701	27-3
JAMES BARKER	9/21/79	65,110	27-5
JAMES BARKER	10/16/79	64,402	27-2
MESABI MINER	12/25/79	61,254	26-0
JAMES BARKER	1/7/80	63,450	26-10
GEORGE STINSON	7/6/80	62,496	26-6
GEORGE STINSON	8/17/80	62,616	26-6
LEWIS WILSON FOY	9/2/80	64,168	27-7
GEORGE STINSON	9/30/80	65,652	27-7

SOURCE: Unpublished Monthly Waterborne Statistics, Dock to Dock Data, 1979-1980, Corps of Engineers.

NOTE: Commercial activity at the Lakefront ore facility is presented for illustrative purposes only. Channel design standards utilized in this report indicate that these vessels could not safely enter the existing Outer Harbor.

Average Age of Great Lakes Fleet by Class

	Average Age in Years						
	CLASS						
	4	5	6	7	8	9	10
Total Great Lakes Fleet (1)	66	44	28	25	25	-	4
Cleveland Harbor Fleet (2)	69	38	27	25	25	-	4

(1) Includes U.S. and Canadian vessels.

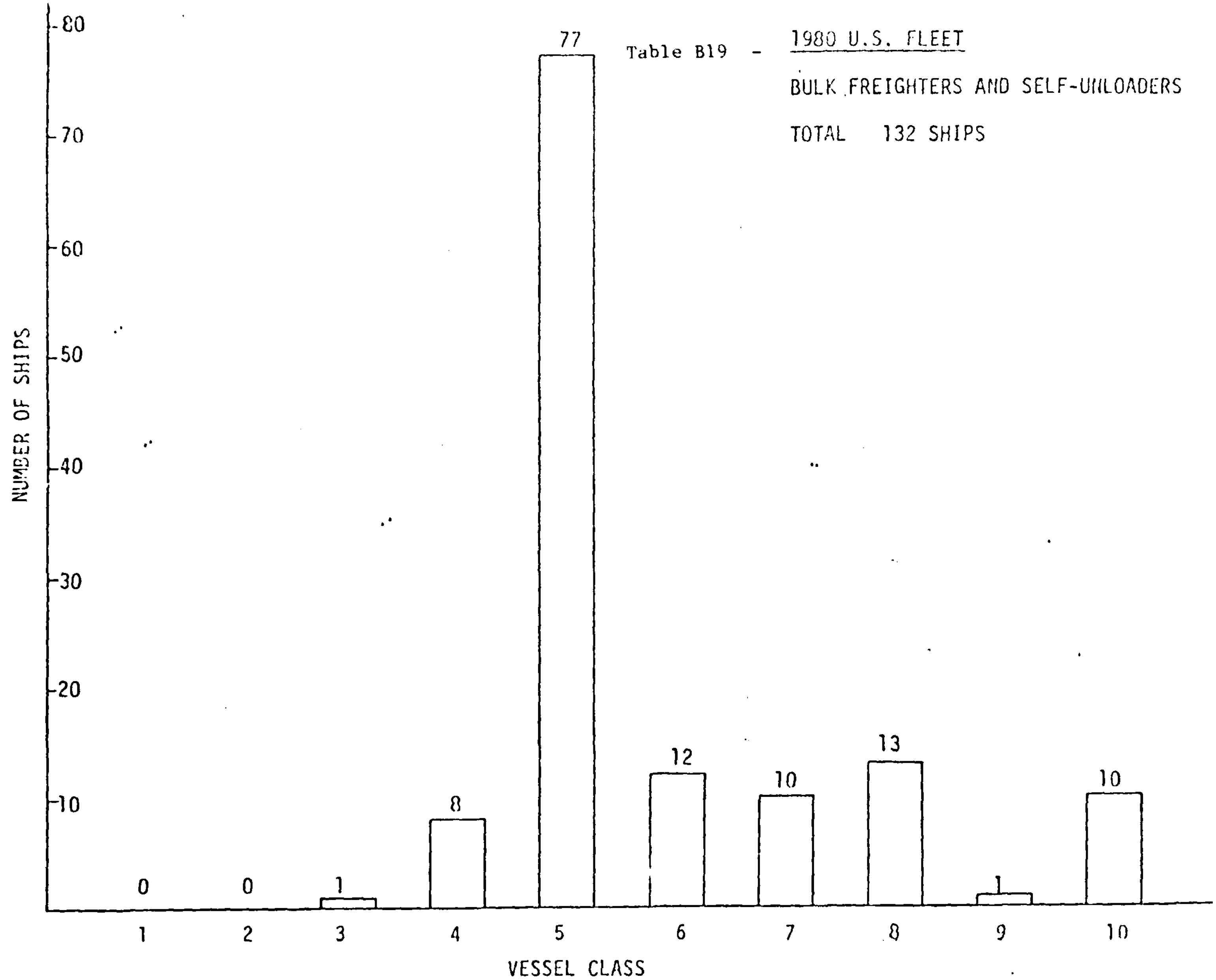
(2) Includes U.S. traffic only, 1980.

The usage of Class 8 vessels for iron ore movements to the Outer Harbor decreased from 24 percent to 20 percent from 1973 to 1980 (Table B17). This decrease in usage is expected to continue in the future at approximately 5 percent per decade. The U.S. fleet currently has 13 Class 8 vessels. Six of these vessels are lengthened Class 5, 6, and 7's. The availability of Class

Table B19 - 1980 U.S. FLEET

BULK FREIGHTERS AND SELF-UNLOADERS

TOTAL 132 SHIPS



Source:Great Lakes/St. Lawrence Seaway Fleet Mix,Arctec Inc.,March,1981.

Table B20 - New Vessel Construction - U.S. Great Lakes Fleet

Vessel Name	Length (feet)	Type	Year Built
BLOUGH, ROGER	858.0	Self Unloader	1972
CORT, STEWART J.	1,000.0	Self Unloader	1972
KYES, ROGER M.	680.0	Self Unloader	1973
MESABI MINER	1,004.0	Self Unloader	1973
PRESQUE ISLE	1,000.0	Self Unloader	1973
ROESCH, WILLIAM R.	630.0	Self Unloader	1973
THAYER, PAUL	630.0	Self Unloader	1973
WILSON, CHARLES E.	680.0	Self Unloader	1973
WHITE, H. LEE	704.0	Self Unloader	1974
WOLVERINE	630.0	Self Unloader	1974
LAUD, SAM	634.8	Self Unloader	1975
BARKER, JAMES R.	1,004.0	Self Unloader	1976
BLOCK, JOSEPH L.	728.0	Self Unloader	1976
ST. CLAIR	770.0	Self Unloader	1976
BELLE RIVER	1,000.0	Self Unloader	1977
FOY, LEWIS WILSON	1,000.0	Self Unloader	1978
STINSON, GEORGE A.	1,004.0	Self Unloader	1978
GOTT, EDWIN H.	1,004.0	Self Unloader	1979
WHITE, JR., FRED R.	636.0	Self Unloader	1979
AMERICAN MARINER	730.0	Self Unloader	1980
BURNS HARBOR	1,000.0	Self Unloader	1980
SPEER, EDGAR B.	1,004.0	Self Unloader	1980
AMERICAN REPUBLIC	634.9	Self Unloader	1981
BEECHLY, CHARLES M.	806.0	Self Unloader	1981
COLUMBIA STAR	1,000.0	Self Unloader	1981
DELANCEY, WILLIAM J.	1,013.6	Self Unloader	1981
INDIANA HARBOR	1,000.0	Self Unloader	1981

Source: Greenwoods Guide To Great Lakes Shipping, 1981.

Table B21 - Percent Distribution of Annual Tons Moved by Vessel Class - Existing Conditions

	Percent of Yearly Tons Moved by Vessel Class							
	Current	1990	1995	2000	2010	2020	2030	2040
Alternatives 1 and 3								
Lakefront Domestic Iron Ore (1)								
Class 10	5	0	0	0	0	0	0	0
Class 8	20	20	15	10	5	0	0	0
Class 7	50	65	75	85	90	100	100	100
Class 6	10	5	5	2.5	2.5	0	0	0
Class 5	15	10	5	2.5	2.5	0	0	0
Lakefront Canadian Iron Ore								
Class 7	100	100	100	100	100	100	100	100
Cuyahoga River Iron Ore								
Class 5	100	100	100	100	100	100	100	100
Alternative 5								
Old River Salt								
Class 5	80	80	80	80	80	80	80	80
Class 4	20	20	20	20	20	20	20	20
Old River Sand								
Class 5	90	90	90	90	90	90	90	90
Class 4	10	10	10	10	10	10	10	10
Old River Stone								
Class 5	75	75	75	75	75	75	75	75
Class 4	25	25	25	25	25	25	25	25
Alternative 6 - Option A and B								
Cuyahoga River Iron Ore								
Class 5	100	100	100	100	100	100	100	100
Cuyahoga River Limestone								
Class 6	10	10	10	10	10	10	10	10
Class 5	65	65	65	65	65	65	65	65
Class 4	25	25	25	25	25	25	25	25

(1) Small Class 5 and 6 vessels will continue to operate in the near term, however, these vessels will be displaced by larger self-unloading vessels during the project planning period.

5 and 6 vessels in the future for lengthening will be restricted by their current advanced age and their present use in delivering coal, grain, and stone.

American shippers servicing Cleveland Harbor have historically preferred Class 7 vessels (Table B17). The percent of total Outer Harbor iron ore moved in Class 7 vessels has risen from 34 percent to 50 percent between 1973 and 1980. The U.S. fleet currently has 10 Class 7 vessels (Table B19). Nine of these vessels are lengthened Class 3, 4, 5, and 6's. The availability of Class 3 and 4 vessels and the high vessel construction costs induced shipowners to lengthen and remodel smaller sized vessels rather than build new, larger ships. These shipowners reduced transportation costs per ton by using lengthened Class 7's. Lengthening of smaller sized vessels to Class 7 and construction of new Class 7's to carry iron ore, is expected to continue in the future. This is based upon the availability of Class 3 and 4 vessels for lengthening and that lengthened Class 7's will not be restricted by the Welland Canal. Thus, Class 7 vessels will be able to service all of the ports on the Great Lakes. This will give shippers greater flexibility in meeting industries demand for iron ore since these fleets will not be captive to the Upper Great Lakes. Class 7's are expected to carry an increasing percentage of iron ore into the Outer Harbor in the "without-project" condition. Seaway-size Class 7 vessels are projected to carry 100 percent of the Outer Harbor iron ore in 2020 (Table B21). This is approximately a 15 percent increase in tonnage moved by Class 7 vessels every 10 years starting in 1990. This reflects the historical increase in Class 7 vessel usage from 1973 to 1980 (Table B17). The change in the Outer Harbor fleet composition to all Class 7 vessels will be gradual due to the large capital costs involved in building new vessels and the age, availability and scrap value of older vessels used in lengthening.

Class 5 and 6 vessels have been carrying a decreasing percentage of Outer Harbor iron ore between 1973 and 1980 (Table B17). This trend is expected to continue in the future at approximately 5 percent every 10 years. The displacement of these vessels by larger self unloading vessels is expected to continue through 2010. This is based on Class 5 and 6 vessels being able to service harbors with operating drafts less than those currently available in Cleveland, OH.

Canadian iron ore receipts at the Outer Harbor historically relied on Class 7 vessels. This pattern is expected to continue in the future since most of the Canadian iron ore is sourced from below the Welland Canal. Also, Class 7 vessels comprise over 50 percent of the present Canadian fleet.

Finally Class 5 vessels are expected to carry 100 percent of the iron ore shipments moving on the Cuyahoga River. This assumption is based on the historical use of Class 5 vessels to deliver upriver iron ore and the physical restriction of the Cuyahoga River upon vessel sizes.

The Old River "without-project" fleet composition is not expected to change from the historical usage patterns developed over time. The limited number of tons moving between any one origin-destination would not warrant any shift in the historical vessel fleet composition.

The Cuyahoga River "without-project" fleet composition is also expected to be the same as that used in 1980. The present fleet composition reflects the most efficient means of transporting Cuyahoga River bulk commodities given the commodities origin port locations and present maximum operating draft and the present configuration of the Cuyahoga River.

(2) "With-Project" Fleet Composition - The "with-project" fleet percent distribution of annual tons moved by each vessel class is presented in Table B22. The Outer Harbor fleet of Alternatives 1 and 3 under improved project conditions will include Class 10 vessels. The present use of Class 10 vessels in the Outer Harbor indicates shippers have found the use of Class 10 vessels at Cleveland economically justifiable (Table B20). This usage of Class 10 vessels is expected to increase in the future under "with-project" conditions. Outer Harbor improvements would allow a deeper operating draft and safer harbor entry conditions. The long distance sourcing patterns of Outer Harbor iron ore (Silver Bay, Duluth-Superior, Escanaba, Presque Isle) also favors the use of larger sized vessels. This shift to Class 10 vessels will be a gradual process (1990 - 15 percent, 1995 - 25 percent). New Class 10 vessel construction is in response to an increase in demand for a specific bulk commodity and is usually tied to a long-term contract. This practice is followed because of the limited number of ports that Class 10 vessels can service. Class 10 vessels are expected to carry 80 percent of Cleveland's Outer Harbor domestic iron ore in 2030.

The use of Class 8 vessels will be phased out under improved Outer Harbor alternatives because of the economies of scale attributed to larger vessels. This phasing out will be a gradual process and is based upon the historical 5 percent decrease in Class 8 vessel usage from 1973 to 1980.

Class 7 vessel usage is expected to grow to 55 percent in 1990 and gradually decrease to 20 percent in 2040. The difference in Class 7 usage between the "without" and "with-project" condition is the usage of Class 10 vessels in the "with-project" condition. This shift is due to the savings in transportation costs attributable to using Class 10 vessels as opposed to Class 7 vessels.

The "with-project" usage of Class 6 and Class 5 vessels to move domestic Lakefront iron ore will decrease at the same rate as the "without-project" fleet projection. Also all the Lakefront Canadian iron ore will be sourced in Class 7 vessels. Finally, Cuyahoga River iron ore affected by the Outer Harbor improvements will be delivered in Class 5 vessels. The usage of these vessels did not differ from the "without-project" condition since these vessel sizes are considered to be optimal under both conditions.

The "with-project" fleet composition for sand and stone will not change from the "without-project" fleet composition. For Old River improvements (Alternative 5), annual tonnage levels are so small between any one origin-destination pair, no upgrading of vessel size is warranted.

The salt "with-project" fleet will be upgraded slightly. Class 7 vessels will carry 20 percent of the total salt movements from 1995 to 2040. This shift will be made due to the deeper operating draft allowed in the Old

Table B22 - Percent Distribution of Annual Tons Moved by Vessel Class - Improved Conditions

	Percent of Yearly Tons Moved by Vessel Class							
	Current	1990	1995	2000	2010	2020	2030	2040
Alternatives 1 and 3								
Lakefront Domestic Iron Ore								
Class 10	5	15	25	35	50	75	80	80
Class 8	20	15	10	5	0	0	0	0
Class 7	50	55	55	55	45	25	20	20
Class 6	10	5	5	2.5	2.5	0	0	0
Class 5	15	10	5	2.5	2.5	0	0	0
Lakefront Canadian Iron Ore								
Class 7	100	100	100	100	100	100	100	100
Cuyahoga River Iron Ore								
Class 5	100	100	100	100	100	100	100	100
Alternative 5								
Old Rivera Salt - with Old River Authorized Improvements and Outer Harbor Improvements Completed								
Old River Salt								
Class 7	0	0	20	20	20	20	20	20
Class 5	80	80	70	70	70	70	70	70
Class 4	20	20	10	10	10	10	10	10
Old River - Sand								
Class 5	90	90	90	90	90	90	90	90
Class 4	10	10	10	10	10	10	10	10
Old River - Stone								
Class 5	75	75	75	75	75	75	75	75
Class 4	25	25	25	25	25	25	25	25
Alternative 6 - Option A and B								
Cuyahoga River Iron Ore								
Class 5	100	100	100	100	100	100	100	100
Cuyahoga River Limestone								
Class 6	10	10	10	10	10	10	10	10
Class 5	65	65	65	65	65	65	65	65
Class 4	25	25	25	25	25	25	25	25

River under improved project conditions, the transportation cost savings Class 7 vessels can provide, and the existence of a straight river channel up to the entrance of the Old River. A relatively large number of salt origin-destination trade routes require a limited amount of tonnage to be moved. This explains the small percentage of total salt tonnage being shifted from Class 5 and Class 4 vessels to Class 7 vessels.

Finally, the "with-project" fleet for the Cuyahoga River deepening alternatives (Alternative 6) did not change from the "without-project" fleet. The future fleet will be able to carry more tons per trip because of the greater river depths. The present Cuyahoga River fleet composition is presumed to deliver bulk commodities at the lowest water cost given the commodities origin port locations and the present configuration of the Cuyahoga River.

B6. FUTURE TRANSPORTATION COSTS OF COMMODITY MOVEMENTS DURING THE PROJECT EVALUATION PERIOD

a. Overview.

Future transportation costs are needed to determine future benefits accruing to any proposed plans of improvement. Average annual transportation costs are calculated for the with and without (base case) project condition for each alternative plan of improvement. The difference between the base case transportation costs and estimated costs associated with proposed plans of improvement are the benefits (transportation cost savings) of each alternative. The required freight rates, vessel fleet composition and traffic forecasts are combined to determine total transportation costs. Total transportation costs are calculated for the "with" and "without-project" condition for each alternative.

The following assumptions were used in determining future transportation costs. For the project evaluation period the present commodity sourcing patterns will not change. The fixed and variable operating costs and loading/unloading rates will not change over time. Consequently, the required freight rates for the "with" and "without-project" conditions will remain constant over the 50-year evaluation period. Transportation costs per ton are presented in Tables B14-B16. The future fleet composition by project alternative, harbor reach, and commodity is assumed to change over the evaluation period for the "with" and "without-project" condition. These changes were presented in Tables B21 and B22.

The tonnage projections, by decade, for commodities affected by alternative were allocated among vessel classes. This allocation was performed according to the projected percentage of tonnage moved by vessel class for the "with" and "without-project" condition.

The result is a forecast by project alternative of affected tonnages moved by vessel class and type of commodity. These tonnage forecasts were multiplied by the "with-project" and "without-project" condition required freight rates for each alternative. This produces future transportation costs for each project alternative by vessel class and affected commodity tonnages for the "with" and "without-project" condition.

The commodity transportation cost time stream by vessel class and project alternative is then converted to an average annual equivalent value for the "with" and "without-project" condition. The average annual equivalents are based upon a discount rate of 7.625 percent, a 50-year project life, and normal growth between intervals.

b. Future Transportation Costs of Commodity Movements - Constrained Commodity Projections.

The commodity tonnage projections that most likely represent Cleveland Harbor's activity over the planning evaluation period is presented in Table B23.

These tonnage projections are based upon information in Table B10, which is based upon the National Waterways Study (NWS) growth projections. The

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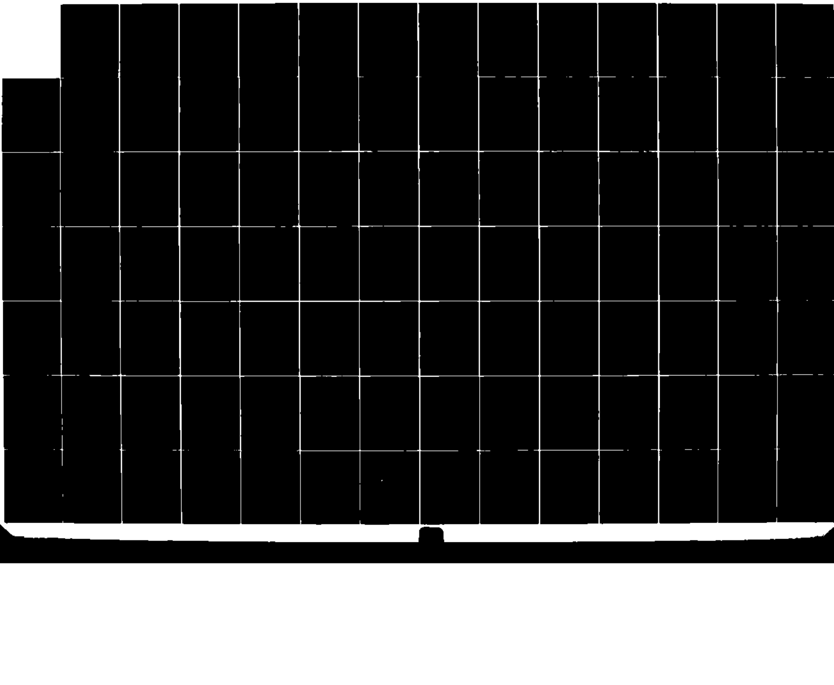
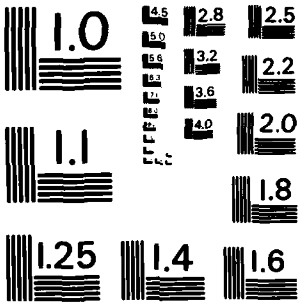




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

iron ore projection has been limited by the steel production capacity of the steel plants receiving iron ore through Cleveland Harbor. Limestone demand is assumed to grow at the same rate as iron ore demand.

The commodity tonnage forecasts in Table B10 have been regrouped to show the commodities and tonnages affected by each improvement alternative (Table B23). Only affected tonnages were used to determine the "with" and "without-project" transportation costs for the four listed alternatives.

Table B24 presents the "with" and "without-project" total transportation costs for Alternatives 1, 3A and 3B. The transportation costs are the same for these three alternatives since they provide the same Outer Harbor channel depths and entrance conditions for Class 10 vessels.

The transportation costs reflect the lightering operation presently taking place at the mouth of the Cuyahoga River. A deeper Outer Harbor allows a portion of the Class 5 Cuyahoga River iron ore vessels to enter the Outer Harbor at a 25.5-foot operating draft instead of the former 23.0-foot draft. These vessels can therefore lighter more tons per trip before proceeding up the Cuyahoga River. This is reflected in the increased lightering costs between the "without" and "with-project" conditions.

Table B25 presents the "with" and "without-project" transportation costs for improvements on the Old River (Alternative 5). This analysis assumes that the Outer Harbor will be deepened to allow a 25.5 maximum operating draft. This change in transportation costs reflect the increase in operating draft and for salt movements a shift to larger size vessels.

Table B26 presents the "with" and "without-project" transportation costs for deepening the Cuyahoga River to 25.5 feet and 28.0 feet, respectively. The "without-project" transportation costs assume the Outer Harbor has been deepened to a 25.5 maximum operating draft. The decrease in transportation costs between the "without-project" and "with-project" conditions reflect the utilization of an increased operating draft. Under Alternative 6B, all lightering costs have been eliminated. This is because the operating draft of the Cuyahoga River and the Outer Harbor are at the same depth of 25.5 feet.

Table B23 - Projected Commodity Tonnages -
Harbor Constrained Tonnage Forecasts
(Thousands of Short Tons)

Alternative/ Reach/Commodity	Project Year 1990	1995	2000	2010	2020	2030	2040
Alternatives 1 and 3							
Outer Harbor							
Iron Ore	7,000	7,500	8,200	9,400	10,800	12,400	13,500
Cuyahoga River							
Iron Ore	6,200	6,600	7,100	7,800	8,100	8,100	8,100
Total Affected Tonnage	13,200	14,100	15,300	17,200	18,900	20,500	21,600
Alternative 5 - Old River Improvements							
Old River							
Salt (1)	800	1,000	1,000	1,000	1,000	1,000	1,000
	(760)	(950)	(950)	(950)	(950)	(950)	(950)
Sand and Gravel (1)	1,300	1,300	1,300	1,300	1,300	1,300	1,300
	(130)	(130)	(130)	(130)	(130)	(130)	(130)
Stone (2)	59	59	59	59	59	59	59
Total Affected Tonnage	949	1,139	1,139	1,139	1,139	1,139	1,139
Alternative 6 - Cuyahoga River Improvements							
Cuyahoga River							
Iron Ore	6,200	6,600	7,100	7,800	8,100	8,100	8,100
Limestone	2,300	2,400	2,500	2,700	2,800	3,000	3,100
Total Affected Tonnage	8,500	9,000	9,600	10,500	10,900	11,100	11,200

(1) Due to restrictive harbor depths at certain origin ports and the vessel sizes currently transporting the commodities 95 percent of the projected salt and 10 percent of the projected sand and gravel tonnages will be affected if Old River improvements are made. The affected tonnages are in parentheses.

(2) The implementation of Old River improvements will cause 59,000 tons of Cuyahoga River stone receipts to be shifted to the Old River.

Table B24 - Future Cost of Commodity Movements, Alternatives 1, 3A, and 3B, Constrained Commodity Projections

Condition/ Location/Commodity	Vessel Size	Thousands of Dollars 1990	1995	2000	2010	2020	2030	2040	Average Annual Transportation Costs (1)
"Without-Project" - Outer Harbor East or West Entrance Plan:									
Outer Harbor Domestic Ore	Class 10	0	0	0	0	0	0	0	
	Class 8	5,674	4,756	3,634	2,222	0	0	0	
	Class 7	20,214	26,066	33,861	43,848	58,926	70,657	78,694	
	Class 6	1,621	1,812	1,038	1,270	0	0	0	
	Class 5	3,766	2,104	1,206	1,475	0	0	0	
Canadian Ore	Class 7	31,995	31,995	31,995	31,995	31,995	31,995	31,995	
Total		63,270	66,733	71,734	80,810	90,921	102,652	110,689	74,084
Cuyahoga River Domestic Ore	Class 5	22,967	24,620	25,854	26,766	27,216	27,216	27,216	
	(Lightered)	543	582	604	604	604	604	604	
Total		23,510	25,202	26,458	27,370	27,820	27,820	27,820	26,080
Total Transportation Costs		86,780	91,935	98,192	108,180	118,741	130,472	138,509	100,164
"With-Project" - Outer Harbor East or West Entrance Plan (2)									
Outer Harbor Domestic Ore	Class 10	2,844	5,297	8,499	14,850	26,940	34,457	38,377	
	Class 8	3,649	2,719	1,558	0	0	0	0	
	Class 7	15,276	17,073	19,569	19,582	13,157	12,621	14,057	
	Class 6	1,412	1,578	904	1,106	0	0	0	
	Class 5	3,357	1,876	1,075	1,315	0	0	0	
Canadian Ore	Class 7	28,755	28,755	28,755	28,755	28,755	28,755	28,755	
Total		55,293	57,298	60,360	65,608	68,852	75,833	81,189	60,923
Cuyahoga River Domestic Ore	Class 5	21,018	22,530	23,687	24,599	25,049	25,049	25,049	
	(Lightered)	960	1,030	1,068	1,068	1,068	1,068	1,068	
Total		21,978	23,560	24,755	25,667	26,117	26,117	26,117	24,309
Total Transportation Costs		77,271	80,858	85,115	91,275	94,969	101,950	107,306	85,232

(1) Average annual costs are based on a discount rate of 7.625 percent, a 50-year project life, and normal growth between intervals, June 1981 prices.

(2) Plan of improvement allows vessel operation during 30-knot winds and 8-foot waves.

Table B25 - Future Cost of Commodity Movements, Alternative 5 - Old River Improvements
Constrained Commodity Projections

Condition/Commodity	Vessel Size	Thousands of Dollars							Average Annual Transportation Costs (1)
		1990	1995	2000	2010	2020	2030	2040	
"Without-Project" - Outer Harbor Improvements Completed									
Salt	Class 5	4,908	6,135	6,135	6,135	6,135	6,135	6,135	
	Class 4	1,298	1,622	1,622	1,622	1,622	1,622	1,622	
Sand and Gravel	Class 5	1,037	1,037	1,037	1,037	1,037	1,037	1,037	
	Class 4	116	116	116	116	116	116	116	
Stone (2)	Class 5	254	254	254	254	254	254	254	
	Class 4	89	89	89	89	89	89	89	
Totals		7,702	9,253	9,253	9,253	9,253	9,253	9,253	9,034
"With-Project" - Authorized Old River Improvements Completed in Conjunction With Outer Harbor Improvements									
Salt	Class 7	0	1,134	1,134	1,134	1,134	1,134	1,134	
	Class 5	4,584	4,966	4,966	4,966	4,966	4,966	4,966	
	Class 4	1,267	792	792	792	792	792	792	
Sand and Gravel	Class 5	945	945	945	945	945	945	945	
	Class 4	115	115	115	115	115	115	115	
Stone (2)	Class 5	223	223	223	223	223	223	223	
	Class 4	87	87	87	87	87	87	87	
Totals		7,221	8,262	8,262	8,262	8,262	8,262	8,262	7,976

(1) Average annual costs are based on a discount rate of 7.625 percent, a 50-year project life, and normal growth between intervals in some 1981 prices.

(2) The above stone traffic movements are the result of a shift of destination from the Cuyahoga River to the Old River due to Old River and East or West Entrance Outer Harbor Improvements.

Table B26 - Future Cost of Commodity Movements, Alternatives 6A and 6B, Constrained Commodity Projections

Condition/Commodity	Vessel Size	Thousands of Dollars 1990	1995	2000	2010	2020	2030	2040	Average Annual Transportation Costs (1)
"Without-Project" - Alternatives 6A and 6B, With Outer Harbor Improvements Only									
Domestic Ore	Class 5	21,018	22,530	23,687	24,599	25,049	25,049	25,049	
	(Lightered)	960	1,030	1,068	1,068	1,068	1,068	1,068	
Limestone	Class 6	1,566	1,566	1,566	1,566	1,566	1,566	1,566	
	Class 5	6,824	7,215	7,596	8,210	8,513	8,513	8,513	
	Class 4	3,249	3,386	3,512	3,712	3,810	3,810	3,810	
Total		33,617	35,727	37,429	39,155	40,006	40,006	40,006	37,034
"With-Project" - Alternative 6A, With Outer Harbor Improvements, Cuyahoga River Deepened to 25.5 Feet									
Domestic Ore	Class 5	20,632	22,116	22,819	24,079	24,495	24,495	24,495	
	(Lightered)	418	448	464	464	464	464	464	
Limestone	Class 6	1,346	1,346	1,346	1,346	1,346	1,346	1,346	
	Class 5	5,792	6,123	6,448	6,974	7,233	7,233	7,233	
	Class 4	3,172	3,306	3,429	3,625	3,722	3,722	3,722	
Total		31,360	33,339	34,506	36,488	37,260	37,260	37,260	34,442
"With-Project" - Alternative 6B, With Outer Harbor Improvements, Cuyahoga River Deepened to 28 Feet									
Domestic Ore	Class 5	19,936	21,370	22,446	23,250	23,657	23,657	23,657	
	(Lightered)	0	0	0	0	0	0	0	
Limestone	Class 6	1,204	1,204	1,204	1,204	1,204	1,204	1,204	
	Class 5	5,698	6,028	6,354	6,880	7,139	7,139	7,139	
	Class 4	3,172	3,306	3,429	3,625	3,722	3,722	3,722	
Total		30,010	31,908	33,433	34,959	35,722	35,722	35,722	33,166

(1) Average annual costs are based on a discount rate of 7.625 percent, a 50-year project life, and normal growth between intervals, June 1981 prices.

NOTE: The level of lightered tonnage is affected by individual plans of improvement.

B7. SENSITIVITY INVESTIGATIONS - TRANSPORTATION COSTS

Transportation costs under various project alternatives can be significantly affected by deviations in the economic assumptions underlaying the forecast scenario and unforeseen changes in future fleet compostion. Three alternative scenarios were developed to determine the impacts or variation in calculated transportation costs. The impacts of two alternative commodity traffic forecasts and one variation in future fleet composition were evaluated.

a. High Growth Scenario.

A higher level of projected tonnage was developed which was not constrained by existing capacity of steel plants serviced by Cleveland Harbor. This analysis utilized the unconstrained iron ore and limestone forecasts presented in Figure B6 and is based on the NWS long-term growth projections. The tonnage projections are not held constant once existing plant capacities are reached, but continue to increase throughout the evaluation period. However, the sand and gravel and salt projections are assumed to remain unchanged. Table B27 summarizes the commodity projections for the high growth scenario.

These tonnage forecasts were grouped to show only the commodities and tonnages affected by each improvement alternative in Table B28. These time series were used to determine future transportation costs by alternative. The tonnage projections in Table B28 were converted to vessel class tonnage movement projections by commodity and harbor reach. This was done by distributing the tonnage projections over time into various vessel classes based upon the percentage of tonnage moved by vessel class under the "without" (Table B21) and "with-project" (Table B22) conditions. This results in a forecast of tonnages moved by vessel class by commodity for specific project alternatives. These tonnage forecasts are then multiplied by the unit transportation costs for the "without" (Table B14) and "with-project" (Tables B15 and B16) condition of each alternative. This produces future transportation costs by project alternative, commodity, and vessel class.

The "with" and "without-project" transportation costs for Alternatives 1, 3A and 3B are presented in Table B29. The "with" and "without-project" transportation costs for Old River improvements are presented in Table B30. This analysis assumes that the Outer Harbor has a maximum operating draft of 25.5 feet in the "without-project" condition.

Table B31 presents the "with" and "without-project" transportation costs for deepening alternatives on the Cuyahoga River. Both deepening alternatives assume the maximum operating draft into the Outer Harbor is 25.5 feet in the "without-project" condition.

b. Low Growth Scenario.

Correspondence with Cleveland Harbor dock operators and review of historical traffic levels indicate that a future scenario of lower growth rates than those exhibited in Table B10 could also be constructed.

Table B27 - Projected Commodity Tonnages - High Growth Scenario

Commodity	Thousands of Short Tons							
	Project Years							
		1	5	10	20	30	40	50
	1980	1990	1995	2000	2010	2020	2030	2040
Iron Ore	11,900	13,200	14,100	15,400	17,700	20,400	23,400	26,900
Limestone	2,000	2,300	2,400	2,500	2,700	3,000	3,300	3,600
Sand and Gravel (1)	1,300 (130)	1,300 (130)	1,300 (130)	1,300 (130)	1,300 (130)	1,300 (130)	1,300 (130)	1,300 (130)
Salt (1)	0.600 (570)	0.800 (760)	1,000 (950)	1,000 (950)	1,000 (950)	1,000 (950)	1,000 (950)	1,000 (950)

(1) Approximately 10 percent of the sand and gravel tonnage and 95 percent of the salt tonnage are affected by Federal Harbor improvements - other sand and gravel and salt movements would not be affected by harbor improvements because of restrictive harbor depths at the port of origin. The affected tonnages for both commodities are shown in parentheses.

Therefore, iron ore and limestone commodity projections were calculated using the maximum tonnage stated in the correspondence with dock users as the values for project year 2040. Straight-line growth was assumed between 1980 and 2040. The sand and gravel and salt projections are assumed to remain unchanged. The commodity projections for this low growth scenario are presented in Table B32.

These forecasted tonnages were then distributed over a range of ship sizes applicable to each alternative for the "with" and "without-project" condition (Tables B22 and B21). The applicable "with" and "without-project" required freight rates (Tables B14, B15 and B16) were applied to the tonnage expected to be carried by vessel class. This procedure results in "with" and "without-project" future transportation costs for each project alternative.

The "with" and "without-project" transportation costs for Outer Harbor improvements (Alternatives 1, 3A, and 3B) are presented in Table B33. Comparable costs for Old River and Cuyahoga River improvements are presented in Tables B34 and B35.

c. Change in Fleet Composition.

Estimated transportation costs in the base case for Outer Harbor improvements assume 1,000-foot vessels are not part of the fleet. However, 1,000-foot vessels have been operating in the Outer Harbor since 1979. Therefore, the following analysis determines future transportation costs for Alternatives 1, 3A and 3B, assuming 1,000-foot vessels are used in the "without-project" conditions to carry iron ore to the transshipment dock adjacent to the Outer Harbor.

The tonnage projections used in calculating the transportation costs for this sensitivity analysis are identical to the projection series used in the most probable future (Table B23). The percent of iron ore moved by vessel class over time for the "without-project" and "with-project" Outer Harbor improvements of Alternatives 1, 3A and 3B is presented in Tables B36 and B37, respectively.

The required freight rates for the "with" and "without-project" condition of Alternatives 1, 3A and 3B are those presented in Tables B15 and B14.

Again the above commodity forecasts, percent distribution of tonnages by vessel class and appropriate required freight rates were combined to determine future transportation costs for Alternatives 1, 3A, and 3B. The "with" and "without-project" transportation costs for Alternatives 1, 3A and 3B are presented in Table B38.

Table B28 - Projected Tonnages by Alternative - High Tonnage Forecast

Alternative/ Reach/Commodity	Thousands of Short Tons						
	Project Year						
	1990	1995	2000	2010	2020	2030	2040
Alternatives 1 and 3							
Outer Harbor Iron Ore	7,000	7,500	8,200	9,400	10,800	12,400	14,200
Cuyahoga River Iron Ore	6,200	6,600	7,200	8,300	9,600	11,000	12,700
Total Affected Tonnage	13,200	14,100	15,400	17,700	20,400	23,400	26,900
Alternative 5 - Old River Improvements							
Old River Salt (1)	800 (760)	1,000 (950)	1,000 (950)	1,000 (950)	1,000 (950)	1,000 (950)	1,000 (950)
Sand and Gravel (1)	1,300 (130)	1,300 (130)	1,300 (130)	1,300 (130)	1,300 (130)	1,300 (130)	1,300 (130)
Stone (2)	59	59	59	59	63	63	63
Total Affected Tonnage	949	1,139	1,139	1,139	1,143	1,143	1,143
Alternative 6 - Cuyahoga River Improvements							
Cuyahoga River Iron Ore	6,200	6,600	7,200	8,300	9,600	11,000	12,700
Limestone	2,300	2,400	2,500	2,700	3,000	3,300	3,600
Total Affected Tonnage	8,500	9,000	9,700	11,000	12,600	14,300	16,300

(1) Due to restrictive harbor depths at certain origin ports and vessel sizes currently transporting the commodities, 95 percent of the projected salt and 10 percent of the projected sand and gravel tonnages will be affected if Old River improvements are made. The affected tonnages are in parentheses.

(2) The implementation of Old River improvements will cause a portion of the Cuyahoga River stone receipts to be shifted to the Old River.

Table B29 - Future Cost of Commodity Movements, Alternatives 1, 3A, and 3B, High Tonnage Forecast

Condition/ Location/Commodity	Vessel Size	Thousands of Dollars 1990	1995	2000	2010	2020	2030	2040	Average Annual Transportation Costs (1)
Without-Project									
Outer Harbor Domestic Ore	Class 10	0	0	0	0	0	0	0	
	Class 8	5,674	4,756	3,634	2,222	0	0	0	
	Class 7	20,214	26,066	33,861	43,848	58,926	70,657	84,133	
	Class 6	1,621	1,811	1,038	1,270	0	0	0	
	Class 5	3,766	2,104	1,206	1,475	0	0	0	
Canadian Ore	Class 7	31,995	31,995	31,995	31,995	31,995	31,995	31,995	
Total		63,270	66,733	71,734	80,810	90,921	102,652	116,128	74,155
Cuyahoga River Domestic Ore	Class 5	22,967	24,620	26,917	30,935	35,548	40,847	46,944	
	(Lightered)	543	582	636	731	840	965	1,110	
Total		23,510	25,202	27,553	31,666	36,388	41,812	48,054	28,801
Total Transportation Costs		86,780	91,935	99,287	112,476	127,309	144,464	164,182	102,956
With Outer Harbor Improvements									
Outer Harbor Domestic Ore	Class 10	2,844	5,297	8,499	14,850	26,940	34,457	41,029	
	Class 8	3,649	2,719	1,558	0	0	0	0	
	Class 7	15,276	17,073	19,569	19,582	13,157	12,621	15,029	
	Class 6	1,412	1,578	904	1,106	0	0	0	
	Class 5	3,357	1,871	1,075	1,315	0	0	0	
Canadian Ore	Class 7	28,755	28,755	28,755	28,755	28,755	28,755	28,755	
Total		55,293	57,298	60,360	65,608	68,852	75,833	84,813	60,970
Cuyahoga River Domestic Ore	Class 5	21,018	22,530	24,633	28,310	32,532	37,382	43,961	
	(Lightered)	960	1,030	1,126	1,294	1,487	1,708	1,963	
Total		21,978	23,560	25,759	29,604	34,019	39,090	45,924	26,925
Total Transportation Costs		77,271	80,858	85,119	95,212	102,871	114,923	130,737	87,895

(1) Average annual costs are based on a discount rate of 7.625 percent, a 50-year project life and normal growth between intervals, June 1981 prices.

Table B30 - Future Cost of Commodity Movements, Alternative 5, Old River Improvements
High Tonnage Forecast

Condition/Commodity	Vessel Size	Thousands of Dollars 1990	1995	2000	2010	2020	2030	2040	Average Annual Transportation Costs (1)
"Without-Project" - Outer Harbor Improvements ›mpleted									
Salt	Class 5	4,908	6,135	6,135	6,135	6,135	6,135	6,135	
	Class 4	',298	1,622	1,622	1,622	1,622	1,622	1,622	
Sand and Gravel	Class 5	',037	1,037	1,037	1,037	1,037	1,037	1,037	
	Class 4	116	116	116	116	116	116	116	
Limestone (2)	Class 5	254	254	254	254	273	273	273	
	Class 4	89	89	89	89	95	95	95	
Totals		7,702	9,253	9,253	9,253	9,278	9,278	9,278	9,038
"With-Project" - Authorized Old River Improvements Completed in Conjunction With Outer Harbor Improvements									
Salt	Class 7	0	1,134	1,134	1,134	1,134	1,134	1,134	
	Class 5	4,584	4,966	4,966	4,966	4,966	4,966	4,966	
	Class 4	1,267	792	792	792	792	792	792	
Sand and Gravel	Class 5	945	945	945	945	945	945	945	
	Class 4	115	115	115	115	115	115	115	
Limestone	Class 5	223	223	223	223	239	239	239	
	Class 4	87	87	87	87	93	93	93	
Totals		7,221	8,262	8,262	8,262	8,284	8,284	8,284	7,979

(1) Average annual costs are based on a discount rate of 7.625 percent, a 50-year project life, and normal growth between intervals, June 1981 prices.

(2) A portion of the limestone traffic movements shift from the Cuyahoga River to the Old River.

Table B31 - Future Cost of Commodity Movements, Alternatives 6A and 6B, Cuyahoga River Improvements, High Tonnage Forecast

Condition/Commodity	Vessel Size	Thousands of Dollars 1990	1995	2000	2010	2020	2030	2040	Average Annual Transportation Costs (1)
"Without-Project" - Alternatives 6A and 6B, With Outer Harbor Improvements Only									
Domestic Ore	Class 5	21,018	22,530	24,633	28,310	32,532	37,382	43,961	
	(Lightered)	960	1,030	1,126	1,294	1,487	1,708	1,963	
Limestone	Class 6	1,567	1,567	1,567	1,567	1,678	1,678	1,678	
	Class 5	6,830	7,221	7,602	8,217	10,254	10,254	10,254	
	Class 4	3,249	3,386	3,512	3,712	4,082	4,082	4,082	
Total		33,624	35,734	38,440	43,100	50,033	55,104	61,938	39,999
"With-Project" - Alternative 6A, Cuyahoga Deepened to 25.5 Feet With Outer Harbor Improvements									
Domestic Ore	Class 5	20,632	22,116	24,180	27,790	31,934	36,694	42,171	
	(Lightered)	418	449	489	563	646	743	854	
Limestone	Class 6	1,347	1,347	1,347	1,347	1,442	1,442	1,442	
	Class 5	5,791	6,122	6,447	6,973	7,750	7,750	7,750	
	Class 4	3,196	3,332	3,458	3,658	4,025	4,025	4,025	
Total		31,384	33,356	35,921	40,331	45,797	50,654	56,242	37,395
"With-Project" - Alternative 6B, Cuyahoga Deepened to 28 Feet With Outer Harbor Improvements									
Domestic Ore	Class 5	19,936	21,370	23,365	26,852	30,857	35,455	40,749	
	(Lightered)	0	0	0	0	0	0	0	
Limestone	Class 6	1,206	1,206	1,206	1,206	1,291	1,291	1,291	
	Class 5	5,697	6,027	6,353	6,879	7,649	7,649	7,649	
	Class 4	3,196	3,332	3,458	3,658	4,025	4,025	4,025	
Total		30,035	31,935	34,382	38,595	43,822	48,420	53,714	35,612

(1) Average annual costs are based on a discount rate of 7.625 percent, a 50-year project life, and normal growth between intervals, June 1981 prices.

NOTE: The level of lightered tonnage is affected by individual plans of improvement.

Table B32 - Projected Tonnages by Alternative -
Low Tonnage Forecast

Alternative/ Reach/Commodity	Project Year 1990	1995	2000	2010	2020	2030	2040
Alternatives 1 and 3							
Outer Harbor							
Iron Ore	6,500	6,600	6,700	7,000	7,200	7,500	7,700
Cuyahoga River							
Iron Ore	5,900	6,100	6,200	6,500	6,900	7,200	7,600
Total Affected Tonnage	12,400	12,700	12,900	13,500	14,100	14,700	15,300
Alternative 5 - Old River Improvements							
Old River							
Salt (1)	800 (760)	1,000 (950)	1,000 (950)	1,000 (950)	1,000 (950)	1,000 (950)	1,000 (950)
Sand and Gravel (1)	1,300 (130)	1,300 (130)	1,300 (130)	1,300 (130)	1,300 (130)	1,300 (130)	1,300 (130)
Stone (2)	56	54	52	50	50	50	50
Total Affected Tonnage	946	1,134	1,132	1,130	1,130	1,130	1,130
Alternative 6 - Cuyahoga River Improvements							
Cuyahoga River							
Iron Ore	5,900	6,100	6,200	6,500	6,900	7,200	7,600
Limestone	2,200	2,200	2,200	2,300	2,300	2,400	2,500
Total Affected Tonnage	8,100	8,300	8,400	8,800	9,200	9,600	10,100

(1) Due to restrictive harbor depths at certain origin ports and the vessel sizes currently transporting the commodities, 95 percent of the projected salt and 10 percent of the projected sand and gravel tonnages will be affected if Old River improvements are made. The affected tonnages are in parentheses.

(2) The implementation of Old River improvements will cause some Cuyahoga River stone receipts to be shifted to the Old River.

Table B33 - Future Cost of Commodity Movements, Alternatives 1, 3A, and 3B, Low Tonnage Forecast

Condition/ Location/Commodity	Vessel Size	1990	1995	2000	2010	2020	2030	2040	Average Annual Transportation Costs (1)
		Thousands of Dollars							
"Without-Project"									
Outer Harbor Domestic Ore	Class 10	0	0	0	0	0	0	0	
	Class 8	5,082	3,821	2,689	1,420	0	0	0	
	Class 7	18,102	20,942	25,050	28,021	32,865	34,653	36,500	
	Class 6	1,452	1,455	768	811	0	0	0	
	Class 5	3,372	1,691	892	943	0	0	0	
Canadian Ore	Class 7	31,995	31,995	31,995	31,995	31,995	31,995	31,995	
Totals		60,003	59,904	61,394	63,190	64,860	66,648	68,495	62,955
Cuyahoga River Domestic Ore		21,660	22,110	22,593	23,525	24,515	25,554	26,640	
	(Lightered)	509	518	527	547	567	587	608	
Totals		22,169	22,628	23,120	24,073	25,082	26,141	27,248	23,393
Total Transportation Costs		82,172	82,532	84,514	87,263	89,942	92,789	95,743	86,348
With Outer Harbor Improvements									
Outer Harbor Domestic Ore	Class 10	2,547	4,255	6,288	9,490	15,025	16,894	17,800	
	Class 8	3,268	2,184	1,153	0	0	0	0	
	Class 7	13,681	13,716	14,477	12,514	7,338	6,190	6,520	
	Class 6	1,265	1,268	669	707	0	0	0	
	Class 5	3,006	1,507	795	840	0	0	0	
Canadian Ore	Class 7	28,755	28,755	28,755	28,755	28,755	28,755	28,755	
Totals		52,522	51,685	52,137	52,306	51,118	51,839	53,075	51,884
Cuyahoga River Domestic Ore	Class 5	19,833	20,249	20,679	21,562	22,481	23,446	24,456	
	(Lightered)	900	916	934	968	1,003	1,039	1,076	
Totals		20,733	21,165	21,613	22,530	23,484	24,485	25,532	21,889
Total Transportation Costs		73,255	72,850	73,750	[illegible]	74,602	76,324	78,607	73,773

(1) Average annual costs are based on a discount rate of 7.625 percent, a 50-year project life and normal growth between intervals, June 1981 prices.

Table B34 - Future Cost of Commodity Movements, Alternative 5, Old River Improvements
Low Tonnage Forecast

Condition/Commodity	Vessel Size	Thousands of Dollars 1990	1995	2000	2010	2020	2030	2040	Average Annual Transportation Costs (1)
"Without-Project" - Outer Harbor Improvements Completed									
Salt	Class 5	4,908	6,135	6,135	6,135	6,135	6,135	6,135	
	Class 4	1,298	1,622	1,622	1,622	1,622	1,622	1,622	
Sand and Gravel	Class 5	1,037	1,037	1,037	1,037	1,037	1,037	1,037	
	Class 4	116	116	116	116	116	116	116	
Stone (2)	Class 5	243	233	224	217	217	217	217	
	Class 4	85	81	78	76	76	76	76	
Totals		7,687	9,224	9,212	9,203	9,203	9,203	9,203	8,997
"With Project" - Authorized Old River Improvements Completed in Conjunction With Outer Harbor Improvements									
Salt	Class 7	0	1,134	1,134	1,134	1,134	1,134	1,134	
	Class 5	4,584	4,966	4,966	4,966	4,966	4,966	4,966	
	Class 4	1,267	792	792	792	792	792	792	
Sand and Gravel	Class 5	945	945	945	945	945	945	945	
	Class 4	115	115	115	115	115	115	115	
Stone (2)	Class 5	213	204	196	190	190	190	190	
	Class 4	83	80	77	74	74	74	74	
Totals		7,207	8,236	8,225	8,216	8,216	8,216	8,216	7,942

(1) Average annual costs are based on a discount rate of 7.625 percent, a 50-year project, and normal growth between intervals, June 1981 prices.

(2) The above stone traffic movements are the result of a shift of destination from the Cuyahoga River to the Old River due to Old River and "All-Weather" Outer Harbor improvements being made.

Table B35 - Future Cost of Commodity Movements, Alternatives 6A and 6B, Cuyahoga River Improvements
Low Tonnage Forecast

Condition/Commodity	Vessel Size	Thousands of Dollars 1990	1995	2000	2010	2020	2030	2040	Average Annual Transportation Costs (1)
"Without Project" - Alternatives 6A and 6B - With Outer Harbor Improvements Only									
Domestic Ore	Class 5	19,833	20,249	20,679	21,562	22,481	23,446	24,456	
	(Lightered)	900	916	934	968	1,003	1,039	1,076	
Limestone	Class 6	1,498	1,433	1,378	1,334	1,334	1,334	1,334	
	Class 5	6,527	6,610	6,684	6,994	7,252	7,252	7,252	
	Class 4	3,108	3,103	3,092	3,162	3,245	3,245	3,245	
Totals		31,866	32,311	32,767	34,020	35,315	36,316	37,363	33,200
"With Project" - Alternative 6A - Cuyahoga Deepened to 25.5 Feet With Outer Harbor Improvements									
Domestic Ore	Class 5	19,462	19,867	20,285	21,144	22,037	22,995	23,956	
	(Lightered)	218	282	226	234	242	251	260	
Limestone	Class 6	1,287	1,234	1,185	1,147	1,147	1,147	1,147	
	Class 5	5,541	5,612	5,674	5,941	6,162	6,162	6,162	
	Class 4	3,034	3,030	3,018	3,088	3,170	3,170	3,170	
Totals		29,542	29,965	30,388	31,554	32,758	33,705	34,695	30,791
"With Project" - Alternative 6B - Cuyahoga Deepened to 28 Feet With Outer Harbor Improvements									
Domestic Ore	Class 5	18,803	19,194	19,597	20,426	21,287	22,190	23,136	
	(Lightered)	0	0	0	0	0	0	0	
Limestone	Class 6	1,152	1,104	1,060	1,026	1,026	1,026	1,026	
	Class 5	5,450	5,525	5,591	5,860	6,081	6,081	6,081	
	Class 4	3,034	3,030	3,018	3,088	3,170	3,170	3,170	
Totals		28,439	28,853	29,266	30,400	31,564	32,467	33,413	29,656

(1) Average annual costs are based on a discount rate of 7.625 percent, a 50-year project life, and normal growth between intervals, June 1981 prices.

Table B36 - Change in Fleet Composition - Base Case -
Outer Harbor Improvements, Alternatives 1, 3A and 3B

	Percent Distribution of Tonnage by Vessel Size						
	1990	1995	2000	2010	2020	2030	2040
Lakefront Domestic Iron Ore							
Class 10	10	15	20	20	25	25	25
Class 8	15	10	5	0	0	0	0
Class 7	60	65	70	75	75	75	75
Class 6	5	5	2.5	2.5	0	0	0
Class 5	10	5	2.5	2.5	0	0	0
Lakefront Canadian Iron Ore							
Class 7	100	100	100	100	100	100	100
Cuyahoga River Iron Ore							
Class 5	100	100	100	100	100	100	100

Table B37 - Change in Fleet Composition - "With-Project"
Outer Harbor Improvements, Alternatives 1, 3A and 3B

	Percent Distribution of Tonnage by Vessel Size						
	1990	1995	2000	2010	2020	2030	2040
Lakefront Domestic Iron Ore							
Class 10	15	25	35	50	75	80	80
Class 8	15	10	5	0	0	0	0
Class 7	55	55	55	45	25	20	20
Class 6	5	5	2.5	2.5	0	0	0
Class 5	10	5	2.5	2.5	0	0	0
Lakefront Canadian Iron Ore							
Class 7	100	100	100	100	100	100	100
Cuyahoga River Iron Ore							
Class 5	100	100	100	100	100	100	100

Table B38 - Future Cost of Commodity Movements, Alternatives 1, 3A and 3B, Change in Fleet Composition

	Vessel Size	Thousands of Dollars							Average Annual
		1990	1995	2000	2010	2020	2030	2040	Transportation Costs (1)
"Without Project"									
Outer Harbor Domestic Ore	Class 10	2,139	3,585	5,479	6,701	10,130	12,147	13,529	
	Class 8	4,256	3,171	1,817	0	0	0	0	
	Class 7	18,659	22,591	27,885	36,540	44,194	52,993	59,021	
	Class 6	1,621	1,812	1,038	1,270	0	0	0	
	Class 5	3,766	2,104	1,206	1,475	0	0	0	
Canadian Ore	Class 7	31,995	31,995	31,995	31,995	31,995	31,995	31,995	
Subtotal Outer Harbor		62,436	65,258	69,420	77,981	86,379	97,135	104,545	71,533
Cuyahoga River Domestic Ore	Class 5	22,967	24,620	25,854	26,766	27,216	27,216	27,216	
	(Lightered)	543	582	604	604	604	604	604	
Subtotal Cuyahoga River		23,510	25,202	26,458	27,370	27,820	27,820	27,820	26,080
Total Transportation Costs		85,946	90,460	95,878	105,351	114,199	124,955	132,365	97,613
"With-Project"									
Outer Harbor Domestic Ore	Class 10	2,844	5,297	8,499	14,850	26,940	34,457	38,377	
	Class 8	3,649	2,719	1,558	0	0	0	0	
	Class 7	15,276	17,073	19,569	19,582	13,157	12,621	14,057	
	Class 6	1,412	1,578	904	1,106	0	0	0	
	Class 5	3,357	1,876	1,075	1,315	0	0	0	
Canadian Ore	Class 7	28,755	28,755	28,755	28,755	28,755	28,755	28,755	
Subtotal Outer Harbor		55,293	57,298	60,360	65,600	68,852	75,833	81,189	60,923
Cuyahoga River Domestic Ore	Class 5	21,018	22,530	23,687	24,599	25,049	25,049	25,049	
	(Lightered)	960	1,030	1,068	1,068	1,068	1,068	1,068	
Subtotal Cuyahoga River		21,978	23,560	24,755	25,667	26,117	26,117	26,117	24,309
Total Transportation Costs		77,271	80,858	85,115	91,267	94,969	101,950	107,306	85,232

(1) Average annual costs are based on a discount rate of 7.625 percent, a 50-year project life and normal growth between intervals, June 1981 prices.

B8. CONGESTION ANALYSIS ON THE CUYAHOGA RIVER

a. Introduction.

In its review of the Cleveland Harbor Final Feasibility Report in August 1977, the Board of Engineers for Rivers and Harbors (BERH) identified severe congestion on the Cuyahoga River with concomitant vessel delays and hazards to navigation. The congestion study for this Phase I General Design Memorandum investigates the need for and justification of improvements to the Cuyahoga River that would alleviate the perceived difficulties in navigation.

For purposes of the study, river congestion is defined as either: (1) vessel delay as a result of physical constrictions (i.e., delay due to movement of a vessel past a fixed object); or (2) vessel delay as a result of vessel-to-vessel interference. Vessel-to-vessel interference can be further divided into (a) vessel delay as a result of two vessels passing (which results in one vessel yielding the right-of-way); or (b) vessel delay as a result of one vessel moving past another which is unloading at a dock.

Congestion on the Cuyahoga will be affected by the implementation of project alternatives that deepen the Outer Harbor (Alternatives 1, 3A and 3B) deepen the Cuyahoga River (Alternatives 6A and 6B) and remove congestion sites on the river (Alternative 7). Deepening alternatives would allow a given level of tonnage to be moved using less trips per year since more tons could be carried per trip. For example, Outer Harbor deepening will affect the lightering operation of iron ore at the mouth of the Cuyahoga River. A deeper Outer Harbor means more tons could be carried per trip to the lightering dock. This decreases the total number of trips needed per year to carry a given annual level of tonnage to an upriver dock location.

First of all, the congestion study would have to identify the location of specific congestion points along the river. Secondly, an estimate of the increase in yearly vessel operating costs due to vessel congestion or related delays on the Cuyahoga would be needed for the "with" and "without-project" conditions for Alternatives 1, 3A, 3B, 6A and 6B. The difference between the "without" and "with-project" condition yearly vessel operating costs over the evaluation period would be the vessel operating costs avoided due to the implementation of the various improvement plans.

The location of the congestion areas on the river were determined by a survey of harbor users conducted during the 1981 navigation season. The survey identified the location of the delays, type or size of vessels affected and duration of the delays encountered at each location on the Cuyahoga River.

Seven fixed object delay points were identified by harbor users:

(1) Site No. 1 - Conrail Bridge No. 1,

(2) Site No. 2 - the Cereal Food Processors Dock,

(3) Site No. 3 - Turn two of the river,

(4) Site No. 4 - Turn four of the river,

(5) Site No. 5 - Turn five of the river,

(6) Site No. 6 - Conrail Bridge No. 14,

(7) Site No. 7 - Jefferson Avenue bridge abutments.

Each loaction is shown in Figure B9. Four of these areas were also identified as a source of vessel-to-vessel interference: the channel adjacent to the Cereal Food Processors Dock and Turns 2, 4 and 5.

The study assumed delays accrue primarily to Class 5 vessels since these are the largest vessels that can navigate the Cuyahoga River in its present configuration. Also, harbor areas identified these vessel sizes as incurring transit delays during preliminary field surveys. Therefore, only the tonnages moved by Class 5 vessels to river side destinations were used in the analysis.

Delay times in minutes for upbound and downbound traffic was determined for each of the seven delay points for each type of vessel congestion. These delay time estimates were based upon the harbor user surveys and/or discussions with the harbor master.

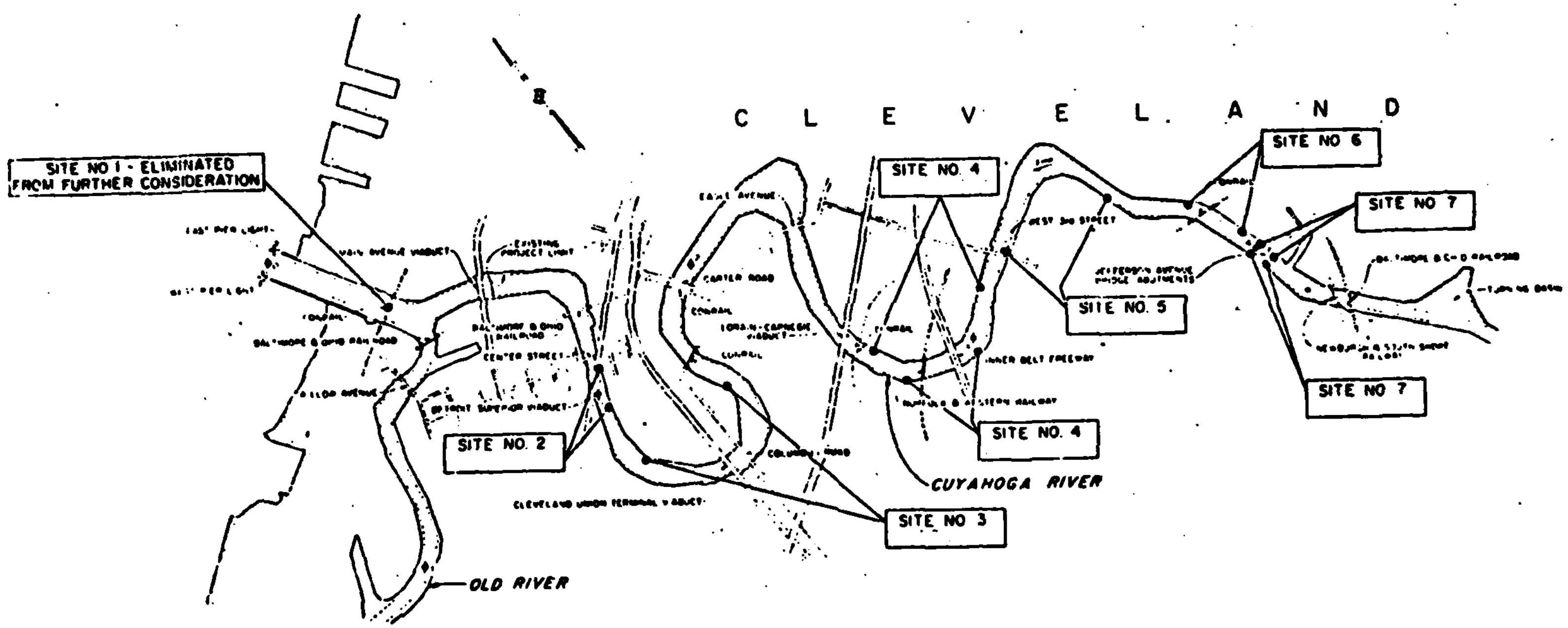
Vessel-to-fixed object upbound and downbound delays ranged from 10 to 30 minutes at each congestion point. The simulation model calculated the vessel-to-vessel delay for ships based upon a decision rule of zero minutes for upbound and 90 minutes for downbound traffic at each applicable congestion point. Vessel-to-vessel delay for a downbound ship passing a docked vessel was 30 minutes. If an upbound vessel encountered another vessel unloading at a dock, the upbound vessel would wait until the docked vessel had completely unloaded.

b. Traffic Simulation Model.

(1) Description - The second major task of the Cuyahoga River congestion study concerns the increase in yearly vessel operating cost due to congestion under "with" and "without-project" conditions. The alternatives affecting congestion are Alternatives 1, 3A and 3B, Cuyahoga River deepening, Alternatives 6A and 6B, and elimination of congestion sites on the Cuyahoga River (Alternative 7).

A computer model, developed by North Central Division, Corps of Engineers, determined the increase in yearly vessel operating costs due to congestion on the Cuyahoga River. The model was designed to simulate traffic patterns on the Cuyahoga River for a 30-day period. Analytical inputs included location of the delay points along the river; vessel sizes affected by these obstructions; delay times incurred by vessels at each congestion point; traffic forecasts for Cuyahoga River docks; vessel operating characteristics (i.e., loading/unloading rates, average river speeds, etc); and

FIGURE B9-CONGESTION AREAS UNDER CONSIDERATION



vessels maximum operating drafts. The output of the computer model consisted of the total hours of vessel delay (i.e., sum of the vessel-to-fixed object and vessel-to-vessel delays) that would accrue to vessels for a 30-day simulation period. Total vessel delays for a 275-day navigation season were obtained by converting a typical 30-day simulation period into an annual value. The total hourly delays for a 30-day period were multiplied by the number of simulation periods in a navigation season. A schematic of the model inputs and outputs are presented in Figure B10 and are discussed below in further detail.

(2) Input Components - Information on the location of the congestion areas, the vessel sizes affected by congestion, and the duration of the delays at each congestion point by vessel size were previously discussed.

Tonnage projections for the most probable future were used to evaluate the hourly vessel delays accrued due to each of the project alternatives under "with" and "without-project" conditions. Only the tonnage carried by Class 5 vessels to nine docks along the Cuyahoga River was used. The Cuyahoga River tonnage projections for Class 5 vessels are based upon the constrained tonnage forecast presented in Table B23. Annual commodity forecasts for five time periods (1990, 1995, 2000, 2010, 2020-40) were made for each of the nine docks. The annual traffic forecasts by dock were divided into nine 30-day simulation periods. The annual tonnage was distributed evenly among the nine periods. This resulted in a typical 30-day commodity traffic pattern for each dock. These 30-day traffic patterns were used in the computer runs to help determine the total vessel delays occurring at each congestion point. Only tonnage moved in Class 5 vessels was used in the congestion analysis.

The average operating characteristics of the vessels historically servicing the nine docks were used as inputs to the computer model. Such vessel characteristics as carrying capacity, maximum draft, tons per inch immersion factors and unloading rates were used. Eight composite Class 5 vessels were developed as input into the computer model and are based upon actual vessels in service to individual docks along the Cuyahoga River.

Finally, the maximum operating draft of Class 5 vessels under various project alternatives were determined. The variation in operating draft results in different levels of vessel traffic on the Cuyahoga. Therefore different vessel transit delay times were incurred. The maximum operating drafts for the "with" and "without-project" condition for Outer Harbor deepening, Cuyahoga River deepening and congestion site elimination alternatives are presented in Table B39.

(3) Model Output - The output of each computer run is a forecast by time period, by plan alternative, of the total vessel-to-fixed object and vessel-to-vessel hourly delays for all of the delay points for a 30-day simulation period. Documentation explaining the inputs of the computer model and a sample computer output run has been provided as Supplement 1 to Appendix B.

FIGURE B10 INPUTS AND OUTPUTS OF THE TRAFFIC SIMULATION MODEL

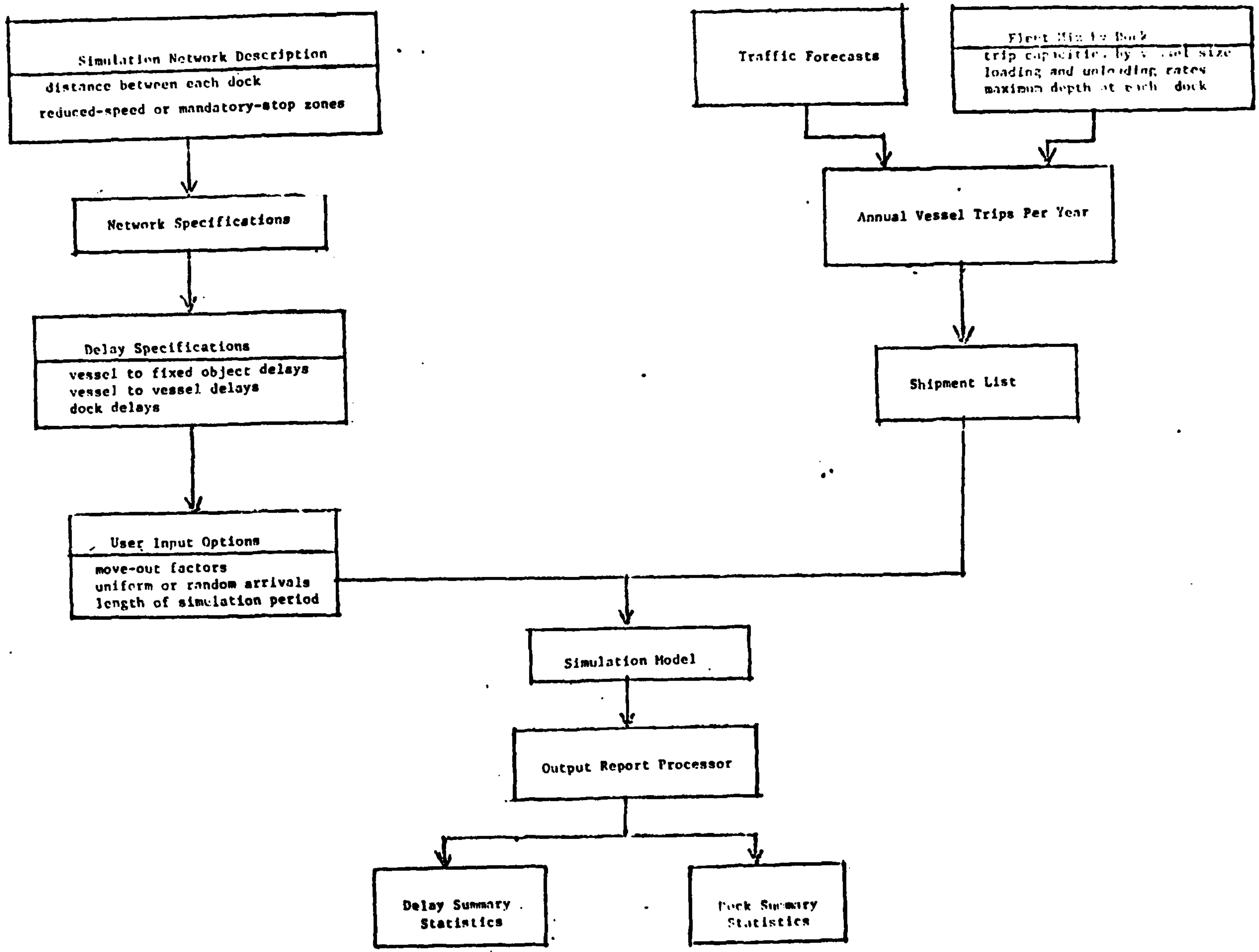


Table B39 - Maximum Operating Draft by Alternative

Alternatives	Time Period	Maximum Operating Draft (Feet) Outer Harbor	Maximum Operating Draft (Feet) Cuyahoga River
Alternatives 1, 3A, 3B - Outer Harbor Deepening			
Without Project	1990-2040	23	21
With Project	1990-2040	25.5	21
Alternative 6A - Deepen Cuyahoga River to 25.5 Feet			
Without Project	1990-2040	25.5	21
With Project	1990-2040	25.5	23.5
Alternative 6B - Deepen Cuyahoga River to 28 Feet			
Without Project	1990-2040	25.5	21
With Project	1990-2040	25.5	25.5
Alternative 7 - Elimination of Congestion Sites			
Without Project	1990-2040	23	21
With Project	1990-2040	23	21

c. Cuyahoga River Congestion Delay Costs - Alternatives 1, 3, 6.

Five individual computer runs were needed to evaluate Alternatives 1, 3 and 6 under the "with" and "without-project" condition to accurately reflect the tonnage projection intervals (i.e., 1990, 1995, 2000, 2010, 2020-2040) at each of the nine docks. The tonnage projections by dock varied by project alternative for any given time period. This was due to the differences in operating drafts among plan alternatives summarized in Table B39. The total Cuyahoga River tonnage projection by time period was the same for all project alternatives evaluated. Only the distribution of these tonnages among the affected docks for any given time period was affected by project alternative. The total hourly monthly (i.e., 30-day simulation period) delays of the "with" and "without-project" condition for project Alternatives 1, 3 and 6 are presented in Table B40.

Delay hours for each simulation period were then converted to an equivalent 275-day navigation season. Annual delay hours were multiplied by a weighted average hourly vessel delay cost of $1,200 per hour. The hourly delay cost components were the fixed and variable costs of various Class 5 vessels, weighted by the percentage of total tonnage moved by each vessel. The total annual costs of transportation delays for the "with" and "without-project" condition for Alternatives 1, 3 and 6 (vessel-to-fixed and vessel-to-vessel) are presented in Table B41.

The total transportation delay costs of Table B41 have been converted to average annual equivalents based upon a discount rate of 7.625 percent, a 50-year project life and a normal growth curve between periods. The decrease in delay costs between the "without-project" condition and the various improvement schemes are the benefits attributable to each plan alternative for reduction of congestion on the Cuyahoga River.

d. Congestion Elimination - Alternative 7.

(1) Overview - The 1981 harbor user survey identified seven locations along the Cuyahoga River that caused congestion because of some physical obstruction to vessel traffic. These seven delay points are:

(a) Site No. 1 - Conrail Bridge No. 1,

(b) Site No. 2 - Cereal Food Processors Dock,

(c) Site No. 3 - Turn 2,

(d) Site No. 4 - Turn 4,

(e) Site No. 5 - Turn 5,

(f) Site No. 6 - Conrail Bridge No. 14,

(g) Site No. 7 - the *Jefferson Avenue Bridge* Abutment.

Alternative 7 consists of improvements needed at each site to eliminate that sites vessel-to-fixed object delays. Site No. 1, Conrail Bridge No. 1 was eliminated from evaluation early in the planning process due to its obvious lack of economic feasibility. The economic feasibility of each of the remaining six plans is evaluated on the basis of the benefits and costs associated with each individual site. The rivers current maximum operating draft (21 feet) is assumed to exist under the "with" and "without-project" condition. No river deepening would take place under any congestion site improvement for Alternative 7.

(2) Traffic Simulation Model - The simulation model discussed previously also was used to determine the "with" and "without-project" condition Cuyahoga River vessel delays attributed to each of the six improvement plans. The 30-day simulation period "without-project" total vessel hourly delays (vessel-to-fixed object and vessel-to-vessel delays) for these six improvement plans are the same as those calculated for the "without-project" total vessel hourly delays of Alternative 1.

The base case traffic simulation runs were then modified to determine the with project Cuyahoga River transportation delay times for each of the improvement alternatives. For example, to evaluate the "with-project" Cuyahoga River transportation delay times for Site No. 3, the base case vessel-to-fixed object delay times associated with Site No. 3 were reduced to zero. All the other sites vessel-to-fixed object delay times reamined the

Table B40 - Future Vessel Delays

Alternative/Condition	Project Evaluation Period 1990	1995	2000	2010	2020-2040
Alternatives 1, 3A, 3B, Outer Harbor Improvements					
Without-Project					
Vessel-to-Fixed Object Delay	176.3	187.3	194.3	213.7	219.9
Vessel-to-Vessel Delay	85.1	84.9	110.7	82.5	102.0
Total Hours (1)	261.4	272.2	305.0	296.2	321.9
With Project Outer Harbor Improvements Only					
Vessel-to-Fixed Object Delay	171.1	184.3	190.9	209.4	216.3
Vessel-to-Vessel Delay	66.5	92.1	87.0	83.2	82.9
Total Hours (1)	237.6	276.4	277.9	292.6	299.2
Alternatives 6A and 6B (2)					
Without-Project, Alternatives 6A and 6B, With Outer Harbor Improvements Only					
Vessel-to-Fixed Object Delay	171.1	184.3	190.9	209.4	216.3
Vessel-to-Vessel Delay	66.5	92.1	37.0	83.2	82.9
Total Hours (1)	237.6	276.4	277.9	292.6	299.2
With-Project, Alternative 6A, Outer Harbor Improvements and River to 25.5 Ft					
Vessel-to-Fixed Object Delay	153.9	162.9	171.5	190.0	197.6
Vessel-to-Vessel Delay	53.2	55.7	82.2	96.3	81.6
Total Hours	207.1	218.6	253.7	286.3	279.2
With-Project, Alternative 6B, Outer Harbor Improvements and River to 28 Ft					
Vessel-to-Fixed Object Delay	148.6	157.5	162.0	179.6	184.0
Vessel-to-Vessel Delay	129.6	80.9	130.4	184.1	163.1
Total Hours (1)	278.2	238.4	292.4	363.7	347.1

(1) Delays are in hours for a typical 30-day simulation period.

(2) The without project condition for the Cuyahoga River deepening alternative assumes the Outer Harbor has been deepened to allow a maximum operating draft of 25.5 feet.

Table B-41 - Cuyahoga River Congestion - Future Transportation Delay Costs

Alternative/Condition	Thousands of Dollars: Project Evaluation Period 1990	1995	2000	2010	2020	2030	2040	Average Annual Delay Costs (1)
Alternatives 1, 3A, 3B, Outer Harbor Improvements								
Without-Project								
Vessel-to-Fixed Object Delay	1,939	2,060	2,137	2,351	2,419	2,419	2,419	2,170
Vessel-to-Vessel Delay	936	934	1,218	908	1,122	1,122	1,122	1,026
Total Delay Cost	2,875	2,994	3,355	3,259	3,541	3,541	3,541	3,196
With Project Outer Harbor Improvements Only								
Vessel-to-Fixed Object Delay	1,882	2,027	2,100	2,303	2,379	2,379	2,379	2,129
Vessel-to-Vessel Delay	732	1,013	957	915	912	912	912	925
Total Delay Cost	2,614	3,040	3,057	3,218	3,291	3,291	3,291	3,054
Alternatives 6A and 6B								
Without Project, Alternatives 6A and 6B, With Outer Harbor Improvements Only								
Vessel-to-Fixed Object Delay	1,882	2,027	2,100	2,303	2,379	2,379	2,379	2,129
Vessel-to-Vessel Delay	732	1,013	957	915	912	912	912	925
Total Delay Cost	2,614	3,040	3,057	3,218	3,291	3,291	3,291	3,054
With Project, Alternative 6A, With Outer Harbor Improvements and River to 25.5								
Vessel-to-Fixed Object Delay	1,693	1,792	1,887	2,090	2,174	2,174	2,174	1,915
Vessel-to-Vessel Delay	585	613	904	1,059	898	898	898	806
Total Delay Cost	2,278	2,405	2,791	3,149	3,072	3,072	3,072	2,721
With Project, Alternative 6B, With Outer Harbor Improvements and River to 28								
Vessel-to-Fixed Object Delay	1,635	1,733	1,782	1,976	2,024	2,024	2,024	1,820
Vessel-to-Vessel Delay	1,426	890	1,434	2,025	1,794	1,794	1,794	1,432
Total Delay Cost	3,061	2,623	3,216	4,001	3,818	3,818	3,818	3,252

(1) Average annual costs are based on a discount rate of 7.625 percent, a 50-year project life, and normal growth between periods, June 1981 price levels.

same. The base case traffic simulation runs were then rerun with the vessel-to-fixed object delay times for Site 3 equal to zero. The total 30-day simulation period delay times generated would now reflect the impact on Cuyahoga River congestion by eliminating the vessel-to-fixed object delays at Site 3 only. These same procedures were followed for all six congestion sites. Also, for Sites No. 3, 4 and 5, computer runs were made where the vessel-to-fixed object and vessel-to-vessel delays associated with these three sites were reduced to zero. These congestion runs would represent the maximum decrease in Cuyahoga River congestion that could take place if all the vessel delays associated with these sites were removed. Table B42 presents the "with-project" and "without-project" total transportation delay times associated with each site improvement alternative for a 30-day simulation period.

(3) Delay Costs - Hourly delay times shown in Table B42 were then converted to a 275-day navigation season. These values were multiplied by a weighted Class 5 hourly vessel cost of $1,200, which resulted in total annual transportation delay costs at each site (Table B43).

The transportation delay cost time stream presented in Table B43 has been transformed to average annual costs in the last column. The average annual equivalents were based upon a 50-year project life, a 7.625 percent discount rate, and normal growth between periods. These total transportation delay costs associated with the six delay points can now be used to evaluate the feasibilty of making improvements to the Cuyahoga River that would eliminate vessel-to-fixed object delays at various locations along the Cuyahoga River. The transportation saving/benefits associated with each improvement alternative can be computed by subtracting the transportation delay costs associated with each project alternative improvement from the base case average annual transportation delay costs.

Table B42 - Future Vessel Delays - Alternative 7

Condition/ Plan Alternative	Plan Evaluation Period 1990 (1)	1995 (1)	2000 (1)	2010 (1)	2020-2040 (1)
Without-Project, Hourly Vessel Delays					
Alternative 7, Site No. 2, 3, 4, 5, 6, 7					
Vessel-to-Fixed	176.3	187.3	194.3	213.7	219.9
Vessel-to-Vessel	85.1	84.9	110.7	82.5	102.0
Total	261.4	272.2	305.0	296.2	321.9
With-Project, Hourly Vessel Delays					
Site No. 2					
Cereal Food Processors Dock (Associated Vessel-to-Fixed Object Delay Times Removed)					
Vessel-to-Fixed	177.2	150.6	156.3	172.0	176.5
Vessel-to-Vessel	96.7	83.1	108.4	79.7	96.7
Total	273.9	233.7	264.7	251.7	273.2
Site No. 3					
Turn 2 (Associated Vessel-to-Fixed Object Delay Times Removed)					
Vessel-to-Fixed	158.7	168.6	175.0	192.4	197.9
Vessel-to-Vessel	79.0	78.5	106.4	78.1	97.8
Total	237.7	247.1	281.4	270.5	295.7
Site No. 3					
Turn 2 (Associated Vessel-to-Fixed Oject and Vessel-to-Vessel Delay Times Removed)					
Vessel-to-Fixed	158.7	167.6	175.0	192.4	197.9
Vessel-to-Vessel	73.0	69.5	98.8	69.1	87.3
Total	231.7	238.1	273.8	261.5	285.2
Site No. 4					
Turn 4 (Associated Vessel-to-Fixed Object Delay Times Removed)					
Vessel-to-Fixed	159.4	169.5	175.8	193.2	198.7
Vessel-to-Vessel	83.5	84.5	112.6	84.3	99.4
Total	242.9	254.0	288.4	277.5	298.1

Table B42 - Future Vessel Delays - Alternative 7 (Cont'd)

Condition/ Plan Alternative	Plan Evaluation Period 1990 (1)	1995 (1)	2000 (1)	2010 (1)	2020-2040 (1)
Site No. 4					
Turn 4 (Associated Vessel-to-Fixed Object and Vessel-to-Vessel Delay Times Removed)					
Vessel-to-Fixed	159.6	169.5	175.8	193.2	198.7
Vessel-to-Vessel	82.0	84.5	108.1	75.2	99.4
Total	241.6	254.0	283.9	268.4	298.1
Site No. 5					
Turn 5 (Associated Vessel-to-Fixed Object Delay Times Removed)					
Vessel-to-Fixed	160.1	170.0	176.3	193.7	199.2
Vessel-to-Vessel	82.0	84.6	111.1	82.8	102.4
Total	242.1	254.6	287.4	276.5	301.6
Site No. 5					
Turn 5 (Associated Vessel-to-Fixed Object and Vessel-to-Vessel Delay Times Removed)					
Vessel-to-Fixed	160.1	170.0	176.3	193.7	199.2
Vessel-to-Vessel	82.0	84.6	111.1	81.3	100.9
Total	242.1	254.6	287.4	275.0	300.1
Site No. 6					
Conrail Bridge No. 14 (Associated Vessel-to-Fixed Object Delay Times Removed)					
Vessel-to-Fixed	153.5	162.8	168.8	190.9	190.9
Vessel-to-Vessel	83.7	84.9	117.2	84.4	107.1
Total	237.2	247.7	286.0	275.3	298.0
Site No. 7					
Jefferson Avenue Bridge Abutments (Associated Vessel-to-Fixed Object Delay Times Removed)					
Vessel-to-Fixed	160.9	171.0	177.3	177.3	200.6
Vessel-to-Vessel	85.0	84.7	118.6	118.6	106.9
Total	246.9	255.7	295.9	295.9	307.5

(1) Delays are in hours for a typical 30-day simulation period.

B9. VESSEL DAMAGES

a. Overview.

Numerous accidents and related physical damages to commercial and recreational craft have occurred on the Cuyahoga River. Accident reports filed with the Cleveland Coast Guard office were examined to determine the magnitude of this problem and to identify specific sites which could be physically modified. A review of Coast Guard accident report data between 1972 and 1981 indicated that several areas of the river could be hazardous to navigation. Historical descriptions of these accidents are included in Table B44. Geographic locations (i.e., site numbers) have been related to specific river locations previously identified during the vessel congestion analysis.

Several accidents, such as when a bridge was accidentally lowered on a vessel, may have occurred as a result of bridge operator error. Therefore, accident report data for Site Number 1 (August 1979) and the lowering of a bridge at Site Number 4 (November 1979) were deleted from the evaluation.

The remaining accident data indicates that vessel damages can be associated with improvement Sites 3, 4 and 7. These accidents were presumed to reoccur at specified intervals in the future if no modifications were made to the Cuyahoga River.

b. Average Annual Vessel Damages Associated With Alternative 7.

The congestion elimination plans formulated for Sites 3, 4 and 7 were considered to eliminate all of the average annual vessel damages at each of these three sites. The present value of future vessel damages for each site were calculated and subsequently amortized at the project interest rate of 7.625 percent. Although the frequency of future vessel damages at each site may increase over the project evaluation period as a result of increases in the volumes of iron ore and limestone and/or recreational boating activity, no adjustment was made to the initial calculations.

A summary of the estimated physical damages and the resultant average annual damages for Sites 3, 4, and 7 are shown in Table B45. Site 3 had average annual damages of $4,600, Sites 4 and 7 had average annual damages of $3,000 and $7,700, respectively.

Table B43 - Future Annual Delay Costs - Alternative 7

Condition Plan/Alternative	Thousands of Dollars, Plan Evaluation Period: 1990	1995	2000	2010	2020	2030	2040	Average Annual (1) Equivalents
Without Project, Alternative 7, Site Nos. 1, 2, 3, 4, 5, 6, 7								
Vessel-to-Fixed	1,939	2,060	2,137	2,351	2,419	2,419	2,419	2,170
Vessel-to-Vessel	936	934	1,218	908	1,122	1,122	1,122	1,026
Total	2,875	2,994	3,355	3,259	3,541	3,541	3,541	3,196
Site No. 2								
Cereal Food Processors Dock								
Vessel-to-Fixed	1,949	1,657	1,719	1,892	1,941	1,941	1,941	1,797
Vessel-to-Vessel	1,064	914	1,192	877	1,064	1,064	1,064	1,016
Total	3,013	2,571	2,911	2,769	3,005	3,005	3,005	2,813
Site No. 3								
Turn 2/Fixed Delays Only Removed								
Vessel-to-Fixed	1,746	1,855	1,925	2,116	2,177	2,177	2,177	1,954
Vessel-to-Vessel	869	864	1,170	859	1,076	1,076	1,076	959
Total	2,615	2,719	3,095	2,975	3,253	3,253	3,253	2,913
Site No. 3								
Turn 2/All Delays Removed								
Vessel-to-Fixed	1,746	1,855	1,925	2,116	2,177	2,177	2,177	1,954
Vessel-to-Vessel	803	765	1,087	760	960	960	960	875
Total	2,549	2,620	3,012	2,876	3,137	3,137	3,137	2,829
Site No. 4								
Turn 4/Fixed Delays Only Removed								
Vessel-to-Fixed	1,753	1,865	1,934	2,125	2,186	2,186	2,186	1,963
Vessel-to-Vessel	918	930	1,239	927	1,093	1,093	1,093	1,027
Total	2,671	2,795	3,173	3,052	3,279	3,279	3,279	2,990

Table B43 - Future Annual Delay Costs - Alternative 7 (Cont'd)

Condition Plan/Alternative	Thousands of Dollars Plan Evaluation Period 1990	1995	2000	2010	2020	2030	2040	Average Annual (1) Equivalents
Site No. 4								
Turn 4/All Delays Removed:								
Vessel-to-Fixed	1,756	1,865	1,934	2,125	2,186	2,186	2,186	1,963
Vessel-to-Vessel	902	930	1,189	827	1,093	1,093	1,093	992
Total	2,658	2,795	3,123	2,952	3,279	3,279	3,279	2,955
Site No. 5								
Turn 5/Fixed Delays Only Removed								
Vessel-to-Fixed	1,761	1,870	1,939	2,131	2,191	2,191	2,191	1,969
Vessel-to-Vessel	902	931	1,222	911	1,126	1,126	1,126	1,022
Total	2,663	2,801	3,161	3,042	3,317	3,317	3,317	2,991
Site No. 5								
Turn 5/All Delays Removed:								
Vessel-to-Fixed	1,761	1,870	1,939	2,131	2,191	2,191	2,191	1,969
Vessel-to-Vessel	902	931	1,222	894	1,110	1,110	1,110	1,017
Total	2,663	2,801	3,161	3,025	3,301	3,301	3,301	2,986
Site No. 6								
Conrail Bridge No. 4								
Vessel-to-Fixed	1,689	1,791	1,857	2,100	2,100	2,100	2,100	1,897
Vessel-to-Vessel	921	934	1,289	928	1,178	1,178	1,178	1,052
Total	2,610	2,725	3,146	3,028	3,278	3,278	3,278	2,949
Site No. 7								
Jefferson Avenue Bridge								
Vessel-to-Fixed	1,770	1,881	1,950	1,950	2,327	2,327	2,327	1,961
Vessel-to-Vessel	935	932	1,305	1,305	1,176	1,176	1,176	1,131
Total	2,705	2,813	3,255	3,255	3,503	3,503	3,503	3,092

(1) Average annual costs are based on a discount rate of 7.625 percent, a 50-year project life, normal growth between periods and June 1981 price levels.

Table B44 - Historical Vessel Damages - Cuyahoga River

Location	Description of Accident	Date of Accident	Estimated Damage (1)
			$
Site No. 1	Small boat hit bridge	August 1979	6,030
Site No. 2	Class 5 vessel struck east bank of river	Not recorded	No reported damage
Site No. 3	Class 5 vessel collided with scow	June 1979	48,250
Site No. 3	Class 5 vessel hit Columbus Road bridge	December 1977	8,560
Site No. 3	Class 4 vessel struck another vessel at dock	December 1977	8,560
Site No. 3	Class 5 vessel hit dock	December 1977	Minor damages only
Site No. 4	N&W Bridge was lowered on Class 5 vessel	November 1979	24,250
Site No. 4	Class 5 vessel strikes east and west banks of river	December 1976	33,720
Site No. 4	Class 5 vessel struck N&W railroad bridge	September 1972	8,310
Site No. 5	No reported accidents	-	-
Site No. 6	No reported accidents	-	-
Site No. 7	Class 5 vessel hit bridge abutments	May 1978	27,860
Site No. 7	Class 5 vessel struck bridge abutments	July 1972	81,000

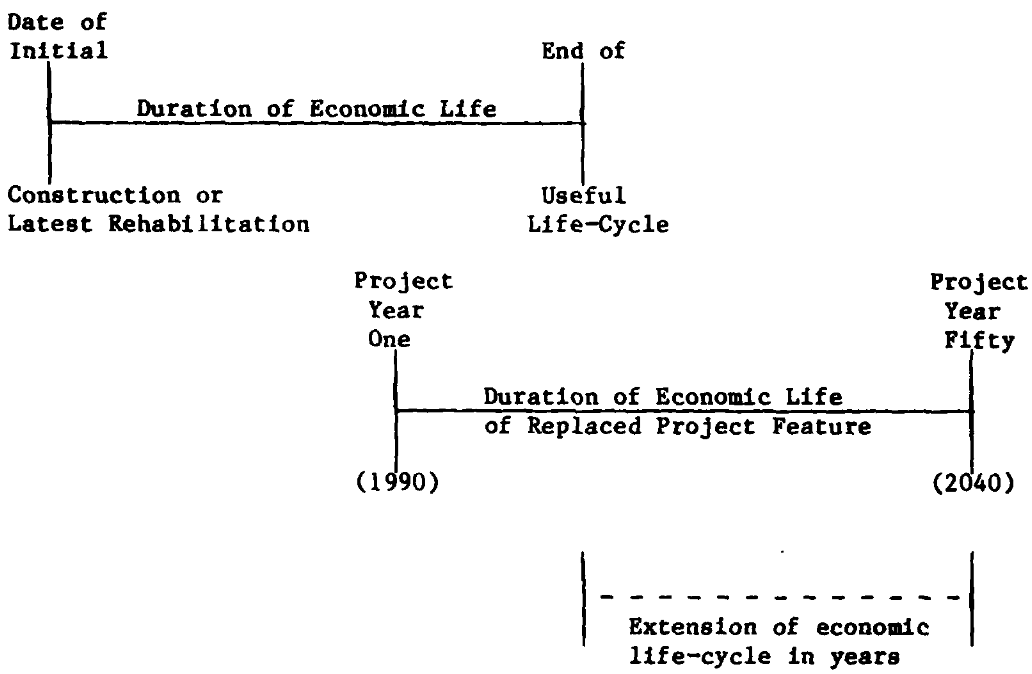
(1) Estimated damages are at June 1982 price levels. These damages are based upon the repair cost given in the accident report to June 1982 price levels. The adjustment factor is based on the ENR Common Labor Index at Cleveland, OH.

B10. ADVANCE REPLACEMENT

a. Overview.

Federal improvements may also extend the remaining economic life of existing project features. Whenever a project improvement involves replacement of an existing project related feature, thus extending the period of economic impacts, an adjustment should be made to include these economic impacts in project feasibility studies.

Traditionally, the full cost of the replaced feature is included as a project cost. Future "replacement-costs-in-kind" are used as a proxy for benefits. These costs are based on the extension of the useful life as outlined below.



A number of bridges and bulkheads along the Cuyahoga River and Old River have been identified for modification to accommodate general navigation interests. Bridge alterations are required because they constrain the navigable width of the rivers. Widening of restricted turns and bends of the Cuyahoga and Old River also require the placement of new steel sheet pile bulkheads along the modified shoreline. Deepening of the river channels also requires the replacement of a majority of the existing bulkheads with new bulkheads since the proposed deepening would make the existing bulkheads unstable.

Also inherent in this evaluation of average annual replacement-costs-in-kind are a 50-year planning period and a 7.625 percent interest rate.

Table B45 - Future Vessel Damages - Alternative 7

Future Time Period	Present Worth Factor (1)	Site 3		Site 4		Site 7	
		Estimated Physical Damages(2)	Present Value	Estimated Physical Damages(2)	Present Value	Estimated Physical Damages(2)	Present Value
		($)	($)	($)	($)	($)	($)
Project Year 10	0.479	65,370	31,350	42,050	20,165	108,860	52,200
Project Year 20	0.230	65,370	15,040	42,050	9,675	108,860	25,040
Project Year 30	0.113	65,370	7,210	42,050	4,640	108,860	12,010
Project Year 40	0.052	65,370	3,460	42,050	2,220	108,860	5,760
Project Year 50	0.025	65,370	1,660	42,050	1,070	108,860	2,760
Total Present Value of Future Damages		-	58,720	-	37,770	-	97,770
Average Annual Damages (3)		-	4,600	-	3,000	-	7,600

(1) Project interest rate is 7.625 percent.
(2) June 1982 price levels.
(3) The average annual equivalent factor for 50 years at 7.625 percent is .07823. Average annual damages are rounded to the nearest hundred dollars.

b. Derivation of Average Annual Advance Replacement Costs.

Advance replacement costs have been computed for bridge and bulkhead replacements for Alternatives 5, 6 and 7. This required estimating "replacement-costs-in-kind" and the remaining useful life after the date of project implementation. Extended useful life is the difference between the useful life-cycle of the project feature (i.e., usually 100 years for railroad bridges, 60 years for automobile bridges and 50 years for steel bulkheads) and the remaining life after project year zero (1990). A summary of the inputs and intermediate calculations used to compute average annual replacement costs are shown in Table B46.

B11. BENEFIT-COST ANALYSIS

a. Most Probable Future.

Benefit-cost ratios will be presented for Alternatives 1, 3, 5, 6, and 7. The benefits associated with these five alternatives are based on the commodity projections for the most probable future presented in Table B10. Benefit-cost ratios are calculated by dividing average annual benefits by average annual costs. These calculations assume a 50-year project life and a 7.625 percent interest rate. Table B47 presents the results of the B/C ratio analysis for the five alternatives mentioned above.

(1) Costs - Costs for project Alternatives 1, 3, 5, 6, and 7 were developed by the Buffalo District. Project first costs included such components as Outer Harbor, Old River, and Cuyahoga River deepening; spur removal; breakwater extension; railroad interchange trackage; new bulkheads; Cuyahoga and Old River channel widening; building relocations; bridge replacement; and utility relocations. Also included in first costs were contingency costs for construction and engineering and supervision. Interest during construction was calculated where applicable, and added to total first costs to obtain total investment costs.

These investment costs were then converted to average annual equivalent costs based on an interest rate of 7.625 percent, 50-year project life, and an amortization factor of .00199. Annual maintenance costs as a result of each plan, over and above existing maintenance costs, were added to the above. The total average annual cost, in June 1982 price levels, for various project alternatives are presented in Table B47.

(2) Benefits - Benefits for the various project alternatives came from four sources: a decrease in average annual transportation costs between the base case and future improved conditions; a decrease in traffic-related delay costs between the base case and the future improved conditions; advance replacement benefits; and the elimination of physical damages expected to occur due to river congestion. Each category will be discussed with respect to the alternatives they apply to and the tables used to derive these benefits. All future benefit streams have been converted to equivalent average annual values.

(a) Transportation Rate Savings - Transportation rate savings are attributable to Alternatives 1 through 6. The "with" and "without-project" average annual transportation costs for Alternatives 1 and 3 came from Table B24. Only iron ore transportation costs were affected by these alternatives. Average annual transportation benefits for Outer Harbor improvements attributable to iron ore were $13,161,000. The benefits for Cuyahoga River iron ore were $1,771,000.

Old River improvements (Alternative 5) are expected to alter salt, sand, and stone transportation costs. The "with" and "without-project" transportation costs came from Table B25. The total average annual benefits for these three commodities were $1,058,000 with 88 percent attributable to salt transportation savings, 9 percent to sand, and the remainder to stone.

Table B46 - Summary of Advance Replacement Calculations

Project Alternative	Useful Life	Initial Date of Construction	Remaining Life After Project Year Zero (1)	Extended Useful Life	Replacement Cost in Kind (3) ($000)	Average Annual Costs (4) ($000)	Present Worth of a $1 per Period (5)	Present Worth Factor (6)	Amortization Factor (7)	Average Annual Advance Replacement Costs ($000)
ALTERNATIVE 5										
Old River Authorized Improvements										
Option A, Replace Bridge No. 23										
Bridges	100	1907	17	33	15,000	1,144.5	11.95427	.28674	.07823	306.9
Bulkheads	50	1955	15	35	36,900	2,886.7	12.11288	.33213	.07823	908.5
Total										1,215.4
Option B, Provide New Interchange System										
Bulkheads	50	1955	15	35	36,900	2,886.7	12.11288	.33213	.07823	908.5
ALTERNATIVE 6										
Deepening of the Cuyahoga River										
Option A, Deepen River to 25.5										
Bulkheads	50	1952	12	38	179,500	14,042.3	12.31109	.41405	.07823	5,599.6
Option B, Deepen River to 28.0										
Bulkheads	50	1952	12	38	179,900	14,073.6	12.31109	.41405	.07823	5,612.1
ALTERNATIVE 7										
Reduce River Congestion										
Site 2 - Cereal Food Processors Dock										
Bulkheads	50	1957	17	33	3,300	258.2	11.95427	.28674	.07823	69.2
Site 3 - Turn 2										
Bridges										
Union Terminal	100	1929	39	11	7,000	534.1(8)	7.27062	.05694	.07823	17.3
Columbus Road	60	1940	10	40	15,000	1,157.8(9)	12.42093	.47959	.07823	539.6
Bulkheads	50	1948	8	42	8,700	680.6	12.51576	.55552	.07823	370.2
Total Site 3										927.1
Site 4 - Turn 4										
Bridge										
N&WRR	100	1957	67	0	17,000	1,297.1(8)	-	-	.07823	0.0
Bulkheads	50	1950	10	40	13,000	1,017.0	12.42093	.47959	.07823	473.9
Total Site 4										473.9
Site 5 - Turn 5										
Bulkheads	50	1951	11	39	6,100	477.2	12.36803	.44562	.07823	205.8
Site 6 - Conrail Bridge No. 4										
Bulkheads	50	1951	11	39	2,700	211.2	12.36803	.44652	.07823	91.1
Site 7 - Jefferson Avenue Bridge										
Bulkheads	50	1951	11	39	3,000	234.7	12.36803	.44562	.07823	101.2

(1) The remaining life after project year zero (1990) for bulkheads is based upon the average age of the bulkheads. The same computation for a bridge uses the original construction date and assumes a 100- (railroad) or 60-year (vehicular) life span.
(2) The extended useful life is the length of the project planning period (50 years) minus the features remaining life after project year zero.
(3) Estimated costs are based on June 1982 prices.
(4) Multiply the replacement cost in kind by the amortization factor for the bridge or bulkheads useful life at a 7.625 percent interest rate. (Bulkheads = .07823. Bridges: 100-year life = .07630; 60-year life = .07719.)
(5) The present worth of a $1 per period for the extended useful life at an interest rate of 7.625 percent.
(6) The present worth factor for a period of time equal to the remaining life after project year zero at an interest rate of 7.625 percent.
(7) The amortization factor for a 50-year project and an interest rate of 7.625 percent.
(8) Average annual costs (benefits) are based upon a 100-year expected useful life. This may underestimate bridge replacement benefits since advance replacement in 1990 will generate benefits beyond the project evaluation period. Only those benefits accruing during the project evaluation period (1990-2060) were credited to advance replacement.
(9) Same as Footnote (8) except that the amortization factor is based on a 60-year expected useful life.

The "with" and "without-project" transportation costs for the two Cuyahoga River deepening alternatives were shown in Table B26. Only iron ore and limestone transportation costs were affected. The average annual commodity benefits for deepening the river to 25.5 feet (Option A) was $2,592,000 and was about 49 percent higher ($3,868,000) for deepening to 28 feet (Option B).

(b) Congestion Savings - Congestion elimination benefits were applicable to Alternatives 1, 3, 6, and 7 only. These benefits are derived from the decrease in average annual delay costs between the base case and improved project condition. These average annual delay costs for Alternatives 1, 3, and 6 came from Tabel B41, while the delay costs for Alternative 7 were shown on Table B43. Congestion elimination average annual benefits for Alternatives 1 and 3 amounted to $142,000. This comprised less than 1 percent of the total benefits for these two alternatives.

Congestion elimination benefits for deepening the Cuyahoga to 25.5 feet were $333,000 which was less than 4 percent of total benefits for this alternative. Congestion benefits for deepening the Cuyahoga River to 28 feet (Alternative 6B) are negative ($-198,000). This result can be explained by observing the change in total delay hours for a 30-day simulation period as presented in Table B40. The deeper river channel depths allow the projected tonnage to be moved in less trips than the base case would otherwise require. This is reflected in the decrease of vessel-to-fixed object delays between the "with" and "without-project" condition. However, the increase in tonnage per trip due to channel deepening requires that all affected vessels will remain at the dock for a longer time period. Therefore, vessel-to-vessel delays have increased over the base case. This increase in vessel-to-vessel delay times more than offsets the vessel-to-fixed object decrease in delay times for the "with project" condition.

Alternative 7 identified seven congestion locations, of which six were evaluated. The "with" and "without-project" average annual transportation costs for these six sites came from Table B43. Congestion elimination benefits were a large percentage of total benefits for Site 2 (85 percent), Site 6 (73 percent), Site 5 (50 percent), and Site 7 (49 percent). This benefit comprised only 23 percent total benefits for Site 3.

(c) Vessel Damages Avoided - Vessel damages avoided applied only to Sites 3, 4, and 7 of Alternative 7. These average annual benefits come from Table B45. Average annual vessel damages avoided for Sites 3, 4, and 7 were $4,600, $3,000, and $7,600, respectively. This category constituted less than 1 percent of the total benefits for Sites 3 and 4 and less than 4 percent for Site 7.

(d) Advance Replacement Benefits - This benefit category applied only to Alternatives 5, 6, and 7 since these alternatives involved the replacement of an existing bridge or bulkhead. The proxy for advance-replacement benefits is advance-replacement costs. These costs/benefits come from Table B46, and are based on bridge or bulkhead replacement costs in kind, the bridge or bulkheads remaining useful life past project year zero, an estimated 100-, 60- and 50-year life span for railroad bridges, automobile bridges, and bulkheads, respectively, and a 7.625 percent interest rate.

Table B47 - Benefit Cost Ratios - Cleveland Harbor
(All Costs and Benefits are in Thousands of Dollars)

Alternative	Reach/Commodity	Without Project Average Annual Transportation Costs	With Project Average Annual Transportation Costs	Average Annual Benefits (1)	Average Annual Costs (2)	Net Average Annual Benefits	Benefit/Cost Ratio
1. East Entrance Plan	Outer Harbor						
	Domestic Iron Ore	42,089	32,168	9,921			
	Canadian Iron Ore	31,995	28,755	3,240			
	Total	74,084	60,923	13,161			
	Cuyahoga River						
	Domestic Iron Ore	26,080	24,309	1,771			
	Traffic Congestion Elimination	3,196	3,054	142			
	Total Alternative 1	103,360	88,286	15,074	395.9	14,678.1	38.08
3. West Entrance Plan							
a. Option A	Outer Harbor						
	Domestic Iron Ore	42,089	32,168	9,921			
	Canadian Iron Ore	31,995	28,755	3,240			
	Total	74,084	60,923	13,161			
	Cuyahoga River						
	Domestic Iron Ore	26,080	24,309	1,771			
	Traffic Congestion Elimination	3,196	3,054	142			
	Total Alternative 3 Option A	103,360	88,286	15,074	3,160.2	11,913.8	4.77

Table B47 - Benefit Cost Ratios - Cleveland Harbor (Cont'd)
(All Costs and Benefits are in Thousands of Dollars)

Alternative	Reach/Commodity	Without Project Average Annual Transportation Costs	With Project Average Annual Transportation Costs	Average Annual Benefits (1)	Average Annual Costs (2)	Net Average Annual Benefits	Benefit/Cost Ratio
3. West Entrance Plan (Cont'd)							
b. Option B	Outer Harbor						
	Domestic Iron Ore	42,089	32,168	9,921			
	Canadian Iron Ore	31,995	28,755	3,240			
	Total	74,084	60,923	13,161			
	Cuyahoga River						
	Domestic Iron Ore	26,080	24,309	1,771			
	Traffic Congestion Elimination	3,196	3,054	142			
	Total Alternative 3 Option B	103,360	88,286	15,074	1,645.2	13,428.8	9.16
5. Old River Authorized Improvements							
a. Option A - Replace Bridge No. 23	Old River						
	Salt	7,538 (3)	6,606	932			
	Sand	1,153 (3)	1,060	93			
	Stone (4)	343	310	33			
	Total	9,034	7,976	1,058			
	Advance Replacement			1,215.4			
	Total Alternative 5 Option A			2,273.4	6,008.5	-3,735.1	0.38

Table B47 - Benefit Cost Ratios - Cleveland Harbor (Cont'd)
(All Costs and Benefits are in Thousands of Dollars)

Alternative	Reach/Commodity	Without Project Average Annual Transportation Costs	With Project Average Annual Transportation Costs	Average Annual Benefits (1)	Average Annual Costs (2)	Net Average Annual Benefits	Benefit/Cost Ratio
5. Old River Authorized Improvements (Cont'd)							
b. Option B - Provide New Interchange System	Old River						
	Salt	7,538 (3)	6,606	932			
	Sand	1,153 (3)	1,060	93			
	Stone (4)	343	310	33			
	Total	9,034	7,976	1,058			
	Advance Replacement			908.5			
	Total Alternative 5 Option B			1,966.5	4,707.5	-2,741.0	0.42
6. Deepening of the Cuyahoga River	Cuyahoga River						
a. Option A - Deepen to 25.5 Feet	Domestic Iron Ore	24,309 (5)	23,153	1,156			
	Limestone	12,725 (5)	11,289	1,436			
	Total	37,034	34,442	2,592			
	Traffic Congestion Elimination	3,054	2,721	333			
	Advance Replacement			5,599.6			
	Total Alternative 6 Option A			8,524.6	20,165.4	-11,640.8	0.42

Table B47 - Benefit Cost Ratios - Cleveland Harbor (Cont'd)
(All Costs and Benefits are in Thousands of Dollars)

Alternative	Reach/Commodity	Without Project Average Annual Transportation Costs	With Project Average Annual Transportation Costs	Average Annual Benefits (1)	Average Annual Costs (2)	Net Average Annual Benefits	Benefit/Cost Ratio
6. Deepening of the Cuyahoga River (Cont'd)							
b. Option B - Deepen to 28 Feet	Domestic Iron Ore	24,309 (5)	22,133	2,176			
	Limestone	12,725 (5)	11,033	1,692			
	Total	37,034	33,166	3,868			
	Traffic Congestion Elimination	3,054	3,252	-198			
	Advance Replacement			5,612.1			
	Total Alternative 6 Option B			9,282.1	21,154.1	-11,872.0	0.44
7. Reduce River Congestion							
Site 2	Cereal Food Processors Dock	3,196	2,813	383			
	Advance Replacement			69.2			
	Total Site 2			452.2	287.1	165.1	1.58
Site 3	Turn 2 - Fixed Delay Only Removed	3,196	2,913	283			
	Advance Replacement			927.1			
	Vessel Damages Avoided			4.6			
	Total Site 3			1,214.7	3,703.7	- 2,489	0.33

Table B47 - Benefit Cost Ratios - Cleveland Harbor (Cont'd)
(All Costs and Benefits are in Thousands of Dollars)

Alternative	Reach/Commodity	Without Project Average Annual Transportation Costs	With Project Average Annual Transportation Costs	Average Annual Benefits (1)	Average Annual Costs (2)	Net Average Annual Benefits	Benefit/Cost Ratio
7. Reduce River Congestion (Cont'd)							
Site 3	Turn 2 - All Delays Removed	3,196	2,829	367			
	Advance Replacement			927.1			
	Vessel Damages Avoided			4.6			
	Total Site 3			1,298.7	3,703.3	- 2,405.5	0.35
Site 4	Turn 4 - Fixed Delays Only Removed	3,196	2,990	206			
	Advance Replacement			473.9			
	Vessel Damages Avoided			3.0			
	Total Site 4			682.9	3,441.3	- 2,758.4	0.20
Site 4	Turn 4 - All Delays Removed	3,196	2,955	241			
	Advance Replacement			473.9			
	Vessel Damages Avoided			3.0			
	Total Site 4			717.9	3,441.3	- 2,723.4	0.21
Site 5	Turn 5 - Fixed Delays Only Removed	3,196	2,991	205			
	Advance Replacement			205.8			
	Total Site 5			410.8	742.6	- 331.8	0.55

Table B47 - Benefit Cost Ratios - Cleveland Harbor (Cont'd)
(All Costs and Benefits are in Thousands of Dollars)

Alternative	Reach/Commodity	Without Project Average Annual Transportation Costs	With Project Average Annual Transportation Costs	Average Annual Benefits (1)	Average Annual Costs (2)	Net Average Annual Benefits	Benefit/Cost Ratio
7. Reduce River Congestion (Cont'd)							
Site 5	Turn 5 - All Delays Removed	3,196	2,986	210			
	Advance Replacement			205.8			
	Total Site 5			415.8	742.6	-326.8	0.56
Site 6	Conrail Bridge No. 14	3,196	2,949	247			
	Advance Replacement			91.1			
	Total Site 6			338.1	229.2	108.9	1.48
Site 7	Jefferson Avenue Bridge	3,196	3,092	104			
	Advance Replacement			101.2			
	Vessel Damages Avoided			7.7			
	Total Site 7			212.8	313	- 100.2	0.68

(1) Average annual advance replacement and vessel damages avoided benefits are based upon June 1982 price levels, a 7.625 percent interest rate, and a 50-year project life. All other average annual benefits are based upon June 1981 price levels, a 7.625 percent interest rate, and a 50-year project life.

(2) Average annual costs are based upon June 1982 price levels, a 7.625 percent interest rate, and a 50-year project life.

(3) "Without-project" transportation costs assumes that Outer Harbor deepening to a maximum vessel operating draft of 25.5 feet has already (Table B25) taken place. Therefore, the "without-project" average annual transportation costs correspond to the "Outer Harbor Improvements Completed."

(4) The benefits associated with the stone traffic are the result of a shift of destination from the Cuyahoga River to the Old River due to the Old River and Outer Harbor improvements.

(5) "Without-project" transportation costs assumes that Outer Harbor deepening to a maximum vessel operating draft of 25.5 feet has already taken place. Therefore, the "without-project" average annual transportation costs correspond to the Outer Harbor improvements only of Table B26.

Average annual advance-replacement benefits of $1,215,400, and $908,500 were attributable to Alternative 5A and 5B. This category accounted for 53 percent and 46 percent of the total average annual benefits for Alternatives 5A and 5B.

Average annual advance replacement benefits of $5,599,600 and $5,612,100 accounted for 65 percent and 60 percent of the total average annual benefits for Alternatives 6A and 6B. Six improvement sites were evaluated for Alternative 7. Advance replacement benefits constituted between 50 percent and 76 percent of total average annual benefits for two thirds of the sites evaluated. The benefits ranged from $69,200 for Site 2 (15 percent) to $927,100 for Site 3 (76 percent).

(3) <u>Summary and Conclusions</u> - Alternative 1 (East Entrance Plan) had the largest B/C ratio (38.08) of any Outer Harbor improvement plan and has estimated net average annual benefits of $14,678,100. Transportation savings accounted for 99 percent of the total benefits. Alternative 3, Option B (West Entrance Plan) had the next highest B/C ratio (9.16) with net average annual benefits of $13,428,800.

The two Old River improvements had B/C ratios below unity. Alternative 5, Option B has a B/C ratio if 0.42 with average annual benefits of $1,966,500. Commodity transportation savings accounted for 54 percent of the total benefits with the remainder being attributed to advance replacement benefits. The B/C ratio for Alternative 5, Option A was 0.38.

The B/C ratios for the two Cuyahoga River deepening improvements of Alternative 6 (deepen to 25.5 feet and deepen to 28 feet) were also well below unity (0.42 and 0.44). Transportation savings only accounted for 30 percent and 42 percent respectively, of the total average annual benefits of these two options. Advance replacement benefits accounted for 66 percent and 60 percent of the total average annual benefits for Options A and B.

Six separate plans for eliminating congestion on the Cuyahoga were evaluated for Alternative 7. Only Sites 2 and 6, Cereal Food Processors Dock and Conrail Bridge No. 14, had positive B/C ratios. The Site 2 improvement alternative is preferred to Site 6 on the basis of B/C ratios (1.58 versus 1.48) and net average annual benefits ($165,100 versus $108,900).

The other congestion elimination alternatives had B/C ratios ranging from 0.68 for Site 7 to 0.20 for Site 4. Sites 3, 4, and 5 had B/C ratios of 0.33, 0.20, and 0.55. These three sites were also evaluated assuming all congestion at these sites were eliminated (vessel-to-fixed object and vessel-to-vessel congestion). The B/C ratios rose by 10 percent or less for all three alternatives under these assumptions.

In conclusion, Alternative 1 (East Entrance) had the highest B/C ratio (38.08) and net average annual benefits ($14,678,100), of any of the Outer Harbor deepening alternatives. No Old River or Cuyahoga River deepening alternatives had B/C ratios greater than 0.45. For Alternative 7 Site No. 2 (Cereal Food Processors Dock) had the highest B/C ratio (1.58) and net average annual benefits ($165,100) of any of the congestion elimination sites.

b. Sensitivity Analysis.

(1) Transportation Rate Savings - In Section B7, future transportation costs under various project alternatives were evaluated with respect to changes in the traffic forecasts and future fleet composition. A high and low traffic forecast, as well as having 1,000-foot vessels in the base case, were evaluated. Variations in these study parameters affected Outer Harbor improvement plans (Alternatives 1, 3A, and 3B), Old River and Cuyahoga River deepening improvement alternatives. The impacts of these parameter variations upon the alternatives transportation costs, savings, and B/C ratios are presented in Table B48.

(a) High Tonnage Growth - The high tonnage forecast assumed the sand and gravel and salt projections of the most likely future would not change. Only the iron ore and limestone forecasts would be affected. Average annual benefits for Alternatives 1, 3A, and 3B rose by less than 1 percent ($129,000). The B/C ratios also increased by less than 1 percent. The B/C ratios for the Old River improvements did not change under the high tonnage forecast. Net transportation benefits increased by $1,000.

The impact of the high tonnage forecast on the B/C ratios of the Cuyahoga River improvement alternatives was also minimal. Average annual transportation savings for deepening the Cuyahoga River to 25.5 feet only increased $12,000 under the high tonnage forecast. The B/C ratio remained at 0.42. The high tonnage forecast added $519,000 in average annual transportation savings to Alternative 6B (deepening the Cuyahoga to 28 feet), thus raising the B/C ratio from 0.44 to 0.46.

(b) Low Tonnage Growth - The low tonnage forecast sensitivity analysis also assumed only iron ore and limestone forecasts would change. This decrease in forecasted tonnage forecasted had a greater impact on project feasibility relative to the increase in traffic discussed above.

Average annual benefits for Alternatives 1, 3A, and 3B decreased by $2,357,000 when compared to the most likely future tonnage projections. The B/C ratios for these three alternatives fell by almost 16 percent in all three cases.

The low tonnage forecast did not change the Old River B/C ratios compared to the initial tonnage projections. Net average annual transportation benefits dropped by $3,000 for Alternative 5A and 5B.

The impact of the low tonnage forecasts on the two Cuyahoga River deepening alternatives was more pronounced. Net average annual benefits for deepening the Cuyahoga River to 25.5 feet fell by $183,000 and for deepening to 28 feet by $324,000. The B/C ratios for Alternatives 6A and 6B fell by 2 percent and 5 percent, respectively.

(c) Change in Fleet Composition - The change in fleet composition sensitivity analysis used the same commodity forecasts as the most probable future projections. The inclusion of Class 10 vessels in the Outer Harbor base case fleet analysis had the greatest effect on the B/C ratios of the

Table B48 - Sensitivity Analysis-Comparison of Transportation Costs, Transportation Benefits, and Benefit-Cost Ratios by Alternative

	Most Probable Future Projections					Unconstrained Tonnage Projections					Low Tonnage Projections					1,000-Foot Vessels in the Base Case				
	Transportation Costs (1) ($1,000)					Transportation Costs (2) ($1,000)					Transportation Costs (3) ($1,000)					Transportation Costs (4) ($1,000)				
Alternative	Without Project	With Project	Net Transportation Benefits	Net Average Annual Benefits ($1,000)	Benefit-Cost Ratio	Without Project	With Project	Net Transportation Benefits	Net Average Annual Benefit ($1,000)	Benefit-Cost Ratio	Without Project	With Project	Net Transportation Benefits	Net Average Annual Benefit ($1,000)	Benefit-Cost Ratio	Without Project	With Project	Net Transportation Benefits	Net Average Annual Benefits ($1,000)	Benefit-Cost Ratio
Outer Harbor Improvements																				
1	100,164	85,232	14,932	14,678.1	38.08	102,956	87,895	15,061	14,807.1	38.40	86,348	73,773	12,575	12,321.1	32.12	97,613	85,232	12,381	12,127.1	31.63
3A	100,164	85,232	16,932	11,913.8	4.77	102,956	87,895	15,061	12,042.8	4.81	86,348	73,773	12,575	9,556.8	4.02	97,613	85,232	12,381	9,362.8	3.96
3B	100,164	85,232	16,932	13,428.8	9.16	102,956	87,895	15,061	13,557.8	9.24	86,348	73,773	12,575	11,071.8	7.73	97,613	85,232	12,381	10,877.8	7.61
Old River Improvements																				
5A	9,034	7,976	1,058	-3,735.1	0.38	9,038	7,979	1,059	-3,734.1	0.38	8,997	7,942	1,055	-3,738.1	0.38					
5B	9,034	7,976	1,058	-2,741.0	0.42	9,038	7,979	1,059	-2,740	0.42	8,997	7,942	1,055	-2744.0	0.42					
Cuyahoga River Improvements																				
6A	37,034	34,442	2,592	-11,640.8	0.42	39,999	37,395	2,604	-11,628.8	0.42	33,200	30,791	2,409	-11,823.8	0.41					
6B	37,034	33,166	3,868	-11,872.0	0.44	39,959	35,612	4,387	-11,353	0.46	33,200	29,656	3,544	-12,196.0	0.42					

(1) Transportation costs for the Outer Harbor Improvements from Table B24; Old River and Cuyahoga River transportation costs from Tables B25 and B26, respectively.

(2) Transportation costs for the Outer Harbor Improvements from Table B29; Old River and Cuyahoga River transportation costs from Tables B30 and B31, respectively.

(3) Transportation costs for the Outer Harbor Improvements from Table B33; Old River and Cuyahoga River transportation costs from Tables B34 and B35, respectively.

(4) Transportation costs for the Outer Harbor Improvements from Table B38.

Outer Harbor improvement plans of any of the sensitivity analyses. All three Outer Harbor improvement plans experienced a decrease in average annual benefits of $2,551,000. All three B/C ratios dropped by approximately 17 percent. Only the Outer Harbor improvement plans were affected by a change in fleet composition.

(2) Summary and Conclusions - Variations in the commodity forecasts and fleet composition did change the level of future transportation costs and directly affected the B/C ratios of the various Outer Harbor, Old River, and Cuyahoga River improvement alternatives.

The higher levels of iron ore and limestone commodity movements changed the B/C ratios in Outer Harbor, Old River, and Cuyahoga River improvement alternatives by less than 1 percent.

Decreases in commodity levels had a slightly more adverse effect on the B/C ratios. The B/C ratios of the Outer Harbor improvement alternatives fell by 16 percent, while the Cuyahoga River deepening alternatives fell by 5 percent or less. There was no change in B/C ratios of the Old River plans due to the low tonnage forecast.

The change in the base case fleet composition (i.e., inclusion of Class 10 vessels) decreased the B/C ratios of the Outer Harbor improvements by approximately 17 percent. This parameter had the greatest effect on B/C ratios of any of the parameters evaluated.

c. Update to June 1982 Prices.

(1) Overview - The transportation and traffic congestion costs presented in the previous sections were based upon June 1981 prices. These costs were updated to June 1982 price levels so all benefits and costs would be comparable at the current price level. The difference in transportation costs between the base case and the "with-project" condition were the benefits for each alternative.

(2) Update Process - The increase in transportation costs by vessel class were assumed to increase at the same rate that vessel construction and operating costs by vessel class have increased from June 1981 to June 1982. Estimates of these cost increases were determined from actual vessel construction and operating costs supplied by MARAD for the 3-year period 1978-1981. These precentage increases of vessel construction and operating costs by vessel class were weighted to form a weighted cost index. The weighted index ranged from 13.4 percent for Class 7 vessels to 12.6 percent for Class 10 vessels.

This weighted cost index increase was then applied to the "with" and "without-project" transportation costs by vessel class for all of the alternatives. The result of this process is presented in Table B49. This table shows all alternative costs and benefits at June 1982 price levels for the most probable future.

Table B-9 - Summary of Benefit Cost Ratios - Cleveland Harbor, OH

Alternative	Reach/Commodity	Thousands of Dollars and June 1982 Prices: Without Project Average Annual Transportation Costs	With Project Average Annual Transportation Costs	Average Annual Benefits (1)	Average Annual Costs (2)	Net Average Annual Benefits	Benefit/Cost Ratio
1. East Entrance Plan	Outer Harbor						
	Domestic Iron Ore	47,597	36,317	11,280			
	Canadian Iron Ore	36,185	32,521	3,664			
	Total	83,782	68,838	14,944			
	Cuyahoga River						
	Domestic Iron Ore	29,883	27,382	2,501			
	Traffic Congestion Elimination	3,600	3,440	160			
	Total Alternative 1	117,265	99,660	17,605	395.9	17,209.1	44.47
3. West Entrance Plan							
a. Option A	Outer Harbor						
	Domestic Iron Ore	47,597	36,317	11,280			
	Canadian Iron Ore	36,185	32,521	3,664			
	Total	83,782	68,838	14,944			
	Cuyahoga River						
	Domestic Iron Ore	29,883	27,382	2,501			
	Traffic Congestion Elimination	3,600	3,440	160			
	Total Alternative 3 Option A	117,265	99,660	17,605	3,160.2	14,444.8	5.57
b. Option B	Outer Harbor						
	Domestic Iron Ore	47,597	36,317	11,280			
	Canadian Iron Ore	36,185	32,521	3,664			
	Total	83,782	68,838	14,944			
	Cuyahoga River						
	Domestic Iron Ore	29,883	27,382	2,501			
	Traffic Congestion Elimination	3,600	3,440	160			
	Total Alternative 3 Option B	117,265	99,660	17,605	1,645.2	15,959.8	10.70
5. Old River Authorized Improvements							
a. Option A - Replace Bridge No. 23	Old River						
	Salt	8,494 (4)	7,445	1,048			
	Sand	1,299 (4)	1,199	105			
	Stone (3)	386 (4)	349	37			
	Advance Replacement			1,215.4			
	Total Alternative 5 Option A			2,405.4	6,008.5	-3,603.1	.40
b. Option B - Provide New Interchange System	Old River						
	Salt	8,494 (4)	7,446	1,048			
	Sand	1,299 (4)	1,194	105			
	Stone (3)	386 (4)	349	37			
	Advance Replacement			908.5			
	Total Alternative 5 Option B			2,098.5	4,707.5	-2,609	.45
6. Deepening of the Cuyahoga River	Cuyahoga River						
a. Option A - Deepen to 25.5 Feet	Domestic Iron Ore	27,382 (4)	26,080	1,302			
	Limestone	14,339 (4)	12,700	1,639			
	Total	41,721	38,780	2,941			
	Traffic Congestion Elimination	3,440	3,065	375			
	Advance Replacement			5,599.6			
	Total Alternative 6 Option A			8,915.6	20,165.4	-11,249.8	.44
b. Option B - Deepen to 28 Feet	Domestic Iron Ore	27,382 (4)	24,931	2,451			
	Limestone	14,339 (4)	12,434	1,905			
	Total	41,721	37,365	4,356			
	Traffic Congestion Elimination	3,440	3,663	- 223			
	Advance Replacement			5,612.1			
	Total Alternative 6 Option B			9,745.1	21,154.1	-11,409	.46

Table B49 - Summary of Benefit Cost Ratios - Cleveland Harbor, OH (Cont'd)

Alternative	Reach/Commodity	Thousands of Dollars and June 1982 Prices: Without Project Average Annual Transportation Costs	With Project Average Annual Transportation Costs	Average Annual Benefits (1)	Average Annual Costs (2)	Net Average Annual Benefits	Benefit/Cost Ratio
7. Reduce River Congestion							
Site 2	Cereal Food Processors Dock	3,600	3,168	432			
	Advance Replacement			69.2			
	Total Site 2			501.2	287.1	214.1	1.75
Site 3	Turn 2 - Fixed Delay Only Removed	3,600	3,280	320			
	Advance Replacement			927.1			
	Vessel Damages Avoided			4.6			
	Total Site 3			1,251.7	3,703.7	- 2,452	.34
Site 3	Turn 2 - All Delays Removed	3,600	3,186	414			
	Advance Replacement			927.1			
	Vessel Damages Avoided			4.6			
	Total Site 3			1,345.7	3,703.3	- 2,358	.36
Site 4	Turn 4 - Fixed Delays Only Removed	3,600	3,368	232			
	Advance Replacement			473.9			
	Vessel Damages Avoided			3.0			
	Total Site 4			708.9	3,441.3	- 2,732.4	.21
Site 4	Turn 4 - All Delays Removed	3,600	3,329	271			
	Advance Replacement			473.9			
	Vessel Damages Avoided			3.0			
	Total Site 4			747.9	3,441.3	- 2,693.4	.22
Site 5	Turn 5 - Fixed Delays Only Removed	3,600	3,369	231			
	Advance Replacement			205.8			
	Total Site 5			436.8	742.6	- 305.8	.59
Site 5	Turn 5 - All Delays Removed	3,600	3,362	238			
	Advance Replacement			205.8			
	Total Site 5			443.8	742.6	- 298.8	.60
Site 6	ConRail Bridge No. 14	3,600	3,322	278			
	Advance Replacement			91.1			
	Total Site 6			369.1	229.2	139.9	1.61
Site 7	Jefferson Avenue Bridge	3,600	3,483	117			
	Advance Replacement			101.2			
	Vessel Damages Avoided			7.6			
	Total Site 7			225.8	313	- 87.2	.72

(1) Average annual benefits are based upon 1982 price levels, a 7.625 percent interest rate, and a 50-year project life.

(2) Average annual costs are based upon 1982 price levels, a 7.625 percent interest rate, and a 50-year project life.

(3) The benefits for limestone traffic are the result of a shift of destination from the Cuyahoga River to the Old River due to the Old River and Outer Harbor improvements.

(4) "Without-Project" transportation costs assumes that Outer Harbor deepening has already taken place.

(3) Conclusions - The price update did not change the relative ranking of any of the project alternatives nor did it make any previously unjustified alternative justified.

B12. ANALYSIS OF RECREATIONAL PIER FISHING

a. Introduction.

Two plans have been formulated to provide recreational fishing access to the existing west breakwater in the Lakefront Harbor. Alternative 8A calls for the existing lake access channel at Edgewater Marina to be closed and a new one provided in the west breakwater. A 5-foot wide concrete walkway with a chain railing will cap the new breakwater closing the existing entrance of Edgewater Marina and chain railway will be provided on the existing west breakwater gap, providing a total of 1,600 feet of additional breakwall fishing access. Also, a new comfort station and parking area will be provided in the west section of the Edgewater complex.

Alternative 8B provides access to the west breakwater by a pedestrian bridge located near the public boat launch ramp adjacent to the wastewater treatment plant. This plan will provide an additional 5,725 feet of fishing access on the west breakwall. The existing west breakwater will be provided with chain railings and two safety platforms. The plan also includes a new parking area at the west end of the Edgewater complex and a new comfort station located near the new pedestrian bridge. The location of these improvements relative to the breakwater and the Edgewater marina facilities are illustrated in Figures B11 and B12.

A preliminary economic evaluation of these two proposed improvements was based upon an investigation of demand and supply for recreational fishing activities within the region, Cuyahoga County, and the Cleveland metropolitan area. The characteristics of fishermen and the desirability and location of competing locations where this type of activity could take place was obtained from existing planning reports.

b. Analysis of Fishing Demand.

(1) Regional Fishing Demand Analysis - Long-term projections of annual recreational fishing activity occasions were developed by the Ohio Department of Natural Resources in their publication "Outdoor Recreation Plan 1975-1980." This planning report utilizes projections of county population, households, and activity participation rates to estimate the total annual fishing activity occasions for selected time periods to 1990. Individual counties within the State of Ohio were subsequently aggregated into 15 planning regions. Planning Region 10A includes Cleveland Harbor and is the planning region of primary interest for this evaluation. This area consists of Lake, Geauga, Cuyahoga, and Lorain Counties and is shown in Figure B13.

More recent population projections of each county within Planning Region 10A have been used to update the fishing demand analysis developed for the State recreation plan. Population estimates to 2005, developed by the Ohio Department of Economic Development, were used to determine the annual fishing activity occasions demanded by Region 10A. Population projections to 2040 were made by extrapolating the population projections from year 2005. The extrapolations are based on a log linear regression curve fit. The revised population projections for the four-county area is presented in Table B50. The estimates of recreational fishing pressures, using the updated

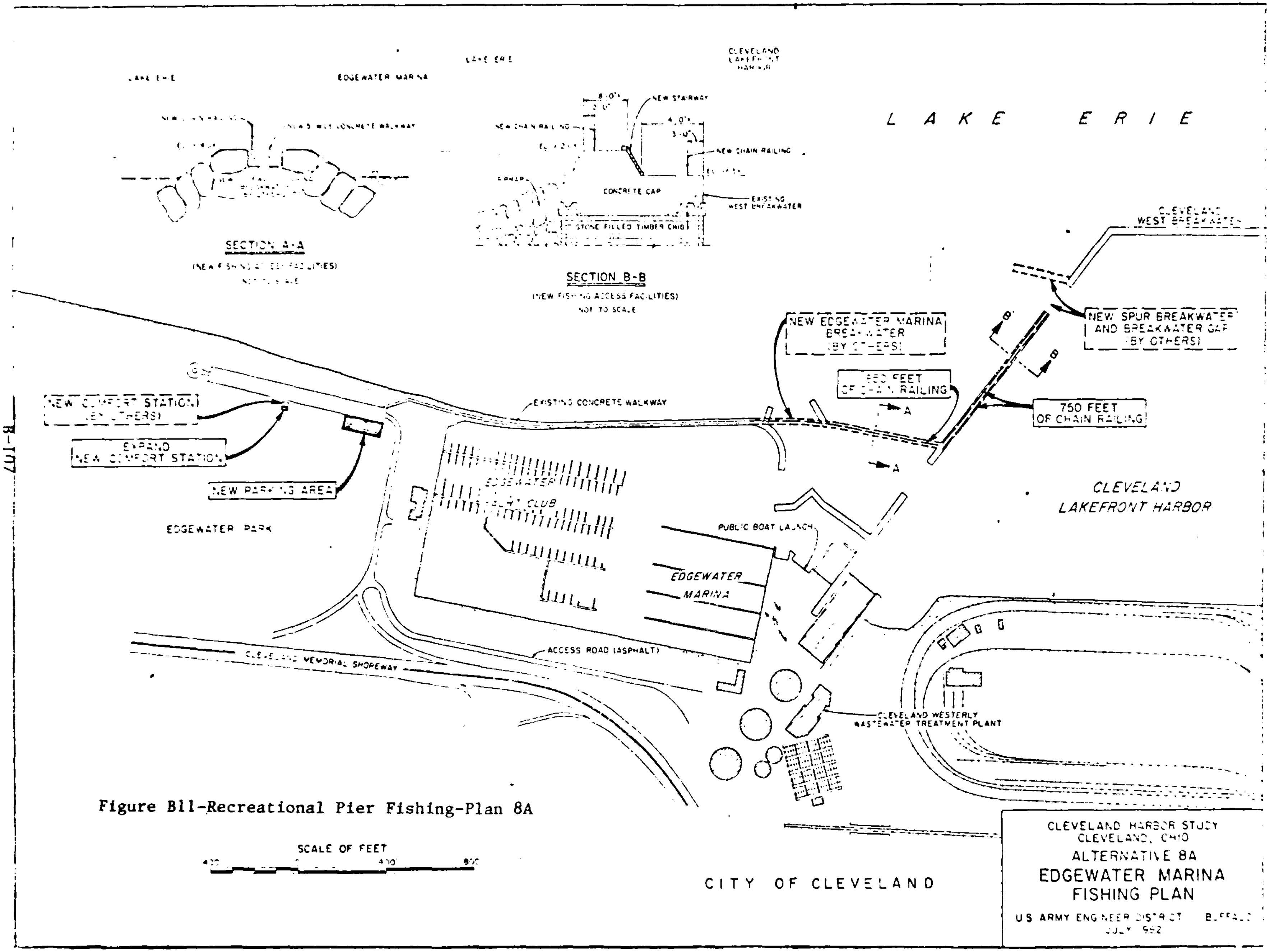


Figure B11-Recreational Pier Fishing-Plan 8A

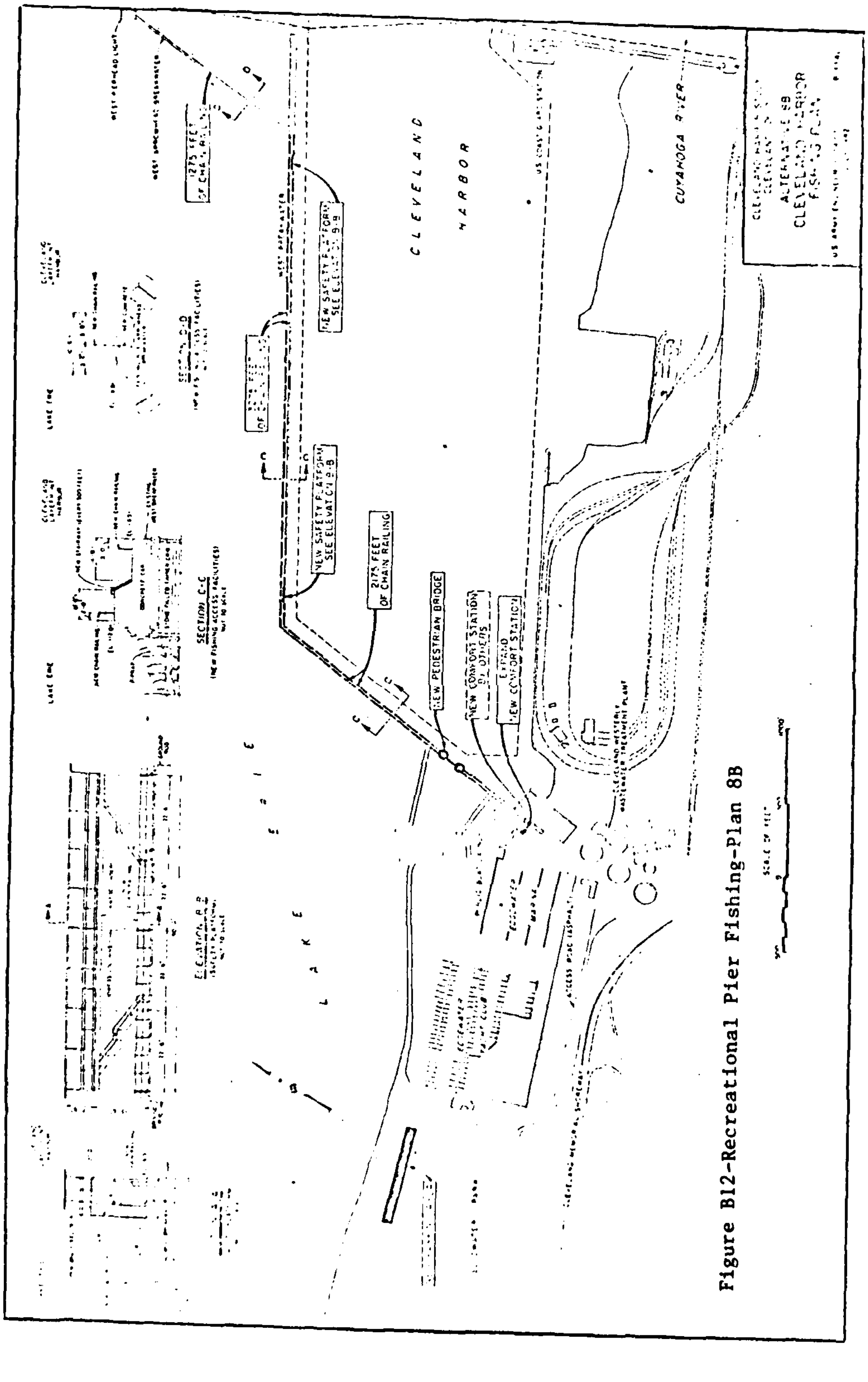


Figure B12-Recreational Pier Fishing-Plan 8B

Figure B13 - Selected Recreational Planning Areas in Ohio

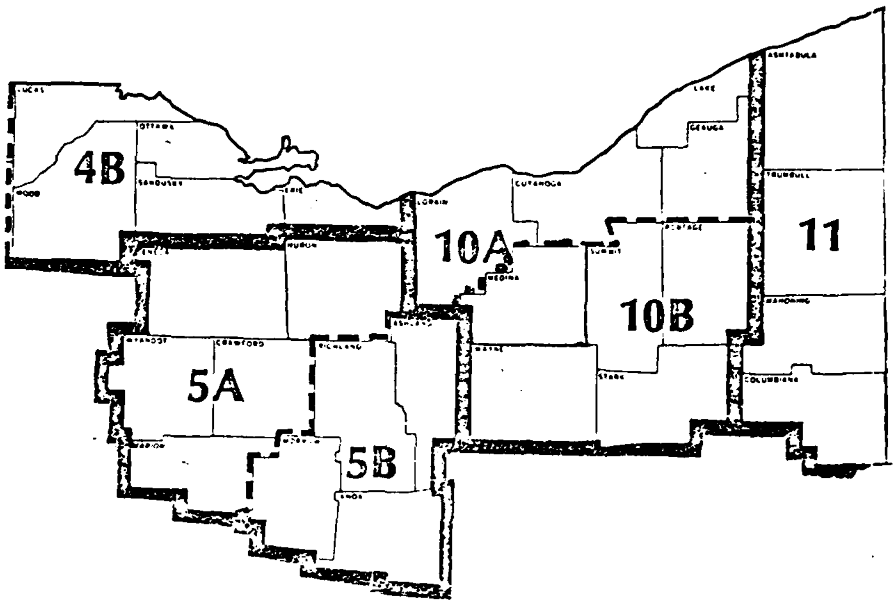


Table B50 - Population Projections, 1980-2040

County	1980	1985	1990	2000	2005	Trend Line Projection 2010	2020	2030	2040
Lake	212,916	217,580	231,703	259,949	274,072	277,201	297,904	318,607	339,311
Geauga	74,549	80,955	87,392	100,266	106,703	112,474	124,945	137,416	149,887
Cuyahoga	1,499,167	1,417,259	1,351,678	1,220,516	1,154,935	1,103,813	1,103,813	1,103,813	1,103,813
Lorain	274,979	284,122	296,718	321,910	334,506	341,848	363,542	385,236	406,930
Total	2,061,611	1,999,916	1,967,491	1,902,641	1,870,216	1,835,336	1,890,204	1,945,072	1,999,941

SOURCE: Projections for 1985-2000 based upon the Ohio Department of Economic Development. Estimates for the period 2010 through 2040 are extrapolated values based upon the 1980-2005 population projections of the Ohio Department of Economic Development.

population projections, retained the initial household size and participation rate assumptions established in the Ohio SCORP document.

The total number of fishing activity occasions for this planning area was then adjusted for movements of fishermen out of Region 10A and an inflow of fishermen from surrounding planning areas. The adjusted net yearly fishing occasions for Planning Region 10A is presented in Table B51.

Table B51 - Net Yearly Fishing Occasions for Planning Area 10A

1980	1985	1990	2000	2010	2020	2030	2040
3,450,646	3,430,014	3,458,643	3,344,643	3,226,329	3,322,781	3,419,233	3,515,687

(2) Regional Fishing Supply - An inventory of existing recreational fishing facilities and their capacities was completed by the State of Ohio in 1973-1974. The total number of yearly fishing activity occasions that Planning Region 10A can sustain, based upon space standards of 3 acres of water per fishing boat, 2.5 persons per boat, an instant capacity of 0.83, a daily turnover rate of 2, a total daily capacity of 1.66 persons per acre, 10 fishermen per mile for streambank fishing, and 20 fishermen per mile for riverbank fishing is 4,032,199. The Ohio SCORP concluded that fishing demand is less than the available supply for the overall region. However, this is not the case for Cuyahoga County.

(3) Cuyahoga County Fishing Demand Analysis - The State of Ohio has established a travel time - distance relationship for individual recreational activities. This relationship for recreational sport fishing indicates that the maximum travel time for fishermen is 120 minutes. This time is

approximately equal to a three-county service area surrounding one's residence, assuming a 45-minute travel time per county. It was also found that less than 10 percent of the total yearly fishing activity occasions were satisfied outside of the county of residence. Therefore, although fishermen are usually willing to travel 120 minutes in order to fish, 90 percent of the time they will fish within their county of residence if public access is available.

An analysis of recreational fishing demand versus supply was performed for Cuyahoga County. The number of fishing activity occasions demanded exceeded the supply in Cuyahoga County. The fishing occasion deficits for Cuyahoga County in the 1975-1980 SCORP document were adjusted to reflect the use of Ohio Department of Economic Development population projections. All of the fishing occasion deficits up to 1990 for Planning Region 10A originates from Cuyahoga County. The excess of demand over supply for fishing activity occasions in Cuyahoga County (fishing occasion deficits) is presented in Table B52.

Table B52 - Needed Fishing Activity Occassions for Cuyahoga County

1980	1985	1990
1,428,712	1,511,643	1,603,774

Similar revisions to the demand study of fishing activity occasions was performed for Geauga, Lorain, and Lake Counties. Future fishing activity occasions demanded within these counties were also adjusted to reflect the most recent outlook for future population levels. This analysis concluded that these counties currently have a surplus of fishing activity occasions (Table B53).

Table B53 - Surplus Fishing Activity Occasions

County	1980	1985	1990
Geauga	40,630	26,750	14,564
Lorain	496,520	441,359	396,801
Lake	876,260	806,023	752,104

SOURCE: Surplus fishing activity occasions are based upon county population projections made by the Ohio Department of Economic Development.

The above county-by-county deficit/surplus fishing activity occasion analysis emphasizes that Cuyahoga County has the greatest need for additional fishing activity occasions in Planning Region 10A. Consequently, over 1,600,000 activity days by residents within Cuyahoga County will be transferred to sites outside Cuyahoga County in 1990 if all demands were to be satisfied.

(4) Cleveland Harbor Fishing Demand Analysis - The city of Cleveland has 14 multipurpose recreational centers that emphasize indoor, year-round activities, approximately 225 playgrounds and mini-playlots, 45 athletic fields, 45 swimming pools, and 17 parks.

The geographical distribution of these recreational facilities, however, does not match the population distribution of Cleveland. Those areas of Cleveland that have the greatest need for accessable recreational space were identified in the Ohio SCORP document as the Inner East Side, Inner West Side, and Inner South Side. These areas have a high concentration of low average income families. These families, due to their low income, rely heavily on public transportation and nearby recreational facilities. A recreational activity that could be engaged in on a daily or weekend basis and is close to these low income residents would have a high probability of heavy utilization.

Public access to pier fishing along the west breakwall could be one such recreational activity. This location is surrounded by neighborhoods characterized as low income. This is the same geographical area of Cleveland that has been identified as in need of accessable recreational space. Also, the accessability of this location for low income famlies is enhanced by the availability of public bus routes which coincide with the major east to west highways parallel to the shoreline.

Assuming that the percentage of excess fishing activity occasions demanded for Cuyahoga County in 1990 attributable to low income families is equal to the percentage of 1979 households in the Cleveland area that have incomes below the poverty level (7.6 percent); low income families alone would demand 121,887 yearly fishing activity occasions. Due to the private transportation restrictions associated with low income families, it could be assumed that all of these 121,877 yearly excess fishing activity occasions demanded would be satisfied at the proposed west breakwall public fishing development.

The number of unmet annual fishing activity occasions demanded that could be attributed to low income families would be 7.6 percent of Table B52, since these families have limited access to transportation for satisfying recreational needs. These low income-generated, unmet, annual fishing activity occasions are presented in Table B54.

Table B54 - Unmet Low Income Fishing Activity Occasions for Cuyahoga County

1980	1985	1990	2000	2010	2020	2030	2040
108,582	114,885	121,887	121,887	121,887	121,887	121,887	121,887

The actual number of fishing activity occasions needed by low income Cuyahoga County residents is probably greater than these figures indicate. This is because, in the 1970 Census, 9.3 percent of the Cleveland SMSA families had incomes less than 125 percent of the poverty level.

In conclusion, although annual fishing activity occasions demanded within Planning Region 10A is not greater than the fishing activity occasion supply, Cuyahoga County has a substantial level of unmet annual fishing activity occasions (1980 = 1,285,841, 1990 = 1,603,774). This demand must be satisfied outside of Cuyahoga County, even though 90 percent of the fishermen prefer to fish in their own county. Out of these needed fishing activity occasions, low income families in Cuyahoga County alone could account for 108,582 and 121,877 of 1980 and 1990 needed annual fishing activity occasions, respectively. This fishing demand by low income families will remain unfulfilled unless additional public fishing access is provided within Cuyahoga County.

c. Analysis of Public Fishing Access Supply.

(1) Availability of Competing Sites - There are 11 public fishing access locations in Cuyahoga County listed in "Lake Erie Fishing Services and Facilities," published by the Ohio Department of Natural Resources, Division of Wildlife.

Pier fishing was offered at five locations: the Rocky River Pier access at W. 223rd and Lake Road, Rocky River access at W. 180th and Detroit Road, Edgewater Park at W. 58th Street, Gordon Park at E. 72nd Street, and White City Park at E. 140th Street (Figure B14). This pier fishing gives access to deep water which traditionally increases the abundance, diversity, and size of fish that can be reached.

Public pier fishing sites in Rocky River are approximately 17 miles west-southwest of Edgewater Marina. Gordon Park and White City Park are approximately 7 and 10 miles northeast from the west breakwater. Given the distance of the Rocky River Pier and river access from Edgewater, the availability of public transportation, the geographical distribution of the Cleveland population, the percentage of the Cleveland population below the poverty level, and the number of Cleveland households with no automobile, only Gordon Park and White City Park would be alternative pier fishing sites that city residents would utilize. The specific site chosen would depend upon a number of variables such as access, availability of support facilities (restrooms, bait shops, etc.), the different types of fish one could expect to catch, the probability of making a catch, and other intangible criteria.

(2) Desirability of the West Breakwall for Pier Fishing - A Water Quality Baseline Assessment for Cleveland Area - Lake Erie, Volume II was performed by Dr. A. White in 1975 for the city of Cleveland. This study documented the number of species of fish and the density thereof at various locations along the Lake Erie shoreline of Cuyahoga County. Ten sampling stations were used. The sample stations included Edgewater, Gordon Park, and White City Park. The Edgewater Marina area near the west breakwall had the highest number of species (11) and density of fish per 1,000 feet of gill net (619) of the former three areas. Table B55 gives data on the number of species and fish density for the three aforementioned areas as well as other sampling stations.

Figure B14 - Cuyahoga County Pier Fishing Locations

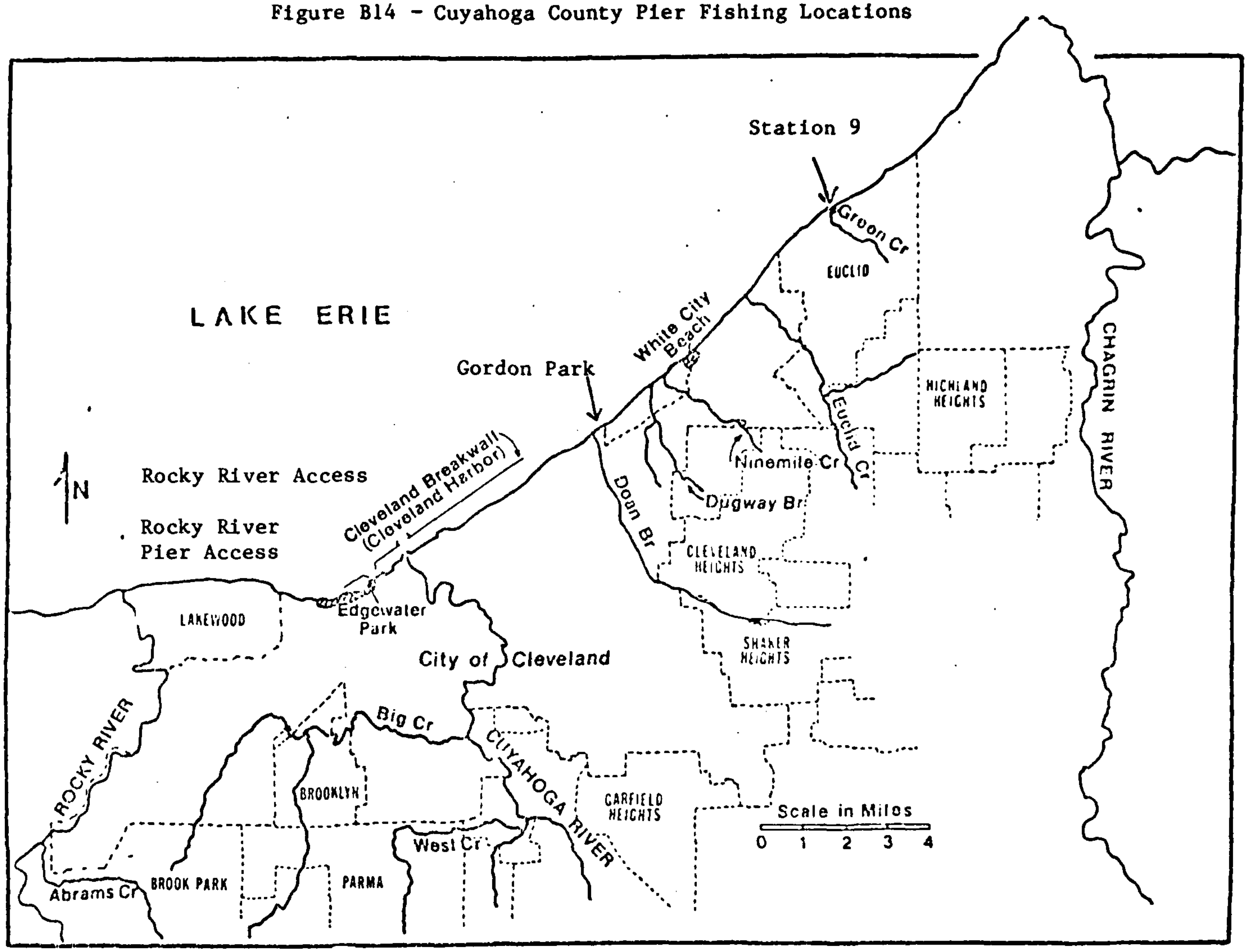


Table B55 - Fish Population Data - Cuyahoga County

	Lakewood Park	Edgewater Park	Gordon Park	White City Park	Sampling Station 9
Number of Species	13	11	9	10	5
Density	596	619	401	585	390

The geographical location of the sampling stations used to develop the field data are shown in Figure B14.

This study also reported that the major fish nurseries along the Lake Erie shoreline, in order of importance, are: the Cleveland breakwall and adjacent marinas, the lower Chagrin River, the lower Rocky River, the Lake Erie shoreline, and the Cuyahoga River. Major fish concentrations were correlated with nearby municipal pollution sources, warm water effluents, or protected water areas formed at marinas, harbors, or river mouths. The report also stated that 24 species of fish used the Cleveland Harbor area and adjacent marinas as a spawning area. There were 46 species and subspecies of fish documented within the Cleveland Harbor and adjacent marina areas.

The water quality assessment also indicated that the species composition of the Lake Erie shoreline area has evolved from one containing sport fish such as Muskellunge, Walleye, and Lake Trout to one dominated by less desirable pan fish such as Carp, Gizzard Shad, Yellow Perch, and Freshwater Drum. The predominant sport fish along the Lake Erie shoreline now are Yellow Perch, Freshwater Drum, Carp, and Bass.

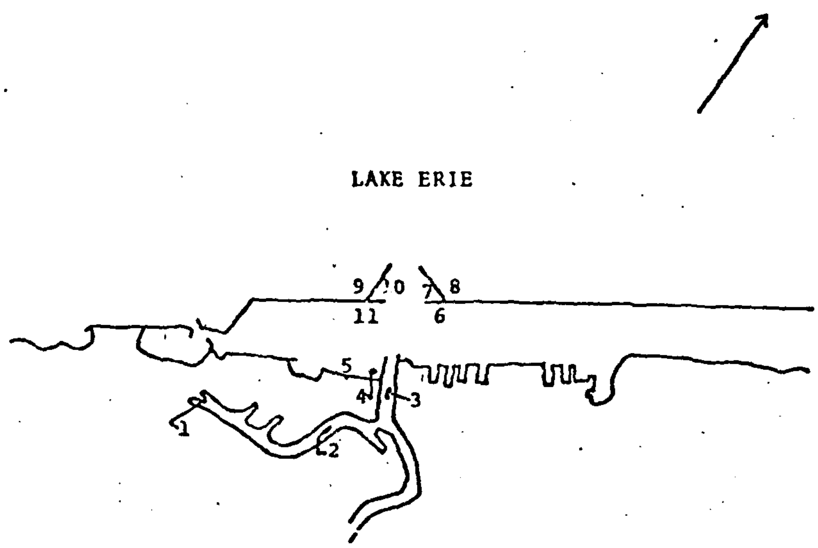
The availability of these fish species at various locations within the Outer Harbor has been documented by the Cleveland Environmental Research group (Environmental Impact Statement, June 1976). Fish populations at 11 different Cleveland Harbor locations were documented during the period 6 June through 15 September 1975. The geographical location of the sampling stations are presented in Figure B15. Stations 8 and 9 contained the highest number of sport fish of all of the stations sampled. Yellow Perch was the most abundant species. The actual number of the larger sport fish species taken is presented in Table B56.

Table B56 - Fishery Resources at Cleveland, OH

Type of Fish				
Eastern Gizzard Shad	Yellow Perch	Freshwater Drum	Alewife	Carp
309	127	77	47	24

Based upon the above information, the Edgewater Marina area and areas along the West Breakwall have a diverse and relatively dense fish specie

Figure B15 - Fish Collection Sites



population. This makes it one of the more attractive public access areas along the shore of Lake Erie in Cuyahoga County for sport fishing. This conclusion is further supported by a shore angler pressure study performed by ODNR, Division of Wildlife, in 1976. The report, Ohio's Annual Lake Erie Creel Census, documented shore angler pressure from Toledo to Conneaut. The Edgewater breakwall had the highest average number of anglers per sample - 42. The average number of anglers from Toledo to Conneaut was approximately 18. There is no evidence that the relative diversity and abundance of sport fish found at the Edgewater Marina and along the west breakwall will change in the future.

d. Evaluation of Recreational Fishing Benefits.

Recreational pier fishing at Cleveland Harbor is primarily related to the demand for this activity by Cuyahoga County residents. Since demand within this county exceeds supply, fishermen will have to travel outside of Cuyahoga County to satisfy their fishing demand. Not all Cuyahoga County residents who comprise this excess fishing demand have access to private transportation. Consequently, those county residents who have transportation restrictions would be limited to public transportation which would restrict their movements within their own county of residence. If these fishermen cannot fish in Cuyahoga County, their participation in this recreational experience approaches zero.

The number of annual excess fishing activity occasions attributable to this group of people is assumed to equal the percentage of families in the Cleveland SMSA with income levels below the poverty level. Thus, for Cuyahoga County, there are 108,582 and 121,887 fishing activity occasions for 1980 and 1990 that need to be fulfilled within Cuyahoga County.

(1) Benefits Methodology - Two plans will be evaluated. Plan 8A and Plan 8B provide 1,600 feet and 5,725 feet of breakwater access, respectively, with a water depth of 4 feet or more during the fishing season. The construction of an access walkway in conjunction with parking and sanitary facilities would provide additional fishing opportunities for Cuyahoga County residents with limited means of transportation.

In general, recreational fishing benefits are the product of the additional number of fishing occasions satisfied by the project, multiplied by the number of expected people fishing from the structure on peak and nonpeak days. This subtotal would then be multiplied by the monetary unit day value attributable to the fishing experience itself. This benefit evaluation follows the procedures outlined in Appendix 3, Subpart K, "NED Benefit Evaluation Procedures, Recreation," of the Procedures for Evaluation of National Economic Development (NED) Benefits and Costs in Water Resources Planning, 14 December 1979. The unit day value method was used to evaluate benefits since there are less than 500,000 annual fishing activity occasions involved. If more than 500,000 annual fishing activity occasions took place, a regional model or a site-specific study would have been used to evaluate the benefits.

(2) Additional Fishing Days - The season length is estimated to be 275 days, March through November. This period consists of about 84 weekend days and 191 weekdays. This season is then adjusted for bad weather days which is defined as any day with more than 0.5 inch of precipitation. There were three weekend days and 14 weekdays lost during the fishing season due to bad weather. Thus, on the average, there are 81 weekend days and 177 weekdays of fishing in Cleveland from March to November.

(3) Peak Day Capacity - Peak day capacity for the west breakwall is defined as the maximum number of fishermen that can safely use the facility on a summer holiday or weekend day. Assuming 1,600 feet of fishing access (Plan 8A), a fisherman density standard of one fisherman every 10 feet, and fishing off of one side of the breakwall only, an instant capacity of 160 fishermen is derived. It is expected that fishermen will participate in this activity for only one-half of a day. Thus, applying a turnover factor of 2 to the instant capacity results in an estimate of the peak day capacity (i.e., 2 X 160 = 320). A similar analysis for Plan 8B, based on 5,725 feet of breakwall access, results in a peak day capacity of 1,145 fishermen.

Based upon the analysis of potential recreational fishing pressure in the Cleveland area originating from fishermen with limited access to transportation and the need for Cuyahoga County fishermen to travel outside of their county of residence, it is assumed that 100 percent of the peak day capacity will be utilized on any weekend or holiday and 10 percent of the peak day utilization will be used on a weekday for Plan 8A. Similar allocations were also made for Plan 8B.

(4) Monetary Evaluation of the Fishing Experience - The recreational fishing experience is converted into a monetary equivalent value based upon the procedures developed by the Water Resources Council (WRC). A dollar value or unit day value is estimated from a range of possible values published annually by the WRC based upon a point rating method.

Pier fishing has been defined as similar in character to general fishing. The current dollar values and corresponding point value range is summarized in Table B57.

Table B57 - Current Unit Day Values and Corresponding Point Ranges

	Point Values										
	0	10	20	30	40	50	60	70	80	90	100
	$	$	$	$	$	$	$	$	$	$	$
General Fishing	2.20	2.40	2.60	2.90	3.20	3.50	3.90	4.00	4.30	4.40	4.50

Five specific criteria and associated measurement standards designed to reflect quality, relative scarcity, capacity of the area, ease of access, and aesthetic features are the basis for determining a site specific point value that can be converted to a unit day value. Table B58 summarizes the guidelines used in assigning points to the proposed improvement.

Table B58 - Assessment of West Breakwall Pier Fishing

Criteria	Point Range		Project Site Characteristics	Points Credit
	Minimum	Maximum		
A. Number of Activities at the Site	0	30	Less than .5 mile distance to Perkins Beach, and Edgewater Park allows participants to enjoy fishing, harbor sightseeing, swimming, and picnicking.	18
B. Availability of Alternative Breakwall Fishing Locations	0	18	Although there are four other pier fishing locations within a 1/2-hour drive, none of these sites offers the diversity or density of fish that the west breakwall offers.	9
C. Carrying Capacity	0	14	Adequate parking in the vicinity of Edgewater Marina area will be provided.	7
D. Accessibility to the Project Site	0	18	Access is via main traffic arterials such as the Cleveland Memorial Shoreway.	15
E. Aesthetic Nature of the Project Site	0	20	The close proximity of the Edgewater Marina, the movement of commercial vessel traffic within the harbor plus fishing from a structure that lacks a man-made appearance all contribute to a pleasing aesthetic experience.	16
Total	0	100		65

The evaluation in Table B58 translates into 65 quality points or an equivalent unit day value of $3.95.

(5) Estimate of Fishing Benefits - Economic benefits attributable to Plan 8A is based upon a 100 percent utilization of the breakwalls peak day capacity (1.00 X 320 = 320) on any weekend day. Weekday usage is assumed to be 10 percent of the breakwalls peak day utilization (320 X 1.00 X .1 = 32).

Thus, the weekend day benefits are equal to the number of fishermen using the breakwall per weekend day (320), times the number of weekend days in the season (81), times the unit day value of $3.95 ($102,384). The weekday recreational fishing benefits are equal to the number of fishermen fishing from the breakwall per weekday (32), times the number of weekdays in the season (177), times the unit day value of $3.95 ($22,373).

This information is presented in tabular form in Table B59. A similar analysis was performed for Plan 8B and is also presented in Table B59.

e. Benefit-Cost Evaluation.

(1) Average Annual Costs - The annual costs were computed at a 7.625 percent interest rate for a 50-year project life. Since construction can be completed in one season, there are no interest charges during construction. Annual maintenance costs are $12,000 for Plan 8A and $63,000 for Plan 8B.

Total average annual costs equal interest and amortization costs on the alternatives total investment cost plus annual maintenance costs. The interest and amortization factor for the 50-year evaluation period is .07625 and 0.00199, respectively. Average annual costs are summarized in Table B60.

(2) Benefit/Cost Comparison - The benefit/cost ratio (BCR) is the ratio of average annual benefits to average annual costs evaluated at a project interest rate of 7.625 percent for a 50-year project life. The projects average annual benefits and costs, B/C ratio, and net benefits are presented in Table B61.

f. Summary and Conclusions.

Plan 8B has the highest net benefits ($250,400) and B/C ratio (2.28).

Table B59 - Benefits Analysis - Cleveland Harbor, OH

	Peak Day Breakwall Capacity	Utilization of Peak Day Breakwall Capacity		Weekend Days and Holidays	Weekdays	Unit Day Value	Average Annual Benefits
		Weekends Holiday	Weekday				
		(percent)	(percent)				
Plan 8A							
Weekend Holiday	320	1.00		81		3.95	102,384
Weekday	320		(1.00) (.10)		177	3.95	22,373
Total							124,757
Plan 8B							
Weekend Holiday	1,145	1.00		81		3.95	366,343
Weekday	1,145		(1.00) (.10)		177	3.95	80,053
Total							446,396

Table B60 - Average Annual Costs

Cost Components	Alternatives	
	Plan 8A	Plan 8B
	$	$
Construction Costs	586,000	1,700,000
Interest During Construction	0	0
Investment Cost	586,000	1,700,000
Interest (.07625)	44,700	129,600
Amortization (.00199)	1,200	3,400
Maintenance	12,000	63,000
Average Annual Costs	57,900	196,000

Table B61 - Benefit/Cost Comparison

	Average Annual Benefits	Average Annual Costs	B/C Ratio	Net Benefits
Plan 8A - 1,600 Feet of Additional Breakwall Access				
100 Percent Utilization of Peak Day Capacity	124,800	57,900	2.16	66,900
Plan 8B - 5,725 Feet of Additional Breakwall Access				
100 Percent Utilization of Peak Day Capacity	446,400	196,000	2.28	250,400

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SUPPLEMENT 1

COMPUTER MODEL INPUT AND OUTPUT

Attached are the base case computer model inputs and outputs for the initial project year, 1990. The components of the input file are divided into six sections:

I Dock Location and Vessel Delay Points

II Location of Delay Zones and Their Delay Times

III Vessel Operating Characteristics

IV Upbound and Downbound Delay Times by Vessel Class

V Vessels Affected by Congestion

VI Tonnage Projections by Dock - Also Vessel Operating and Arrival Characteristics

The content of these sections is described in further detail.

A sample model output of total delay times for the base case in the initial project year 1990 is also provided. The delay times accruing to each vessel at each congestion point for vessel-to-fixed object and vessel-to-vessel delays are depicted. These hourly delays are for a 30-day simulation period. For example, the total hourly delay of 261.4 was used as output to Table B40 in the Without-Project Condition for the year 1990.

******* LISTING OF INPUT DATA FILE *******

**********TRAFFIC FORECASTS FOR PROJECT YEAR 1**********

I. Dock Location and Vessel Delay Points.

D	720	4	2			2.5LEAP DOCK 20
C		4	2	1	2	CONRAIL #1
D	716	24	14			2.5ALPHA CEMENT
D*	700	8	5	0	7	2.5SHERWIN AVE (CFP)
C	700	1	1	3	4	2.5SHERWIN AVE (CFP)
N		8	5			DELAY ZONE I START
D	680	14	8			2.5CUYAHOGA LIME
N		32	19			DELAY ZONE I END
D	275	10	6			2.5M-C-C
N		6	4			DELAY ZONE II START
D	598	6	4			2.5FORD MOTOR
D	590	6	4			2.5CBS #1
N		6	4			DELAY ZONE II END
D	327	5	3			2.5CBS #2
D	329	6	4			2.5CBS #3
D	580	6	4			2.5ONTARIO STONE
N		12	7			DELAY ZONE III START
N		6	4			DELAY ZONE III END
D	360	6	4			2.5CLIFTON CONCRETE
C		8	5	5	6	CONRAIL #14
D	378	3	2			2.5CBS #4
C		28	17	8	9	JEFF AVE BRIDGE
D	410	10	1			2.5REPUBLIC #1
D	495	16	10			2.5REPUBLIC #2
D	435	12	7			2.5J&L
D	440	10	10			2.5REPUBLIC #3

******

II. Location of Delay Zones and Their Delay Times.

7	9	10	10	0	90
11	14	10	10	0	90
18	19	10	10	0	90

*****

III. Vessel Operating Characteristic

6	25050	27.6	1296	3.50
5A	20450	25.8	1140	3.00
5B	22700	26.4	1068	5.00
5C	26300	28.0	1032	6.00
5D	13400	21.9	624	0.30
5E	17650	23.8	852	3.00
5F	19800	25.3	912	3.00
5G	16200	23.5	828	3.00
5H	18600	25.1	948	3.00

*****

IV. Upbound and Downbound Delay Times By Vessel Class.

1	30	30	30	30	30	30	30	30	30
2	30	30	30	30	30	30	30	30	30
3	20	20	20	20	20	20	20	20	20
4	20	20	20	20	20	20	20	20	20
5	15	15	15	15	15	15	15	15	15
6	15	15	15	15	15	15	15	15	15
7	30	30	30	30	30	30	30	30	30
8.	10	10	10	10	10	10	10	10	10
9	10	10	10	10	10	10	10	10	10

*****END OF FUNCTION DESCRIPTOR MATRIX CARDS

V. Vessels Affected By Congestion.

700	5D	6	5A	5B	5C	5D	5E	5F	5G	5H

*****END OF VESSEL INTERFERENCE MATRIX CARDS

VI. Tonnage Projections by Dock. Also Vessel Operating and Arrival Characteristics.

720	302000	0.11	23.4	5B	1.00R		
700	99000	0.11	20.8	5D	1.00R		
680	363000	0.11	20.8	6	.60R	5A	.40R
598	15000	0.11	20.8	5F	1.00R		
580	53300	0.11	20.8	5E	1.00R		
410	2020000	0.11	20.8	5C	.90U	5G	.10R
495	306000	0.11	20.8	5C	.19U	5G	.81R
435	2378000	0.11	20.8	5B	.86R	5F	.14R
440	2238000	0.11	20.8	5C	.86U	5H	.14R

*****

I. <u>Dock Location and Vessel Delay Points</u>.

Column 1 - Indicates whether the location is a node (N), dock (D), a constraint area (C), or a vessel-to-fixed object delay point where the fixed object is a vessel unloading at a dock (D).

Column 2 - Dock Code Number.

Column 3 - Time between points in minutes for upbound vessels.

Column 4 - Time between points in minutes for downbound vessels.

Column 5 - A locator number where the upbound vessel delay by class is stored. The delay times are presented in Section 4 by vessel class.

Column 6 - A locator number where the downbound vessel delay by class is stored. The delay times by vessel class are presented in Section 4.

Column 7 - The names of the nodes, constraint areas and docks. All docks have their unloading rate in thousands of tons per hour placed in front of their name.

II. <u>Location of Delay Zones and Their Delay Times</u>. Three delay zones are outlined. Row 1 is Delay Zone 1, Turn 2 in the river. Row 2 is Delay Zone 2, Turn 4 in the river. Row 3 is Delay Zone 3, Turn 5 in the river.

Column 1 - The number of the computer card depicting the beginning of the delay zone.

Column 2 - The number of the computer card depicting the end of the delay zone.

Column 3 - Vessel-to-fixed object delay time for all upbound vessels.

Column 4 - Vessel-to-fixed object delay time for all downbound vessels.

Column 5 - Vessel-to-vessel delay time for all upbound vessels.

Column 6 - Vessel-to-vessel delay time for all downbound vessels.

III. <u>Vessel Operating Characteristics</u>.

Column 1 - Vessel class.

Column 2 - The vessels deadweight carrying capacity.

Column 3 - Maximum vessel midsummer draft.

Column 4 - Tons per foot immersion factor.

Column 5 - Unloading rate per hour/thousands of tons.

IV. Upbound and Downbound Delay Times by Vessel Class.

Column 1 - A card locator row number which contains the upbound or downbound delay times incurred by each vessel class. If the row number appears in Column 5 of Section 1, the values are upbound delay times by vessel class. If the row number appears in Column 6 of Section 1, the values are downbound delay times by vessel class.

Column 2 - Upbound and downbound delay times for vessel 5D.

Column 3 - Upbound and downbound delay times for vesesl 6.

Column 4 - Upbound and downbound delay times for vessel 5A.

Column 5 - Upbound and downbound delay times for vessel 5B.

Column 6 - Upbound and downbound delay times for vessel 5C.

Column 7 - Upbound and downbound delay times for vessel 5D.

Column 8 - Upbound and downbound delay times for vessel 5E.

Column 9 - Upbound and downbound delay times for vessel 5F.

Column 10 - Upbound and downbound delay times for vessel 5G.

V. Vessels Affected by Congestion.

Column 1 - Dock code number.

Column 2 - The vessel size that services Dock 700.

Column 3 - 2 - Vessels that incur delay times when a 5D vessel is unloading at Dock 700.

VI. Tonnage Projections by Dock. Also, vessel operating and arrival characteristics.

Column 1 - Dock code number.

Column 2 - Thirty-day tonnage projection.

Column 3 - Thirty-day tonnage projection divided by the season tonnage projection by dock.

Column 4 - Maximum operating draft at each dock.

Column 5 - Vessel class servicing each dock.

Column 6 - Percent of tonnage moved by vessel class.

Column 7 - Vessel class servicing each dock.

Column 8 - Percent of tonnage moved by the previous columns vessel class.

PERIOD = 30 DAYS **********TRAFFIC FORECASTS FOR PROJECT YEAR 1********** Without Project Conditions - 1990.

DELAY TYPE/LOCATION	DELAYS BY VESSEL CLASS 6	5A	5B	5C	5D	5E	5F	5G	5H	N/A	TOTAL DELAY
TOTAL VESSEL TO FIXED OBJECT											
MERWIN AVE (CFP)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0 0	0.0
CONRAIL #1	2.0	2.0	14.0	25.0	1.0	1.0	4.0	4.0	0.0	0.0	53.0
MERWIN AVE (CFP)	1.3	1.3	9.3	16.7	0.0	.7	2.7	2.7	0.0	0.0	34.7
CONRAIL #14	0.0	0.0	7.0	12.3	0.0	0.0	1.5	2 0	0.0	0.0	22.8
JEFF AVE BRIDGE	0.0	0.0	4.7	8.2	0.0	0.0	1.0	1.3	0.0	0.0	15.2
DELAY ZONE I START	.3	.3	4.7	8.3	0.0	.3	1.3	1.3	1.0	0.0	17.7
DELAY ZONE II START	0.0	0.0	4.7	8.2	0.0	.3	1.2	1.3	1 0	0.0	15.7
DELAY ZONE III START	0.0	0.0	4.7	8.2	0.0	0.0	1.0	1.3	1.0	0.0	16.2
TOTAL VES TO FXD	3.7	3.7	49.0	86.8	1.0	2.3	12.7	14.0	3.0	0.0	176.3
TOTAL VESSEL TO VESSEL											
MERWIN AVE (CFP)	0.0	0.0	19.0	41.5	0.0	0.0	0.0	9.6	0.0	0.0	70.0
DELAY ZONE I START	0.0	0.0	3.0	4.5	0.0	0.0	1.5	3.1	0.0	0.0	12.1
DELAY ZONE II START	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
DELAY ZONE III START	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	1.5
TOTAL VES TO VES	0.0	0.0	23.5	47.5	0.0	0.0	1.5	12.7	0.0	0.0	85.1
TOTAL DELAY											261.4

APPENDIX C

COASTAL ENGINEERING DESIGN

CLEVELAND HARBOR, OHIO

STAGE 2 REPORT
OF
REFORMULATION PHASE I
GENERAL DESIGN MEMORANDUM

U. S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, NY 14207

CLEVELAND HARBOR, OHIO
STAGE 2 REPORT
OF
REFORMULATION PHASE I
GENERAL DESIGN MEMORANDUM

APPENDIX C
COASTAL ENGINEERING DESIGN

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APPENDIX C

COASTAL ENGINEERING DESIGN

C1. INTRODUCTION

The fundamental commercial navigation issue in the Cleveland Harbor study is the evaluation of modifications to existing harbor features in order to provide more efficient and safer movement of waterborne commerce through the Port of Cleveland. This appendix presents the design criteria, assumptions, and detailed design of the harbor modifications required to permit operation of Great Lakes bulk cargo vessels up to 1,000 feet in length with a draft of 25.5 feet in the Lakefront Harbor of the Port of Cleveland. Also included in this appendix is a discussion of improvements required in the Cuyahoga River to reduce congestion among vessels in the present fleet (up to 630-foot long vessels) that use the river and also a discussion of the improvements that would be required to permit these vessels (630-foot long) destined for upriver docks to navigate the river at fully loaded drafts of 25.5 feet.

Most commercial vessels use the main (west) entrance from Lake Erie into Cleveland Harbor (see existing Lakefront Harbor area shown on Plate C1). The main entrance consists of a dredged channel between the outer ends of the west and east arrowhead breakwaters which extend outward from the east basin and west basin breakwaters. The lake approach channel is presently maintained to a depth of 29 feet below low water datum and has a width of 600 feet at the outer ends of the arrowhead breakwaters and increases to 750 feet between the east and west breakwater spurs. The dimensions of the entrance features at the main entrance are depicted on Plate C2.

The east and west breakwater spurs represent hazards to vessels, particularly during storm conditions. The channel depths are also inadequate for vessel clearance under pitching and rolling conditions. Therefore, alternative "all-weather" entrance plans for operation of vessels in the Lakefront Harbor of the Port of Cleveland were developed at two locations. The "all-weather" entrance locations are a west entrance at the existing main entrance into Cleveland Harbor and an east entrance through the existing east basin. Structural improvements consisting of construction of new breakwaters and modifications to existing breakwaters, in addition to deepening of channels, are required at the west entrance location whereas only deepening and enlargement of existing channels is required at the east entrance location.

In addition to the "all-weather" plan at the existing main entrance, a plan of improvement was developed to facilitate entering into the Lakefront Harbor through the west entrance during "fair-weather" conditions. This "fair-weather" plan would require structural improvements consisting of construction of new breakwaters and modifications to the existing west arrowhead breakwater and to the existing east and west breakwater spurs. There would be no channel deepening required for the "fair-weather" plan.

C2. DESIGN CRITERIA AND ASSUMPTIONS

This section will address the criteria and assumptions for the detailed design of the channels and structural features for improvement of entrances to Cleveland Harbor for bulk cargo vessels up to 1,000 feet in length. Two "all-weather" entrance plans and one "fair-weather" entrance plan are discussed. The entrance plans are designed to create a safe navigation entrance channel from Lake Erie into the Port of Cleveland for bulk cargo vessels up to 1,000 feet in length.

A workshop was held in Cleveland, OH, on 8 April 1981, with vessel masters of 1,000-foot long bulk cargo vessels operating on the Great Lakes. The purpose of the workshop was to obtain information on vessel operating characteristics in order to establish design criteria for safe and efficient entrance into the Lakefront Harbor for the various entrance plans being considered. An "all-weather" entrance was defined as an entrance that would allow 1,000-foot long vessels to enter the Lakefront Harbor under all weather conditions for which they would be able to dock and unload their cargo in the Lakefront Harbor. According to the vessel masters, for an "all-weather entrance," regardless of the improvements implemented, they would not attempt to enter Cleveland Harbor with 1,000-foot long vessels when winds exceed 30 knots from the west through north to northeast nor when wave heights in the lake approach channel exceed 8.0 feet. The vessel masters also indicated that wave heights in the protected area of the entrance channel must not exceed 2 to 3 feet in order for vessel control to be maintained with side trusters as the vessel slows down to turn into the Lakefront Harbor. Under the "all-weather" wind and wave conditions defined above, the 1,000-foot long vessel would have to enter into the protected area of the entrance channel traveling at a speed of about 6 miles per hour to maintain vessel controllability. When entering at 6 miles per hour under design conditions (8-foot waves and 30-knot winds), a vessel roll value of 3-5 degrees can be expected on a 1,000-foot long vessel. For determination of required channel depth, a 4-degree value for roll will be used for 1,000-foot long vessels. The vessel masters stated that smaller vessels (vessels 730 feet in length and less) could probably enter under more severe weather conditions than a 1,000-foot long vessel and that the amount of roll would be 1-1/2 times the roll of the 1,000-foot long vessel for the corresponding wave condition, or between 5-7 degrees for an 8-foot wave. For determination of required channel depth, a 6-degree value for roll will be used for vessels less than 1,000 feet in length.

For "fair-weather" entrance conditions, defined as maximum wave heights of 4.0 feet in the lake approach channel and winds not exceeding 20 knots from the west through north to northeast, the vessel masters indicated that a 1,000-foot long vessel would enter the harbor at 2 to 3 miles per hour and would not experience any roll under the "fair-weather" design conditions.

When conditions are more severe than those listed for the "all-weather" plans, the vessel masters stated that the conditions in the Lakefront Harbor would be too severe to unload and therefore, they would lay up offshore until conditions subsided.

The structural improvements are designed as standard rubblemound structures composed of two underlayers of randomly placed stones, protected with a cover layer of selected armor stone. In accordance with a 4 May 1976 Guidance letter provided by NCDED-H for use of WES Technical Report H-76-1 entitled "Design Wave Information for the Great Lakes - Report 1 - Lake Erie," for projects having a 50-year design economic lifetime, a combined lake level and deep water wave corresponding to a 200-year recurrence event is recommended. Therefore, for analyzing the stability of structural improvements for the "all-weather" and "fair-weather" entrance plans, a 20-year wave recurrence interval will be used with a 10-year recurrence design maximum lake level to obtain a 200-year recurrence event.

As recommended in DAEN-CWE-HD draft Engineer Technical Letter dated 9 June 1980, entitled "Deep Draft Navigation Project Design," a design water level which is exceeded 95 percent of the time will be utilized in determination of required channel depths.

NATURAL FACTORS AFFECTING DESIGN AND NAVIGATION CONDITIONS

C3. EXPOSURE TO AND EFFECT OF STORMS

Cleveland Harbor is exposed to storm waves generated by winds from the west-southwest through north to east-northeast directions. Storm waves from the north-northeast through east-northeast directions have the greatest fetch and cause severe wave action at the harbor. Although storms from the northeastly directions are more intense, they occur less frequently than storms from the westerly directions. A wind diagram showing the relative directional frequency and intensity of winds at Cleveland, Ohio, based on United States Coast Guard recorded observations, is shown on Figure C1. The wind diagram is considered to reflect, reasonably well, the conditions that prevail at Cleveland Harbor.

C4. WATER LEVELS AND FLUCTUATIONS

Water levels on the Great Lakes vary from year to year and from month to month. Locally, water levels vary from day to day and from hour to hour. The lake level is subject to a seasonal rise and fall usually consisting of high levels in May and June and low levels in January and February. Yearly and seasonal fluctuations are caused by variations in precipitation rates within the Great Lakes Basin. Short-term fluctuations lasting from a few hours to several days are caused by meteorological disturbances. Differences in barometric pressure and winds blowing over the surface of the lake create temporary water level fluctuations which vary locally. Astronomical tides are assumed to have a negligible influence on water levels at the project site.

Continous records of water levels in Lake Erie have been monitored at Cleveland, Ohio by the Lake Survey Center and National Oceanic and Atmospheric Administration (NOAA) since 1860. The gage at Cleveland serves as the master gage for Lake Erie. Table C1 summarizes the average and extreme water levels recorded by the Cleveland water level gage. In the 122 years of record at the Cleveland gage, from 1860 to 1981 inclusive, the level

Table C1 - Average and Extreme Water Levels

LAKE ERIE WATER LEVEL DATA
AT
CLEVELAND, OH
PERIOD 1860-1981

STAGE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	1973	1973	1973	1973	1973	1973	1973	1973	1973	1973	1972	1972
HIGH	572.39	572.53	572.88	573.30	573.25	573.51	573.34	573.03	572.51	572.14	572.17	572.35
MEAN	569.98	569.94	570.18	570.71	571.04	571.18	571.14	570.95	570.67	570.34	570.08	570.01
	1935	1936	1934	1934	1934	1934	1934	1934	1934	1934	1934	1934
LOW	567.62	567.49	567.65	568.20	568.43	568.46	568.46	568.36	568.23	567.95	567.60	567.53

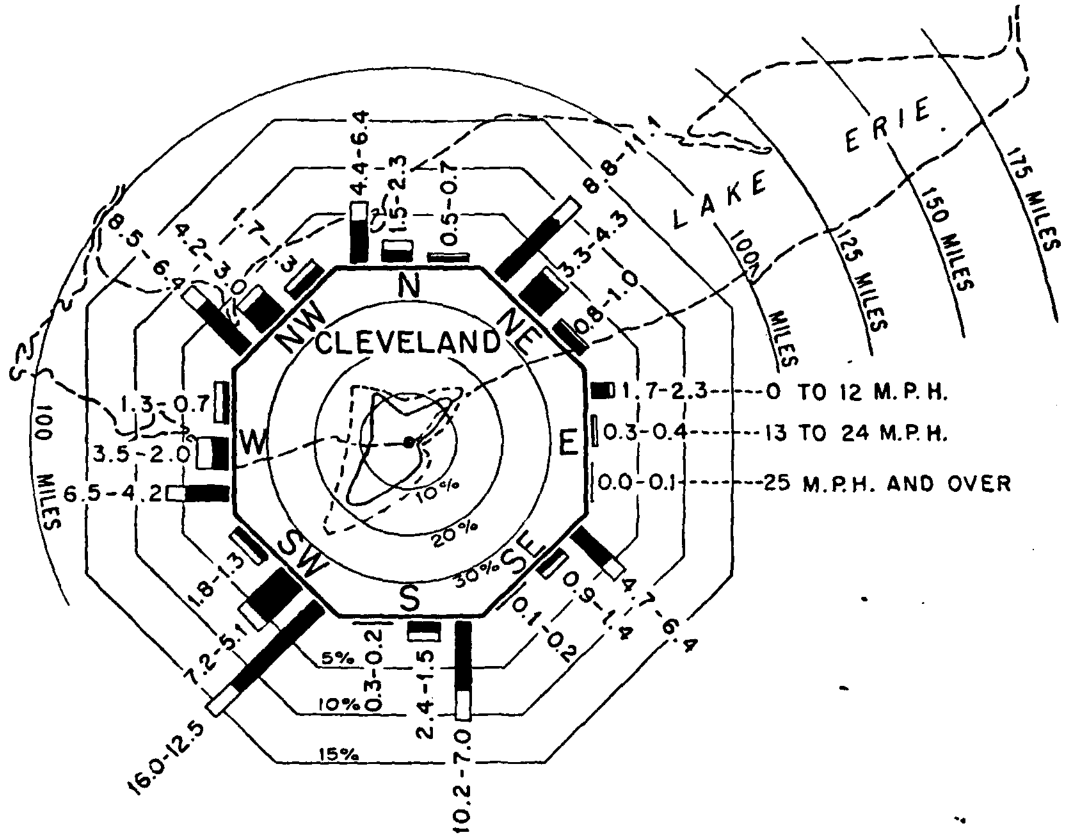
CHANGES

	Jan-Feb	Feb-Mar	Mar-Apr	Apr-May	May-Jun	Jun-Jul	Jul-Aug	Aug-Sep	Sep-Oct	Oct-Nov	Nov-Dec	Dec-Jan
	1952	1976	1913	1947	1892	1902	1915	1926	1926	1917	1927	1949-50
MAXIMUM RISE	+0.67	+1.12	+1.57	+0.95	+0.76	+0.63	+0.26	+0.13	+0.28	+0.14	+0.52	+0.78
AVERAGE	-0.04	+0.24	+0.53	+0.32	+0.15	-0.04	-0.19	-0.28	-0.33	-0.27	-0.06	-0.03
	1886	1931	1891	1891	1977	1890	1868	1937	1871	1924	1882	1917-18
MAXIMUM FALL	-0.73	-0.31	-0.13	-0.18	-0.24	-0.38	-0.52	-0.57	-0.67	-0.64	-0.51	-0.67

Ave. 1860-1981 570.52
Ave. 1900-1981 570.38

LWD 568.6

May 1983



WIND DIAGRAM FOR CLEVELAND, OHIO

NOTES

INDICATES DURATION FOR ICE-FREE PERIOD (MAR. TO DEC. INCL.) IN PERCENT OF TOTAL DURATION.

INDICATES DURATION FOR ICE PERIOD (JAN. TO FEB. INCL.) IN PERCENT OF TOTAL DURATION

INDICATES PERCENT OF TOTAL WIND MOVEMENT OCCURRING DURING ICE-FREE PERIOD

INDICATES PERCENT OF TOTAL WIND MOVEMENT OCCURRING DURING COMBINED ICE AND ICE-FREE PERIODS.

FIGURES AT ENDS OF BARS INDICATE PERCENT OF TOTAL WIND DURATION FOR ICE-FREE PERIOD AND COMBINED ICE-FREE AND ICE PERIODS, RESPECTIVELY.

WIND DATA BASED ON RECORDS OF THE U.S. COAST GUARD AT CLEVELAND HARBOR, OHIO FOR PERIOD 1 JAN. 1936 TO 31 DEC. 1971.

FIGURE C1

of Lake Erie has fluctuated from a high monthly mean of 573.5 feet in June 1973 to a low monthly mean of 567.5 feet in December 1934 and again in February 1936. The greatest annual fluctuation, as shown by the highest and lowest monthly mean of the year, was 2.75 feet in 1947, and the least annual fluctuation was 0.87 foot in 1895. In the last 5 years of record (1977 to 1981), the maximum monthly mean stages have ranged from +3.96 feet in June 1980 to +3.34 feet above low water datum in May 1977. The minimum monthly mean stages have ranged from +2.55 feet in December 1980 to +1.62 feet above low water datum in February 1977. Similar fluctuations are assumed to occur during the life of the project.

C5. DESIGN MAXIMUM WATER LEVEL (DWL)

The design maximum water level is a combination of the joint occurrence of long-term average lake level with a short-term rise due to a storm setup. The water levels for this analysis were obtained from the "Standardized Frequency Curves for Design Water Level Determination on the Great Lakes" prepared by Detroit District in 1979. The 10-year recurrence water level was used in this design for analyzing the stability and crest elevations of the structural improvements and is determined by combination of a 10-year annual mean lake level with a 1-year annual peak rise. The frequency curve for annual mean levels of Lake Erie is shown in Figure C2 and indicates that an annual mean level of approximately 572.7 occurs once in 10 years. The frequency curve for annual peak rise at Cleveland, Ohio is shown on Figure C3 and indicates that a peak rise of 0.9 foot can occur each year. Combining the annual mean level for Lake Erie which has a 10-year recurrence with a peak rise that has a 1-year recurrence, yields a 10-year recurrence maximum design lake level of 573.6.

C6. DESIGN MINIMUM WATER LEVEL

The design minimum water level is used for channel depth evaluation. As recommended in DAEN-CWE-HD draft Engineer Technical Letter dated 9 June 1980, entitled "Deep Draft Navigation Project Design," a design water level which is exceeded 95 percent of the time should be used in determination of required channel depths. The water level for this analysis was obtained from the "Standardized Frequency Curves for Design Water Level Determination on the Great Lakes" prepared by Detroit District in 1979. The frequency curve for the first quarter mean lake level of Lake Erie is shown in Figure C4 and indicates that a mean level of approximately 568.6 is exceeded 95 percent of the time.

C7. DEEP WATER WAVE CHARACTERISTICS

a. General. Cleveland Harbor, Ohio can be subjected to waves spanning approximately 135 degrees of Lake Erie from the west-southwest through north to east-northeast directions. Measured clockwise from the west, this range extends from approximately 275 degrees to 50 degrees. Three angle classes can be defined as viewed by an observer standing on shore and are depicted on Figure C5 and distinguished below:

(1) Angle Class 1 - Mean wave approach angle greater than 30 degrees to the right of a normal to shore (north through east-northeast);

(2) Angle Class 2 - Mean wave approach angle within 30 degrees to either side of a normal to shore (west-northwest through north);

(3) Angle Class 3 - Mean wave approach angle greater than 30 degrees to the left of a normal to shore (west-southwest through west-northwest).

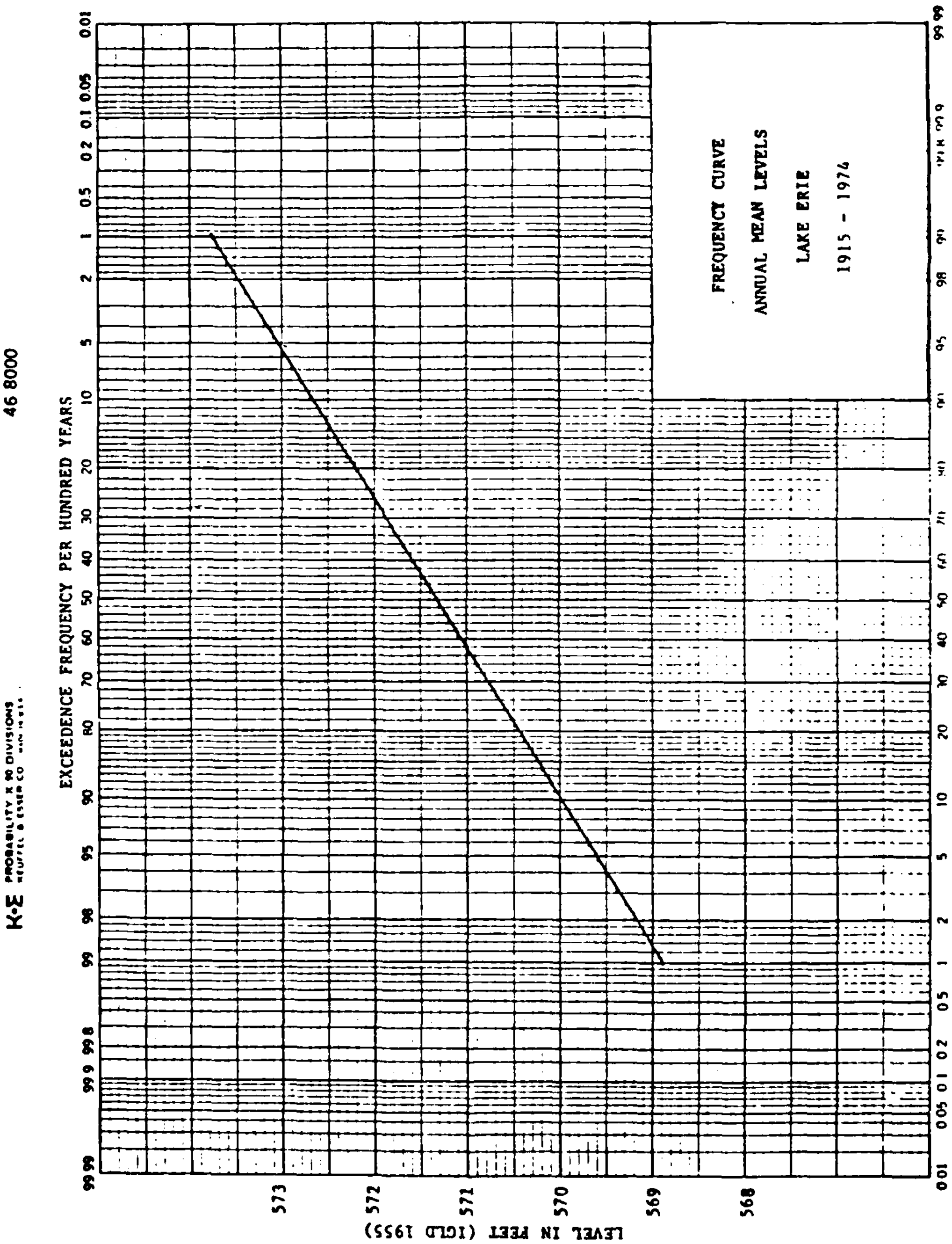
b. Significant Deep Water Wave Heights (H_o) - The significant deep water wave heights which can be expected at Cleveland, OH were determined by Waterways Experiment Station and published in Technical Report H-76-1, entitled "Design Wave Information for the Great Lakes - Report 1," dated January 1976. Table C2 presents the significant deep water wave heights at Cleveland, OH, for three angle classes as distinguished above, for each season of the year, and for various recurrence intervals.

c. Wave Period (T_o) - Table C3 presents the wave periods associated with each significant deep water wave height at Cleveland, OH, as a function of angle class and wave height as presented in Technical Report H-76-1.

DETAILED DESIGN - "ALL-WEATHER" WEST ENTRANCE PLAN

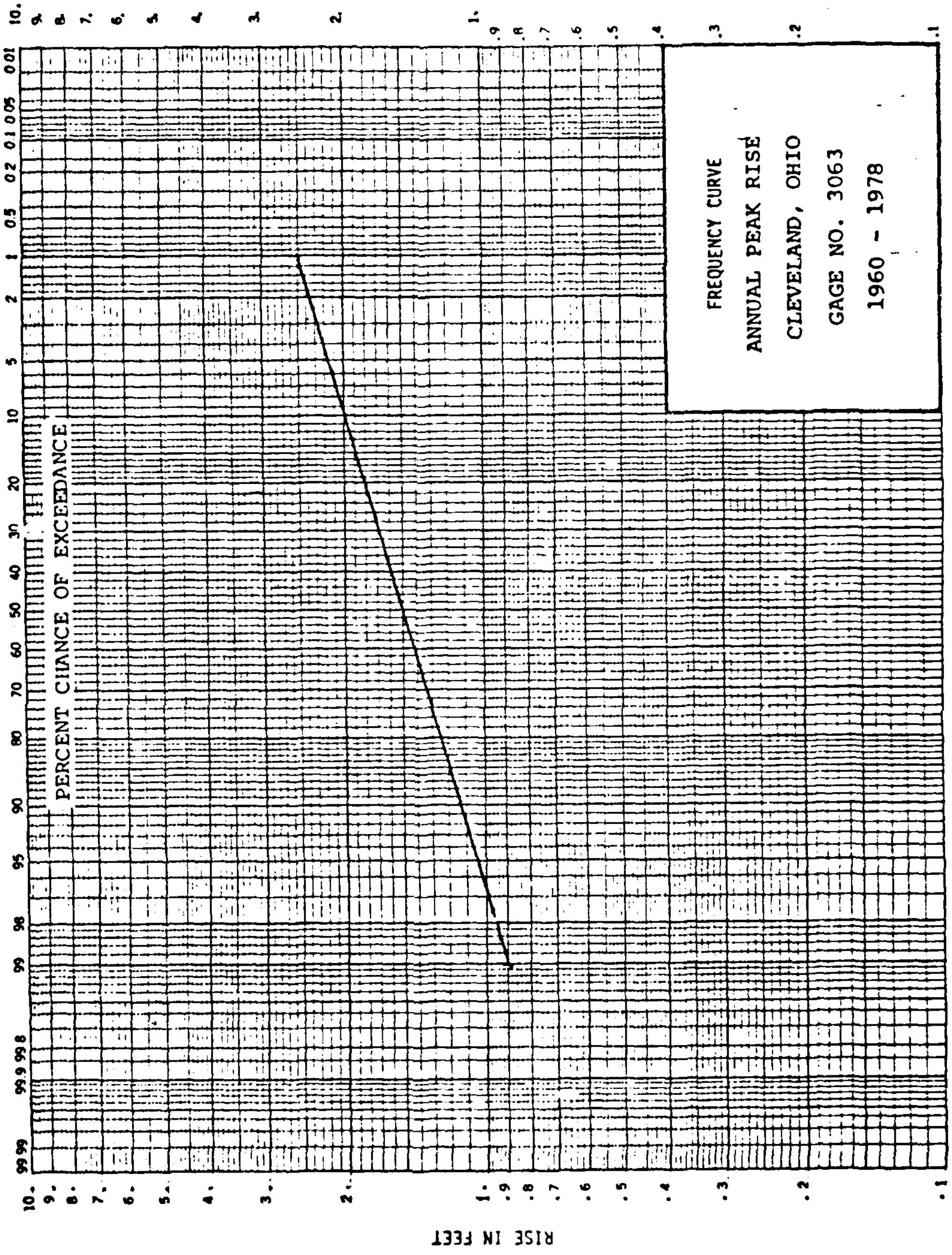
C8. GENERAL

The primary objective of an "all-weather" west entrance plan is to provide improvements required for a safe and efficient entrance into the Cleveland Lakefront Harbor through the existing main entrance by bulk cargo vessels up to 1,000 feet in length. An "all-weather" entrance is defined as an entrance that would allow 1,000-foot long vessels to enter the Lakefront Harbor under all weather conditions for which they would dock and unload their cargo. Based on discussions during the 8 April 1981 meeting with vessel masters in Cleveland, the "all-weather" condition was further defined as that when waves in the lake approach channel are a maximum of 8 feet in height and when winds are a maximum of 30 knots from the west through north to northeast. An "all-weather" west entrance involves major structural changes to the existing main entrance. The Buffalo District Corps of Engineers developed several "all-weather" west entrance concepts which included detached arrowhead breakwaters, a dogleg extension of the existing east or west arrowhead breakwaters with a west or east detached breakwater, parallel extension of the east and west arrowhead breakwaters, a dogleg extension of the east or west arrowhead breakwater with a parallel extension of the west or east arrowhead breakwater, and an extension of the east arrowhead breakwater and shortening of the west arrowhead breakwater (NOTE: Exhibit G - 2 in Appendix G includes sketches of these concepts). The vessel masters at the 8 April 1981 workshop meeting expressed viewpoints where they did not feel that any of the concepts developed by the Buffalo District would provide an adequate "all-weather" entrance. The vessel masters suggested two alternate concepts: (1) an "L" shaped breakwater concept similar to the entrance plan studied during the feasibility study in the 1970's; and (2) a detached east arrowhead extension concept similar to the breakwater arrangement at Lorain Harbor (a deep draft harbor approximately 30 miles west of Cleveland). The detached east



FREQUENCY CURVE
ANNUAL MEAN LEVELS
LAKE ERIE
1915 - 1974
EXCEEDENCE FREQUENCY PER HUNDRED YEARS
LEVEL IN FEET (IGLD 1955)
573
572
571
570
569
568
46 8000
K·E

FIGURE C2



FREQUENCY CURVE
ANNUAL PEAK RISE
CLEVELAND, OHIO
GAGE NO. 3063
1960 - 1978
PERCENT CHANCE OF EXCEEDANCE
RISE IN FEET

FIGURE C3

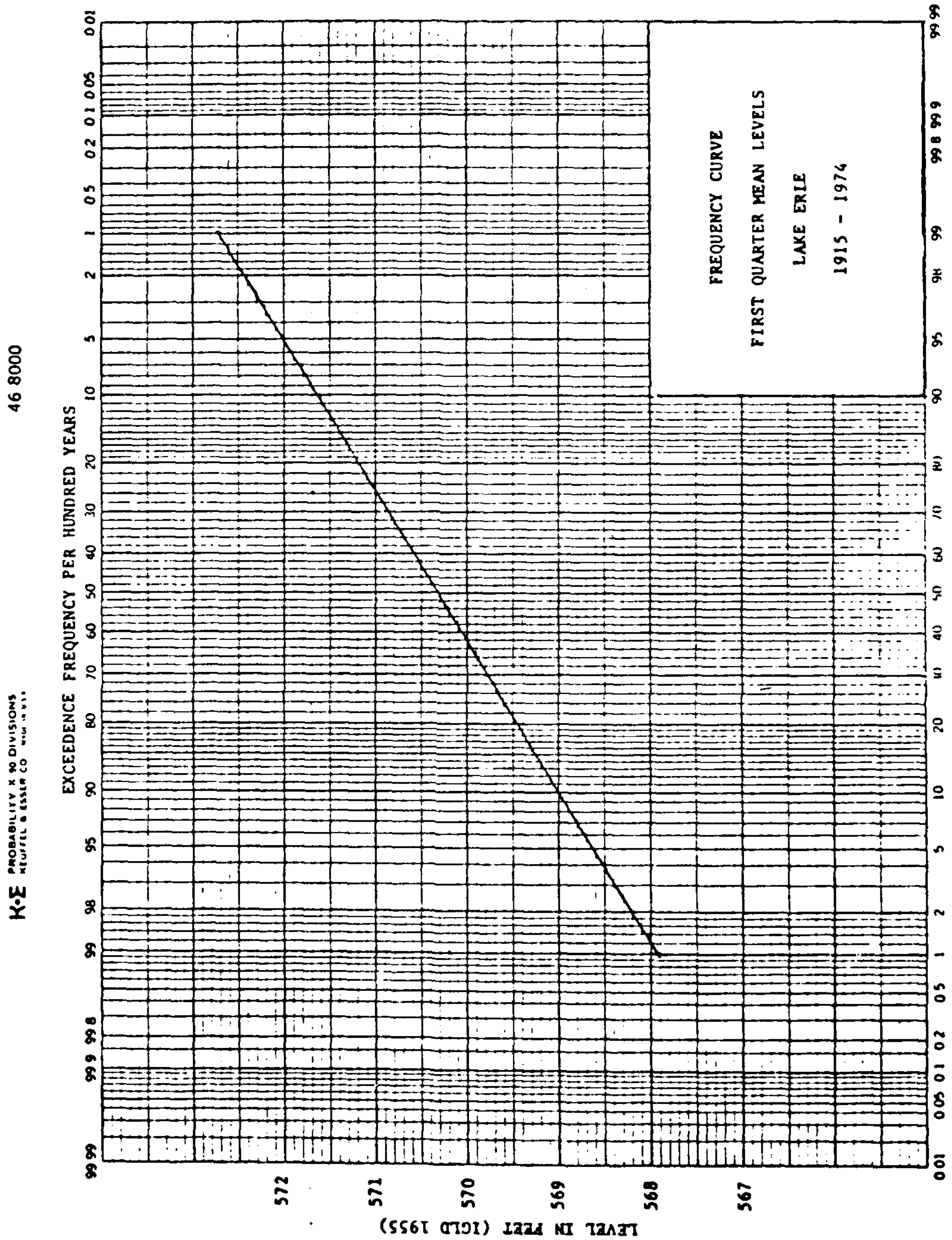
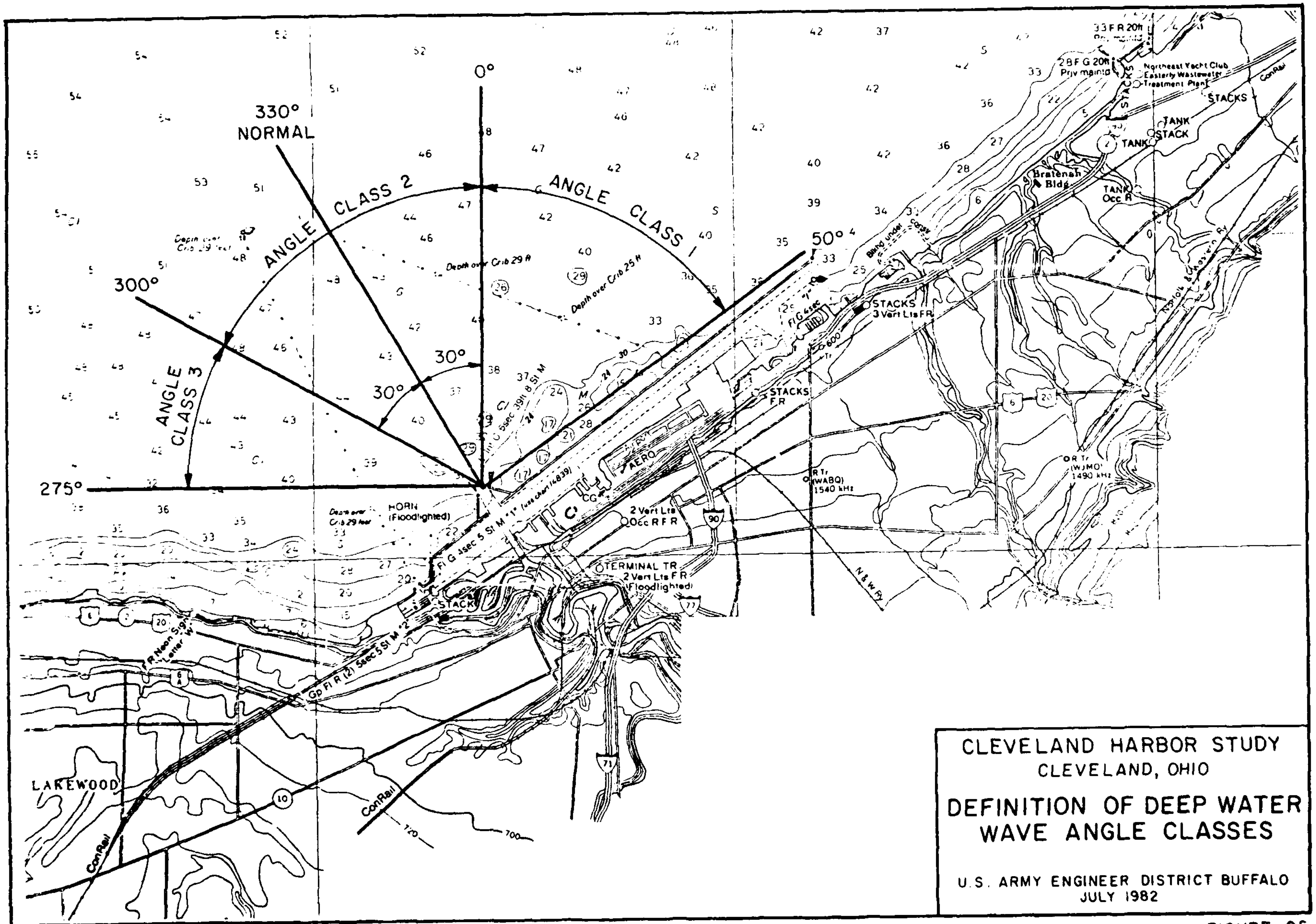

FREQUENCY CURVE
FIRST QUARTER MEAN LEVELS
LAKE ERIE
1915 - 1974
EXCEEDENCE FREQUENCY PER HUNDRED YEARS
LEVEL IN FEET (IGLD 1955)
572
571
570
569
568
567
46 8000
K·E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO.

FIGURE C4



CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

DEFINITION OF DEEP WATER WAVE ANGLE CLASSES

U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

FIGURE C5

TABLE C2

Significant Deep Water Wave Heights at Cleveland, Ohio

TABLE OF EXTREMES ESTIMATES
GRID LOCATION 11,10 LAT=41.56 LON=81.73 CLEVELAND OH
SHORELINE GRID POINT 10

WINTER
ANGLE CLASSES

	1	2	3	ALL
5	8.2(0.6)	11.2(0.4)	10.8(0.3)	12.3(0.6)
10	10.2(0.8)	12.1(0.6)	11.5(0.4)	13.3(0.8)
20	11.5(1.0)	13.4(0.7)	12.1(0.5)	14.3(1.0)
50	13.8(1.2)	14.8(0.9)	13.1(0.6)	15.7(1.2)
100	15.1(1.4)	15.7(1.0)	13.8(0.7)	16.8(1.4)

SPRING
ANGLE CLASSES

	1	2	3	ALL
5	3.9(0.4)	5.2(0.5)	6.9(0.4)	7.6(0.5)
10	4.9(0.6)	6.6(0.6)	7.9(0.5)	8.6(0.7)
20	6.2(0.7)	7.5(0.8)	8.9(0.7)	9.6(0.8)
50	7.5(0.9)	9.2(1.0)	10.2(0.8)	11.0(1.0)
100	8.5(1.0)	10.2(1.1)	11.2(0.9)	12.0(1.2)

SUMMER
ANGLE CLASSES

	1	2	3	ALL
5	4.9(1.7)	5.6(0.8)	6.2(0.9)	7.3(1.8)
10	5.9(2.3)	6.2(1.1)	7.2(1.1)	8.4(2.4)
20	7.5(2.8)	7.2(1.4)	8.2(1.4)	9.7(3.0)
50	10.2(3.5)	8.5(1.7)	9.5(1.8)	11.4(3.7)
100	12.1(4.1)	9.2(1.9)	10.5(2.0)	12.9(4.3)

FALL
ANGLE CLASSES

	1	2	3	ALL
5	8.9(0.3)	9.5(0.4)	9.8(0.3)	10.9(0.5)
10	9.8(0.4)	10.8(0.6)	10.5(0.4)	11.7(0.6)
20	10.5(0.5)	11.8(0.7)	11.2(0.5)	12.6(0.8)
50	11.5(0.6)	13.1(0.9)	12.1(0.6)	13.9(0.9)
100	12.1(0.7)	14.4(1.0)	12.8(0.7)	14.9(1.1)

AD-A127 216 STAGE 2 REPORT FOR REFORMULATION PHASE I GENERAL DESIGN MEMORANDUM CLEVEL..(U) CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT FEB 83 3/7

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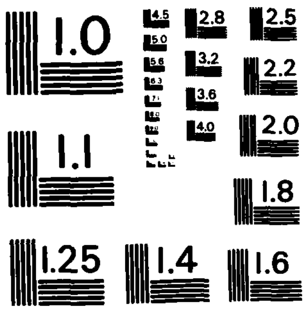

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE C3

Significant Deep Water Wave Periods at Cleveland, Ohio

GRID LOCATION 11,10 LAT=41.56 LON=81.73 CLEVELAND OH

GRID POINT NUMBER 10

SIGNIFICANT PERIOD BY ANGLE CLASS AND WAVE HEIGHT

WAVE HEIGHT (FT)	ANGLE CLASS		
	1	2	3
1	2.5	2.4	2.5
2	3.8	3.8	3.9
3	4.7	4.7	4.9
4	5.4	5.3	5.6
5	6.0	5.9	6.1
6	6.3	6.3	6.5
7	6.7	6.6	6.9
8	7.0	6.9	7.4
9	7.4	7.3	7.8
10	7.7	7.6	8.2
11	8.0	8.0	8.6
12	8.4	8.4	9.0
13	8.7	8.7	9.5
14	9.1	9.0	9.9
15	9.4	9.4	10.3
16	9.7	9.8	10.7
17	10.1	10.1	11.1
18	10.4	10.5	11.6
19	10.8	10.8	12.0
20	11.1	11.1	12.4
21	11.4	11.5	12.8
22	11.8	11.9	13.2
23	12.1	12.2	13.7
24	12.5	12.6	14.1
25	12.8	12.9	14.5

arrowhead extension concept was initially selected by the vessel masters as the preferred concept for development of an "all-weather" west entrance plan. However, as discussed in the following paragraphs, this concept did not satisfy the design criteria established by the vessel masters for various wave conditions and, therefore, the "L" shaped breakwater concept was analyzed.

C9. HYDRAULIC MODEL INVESTIGATIONS

Proposed "all-weather" west entrance plans consisted of a detached east arrowhead extension concept and a "L" shaped breakwater concept. These concepts were tested and refined in the hydraulic model investigation of the Lakefront Harbor conducted by the Corps Waterways Experiment Station in Vicksburg, MS. The tests performed and results obtained for these concepts are discussed in detail in the following paragraphs. For an improvement plan to be acceptable, the following wave height criteria were established by the vessel masters at the 8 April 1981 workshop: (a) Wave heights in the Lakefront Harbor should be equal to or less than those which occur for existing conditions, and (b) Wave heights at the existing entrance (at the outer ends of the existing arrowhead breakwaters) should not exceed 3.0 feet when incident waves in the lake approach channel are 8.0 feet in height and less. The hydraulic model investigation insured that all design criteria were satisfied. Included in the hydraulic model investigation were naviation tests using a scale model of a 1,000-foot long vessel which was operated by experienced masters of Great Lakes vessels.

C10. DETACHED EAST ARROWHEAD EXTENSION CONCEPT (ALTERNATIVE PLAN 3C)

The detached east arrowhead extension concept, which was suggested by the vessel masters as the preferred concept for development of an "all-weather" west entrance plan, is shown on Plate C3. The plan entailed removal of 600 feet from the lakeward end of the existing west arrowhead breakwater, removal of 300 feet of the existing west breakwater spur, removal of 200 feet of the existing east breakwater spur, a new 3,000-foot long detached east breakwater with a crest elevation of 8 feet above LWD, a new 1,500-foot long detached west breakwater with a crest elevation of 8 feet above LWD, and a 900-foot wide, 32-foot deep, 3,000-foot long entrance channel. The breakwaters in this plan were aligned to provide an entrance channel oriented in a northwesterly direction. The wind diagram for Cleveland (see Figure C1) indicates that storms from the westerly directions are more frequent, although of less intensity than storms from the northeast. An entrance channel oriented in a westerly direction was therefore selected since the degree of maneuverability and controllability of a 1,000-foot long vessel is greater when the vessel is entering with and leaving into the winds and waves than when the winds and waves are to the beam or parallel to the side of the vessel. The new 3,000-foot long detached east breakwater was aligned parallel to the east arrowhead and was positioned 300 feet off the existing east arrowhead. This new 3,000-foot long breakwater would provide a protected entrance area during episodes of north through east-northeast wave attack. The 300-foot offset was incorporated to provide a gap for water circulation and to provide a more spacious protected entrance area. The new detached west breakwater was aligned roughly normal to the primary directions of wave approach. This new west breakwater is required to prevent increased wave activity in the Lakefront Harbor area when the existing west arrowhead breakwater and the breakwater spurs are shortened. At the 8 April 1981 workshop, the vessel masters indicated that the stopping distance for a 1,000-foot long vessel, traveling at a speed of 6 miles per hour, as required under design conditions, is approximately 1,700 to 1,800 feet after the vessel is completely into the protected entrance area. Therefore, the length of the new detached east breakwater was established at 3,000 feet. This length of new breakwater would allow adequate distance for a 1,000-foot long vessel to slow down before making the turn into the Lakefront Harbor.

Hydraulic model testing of the detached east arrowhead extension plan indicated that this plan could not meet the design wave height criteria. Test waves in the lake approach channel of 8.0 feet in height or less from the west caused wave heights inside the harbor which were greater than those obtained for existing conditions. Test waves from the north-northeast, northwest, and north-northwest directions caused wave heights at the existing entrance that were greater than 3.0 feet. To alleviate the undesirable wave conditions at the existing entrance that were caused by test waves from the north-northeast, the new east breakwater was incrementally extended shoreward until a 500-foot extension, with a crest elevation of 10.0 feet above low water datum, satisfied the 3.0-foot wave criterion. Several modifications were made to alleviate undesirable wave conditions caused inside the Lakefront Harbor and at the existing entrance for test waves from the northwest and north-northwest directions. These modifications included the following: (a) Installing a revetment along the lakeward side of the existing west breakwater to an elevation of 12.0 feet above low water datum in order to reduce wave reflection off the existing west breakwater; (b) Extension of the new offshore west breakwater shoreward to the existing west breakwater and raising and sealing the entire new structure to prevent wave overtopping and/or transmission through the new breakwater; (c) Reduction of the 900-foot wide entrance channel recommended by the vessel masters to 600 feet and a slight reorientation of the new 1,500-foot offshore west breakwater; and (d) Reduction of the 900-foot wide entrance channel to 600 feet and extension of the new offshore west breakwater shoreward to the existing west breakwater and raising and sealing the entire new structure to prevent wave overtopping and/or transmission through the new breakwater. For each of the modifications investigated, the wave height criteria which were established for a plan to be acceptable could not be satisfied for test waves from the northwest and north-northwest directions. In each case, the 8.0-foot incident waves in the lake approach channel caused greater than 3.0-foot waves in the existing entrance and wave heights inside the Lakefront Harbor that were greater than those obtained for existing conditions. Therefore, there was no further testing of a detached east arrowhead extension concept as an "all-weather" plan and this concept was eliminated from further consideration.

C11. "L" SHAPED BREAKWATER CONCEPT (ALTERNATIVE PLAN 3D)

The "L" shaped breakwater concept investigated was similar to the entrance plan studied during the Feasibility Study in the 1970's and is shown on Plate C4. This plan would entail removal of 600 feet from the lakeward end of the existing west arrowhead breakwater, removal of 300 feet of the existing west breakwater spur, removal of 200 feet of the existing east breakwater spur, a new 4,000-foot long east breakwater with a crest elevation of 8.0 feet above low water datum, and a 32-foot deep entrance channel. The "L" shaped breakwater originates at the lakeward end of the existing east arrowhead breakwater and extends lakeward for 1,000 feet then turns westerly and parallels the existing west breakwater for 3,000 feet. The breakwater in this plan, as with the east arrowhead extension concept, is aligned to provide an entrance channel oriented in a westerly direction. An entrance channel oriented in a westerly direction was selected since the degree of maneuverability and controllability of a 1,000-foot long vessel is greater when the vessel is entering with and leaving into the winds and waves than when the winds and waves are to the beam or parallel to the side of the vessel.

Hydraulic model testing of the "L" shaped breakwater concept indicated that the wave height criteria which were established for an improvement plan to be acceptable were satisfied for the "L" shaped breakwater. Test waves from the west, with an incident height in the lake approach channel of 8.0 feet, satisfied the 3.0-foot wave height criterion at the existing entrance and caused waves inside the Lakefront Harbor to be equal to or less than those obtained for existing conditions.

To improve navigation conditions, the outer 3,000-foot length of new breakwater was reoriented approximately 20 degrees northerly on a 250-degree azimuth. The 3.0-foot wave height criterion at the existing entrance for 8.0-foot incident waves in the lake approach channel was satisfied but wave heights inside the Lakefront Harbor were greater than those obtained for existing conditions with corresponding wave conditions. Therefore, several modifications were tested to alleviate the undesirable wave conditions caused inside the Lakefront Harbor. These modifications included various combinations of a new 500-foot long offshore west breakwater and/or a new 400-foot long extension of the existing west arrowhead breakwater parallel to the entrance channel with crest elevations at 8.0 feet and 14.0 feet above low water datum. The wave height criteria inside the Lakefront Harbor and at the existing entrance were satisfied for most of the modifications tested. Therefore, to further improve navigation conditions, the outer 3,000-foot length of new breakwater was reoriented another 10 degrees northerly, such that the breakwater was on a 260-degree azimuth. Again, several modifications using combinations of a new detached west breakwater of varying lengths and crest elevations and/or a new west arrowhead breakwater extension of varying lengths, crest heights and orientations were tested to obtain the optimum plan for the "L" shaped breakwater concept.

The plan which was determined to be optimum is the modified "L" shaped breakwater concept (Alternative Plan 3A) as shown on Plate C5. This plan entailed removal of 300 feet of the existing west breakwater spur, removal of 200 feet of the existing east breakwater spur, removal of 600 feet from the lakeward end of the existing west arrowhead breakwater, a new 4,000-foot long east breakwater with a crest elevation of 8.0 feet above low water datum, a new 1,000-foot long extension of the existing west arrowhead breakwater with a crest elevation of 8.0 feet above low water datum, and a 32-foot deep entrance channel. The new 4,000-foot long east breakwater originates at the head of the existing east arrowhead and extends lakeward on a 290-degree azimuth for 1,600 feet then turns shoreward and extends 2,400 feet on a 255-degree azimuth. For this plan, maximum wave heights at the existing entrance were 3.0 feet or less for incident waves of 8.0 feet or less in the lake approach channel. Wave heights inside the Lakefront Harbor, considering all wave conditions, were less than those obtained for existing conditions and were less than those obtained for the other plans and modifications tested. This plan was also felt to be better for navigation since the degree of turning required to enter between the arrowhead breakwater was less for this plan than for the other "L" shaped breakwater plans.

Navigation tests were conducted for the modified "L" shaped breakwater plan using the scale model of the 1,000-foot long vessel operated by three masters that had experience operating 1,000-foot long vessels on the Great Lakes. The navigation tests were conducted for incident waves in the lake approach channel of 8.0 feet or less from the west, northwest, north-northwest, and north-northeast directions. Thirty-knot winds were superimposed on the waves by a series of calibrated fans to represent the "all-weather" entrance conditions. The masters felt confident that the maneuverability of the model ship was realistic, as compared to that of the prototype vessel, under various wave and wind conditions. It was determined from these navigation tests that the harbor configuration shown on Plate C5 was optimum with respect to an "all-weather" west entrance oriented toward the west. The vessel's approach upon entry was somewhat parallel to shore and slow speeds had to be maintained to make the turn into the Lakefront Harbor at the existing entrance. Due to the slow speeds however, the vessels maneuverability was decreased and some wave and wind conditions from the northwest, north-northwest and north-northeast directions tended to set the stern toward shore and the bow toward the new east breakwater. It was felt that only the more experienced and skillful masters would be able to safely and efficiently enter the harbor for the worst wave and wind conditions, thus leaving a narrow margin of error for the average vessel master.

C12. 1,000-FOOT PARALLEL BREAKWATER EXTENSIONS CONCEPT (ALTERNATIVE PLAN 3B)

After completion of the navigation tests discussed in the preceding paragraph and upon consideration of several additional alternatives, the three vessel masters expressed a preference for 1,000-foot long parallel extensions on the lakeward ends of the existing east and west arrowhead breakwaters for the optimum "all-weather" west entrance plan. This optimum "all-weather" west entrance plan is shown on Plate C6. The plan entails removal of 300 feet of the existing west breakwater spur, removal of 200 feet of the existing east breakwater spur, two new 1,000-foot long parallel breakwaters with a crest elevation of 8.0 feet above low water datum, and a 32-foot deep entrance channel. Ship navigation tests were also conducted for this plan by the three vessel masters with "all-weather" conditions of 8-foot waves and 30-knot winds from the west. These conditions were considered to be the most difficult conditions for entering the harbor for this plan. The vessel masters were unanimous in their preference for this plan over the modified "L" shaped breakwater plan shown on Plate C5. This plan has a larger margin for error when compared to the previous plan and would be considerably less expensive to construct due to the decrease in length of the breakwaters required. Hydraulic model testing of the parallel breakwater extension plan also indicated that wave heights inside the Lakefront Harbor, in general, were less than those obtained previously for existing conditions with test waves from the west, northwest, north-northwest and north-northeast directions. It was therefore concluded that the parallel breakwater extension plan would be considered as the optimum "all-weather" west entrance plan, although the modified "L" shaped breakwater plan would continue to be carried forward for further analysis during Stage 2. The discussions in the following paragraphs concerning the "all-weather" west entrance will make reference to only the 1,000-foot long parallel breakwater extensions at the lakeward ends of the existing arrowhead breakwaters, however, the discussions would also be applicable to the modified "L" shaped breakwater plan being carried through Stage 2 planning.

C13. DESIGN STRUCTURE DEPTH (d_s)

The parallel breakwater extensions on the lakeward ends of the existing arrowhead structures for the "all-weather" west entrance plan were analyzed at a single location (structure trunk) in the design of a typical breakwater section for use in determining the economic efficiency of navigation improvements for an "all-weather" west entrance at the existing main entrance to the Port of Cleveland. The design structure depth (d_s) of the structure toe for the typical section was determined from soundings obtained from NOAA's Nautical Chart for Cleveland Harbor (chart number 14839). The design structure toe depth was determined at the depth contour at which the longest reach of breakwater would be positioned. Based on the layout of the "all-weather" west entrance plan shown on Plate C6, the 32-foot depth contour was selected for development of the typical section. The depth contour at the structure toe plus the design maximum water level (DWL) minus the low water datum (LWD) elevation equals the design depth of water at the structure toe (d_s). The design structure depth value used in this analysis is as follows:

d_s = depth contour + DWL - LWD
where LWD = 568.6
d_s = 32.0 + 573.6 - 568.6 = 37.0 feet

C14. WAVE REFRACTION AND SHOALING ANALYSIS

A wave refraction and shoaling analysis was conducted by Waterways Experiment Station for various deep water wave directions and wave periods. The analysis was accomplished in conjunction with WES's efforts in conducting the hydraulic model investigation and design study of the Cleveland Harbor west (main) entrance. Table C4 summarizes the results of the refraction and shoaling analysis conducted by Waterways Experiment Station.

C15. DESIGN INCIDENT WAVES

The structural features required for an "all-weather" west entrance were designed using the significant deep water waves that have a 20-year recurrence interval as determined by Waterways Experiment Station and published in TR H-76-1. Table C2 indicates that the largest significant deep

TABLE C4

SUMMARY OF REFRACTION AND SHOALING ANALYSIS FOR CLEVELAND HARBOR

Deepwater Direction	Wave Period (sec)	Shallow-water* Azimuth (deg)	Refraction* Coefficient	Shoaling** Coefficient	Wave-Height Adjustment Factor
West (270°)	5	274.7	0.91	1.00	0.91
	6	278.6	0.84	0.99	0.83
	7	278.8	0.81	0.97	0.79
	8	280.2	0.78	0.94	0.73
	9	281.5	0.77	0.92	0.71
	10	282.9	0.74	0.91	0.67
WNW (292.5°)	5	296.1	0.97	1.00	0.97
	6	297.5	0.95	0.99	0.94
	7	299.8	0.91	0.97	0.88
	8	300.8	0.90	0.94	0.85
	9	301.5	0.90	0.92	0.83
	10	302.2	0.90	0.91	0.82
NW (315°)	5	315.2	1.02	1.00	1.02
	6	315.6	1.01	0.99	1.00
	7	315.5	1.00	0.97	0.97
	8	316.2	0.98	0.94	0.92
	9	316.1	0.97	0.92	0.89
	10	316.6	0.95	0.91	0.86
NNW (337.5°)	5	337.2	1.02	1.00	1.02
	6	336.8	1.01	0.99	1.00
	7	336.4	0.99	0.97	0.96
	8	336.2	0.98	0.94	0.92
	9	335.9	0.97	0.92	0.89
	10	336.0	0.96	0.91	0.87
North (360°)	5	358.8	1.03	1.00	1.03
	6	358.0	1.01	0.99	1.00
	7	356.7	0.99	0.97	0.96
	8	356.3	0.96	0.94	0.90
	9	355.4	0.96	0.92	0.83
	10	355.1	0.95	0.91	0.86
NNE (22.5°)	5	20.6	0.99	1.00	0.99
	6	18.3	0.96	0.99	0.95
	7	16.9	0.92	0.97	0.89
	8	16.7	0.90	0.94	0.85
	9	15.1	0.89	0.92	0.82
	10	14.7	0.87	0.91	0.79

* At model contours
** At 90-ft depth (model pit elevation)

water waves with a 20-year recurrence interval occur during the winter season for each angle class. The design curves from Appendix B of Technical Paper No. 80-3 entitled "Estimating Nearshore Conditions for Irregular Waves," were used to analyze the waves as they move from deep water into shallower water and to determine the incident wave height (H_{sig}) at the breakwater locations for each angle class with a 10-year recurrence water level. The significant deep water wave heights and wave periods used in the wave analysis and resulting design incident wave heights are presented in Table C5.

C16. STONE DESIGN

The 1,000-foot long parallel breakwater extensions on the existing east and west arrowhead breakwaters were designed as standard rubblemound structures. The procedures outlined in Sections 7.373 and 7.377 of the Shore Protection Manual (SPM) were used to determine the breakwater geometry. The stone to be used for construction of the breakwaters was designed to be stable against the largest design incident wave which is 12.6 feet (see Table C5). The stone design calculations are presented in the computations attached to the end of this appendix.

a. Armor Units. Armor units were designed by application of Hudson's formula from Section 7.373 of the Shore Protection Manual.

$$W = \frac{W_r H^3}{K_D (S_r - 1)^3 \cot \theta}$$

Where:

W = Weight of armor unit in primary cover layer.
W_r = Stone density in pounds/feet^3, assume W_r = 155 pcf.
H = Incident design wave height at the structure (feet).
K_D = Stability coefficient of the armor layer; use K_D = 4.0 for nonbreaking wave at structure trunk.
Sr = Specific gravity of armor stone = 155/62.4 = 2.48.
Cot θ = Structure sideslope = 1.5.

The stability coefficient was selected for structures comprising two layers of angular quarry stone randomly placed and subjected to a 12.6-foot nonbreaking wave. The stability coefficient used corresponds to that for a structure trunk section. The armor unit stone size was computed as a range which is a function of W. The limits of the stone size range are as follows:

W_{max} = 2.0W
W_{min} = 0.9W

A range of 0.9W to 2.0W is used to define the minimum and maximum limits for armor stone weight. This range is adequate in size to insure that suppliers can produce the stone economically. Also, the 0.9W is close enough to W to insure that at least 75 percent of the individual armor units as required by the Shore Protection Manual will have a weight greater than W without any

Table C5 - Significant Deep Water Wave Heights, Wave Periods, Refraction and Shoaling Coefficients, and Design Incident Wave Heights

Direction	Deep Water Wave Height (H_o)	Wave Period (T_o)	Refraction Coefficient (K_r)	Shoaling Coefficient (K_s)*	Incident Wave Heights (H_{sig})
East-northeast thru North	11.5 ft.	8.2 sec.	0.90	0.98	10.1 ft.
North thru West-northwest	13.4 ft.	8.8 sec.	0.97	0.97	12.6 ft.
West-northwest thru West-southwest	12.1 ft.	9.0 sec.	0.77	0.97	9.0 ft.

*Shoaling Coefficient computed at the contour of interest using design curves in Technical Paper No. 80-3.

further gradation restrictions. Table C6 summarizes the size of the armor units required for the "all-weather" west entrance structures into the Port of Cleveland.

b. Underlayer Stone. The underlayer stone is required to enhance stability and to provide support at the bottom of the armor layer. The underlayer stone size was computed as a range which is a function of W. The limits of the stone size range are as follows:

$$W_{max} = 0.2\ W$$
$$W_{min} = 0.06W$$

Table C6 summarizes the size of the underlayer stone required for the entrance structures.

c. Bedding Layer and Core Stone. A bedding layer is required under the entire base of the 1,000-foot long parallel extensions of the existing east and west arrowhead breakwaters and will extend 5 feet beyond the underlayer stone to form a toe. The bedding layer will provide a firm foundation and protect the structures against excessive settlement and thereby prevent the underlayer stone and armor units above them from sliding down the slope. The bedding layer is raised in the center of the structures to provide a core which forms a transition between the underlayer stone and bedding layer. The core stone provides the support for the armor and underlayer stone. The bedding and core stone sizes were computed as a range which is a function of W. The limits of the stone range are as follows:

$$W_{max} = 0.01W$$
$$W_{min} = 0.00015W$$

Table C6 summarizes the size of the bedding and core stone required for the entrance structures.

C17. CREST ELEVATIONS

Overtopping of rubblemound structures can be tolerated only if it does not cause damaging waves behind the structures. Whether overtopping will occur depends on the height of the crest of the structure relative to wave runup which depends on wave characteristics, structure slope, porosity, and roughness of the cover layer. The crest elevation of the rubblemound structures is designed for the lowest height that provides the protection required and thereby keeps the construction and maintenance costs at a minimum. At the 8 April 1981 workshop held in Cleveland, vessel masters indicated that the breakwaters for the "all-weather" entrance should be designed to limit wave heights in the entrance channel during design conditions (i.e, 8-foot waves and 30-knot winds) to 2 to 3 feet thereby allowing the vessel to slow down to 2 to 3 miles per hour before making the turn into the Lakefront Harbor. By slowing down to 2 to 3 miles per hour, the vessel masters would use the vessel's side thrusters as the vessel turns into the Lakefront Harbor (NOTE: according to vessel masters, above 2 to 3 mph, side thrusters lose their effectiveness in controlling a vessel). Therefore, the "all-weather" entrance structures for Cleveland Harbor are designed to allow overtopping which would regenerate a maximum interior wave of 3 feet in entrance channel.

The 3-foot maximum interior wave is of concern during the navigation season only, therefore, an analysis was undertaken to determine the significant deep water waves that would create a 8.0-foot incident wave at the breakwaters. The resulting significant deep water waves that create an 8.0-foot incident wave were compared to the waves presented in the WES Technical Report H-76-1 entitled "Design Wave Information for the Great Lakes" to assure that the 8.0-foot wave can occur during the navigation season (spring through fall). The 8.0-foot wave was defined as the maximum wave in the lake approach channel at which vessel masters would enter Cleveland Harbor. The analysis (see computations attached to the end of this appendix) shows that the following significant deep water wave conditions are required to yield an 8.0-foot incident wave at the proposed entrance:

a. Angle Class 1: H_o = 9.2 feet T_o = 7.5 seconds

b. Angle Class 2: H_o = 8.4 feet T_o = 7.1 seconds

c. Angle Class 3: H_o = 10.5 feet T_o = 8.4 seconds

Comparison of the calculated significant deep water waves required to yield the 8.0-foot incident wave with those determined by Waterways Experiment Station (see Table C2) indicates that the computed waves each has a recurrence interval of 10 years or less during both the fall and winter seasons when superposed on the 10-year recurrence maximum design water level. A significant deep water wave that yields an 8.0-foot incident wave and has the longer wave period will give a larger degree of wave runup and will be more critical in determining the crest elevation of the entrance structures while limiting the transmitted wave in the entrance channel to 3.0 feet. Therefore, the angle class 3 wave (10.5 feet, 8.4 seconds) was used in the analysis to determine the crest elevation of the breakwaters that will yield a 3.0-foot wave in the entrance channel.

The wave runup on the entrance structures was determined by using the method presented in Section 7.21 of the Shore Protection Manual. The runups computed using the SPM method are overestimated due to the fact that Figures 7-11 and 7-12 are from tests with 1:10 slopes, whereas the actual lakebed slope is much flatter. To remedy this discrepancy, Goda's Charts (T. P. 80-3) were used to calculate the wave heights at the structure for the 1:10 lakebed slope and for the lesser lakebed slope, in order to obtain a reduction ratio to apply to the wave runups. The wave runup was used in computing the required crest elevation of the structures which when overtopped will yield a maximum 3-foot transmitted wave in the entrance channel. The Cross and Sollitt method was used in computing the required crest elevation. The crest elevation was computed by:

$$H_{b_i} = R\,(1.04 - H_t/0.54\,H_i)$$

Where H_{b_i} = Breakwater crest elevation above design water level
R = Wave runup
Ht = Height of transmitted wave, use 3.0 feet
H_i = Height of incident wave, use 8.0 feet

and

Crest Elevation = DWL + H_{b_i}
where DWL = 573.6

The results of the analysis indicates that a crest elevation of 8.0 feet above low water datum is required to limit the transmitted wave height to 3 feet in the entrance channel. The computations for wave runup and wave overtopping and transmission are presented in the calculations attached to the end of this appendix and the results are summarized in Table C6. The hydraulic model investigation conducted by the Waterways Experiment Station verified that the 3.0-foot wave height criterion is satisfied for the 1,000-foot long parallel breakwater extensions on the existing east and west arrowhead breakwaters.

C18. CREST WIDTH

The width of the crest of the "all-weather" entrance structures depends on the degree of allowable wave overtopping. The amount of allowable overtopping was previously discussed as that which would regenerate a 3-foot maximum wave in the entrance channel. As a general guide for overtopping conditions, the minimum crest width should equal the combined widths of three armor units. Therefore, the method presented in Section 7.377 of the Shore Protection Manual requires that the minimum crest width be equal to the combined widths of three armor units. The crest width was computed by:

$$B = nk_{\Delta}\left(\frac{W}{W_r}\right)^{1/3}$$

Where: B = Crest width (ft)
n = Number of stones in crest width = 3
k_{Δ} = Layer coefficient = 1.15 for two layers of randomly placed rough quarry stone.
W = Weight of an individual armor stone
W_r = Stone density, assume W_r = 155 pcf

The crest width computation is presented in the calculations attached to the end of this appendix and indicates that a crest width of 16.5 feet is required. The results are summarized in Table C6.

C19. DESIGN SECTION

The typical design cross-section for the parallel breakwater extensions of the existing east and west arrowhead breakwaters is shown on Plate C7. The section is typical for the entire length of each entrance structure. A 1.0 vertical on 1.5 horizontal sideslope is used on both the lake side and channel side of the breakwaters. The rubblemound cross-section is designed to be stable against a 12.6-foot nonbreaking wave (H_{sig}) and the bottom elevation of the armor unit layer is extended downslope to an elevation below the design minimum water level equal to 1.5 H_{sig} on the lake side and on the channel side. The thickness of the armor layer and underlayer was determined by:

$$r = nk_{\Delta}\left(\frac{W}{W_r}\right)^{1/3}$$

Where r = Average layer thickness (ft)

n = Number of stones in thickness comprising the cover layer, use 2

k_{Δ} = Layer coefficient = 1.15 for two layers of randomly placed rough quarry stone

W = Weight of an individual armor stone in cover layer (for determining thickness of armor layer)

W_{10} = One-tenth the weight of an individual armor stone in cover layer (W = .1W for determining thickness of the underlayer)

W_r = Stone density, assume 155 pcf

The computations for determining the dimensions for the design section are presented in the calculations attached to the end of this appendix.

Table C6 - Summary of Structure Parameters for "All-Weather" West Entrance Plans

	Crest	Crest	Armor Stone		Underlayer Stone		Bedding/Core Stone	
	Height	Width	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
		(ft)	(Tons)	(Tons)	(Tons)	(Tons)	(lbs)	(lbs)
All New Breakwaters	+8.0	16.5	16.0	7.0	2.0	0.5	160	2

C20. MODIFICATIONS TO EXISTING STRUCTURES

In addition to the new parallel breakwater extensions on the lakeward ends of the existing arrowhead breakwaters, modifications to other existing entrance structures are required to provide a safe and efficient "all-weather" west entrance into the Port of Cleveland. These modifications to other existing structures are as follows:

a. Remove 300 feet of structure from the east end of the existing west breakwater spur; and

b. Remove 200 feet of structure from the west end of the existing east breakwater spur.

These structural modifications result from the navigation tests conducted in the hydraulic model of the Lakefront Harbor and are required to provide an entrance channel of sufficient width to facilitate the maneuverability of

1,000-foot long vessels as they make the turn into the east and west basins of the Port of Cleveland.

C21. CHANNEL DESIGN

Adequate channel depths and widths are required for safe and efficient navigation of ships. Therefore, at the 8 April 1981 workshop in Cleveland, vessel masters were requested to provide their professional and expert views on 1,000-foot long vessel operating characteristics that are required for the design of an "all-weather" west entrance at Cleveland Harbor. According to the vessel masters, when entering Cleveland Harbor under design "all-weather" conditions (i.e., 8-foot waves and 30-knot winds), a 1,000-foot long vessel would have to be traveling at a speed of approximately 6 miles per hour in order to maintain proper vessel control. Once in the protected entrance channel, the vessel would slow down to 2 to 3 miles per hour before turning into the Lakefront Harbor. When entering at a speed of 6 miles per hour under the design conditions, an angle of roll of 3 to 5 degrees can be expected on a 1,000-foot long vessel. The vessel masters also indicated that the angle of roll for smaller vessels would be about 1-1/2 times the angle of roll of a 1,000-foot long vessel, or between 5 to 7 degrees. The vessel masters also stated that they need sufficient water under their vessel in order to be able to use their engines without rupturing oil and air lines due to excessive vibration of the vessel.

a. Channel Depth. The design minimum water level of 568.6, which represents a lake level which is exceeded 95 percent of the time, will be used for channel depth evaluation and will allow for safe design vessel passage under most conditions. The channel depth requirements will include consideration of the following significant criteria:

(1) The static draft of the vessel at rest;

(2) The sinkage or squat of the vessel underway;

(3) The amount of vessel roll;

(4) The effect of vessel pitch and heave; and

(5) Nominal bottom clearance.

The channel depths were selected to safely and efficiently accommodate the passage of the design vessel which is normally the largest vessel (length, beam, and draft) expected to use the channel during the project life. At Cleveland Harbor, the largest vessel expected to use the port is the Class 10 (1,000 feet X 105 feet) bulk cargo vessel. However, the combined effect of roll and squat for smaller vessels is greater than for larger vessels and if loaded drafts are identical, the channel depth requirements may be based upon criteria for the smaller Great Lakes vessels. Therefore, the channel depth requirement for entrance into the Lakefront Harbor was evaluated for the Class 5 vessel (600-649 feet X 68 feet), the Class 6 vessel (650-699 feet X 72 feet), the Class 7 vessel (700-730 feet X 75 feet), the Class 8 vessel (731-849 feet X 70 feet), and the Class 10 vessel (950-1,000 feet X 105 feet). The numerical calculations of required depths were developed from practical and theoretical information in technical reports and papers. The calculations are attached to the end of this appendix and are based on a 25.5-foot design system draft. The following paragraphs discuss the significant criteria which were considered in determining the required channel depths. The results of the channel depth evaluation are summarized in Table C7. The depth requirements include the greater of the values for either vessel roll or the combination of pitch and heave.

(1) Vessel Squat. Vessel squat is the lowering of the water surface around a moving vessel which produces a relative change in the ship's position with respect to the channel bottom. Vessel squat was calculated on the basis of procedures outlined in Chapter 9 of the draft Engineer Manual (EM 1110-2-xxxx) entitled "Deep Draft Navigation Project Design" dated December 1979 (see Figure C6) and also by an empirical method recommended in the "Study Report of Vessel Clearance Criteria for the Great Lakes Connecting Channels" prepared by Detroit District, Corps of Engineers using the following formula:

$$S = \frac{V_i^2}{2g}\left[\left(1.01\frac{A_i}{A_w}\right)^2 - 0.84\right]$$

Where: S = Squat at speed V_i (ft)
V_i = Ship velocity (ft/sec) relative to water
A_i = Channel cross-sectional area (sq ft)
A_w = Channel cross-sectional area less ship cross-sectional area (sq ft)
g = 32.2 ft/sec

Pertinent parameters include: static draft of 25.5 feet; vessel beam widths, entrance speed at 6 mph, reduced speed of 3 mph, waterway width of 600 feet, and channel depth (assumed). The computed squat values are 0.7 foot for the 1,000-foot long vessel and 0.5 foot for the smaller class vessels.

(2) Vessel Roll. Vessel roll is rotation of a vessel around its longitudinal axis as a result of waves, wind, and turn angle. Roll is greatest when the vessel hull is parallel to the wave crests. According to vessel masters, an angle of roll of between 3 and 5 degrees can be expected on the Class 10 vessel and 1-1/2 times that amount (5 to 7 degrees) for smaller vessels. This analysis will use an angle of 4 degrees of roll for the Class 10 vessel and an angle of 6 degrees of roll for Class 5 through Class 8 vessels. The following formula is used to compute vessel roll:

$$Y = \frac{B}{2} \text{ sine } \theta$$

Where: Y = Depth requirement due to roll (ft)
B = Vessel beam
θ = Angle of roll in degrees

The computed roll values were 3.7 feet for the 1,000-foot long vessel and ranged from 3.6 feet to 3.9 feet for the smaller class vessels.

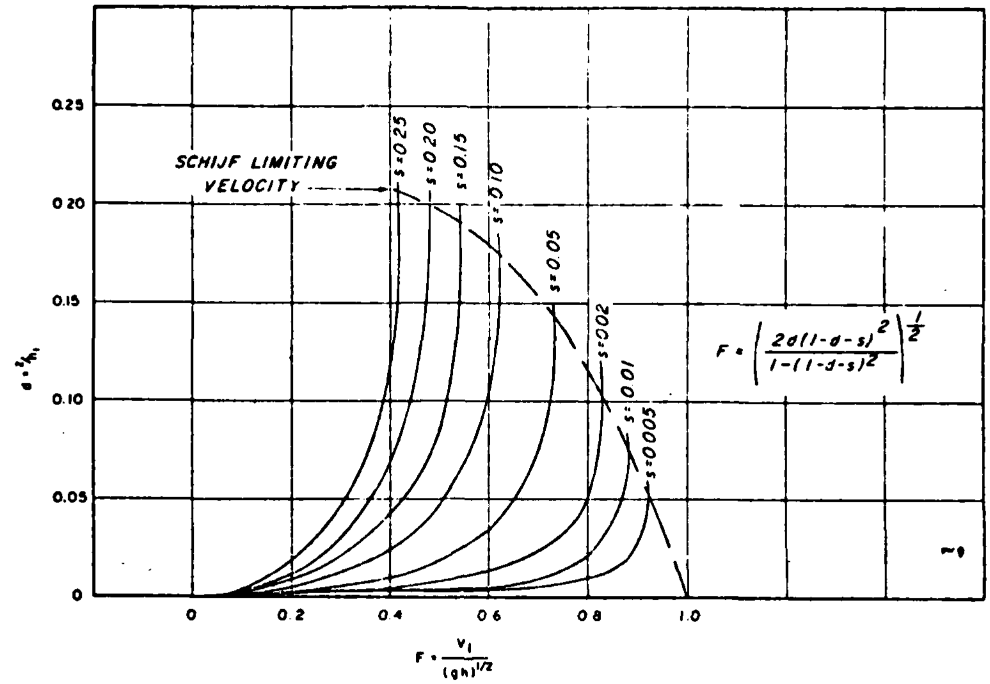

FIGURE C6- Dimensionless squat as a function of the Froude number

$S = \frac{A}{WH}$ where

S = ratio of ship cross section to channel cross section
A = vessel cross sectional area
W = channel width
H = channel water depth

$F = \frac{V}{\sqrt{gh}}$ where

F = the Froude Number
V = speed of the ship relative to the water
g = acceleration of gravity
h = depth of water in the channel

(3) Vessel Pitch and Heave. Vessel pitch is rotation of a vessel about its transverse axis and heave is the vertical body motion of a vessel. These motions are caused by waves and are greatest when a vessel hull is normal to wave crests. The equations presented in the "Study Report of Vessel Clearance Criteria for the Great Lakes Connecting Channels" prepared by Detroit District of the Corps of Engineers were used to compute the depth requirement due to pitch and heave. These equations are as follows:

$$\frac{\theta L}{2} = 0.1\ H$$

and

$$\frac{Heave}{H} = 0.1$$

Where:

$\frac{\theta L}{2}$ = Pitch amplitude in feet

H = Wave amplitude in feet

The pitch and heave value was determined to be 1.6 feet for each class vessel. However, the maximum values of roll, or pitch and heave are not additive since their occurrence is a function of hull and wave crest orientation (i.e., if the vessel hull is parallel to the wave crest, roll is maximum and pitch and heave approach zero). Therefore, the larger of the values of roll, or pitch and heave are used in determining the required channel depth. For the "all-weather" west entrance plan at Cleveland, the depth requirement for roll governs over the value of pitch and heave.

(4) Nominal Bottom Clearance. After all depth requirements are made for vessel squat, roll, and pitch and heave, it is desirable to design for additional bottom clearance for vessel safety and efficiency. The common allowances for bottom clearance are 2 feet in soft material and 3 feet in hard material. At Cleveland Harbor, all material is considered to be soft and therefore, a nominal bottom clearance value of 2 feet will be included in the channel depth requirement. This additional clearance will provide sufficient water under the vessel to reduce excessive ship vibrations caused by operation of the engines.

b. Channel Width. The width of the navigation channel is measured at the bottom of the channel that is required for safe navigation of the design vessel. The design vessel for determining the required width of the channels for Cleveland Harbor will be the Class 10 (950-1,000 feet X 105 feet) bulk cargo vessel. Some of the factors that will be given consideration in determining the proper width of the channel are: whether the design vessel must pass another vessel; the controllability of the vessel; the normal speeds of the vessel relative to the channel bottom; current velocities and directions; wave action or wind that will cause the vessel to yaw; the depth of water under the keel of the vessel; whether the channel occupies the entire waterway or is in a wide waterway; and the characteristics of the banks of the channel. The guidance presented in Chapter 10 of the draft Engineer Manual

(EM 1110-2-xxxx) entitled "Deep Draft Navigation Project Design" dated December 1979 was used in the channel width evaluation for Cleveland Harbor. Since the length of the entrance channel comprising the "all-weather" west entrance plan is only about 2,000 feet long, the channel will be designed to accommodate one-way traffic. The required channel width will be determined by computing the widths of a maneuvering lane, and bank clearance lanes for the design vessel.

(1) Maneuvering Lane. The maneuvering lane width is defined as that portion of the channel within which the ship may maneuver without encroaching on the channel banks or without approaching the entrance structures so closely that dangerous interference between the ship and entrance structures will occur. The recommended minimum maneuvering lane width is 160 percent of the design vessel beam (105 feet) for a vessel with no yawing forces and with very good controllability. In the case of Cleveland Harbor however, the 1,000-foot long design vessel will experience yawing forces due to the winds and waves under the design "all-weather" condition (i.e., 8.0-foot waves and 30-knot winds), which in turn will affect the movement and controllability of the ship. The maneuverability of the vessel will be further complicated by the fact that strong crosscurrents, as reported by vessel masters, exist in the vicinity of the main entrance to Cleveland Harbor. Therefore, a maneuvering lane width equivalent to 200 percent of the vessel beam, or about 210 feet, was selected as the minimum width for the maneuvering lane at Cleveland Harbor.

(2) Bank Clearance Lane. The bank clearance lane is the horizontal distance between the outer boundary of the maneuvering lane and the bottom of the channel sideslope. The recommended minimum width of the bank clearance lane is 60 percent of the design vessel beam for vessels with very good controllability in channels with no yawing forces. Since strong crosscurrents and yawing forces under the design "all-weather" conditions are expected to occur at the west entrance to Cleveland Harbor and due to the many obstacles at the west entrance (i.e., pierhead lights, breakwater arms, etc.), the minimum width of each bank clearance lane at Cleveland Harbor will be equal to 150 percent of the beam of the design vessel, or approximately 160 feet.

c. "All-Weather" West Entrance Channel Dimensions. The results from the evaluation of the channel depth requirements for the 1,000-foot long bulk cargo vessels, as well as for the smaller class vessels, as summarized in Table C7, indicate that the lake approach channel and entrance channel must be deepened to a depth of 32.0 feet below low water datum. The lake approach channel would be fan-shaped and extend lakeward to the 32-foot depth contour. A 2,000-foot long entrance channel connects the lake approach channel to the Lakefront Harbor. The outer portion of the entrance channel is 1,000 feet long and the width, as shown in Figure C7, is 600 feet (rounded up from the required minimum of 530 feet). The inner portion of the entrance channel is also about 1,000 feet long and the width widens from 600 feet where it connects the outer portion to 1,250 feet between the east and west breakwater spurs where it turns into the Lakefront Harbor. These channel depths and widths will allow all vessels presently operating on the Great Lakes to safely enter the improved west entrance under the "all-weather" condition.

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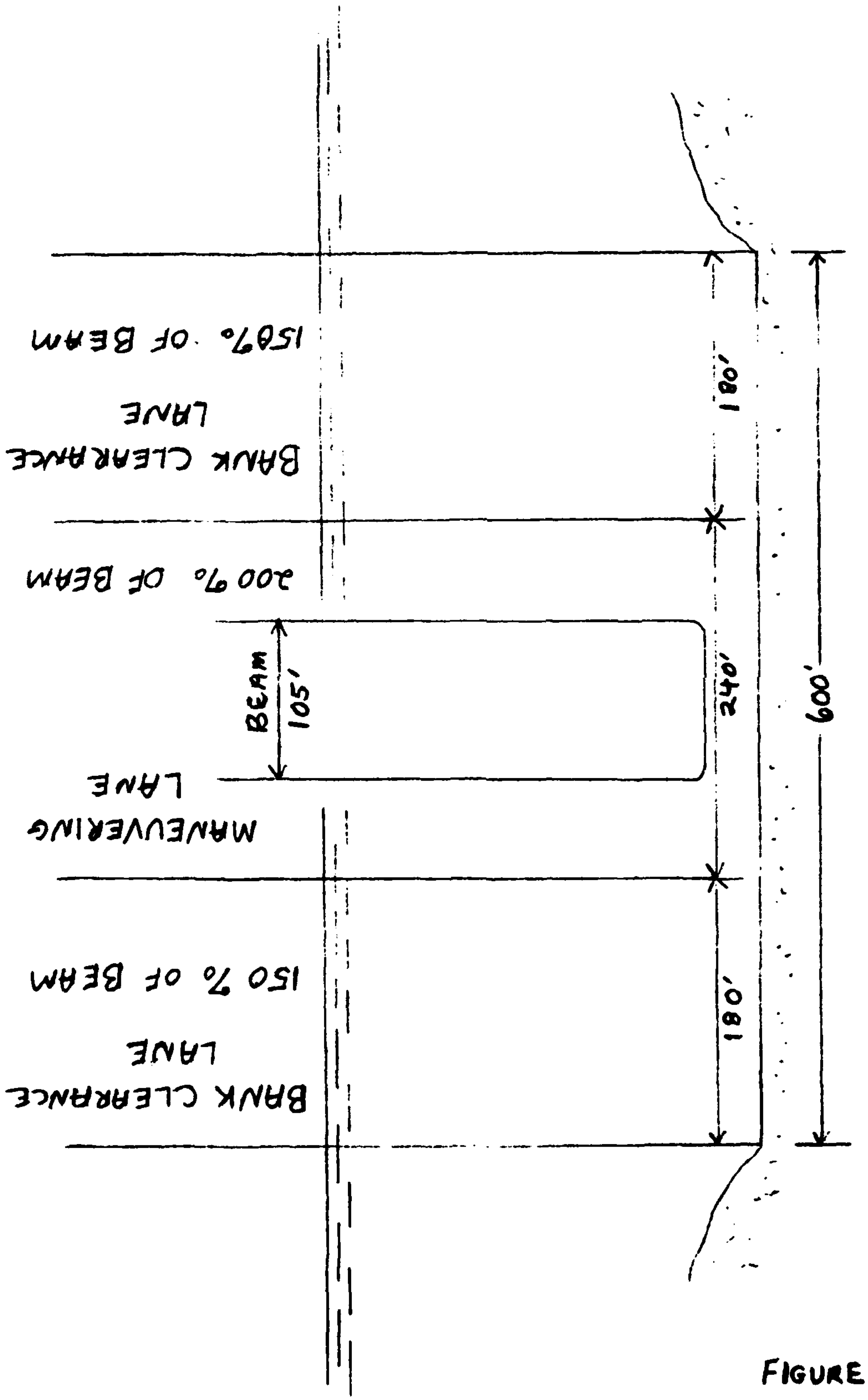

ELEMENTS OF ENTRANCE CHANNEL WIDTH FOR "ALL-WEATHER" WEST ENTRANCE PLAN

FIGURE C7

The proposed channel depths and widths for the "all-weather" west entrance are consistent with those which the vessel masters feel are required for a safe entrance into Cleveland Harbor.

DETAILED DESIGN - "ALL-WEATHER" EAST ENTRANCE PLAN

C22. GENERAL

The primary objective of an "all-weather" east entrance plan is to provide improvements required for a safe and efficient entrance into the Cleveland Lakefront Harbor through the existing east entrance and east basin by bulk cargo vessels up to 1,000 feet in length. An "all-weather" entrance is defined as an entrance that would allow 1,000-foot long vessels to enter the Lakefront Harbor under all weather conditions for which they would dock and unload their cargo. Based on discussions during the 8 April 1981 meeting with vessel masters in Cleveland, the "all-weather" condition was further defined as that when waves in the lake approach channel are a maximum of 8 feet in height and when winds are under 30 knots from the west through north to northeast. An "all-weather" east entrance primarily involves deepening and enlarging the existing east entrance channel and east basin channel. The vessel masters agreed that under design conditions (i.e., 8-foot waves and 30-knot winds), breakwater improvements at the east entrance are not required.

At the 8 April 1981 workshop, the vessel masters were unanimous in their preference for the east entrance for 1,000-foot long vessels and in their opinion, it is far superior to any west entrance plan. The vessel masters' main reason for their preference is the potential damage to the vessel that could be caused by striking the many obstacles at the west entrance (i.e., pierhead lights, breakwater arms, etc.), especially since the masters lose sight of an object when it is closer than 300 to 400 feet away. The master is then forced to rely on instruments and/or lookouts at the bow of the vessel. The problem is intensified at Cleveland due to strong crosscurrents at the existing arrowhead (west) entrance.

Table C7 - Summary of Channel Depths Required for the "All-Weather" West Entrance Plan (Lake Approach and Outer Entrance Channels)

Vessel Class	Static Draft (ft)	Squat Requirement (ft)	Roll Requirement (ft)	Pitch and Heave Requirement (ft)	Nominal Bottom Clearance (ft)	Required* Channel Depth (ft)
10	25.5	0.5	3.7	1.6	2.0	31.7
8	25.5	0.4	3.7	1.6	2.0	31.6
7	25.5	0.4	3.9	1.6	2.0	31.8
6	25.5	0.4	3.8	1.6	2.0	31.7
5	25.5	0.4	3.6	1.6	2.0	31.5

* Does not include the Pitch and Heave Requirement since the Roll Requirement is greater.

C23. CHANNEL DESIGN

Adequate channel depths and widths are required for safe and efficient navigation of ships. Therefore, at the 8 April 1981 workshop in Cleveland, vessel masters were requested to provide their professional and expert views on 1,000-foot long vessel operating characteristics that are required for the design of an "all-weather" east entrance at Cleveland Harbor. According to the vessel masters, when entering Cleveland Harbor under design "all-weather" conditions (i.e., 8-foot waves and 30-knot winds), a 1,000-foot long vessel would have to be traveling at a speed of approximately 6 miles per hour in order to maintain proper vessel control. Once in the protected east basin, the vessel would slow down to 2 to 3 miles per hour. When entering at a speed of 6 miles per hour under the design conditions, an angle of roll of 3 to 5 degrees can be expected on a 1,000-foot long vessel. The vessel masters also indicated that the angle of roll for smaller vessels would be about 1-1/2 times the angle of roll of a 1,000-foot long vessel, or between 5 to 7 degrees. The masters also agreed that their vessel would not experience roll in the protected east basin until it reached the existing arrowhead entrance where the 1,000-foot long vessel can be expected to roll up to 2 to 3 degrees as a result of waves entering between the existing arrowhead breakwaters.

a. Channel Depth. The channel depths for the lake approach channel, outer entrance channel, and the east basin channel were selected to safely and efficiently accommodate the passage of the Great Lakes vessels which are expected to use the channels during the life of the project. Channel depth requirements were evaluated for the Class 5 vessel (600-649 feet X 68 feet), the Class 6 vessel (650-699 feet X 72 feet), the Class 7 vessel (700-730 feet X 75 feet), the Class 8 vessel (731-849 feet X 70 feet), and the Class 10 vessel (950 - 1,000 feet X 105 feet). Numerical calculations for the depth requirements for the channels for the "all-weather" east entrance were computed to determine vessel squat, vessel roll, the effect of pitch and heave, and nominal bottom clearance (see paragraphs C21.a(1) through C21.a(4) for a discussion of these depth requirements). The calculations for the depth requirements are attached to the end of this appendix and are based on a 25.5-foot design system draft. The results of the channel depth evaluation are summarized in Table C8. The depth requirements include the greater of the values for either vessel roll or the combination of pitch and heave. The features of the "all-weather" east entrance plan are shown on Plate C8.

The results from the evaluation of the channel depth requirements for the 1,000-foot long bulk cargo vessels, as well as for the smaller class vessels, indicated that the lake approach channel and entrance channel must be deepened to a depth of 32.0 feet below low water datum. The lake approach channel would be fan-shaped and extend lakeward to the 32-foot depth contour. A 2,900-foot long entrance channel connects the lake approach channel to the east basin channel. Once into the protected area of the entrance channel, the vessel will begin to slow down as it enters into the 14,600-foot long east basin channel. The required channel depth for the east basin channel which connects the entrance channel to the Lakefront Harbor is 28.0 feet. This 28.0-foot depth will extend for 3,800 feet through the eastern portion of the Lakefront Harbor, to the area at the existing main entrance, where the harbor will be deepened to 30.0 feet to account for increased wave activity

Table C8 - Summary of Channel Depths Required for the "All-Weather" East Entrance Plan

Vessel Class	Static Draft (ft)	Squat Requirement (ft)	Roll Requirement (ft)	Pitch and Heave Requirement (ft)	Nominal Bottom Clearance (ft)	Required Channel Depth (ft)
	LAKE APPROACH AND OUTER ENTRANCE CHANNELS					
10	25.5	0.3	3.7	1.6	2.0	31.5
8	25.5	0.3	3.7	1.6	2.0	31.5
7	25.5	0.3	3.9	1.6	2.0	31.7
6	25.5	0.3	3.8	1.6	2.0	31.6
5	25.5	0.3	3.6	1.6	2.0	31.4
	INNER (EAST BASIN) ENTRANCE CHANNEL					
10	25.5	0.1	0.0	0.0	2.0	27.6
	EAST BASIN CHANNEL AT EXISTING ARROWHEAD					
10	25.5	0.1	1.8	0.0	2.0	29.4

entering the harbor through the existing west entrance which will affect vessel operating characteristics.

b. Channel Width. The width of the navigation channel is measured at the bottom of the channel that is required for safe navigation of the design vessel. The design vessel for determining the required width of the channels for Cleveland Harbor will be the Class 10 (950-1,000 feet X 105 feet) bulk cargo vessel. Some of the factors that will be given consideration in determining the proper width of the channel are: whether the design vessel must pass another vessel; the controllability of the vessel; the normal speeds of the vessel relative to the channel bottom; current velocities and directions; wave action or wind that will cause the vessel to yaw; the depth of water under the keel of the vessel; whether the channel occupies the entire waterway or is in a wide waterway; and the characteristics of the banks of the channel. The guidance presented in Chapter 10 of the draft Engineer Manual (EM 1110-2-xxxx) entitled "Deep Draft Navigation Project Design" dated December 1979 was used in the channel width evaluation for Cleveland Harbor. Since the length of channel comprising the "all-weather" east entrance plan is over 4 miles long, the channels will be designed to accommodate passing vessels. The required widths for the entrance channel and east basin channel will be determined by computing the widths of maneuvering lanes, a ship clearance lane, and bank clearance lanes for the design vessel.

(1) Maneuvering Lane. The maneuvering lane width is defined as that portion of the channel within which the ship may maneuver without encroaching on the channel bank or without approaching another ship so closely that dangerous interference between ships will occur. The recommended minimum maneuvering lane width is 160 percent of the design vessel beam (105 feet) for a vessel with no yawing forces and with good controllability. In the case of Cleveland Harbor, under the design "all-weather" condition (i.e., 8.0-foot waves and 30-knot winds), the 1,000-foot long design vessel will experience yawing forces due to the winds and waves which in turn will affect the movement and controllability of the ship. Therefore, a maneuvering lane equivalent to 200 percent of the vessel beam, or about 210 feet, was selected as the minimum width for the maneuvering lanes in the entrance channel. Once in the protected area behind the east breakwater, the controllability of the vessel will be improved. The yawing forces will be reduced with only the winds acting on the side of the vessel, therefore, a maneuvering lane equivalent to 180 percent of the beam, or about 190 feet, was selected as the minimum width for the maneuvering lanes in the east basin channel.

(2) Ship Clearance Lane. Since the channel width of the "all-weather" east entrance is being designed to accommodate two-way traffic, a ship clearance lane must be provided between the inner boundaries of the two maneuvering lanes. The recommended minimum width of the ship clearance lane is set at 80 percent of the beam of the design vessel assuming no yawing forces. The east entrance into Cleveland Harbor will be subjected to strong yawing forces under the design "all-weather" condition. Therefore, a ship clearance lane equal to 100 percent of the beam of the design vessel, or 105 feet, will be used as the minimum width for this lane in the entrance

channel. Once in the protected area behind the east breakwater, the yawing forces will be reduced and therefore, a ship clearance lane equal to 90 percent of the beam of the design vessel, or 95 feet, will be used as the minimum width for this lane in the east basin channel.

(3) Bank Clearance Lane. The bank clearance lane is the horizonal distance between the outer boundary of the maneuvering lane and the bottom of the channel sideslope. The recommended minimum width of the bank clearance lane is 60 percent of the design vessel beam for vessels with very good controllability in channels with no yawing forces. Since strong yawing forces are expected under the design "all-weather" condition at the east entrance to Cleveland Harbor, the minimum width of each bank clearance lane in the entrance channel will be equal to 150 percent of the beam of the design vessel, or approximately 160 feet. Once in the protected area behind the east breakwater, the vessel will be traveling at a slow speed where the vessel's side thrusters will be effective in improving controllability of the vessel. Also, the waterway is much wider than will be needed in the east basin and the adjacent material is a soft silty material. Therefore, a minimum bank clearance lane equal to 60 percent of the beam of the design vessel, or 65 feet, will be used for each bank clearance lane through the east basin channel.

According to the guidance presented in Chapter 10 of the draft Engineer Manual (EM 1110-2-xxxx) entitled "Deep Draft Navigation Project Design," the channel width required for the east basin channel is approximately 600 feet (see Figure C9). However, at the 8 April 1981 workshop, the vessel masters stated that only a 500-foot wide east basin channel is needed. Therefore, based on experience of the vessel masters, a 500-foot wide east basin channel was incorporated into the "all-weather" east entrance plan.

c. "All-Weather" East Entrance Channel Dimensions. The plan for an "all-weather" entrance is shown on Plate C8 and includes the following improvements:

(1) Deepening to the 32-foot depth contour, a fan-shaped lake approach channel and a 900-foot wide (rounded up from the required minimum 845 feet) entrance channel (see Figure C8) extending 2,900 feet into the east basin;

(2) Deepening of the existing 14,600-foot long, 500-foot wide east basin channel to 28.0 feet in depth;

(3) Deepening of a 500-foot wide channel to a depth of 28.0 feet through the 3,800-foot long east basin in the Lakefront Harbor area to 28.0 feet in depth;

(4) Deepening to 30.0 feet, a 500-foot wide channel through the Lakefront Harbor area bounded by a line drawn perpendicular to the existing east breakwater where the east arrowhead breakwater joins and a line drawn perpendicular to the existing west breakwater where the west arrowhead breakwater joins.

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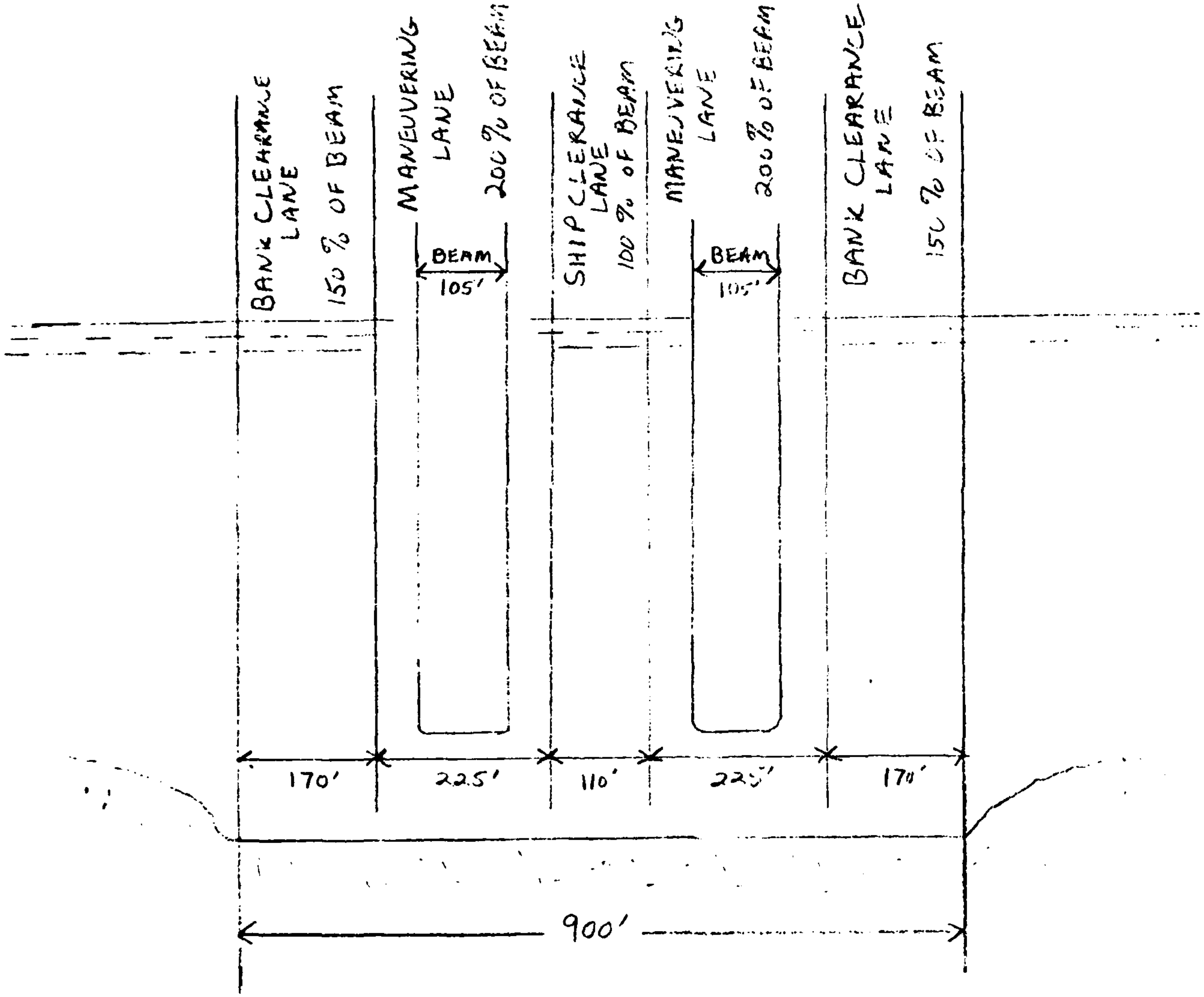
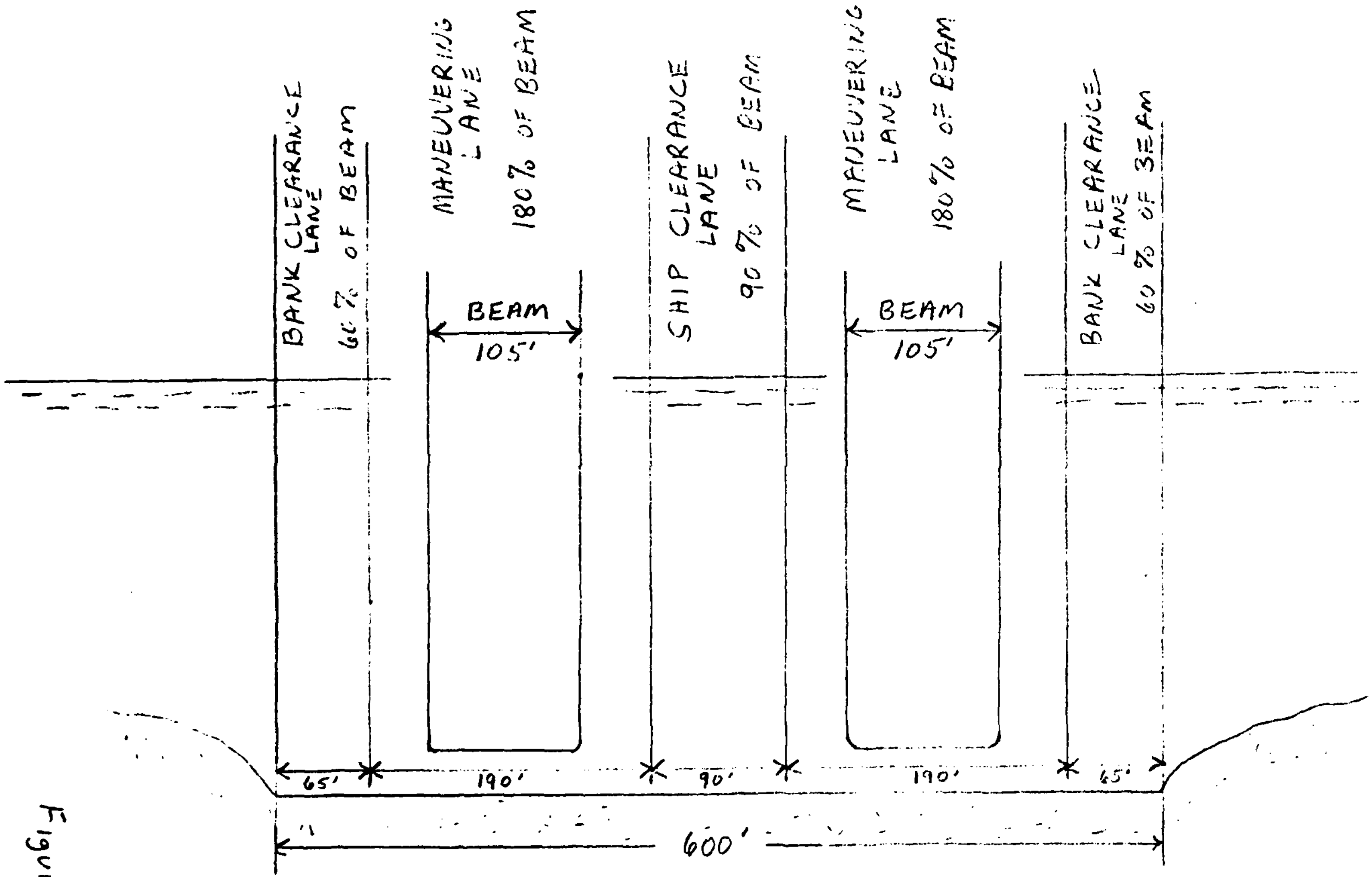


ELEMENTS OF ENTRANCE CHANNEL WIDTH FOR "ALL-WEATHER" EAST ENTRANCE. PLAN

FIGURE C6



ELEMENTS OF EAST BASIN CHANNEL WIDTH FOR "ALL-WEATHER" EAST ENTRANCE PLAN

Note: The 600-foot wide channel is based on design guidance per engineer manuals, however, the actual channel width will be 500 feet per vessel masters stated need based on experience

Figure C9

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DETAILED DESIGN - "FAIR-WEATHER" WEST ENTRANCE PLAN

C24. GENERAL

A "fair-weather" west entrance plan would provide improvements required for a safe entrance, except during storm conditions, into the Cleveland Lakefront Harbor through the existing main entrance by bulk cargo vessels up to 1,000 feet in length. Based on discussions during the 8 April 1981 meeting with the vessel masters in Cleveland, the "fair-weather" condition was defined as that when waves in the lake approach channel are a maximum of 4 feet in height and when winds are under 20-knots from the west through north to northeast. A "fair-weather" west entrance involves minor structural changes to the west entrance with the realization that vessels would not be able to enter the Lakefront Harbor under storm conditions. The "fair-weather" west entrance plan was developed in a hydraulic model study of Cleveland Harbor at the Corps of Engineers Waterways Experiment Station in Vicksburg, Mississippi using a scale model of a 1,000-foot vessel operated by an experienced vessel master.

C25. HYDRAULIC MODEL INVESTIGATIONS

The "fair-weather" entrance plan was developed through navigation tests using the scale model of the 1,000-foot vessel operated by a master that had experience operating 1,000-foot long vessels on the Great Lakes. The navigation tests were conducted in the hydraulic model of the Cleveland Lakefront Harbor for test waves from the north-northeast, northwest, north-northwest and west with 20-knot winds superimposed by a series of calibrated fans for some of the tests for existing conditions and during the incremental removal of the east and west breakwater spurs. It was determined from the navigation tests that, for safe and efficient use of the main entrance, the east and west breakwater spurs should be reduced in length by 200 feet and 300 feet, respectively. By removing the 200-foot and 300-foot lengths from the east and west breakwater spurs, as required from the navigation tests, wave heights, particularly at the Port Authority docks in the Lakefront Harbor, increased over those for existing conditions for nearly all test wave conditions, with the maximum increase being 2.6 feet for 9-second, 8.6-foot waves from the west (increased from 2.5 feet to 5.1 feet). To alleviate undesirable wave conditions in the Lakefront Harbor resulting from shortening of the breakwater spurs, several modifications were made to the main entrance and tested. These modifications included: (1) Raising and sealing the east and west arrowhead breakwaters to prevent wave overtopping and/or transmission through these structures; (2) Incremental extensions of the lakeward end of the west arrowhead breakwater; (3) A 400-foot lakeward extension of the west arrowhead breakwater with combinations of the extension with or without the west arrowhead breakwater sealed and raised; (4) A 300-foot extension of the lakeward end of the east arrowhead breakwater parallel to the new west extension; and (5) Raising and sealing the east arrowhead breakwater with 300-foot long parallel extensions on the arrowhead breakwaters. The optimum plan tested consisted of a 300-foot long lakeward extension of the west arrowhead breakwater with the west arrowhead breakwater raised and sealed to prevent wave overtopping and wave transmission through the structure and a 300-foot long lakeward extension to the east arrowhead breakwater, parallel to the west extension. Results from wave tests indicated that a sealed west arrowhead breakwater with a crest elevation at 10.0 feet above low water datum or an unsealed west arrowhead breakwater with a crest elevation at 14.0 feet above low water datum yield comparable wave conditions in the Lakefront Harbor. The +14.0 LWD crest elevation on the existing west arrowhead breakwater was incorporated in this analysis. Therefore, in summary, the "fair-weather" entrance plan into the Cleveland Lakefront Harbor consists of the following:

a. Removal of 200 feet from the east breakwater spur and 300 feet from the west breakwater spur for safe and efficient use of the main entrance by 1,000-foot long vessels; and,

b. A 300-foot long lakeward extension of the west arrowhead breakwater, a 300-foot long lakeward extension of the east arrowhead breakwater parallel to the west extension, and raising the crest elevation of the 1,250-foot long west arrowhead breakwater from +8.0 LWD to +14.0 LWD to compensate for increased wave activity in the Lakefront Harbor as a result of removing the breakwater spurs.

The plan of improvement developed for a "fair-weather" west entrance is shown on Plate C9.

C26. DESIGN STRUCTURE DEPTH (d_s)

The design structure depth (d_s) of the structure toe for the east and west arrowhead breakwater extensions and existing west arrowhead was determined from soundings obtained from NOAA's Nautical Chart for Cleveland Harbor (chart number 14839). The design structure toe depth for the breakwater extensions and arrowhead breakwater was determined at the depth contour at which the breakwaters would be positioned. Based on the layout of the "fair-weather" west entrance plan shown on Plate C9, the breakwater extensions are positioned at about the 30-foot depth contour and the existing west arrowhead is located at about the 25-foot depth contour. The depth contour at the structure toe plus the design maximum water level (DWL) minus the low water datum (LWD) elevation equals the design depth of water at the structure toe (d_s). The design structure depth values were determined as follows:

d_s = Depth contour + DWL - LWD
where LWD = 568.6
d_s = 30.0 + 573.6 - 568.6 = 35.0 feet for breakwater extensions
d_s = 25.0 + 573.6 - 568.6 = 30.0 feet for west arrowhead breakwater

C27. STONE DESIGN

a. General. The design incident wave for the 300-foot east and west arrowhead breakwater extensions is approximately a 12.6-foot nonbreaking wave which is the same as that computed for analyzing the "all-weather" west entrance structures (see paragraph C15) due to the parameters used in irregular wave prediction techniques developed by Goda. Therefore, the breakwater geometry and armor untis, underlayer stone, and core stone designed for the

the "all-weather" west entrance structures (see paragraphs C16, C16a, C16b, and C16c) are assumed to be applicable to the breakwater extensions and will be used in determining the economic efficiency of navigation improvements for the "fair-weather" plan. A typical crosssection of the east and west arrowhead breakwater extensions is shown on Plate C10.

In addition to the arrowhead breakwater extensions, the crest elevation of the existing west arrowhead breakwater (see existing typical breakwater section shown on Plate C11) would be raised from +8 LWD to +14 LWD. The design incident wave for the existing west arrowhead breakwater is approximately a 12.6-foot nonbreaking wave which is about the same as that computed for analyzing the "all-weather" west entrance structures (see paragraph C15) due to the range of the input parameters used in irregular wave prediction techniques developed by Goda. Therefore, the armor units, underlayer stone, and bedding stone designed for the "all-weather" west entrance structures (see paragraphs C16, C16a, C16b, and C16c) was used in developing a typical crosssection to raise the crest elevation of the existing west arrowhead breakwater. A berm, 25 feet wide, was incorporated below -18.0 feet LWD in order to provide adequate slope stability (see Appendix A for discussion on the need for the berm). A typical section of the west arrowhead breakwater improvement is shown on Plate C12.

C28. MODIFICATIONS TO EXISTING STRUCTURES

In addition to the 300-foot long parallel extensions on the east and west arrowhead breakwaters and the raising the crest elevation of the existing west arrowhead breakwater, other modifications to existing entrance structures are required to provide a safe "fair-weather" west entrance into the Port of Cleveland. These modifications to existing structures are as follows:

a. Remove 300 feet of structure from the east end of the existing west breakwater spur; and

b. Remove 200 feet of structure from the west end of the existing east breakwater spur.

These structural modifications are required to provide an entrance channel of sufficient width to facilitate the maneuverability of 1,000-foot long vessels as they make the turn into the east and west basins of the Port of Cleveland.

C29. CHANNEL DESIGN

Adequate channel depths and widths are required for safe and efficient navigation of ships. Therefore, at the 8 April 1981 workshop in Cleveland, vessel masters were requested to provide their views on 1,000-foot long vessel operating characteristics that are required for the design of a "fair-weather" west entrance at Cleveland Harbor. According to the vessel masters, when entering Cleveland Harbor under design "fair-weather" conditions (i.e., a maximum 4-foot wave and 20-knot winds), a 1,000-foot long vessel would be traveling at a speed of approximately 2 to 3 miles per hour as it enters the lake approach channel and would not experience any vessel roll.

a. Channel Depths. Because there would be no vessel roll under the "fair-weather" design condition, the vessel masters stated that the existing 29-foot depth in the lake approach channel and entrance channel and 28-foot depth in the west basin channel are adequate. Numerical calculations for the depth requirements for the channels for the "fair-weather" west entrance were computed to determine the effects of vessel squat, nominal bottom clearance, and pitch and heave (see paragraphs C21.a(1) through C21.a(4) for a discussion of these depth requirements). The calculations for the depth requirements are attached to the end of this appendix and are based on a 25.5-foot design system draft. Evaluation of the channel depth requirement indicates that because there would be no vessel roll under the "fair-weather" design condition, the existing depths in the lake approach channel, entrance channel, and interior harbor channel would be adequate.

b. Channel Width. The width of the navigation channel is measured at the bottom of the channel that is required for safe navigation of the design vessel. The design vessel for determining the required width of the channels for Cleveland Harbor will be the Class 10 (950-1,000 feet X 105 feet) bulk cargo vessel. The guidance presented in Chapter 10 of the draft Engineer Manual (EM 1110-2-xxxx) entitled "Deep Draft Navigation Project Design" dated December 1979 was used in the channel width evaluation for Cleveland Harbor. Since the length of channel comprising the "fair-weather" west entrance plan is only about 1,400 feet long, the channels will be designed to accommodate one-way traffic. The required width for the entrance channel will be determined by computing the widths of a maneuvering lane and bank clearance lanes for the design vessel.

(1) Maneuvering Lane. The maneuvering lane width is defined as that portion of the channel within which the ship may maneuver without encroaching on the channel banks so closely that dangerous interference between the ship and entrance structures will occur. The recommended minimum maneuvering lane width is 160 percent of the design vessel beam (105 feet) for a vessel with no yawing forces and with very good controllability. In the case of Cleveland Harbor, where under the design "fair-weather" condition (i.e., maximum 4-foot waves and 20-knot winds), the 1,000-foot long design vessel will experience yawing forces due to the winds and waves which in turn will affect the movement and controllability of the vessel. The maneuverability of the vessel will be further complicated by the fact that strong crosscurrents, as reported by the vessel masters, exist in the vicinity of the main entrance to Cleveland Harbor. Therefore, a maneuvering lane equivalent to 200 percent of the vessel beam, or about 210 feet, was selected as the minimum width for the maneuvering lane at Cleveland Harbor.

(2) Bank Clearance Lane. The bank clearance lane is the horizontal distance between the outer boundary of the maneuvering lane and the bottom of the channel sideslope. The recommended minimum width of the bank clearance lane is 60 percent of the design vessel beam for vessels with very good controllability in channels with no yawing forces. Since crosscurrents and yawing forces under the design "fair-weather" condition are expected to occur at the west entrance to Cleveland Harbor and due to the many obstacles at the west entrance (i.e., pierhead lights, breakwater arms, etc.), the minimum width of each bank clearance lane at Cleveland Harbor will be equal to 150 percent of the beam of the design vessel, or approximately 160 feet.

c. "Fair-Weather" West Entrance Channel Dimensions. The results from the evaluation of the channel depth requirements for the 1,000-foot long bulk cargo vessels indicate that the existing project depth of 29 feet below low water datum in the lake approach channel and entrance channel are adequate. The 29-foot depth will be adequate for the smaller class vessels as well. The lake approach channel would be fanshaped and extend lakeward to the 29-foot depth contour. A 1,400-foot long entrance channel connects the lake approach channel to the east basin and west basin channels. The outer portion of the entrance channel is 300 feet long and located between the parallel extensions of the east and west arrowhead breakwaters. The required minimum width of the entrance channel is 530 feet, however, the existing 600-foot width (see Figure C10) between the outer ends of the arrowhead breakwaters will be maintained and extended through the outer portion of the entrance channel. The inner portion of the entrance channel is 1,100 feet long and the width widens from 600 feet at the outer ends of the arrowhead breakwaters to 1,250 feet between the east and west breakwater spurs where it turns into the Lakefront Harbor. These channel depths and widths will allow all vessels presently operating on the Great Lakes to safely enter the improved west entrance under the "fair-weather" condition.

CUYAHOGA RIVER CONGESTION

C30. GENERAL

The harbor area of the Port of Cleveland includes the lower 5.8 miles of the Cuyahoga River (see Plate C13). Vessels up to 630 feet in length and with a beam of 68 feet navigate the river destined for upriver docks. The Cuyahoga River channel is a winding narrow channel and the numerous bridge crossings and bends impede vessel movement and prohibit passage of larger vessels. The sharp bends and narrow channels also impose slow speeds of about 2 miles per hour on vessels and make navigation hazardous. Shipping companies have reported that vessels frequently run into the banks and bulkheads, come in contact with bridge piers, and have had mishaps with small boats moored along the banks. This secion will address congestion along the Cuyahoga River, which the shipping companies identified as restrictions to navigation and present the assumptions and criteria used to develop alternatives to alleviate the restrictions and facilitate passage of vessels.

The shipping companies identified seven congestion areas, which are listed below, as the primary restrictions to navigation. The congestion areas are listed in the order in which a vessel would encounter the restriction as it travels from the Cleveland Lakefront Harbor to its destination upriver. The congestion areas are located on Plate C13.

(1) Conrail Bridge No. 1.

(2) Dock at Cerial Foods Processors, Inc.

(3) Channel bend at Union Terminal Railroad Bridge and Columbus Road Bridge.

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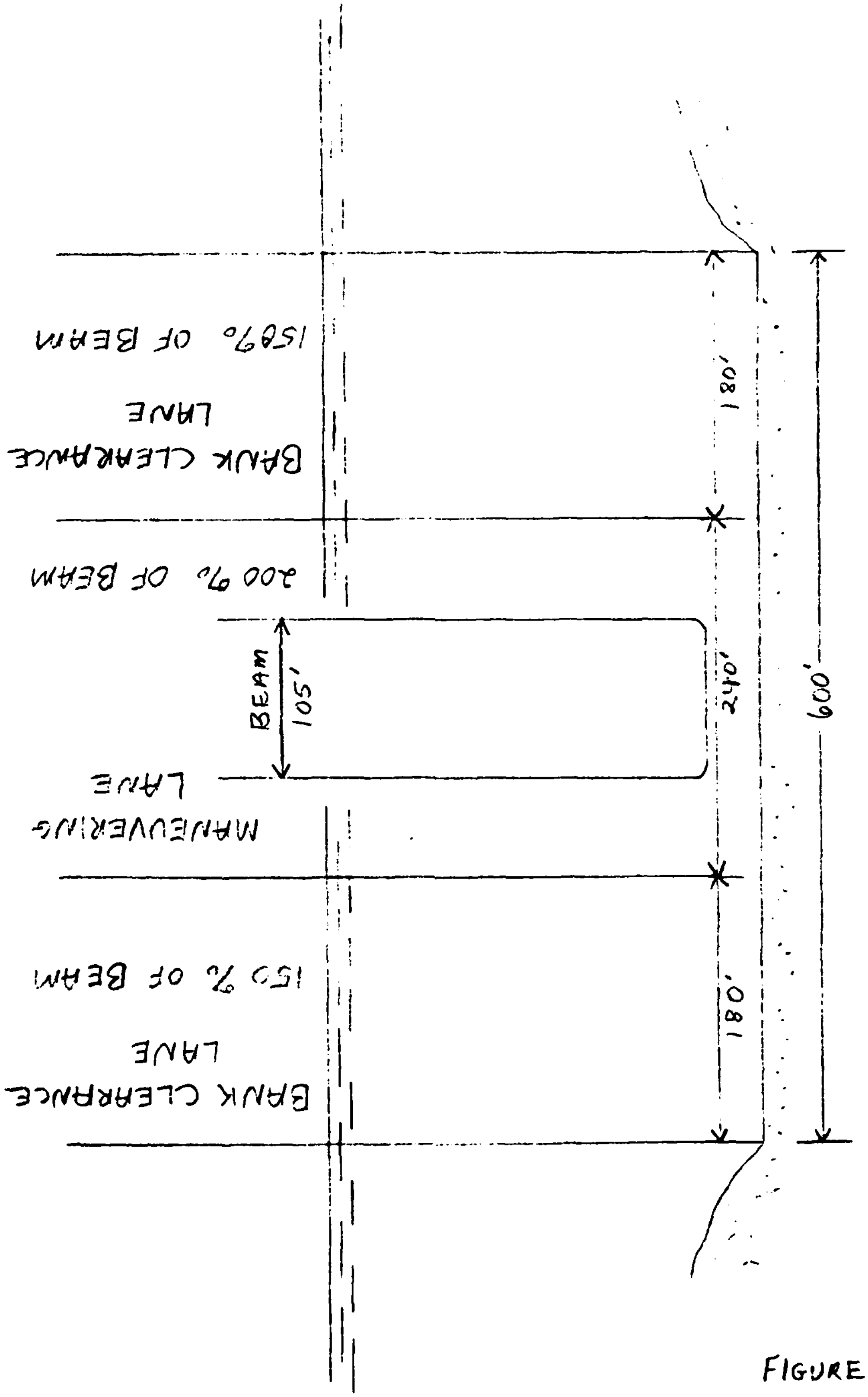

ELEMENTS OF ENTRANCE CHANNEL WIDTH FOR "FAIR-WEATHER" WEST ENTRANCE PLAN

FIGURE C10

(4) Channel bend at Norfolk & Western Railroad Bridge and Inner Belt Freeway Bridge.

(5) Channel bend upstream of West 3rd Street Bridge.

(6) Bridge Abutments at Existing Conrail Bridge No. 14.

(7) Jefferson Avenue Bridge Abutments.

The congestion areas are described and discussed in detail in the following paragraphs.

C31. CONGESTION AREA NO. 1

The first congestion area is the Conrail Bridge located approximately 1,600 feet upriver from the outer ends of the river entrance piers. The bridge is a vertical lift bridge operated by Conrail and provides access to the railroad yards located on Whiskey Island, and facilitates east-west passage of through freight trains. Vessels operating on the Cuyahoga River often encounter delays when moving upriver and downriver while waiting for the bridge to open. Elimination of this congestion area would require a high-level bridge. Due to the costs that would be associated with providing a high-level railroad bridge and necessary approach tracks, it was determined that alleviation of this restriction would be economically unfeasible and therefore, it was eliminated from further consideration during the initial phase of Stage 2 study.

C32. CONGESTION AREA NO. 2

The second area of congestion on the Cuyahoga River is at Cerial Food Processors, Inc. which is located approximately one mile upriver. The dock on the east bank juts out into the river and restricts the navigation channel. In addition, because of bulkhead instability, the navigation channel cannot be dredged closer than 30 feet from the face of the dock. These two factors reduce the width of the navigation channel to about 100 feet. The restriction causes vessels to reduce their speed while moving past the dock and also causes delays to vessels moving upriver and downriver when a vessel is unloading at the dock. To reduce the delay time at this congestion area and facilitate navigation past the dock, it would be necessary to replace existing bulkheads and widen the navigation channel. Such improvements are the remaining portion of Cut No. 4, a bank cut originally authorized by the River and Harbor Act of 1937 and reauthorized by the River and Harobr Act of 1946, which requiires widening the river to 200 feet. Cut No. 4 would entail relocation of the mill owned by Cerial Food Processors, Inc. and because of problems related to real estate acquisition required for the bank cut, has been classified inactive and has not been completed. To avoid relocation of the mill owned by Cerial Food Procesors, Inc., a new channel limit was established during this Stage 2 Study by connecting the existing channel point located under the Center Street Bridge directly to the existing channel point immediately upstream of the mill. This new channel limit will increase the width of the navigation channel to about 150 feet and requires replacement of the existing bulkhead and the

Cerial Food Processors, Inc. ship unloading building. This increased channel limit, although not a complete solution to the congestion problem, will facilitate navigation through the existing restriction. It will not, however, facilitate vessel passage when a ship is unloading at the dock since this would require relocation of the mill and/or relocation of the unloading dock, both of which the mill owner opposes. The details of the restriction and proposed widening are whown on Plate C14.

C33. CONGESTION AREA NO. 3

The third congestion area on the Cuyahoga River is the bend in the vicinity of the Cleveland Union Terminal Railroad Bridge and Columbus Road Bridge. The bend is horseshoe shaped and starts about 1.2 miles upriver from the outer ends of the entrance piers and extends upriver for approximately 2,200 feet. The present width of the navigation channel at some places in the bend is about 190 feet. To navigate the channel in this bend vessels must move at reduced speeds. This restriction also causes delays when vessels moving in opposite directions encounter the bend at the same time. To reduce vessel delay time and facilitate navigation throughout the bend, it is necessary to replace bulkheads and widen the bend; unfortunately there is not much guidance available to determine the amount of widening that is desirable in bends. The Apex or Cutoff Method described in Chapter 10 of Report No. 3 entitled "Evaluation of Present State of Knowledge of Factors Affecting Tidal Hydraulics and Related Phenomena" dated May 1965 was utilized to approximate the required widening in the bend. A scale two-dimensional model of a 630-foot vessel was then used to optimize the required bank cut as the vessel navigates the bend. In order to minimize the amount of new bulkheads that would be required, the widening would be accomplished with a bank cut on the inside (north) bank only. It was determined that the navigation channel could be widened to about 310 feet and would avoid any major building relocations. Widening this bend to provide a 310-foot wide navigation channel will facilitate one way navigation through the restriction but will require replacement of existing bulkheads on the north river bank and replacement of the two bridges. The details of the restriction and proposed widening are shown on Plate C15. A proposed plan to facilitate two-way navigation at the bend was not formulated during Stage 2 since the 200 to 300 feet of additional widening required for two-way traffic would obviously be economically unfeasible.

C34. CONGESTION AREA NO. 4

The fourth area of congestion on the Cuyahoga River is the bend in the vicinity of the Norfolk & Western Railroad Bridge and Inner Belt Freeway Bridge. The bend starts about 2.8 miles upriver from the outer ends of the entrance piers and extends upriver for approximately 2,100 feet. The width of the navigation channel at some places in the bend is about 200 feet. To navigate the channel in this bend, vessels must move at reduced speeds. Delays also result when vessels moving in opposite directions encounter the bend at the same time. To reduce vessel delay time and facilitate one-way navigation through the bend it is necessary to replace bulkheads and widen the bend. The Apex or Cutoff Method was utilized to approximate the required widening in the bend and the scale two-dimensional model of a 630-foot vessel was used to optimize the required bank cuts as the vessel navigates through the bend. In order to avoid replacement of the Inner Belt Freeway Bridge while providing a navigation channel of sufficient width in the bend, it was necessary to establish a bank cut on both the inner (north) and outer (south) river banks. The bank cut on the inside bank is the major cut with the outer bank cut being required under the freeway bridge to provide increased width in the navigation channel. The navigation channel in this bend would be widened to about 350 feet without replacing the Inner Belt Freeway Bridge, however, replacement of the Norfolk & Western Railroad Bridge, replacement of bulkheads and relocation of 850 feet of existing railroad tracks would be required. The details of the restriction and proposed widening are shown on Plate C16. Again, a plan was not formulated to facilitate two-way navigation due to its obvious lack of economic feasibility.

C35. CONGESTION AREA NO. 5

The fifth congestion area on the Cuyahoga River that was identified by the shipping interests is the bend immediately upstream of the West 3rd Street vertical lift bridge at the Shell Oil Company and Texaco Inc. oil storage tank area. The bend starts about 3.2 miles upriver from he outer ends of the entrance piers and extends upriver for approximately 2,000 feet. The width of the navigation channel going into the bend and coming out of the bend is about 170 feet and 160 feet, respectively. As with the other bends, vessels must travel at reduced speeds to navigate the channel in the bend. Delays also occur when vessels traveling in opposite directions encounter each other at the bend. In order to reduce vessel delay time and facilitate navigation through the bend, it is necessary to replace bulkheads and widen the bend. The Apex or Cutoff Method was used to approximate the required widening in the bend and the scale two-dimensional model of a 630-foot vessel was used to optimize the bank cut. To minimize the amount of new bulkheads that would be required, the widening would be accomplished with a bank cut on the inside (south) bank only. The width of the navigation channel in this bend would be increased by about 120 to 140 feet. Widening this bend to increase the width of the navigation channel will facilitate one-way navigation through the restriction but will require replacement of existing bulkheads on the south river bank and relocation of an office building. The details of the restriction and proposed widening are shown on Plate C17. Again, a plan was not formulated to facilitate two-way traffic due to its obvious lack of economic feasibility.

C36. CONGESTION AREA NO. 6

The sixth area of congestion on the Cuyahoga River is at the existing former Erie-Lackawanna Railroad Bridge which is now owned by Conrail. The bridge is a bascule bridge located approximately 4.0 miles upriver. The bridge is on a slight bend in the river and the center pier restricts the navigation channel to a width of about 115 feet. This restriction is a hazard to navigation and causes vessels to reduce their speed while moving past the center pier. This congestion area is the location of improvements authorized by the 1958 River and Harbor Act. The authorized improvements require replacement of the railroad bridge, a river bank cut (Cut No. 11) on the west bank, and dredging along the east bank of the river to widen the navigation channel to about 210 feet. The greater portion of Cut No. 11 would be made in the Gulf Refining Co. property. The maximum width of cut would be about 45 feet and would be protected by a bulkhead and, in addition, a retaining wall for protection of the petroleum company's storage tanks would have to be rebuilt. Plans and specifications for the bridge replacement have been completed however, construction has been delayed indefinitely pending resolution of related real estate problems. Cut No. 11 and the dredging along the bank on the east side of the river, which would widen the navigation channel, would follow completion of the bridge replacement.

Conrail is presently in the process of abandoning the rail line that crosses the bridge at this location, thereby eliminating the need for replacement of the bridge. Therefore, during this Stage 2 study, a new channel limit was established. By abandoning the existing railroad bridge, the navigation hazard and restriction can be alleviated by removing the abandoned railroad bridge and the center pier of the bascule bridge (which is assumed will be accomplished by Conrail when they abandon the bridge) and widening the navigation channel. The navigation channel can be widened to 190 feet, which is the present width of the navigation channel immediately upstream and downstream of the existing restriction, without completing Cut No. 11 nor structural relocations. The bulkhead along the east bank would need to be replaced when the navigation channel is widened and deepened. The details of the restriction and proposed widening are shown on Plate C18.

C37. CONGESTION AREA NO. 7

The seventh congestion area on the Cuyahoga River is at the bridge abutments of the former Jefferson Avenue Bridge. The bridge abutments are located approximately 4.3 miles upriver from the outer ends of the entrance piers. The Jefferson Avenue Bridge which crossed the river at this location has been removed however, the bridge abutments located on each side of the navigation channel were left in place and restrict the navigation channel to a width of about 130 feet. This restriction is a hazard to navigation and has been the site of several vessel mishaps. The restriction also causes vessels to reduce their speed while moving past the abutments. To reduce delay time at the congestion area, eliminate the hazard to navigation, and facilitate navigation through this area, it would be necessary to remove the Jefferson Avenue Bridge abutments and widen the navigation channel. During the Stage 2 study, a new channel limit was established whereby the width of the navigation channel would be increased to about 190 feet, which is the present width of navigation channel immediately upstream and downstream of the existing restriction. To widen the channel, the bridge abutment on each side of the river would be removed, a bank cut would be made on each side of the channel and existing bulkheads would be replaced. The details of the restriction and proposed widening are shown on Plate C18.

CUYAHOGA RIVER DEEPENING

C38. GENERAL

The Port of Cleveland includes the lower 5.8 miles of the Cuyahoga River (see Plate C13). Vessels up to 630 feet in length and with a beam of 68 feet navigate the river destined for upriver docks. The Cuyahoga River channel is a feature of the Federally improved harbor and is maintained by the Federal

Government to an authorized project depth of 23 feet below Low Water Datum. The current design static draft for vessels operating in harbors and channels on the Great Lakes is 25.5 feet. Therefore, vessels destined for upriver docks enter Cleveland Harbor either light-loaded in order to navigate the Cuyahoga River or fully-loaded in which case they unload a sufficient amount of cargo at docks in the Lakefront Harbor to attain the draft at which they can navigate the Cuyahoga River. This section will address the design criteria and assumptions used for developing the channel depth that is required to allow vessels that are 630 feet long and 68 feet wide, to navigate the Cuyahoga River at fully loaded drafts of 25.5 feet.

C39. DESIGN CHANNEL DEPTH

The new channel depth was selected to safely and efficiently accomodate the passage of the design vessel which is normally the largest vessel (length, beam, and draft) expected to use the channel during the project life. On the Cuyahoga River, the largest vessel expected to use the navigation channel is the Class 5 (630 feet X 68 feet) bulk cargo vessel. The channel depth requirement is based on the following significant criteria:

a. The static draft of the vessel at rest;

b. The sinkage or squat of the vessel underway;

c. The amount of vessel roll;

d. The effect of vessel pitch and heave; and

e. Nominal bottom clearance.

The numerical calculations for the required depth were developed from practical and theoretical information in technical reports and papers. The calculations are attached to the end of this appendix and are based on 25.5-foot design system draft and a design minimum water level of 568.6. The following paragraphs discuss the significant criteria which were considered in determining the required channel depth. The results of the channel depth evaluation are summarized in Table C9.

(1) Vessel Squat - Vessel squat is the lowering of the water surface around a moving vessel which produces a relative change in the ship's position with respect to channel bottom. The procedures which are discussed in paragraph C21a (1), were used in computing the amount of squat that a vessel will experience on the river. Pertinent parameters include: static draft of 25.5 feet; vessel beam width of 68 feet; vessel speed of 2 mph; waterway width of 140 feet (minimum width on river at Cerial Foods Processors, Inc. dock); and channel depth of 28 feet (assumed). The computed squat value is approximately 0.7-foot for the 630-foot long vessel.

(2) Vessel Roll - Vessel roll is rotation of a vessel around its longitudinal axis as a result of waves, wind, and turn angle. Roll is greatest when the vessel hull is parallel to the wave crests. A vessel traveling on the Cuyahoga River will not encounter waves parallel to its hull and therefore

will not experience any roll due to waves. It is assumed that wind acting on either the port or starboard side of the vessel would cause an insignificant amount of roll. It is also assumed that a vessel, equipped with side thrusters and traveling at a speed of about 2 miles per hour, will not experience any appreciable amount of roll while turning in the bends on the river. Therefore, an allowance for vessel roll will not be included in the channel depth requirement for the Cuyahoga River.

(3). Vessel Pitch and Heave - Vessel pitch is rotation of a vessel about its transverse axis and heave is the vertical body motion of a vessel. The motions are caused by waves and are greatest when a vessel hull is normal to wave crests. Vessels traveling on the Cuyahoga River will not encounter waves with a sufficient wave length that would cause the vessel to experience any pitch or heave. Therefore, an allowance for vessel pitch or heave will not be included in the channel depth requirement for the Cuyahoga River.

(4). Nominal Bottom Clearance - After all depth requirements are made for vessel squat, roll, pitch and heave, it is desirable to design for additional bottom clearance for vessel safety and efficiency. The common allowances for bottom clearance are 2 feet in soft material and 3 feet in hard material. On the Cuyahoga River all material is considered to be soft and therefore, a nominal bottom clearance value of 2 feet will be included in the channel depth requirement.

The results from the evaluation of the channel depth requirement for the 630-foot bulk cargo vessels traveling on the Cuyahoga River, as summarized in Table C9, indicate that the river must be deepened to a depth of 28 feet below low water datum.

Table C9 - Summary of Channel Depth Required on the Cuyahoga River

Depth Requirement	Value
a. Design Minimum Water Level	el. 568.6
b. Vessel Draft	- 25.5 feet
c. Vessel Squat	- 0.7 feet
d. Vessel Roll	0.0
e. Vessel Pitch and Heave	0.0
f. Nominal Bottom Clearance	- 2.0 feet
Channel Bottom Elevation	el. 540.4 feet
Channel Bottom Below LWD*	28.2 feet Use 28.0 feet

*Low Water Datum = 568.6 feet above Father Point, Quebec, Canada

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CLEVELAND HARBOR STUDY
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STONE DESIGN AND CHANNEL DESIGN COMPUTATIONS

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b) Nominal Bottom Clearance	1E
c) Roll	1E
d) Pitch and Heave	1E
e) Required Depth	2E
F) CUYAHOGA RIVER DEEPENING	—
1) Class 5 Vessels	1F
a) Squat	1F
b) Nominal Bottom Clearance	1F
c) Vessel Roll	1F
d) Pitch and Heave	2F
e) Required Depth	2F

STONE DESIGN

a) Determine H_{sig} using Technical Paper No 80-3 entitled "Estimating Nearshore Conditions for Irregular Waves" dated June 1980.

$H_o = 13.4$ feet - maximum deep water significant wave height from north through westerly directions

$m = 0.003$ - offshore slope from East Breakwater Major Rehab. Report dated Feb. 79 ; pg A-10

$T_o = 8.8$ seconds

$L_o = 5.12 T_o^2 = 5.12 (8.8)^2 = 396.5$ feet

NOAA chart 14839 for Cleveland Harbor indicates that the lake bottom at the location of any improvements is approximately 32 feet below LWD.

d_{max} = design maximum lake levels - LWD + 32.0

$d_{max} = 573.6 - 568.6 + 32.0 = 37.0$ feet

$k_R = 0.97$ (from Table C5)

$H_o' = k_R H_o = (0.97)(13.4) = 13.0$ feet

$$\frac{H_o'}{L_o} = \frac{13.0}{396.5} = 0.033$$

$$\frac{d_{max}}{H_o'} = \frac{37.0}{13.0} = 2.85$$

$$\frac{H_{sig}}{H_o'} = 0.97$$ (Interpolated Value from Figures B-2 & B-3 of T.P. No. 80-3)

$H_{sig} = 0.97\, H_o' = (0.97)(13.0) = 12.6$ feet

Figure 7-4 of SPM will be used to check the breaking wave condition with the minimum design water depth.

d_{min} = design minimum lake level - LWD + 32.0

$d_{min} = 568.6 - 568.6 + 32.0 = 32.0$ feet

$$\frac{d_{min}}{gT^2} = \frac{32.0}{(32.2)(8.8)^2} = 0.0128$$

$m = 0.003$

$$\frac{H_b}{d_{min}} = 0.78$$ (from Fig 7-4 of SPM)

$H_b = 0.78\, d_{min} = (0.78)(32.0) = 25.0$ feet

H_{sig} (12.6 feet) is less than the wave height H_b (25.0 feet) necessary to create a breaking wave for the minimum design water level. Therefore, the design wave H_{sig} is a non-breaking wave.

b) $W = \dfrac{w_r (H_{sig})^3}{k_D (S_r - 1)^3 \cot\theta}$

$w_r = 155 \text{ lb/ft}^3$

$H_{sig} = 12.6$ feet (non-breaking)

$k_D = 4.0$

$S_r = \dfrac{155}{62.4} = 2.48$

$\cot\theta = 1.5$

$W = \dfrac{(155)(12.6)^3}{(4.0)(2.48-1)^3(1.5)} = 15,940 \text{ lbs}$

Armor Stone

$W_{max} = 2.0\,W = (2)(15,940) = 31,880 \text{ lbs} = 15.94 \text{ Tons}$

$W_{min} = 0.9\,W = (0.9)(15,940) = 14,346 \text{ lbs} = 7.17 \text{ Tons}$

Use Armor Stone ranging from 7.0 Tons to 16.0 Tons

Thickness of Armor Layer

$r = n k_\Delta \left(\dfrac{W}{w_r}\right)^{1/3}$

$n = 2.0$

$k_\Delta = 1.15$

$W = 15940 \text{ lbs}$

$w_r = 155 \text{ lbs/ft}^3$

$r = (2)(1.15)\left(\dfrac{15,940}{155}\right)^{1/3} = 10.78 \text{ feet}$

Use 11.0 feet

Crest Width

$B = n k_\Delta \left(\dfrac{W}{w_r}\right)^{1/3}$

$n = 3$

$k_\Delta = 1.15$

$W = 15,940 \text{ lbs}$

$w_r = 155 \text{ lbs/ft}^3$

$B = (3)(1.15)\left(\dfrac{15940}{155}\right)^{1/3} = 16.16 \text{ feet}$

Use 16.5 feet

Underlayer Stone

$W_{max} = 0.2\,W = (0.2)(15{,}940) = 3188$ lbs $= 1.59$ Tons

$W_{min} = 0.06\,W = (0.06)(15{,}940) = 956$ lbs $= 0.48$ Ton

Use Underlayer Stone ranging from 0.5 Ton to 2.0 Tons

Thickness of Underlayer

$r = n k_\Delta \left(\frac{W}{w_r}\right)^{1/3}$

$n = 2$

$k_\Delta = 1.15$

$W = \frac{W}{10} = \frac{15{,}940}{10} = 1594$ lbs

$w_r = 155$ lb/ft^3

$r = (2)(1.15)\left(\frac{1594}{155}\right)^{1/3} = 5.0$ feet

Bedding and Core Stone

$W_{max} = 0.01\,W = (0.01)(15{,}940) = 159$ lbs

$W_{min} = 0.00015\,W = (0.00015)(15{,}940) = 2.4$ lbs

Use Bedding/Core Stone ranging from 2 lbs to 160 lbs

CREST ELEVATION

Wave Runup By Design Wave

$H_o = 13.4$ feet

$T_o = 8.8$ seconds

$L_o = 5.12\,T_o^2 = (5.12)(8.8)^2 = 396.5$ feet

$k_R = 0.97$

$H_o' = H_o k_R = (13.4)(0.97) = 13.0$ feet

$\frac{H_o'}{gT^2} = \frac{13.0}{(32.2)(8.8)^2} = 0.0052$

$d_{max} = 37.0$ feet

$\frac{d_{max}}{H_o'} = \frac{37.0}{13.0} = 2.85$

$\frac{d_s}{H_o'} = 2.0$ $\frac{R}{H_o'} = 2.54$ (from Fig 7-11 of SPM)

$\frac{d_s}{H_o'} = 2.85$ $\frac{R}{H_o'} = 2.06$ (Interpolated Value)

$\frac{d_s}{H_o'} = 3.0$ $\frac{R}{H_o'} = 1.98$ (from Fig 7-12 of SPM)

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$R = 2.06\, H_o' = 2.06(13.0) = 26.8$ feet

$k = 1.206$ (from Fig 7-13 of SPM)

$R_{smooth} = (26.8)(1.206) = 32.3$ feet

$r = 0.45$ - from CETA 79-1, APPENDIX D - Runup Ratio for rough to smooth for $d_s/H_o' < 3$

$R_{riprap} = (0.45)(32.3) = 14.5$ feet

This runup may be overestimated due to the fact that Figs 7-8 through 7-12 and 7-14 through 7-18 of SPM are from tests with 1:10 slopes whereas the actual beach slope is less in most cases. To remedy this discrepency, we use Goda's charts to calculate the wave heights at the structure for the 1:10 lakebed slope and for the lesser lakebed slope.

Goda correction:

m = 0.003 slope

$$\frac{H_{sig}}{H_o'} = 0.97$$

m = 0.10 slope

$$\frac{d}{H_o'} = \frac{37}{13} = 2.85$$

$$\frac{H_o'}{L_o} = \frac{13.0}{(5.12)(8.8)^2} = 0.033$$

$$\frac{H_o'}{L_o} = 0.040 \qquad \frac{H_{sig}}{H_o'} = 0.95$$

$$\frac{H_o'}{L_o} = 0.033 \qquad \frac{H_{sig}}{H_o'} = 0.97$$

$$\frac{H_o'}{L_o} = 0.020 \qquad \frac{H_{sig}}{H_o'} = 1.02$$

$$\frac{\left(\frac{H_{sig}}{H_o'}\right)_{0.003}}{\left(\frac{H_{sig}}{H_o'}\right)_{0.10}} = \frac{0.97}{0.97} = 1.0$$

Actual runup $= (1)(R_{riprap}) = 14.5$ feet

Wave Overtopping and Transmission By Design Wave

The Cross and Sollitt Method will be used to determine the crest elevation required to limit the transmitted wave to 4.0 under the design condition of a 20 year deep water wave and a 10-year water level.

$$K_T = \frac{H_t}{H_i} = 0.54\,(1.04 - H_{bi}/R)$$

Solving for breakwater height (H_{bi}) where the maximum allowable transmitted wave is 4.0 feet;

$$H_{bi} = R\left(1.04 - \frac{H_t}{0.54\,H_i}\right) = (14.5)\left(1.04 - \frac{4.0}{(0.54)(12.6)}\right) = 6.56 \text{ feet}$$

Crest Height $= H_{bi}$ + design water level $= 6.6 + 573.6 = 580.2$
or +11.6 feet above LWD.
use +11.5

This crest height (580.2) is that which is required to allow a 4 ft wave in the entrance channel under the maximum design condition. However, at a 8 April 1981 workshop meeting held with vessel masters of 1000 foot vessels which are operating on the Great Lakes, it was stated that the masters would not attempt to enter the harbor when wave conditions at the entrance exceed 8.0 feet. It was also stated at the workshop that the wave in the entrance channel should be in the 2-3 foot range in order for the masters to be able to maintain control of their vessels with thrusters under reduced speeds. Therefore, the following analysis was used to determine the crest height required to yield a 3.0 foot transmitted wave due to overtopping caused by a 8.0 foot incident wave.

$H_{sig} = 8.0$ was determined using Technical Paper No 80-3 for for each angle class shown in Table C2.

	Angle Class 1	Angle Class 2	Angle Class 3
H_o (assumed height)	9.2 ft	8.4 ft	10.5 ft
T_o (from Table C3)	7.5 sec	7.1 sec	8.4 sec
k_R (from Table C4)	0.91	1.00	0.78
H_o'	8.4 ft.	8.4 ft	8.2 ft
L_o	288.0 ft	258.1 ft	361.3 ft
$\frac{H_o'}{L_o}$	0.029	0.033	0.023
d_s	37.0 ft	37.0 ft	37.0 ft
$\frac{d_s}{H_o'}$	4.40	4.40	4.51
$\frac{H_{sig}}{H_o'}$ (from TP-80-3)	0.95	0.95	0.97
H_{sig}	8.0 ft	8.0 ft	8.0 ft

The wave with the longer period will yield a larger degree of runup and therefore would be more critical in determining the crest elevation of the structure required to limit the wave transmitted in the entrance channel to 3.0 feet. Therefore, the angle class 3 wave will be analyzed to determine the crest elevation of the breakwaters that will yield a 3.0 foot wave in the entrance channel.

<u>Wave Runup By 8-Foot Incident Wave</u>

$H_o = 10.5$ feet

$T_o = 8.4$ sec

$L_o = 361.3$ feet

$k_R = 0.78$

$H_o' = 8.2$ feet

$$\frac{H_o'}{gT^2} = \frac{8.2}{(32.2)(8.4)^2} = 0.0036$$

$d_s = 37.0$ feet

$$\frac{d_s}{H_o'} = \frac{37.0}{8.2} = 4.51$$

$\frac{R}{H_o'} \simeq 1.0$ from CETA 79-1, APPENDIX E, Figures E-1&2

$R_{riprap} = 1.0\, H_o' = 8.2$ feet

<u>Wave Overtopping and Transmission By 8-Foot Incident Wave</u>

The Cross and Sollitt Method will be used to determine the crest elevation required to limit the transmitted wave to 3.0 feet under the design condition of an 8.0 foot incident wave.

$$k_T = \frac{H_t}{H_i} = 0.54\,(1.04 - H_{bi}/R)$$

Solve for breakwater height (H_{bi}) where the maximum allowable trasmitted wave is 3.0 feet.

$$H_{bi} = R\left(1.04 - \frac{H_t}{0.54 H_i}\right) = 8.2\left(1.04 - \frac{3.0}{(0.54)(8.0)}\right) = 2.83$$

Crest Height = H_{bi} + design water level = 2.8 + 573.6 = 576.4
or +7.8 feet above LWD
Use +8.0

The severity of overtopping the breakwater with a crest height at +8.0 by the 13.4 foot deep water wave with a 20-year recurrence will be checked using the Cross and Sollitt Method.

$$H_t = 0.54\,(1.04 - H_{bi}/R)\,H_i$$

$$H_t = 0.54\,(1.04 - 3.0/14.5)(12.6) = 5.67 \text{ feet}$$

Say 6.0 ft. transmitted wave

The +8.0 crest elevation is equivalent to the existing east and west arrowhead breakwaters and therefore, it is not anticipated that the proposed breakwaters would create a more severe condition in the inner harbor than which is presently being experienced. Therefore, the proposed breakwaters are design with a +8.0 crest height and the ongoing model study will be used as a tool to compare the design cases under existing conditions and with the proposed improvements with the proposed plan being modified accordingly such that conditions are equivalent or improved over existing conditions.

TYPICAL SECTION

The typical section for the breakwater improvements at the existing main entrance to Cleveland Harbor are shown on Plate C4. The armor stone will be placed to 1.5 H_{sig} below the minimum design water level on the lake side and to 1.0 H_{sig} below the minimum design water level on the harbor side. Therefore,

$1.5(12.6) + (568.6 - 568.6) = 18.9$ feet — Lake Side
use 19.0 feet below LWD

$1.0(12.6) + (568.6 - 568.6) = 12.6$ feet — Harbor Side
use 13.0 feet below LWD

A) ALL WEATHER WEST ENTRANCE PLAN

1) Class 10 Vessels (950'–1000' × 105')

a) Squat – Graphical Method

A = Vessel cross sectional area = 105' × 25.5' = 2677.5 ft^2
W = channel width = 600 ft

H = Channel water depth = 32.0 feet = assumed depth based on minimum design water level

$$S = \frac{A}{WH} = \frac{2677.5}{(600)(32.0)} = 0.14$$

V = 6 mph = 8.8 ft/sec (per vessel masters at 8 April 81 workshop held in Cleveland, OH)
g = acceleration of gravity = 32.2 ft/sec^2

$$F = \frac{V}{\sqrt{gH}} = \frac{8.8}{\sqrt{(32.2)(32)}} = 0.27$$

$$D = \frac{Z}{H} = 0.015 \text{ (from Figure C6)}$$

$$Z = 0.015\,H = (0.015)(32.0) = 0.5 \text{ feet}$$

Squat – Empirical Method

V_1 = Ship velocity relative to Water = 6 mph = 8.8 ft/sec
A_1 = Cross sectional area of channel = 600' × 32' = 19,200 ft^2
A_2 = Cross sectional area of vessel = 105' × 25.5' = 2677.5 ft^2

$$A_w = A_1 - A_2 = 19{,}200 - 2677.5 = 16{,}522.5 \ ft^2$$

g = 32.2 ft/sec^2

$$S = \frac{V_1^2}{2g}\left[\left(1.01\left(\frac{A_1}{A_w}\right)\right)^2 - 0.84\right]$$

$$S = \frac{(8.8)^2}{2(32.2)}\left[\left(1.01\left(\frac{19{,}200}{16{,}522.5}\right)\right)^2 - 0.84\right] = 0.7 \text{ feet}$$

b) Nominal Bottom Clearance:

Use 2.0 feet

c) Roll – According to the Study Report of Vessel Clearance Criteria for the Great Lakes Connecting Channels prepared by Michael Baker, Inc for Detroit District, the maximum roll on 1000 ft vessels is in the range of 2-3 degrees. At a 8 April 1981 workshop held in Cleveland, the vessel masters of 1000 ft vessels indicated that the maximum roll on the 1000 ft vessels entering Cleveland would be in the range of 3-5 degrees. This analysis will use 4°.

Y = depth requirement due to roll

B = vessel beam = 105 feet
θ = maximum roll in degrees = 4°
Y = (½) (B) Sine θ = (½)(105)(sine 4°) = 3.7 feet

d) Pitch and Heave – At the 8 April 1981 workshop held with the vessel masters of 1000 ft vessels which are presently operating on the Great Lakes, it was stated that the masters would not attempt to enter Cleveland Harbor when wave conditions at the entrance exceed 8.0 feet. Therefore, the pitch and heave will be determined based on a 8.0 ft wave height.

pitch = $\frac{\theta L}{2}$ = 0.1 H ; $\frac{Heave}{H}$ = 0.1 where H = wave amplitude
H = 8.0 feet

$\frac{\theta L}{2}$ + Heave = (2)(0.1)(H) = (2)(0.1)(8.0)

$\frac{\theta L}{2}$ + Heave = 1.6 feet

*The roll requirement governs over this pitch and heave value

e) Required depth in the Lake Approach and Entrance Channels at the West Entrance for the "All Weather" Condition by the Class 10 vessels (950'-1000' x 105'):

Case 1 utilizes squat value from Graphical Method
Case 2 utilizes squat value from Empirical Method.

	Case 1	Case 2
Static Draft	25.5	25.5
Squat	0.5	0.7
Roll	3.7	3.7
Pitch and Heave	*	*
Nominal Clearance	2.0	2.0
Required Depth	31.7 ft	31.9 ft

Use a channel depth requirement of 32 feet below LWD in the lake approach channel and entire entrance channel.

2) Class 8 Vessels (731'-849' x 70')

a) Squat – Graphical Method

A = Vessel cross sectional area = 70' x 25.5' = 1785 ft²
W = channel width = 600 feet

H = Channel waterdepth = 32.0 feet = assumed depth based on minimum design water depth

$$S = \frac{A}{WH} = \frac{1785.0}{(600)(32)} = 0.09$$

V = 6 mph = 8.8 ft/sec (per vessel masters at 8 April 81 workshop held in Cleveland, OH)

g = acceleration of gravity = 32.2 ft/sec²

$$F = \frac{V}{\sqrt{gH}} = \frac{8.8}{\sqrt{(32.2)(32)}} = 0.27$$

$$D = \frac{Z}{H} = 0.009 \text{ (from Figure C6)}$$

$$Z = 0.009\,H = (0.009)(32) = 0.3 \text{ feet}$$

Squat-Empirical Method

V_1 = Ship velocity relative to water = 6 mph = 8.8 ft/sec

A_1 = Cross sectional area of channel = 600×32′ = 19,200 ft²

A_2 = Cross sectional area of vessel = 70′ × 25.5′ = 1785.0 ft²

$A_w = A_1 - A_2 = 19{,}200 - 1785 = 17{,}415 \text{ ft}^2$

g = 32.2 ft/sec²

$$S = \frac{V_1^2}{2g}\left[\left(1.01\left(\frac{A_1}{A_w}\right)\right)^2 - 0.84\right]$$

$$S = \frac{(8.8)^2}{(2)(32.2)}\left[\left(1.01\left(\frac{19{,}200}{17{,}415}\right)\right)^2 - 0.84\right] = 0.5 \text{ feet}$$

b) Nominal Bottom Clearance

Use 2.0 feet

c). Roll - According to the Study Report of Vessel Clearance Criteria for the Great Lakes Connecting Channels prepared by Michael Baker, Inc for Detroit District, the roll on smaller vessels is greater than for 1000 ft vessels, with a value of about 5 degrees. At the 8 April 1981 workshop held in Cleveland, the vessel masters of the 1000 ft vessels indicated that the roll on smaller vessels is about 1½ times that of the 1000 ft vessels or approximately 5 to 7 degress. This analysis will use 6°.

Y = depth requirement due to roll

B = vessel beam = 70 feet

θ = maximum roll in degrees = 6°

$$Y = (1/2)(B)(\sin\theta) = (1/2)(70)(\sin 6^\circ) = 3.7 \text{ feet}$$

d). Pitch and Heave - At the 8 April 1981 workshop meeting held with the vessel masters of 1000 ft vessels, it was stated that the masters would not attempt to enter Cleveland Harbor when wave conditions at the entrance exceed 8.0 feet. Therefore, the pitch and heave will be determined based on a 8.0 ft wave height.

pitch $= \frac{\theta L}{2} = 0.1H$ $\frac{Heave}{H} = 0.1$ where H = wave amplitude = 8.0 ft

$\frac{\theta L}{2}$ + Heave = (2)(0.1)(H) = (2)(0.1)(8)

$\frac{\theta L}{2}$ + Heave = 1.6 ft

*The roll requirement governs over this pitch and heave value

2) Required depth in the Lake Approach and Entrance Channels at the West Entrance for the "All Weather" Condition by the Class 8 vessels (731'-849' x 70'):

Case 1 utilizes squat value from Graphical Method
Case 2 utilizes squat value from Empirical Method

	Case 1	Case 2
Static Draft	25.5	25.5
Squat	0.3	0.5
Roll	3.7	3.7
Pitch and Heave	*	*
Nominal Clearance	2.0	2.0
Required Depth	31.5 ft	31.7 ft.

Use a channel depth requirement of 32 feet below LWD in the lake approach channel and entire entrance channel.

3) Class 7 Vessels (700'-730' x 75'):

a) Squat - Graphical Method

A = Vessel cross sectional area = 75' x 25.5' = 1912.5 ft²
W = channel width = 600 feet
H = Channel water depth = 32.0 feet = assumed depth based on minimum design water depth

$$S = \frac{A}{WH} = \frac{1912.5}{(600)(32)} = 0.10$$

V = 6 mph = 8.8 ft/sec (per vessel masters at 8 April 1981 workshop held in Cleveland, OH)
g = acceleration of gravity = 32.2 ft/sec²

$$F = \frac{V}{\sqrt{gH}} = \frac{8.8}{\sqrt{(32)(32.2)}} = 0.27$$

$$D = \frac{Z}{H} = 0.012 \text{ (from Figure C6)}$$

$$Z = 0.012H = (0.012)(32) = 0.4 \text{ feet}$$

Squat - Empirical Method

V_1 = Ship velocity relative to water = 6 mph = 8.8 ft/sec
A_1 = Cross sectional area of channel = 600' x 32' = 19,200 ft²
A_2 = Cross sectional area of vessel = 75' x 25.5' = 1912.5 ft²
$A_w = A_1 - A_2 = 19,200 - 1912.5 = 17,287.5$ ft²

$g = 32.2$ ft/sec

$$S = \frac{V_1^2}{2g}\left[\left(1.01\left(\frac{A_1}{A_{w1}}\right)\right)^2 - 0.84\right]$$

$$S = \frac{(8.8)^2}{(2)(32.2)}\left[\left(1.01\left(\frac{19200}{172875}\right)\right)^2 - 0.84\right] = 0.5 \text{ feet}$$

b) Nominal Bottom Clearance
Use 2.0 feet

c) Roll – According to the Study Report of Vessel Clearance Criteria for the Great Lakes Connecting Channels prepared by Michael Baker, Inc for Detroit District, the roll on smaller vessels is greater than for 1000-ft vessels, with a value of about 5 degrees. At the 8 April 1981 workshop held in Cleveland, the vessel masters of the 1000 ft vessels indicated that the roll on smaller vessels is about 1½ times that of the 1000 ft vessels or approximately 5 to 7 degrees. This analysis will use 6°.

Y = depth requirement due to roll
B = vessel beam = 75 ft.
θ = maximum roll in degrees = 6°
$Y = (1/2)\, B \sin\theta = (1/2)(75)(\sin 6°) = 3.9$ feet

d) Pitch and Heave – At the 8 April 1981 workshop meeting held with the vessel masters of 1000 ft vessels, it was stated that the masters would not attempt to enter Cleveland Harbor when wave conditions at the entrance exceed 8.0 feet. Therefore, the pitch and heave will be determined based on a 8.0 ft wave height.

$\text{pitch} = \frac{\theta L}{2} = 0.1 H \qquad \frac{\text{Heave}}{H} = 0.1$

where H = wave amplitude = 8.0 ft

$\frac{\theta L}{2} + \text{Heave} = (2)(0.1)(H) = (2)(0.1)(8)$

$\frac{\theta L}{2} + \text{Heave} = 1.6$ feet

* The roll requirement governs over this pitch and heave value

e) Required depth in the Lake Approach and Entrance Channels at the West Entrance for the "All Weather" Condition by the Class 7 vessels (700'–730' x 75'):

Case 1 utilizes squat value from Graphical Method
Case 2 utilizes squat value from Empirical Method

	Case 1	Case 2
Static Draft	25.5	25.5
Squat	0.4	0.5
Roll	3.9	3.9
Pitch and Heave	*	*
Nominal Clearance	2.0	2.0
Required Depth	31.8 ft	31.9 ft

Use a channel depth requirement of 32 feet below LWD in the lake approach channel and entire entrance channel

4) Class 6 Vessels (650'-699' x 72'):

a) Squat - Graphical Method

A = Vessel cross sectional area = 72' x 25.5' = 1836 ft²

W = channel width = 600 feet

H = Channel water depth = 32 feet = assumed depth based on minimum design water depth

$$S = \frac{A}{WH} = \frac{1836}{(600)(32)} = 0.10$$

V = 6 mph = 8.8 ft/sec (per vessel masters at 8 April 1981 workshop held in Cleveland, OH)

g = acceleration of gravity = 32.2 ft/sec²

$$F = \frac{V}{\sqrt{gH}} = \frac{8.8}{\sqrt{(32)(32.2)}} = 0.27$$

$$D = \frac{Z}{H} = 0.012 \quad \text{(from Figure C6)}$$

$$Z = 0.012H = (0.012)(32) = 0.4 \text{ feet}$$

Squat - Empirical Method

V_1 = Ship velocity relative to water = 6 mph = 8.8 ft/sec

A_1 = Cross sectional area of channel = 600' x 32' = 19,200 ft²

A_2 = Cross sectional area of vessel = 72' x 25.5' = 1836 ft²

$A_w = A_1 - A_2 = 19,200 - 1836 = 17,364$ ft²

g = 32.2 ft/sec²

$$S = \frac{V_1^2}{2g}\left[\left(1.01\left(\frac{A}{A_w}\right)\right)^2 - 0.84\right]$$

$$S = \frac{(8.8)^2}{(2)(32.2)}\left[\left(1.01\left(\frac{19,200}{17,364}\right)\right)^2 - 0.84\right] = 0.5 \text{ feet}$$

b) Nominal Bottom Clearance

Use 2.0 feet

BY RJC DATE 4/21/81 SUBJECT Cleveland Harbor, OH SHEET NO. 7A OF 7A
CHKD. BY ___ DATE ___ Channel Depth Requirement for JOB NO. ___
Lake Approach and Entrance Channel

C) Roll - According to the Study Report for Vessel Clearance Criteria for the Great Lakes Connecting Channels prepared by Michael Baker, Inc for Detroit District, the roll on smaller vessels is greater than for 1000-ft vessels, with a value of about 5 degrees. At the 8 April 1981 workshop held in Cleveland, the vessel masters of the 1000 ft vessels indicated that the roll on the smaller vessels is about 1½ times that of the 1000 ft vessels or approximately 5 to 7 degrees. This analysis will use 6°.

Y = depth requirement due to roll
B = vessel beam = 72 feet
θ = maximum roll in degrees = 6°

$Y = \frac{1}{2} B \sin\theta = (\frac{1}{2})(72)(\sin 6°) = 3.8$ feet

d) Pitch and Heave - At the 8 April 1981 workshop meeting held with the masters of 1000 ft vessels, it was stated that the masters would not attempt to enter Cleveland Harbor when wave conditions at the entrance exceed 8.0 feet. Therefore, the pitch and heave will be determined based on a 8.0 ft wave height.

pitch $= \frac{\theta L}{2} = 0.1H$ $\quad \frac{Heave}{H} = 0.1$

where H = wave amplitude = 8.0 ft

$\frac{\theta L}{2} + heave = (2)(0.1)(H) = (2)(0.1)(8)$

$\frac{\theta L}{2} + Heave = 1.6$ feet

* Roll requirement governs over this pitch and heave value

e) Required depth in the Lake Approach and Entrance Channels at the West Entrance for the "All Weather" Condition by the Class 6 Vessels (650'-699' x 72'):

Case 1 utilizes the squat value from Graphical Method
Case 2 utilizes the squat value for the Empirical Method

	Case 1	Case 2
Static Draft	25.5	25.5
Squat	0.4	0.5
Roll	3.8	3.8
Pitch and Heave	*	*
Nominal Clearance	2.0	2.0
Required Depth	31.7 ft	31.8 ft

Use a channel depth requirement of 32 feet below LWD in the lake approach channel and entire entrance channel

5) Class 5 Vessels (600-649' X 68'):

a) Squat - Graphical Method

A = Vessel Cross Sectional Area = 68' x 25.5' = 1734 ft^2

W = channel width = 600 feet

H = Channel water depth = 32.0 feet = assumed depth based on minimum design water depth

$$S = \frac{A}{WH} = \frac{1734}{(600)(32)} = 0.09$$

V = 6 mph = 8.8 ft/sec (per vessel masters at 8 April 1981 workshop held in Cleveland, OH)

g = acceleration of gravity = 32.2 ft/sec^2

$$F = \frac{V}{\sqrt{gH}} = \frac{8.8}{\sqrt{(32.2)(32)}} = 0.27$$

$$D = \frac{Z}{H} = 0.009 \text{ (from Figure C6)}$$

$$Z = 0.009\,H = (0.009)(32) = 0.3 \text{ feet}$$

Squat - Empirical Method

V_1 = Ship velocity relative to water = 6 mph = 8.8 ft/sec

A_1 = Cross sectional area of channel = 600' x 32' = 19,200 ft^2

A_2 = Cross sectional area of vessel = 68' x 25.5' = 1734 ft^2

$A_w = A_1 - A_2$ = 19,200 - 1734 = 17466 ft^2

g = 32.2 ft/sec^2

$$S = \frac{V_1^2}{2g}\left[\left(1.01\left(\frac{A_1}{A_w}\right)\right)^2 - 0.84\right]$$

$$= \frac{(8.8)^2}{(2)(32.2)}\left[\left(1.01\left(\frac{19200}{17,466}\right)\right)^2 - 0.84\right] = 0.5 \text{ feet}$$

b) Nominal Bottom Clearance

use 2.0 feet

c) Roll - According to the Study Report of Vessel Clearance Criteria for the Great Lakes Connecting Channels prepared by Michael Baker, Inc for Detroit District, the roll on smaller vessels is greater than for 1000-ft vessels, with a value of about 5 degrees. At the 8 April 1981 workshop held in Cleveland, the vessel masters of the 1000 ft vessels indicated that the roll on smaller vessels is about 1½ times that of the 1000 ft vessels or approximately 5 to 7 degrees. This analysis will use 6°.

Y = depth requirement due to roll

B = Vessel beam = 68 ft

θ = maximum roll in degrees = 6°

$$Y = (1/2) B \sin\theta = (1/2)(68)(\sin 6°) = 3.6 \text{ feet}$$

d) Pitch and Heave - At the 9 April 1981 workshop meeting held with the vessel masters of 1000 ft vessels, it was stated that the masters would not attempt to enter Cleveland Harbor when wave conditions at the entrance exceed 8.0 feet. Therefore, the pitch and heave will be determined based on a 8.0 ft wave height.

$$\text{pitch} = \frac{\theta L}{2} = 0.1\,H \qquad \frac{\text{Heave}}{H} = 0.1$$

where H = wave amplitude = 8.0 ft

$$\frac{\theta L}{2} + \text{Heave} = (2)(0.1)(H) = (2)(0.1)(8)$$

$$\frac{\theta L}{2} + \text{heave} = 1.6\text{ ft}$$

* The roll requirement governs over the pitch and heave value

e) Required depth in the Lake Approach and Entrance Channels at the West Entrance for the "All Weather" Condition by the Class 5 vessels (600-649' x 68'):

Case 1 utilizes squat value from Graphical Method
Case 2 utilizes squat value from Empirical Method

	Case 1	Case 2
Static Draft	25.5	25.5
Squat	0.3	0.5
Roll	3.6	3.6
Pitch and Heave	*	*
Nominal Clearance	2.0	2.0
Required Depth	31.4 ft	31.6 ft

Use an entrance depth requirement of 32 feet below LWD in the Lake Approach Channel and entire Entrance Channel

B) ALL WEATHER EAST ENTRANCE PLAN

1) Class 10 Vessels (950'-1000' × 105')

a) Squat - Graphical Method

A = Vessel cross sectional area = 105' × 25.5 = 2677.5 ft^2
W = channel width = 2400 feet = distance between East Breakwater and marina bulkhead
H = Channel water depth = 32.0 feet = assumed depth based on minimum design water level.

$$S = \frac{A}{WH} = \frac{2677.5}{(2400)(32)} = 0.035$$

V = 6 mph = 8.8 ft/sec (per vessel masters at 8 April 81 workshop held in Cleveland, OH)
g = acceleration of gravity = 32.2 ft/sec^2

$$F = \frac{V}{\sqrt{gH}} = \frac{8.8}{\sqrt{(32.2)(32)}} = 0.27$$

$$D = \frac{Z}{H} = 0.005 \quad \text{(from Figure C6)}$$

$$Z = (0.005)H = (0.005)(32) = 0.2 \text{ feet}$$

Squat - Empirical Method

V_1 = Ship velocity relative to water = 6 mph = 8.8 ft/sec
A_1 = Cross sectional area of channel = 2400' × 32' = 76,800 ft^2
A_2 = Cross sectional area of vessel = 105 × 25.5 = 2677.5 ft^2
$A_w = A_1 - A_2 = 76800 - 2677.5 = 74122.5 \ ft^2$
g = 32.2 ft/sec^2

$$S = \frac{V_1^2}{2g}\left[\left(1.01\left(\frac{A_1}{A_w}\right)\right)^2 - 0.84\right]$$

$$S = \frac{(8.8)^2}{(2)(32.2)}\left[\left(1.01\left(\frac{76,800}{74,122.5}\right)\right)^2 - 0.84\right] = 0.3 \text{ feet}$$

b) Nominal Bottom Clearance:

Use 2.0 feet

c) Roll - According to the Study Report of Vessel Clearance Criteria for the Great Lakes Connecting Channels prepared by Michael Baker, Inc for Detroit District, the maximum roll on 1000 ft vessels is in the range of 2-3 degrees. At a 8 April 1981 workshop held in Cleveland, the vessel masters of 1000 ft vessels indicated that the maximum roll on the 1000 ft vessels entering Cleveland Harbor would be in the range of 3-5 degrees. This analysis will use 4°.

Y = depth requirement due to roll
B = vessel beam = 105 feet
θ = maximum roll in degrees = 4°

$Y = (1/2)(B) \sin\theta = (1/2)(105)(\sin 4°) = 3.7$ feet

d) Pitch and Heave - At the 8 April 1981 workshop held with the vessel masters of 1000 ft vessels which are presently operating on the Great Lakes, it was stated that the masters would not attempt to enter Cleveland Harbor when wave conditions at the entrance exceed 8.0 feet. Therefore, the pitch and heave will be determined based on a 8.0 ft wave height.

pitch $= \frac{\theta L}{2} = 0.1H$ $\frac{Heave}{H} = 0.1$ where H = wave amplitude
H = 8.0 ft

$\frac{\theta L}{2} + Heave = (2)(0.1)(H) = (2)(0.1)(8.0)$

$\frac{\theta L}{2} + Heave = 1.6$ feet

* The roll requirement governs over the pitch and heave value

e) Required depth in the Lake Approach and Outer Entrance Channels at the East Entrance for the "All Weather" Condition by the Class 10 vessels (950'–1000' x 105'):

Case 1 utilizes squat value from Graphical Method
Case 2 utilizes squat value from Empirical Method

	Case 1	Case 2
Static Draft	25.5	25.5
Squat	0.2	0.3
Roll	3.7	3.7
Pitch and Heave	*	*
Nominal Clearance	2.0	2.0
Required Depth	31.4 ft	31.5 ft

Use an entrance channel depth of 32 feet below LWD in the lake approach channel and outer entrance channel.

2) Class 8 Vessels (731-849 x 70')

a) Squat - Graphical Method

A = Vessel cross sectional area = 70' x 25.5' = 1785 ft²
W = channel width = 2400 ft = distance between East Breakwater and marina bulkhead
H = Channel water depth = 32.0 feet = assumed depth based on minimum design water level

$$S = \frac{A}{WH} = \frac{1785}{(2400)(32)} = 0.023$$

V = 6 mph = 8.8 ft/sec (per vessel masters at 8 April 1981 workshop held in Cleveland, OH)

g = acceleration of gravity = 32.2 ft/sec

$$F = \frac{V}{\sqrt{gH}} = \frac{8.8}{\sqrt{(32.2)(32)}} = 0.27$$

$$D = \frac{Z}{H} = 0.003 \quad \text{(from Figure C6)}$$

$$Z = (0.003)(H) = (0.003)(32) = 0.1 \text{ feet}$$

Squat - Empirical Method

V_1 = Ship Velocity relative to water = 6 mph = 8.8 ft/sec

A_1 = cross sectional area of channel = 2400' × 32' = 76,800 ft²

A_2 = cross sectional area of vessel = 70' × 25.5' = 1785 ft²

$A_w = A_1 - A_2 = 76800 - 1785 = 75015$ ft²

$g = 32.2$ ft/sec²

$$S = \frac{V_1^2}{2g}\left[\left(1.01\left(\frac{A_1}{A_w}\right)\right)^2 - 0.84\right]$$

$$S = \frac{(8.8)^2}{(2)(32.2)}\left[\left(1.01\left(\frac{76800}{75015}\right)\right)^2 - 0.84\right] = 0.3 \text{ feet}$$

b) Nominal Bottom Clearance

Use 2.0 feet

c) Roll – According to the Study Report of Vessel Clearance Criteria for the Great Lakes Connecting Channels prepared by Michael Baker, Inc for Detroit District, the roll on smaller vessels is greater than for 1000 ft vessels, with a value of about 5 degrees. At the 8 April 1981 workshop held in Cleveland, the vessel masters of the 1000 ft vessels indicated that the roll on smaller vessels is about 1½ times that of the 1000 ft vessels or approximately 5 to 7 degrees. This analysis will use 6°.

Y = depth requirement due to roll

B = vessel beam = 70 feet

θ = maximum roll in degrees = 6°

$$Y = (1/2)(B)(\sin\theta) = (1/2)(70)(\sin 6°) = 3.7 \text{ feet}$$

d) Pitch and Heave – At the 8 April 1981 workshop held with the vessel masters of 1000 ft vessels which are presently operating on the Great Lakes, it was stated that the masters would not attempt to enter Cleveland Harbor when wave conditions at the entrance exceed 8.0 feet. Therefore, the pitch and heave will be determined based on a 8.0 ft wave height.

pitch = $\frac{\theta L}{2}$ = 0.1 H $\frac{Heave}{H}$ = 0.1 where H = wave amplitude, H = 8.0 ft

$\frac{\theta L}{2}$ + Heave = (2)(0.1)(H) = (2)(0.1)(8)

$\frac{\theta L}{2}$ + Heave = 1.6 feet

*The roll requirement governs over this pitch and heave value

2) Required depth in the Lake Approach and Outer Entrance Channels at the East Entrance for the "All Weather" Condition by the Class 8 vessels (731'-849' x 70'):

Case 1 utilizes squat value from Graphical Method
Case 2 utilizes squat value from Empirical Method

	Case 1	Case 2
Static Draft	25.5	25.5
Squat	0.1	0.3
Roll	3.7	3.7
Pitch and Heave	*	*
Nominal Clearance	2.0	2.0
Required Depth	31.3 ft	31.5 ft

Use an entrance channel depth of 32 feet below LWD in the lake approach channel and outer entrance channel.

3) Class 7 Vessels (700'-730' x 75'):

a) Squat - Graphical Method

A = Vessel cross sectional area = 75' x 25.5' = 1912.5 ft²
W = channel width = 2400 ft = distance between East Breakwater and marina bulkhead
H = Channel water depth = 32.0 feet = assumed depth based on minimum design water level.

$$S = \frac{A}{WH} = \frac{1912.5}{(2400)(32)} = 0.025$$

V = 6 mph = 8.8 ft/sec (per vessel masters at 8 April 1981 workshop held in Cleveland, OH)
g = acceleration of gravity = 32.2 ft/sec

$$F = \frac{V}{\sqrt{gH}} = \frac{8.8}{\sqrt{(32.2)(32)}} = 0.27$$

$D = \frac{Z}{H} = 0.003$ (from Figure C6)

$Z = (0.003)(H) = (0.003)(32) = 0.1$ feet

Squat - Empirical Method

V_1 = Ship Velocity relative to water = 6 mph = 8.8 ft/sec

A_1 = cross sectional area of channel = 2400' x 32' = 76,800 ft²

A_2 = cross sectional area of vessel = 75' x 25.5' = 1912.5 ft²

$A_w = A_1 - A_2 = 76,800 - 1912.5 = 74,887.5$ ft²

$g = 32.2$ ft/sec²

$$S = \frac{V_1^2}{2g}\left[\left(1.01\left(\frac{A_1}{A_w}\right)\right)^2 - 0.84\right]$$

$$S = \frac{(8.8)^2}{(2)(32.2)}\left[\left(1.01\left(\frac{76800}{74,887.5}\right)\right)^2 - 0.84\right] = 0.3 \text{ feet}$$

b) Nominal Bottom Clearance

Use 2.0 feet

c) Roll - According to the Study Report of Vessel Clearance Criteria for the Great Lakes Connecting Channels prepared by Michael Baker, Inc for Detroit District, the roll on smaller vessels is greater than for 1000 ft vessels, with a value of about 5 degrees. At the 8 April 1981 workshop held in Cleveland the vessel masters of the 1000 ft vessels indicated that the roll on smaller vessels is about 1½ times that of the 1000 ft vessels or approximately 5 to 7 degrees. This analysis will use 6°.

Y = depth requirement due to roll

B = Vessel beam = 75 feet

θ = maximum roll in degrees = 6°

$Y = (1/2) B \sin\theta = (1/2)(75) \sin 6° = 3.9$ feet

d) Pitch and Heave - At the 8 April 1981 workshop held with the vessel masters of 1000 foot vessels which are presently operating on the Great Lakes, it was stated that the masters would not attempt to enter Cleveland Harbor when wave conditions at the entrance exceed 8.0 feet. Therefore, the pitch and heave will be determined based on a 8.0 ft wave height.

pitch $= \frac{\theta L}{2} = 0.1H$ $\quad \frac{\text{Heave}}{H} = 0.1$ where H = wave amplitude, H = 8.0 ft.

$\frac{\theta L}{2} + \text{Heave} = (2)(0.1)(H) = (2)(0.1)(8)$

$\frac{\theta L}{2} + \text{Heave} = 1.6$ feet

* The roll requirement governs over this pitch and heave value

e) Required depth in the Lake Approach and Outer Entrance Channels at the East Entrance for the "All Weather" Condition by the Class 7 Vessel (700'-730' x 75'):

Case 1 utilizes squat value from the Graphical Method
Case 2 utilizes squat value from the Empirical Method

	Case 1	Case 2
Static Draft	25.5	25.5
Squat	0.1	0.3
Roll	3.9	3.9
Pitch and Heave	*	*
Nominal Clearance	2.0	2.0
Required Depth	31.5 ft	31.7 ft

Use an entrance channel depth of 32 feet below LWD in the Lake Approach channel and Outer Entrance Channel.

4) Class 6 Vessels (650'-699' x 72'):

a) Squat - Graphical Method

A = Vessel cross sectional area = $72' \times 25.5 = 1836\ ft^2$
W = Channel width = 2400 ft = distance between East Breakwater and marina bulkhead
H = Channel water depth = 32 feet = assumed depth based on minimum design water level

$$S = \frac{A}{WH} = \frac{1836}{(2400)(32)} = 0.024$$

V = 6 mph = 8.8 ft/sec (per vessel masters at 8 April 1981 workshop held in Cleveland, OH)
g = acceleration of gravity = $32\ ft/sec^2$

$$F = \frac{V}{\sqrt{gH}} = \frac{8.8}{\sqrt{(32.2)(32)}} = 0.27$$

$$D = \frac{Z}{H} = 0.003 \text{ (from Fig C6)}$$

$$Z = 0.003H = (0.003)(32) = 0.1\ ft$$

Squat - Empirical Method

V_1 = Ship velocity relative to water = 6 mph = 8.8 ft/sec
A_1 = Cross Sectional area of Channel = $2400 \times 32 = 76800\ ft^2$
A_2 = Cross Sectional area of vessel = $72' \times 25.5' = 1836\ ft^2$

$$A_w = A_1 - A_2 = 76800 - 1836 = 74964\ ft^2$$

$g = 32.2\ ft/sec^2$

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$$S = \frac{V^2}{2g}\left[\left(1.01\left(\frac{A}{A_w}\right)\right)^2 - 0.84\right]$$

$$S = \frac{(8.5)^2}{2(32.2)}\left[\left(1.01\left(\frac{76800}{74964}\right)\right)^2 - 0.84\right] = 0.3 \text{ feet}$$

b) <u>Nominal Bottom Clearance:</u>

Use: 2.0 feet

c) <u>Roll</u> - According to the Study Report of Vessel Clearance Criteria for the Great Lakes Connecting Channels prepared by Michael Baker, Inc for Detroit District, the maximum roll on smaller vessels is greater than for 1000 ft vessels, with a value of about 5 degrees. At the 8 April 1981 workshop held in Cleveland, the vessel masters of the 1000-ft. vessels indicated that the roll on smaller vessels is about 1½ times that of the 1000 ft vessels or approximately 5 to 7 degrees. This analysis will use 6°.

Y = depth requirement due to roll

B = vessel beam = 72 ft

θ = maximum roll in degrees = 6°

$$Y = (1/2)\, B \sin\theta = (1/2)(72)(\sin 6°) = 3.8 \text{ ft.}$$

d) <u>Pitch and Heave</u> - At the 8 April 1981 workshop held with the vessel masters of 1000 ft vessels which are presently operating on the Great Lakes, it was stated that the masters would not attempt to enter Cleveland Harbor when wave conditions at the entrance exceed 8.0 feet. Therefore the pitch and heave will be determined based on a 8.0 ft wave height.

$$\text{pitch} = \frac{\theta L}{2} = 0.1\,H \qquad \frac{\text{Heave}}{H} = 0.1 \quad \text{where } H = \text{wave amplitude}, \; H = 8.0 \text{ ft}$$

$$\frac{\theta L}{2} + \text{heave} = (2)(0.1)H = (2)(.1)(8)$$

$$\frac{\theta L}{2} + \text{heave} = 1.6 \text{ feet}$$

* The roll requirement governs over this pitch and heave value

e) <u>Required depth in the Lake Approach and Outer Entrance Channels at the East Entrance for the All Weather condition by the Class 6 vessels (650'-699' × 72'):</u>

Case 1 utilizes squat value from Graphical Method

Case 2 utilizes squat value from Empirical Method

	Case 1	Case 2
Static Draft	25.5	25.5
Squat	0.1	0.3
Roll	3.8	3.8
Pitch and Heave	*	*
Nominal Clearance	2.0	2.0
Required Depth	31.4 ft	31.6 ft

Use an entrance depth of 32 feet below LWD in the lake approach channel and Outer Entrance Channel.

5) Class 5 Vessels (600'- 649' × 68'):

a) Squat - Graphical Method

A = Vessel Cross Sectional Area = 68' × 25.5' = 1734 ft²

W = Channel width = 2400 feet = distance between East Breakwater and marina bulkhead

H = Channel water depth = 32 feet = assumed depth based on minimum design water depth

$$S = \frac{A}{WH} = \frac{1734}{(2400)(32)} = 0.023$$

V = 6 mph = 8.8 ft/sec (per vessel masters at 8 April 1981 workshop held in Cleveland, OH)

g = acceleration of gravity = 32.2 ft/sec²

$$F = \frac{V}{\sqrt{gH}} = \frac{8.8}{\sqrt{(32.2)(32)}} = 0.27$$

$$D = \frac{Z}{H} = 0.003 \text{ (from Figure C6)}$$

$$Z = 0.003(H) = (0.003)(32) = 0.1 \text{ ft}$$

Squat - Empirical Method

V_1 = Ship velocity relative to water = 6 mph = 8.8 ft/sec

A_1 = Cross sectional area of channel = 2400' × 32' = 76800 ft²

A_2 = Cross sectional area of vessel = 68' × 25.5' = 1734 ft²

$A_w = A_1 - A_2 = 76800 - 1734 = 75,066$ ft²

$g = 32.2$ ft/sec²

$$S = \frac{V_1^2}{2g}\left[\left(1.01\left(\frac{A_1}{A_w}\right)\right)^2 - 0.84\right]$$

$$S = \frac{(8.8)^2}{(2)(32.2)}\left[\left(1.01\left(\frac{76800}{75066}\right)\right)^2 - 0.84\right] = 0.3 \text{ feet}$$

b) Nominal Bottom Clearance

use 2.0 feet

c) Roll - According to the Study Report of Vessel Clearance Criteria for the Great Lakes Connecting

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Lake Approach & Outer Entrance Channels

Channels prepared by Michael Baker, Inc for Petroit District, the roll on smaller vessels is greater than for 1000-ft vessels with a value of about 5 degrees. At the 8 April 1981 workshop held in Cleveland, the vessel masters of the 1000-ft vessels indicated that the roll on smaller vessels is about 1½ times that of the 1000 ft vessels or approximately 5 to 7 degrees. This analysis will use 6°.

Y = dept requirement due to roll
B = vessel beam = 68 ft θ = maximum roll in degrees = 6°
Y = ½ B sine θ = (½)(68)(sine 6°) = 3.6 ft.

d) Pitch and Heave - At the 8 April 1981 workshop held with the vessel masters of 1000 ft vessels, it was stated that the masters would not attempt to enter Cleveland Harbor when wave conditions at the entrance exceed 8.0 feet. Therefore the pitch and heave will be determined based on a 8.0 ft wave height.

pitch = $\frac{\theta L}{2}$ = 0.1 H $\frac{Heave}{H}$ = 0.1 where H = wave amplitude, H = 8.0 feet

$\frac{\theta L}{2}$ + heave = (2)(0.1) H = (2)(0.1)(8)

$\frac{\theta L}{2}$ + heave = 1.6 feet

* The roll requirement governs over this pitch and heave value.

e) Required Depth in the Lake Approach and Outer Entrance Channels at the East Entrance for the "ALL WEATHER" Condition by Class 5 Vessels (600'-649' x 68'):

Case 1 utilizes squat value from Graphical Method
Case 2 utilizes squat value from Empirical Method

	Case 1	Case 2
Static Draft	25.5	25.5
Squat	0.1	0.3
Roll	3.6	3.6
Pitch and Heave	*	*
Nominal Clearance	2.0	2.0
Required Depth	31.2 ft	31.4 ft

Use an entrance channel depth of 32.0 feet below LWD in the Lake Approach Channel and Outer Entrance Channel.

C). ALL WEATHER EAST ENTRANCE PLAN

1) Class 10 Vessels (950'-1000' x 105')

a) Squat - Graphical Method

A = Vessel cross sectional area = 105' x 25.5' = 2677.5 ft²
W = channel width = 1000 ft = distance between East Breakwater and Corps disposal area
H = Channel water depth = 28 ft = assumed depth based on minimum design water level

$$S = \frac{A}{WH} = \frac{2677.5}{(1000)(28)} = 0.096$$

V = 3 mph = 4.4 ft/sec (per vessel masters at April 1981 workshop held in Cleveland, OH)

g = acceleration of gravity = 32.2 ft/sec²

$$F = \frac{V}{\sqrt{gH}} = \frac{4.4}{\sqrt{(32.2)(28)}} = 0.15$$

$$D = \frac{Z}{H} = 0.002 \text{ (from Figure C6)}$$

$$Z = 0.002\,H = (0.002)(28) = 0.1 \text{ feet}$$

Squat - Empirical Method

V_1 = Ship velocity relative to water = 3 mph = 4.4 ft/sec
A_1 = Cross sectional area of channel = 1000' x 28' = 28,000 ft²
A_2 = Cross sectional area of vessel = 105' x 25.5' = 2677.5 ft²
$A_w = A_1 - A_2 = 28000 - 2677.5 = 25,322.5$ ft²
g = 32.2 ft/sec²

$$S = \frac{V_1^2}{2g}\left[\left(1.01\left(\frac{A_1}{A_w}\right)\right)^2 - 0.84\right]$$

$$S = \frac{(4.4)^2}{(2)(32.2)}\left[\left(1.01\left(\frac{28,000}{25,322.5}\right)\right)^2 - 0.84\right] = 0.1 \text{ feet}$$

b). Nominal Bottom Clearance
Use 2.0 feet

c) Roll - According to the vessel masters of 1000-foot vessels at the 8 April 1981 workshop, it was indicated that under the conditions which would exist for the 1000 ft vessel to be able to enter Cleveland Harbor (ie. maximum 8.0 ft wave height at the entrance channel), there would be no roll in the inner entrance channel (east basin channel).

d) Pitch and Heave - The inner entrance channel or east basin channel is in the lee of the east breakwater and therefore wave action would be insignificant, except during periods of severe wave overtopping of the breakwater. These waves

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caused by overlapping would be parallel to the hull of the vessel and therefore pitch and heave would be minimal. This analysis will assume no pitch or heave.

2). Required Depth in the inner entrance channel (east basin channel) for the east entrance of class 10 vessels (950'-1000' x105'):

Case 1 utilizes squat value from Graphical Method.
Case 2 utilizes squat value from Empirical Method

	Case 1	Case 2
Static Draft	25.5	25.5
Squat	0.1	0.1
Roll	0.0	0.0
Pitch and Heave	0.0	0.0
Nominal Clearance	2.0	2.0
Required Depth	27.6 ft	27.6 ft

Use an inner entrance channel depth of 28 feet below LWD through the east basin.

D). ALL WEATHER EAST ENTRANCE PLAN

1) Class 10 Vessels (950'-1000' x 105')

a) Squat - Graphical Method

A = Vessel Cross Sectional Area = 105 x 25.5 = 2677.5 ft^2

W = Channel Width = 1150 ft = distance between east and west crosswater spurs and river piers

H = Channel Water Depth = 30 feet = assumed depth based on minimum design water level

$$S = \frac{A}{WH} = \frac{2677.5}{(1150)(30)} = 0.078$$

V = 3 mph = 4.4 ft/sec (per vessel masters at 8 April 81 workshop held in Cleveland, OH)

g = acceleration of gravity = 32.2 ft/sec²

$$F = \frac{V}{\sqrt{gH}} = \frac{4.4}{\sqrt{(32.2)(30)}} = 0.14$$

$$D = \frac{Z}{H} = 0.002 \text{ (from Figure C6)}$$

$$Z = 0.002\,H = (0.002)(30) = 0.1 \text{ feet}$$

Squat - Empirical Method

V_1 = Ship velocity relative to water = 3 mph = 4.4 ft/sec

A_1 = Cross sectional area of channel = 1150' x 30' = 34500 ft^2

A_2 = Cross sectional area of vessel = 105' x 25.5' = 2677.5 ft^2

$A_w = A_1 - A_2 = 34,500 - 2677.5 = 31822.5\ ft^2$

g = 32.2 ft/sec²

$$S = \frac{V_1^2}{2g}\left[\left(1.01\left(\frac{A}{A_w}\right)\right)^2 - 0.84\right]$$

$$S = \frac{(4.4)^2}{(2)(32.2)}\left[\left(1.01\left(\frac{34500}{31822.5}\right)\right)^2 - 0.84\right] = 0.1 \text{ feet}$$

b.) Nominal Bottom Clearance

Use 2.0 feet

c.) Roll - According to the vessel masters at the 8 April 81 Workshop held in Cleveland, a 1000-ft vessel can be expected to roll up to 2-3 degrees as the ship passes the existing main entrance as a result of waves entering between the arrowhead breakwaters. This analysis will use 2 degrees.

Y = depth requirement due to roll

B = vessel beam = 105 ft

θ = maximum roll in degrees = 2°

$$Y = \tfrac{1}{2} B \sin\theta = (\tfrac{1}{2})(105)(\sin 2°) = 1.8 \text{ feet}$$

d) Pitch and Heave – The waves entering through the existing arrowhead (main) entrance would be parallel to the hull of the vessel and therefore pitch and heave would be minimal. This analysis will assume no pitch or heave.

e) Required depth in the east basin channel at the existing arrowhead for the east entrance plan by Class 10 vessels (950'-1000' x 105'):

Case 1 utilizes squat value from Graphical Method
Case 2 utilizes squat value from Empirical Method

	Case 1	Case 2
Static Draft	25.5	25.5
Squat	0.1	0.1
Roll	1.8	1.8
Pitch and Heave	0.0	0.0
Nominal Clearance	2.0	2.0
Required Depth	29.4	29.4

Use an entrance channel depth of 30 feet below LWD in the east basin at the existing arrowhead entrance.

E) FAIR WEATHER WEST ENTRANCE PLAN

1) Class 10 Vessels (950′ - 1000′ x 105′)

a) Squat - Graphical Method

A = vessel cross sectional area = 105′ x 25.5′ = 2677.5 ft^2
W = channel width = 700 feet = distance between parallel extensions on the arrowheads.
H = channel water depth = 29.0 feet = existing project depth on minimum design water level

$$S = \frac{A}{WH} = \frac{2677.5}{(700)(29)} = 0.13$$

V = 3 mph = 4.4 ft/sec (per vessel masters at 8 April 1981 workshop held in Cleveland, OH)
g = acceleration of gravity = 32.2 ft/sec^2

$$F = \frac{V}{\sqrt{gH}} = \frac{4.4}{\sqrt{(32.2)(29)}} = 0.14$$

$$D = \frac{Z}{H} = 0.005 \quad \text{(from Figure C6)}$$

$$Z = 0.005\,H = (0.005)(29) = 0.2 \text{ feet}$$

Squat - Empirical Method

V_1 = Ship velocity relative to water = 3 mph = 4.4 ft/sec
A_1 = Cross sectional area of channel = 700′ x 29′ = 20,300 ft^2
A_2 = Cross sectional area of vessel = 105′ x 25.5′ = 2677.5 ft^2
$A_w = A_1 - A_2 = 20{,}300 - 2677.5 = 17{,}622.5\ ft^2$
g = 32.2 ft/sec^2

$$S = \frac{V_1^2}{2g}\left[\left(1.01\left(\frac{A_1}{A_w}\right)\right)^2 - 0.84\right]$$

$$S = \frac{(4.4)^2}{2(32.2)}\left[\left(1.01\left(\frac{20{,}300}{17{,}622.5}\right)\right)^2 - 0.84\right] = 0.2 \text{ feet}$$

b). Nominal Bottom Clearance:

Use 2.0 feet

c). Roll

- At the 8 April 1981 workshop held in Cleveland with the vessel masters of 1000 ft vessels, it was stated that under the conditions which would exist for the 1000 ft vessel to be able to enter Cleveland Harbor as a fair weather harbor, There would be no roll.

d). Pitch and Heave

- At the 8 April 1981 workshop held with the vessel masters of 1000 ft vessels, it was stated that the masters would not attempt to enter Cleveland Harbor as a fair weather harbor when wave conditions at the entrance exceed 4.0 feet. Therefore, the pitch and heave will be determined based on a 4.0 ft wave height.

$$\text{pitch} = \frac{\theta L}{2} = 0.1H \qquad \frac{\text{Heave}}{H} = 0.1 \quad \text{where } H = \text{wave amplitude}, \; H = 4.0 \text{ feet}$$

$$\frac{\theta L}{2} + \text{Heave} = (2)(0.1)(H) = (2)(0.1)(4)$$

$$\frac{\theta L}{2} + \text{Heave} = 0.8 \text{ feet}$$

*Pitch and heave requirement governs over the roll value

2). <u>Required Depth in the Outer Entrance Channel at the West Entrance</u> for the fair weather condition by the class 10 vessels (950'-1000' x 105'):

Case 1 utilizes the squat value from the Graphical Method
Case 2 utilizes the squat value from the Empirical Method

	Case 1	Case 2
Static Draft	25.5	25.5
Squat	0.2	0.2
Roll	*	*
Pitch and Heave	0.8	0.8
Nominal Clearance	2.0	2.0
Required Depth	28.5 ft	28.5 ft

Use the existing project depth of 29 feet below LWD in the lake approach channel and entrance channel.

BY KJG DATE .... SUBJECT Cleveland Harbor, OH SHEET NO. 1F OF 2F
CHKD. BY .... DATE .... Channel Depth Requirements for JOB NO. ....
Cuyahoga River

F). CUYAHOGA RIVER DEEPENING

1) Class 5 Vessels (630 feet × 68 feet)

a) Squat - Graphical Method

A = Vessel Cross Sectional Area = 68 × 25.5 = 1734 ft²

W = Channel Width = 105 feet = minimum width on river which is located at Cerial Foods Processor, Inc. dock.

H = Channel Water Depth = 28.0 feet = assumed depth based on minimum design water level

$$S = \frac{A}{WH} = \frac{1734}{(105)(28)} = 0.59$$

V = 2 mph = 2.93 ft/sec

g = acceleration of gravity = 32.2 ft/sec²

$$F = \frac{V}{\sqrt{gH}} = \frac{2.93}{\sqrt{(32.2)(28)}} = 0.10$$

$$D = \frac{Z}{H} = 0.01$$ (the value for S exceeds the value for S in Figure C6, however the upper value in the Figure will be used.)

$$Z = 0.01(H) = (0.01)(28) = 0.3 \text{ feet}$$

Squat - Empirical Method

V_1 = Ship velocity relative to water = 2 mph = 2.93 ft/sec

A_1 = Cross sectional area of channel = 105′ × 28′ = 2940 ft²

A_2 = Cross sectional area of vessel = 68′ × 25.5′ = 1734 ft²

$A_W = A_1 - A_2 = 2940 - 1734 = 1206$ ft²

g = 32.2 ft/sec²

$$S = \frac{V_1^2}{2g}\left[\left(1.01\left(\frac{A_1}{A_W}\right)\right)^2 - 0.84\right]$$

$$S = \frac{(2.93)^2}{(2)(32.2)}\left[\left(1.01\left(\frac{2940}{1206}\right)\right)^2 - 0.84\right] = 0.7 \text{ feet}$$

Use a squat value of 0.7 feet as the depth requirement.

b) Nominal Bottom Clearance

Use 2.0 feet

c) Vessel Roll

The amount of vessel roll in the Cuyahoga River would be insignificant. A vessel on the river would not encounter waves parallel to its hull which would cause the vessel to roll. Wind on the side of the vessel may cause an insignificant amount of roll. A vessel equipped with side thrusters and traveling at 2 mph would probably not experience any roll while making a turn in the bend. Therefore, use 0.0 feet for vessel roll requirement.

d. Pitch and Heave

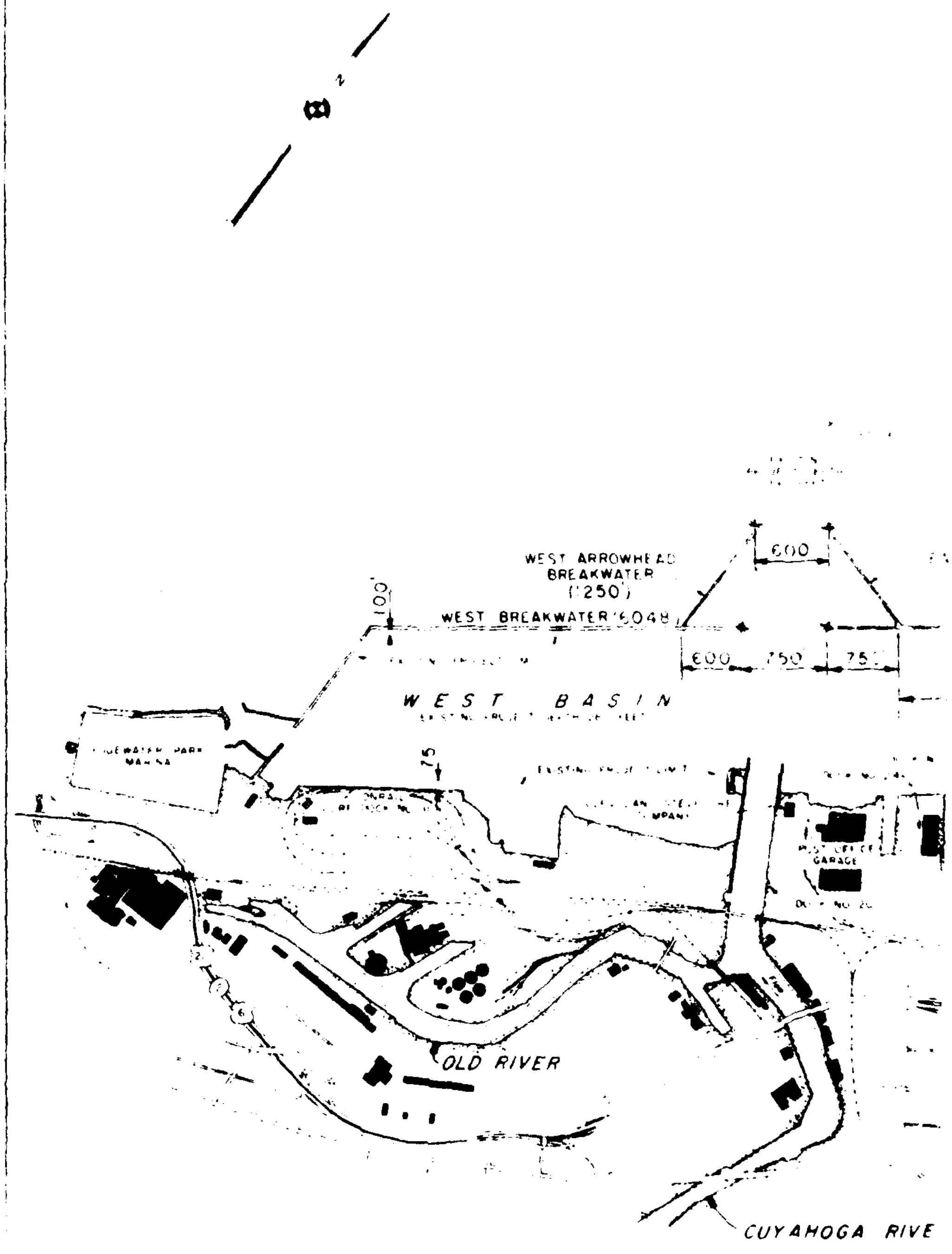
A vessel traveling on the Cuyahoga River would not encounter waves with a sufficient wave length to cause the vessel to experience pitch or heave. Therefore, use 0.0 feet for vessel pitch and heave requirement

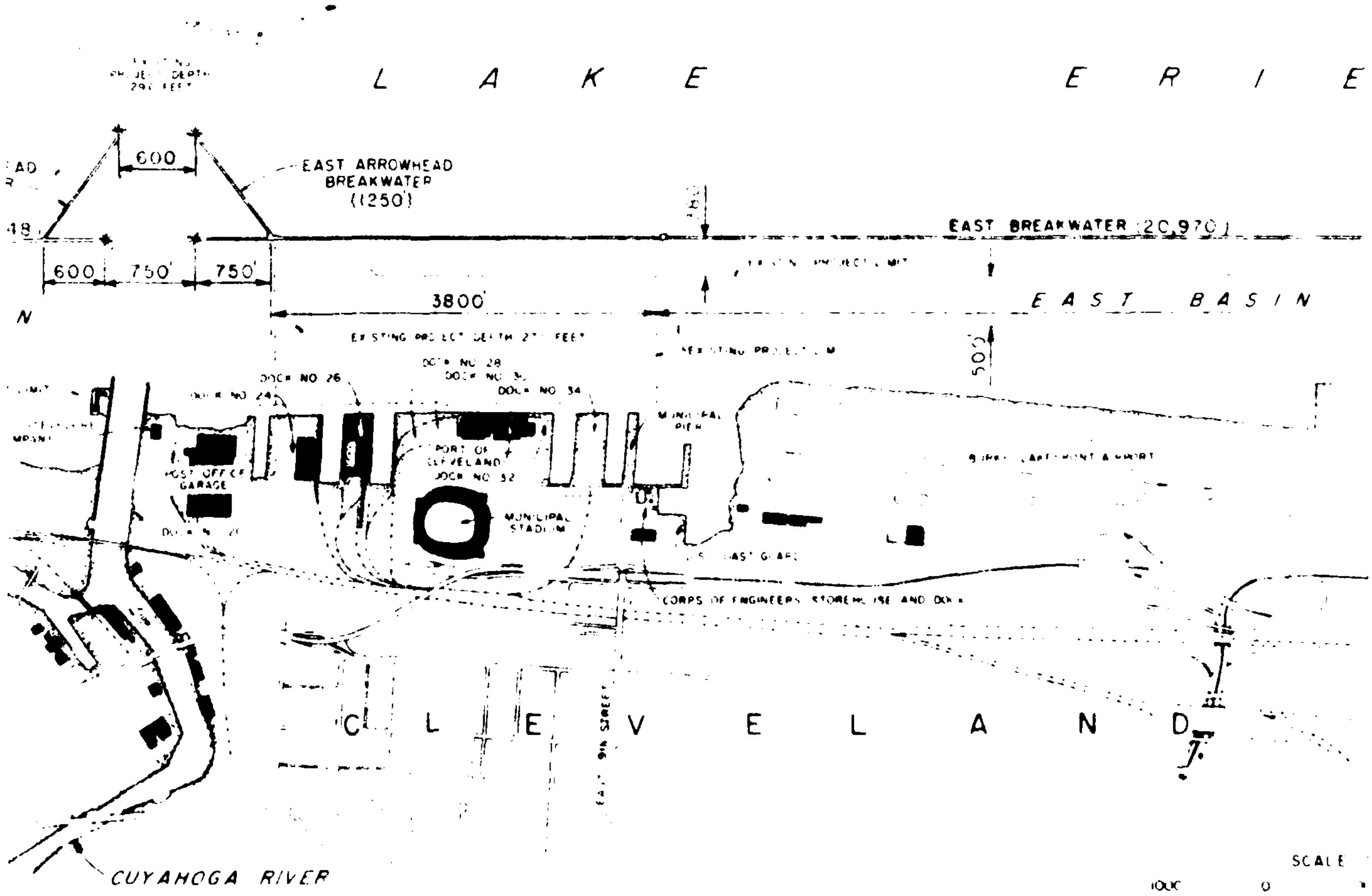
e) Required depth in the Cuyahoga River

Case 1 utilizes squat value from Graphical Method
Case 2 utilizes squat value from Empirical Method

	Case 1	Case 2
Static Draft	25.5	25.5
Squat	0.3	0.7
Roll	0.0	0.0
Pitch and Heave	0.0	0.0
Nominal Clearance	2.0	2.0
Required Depth	27.8	28.2

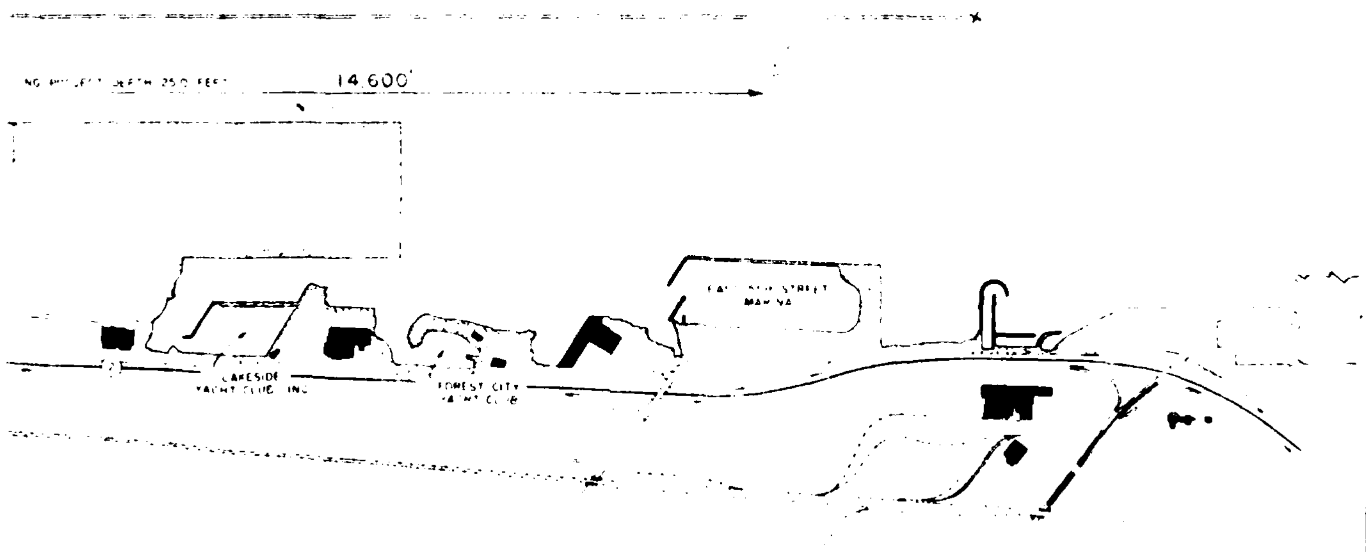
Use a river channel depth of 28 feet below LWD on the Cuyahoga River


WEST ARROWHEAD
BREAKWATER
('250')
WEST BREAKWATER (6048')
600
600
750
750
100'
75
WEST BASIN
OLD RIVER
CUYAHOGA RIVE
POST OFFICE
GARAGE



LAKE ERIE
600
EAST ARROWHEAD BREAKWATER (1250')
EAST BREAKWATER (20,970')
600
750'
750'
3800'
EAST BASIN
500'
DOCK NO. 26
DOCK NO. 24
DOCK NO. 28
DOCK NO. 34
POST OFFICE GARAGE
PORT OF CLEVELAND DOCK NO. 32
MUNICIPAL STADIUM
MUNICIPAL PIER
CORPS OF ENGINEERS STOREHOUSE AND DOCK
CLEVELAND
CUYAHOGA RIVER
SCALE

2



NOTE

ALL DEPTHS ARE REFERRED TO LOW WATER DATUM EL 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD 1955) INTERNATIONAL GREAT LAKES DATUM 1955

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

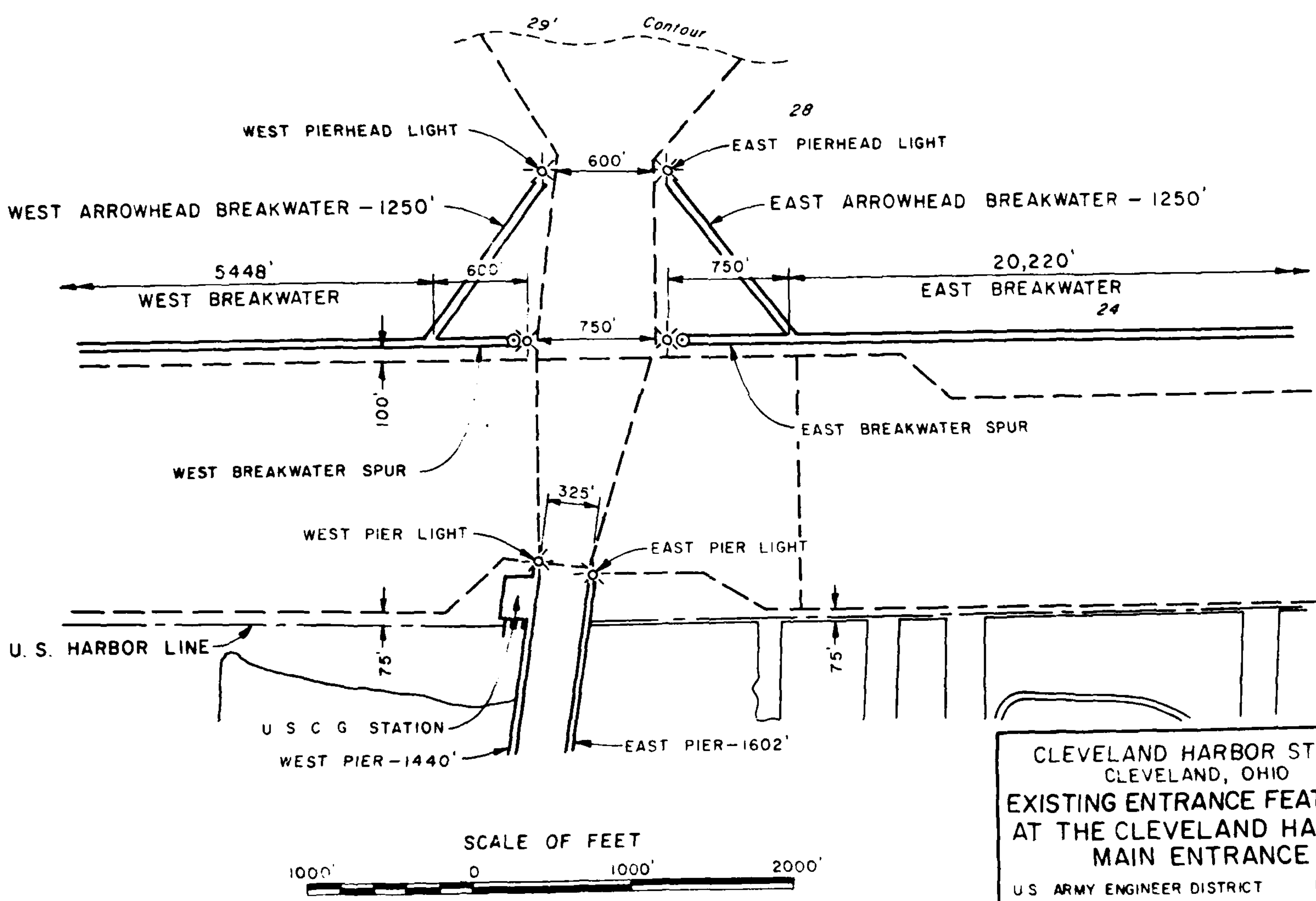
EXISTING
LAKEFRONT HARBOR AREA

U.S. ARMY ENGINEER DISTRICT BUFFALO

JULY 1982

3

PLATE C1



CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

EXISTING ENTRANCE FEATURES AT THE CLEVELAND HARBOR MAIN ENTRANCE

U S ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE C2

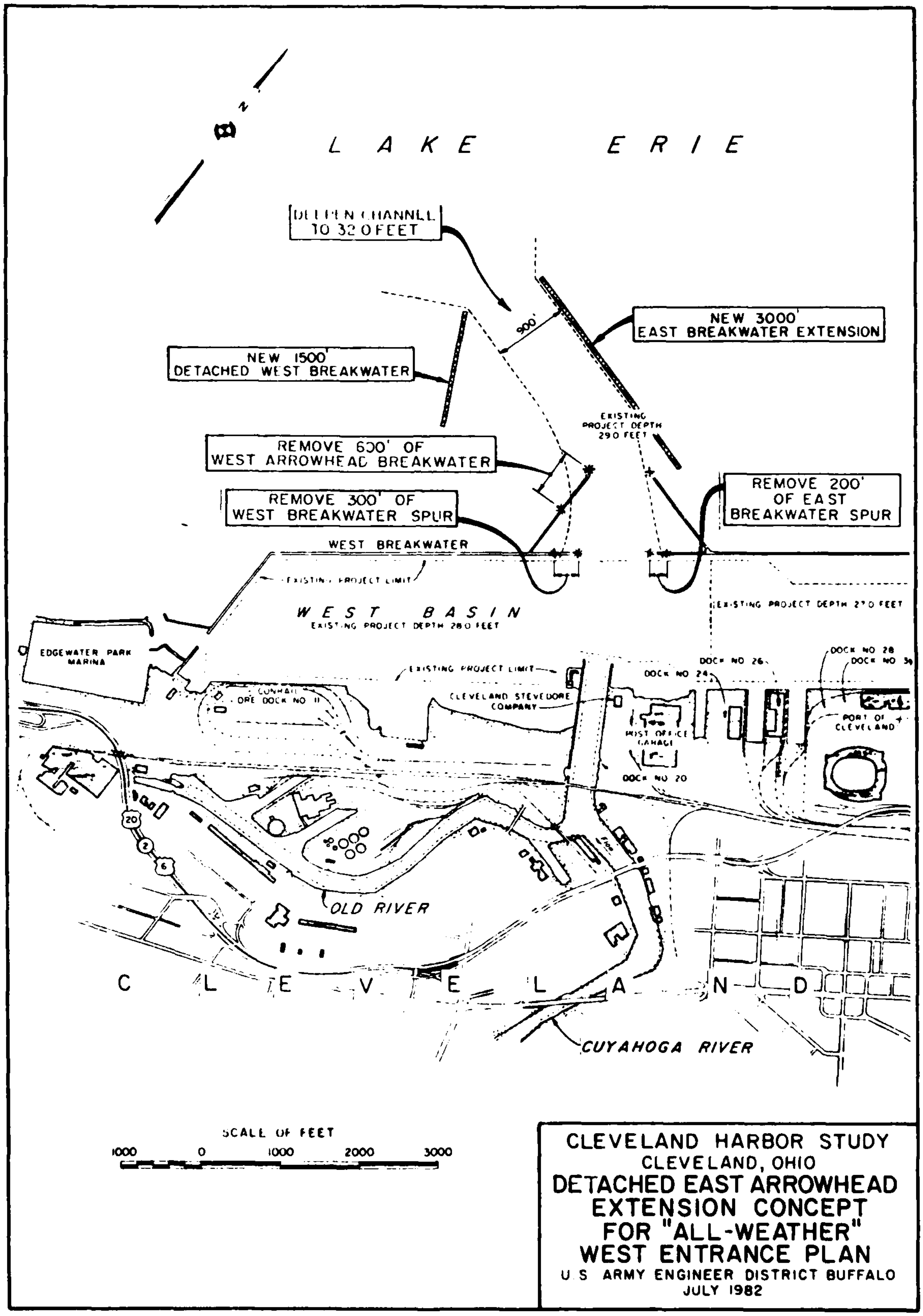
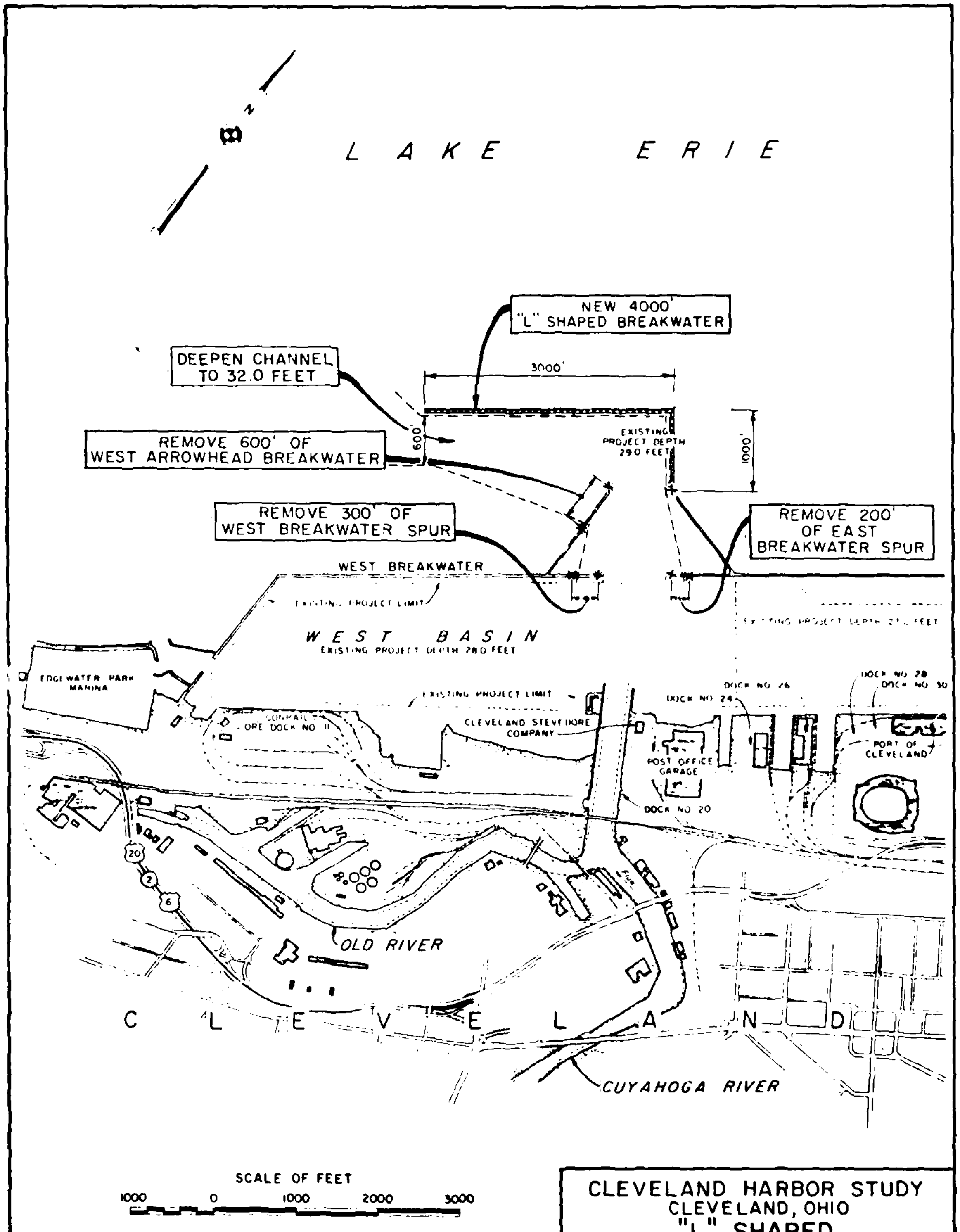
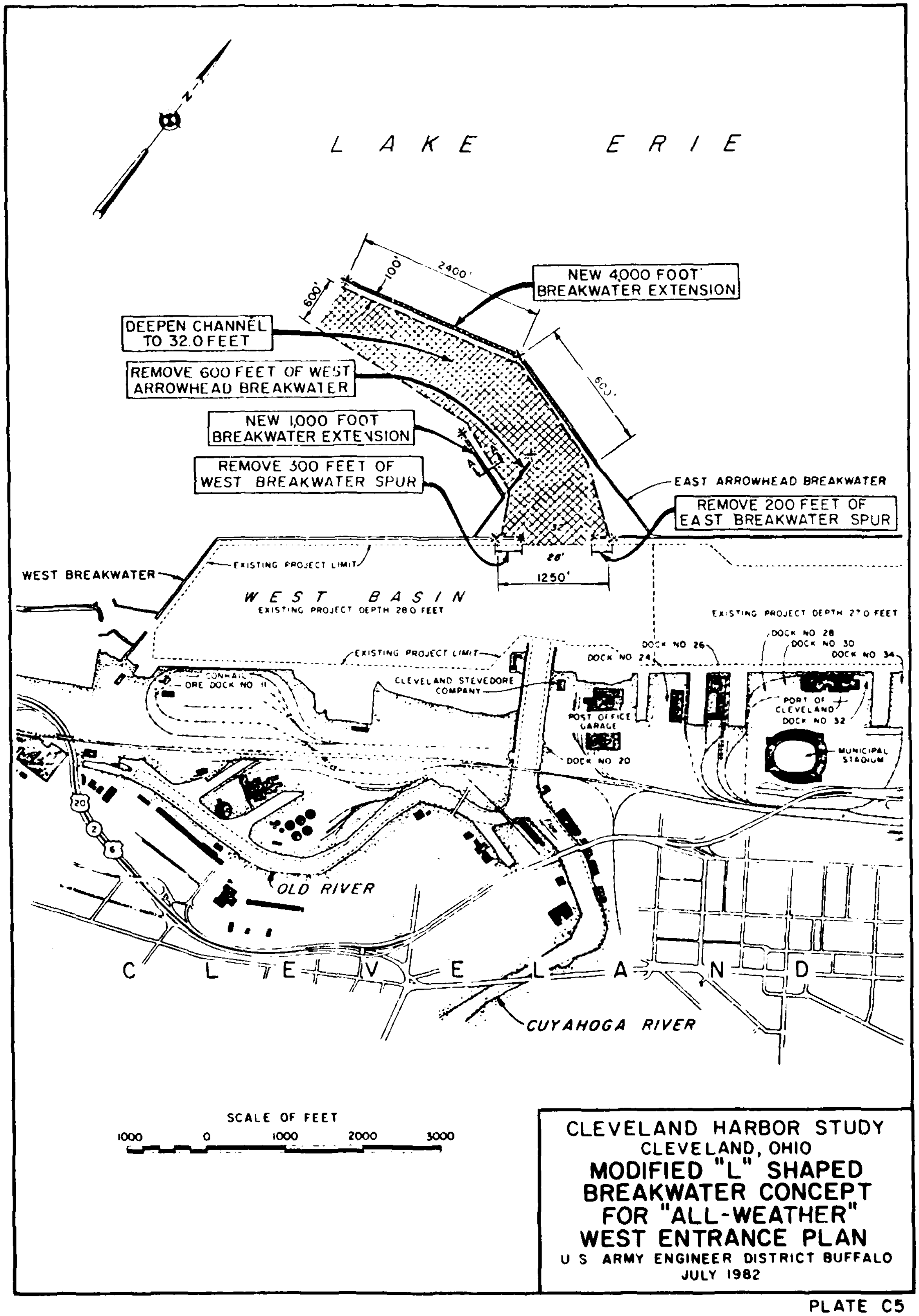

LAKE ERIE
DEEPEN CHANNEL TO 32.0 FEET
900'
NEW 3000' EAST BREAKWATER EXTENSION
NEW 1500' DETACHED WEST BREAKWATER
EXISTING PROJECT DEPTH 29.0 FEET
REMOVE 600' OF WEST ARROWHEAD BREAKWATER
REMOVE 300' OF WEST BREAKWATER SPUR
REMOVE 200' OF EAST BREAKWATER SPUR
WEST BREAKWATER
EXISTING PROJECT LIMIT
WEST BASIN
EXISTING PROJECT DEPTH 28.0 FEET
EXISTING PROJECT DEPTH 27.0 FEET
EDGEWATER PARK MARINA
EXISTING PROJECT LIMIT
CLEVELAND STEVEDORE COMPANY
DOCK NO 26
DOCK NO 24
DOCK NO 28
DOCK NO 32
PORT OF CLEVELAND
DOCK NO 20
OLD RIVER
CLEVELAND
CUYAHOGA RIVER
SCALE OF FEET
1000 0 1000 2000 3000
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
DETACHED EAST ARROWHEAD EXTENSION CONCEPT FOR "ALL-WEATHER" WEST ENTRANCE PLAN
U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE C3



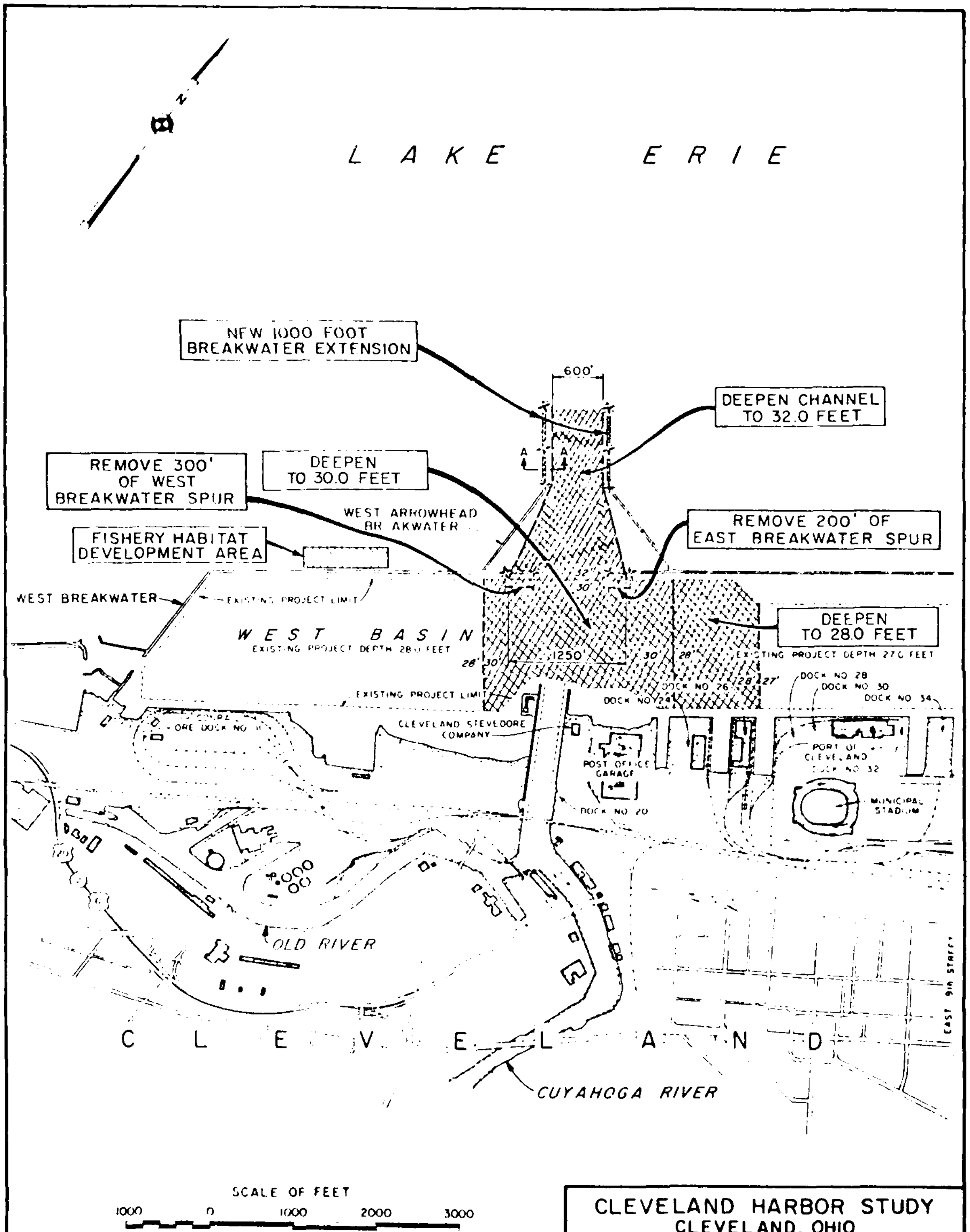
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
"L" SHAPED
BREAKWATER CONCEPT
FOR "ALL-WEATHER"
WEST ENTRANCE PLAN
U S ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE C4



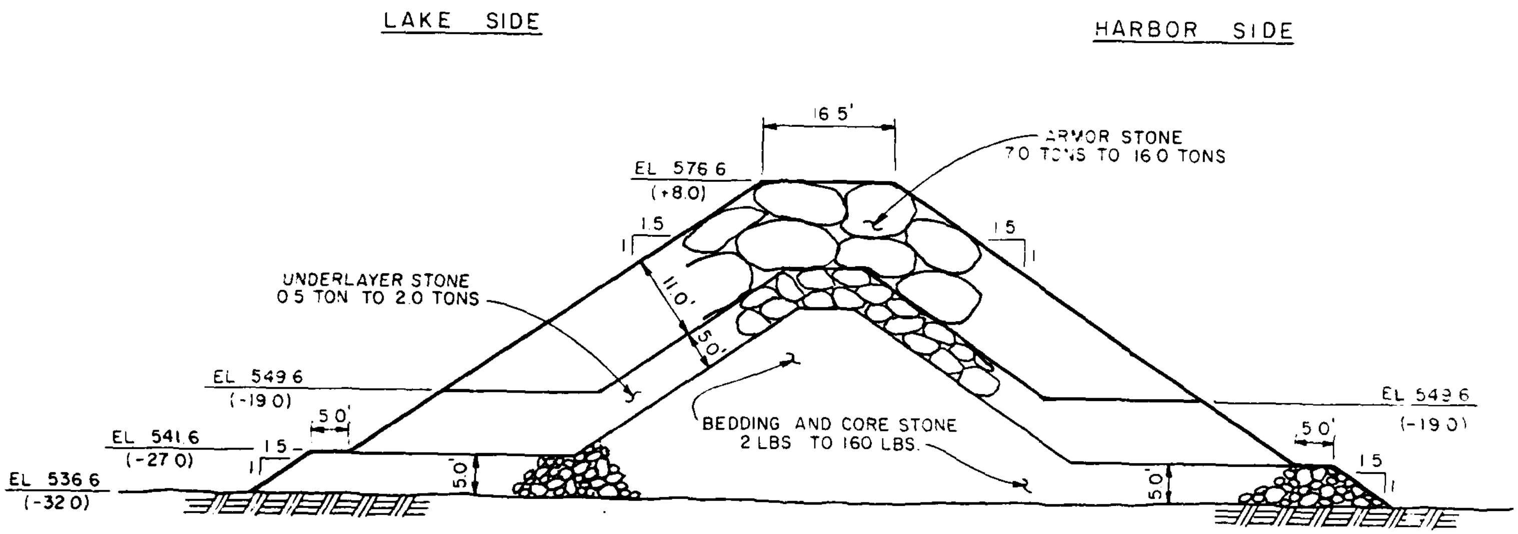
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
MODIFIED "L" SHAPED BREAKWATER CONCEPT FOR "ALL-WEATHER" WEST ENTRANCE PLAN
U S ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE C5



CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
1000' PARALLEL BREAKWATER EXTENSIONS CONCEPT FOR "ALL-WEATHER" WEST ENTRANCE PLAN
U S ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

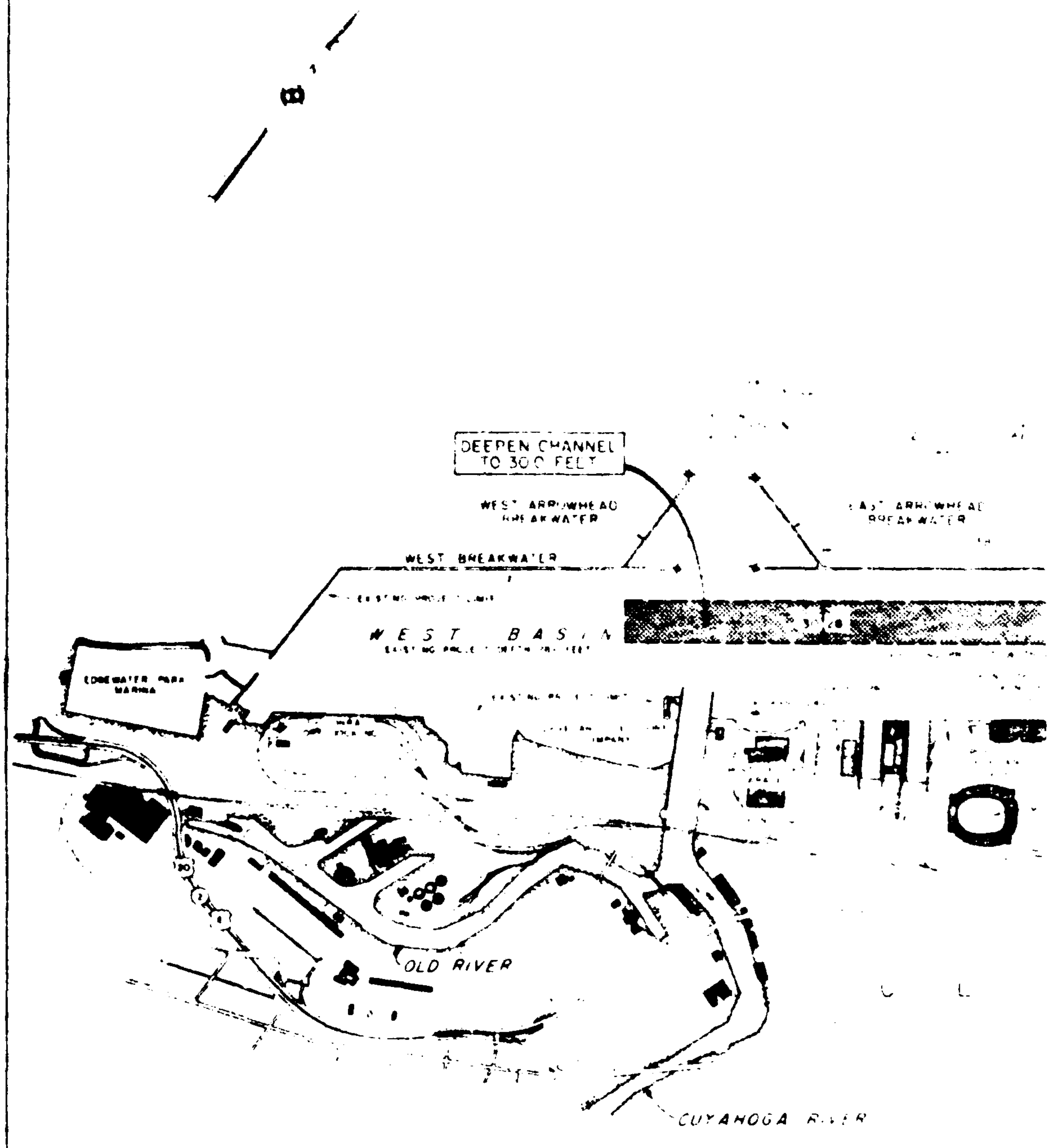
PLATE C6

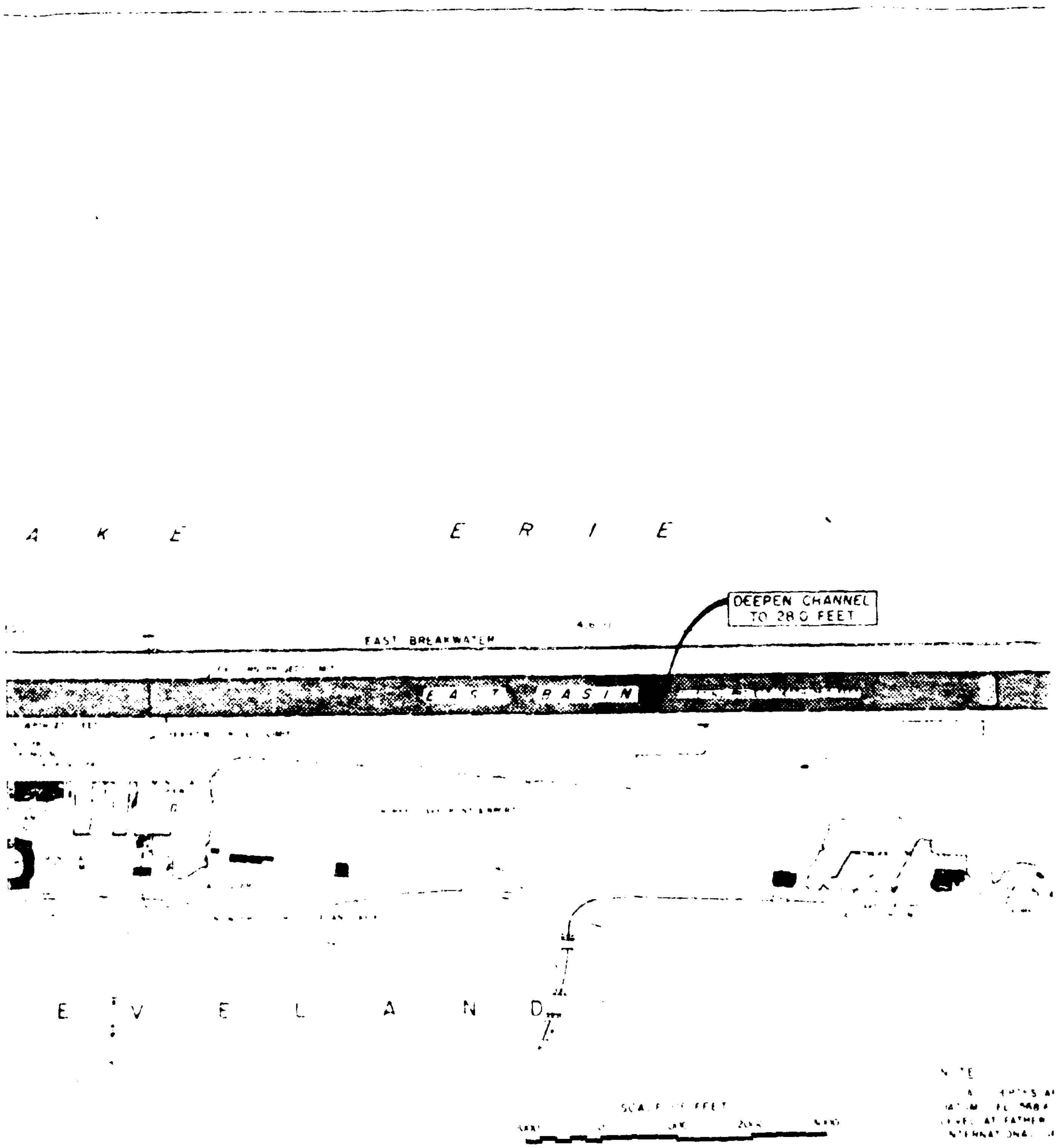


TYPICAL BREAKWATER SECTION

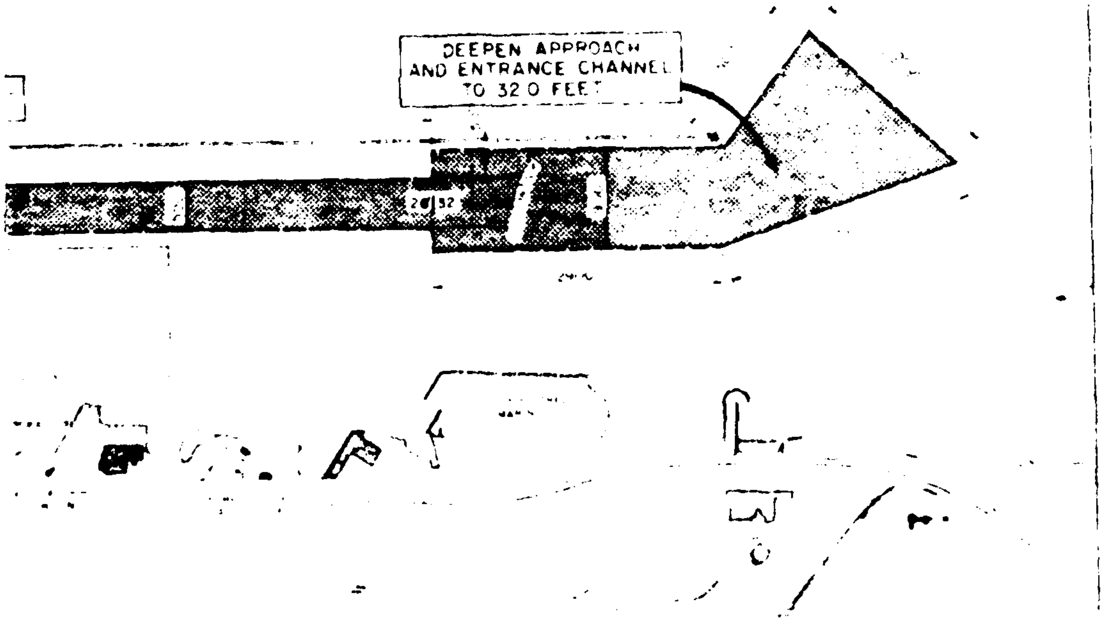
SCALE: 1" = 20'

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
TYPICAL BREAKWATER SECTION
FOR "ALL-WEATHER"
WEST ENTRANCE PLAN
U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982


DEEPEN CHANNEL
TO 30.0 FEET
WEST ARROWHEAD
BREAKWATER
EAST ARROWHEAD
BREAKWATER
WEST BREAKWATER
WEST BASIN
EDGEWATER PARK
MARINA
OLD RIVER



DEEPEN CHANNEL
TO 28.0 FEET
EAST BREAKWATER
EAST BASIN

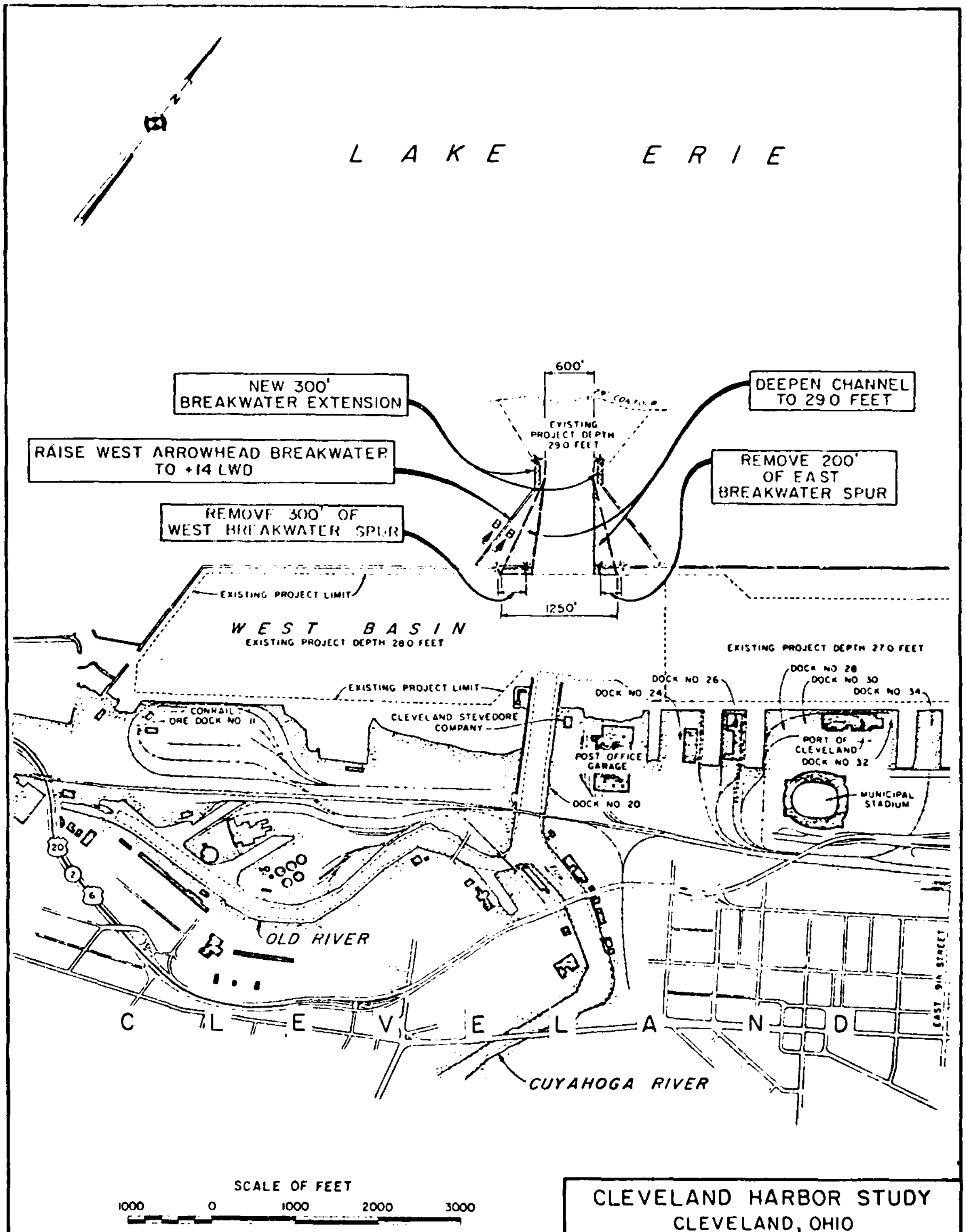


NOTE

ALL DEPTHS ARE REFERRED TO LOW WATER DATUM (EL 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD 1955) INTERNATIONAL GREAT LAKES DATUM 1955)

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 1
"ALL WEATHER"
EAST ENTRANCE PLAN

U.S. ARMY ENGINEER DISTRICT, BUFFALO

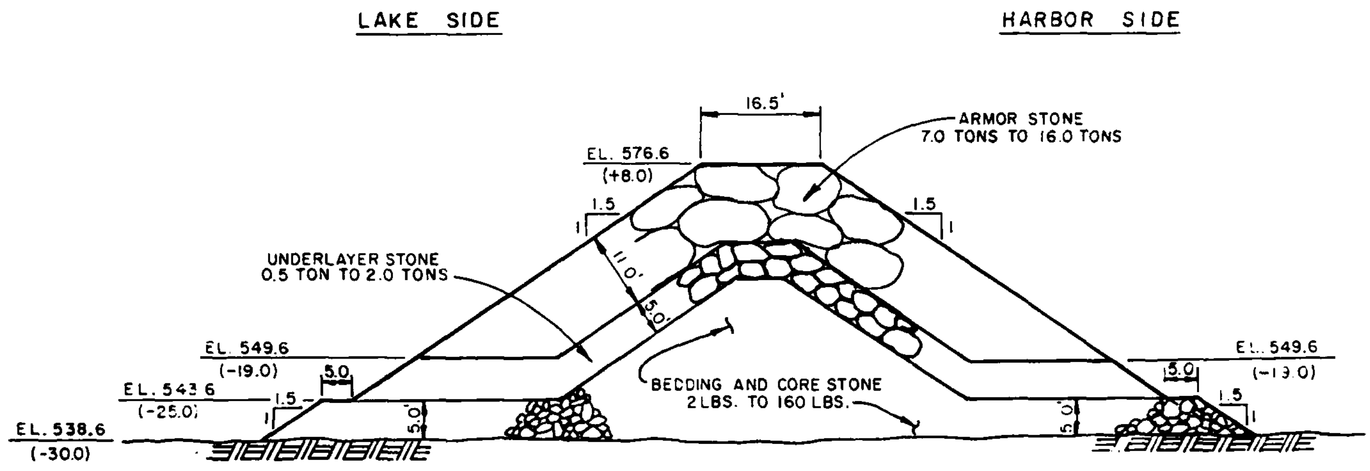


CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

"FAIR-WEATHER"
WEST ENTRANCE PLAN

U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE C9



TYPICAL BREAKWATER SECTION FOR EAST AND WEST ARROWHEAD EXTENSIONS

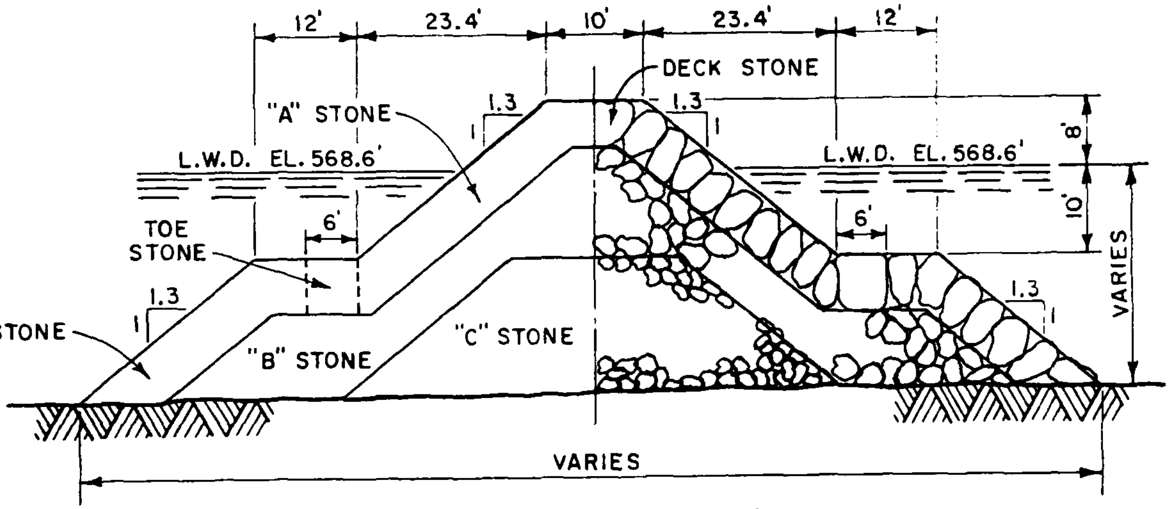
SCALE: 1" = 20'

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

TYPICAL BREAKWATER SECTION
"FAIR–WEATHER"
WEST ENTRANCE PLAN

U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE C10



(BUILT 1904 - 1909)

NOTES:

A STONE - MIN. WEIGHT 3 TONS, NOT LESS THAN 50% 5 TONS OR MORE.

B STONE - MIN. WEIGHT 100 LBS.

C STONE - NOT LESS THAN 35% 75 LBS. OR MORE, NOT MORE THAN 3% LESS THAN 1 LB.

D STONE - MIN. WEIGHT 3 TONS.

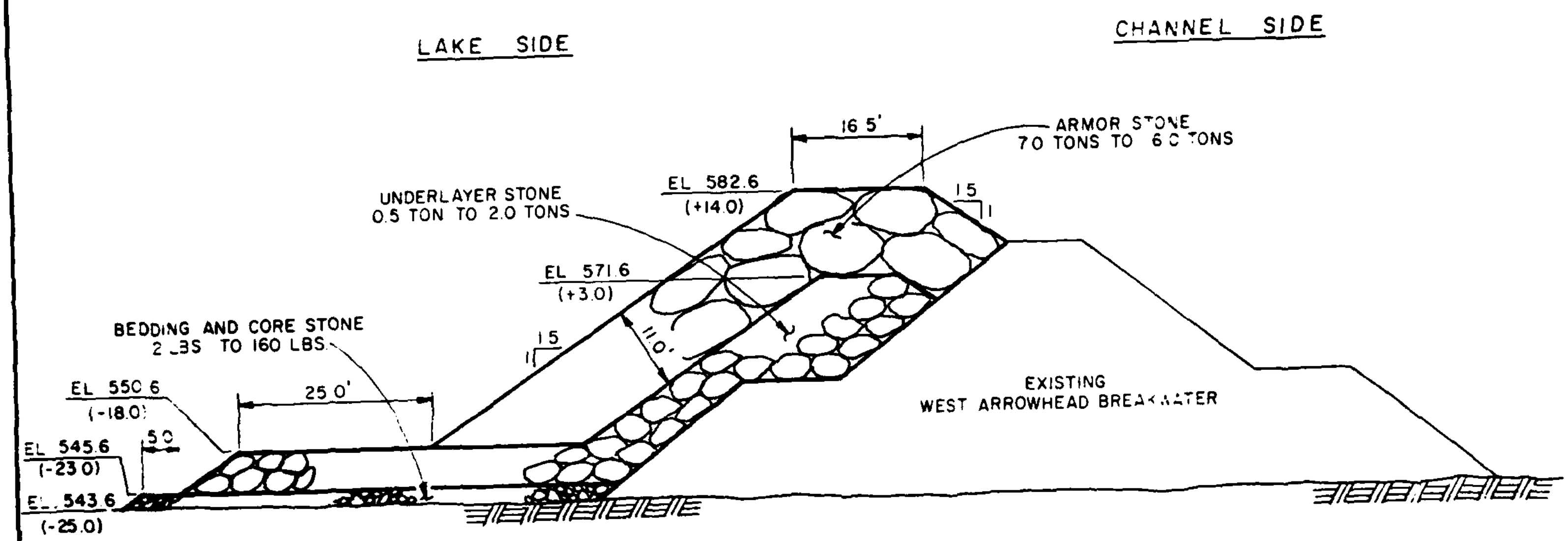
DECK STONE - MIN. WEIGHT 5 TONS.

TOE STONE - MIN. WEIGHT 7 TONS.

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

TYPICAL SECTION OF EXISTING WEST ARROWHEAD BREAKWATER

U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982



TYPICAL NEW WEST ARROWHEAD BREAKWATER SECTION

SCALE: 1" = 20'-0"

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
TYPICAL BREAKWATER SECTION
"FAIR-WEATHER"
WEST ENTRANCE PLAN
U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE C12

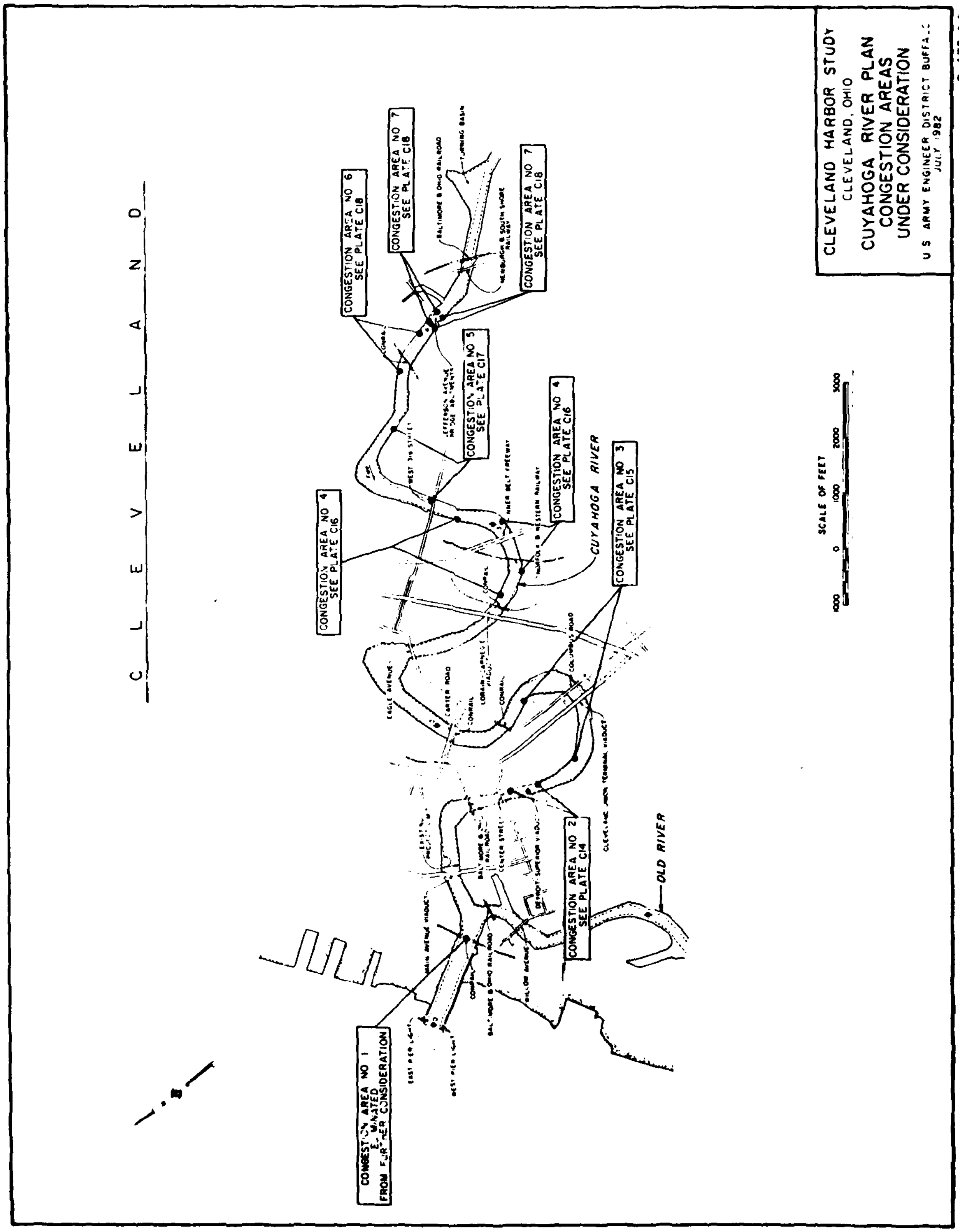
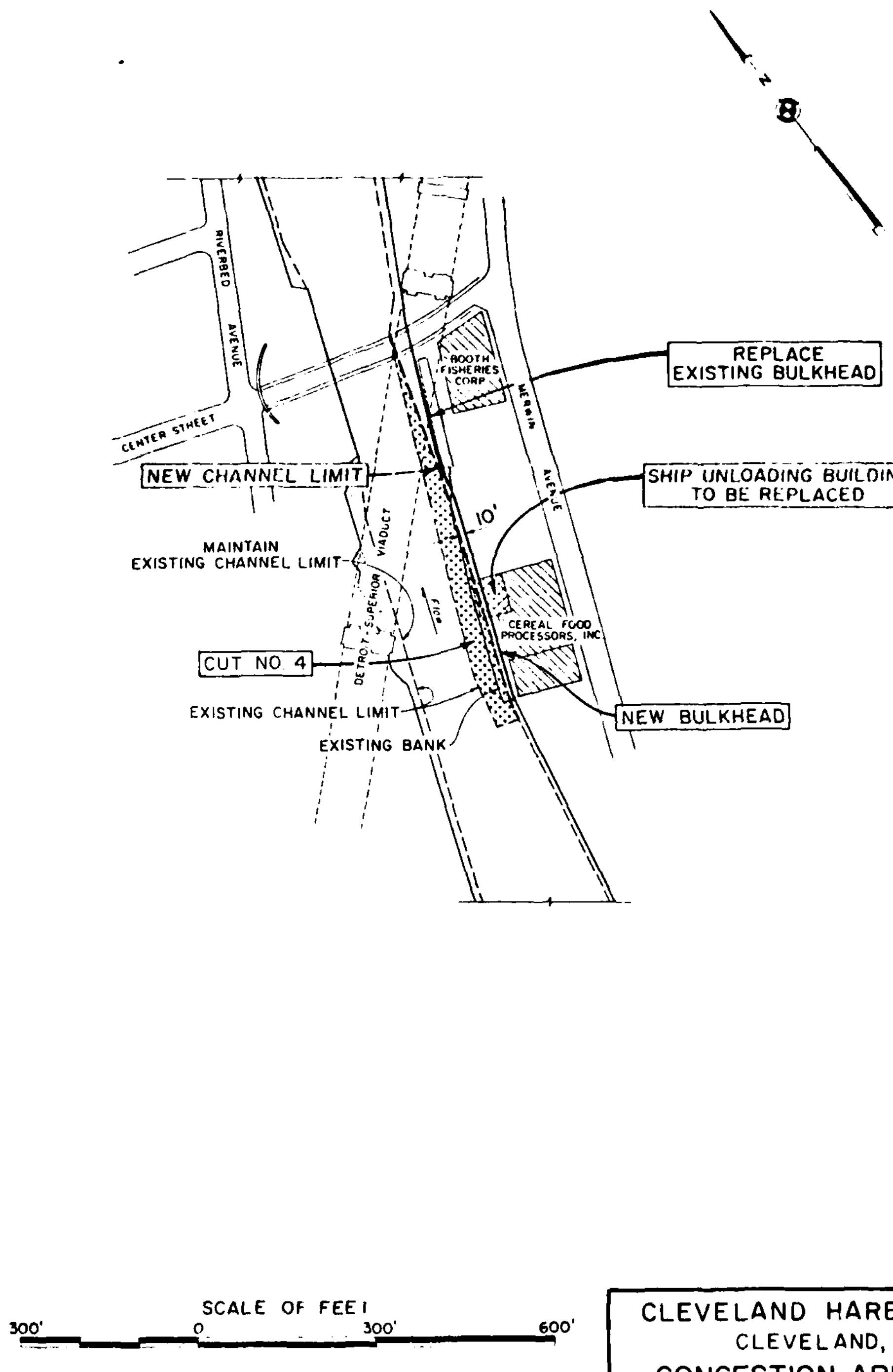
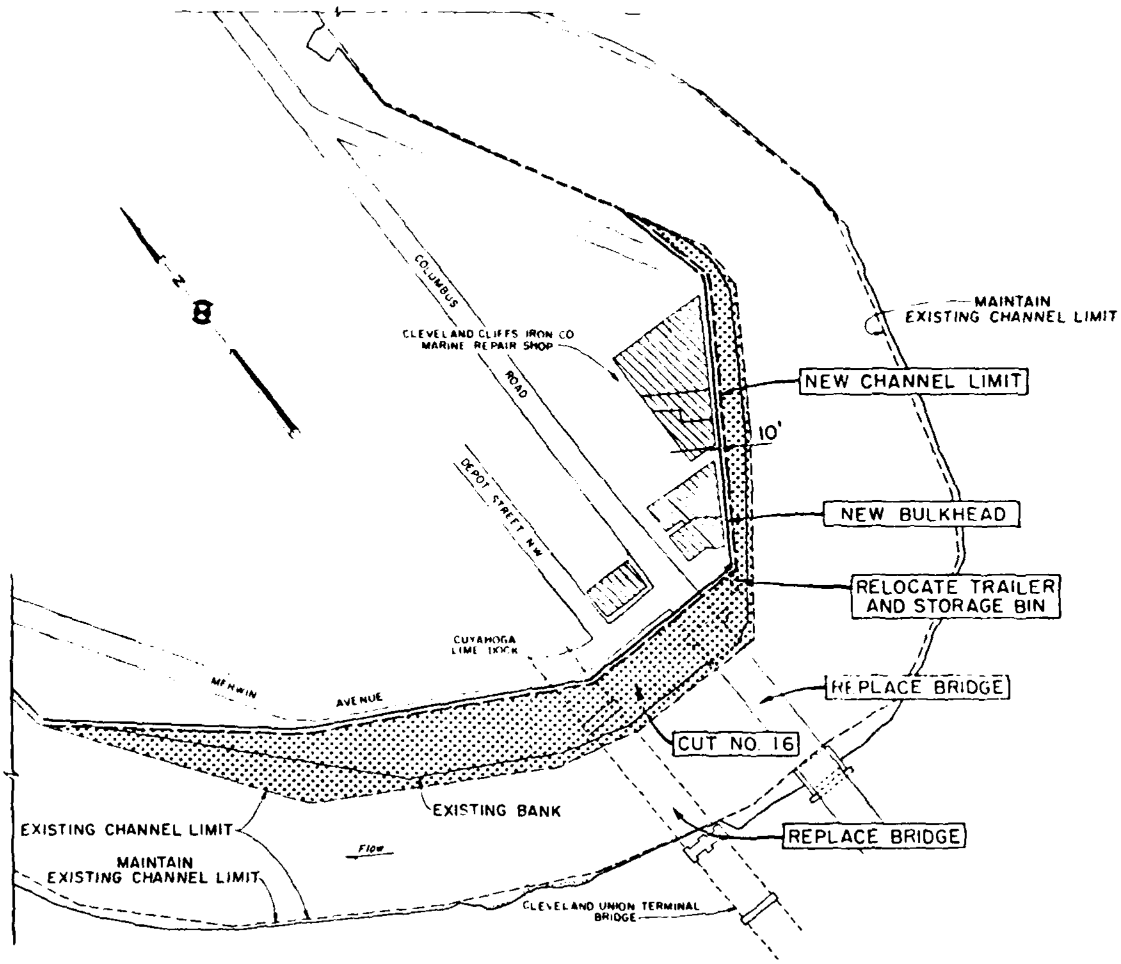

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
CUYAHOGA RIVER PLAN
CONGESTION AREAS
UNDER CONSIDERATION
U S ARMY ENGINEER DISTRICT BUFFALO
JULY 1982
C L E V E L A N D
CUYAHOGA RIVER
OLD RIVER
SCALE OF FEET
CONGESTION AREA NO 1 ELIMINATED FROM FURTHER CONSIDERATION
CONGESTION AREA NO 2 SEE PLATE C14
CONGESTION AREA NO 3 SEE PLATE C15
CONGESTION AREA NO 4 SEE PLATE C16
CONGESTION AREA NO 4 SEE PLATE C16
CONGESTION AREA NO 5 SEE PLATE C17
CONGESTION AREA NO 6 SEE PLATE C18
CONGESTION AREA NO 7 SEE PLATE C18
CONGESTION AREA NO 7 SEE PLATE C18
EAGLE AVENUE
CARTER ROAD
COLUMBUS ROAD
WEST 3rd STREET
INNER BELT FREEWAY
CONRAIL
TURNING BASIN

PLATE C13



CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
CONGESTION AREA NO. 2
RESTRICTION
AND PROPOSED WIDENING
U S ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE C14



SCALE OF FEET

300' 0 300' 600'

CLEVELAND HARBOR STUDY

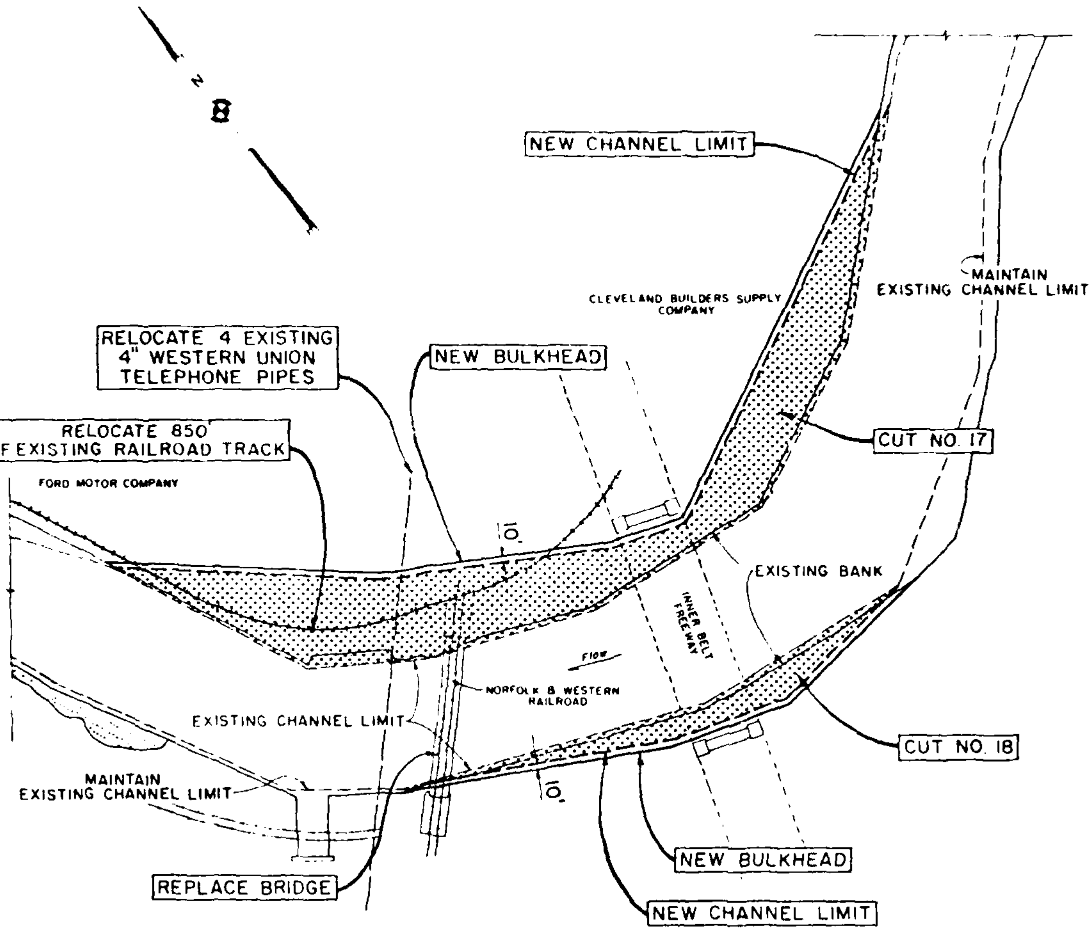
CLEVELAND, OHIO

CONGESTION AREA NO. 3 RESTRICTION AND PROPOSED WIDENING

U S ARMY ENGINEER DISTRICT BUFFALO

JULY 1982

PLATE C15



SCALE OF FEET

300' 0 300' 600'

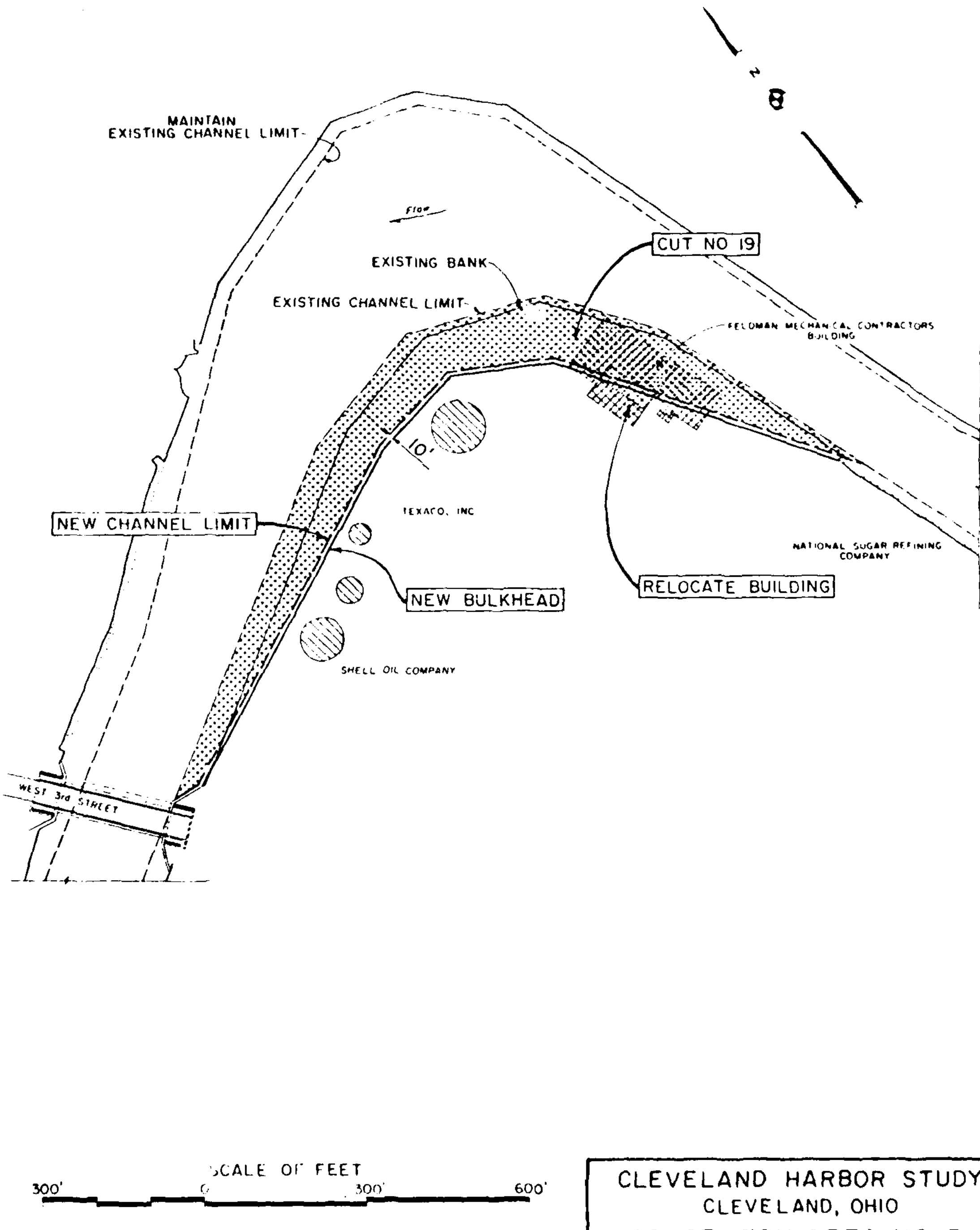
CLEVELAND HARBOR STUDY

CLEVELAND, OHIO

CONGESTION AREA NO. 4 RESTRICTION AND PROPOSED WIDENING

U.S. ARMY ENGINEER DISTRICT BUFFALO

JULY 1982



CLEVELAND HARBOR STUDY

CLEVELAND, OHIO

CONGESTION AREA NO. 5

RESTRICTION

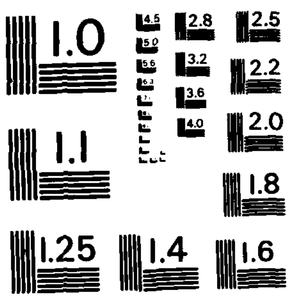
AND PROPOSED WIDENING

U.S. ARMY ENGINEER DISTRI[illegible] B[illegible]

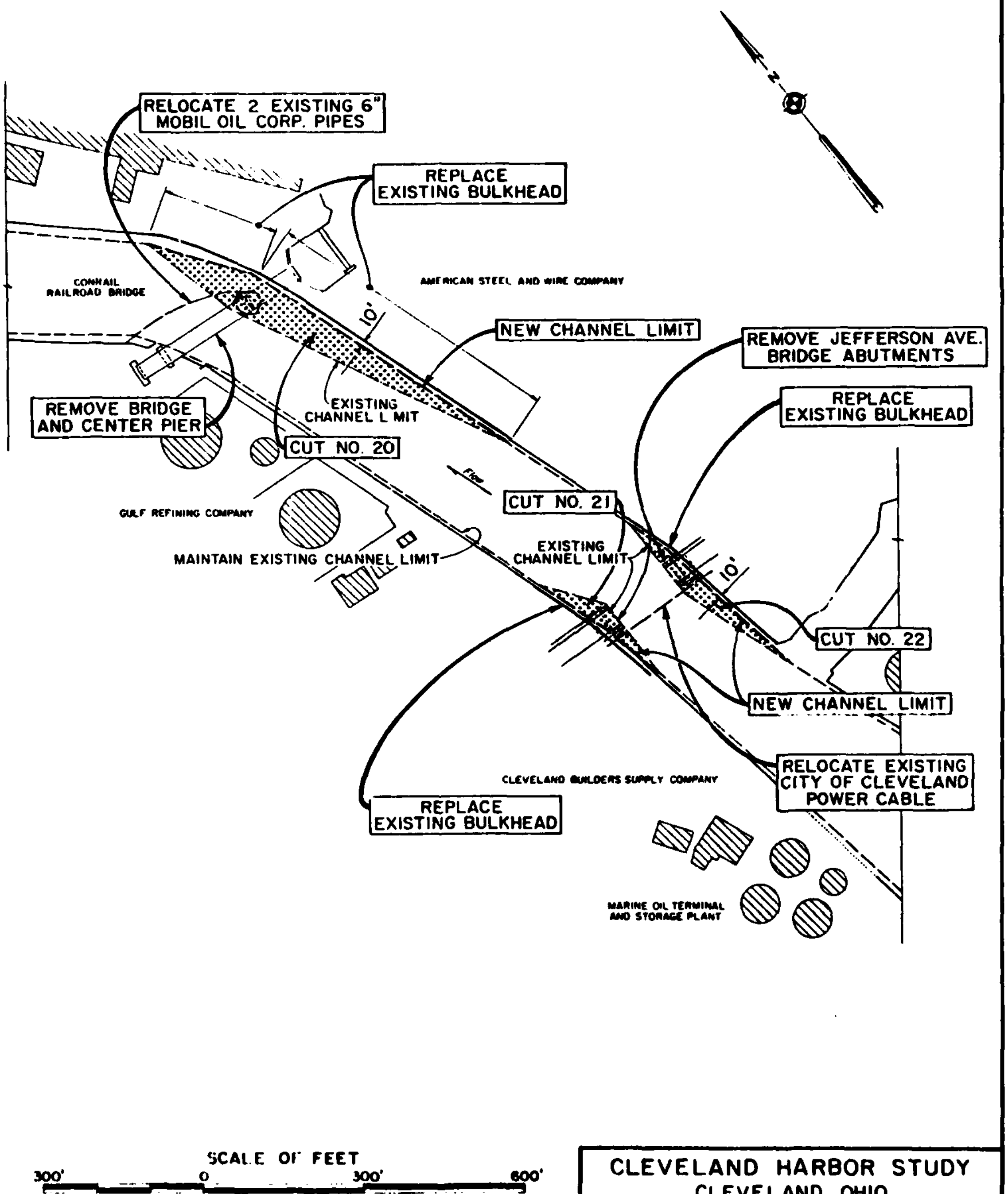
JULY 196[illegible]

AD-A127 218 STAGE 2 REPORT FOR REFORMULATION PHASE I GENERAL DESIGN MEMORANDUM CLEVEL..(U) CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT FEB 83 4/7

UNCLASSIFIED F/G 13/10 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

CONGESTION AREA NO. 6 & 7
RESTRICTION
AND PROPOSED WIDENING

U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE C18

APPENDIX D

DESIGN

CLEVELAND HARBOR, OHIO

STAGE 2 REPORT

OF

REFORMULATION PHASE I GENERAL DESIGN MEMORANDUM

U. S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, NY 14207

CLEVELAND HARBOR, OHIO

STAGE 2 REPORT
OF
REFORMULATION PHASE I
GENERAL DESIGN MEMORANDUM

APPENDIX D
DESIGN

TABLE OF CONTENTS

PLATES

APPENDIX D

DESIGN

D1. INTRODUCTION

The design work involved in the Cleveland Harbor Stage 2 study is concerned primarily with the design of anchored steel sheetpile walls or bulkheads for three alternatives, proposing either deepening, widening or a combination of deepening and widening, of the Cuyahoga and Old Rivers.

Alternative 6, Options A and B involve deepening of the Cuyahoga River to depths of 25.5 feet and 28.0 feet, respectively, below low water datum (EL 568.6). Alternative 7 involves widening of the Cuyahoga River at a number of locations to reduce congestion and facilitate ship movements. Alternative 5 involves both deepening the Old River to a depth of 28.0 feet below low water datum (EL 568.6) and widening at constricted areas to allow longer, deeper-draft vessels access to the river. The design problems and assumptions, for each of the three alternatives, will be presented separately.

D2. ALTERNATIVE 6 - CUYAHOGA RIVER DEEPENING

This alternative involves deepening the navigation channel of the Cuyahoga River from it's present depth of 23.0 feet below LWD to 25.5 feet below LWD for Option A and 28.0 feet below LWD for Option B. The method of approach involved investigation of the most critical loading condition for the existing bulkhead walls first, to determine how many linear feet of wall would require replacement due to the improved depth of 31.0 feet (28.0 feet plus 3.0 feet of overdepth). From the results of this investigation , it would then be possible to determine the linear feet of replacement wall that would be required for the improved depth of 28.5 feet (25.5 feet plus 3.0 feet of overdepth).

Using information obtained from the permit applications for a number of typical bulkhead walls in representative reaches of the river, and design assumptions for hydrostatic head differential, soil design parameters for the various soil layers and uniform surcharge loading, the representative existing bulkhead walls were analyzed to determine the resulting factor of safety if the channel was deepened to an improved depth of 31.0 feet. A Computer-Aided Structural Engineering (CASE) program entitled, "CSHTWAL - Design or Analysis of Cantilever or Anchored Sheet Pile Walls by Classical Methods", was used to make the design analyses. The results of these analyses indicated that the factors of safety were all well below 1.0. Even when the existing walls were analyzed for balanced hydrostatic head, no surcharge loading and unimproved or existing channel bottom, the factors of safety were marginal (F.S.$\leq$1.0) in all but one or two instances. In those cases, factors of safety approaching the required 1.5 were obtained only by using the "Free Earth" method of design, the least conservative of the five methods of design employed in the CASE program. Since it was known from inspection that many of the existing walls in the river were not in a state of failure or impending failure, it was decided that some of the design assumptions were too severe. This became more apparent when designing for improved channel bottom, surcharge loading and a factor of safety of 1.5. Required penetrations under these circumstances were excessive and in some cases the computer output data indicated that no solution for required penetration was attainable due possibly to insufficient passive resistance from the channelside soil layers. As a result of this problem a review of the design parameters for the soil layers and the assumptions for surcharge loads, was initiated. The cohesion values for the clays into which the bulkheads are to be driven range from 250 psf to 725 psf. These clay layers, which are encountered at various depths throughout the project area, but usually not above El.550, are relatively soft, weak clays that provide little passive resistance to the sheet piling below the channel bottom. When these cohesion values were compared with those obtained from several reports prepared by the geotechnical consulting firm of David V. Lewin and Associates in Cleveland, Ohio, an appreciable difference was noted. The consultant's cohesion values were in the range of 1,000 to 2,000 psf (see pages D-8 and D-9) and were extracted from two separate reports which the consulting firm had prepared for clients with property adjacent to the Cuyahoga River. Since the cohesion values initially used were average values and based on limited information, it was determined that they could be increased. Subsequently the range of cohesion values was increased to 500 to 1450 psf. In addition, the assumed uniform surcharge loading of 1600 psf, which was based upon a known tonnage of bulk material distributed over a known area, was reduced to 1000 psf to take into consideration the slope or terrace effect that occurs when bulk materials, such as iron ore, sand, crushed stone, and salt, etc., are stockpiled. With the revised assumptions for soil design parameters (see Plate Nos. D1 and D2) and surcharge loading, the existing bulkhead walls were analyzed again for revised parameters and improved channel bottom. Although the factors of safety were higher than had been previously determined, the required minimum factor of safety of 1.5 was not obtained. Based on the results of these analyses, it was determined that for the proposed channel deepening under Option B, virtually all of the bulkhead walls in the river would require replacement. Two exceptions to this are the walls in the turning basin where no deepening is proposed and a stretch of the left bank at the upstream end of the project where the existing wall is steel sheetpile, diaphragm-type, cellular construction.

For the proposed deepening to 28.5 feet below low water datum in Option A, new bulkheads will be required throughout most of the river also. This determination is based on the results of the analyses for Option B, which indicated that a 50-60 percent increase in the embedded length of the pile was required for a factor of safety of 1.5. The 2.5' additional embedment provided by Option A over Option B represents only a 10-15 percent increase.

The equivalent beam method of design for replacement bulkheads was selected because although it requires deeper penetrations than some of the other methods, it also decreases bending moments and deflections in the sheetpiling and reduces the tension in the tie rods. All new bulkheads were designed for a factor of safety of 1.5 and for one or the other of two profiles of subsurface soil strata which, although generalized, are felt to be representative of soil conditions that exist along the river in the project area. The soil profiles are shown on Plate Nos. D1 and D2. Both of the bulkhead designs as described above were also designed for a uniform surcharge load resulting from stockpiled bulk materials.

Using the CASE program in the design mode, depths of penetration below the dredge line, maximum bending moments, deflections and anchor forces were determined for the four typical bulkhead designs resulting from the various combinations of subsurface soil conditions and surcharge loading. The computer output values for each bulkhead are shown in Table D-1 on page D-10. Using the values in Table D-1, the final detailed design for each bulkhead was prepared including reinforcing for the sheetpiling, determination of tie rod and wale sizes and location and depth of the anchor wall. Sample computer printouts and calculations are included on pages D-11 through D-21, and sketches of each bulkhead design are shown on Plate Nos. D6 through D9.

D3. ALTERNATIVE 7 - CUYAHOGA RIVER CONGESTION STUDY

This alternative provides for widening the Cuyahoga River at a number of locations to facilitate the passage of large bulk cargo ships. Where widening is required, new steel sheetpile bulkheads have been designed. The designs for the new bulkheads are based on the same design assumptions that were used in Alternative 6, except that the elevation of the dredge line for this alternative is assumed to be the existing channel botton (23.0 feet below LWD plus 3.0 feet of overdepth). Alternative 7 includes the design of two different methods for anchoring the bulkhead walls. In addition to the tie rod and anchor wall anchorage system used exclusively in the Cuyahoga River deepening study, an alternate method of anchorage, involving battered tension piles, was designed for areas where proximity to buildings or bridge piers makes the tie rod anchorage system unfeasible. This method was not used in Alternative 6 because a cost comparision study had shown that the battered tension pile anchorage system was more expensive than the tie rod and anchor wall system. Since it appeared that the benefit-cost ratio was going to be unfavorable for Alternative 6 regardless of which anchorage system was used (due to the extensive bulkhead replacement that would be required for Alternative 6), the least expensive method of anchorage was selected to be used whereever bulkhead replacement was required.

Alternative 7 involved some sites where the banks were actually being cut back to make the river wider at those points, and other sites where only the channel limits were being moved closer to the existing bulkhead walls. In the case of sites where the banks were being cut back, new bulkheads were designed based on existing soil conditions at the site, a 3-foot hydrostatic head differential between the saturation line in the material behind the bulkhead wall and the rivers's water surface elevation, a uniform surcharge load where applicable and the assumed existing channel bottom. In the case of sites where channel limits were being moved closer to the existing bulkhead wall, where permit information was available for the wall, a design analysis for stability of the bulkhead was made to determine if replacement was required, At every one of these sites, it was found that the existing bulkhead did not have a factor of safety of 1.5 and therefore, replacement was required. Where permit information concerning the existing bulkhead walls was not available or non-existent, it was assumed that removal of channel bottom material at the base of the wall would make the wall unstable and replacement was assumed to be necessry. Unlike Alternative 6, the bulkhead replacements for the congestion study are concentrated in relatively short stretches of the river. Most of the bank cuts proposed under the congestion study occur in a reach of the river where subsurface soil conditions are fairly uniform. Accordingly, all bulkhead designs for Alternative 7 are based on the same soil strata and design parameters and two loading conditions, one condition with a surcharge load and one without. Soil strata and design parameters for Alternative 7 are shown on Plate No. D3.

Computer output for the bulkheads designed are contained in Table D-2 on page D-10. Sample computer printouts and calculations are shown on pages D-22 through D-40 and sketches of each bulkhead design are shown Plate Nos. D10 through D13.

D4. ALTERNATIVE 5 - OLD RIVER IMPROVEMENTS

This alternative involves both widening and deepening in the Old River. The river is to be deepened throughout its navigable portion from the existing depth of 23.0 feet below LWD to a depth of 28.0 feet below LWD. The major widening of the river is on the left bank at the downstream end of the river with several minor cuts on the right bank. The design assumptions for the Old River are basically the same as those for Alternative 6 except that the subsurface soil strata are slightly different. Six existing bulkheads at various locations in the Old River where only deepening is proposed and for which permit information was available, were analyzed for improved conditions. Of the six bulkheads analyzed, two were found to be stable enough (F.S. = 1.45) to make replacement unnecessary. However, the great majority of bulkheads in the Old River do require replacement either because they are unstable under the load assumptions for improved conditions or because they are located in areas where the river is being widened by cutting the banks back. Six typical bulkhead designs were prepared using the CASE computer program and assuming two separate and distinct sets of subsurface soil conditions and designing bulkhead walls for these soil conditions. Soil profiles and design parameters for Alternative No. 5 are shown on Plate Nos. D4 and D5. The resulting designs were then modified to withstand a surcharge load due to stockpiled bulk material. As a result of the slightly better subsurface soil conditions in the Old River, the bulkheads designed without surcharge loads (Type NS-AW and NS-BP) did not require the sheet piling to be reinforced with stiffner plates except in the first thousand feet of the river upstream from the confluence with the Cuyahoga River. As in Alternative 7, two separate anchorage systems were designed, one utilizing tie rods and sheetpile anchor walls and the other, battered tension piles. Computer output design data for each bulkhead design is shown in Table D-3 on page D-10. Sample computer printouts and calculations are shown on pages D-41 through D-53 and sketches of each bulkhead design are shown on Plate Nos. D14 through D17.

D5. SUMMARY AND CONCLUSIONS

The major problems encountered in the design of the steel sheetpile bulkheads for Alternatives 5, 6 and 7 were lack of information pertaining to existing bulkhead walls and the basis for their design, lack of adequate subsurface soil information and the low values of cohesion that were originally assumed for the clay strata. In addition to these problems, the extensive reach of river involved (roughly six miles of navigation channel in the Cuyahoga and Old Rivers combined) required that broad generalizations be made concerning subsurface soil strata, soil design parameters and surcharge loads applied to the bulkhead walls. As a result of these generalizations the designs for bulkheads as contained in the appendix are intentionally conservative. Most of the bulkheads as designed in this appendix exceed 35 feet in height (distance from dredge line to top of wall) and some exceed 40 feet in height. Consequently it was necessary to reinforce the sheet piling in addition to using high strength steel for the piling, in order to resist the high bending moments and deflections resulting from pressure applied to the walls. The decision as to where surcharge loads should be used in the design of the bulkheads was based on observations made in the field and from aerial photos.

D6. USEFUL LIFE OF BRIDGES AND BULKHEADS

In order to determine advance replacement benefits for the bulkheads being replaced under Alternatives 5, 6, and 7 and for the bridges being replaced under Alternatives 5 and 7, it was necessary to determine the remaining useful life of these structures.

In the case of the three railroad bridges and one vehicular bridge that would require replacement under one or the other of the alternatives, it was assumed that total useful life for railroad bridges is 100 years and for vehicular bridges the total useful life is 60 years. Knowing the date when the bridges were constructed and using the year 1990 as the year of reference, the remaining useful life beyond the year 1990 is the difference between the total useful life of the structure and the elapsed time from the date of construction to the year 1990 (see Table D-4 on page D-54).

In the case of the existing bulkheads requiring replacement, the determination of the remaining useful life of such structures is at best an "educated guess." This is due to the fact that bulkheads are not major structures like bridges and, therefore, the dates when they were built or constructed were not carefully documented. In addition, throughout the length of the Cuyahoga and Old Rivers, there are hundreds of bulkheads that were built over the years from as far back as the late 1920's to the present time, and information pertaining to these structures is very limited and covers less than half of the total length of the bulkheads that exist throughout the rivers.

To determine the remaining useful life of bulkheads, it was assumed that their total useful life was 50 years. The rivers were divided into reaches (see page D-58) and the average useful remaining life of existing bulkheads in each reach was determined by using the dates of the permit applications that had been filed for the various reaches. Here, another assumption was made to the effect that the structure was built within one year of the date shown on the permit application. Using this assumption and the reference year of 1990, the average remaining life of bulkheads in each reach was determined. The average was actually a "weighted average" based on the total linear feet of each bulkhead in a particular reach. A tabulation by reaches of all bulkheads for which permit information was available is contained on pages D-55 through D-57, and the average remaining useful life for each reach is contained in Table D-5 on page D-54.

D7. RECREATIONAL FISHING SAFETY PLATFORMS

One of the proposals for improvements to the harbor includes providing access to the west breakwater so that it can be used for recreational fishing. Because of the length of the breakwater, its exposed position to overtopping by waves during lake storms, and the possibility that some fishermen could be stranded on the breakwater by sudden storms, safety platforms are to be provided at two locations on the breakwater.

The decks of the platforms are to be at least 20 feet above LWD and each platform shall be large enough to accommodate 145 people without crowding. The deck is to be completely enclosed by handrail and shall be open, nonslip grating construction. A roof for the platform is optional.

The assumptions for the planned design of the platform included a 100 psf live load and a minimum of 4 square feet of deck space per person. Since the design of this type of structure, because of its indeterminacy, involves frame analysis and the elastic property of the frame members, it was decided to adapt a similar structure, designed as an overlook platform for the New Second Lock at Sault Ste. Marie, to be used for the west breakwater safety platforms.

The overlook platform for the New Second Lock is the correct height and area and its dimensions will fit the top width of the west breakwater adequately. It is designed for a live load of 125 pounds per square foot of deck area and a stair loading of 100 pounds per square foot. In addition, it is designed for a snow load of 35 pounds per square foot of roof area, 20 pounds per square foot of horizontal wind pressure on the projected area of the platform above the floor level and an uplift pressure of 12 pounds per square foot on the roof and floor. Adaptation of the overlook platform to the west breakwater includes substitution of a nonskid grating deck in place of the concrete deck and elimination of the lighting system and the concrete foundations for the platform and stairs.

DESIGN DATA AND REFERENCES

1. References:

a. USS Steel Sheet Piling Design Manual

b. USS Steel Sheet Piling Design Handbook

c. AISC Manual of Steel Construction, 8th Edition

d. Computer Program for Design and Analysis of Sheet Pile Walls by Classical Methods - Users Handbook, Army Waterways Experiment Station, Vicksburg, Miss.

e. Foundation Engineering Handbook, Hans F. Winterkorn & Hsai-Yang Fang, Van Nostrand Reinhold Co., 1975

2. Design Data.

a. Steel Sheetpiling, Plate Stiffners and Wales
F_y = 55,000 psi (Ref.: USS Steel Sheet Piling Design Manual)

b. Steel Tie Rods
F_y = 50,000 psi (Ref.: ASTM A-588)

We visited the site while the test borings were being drilled. Loss of soil was evident adjacent to the sheeting at a number of spots along the wall. An attempt was made during our visit to expose one of the existing anchor rods by digging a hole with a backhoe. However, groundwater flowed quickly into the hole at a depth of about 6 feet below grade and the rod could not be observed. You have informed us that a diver's recent inspection of the sheeting along the dock disclosed many holes in the sheeting through which soil is being washed out as well as severe corrosion along the entire length of the sheeting at a depth of 5 to 10 feet below the level of the river. This is not an unusual condition for sheeting of this age in the Cuyahoga River.

The use of the dock in the future will require the repair or replacement of the existing sheeting. Depending upon the location of the harbor line, it may be possible to drive new sheeting outside of the existing sheeting and avoid cutting the existing anchor rods. The void between the new and existing sheeting above the river bottom may then be filled with slag or crushed stone. For the computation of lateral pressures for sheeting design, the following soil parameters may be used:

Above Elevation 550: unit weight γ = 120 lbs. per cu. ft. (above water level) and 70 lbs. per cu. ft. (below water level).
angle of internal friction $\phi = 25^{\circ}$
cohesion c = 0

Elevation 535 to 550: γ = 70 lbs. per cu. ft.
$\phi = 30^{\circ}$
c = 0

Below Elevation 535: γ = 70 lbs. per cu. ft.
$\phi = 0$
c = 1600 lbs. per sq. ft. *

The additional fill planned for the site as well as a dredge line in the river deeper than what has been previously used indicates that a retaining structure stronger than the present design may be required. In our judgment, the factor of safety of the present sheeting is probably very close to 1.0.

The crane runway may be supported on piles. Minimum pile lengths in the order of 60 feet would be required to transfer

May 15, 1978

David V Lewin Corp
GEOTECHNICAL ENGINEERING
THE ARCADE
CLEVELAND OHIO
44114

Dr. A. T. Yu, President
ORBA Corporation
One Gothic Plaza
Fairfield, N. J. 07006

Re: Proposed Ore Transfer Terminal
Dock 20
Cleveland, Ohio
Your P.O. No. 5070/2ES
C. 3033A

Dear Dr. Yu:

Refer to our letter of May 5, 1978. Since that time borings B-13, B-14, B-15, B-16 and B-17 were completed on land and borings B-5 and B-29 in the lake. The samples obtained were subjected to a testing and evaluation program.

A careful review of the results obtained in the borings along the Cuyahoga River (west end of the site) indicates that the soil strength in this area is somewhat higher than along the lake (north end). In our opinion the following parameters for soil strength can be used:

From present grade to El. 570:	$\gamma = 120$ pcf,	$\phi = 30^\circ$	
570 to 558:	$\gamma^1 = 70$ pcf,	$\phi = 30^\circ$	
558 to 540:	$\gamma^1 = 70$ pcf,	$\phi = 0$	, $c = 1300$ psf
540 to 528:	$\gamma^1 = 70$ pcf,	$\phi = 0$	, $c = 1000$ psf
528 to 520:	$\gamma^1 = 70$ pcf,	$\phi = 0$	, $c = 1400$ psf
below 520:	$\gamma^1 = 70$ pcf,	$\phi = 10^\circ$,	$c = 2000$ psf

Applying the above criteria, a 30 ft. high pellet pile placed in such a manner as to have its toe at 110 ft. from the harbor line and an approximately 50 ft. plateau, shows a factor of safety against overturning of approximately 1.2. Thus, we believe that a 30 ft. pile of pellets may be achieved along the Cuyahoga River. As stated previously, a careful monitoring system would have to be installed and the behaviour of the soil mass checked periodically.

PHONE (216) [illegible]

SAMPLE
COMPUTER PRINTOUTS
AND
CALCULATIONS

COMPUTER PROGRAM OUTPUT DATA

BULKHEAD NO	REQUIRED PENETRATION (FT)	MAX. BENDING MOMENT (LB-FT)	MAX. SCALED DEFLECTION (LB-IN³)	ANCHOR FORCE (LB)
A-1	40.27	244,523	8.56×10^{10}	19,220
A-2	69.18	384,935	1.54×10^{11}	32,870
B-1	26.31	195,881	4.67×10^{10}	17069
B-2	64.45	288,297	6.87×10^{10}	28,705

TABLE D-1 (ALTERNATIVE 6)

BULKHEAD NO.	REQUIRED PENETRATION (FT.)	MAX. BENDING MOMENT (LB-FT.)	MAX. SCALED DEFLECTION (LB.-IN.³)	ANCHOR FORCE (LB.)
NS-AW NS-BP	29.80	204,556	4.87×10^{10}	19,281
S-AW S-BP	65.03	294,374	6.98×10^{10}	31,893

TABLE D-2 (ALTERNATIVE 7)

BULKHEAD NO.	REQUIRED PENETRATION (FT)	MAX BENDING MOMENT (LB-FT.)	MAX SCALED DEFLECTION (LB-IN³)	ANCHOR FORCE (LB.)
NS-AW NS-BP	36.26	128,787	2.49×10^{10}	15,364
S-BP S-AW	73.94	266,250	7.51×10^{10}	29079
NS-AW, NS-BP (Rivermile 0.0 to 0.2)	36.77	195,521	5.19×10^{10}	18,850
S-AW (Rivermile 0.0 to 0.2)	74.17	264,014	6.99×10^{10}	30,453
B-1	SEE TABLE D-1 ABOVE			
B-2	SEE TABLE D-1 ABOVE			

TABLE D-3 (ALTERNATIVE 5)

```
PROGRAM SHTWAL - DESIGN/ANALYSIS OF ANCHORED
OR CANTILEVER SHEET PILE WALLS BY CLASSICAL METHODS
DATE: 09/22/81                       TIME: 07:52:09

1. INPUT DATA

1.A.--HEADING

CLEVE. HARBOR STUDY - CUYA. R. DEEPENING - BULKHD. A
COND. 2TYP. BLKHD. DESIGN FOR SSP WALL IN COHESIONLESS MAT.
W/IMP. CHANNEL BOT.,3 HYDROSTAT. HD. DIFF., 1000 PSF SURCH.


1.B.--WALL TYPE, MODE, METHOD
     ANCHORED WALL DESIGN   BY EQUIVALENT BEAM METHOD


1.C.--WALL DESCRIPTION
     TOP OF WALL ELEVATION =  578.00 (FT)
     ANCHOR ELEVATION      =  571.60 (FT)
     FACTOR OF SAFETY      =    1.50


1.D.--RIGHT SIDE SOIL DESCRIPTION
     NUMBER OF RIGHT SIDE SURFACE POINTS =  1
     NUMBER OF RIGHT SIDE SOIL LAYERS    =  3


     RIGHT SIDE SURFACE POINT COORDINATES
     POINT      ELEVATION      X-COORD
      NO.          (FT)          (FT)
       1         578.00          0.00
```

RIGHT SIDE SOIL LAYER DATA

LAYER NO.	UNIT WEIGHT (PCF)	INTERNAL FRICTION ANGLE (DEG)	COHESION (PSF)	WALL FRICTION ANGLE (DEG)	BOTTOM ELEV AT WALL (FT)	BOTTOM SLOPE (FT/FT)
1	115.00	35.00	0.00	0.00	571.60	1:0.0
2	125.00	35.00	0.00	0.00	524.10	1:0.0
3	186.00	5.00	1450.00	0.00		

1.E.--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	537.60	0.00

LEFT SIDE SOIL LAYER DATA

LAYER NO.	UNIT WEIGHT (PCF)	INTERNAL FRICTION ANGLE (DEG)	COHESION (PSF)	WALL FRICTION ANGLE (DEG)	BOTTOM ELEV AT WALL (FT)	BOTTOM SLOPE (FT/FT)
1	125.00	35.00	0.00	0.00	524.10	1:0.0
2	186.00	5.00	1450.00	0.00		

1.F.--WATER DATA

RIGHT SIDE ELEVATION = 571.60 (FT)
LEFT SIDE ELEVATION = 568.60 (FT)
WATER UNIT WEIGHT = 62.40 (PCF)

```
     SEEPAGE GRADIENT              =    0.00 (FT/FT)

1.G.--SURCHARGE LOADS
     NUMBER OF LINE LOADS          =  0
     DISTRIBUTED LOAD DISTRIBUTION = UNIF


     UNIFORM SURCHARGE LOAD
     LOAD                 = 1000.00 PSF


1.H.--HORIZONTAL LOADS
     NUMBER OF HORIZONTAL LINE LOADS         =    0
     NUMBER OF HORIZONTAL PRESSURE POINTS    =    0
     EARTHQUAKE ACCELERATION                 =    0.00 (G'S)
```

```
PROGRAM SHTWAL - DESIGN/ANALYSIS OF ANCHORED
OR CANTILEVER SHEET PILE WALLS BY CLASSICAL METHODS
DATE: 09/22/81                     TIME: 07:55:26
```

2. RESULTS

2.A.--HEADING

PROGRAM SHTWAL - DESIGN/ANALYSIS OF ANCHORED
OR CANTILEVER SHEET PILE WALLS BY CLASSICAL METHODS
DATE: 09/22/81 TIME: 07:55:26

2. RESULTS

2.A.--HEADING

CLEVE. HARBOR STUDY - CUYA. R. DEEPENING - BULKHD. A
COND. 2TYP. BLKHD. DESIGN FOR SSP WALL IN COHESIONLESS MAT.
W/IMP. CHANNEL BOT.,3 HYDROSTAT. HD. DIFF., 1000 PSF SURCH.

2.B.--SUMMARY OF RESULTS FOR ANCHORED WALL DESIGN

METHOD	WALL PEN (FT)	BOTTOM ELEV (FT)	MAXIMUM BENDING MOMENT (LB-FT)	MAX SCALED DEFLECTION (LB-IN3)	ANCHOR FORCE (LB)
EQUIV BEAM :	69.18	468.42	384935.	1.54E+11	32870.

(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)

CCUS 14.33E

2.C.--COMPLETE RESULTS FOR ANCHORED WALL DESIGN
BY EQUIV BEAM METHOD

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
578.00	0.	0.	-6.44E+10	405.49
577.00	-211.	-429.	-5.43E+10	452.12
576.00	-873.	-904.	-4.43E+10	498.76
575.00	-2035.	-1426.	-3.42E+10	545.39
574.00	-3741.	-1995.	-2.42E+10	592.02
573.00	-6040.	-2610.	-1.41E+10	638.65
572.00	-8978.	-3272.	-4.03E+09	685.28
571.60	-10342.	-3550.	0.	703.94
571.60	-10342.	29320.	0.	703.94
571.00	7120.	28882.	6.05E+09	756.61
570.00	35609.	28081.	1.61E+10	844.39
569.00	63254.	27193.	2.61E+10	932.17
568.60	74055.	26813.	3.01E+10	967.29
568.00	89968.	26228.	3.60E+10	982.52
567.00	115701.	25233.	4.58E+10	1007.90
566.00	140426.	24212.	5.53E+10	1033.29
565.00	164117.	23166.	6.46E+10	1058.67
564.00	186750.	22095.	7.36E+10	1084.05
563.00	208299.	20998.	8.23E+10	1109.44
562.00	228738.	19876.	9.07E+10	1134.82
561.00	248042.	18729.	9.86E+10	1160.20
560.00	266187.	17556.	1.06E+11	1185.59
559.00	283145.	16357.	1.13E+11	1210.97
558.00	298893.	15134.	1.20E+11	1236.36
557.00	313405.	13885.	1.26E+11	1261.74
556.00	326654.	12610.	1.31E+11	1287.12

555.00	338617.	11311.	1.36E+11	1312.51
554.00	349267.	9985.	1.41E+11	1337.89
553.00	358579.	8635.	1.44E+11	1363.28
552.00	366528.	7259.	1.47E+11	1388.66
551.00	373088.	5857.	1.50E+11	1414.04
550.00	378234.	4431.	1.52E+11	1439.43
549.00	381941.	2979.	1.53E+11	1464.81
548.00	384183.	1501.	1.54E+11	1490.19
547.00	384935.	-2.	1.53E+11	1515.58
546.00	384171.	-1530.	1.53E+11	1540.96
545.00	381866.	-3084.	1.51E+11	1566.35
544.00	377995.	-4663.	1.49E+11	1591.73
543.00	372532.	-6267.	1.46E+11	1617.11
542.00	365452.	-7897.	1.43E+11	1642.50
541.00	356729.	-9552.	1.39E+11	1667.88
540.00	346339.	-11233.	1.34E+11	1693.27
539.00	334255.	-12939.	1.29E+11	1718.65
538.00	320453.	-14670.	1.23E+11	1744.03
537.60	314445.	-15370.	1.21E+11	1754.19
537.00	304912.	-16399.	1.17E+11	1676.79
536.00	287696.	-18011.	1.10E+11	1547.79
535.00	268933.	-19495.	1.02E+11	1418.80
534.00	248750.	-20849.	9.46E+10	1289.80
533.00	227278.	-22074.	8.63E+10	1160.80
532.00	204645.	-23171.	7.76E+10	1031.81
531.00	180980.	-24138.	6.86E+10	902.81
530.00	156412.	-24976.	5.92E+10	773.82
529.00	131070.	-25685.	4.96E+10	644.82
528.00	105084.	-26266.	3.97E+10	515.82
527.00	78582.	-26717.	2.97E+10	386.83
526.00	51693.	-27039.	1.95E+10	257.83
525.00	24546.	-27233.	9.27E+09	128.83
524.10	0.	-27296.	0.	12.74

Subject: CLEVE. HARBOR STUDY - CUYA R. DEEPENING

Computation of: Bulkhead "A" Design Cond. 2

Computed by: RCJ 9/24/81 Checked by: ________ Date: ________

Results of the design as determined by the computer program "SHTWAL" are as follows:

Penetration below dredge line (F.S. = 1.5) = 69.18 ft

Max bending moment (lb-ft) = 384,935

Max. deflection (lb-in³) = 1.54 x 10"

Anchor force per foot of wall = 32870

The bending moment and deflection are too large to be sustained by the PZ 38 steel sheet piling alone

∴ Reinforce piling with cover plates

$F_y = 55000$ psi $\quad F_b = 0.65 F_y = 35000$ psi

Section Modulus of PZ 38 = 46.8 in³/ft of wall

Resisting moment of piling alone

$$M_R = \frac{46.8 \times 35000}{12} = 136500 \text{ lb-ft}$$

Bending Moment to be taken by cover plates

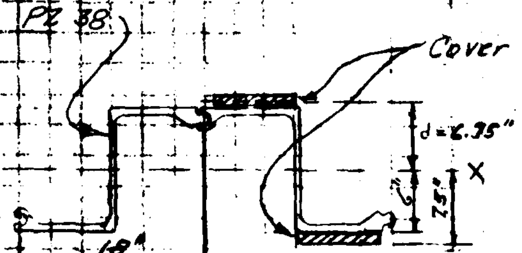
384935 - 136500 = 248435 lb-ft

Additional section modulus req'd = $\frac{248435(12)}{35000} = 85.18 \text{ in}^3$

$S_{req'd}$/ft of wall = 85.18 in³

Assume cover plate: 8" x 1½" extending from El. 567 to El. 529. See sketch on pg. 2

Subject CLEVE. HARBOR STUDY - CUYA. R. DEEPENING
Computation of Bulkhead "A" Design Cond 2
Computed by RCT 9/24/81 Checked by ___ Date ___



I of PZ 38 about axis x-x = 421.2 in^4

I of 8" x 1½" Pl = $\frac{bl^3}{3} = \frac{8(1.5)^3}{3}$ = 9.00 in^4

Ad^2 of 8" x 1½" Pl = $(8)(1.5)(6.75)^2$ = 546.75 in^4

I + Ad^2 of one Pl = 555.75 in^4

I + Ad^2 of two Pls. = 1111.50 in^4 1111.50 in^4

I_{xx} of reinforced piling = 1532.70 in^4

I_{xx} per foot of wall = $\frac{(1532.70)(12)}{18}$ = 1021.80 in^4

$S_{xx} = \frac{I}{c} = \frac{1021.80}{7.5}$ = 136.24 in^3

Check bending stress for reinforced piling

$f_b = \frac{384.35(12)}{136.24}$ = 33905 psi > 35000 ok

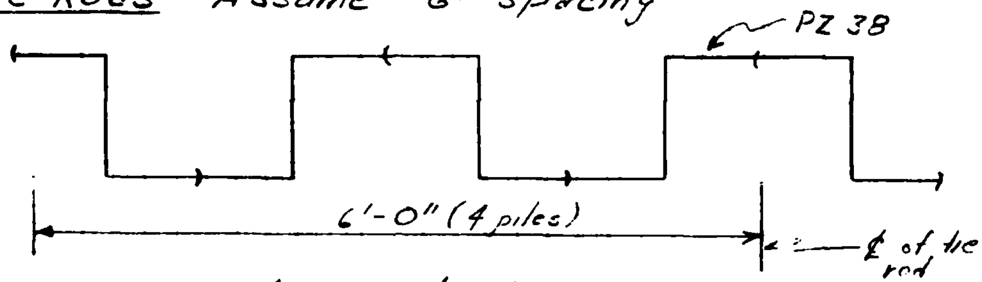
Deflection - Divide max. deflection in lb-in³ by the product of the modulus of elasticity and the moment of inertia of the reinforced piling.

Defl. (in) = $\frac{1.54 \times 10^{11}}{(2.9 \times 10^7)(1.0218 \times 10^3)}$ = 0.52 x 10^1 = 5.2 inches

O.K.

Subject CLEVE. HARBOR STUDY - CUYA. R. DEEPENING
Computation of Bulkhead "A" Design Cond 2
Computed by RCJ 9/29/81 Checked by ____________ Date ________

Design Anchorage System
Tie Rods - Assume 6' spacing



Assume tie rods are level ($\alpha = 0$)

$A_p = \frac{T \times d}{\cos \alpha} = \frac{32870 \times 6}{1} = 197220$ lb/tie rod

Increase 30% for design. Then A_p = 256000 lb/rod

Use high strength steel ! A-586 F_y = 50,000 psi

Required cross-sectional area = $\frac{256000 \text{ lb}}{0.6\,(50000)} = 8.53 \square''$

Use 3⅜"ϕ bar upset to 4¼" $A_{s\,furn} = 8.94 \square''$

Wales

For Max. Moment, use $M_{max} = 1/9\, T d^2$

$M_{max} = \frac{32870\,(6)^2}{9} = 131480$ lb·ft

$F_b = 0.60(F_y) = 0.60(55000) = 33000$ psi

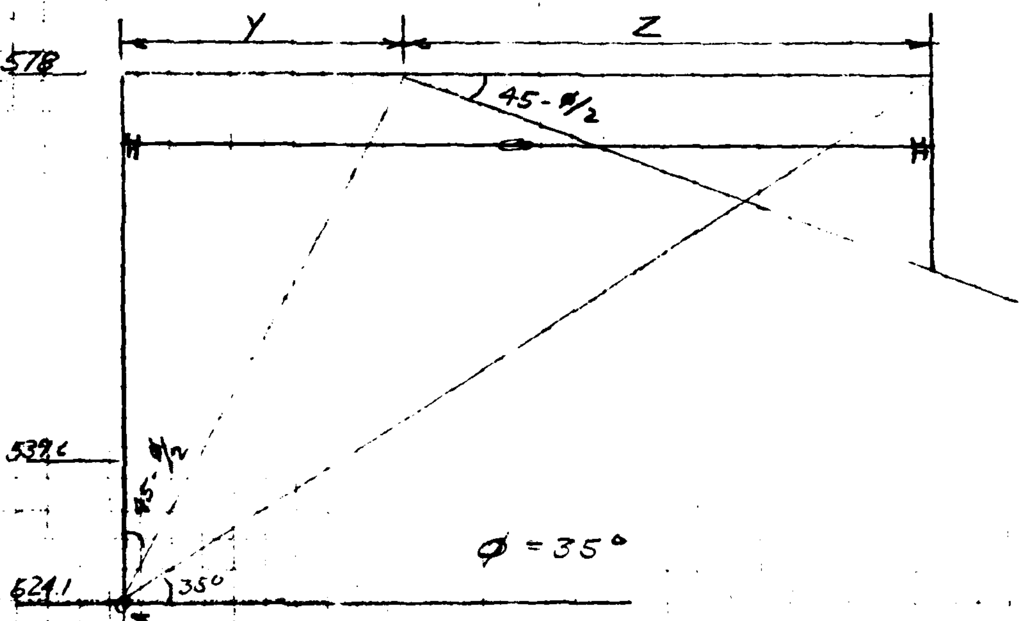
$S_{x\text{-}x}$ req'd $= \frac{131480\,(12)}{33000} = 47.81 \text{ in}^3$ or 24 in³/channel

Use 2 C 12×25
$S_{x\text{-}x}$ furn = 48.2 in³

Use 1½" bolts and 2" pipe sleeves to bolt channels back to back. Assume clear distance of 4½ inches.

Subject: CLEVELAND HARBOR STUDY - CUYAHOGA R. DEEPENING
Computation of: Bulkhead "A" Design - Cond 2
Computed by: RCJ 9/30/81 Checked by: ________ Date: ________

Location of Anchor Wall



Pt. of zero moment

$Y = 53.9 \tan 27.5° = 28.06'$

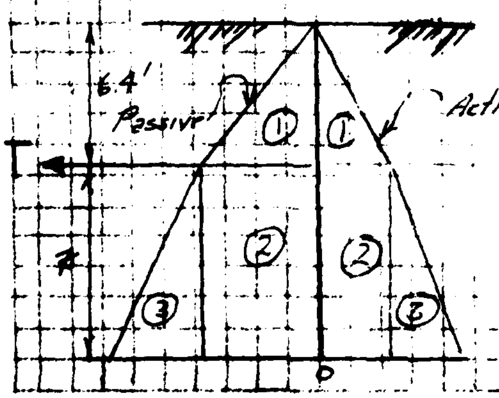
$Z = 53.9 \cot 35 - Y = 76.98 - 28.06 = 48.92$

$Y + Z = 77'$ approx.

Pressure Diagram for Anchor Wall

Assume water level at El. 571.6

$\gamma_{mst} = 115$ pcf
$\gamma_{sub} = 63$ pcf
$\phi = 35°$
Angle of wall friction, $\delta = 14°$
$\delta/\phi = -0.4$
$K_a = 0.27$
$K_p = 6.63$



$\Sigma F = 0$

$0 = (P_{P1} - P_{A1}) + (P_{P2} - P_{A2}) + (P_{P3} - P_{A3}) - T$

Subject: CLEVE. HARBOR STUDY - CUYAHOGA R. DEEPENING
Computation of: Bulkhead "A" Design Cond. 2
Computed by: RCJ 9/30/81 Checked by: ______ Date: ______

$$P_{P_1} - P_{A_1} = \frac{(115)(6.4)^2}{2}(6.63-0.27) = 14979$$

$$P_{P_2} - P_{A_2} = 115(6.4)(6.63-0.27)z = 4681z$$

$$P_{P_3} - P_{A_3} = \frac{63(z)^2}{2}(6.63-0.27) = 200z^2$$

$$\Sigma F = 0 = 14979 + 4681z + 200z^2 - T \quad (1)$$

$$\Sigma M_o = 0 = 14979(z+2.13) + 4681z\left(\frac{z}{2}\right) + 200z^2\left(\frac{z}{3}\right) - Tz \quad (2)$$

Combine equations (1) and (2)

$$0 = 14979(z+2.13) + 4681z\left(\frac{z}{2}\right) + 200z^2\left(\frac{z}{3}\right) - [14979 + 4681z + 200z^2]z$$

$$0 = 14979z + 31905 + 2340z^2 + 67z^3 - 14979z - 4681z^2 - 200z^3$$

$$0 = -133z^3 - 2341z^2 + 31905$$

$$z^3 + 17.6z^2 = 239.89$$

$$z = 3.4'$$

$$T = 33206 \text{ lb} > 32870 \qquad F.S. = \frac{33206}{32870} = 1.01$$

O.K.

Depth of Anchor Wall = 6.4 + 3.4 = 9.8'
say 12'

```
I>BOTH
   ENTER FILE NAME FOR ECHOPRINT OF INPUT DATA
   (6 CHARACTERS MAXIMUM)
I>RCJC16


   OR CANTILEVER SHEET PILE WALLS BY CLASSICAL METHODS
   DATE: 10/21/81                          TIME: 10:11:15

   1. INPUT DATA

   1.A.--HEADING

   CLEVE. HARBOR STUDY - CONGESTION STUDY - BLKHD. DESIGN FOR CUT#16 COND.1
   SSP WALL IN COHESIVE MAT. LEWINS SOIL PARAMETERS 3 HYDROSTAT. HD. DIFF.
   EXIST. CHANNEL BOT. AT EL. 542.6 NO SURCHARGE ANCHOR ROD ELEV AT 571.6


   1.B.--WALL TYPE, MODE, METHOD
        ANCHORED WALL DESIGN   BY FREE EARTH METHOD
        ANCHORED WALL DESIGN   BY FIXED EARTH METHOD
        ANCHORED WALL DESIGN   BY EQUIVALENT BEAM METHOD
        ANCHORED WALL DESIGN   BY EQUAL MOMENT METHOD
        ANCHORED WALL DESIGN   BY TERZAGHI METHOD


   1.C.--WALL DESCRIPTION
        TOP OF WALL ELEVATION =  580.00 (FT)
        ANCHOR ELEVATION      =  571.60 (FT)
        FACTOR OF SAFETY      =    1.50


   1.D.--RIGHT SIDE SOIL DESCRIPTION
        NUMBER OF RIGHT SIDE SURFACE POINTS =  1
        NUMBER OF RIGHT SIDE SOIL LAYERS    =  4


        RIGHT SIDE SURFACE POINT COORDINATES
        POINT      ELEVATION      X-COORD
         NO.         (FT)          (FT)
          1         580.00         0.00


   RIGHT SIDE SOIL LAYER DATA
```

LAYER NO.	UNIT WEIGHT (PCF)	INTERNAL FRICTION ANGLE (DEG)	COHESION (PSF)	WALL FRICTION ANGLE (DEG)	BOTTOM ELEV AT WALL (FT)	BOTTOM SLOPE (FT/FT)
1	115.00	35.00	0.00	0.00	571.60	1:0.0
2	125.00	35.00	0.00	0.00	548.10	1:0.0
3	120.00	0.00	500.00	0.00	535.00	1:0.0
4	132.50	0.00	2000.00	0.00		

```
   1.E.--LEFT SIDE SOIL DESCRIPTION
        NUMBER OF LEFT SIDE SURFACE POINTS    =  1
        NUMBER OF LEFT SIDE SOIL LAYERS       =  2


        LEFT SIDE SURFACE POINT COORDINATES
        POINT      ELEVATION      X-COORD
         NO.         (FT)          (FT)
          1         542.60         0.00
```

[illegible]

LAYER NO.	UNIT WEIGHT (PCF)	INTERNAL FRICTION ANGLE (DEG)	COHESION (PSF)	WALL FRICTION ANGLE (DEG)	BOTTOM ELEV AT WALL (FT)	BOTTOM SLOPE (FT/FT)
1	120.00	0.00	500.00	0.00	535.00	1:0.0
2	132.50	0.00	2000.00	0.00		

```
1.F.--WATER DATA
     RIGHT SIDE ELEVATION         =  571.60 (FT)
     LEFT SIDE ELEVATION          =  568.60 (FT)
     WATER UNIT WEIGHT            =   62.40 (PCF)
     SEEPAGE GRADIENT             =    0.00 (FT/FT)

1.G.--SURCHARGE LOADS
     NUMBER OF LINE LOADS              =  0
     DISTRIBUTED LOAD DISTRIBUTION = NONE

1.H.--HORIZONTAL LOADS
     NUMBER OF HORIZONTAL LINE LOADS          =    0
     NUMBER OF HORIZONTAL PRESSURE POINTS     =    0
     EARTHQUAKE ACCELERATION                  =    0.00 (G'S)


    DO YOU WANT INPUT DATA SAVED IN A FILE? ENTER 'YES' OR 'NO'
I>YES
    ENTER FILE NAME IN WHICH INPUT DATA WILL BE SAVED.
     (6 CHARACTERS MAXIMUM)
I>RCJC16
    DO YOU WANT A PLOT OF INPUT GEOMETRY?
    ENTER 'YES' OR 'NO'
I>NO
    INPUT SEQUENCE COMPLETE.
    DO YOU WANT TO CONTINUE SOLUTION?
    ENTER 'YES' OR 'NO'
I>YES


    DO YOU WANT ACTIVE AND PASSIVE SOIL PRESSURES
    PRINTED AT YOUR TERMINAL?  ENTER 'YES' OR 'NO'
I>NO
    SOLUTION COMPLETE
    DO YOU WANT RESULTS PRINTED AT YOUR TERMINAL,
    WRITTEN TO A FILE, OR BOTH?
    ENTER 'TERMINAL', 'FILE', OR 'BOTH'
I>TERMINAL
```

2. RESULTS

2.A.--HEADING

CLEVE. HARBOR STUDY - CONGESTION STUDY - BLKHD. DESIGN FOR CUT#16 COND.1
SSP WALL IN COHESIVE MAT. LEWINS SOIL PARAMETERS 3 HYDROSTAT. HD. DIFF.
EXIST. CHANNEL BOT. AT EL. 542.6 NO SURCHARGE ANCHOR ROD ELEV AT 571.6

2.B.--SUMMARY OF RESULTS FOR ANCHORED WALL DESIGN

SOIL PRESSURES DETERMINED BY COULOMB
COEFFICIENTS AND THEORY OF ELASTICITY
EQUATIONS FOR SURCHARGE LOADS

METHOD	WALL PEN (FT)	BOTTOM ELEV (FT)	MAXIMUM BENDING MOMENT (LB-FT)	MAX SCALED DEFLECTION (LB-IN3)	ANCHOR FORCE (LB)
FREE EARTH :	17.39	525.21	275073.	9.84E+10	22414.
FIXED EARTH:	31.70	510.90	207911.	7.15E+10	19440.
EQUIV BEAM :	29.80	512.80	204556.	4.87E+10	19281.
EQUAL MOM :	31.56	511.04	-187330.	5.23E+10	18447.
TERZAGHI :	29.50	513.10	207411.	7.11E+10	19416.

(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)

DO YOU WANT COMPLETE RESULTS OUTPUT?
ENTER 'YES' OR 'NO'
I>YES

COMPLETE RESULTS ARE AVAILABLE FOR FOLLOWING
METHODS OF ANALYSIS:
FREE EARTH : ENTER 'FR' ON CUE
FIXED EARTH: ENTER 'FI' ON CUE
EQUIV BEAM : ENTER 'EB' ON CUE
EQUAL MOM : ENTER 'EM' ON CUE
TERZAGHI : ENTER 'TE' ON CUE

ENTER METHOD FOR WHICH COMPLETE RESULTS ARE DESIRED
I>EB

2.C.--COMPLETE RESULTS FOR ANCHORED WALL DESIGN
BY EQUIV BEAM METHOD

(FT)	(LB-FT)	(LB)	(LB-IN3)	(PSF)
580.00	-0.	0.	-3.36E+10	0.00
579.00	-8.	-21.	-2.96E+10	46.63
578.00	-62.	-93.	-2.56E+10	93.26
577.00	-210.	-210.	-2.16E+10	139.90
576.00	-497.	-373.	-1.76E+10	186.53
575.00	-971.	-583.	-1.36E+10	233.16
574.00	-1679.	-839.	-9.61E+09	279.79
573.00	-2666.	-1142.	-5.61E+09	326.42
572.00	-3979.	-1492.	-1.60E+09	373.05
571.60	-4606.	-1645.	0.	391.71
571.60	-4606.	17636.	0.	391.71
571.00	5902.	17386.	2.41E+09	444.38
570.00	23050.	16897.	6.41E+09	532.16
569.00	39667.	16321.	1.04E+10	619.94
568.60	46145.	16066.	1.19E+10	655.06
568.00	55666.	15669.	1.43E+10	670.29
567.00	70995.	14986.	1.81E+10	695.67
566.00	85628.	14277.	2.17E+10	721.06
565.00	99541.	13543.	2.53E+10	746.44
564.00	112707.	12784.	2.86E+10	771.82
563.00	125101.	12000.	3.18E+10	797.21
562.00	136698.	11190.	3.47E+10	822.59
561.00	147473.	10355.	3.74E+10	847.97
560.00	157399.	9494.	3.99E+10	873.36
559.00	166452.	8608.	4.21E+10	898.74
558.00	174606.	7697.	4.40E+10	924.13
557.00	181837.	6760.	4.56E+10	949.51
556.00	188117.	5797.	4.68E+10	974.89
555.00	193423.	4810.	4.78E+10	1000.28
554.00	197729.	3797.	4.84E+10	1025.66
553.00	201009.	2759.	4.87E+10	1051.05
552.00	203237.	1695.	4.86E+10	1076.43
551.00	204390.	606.	4.82E+10	1101.81
550.45	204556.	0.	4.78E+10	1115.68
550.00	204440.	-509.	4.74E+10	1127.20
549.00	203364.	-1649.	4.63E+10	1152.58
548.10	201410.	-2696.	4.50E+10	1175.43
548.10	201410.	-2696.	4.50E+10	1957.63
547.00	197247.	-4885.	4.30E+10	2020.99
546.00	191342.	-6934.	4.09E+10	2078.59
545.00	183359.	-9042.	3.84E+10	2136.19
544.00	173240.	-11207.	3.55E+10	2193.79
543.00	160927.	-13429.	3.24E+10	2251.39
542.60	155374.	-14334.	3.11E+10	2274.43
542.60	155374.	-14334.	3.11E+10	1607.77
542.00	146484.	-15299.	2.90E+10	1607.77
541.00	130381.	-16907.	2.54E+10	1607.77
540.00	112670.	-18515.	2.15E+10	1607.77
539.00	93352.	-20122.	1.75E+10	1607.77
538.00	72426.	-21730.	1.33E+10	1607.77
537.00	49891.	-23338.	8.91E+09	1607.77
536.00	25750.	-24946.	4.48E+09	1607.77
535.00	-0.	-26553.	0.	1607.77

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS
OF ELASTICITY IN PSI TIMES PILE MOMENT OF
INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES)

(NOTE: OUTPUT TABLE FOR EQUIVALENT BEAM
METHOD ENDS AT ASSUMED POINT OF INFLECTION)
DO YOU WANT RESULTS FOR ANOTHER METHOD? ENTER 'YES' OR 'NO'

```
I>0

    DISTRIBUTED LOAD DESCRIPTION
    ENTER 'NONE', 'STRIP', 'RAMP', 'TRIANG', OR 'UNIF'
I>UNIF

    ENTER UNIFORM LOAD INTENSITY (PSF)
I>1000.0

    HORIZONTAL LOAD DATA. ENTER
    NUMBER OF       NUMBER OF        EARTHQUAKE
    LINE LOADS     PRESSURE PTS     ACCELERATION
     (0 TO 4)     (0 OR 2 TO 12)       (G'S)
I>0 0 0
    INPUT COMPLETE. NO ERRORS DETECTED
    DO YOU WANT TO EDIT INPUT DATA? ENTER 'YES' OR 'NO'
I>NO
    DO YOU WANT INPUT DATA ECHOPRINTED TO YOUR
    TERMINAL, TO A FILE, TO BOTH, OR NEITHER?
    ENTER 'TERMINAL', 'FILE', 'BOTH', OR 'NEITHER'
I>BOTH
    ENTER FILE NAME FOR ECHOPRINT OF INPUT DATA
    (6 CHARACTERS MAXIMUM)
I>RJ2C16


    PROGRAM SHTWAL - DESIGN/ANALYSIS OF ANCHORED
    OR CANTILEVER SHEET PILE WALLS BY CLASSICAL METHODS
    DATE: 10/21/81                          TIME: 10:42:49

    1. INPUT DATA

    1.A.--HEADING

    CLEVE. HARBOR STUDY - CONGESTION STUDY,BLKHD. DESIGN FOR CUT#16,COND.2
    SSP WALL IN COHESIVE MATERIAL, LEWINS SOIL PARAM. 3 HYDROSTAT. HD. DIFF.
    EXIST. CHANNEL BOT. AT EL.542.6 ,SURCHARGE=1000PSF, ANCH. ROD AT ELEV. 571.6


    1.B.--WALL TYPE, MODE, METHOD
         ANCHORED WALL DESIGN   BY FREE EARTH METHOD
         ANCHORED WALL DESIGN   BY FIXED EARTH METHOD
         ANCHORED WALL DESIGN   BY EQUIVALENT BEAM METHOD
         ANCHORED WALL DESIGN   BY EQUAL MOMENT METHOD
         ANCHORED WALL DESIGN   BY TERZAGHI METHOD


    1.C.--WALL DESCRIPTION
         TOP OF WALL ELEVATION =  580.00 (FT)
         ANCHOR ELEVATION      =  571.60 (FT)
         FACTOR OF SAFETY      =    1.50


    1.D.--RIGHT SIDE SOIL DESCRIPTION
         NUMBER OF RIGHT SIDE SURFACE POINTS =  1
         NUMBER OF RIGHT SIDE SOIL LAYERS    =  4


         RIGHT SIDE SURFACE POINT COORDINATES
         POINT       ELEVATION       X-COORD
          NO.          (FT)           (FT)
           1          580.00          0.00
```

RIGHT SIDE SOIL LAYER DATA

LAYER NO.	UNIT WEIGHT (PCF)	INTERNAL FRICTION ANGLE (DEG)	COHESION (PSF)	WALL FRICTION ANGLE (DEG)	BOTTOM ELEV AT WALL (FT)	BOTTOM SLOPE (FT/FT)
1	115.00	35.00	0.00	0.00	571.60	1:0.0
2	125.00	35.00	0.00	0.00	548.10	1:0.0
3	120.00	0.00	500.00	0.00	535.00	1:0.0
4	132.50	0.00	2000.00	0.00		

1.E.--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	542.60	0.00

LEFT SIDE SOIL LAYER DATA

LAYER NO.	UNIT WEIGHT (PCF)	INTERNAL FRICTION ANGLE (DEG)	COHESION (PSF)	WALL FRICTION ANGLE (DEG)	BOTTOM ELEV AT WALL (FT)	BOTTOM SLOPE (FT/FT)
1	120.00	0.00	500.00	0.00	535.00	1:0.0
2	132.50	0.00	2000.00	0.00		

1.F.--WATER DATA

RIGHT SIDE ELEVATION = 571.60 (FT)
LEFT SIDE ELEVATION = 568.60 (FT)
WATER UNIT WEIGHT = 62.40 (PCF)
SEEPAGE GRADIENT = 0.00 (FT/FT)

1.G.--SURCHARGE LOADS

NUMBER OF LINE LOADS = 0
DISTRIBUTED LOAD DISTRIBUTION = UNIF

UNIFORM SURCHARGE LOAD
LOAD = 1000.00 PSF

1.H.--HORIZONTAL LOADS

NUMBER OF HORIZONTAL LINE LOADS = 0
NUMBER OF HORIZONTAL PRESSURE POINTS = 0
EARTHQUAKE ACCELERATION = 0.00 (G'S)

DO YOU WANT INPUT DATA SAVED IN A FILE? ENTER 'YES' OR 'NO'
I>YES
ENTER FILE NAME IN WHICH INPUT DATA WILL BE SAVED.
(6 CHARACTERS MAXIMUM)
I>RJ2C16
DO YOU WANT A PLOT OF INPUT GEOMETRY?
ENTER 'YES' OR 'NO'

```
INPUT SEQUENCE COMPLETE.
    DO YOU WANT TO CONTINUE SOLUTION?
    ENTER 'YES' OR 'NO'
I>YES


    DO YOU WANT ACTIVE AND PASSIVE SOIL PRESSURES
    PRINTED AT YOUR TERMINAL?  ENTER 'YES' OR 'NO'
I>NO
    SOLUTION COMPLETE
    DO YOU WANT RESULTS PRINTED AT YOUR TERMINAL,
    WRITTEN TO A FILE, OR BOTH?
    ENTER 'TERMINAL', 'FILE', OR 'BOTH'
I>TERMINAL
```

PROGRAM SHTWAL - DESIGN/ANALYSIS OF ANCHORED
OR CANTILEVER SHEET PILE WALLS BY CLASSICAL METHODS
DATE: 10/21/81 TIME: 10:45:59

2. RESULTS

2.A.--HEADING

CLEVE. HARBOR STUDY - CONGESTION STUDY,BLKHD. DESIGN FOR CUT#16,COND.2
SSP WALL IN COHESIVE MATERIAL, LEWINS SOIL PARAM. 3 HYDROSTAT. HD. DIFF.
EXIST. CHANNEL BOT. AT EL.542.6 ,SURCHARGE=1000PSF, ANCH. ROD AT ELEV. 57..

2.B.--SUMMARY OF RESULTS FOR ANCHORED WALL DESIGN

SOIL PRESSURES DETERMINED BY COULOMB
COEFFICIENTS AND THEORY OF ELASTICITY
EQUATIONS FOR SURCHARGE LOADS

METHOD	WALL BOTTOM PEN (FT)	WALL BOTTOM ELEV (FT)	MAXIMUM BENDING MOMENT (LB-FT)	MAX SCALED DEFLECTION (LB-IN3)	ANCHOR FORCE (LB)
FREE EARTH :	29.66	512.94	515541.	2.69E+11	41152.
FIXED EARTH:	50.42	492.18	433985.	2.16E+11	37894.
EQUIV BEAM :	65.03	477.57	294374.	6.98E+10	31893.
EQUAL MOM :	56.98	485.62	-367413.	-1.53E+11	35112.
TERZAGHI :	48.76	493.84	433813.	2.16E+11	37867.

(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)

DO YOU WANT COMPLETE RESULTS OUTPUT?
ENTER 'YES' OR 'NO'
1>YES

COMPLETE RESULTS ARE AVAILABLE FOR FOLLOWING
METHODS OF ANALYSIS:
FREE EARTH : ENTER 'FR' ON CUE
FIXED EARTH: ENTER 'FI' ON CUE
EQUIV BEAM : ENTER 'EB' ON CUE
EQUAL MOM : ENTER 'EM' ON CUE
TERZAGHI : ENTER 'TE' ON CUE

ENTER METHOD FOR WHICH COMPLETE RESULTS ARE DESIRED
1>EB

2.C.--COMPLETE RESULTS FOR ANCHORED WALL DESIGN
BY EQUIV BEAM METHOD

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
580.00	-0.	0.	-4.69E+10	405.49
579.00	-211.	-429.	-4.13E+10	452.12
578.00	-873.	-904.	-3.58E+10	498.76
577.00	-2035.	-1426.	-3.02E+10	545.39
576.00	-3741.	-1995.	-2.46E+10	592.02
575.00	-6040.	-2610.	-1.91E+10	638.65
574.00	-8978.	-3272.	-1.35E+10	685.28
573.00	-12600.	-3981.	-7.88E+09	731.91
572.00	-16955.	-4736.	-2.26E+09	778.55
571.60	-18912.	-5051.	0.	797.20
571.60	-18912.	26841.	0.	797.20
571.00	-2954.	26347.	3.39E+09	849.87
570.00	22954.	25454.	9.04E+09	937.65
569.00	47924.	24472.	1.47E+10	1025.44
568.60	57630.	24055.	1.69E+10	1060.55
568.00	71871.	23414.	2.02E+10	1075.78
567.00	94743.	22325.	2.56E+10	1101.16
566.00	116513.	21212.	3.08E+10	1126.55
565.00	137158.	20072.	3.59E+10	1151.93
564.00	156650.	18908.	4.07E+10	1177.32
563.00	174965.	17718.	4.52E+10	1202.70
562.00	192077.	16502.	4.95E+10	1228.08
561.00	207961.	15262.	5.34E+10	1253.47
560.00	222591.	13995.	5.69E+10	1278.85
559.00	235943.	12704.	6.01E+10	1304.24
558.00	247991.	11387.	6.28E+10	1329.62
557.00	258709.	10045.	6.51E+10	1355.00
556.00	268072.	8677.	6.70E+10	1380.39
555.00	276054.	7284.	6.84E+10	1405.77
554.00	282631.	5865.	6.93E+10	1431.15
553.00	287776.	4422.	6.98E+10	1456.54
552.00	291466.	2952.	6.97E+10	1481.92
551.00	293673.	1458.	6.92E+10	1507.31
550.00	294373.	-62.	6.81E+10	1532.69
549.00	293540.	-1608.	6.66E+10	1558.07
548.10	291459.	-3020.	6.47E+10	1580.92

547.00	286[illegible]34.	-6305.	6.19E+10	3020.99
546.00	278506.	-9358.	5.88E+10	3078.59
545.00	267599.	-12466.	5.53E+10	3136.19
544.00	253555.	-15631.	5.12E+10	3193.79
543.00	236318.	-18853.	4.68E+10	3251.39
542.60	228516.	-20158.	4.49E+10	3274.43
542.60	228516.	-20158.	4.49E+10	2607.77
542.00	215952.	-21723.	4.19E+10	2607.77
541.00	192925.	-24331.	3.67E+10	2607.77
540.00	167290.	-26939.	3.11E+10	2607.77
539.00	139048.	-29546.	2.53E+10	2607.77
538.00	108197.	-32154.	1.92E+10	2607.77
537.00	74739.	-34762.	1.29E+10	2607.77
536.00	38674.	-37370.	6.48E+09	2607.77
535.00	0.	-39977.	0.	2607.77

```
          (NOTE: DIVIDE SCALED DEFLECTION BY MODULUS
          OF ELASTICITY IN PSI TIMES PILE MOMENT OF
          INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES)


          (NOTE: OUTPUT TABLE FOR EQUIVALENT BEAM
          METHOD ENDS AT ASSUMED POINT OF INFLECTION)
    DO YOU WANT RESULTS FOR ANOTHER METHOD? ENTER 'YES' OR 'NO'
I>NO


    DO YOU WANT GEOMETRY AND/OR RESULTS PLOTTED?
    ENTER 'GEOMETRY', 'RESULTS', 'BOTH', OR 'NEITHER'
I>NEITHER


    OUTPUT COMPLETE
    DO YOU WANT TO EDIT INPUT DATA FOR THE
    PROBLEM JUST COMPLETED?  ENTER 'YES' OR 'NO'
I>NO
    DO YOU WANT TO MAKE ANOTHER RUN?  ENTER 'YES' OR 'NO'
I>NO


        **********  NORMAL TERMINATION  **********
EXIT.
N>PURGE,RCJC16,RJ2C16
N>BYE
 JOB PROCESSING CCUS    114.854
BYE  81/10/21. 10.51.47.

select desired service:
```

Page 1 of ___ pages,

Subject: CLEVELAND HARBOR STUDY – CONGESTION STUDY
Computation of: New Bulkhead Walls for Cut #16, Site #3
Computed by: RCJ 10/20/81 Checked by: ________ Date: ________

Assumptions:

Existing channel bottom at 26' below LWD or El. 542.6

Water surface elevation in river at LWD or El 568.6

Saturation line in back of wall El 571.6

PZ 38 piles with anchor rods at El 571.6

Site #3 stretches from approximately rivermile 1.2 to rivermile 1.6, therefore the same soil design parameters that were used to design the typical bulkhead "B" will be used in the design of the new SSP bulkhead for Cut #16.

El. 580.0 Top of Ground

γ_{mst} = 115 pcf
ϕ = 35°
c = 0 psf

El. 571.6 Sat. Line

γ_{sat} = 125 pcf
ϕ = 35°
c = 0

El. 548.1

γ_{sat} = 120 pcf
ϕ = 0°
c = 500 psf

El 535.0

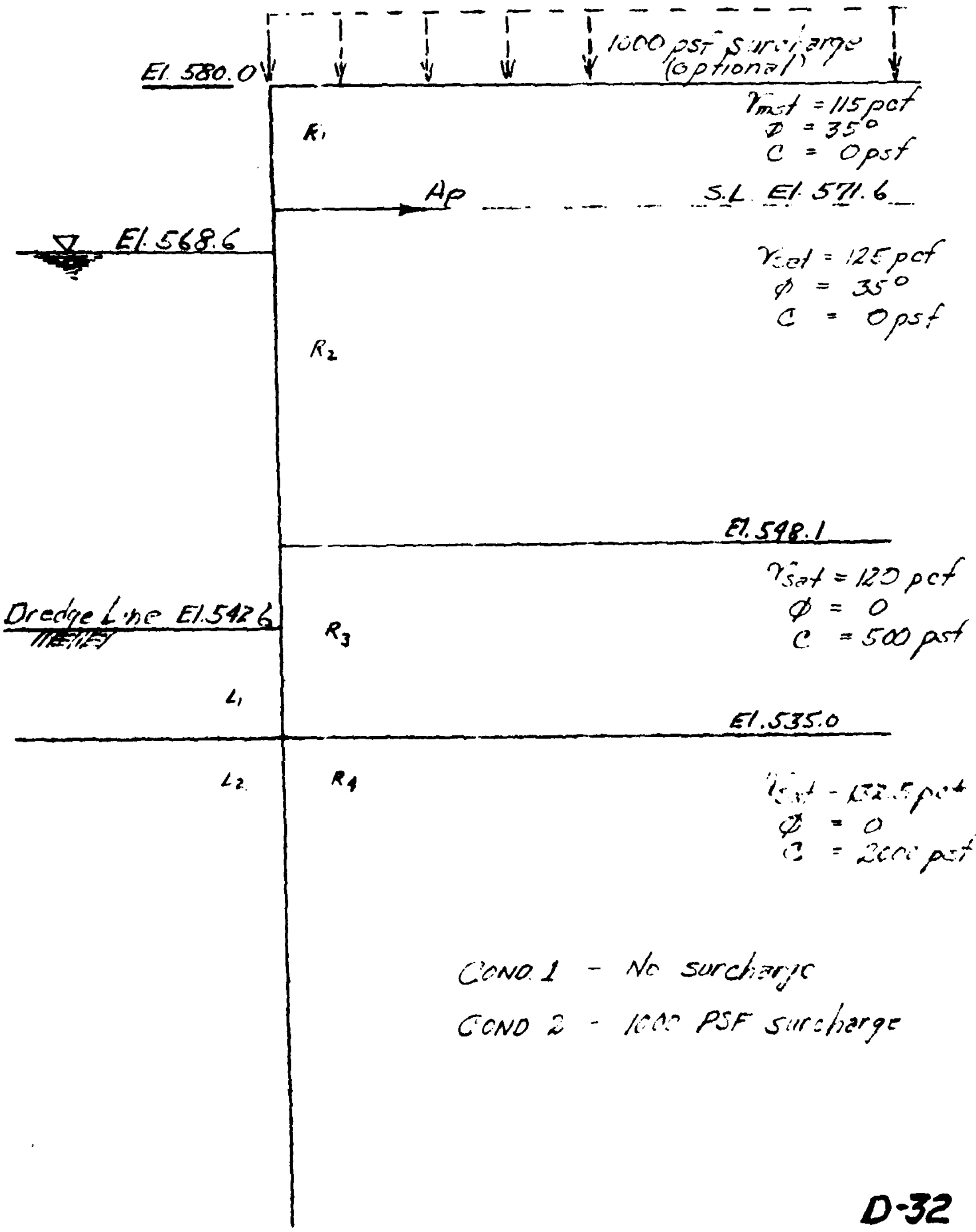
γ_{sat} = 132.5 pcf
ϕ = 0
c = 2000 psf

Page 2 of ___ pages,

Subject CLEVELAND HARBOR STUDY - CONGESTION STUDY

Computation of Bulkhead Design Section for Cut #16

Computed by RCJ 10/20/81 Checked by ______ Date ______



Subject: CLEVELAND HARBOR STUDY - CONGESTION STUDY
Computation of: Bulkhead Details for Cut #16 (No surcharge)
Computed by: RJT 11/4/81 Checked by ________ Date ________

The results of the design as determined by the computer program "SHTWAL" are as follows; For "Equivalent Beam" method:

Penetration below El. 542.6 (F.S. = 1.5)	=	29.8 ft.
Maximum Bending Moment	=	204556 lb-ft
Maximum Scaled Deflection	=	4.87×10^{10} lb-in^3
Anchor Force	=	19281 lbs

The bending moment, bending stress and resulting deflection are too large to be taken by the PZ 38 steel sheet piling alone

∴ Reinforce piling with cover plates!

$F_y = 55000$ psi , $F_b = 0.65 F_y = 0.65(55000) = 35000$ psi

Section Modulus of PZ 38 = 46.8 in^3/foot of wall

Resisting Moment of Piling Alone, $M_R = \frac{35000(46.8)}{12} = 136500$ lb-ft

Bending Moment to be resisted by cover plates.

$204556 - 136500 = 68056$ lb-ft

Additional Section Modulus Required

$S_{req'd} = \frac{68056(12)}{35000} = 23.33$ in^3/foot of wall

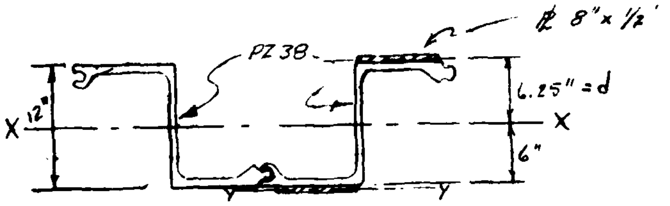
Assume cover plates 8" x ½" extending from El. 562 to El. 541. See sketch on page 2B

Page 2B of ____ pages.

Subject CLEVELAND HARBOR STUDY - CONGESTION STUDY

Computation of Bulkhead Design for Cut #16 (No surcharge)

Computed by RCJ 11/5/81 Checked by ____________ Date ________



Ixx of PZ38 about axis X-X = 421.2 in⁴

I_{yy} of Plate $= \frac{bd^3}{3} = \frac{8(0.5)^3}{3} = 0.33\ in^4$

Ad^2 of Plate $= 8(0.5)(6.25)^2 = 156.25\ in^4$

$I_{yy} + Ad^2$ of one plate $= 156.58\ in^4$

" " " two plates $= 313.16\ in^4$

313.16 in⁴

Ixx of reinforced piling 734.36 in⁴/pile

489.57 in⁴/ft. of wall

$S_{xx} = \frac{734.36}{6.5} = 112.98\ in^3/Pile$

S_{xx} per foot of wall $= \frac{112.98(12)}{18} = 75.32\ in^3$

Check bending stress in piling.

$f_b = \frac{209{,}[illegible](12)}{75.32}$ = 33,300 psi < [illegible] ok.

Deflection - Divide scaled maximum deflection in lb-in³ by the product of the modulus of elasticity and the moment of inertia of the reinforced pile

$$Deflection = \frac{4.97 \times 10^{10}}{(2.9 \times 10^7)(4.8957 \times 10^2)} = 0.34 \times 10^1\ in$$

or 3.4 inches

O.K.

Subject: Cleveland Harbor Study - Condition Study
Computation of: Bulkhead Design for Cut #2 (No surcharge)
Computed by: RCT 11/5/81 Checked by ____ Date ____

Tie Rods

Assume a 9' spacing on tie rods, and level ($\alpha = 0°$) tie rods.

$Ap = \frac{T \times d}{\cos \alpha} = 19281 \times 9' = 173529$ lb/rod

increase by 30% for design

$173529 (1.30) = 225588$ lb say 225000 lb

Use high strength steel (A-588) $F_y = 50000$

Req'd cross sectional area $= \frac{225000}{0.6(50000)} = 7.5 \text{ in}^2$

Use 3 1/8"φ bar upset to 4" $A_{s\,furn} = 7.67 \text{ in}^2$

Wales

For Max Mom. use $M_{max} = \frac{1}{9} T d^2$

$M_{max} = 1/9 (19281)(9)^2 = 173529$ lb-ft

$F_b = 0.6 F_y$, $F_y = 55000$ and $F_b = 33000$ psi

S_{xx} req'd $= \frac{173529(12)}{33000} = 63.10 \text{ in}^3$

or 32 in^3/channel

Use two C15 x 33.9 $S_{furn} = 84 \text{ in}^3$

or Use two MC 12 x 37 $S_{furn} = 68.4 \text{ in}^3$

Based on previous designs for the river deepening locate anchor wall (continuous) 70 feet back from bulkhead wall. Use PZ 38 piling 10 feet long minimum.

Subject: CLEVELAND HARBOR STUDY - CONGESTION STUDY
Computation of: Bulkhead Design for Cut #16 (with surcharge)
Computed by: RCT 11/5/81 Checked by: ___ Date: ___

Results of the design as determined by the computer program "SHTWAL" are as follows:

For the "Equivalent Beam" method (F.S. = 1.5)

Penetration below El 542.6	= 65.03 Ft
Maximum Bending Moment	= 294374 lb-ft
Maximum Scaled Deflection	= 6.98×10^{10} lb-in^3
Anchor Force	= 31893 lbs.

The maximum bending moment, maximum scaled deflection and resulting bending stress developed are too large to be taken by the PZ 38 piling alone.

∴ It will be necessary to reinforce the piles with stiffner or cover plates.

F_y (of piling) = 55000 $F_b = 0.65 F_y = 0.65(55000) = 35000$ psi

Section Modulus of PZ 38 = 46.8 in³/foot of wall

Resisting Moment of PZ38 alone.

$$M_R = \frac{35000(46.8)}{12} = 136500 \text{ lb-ft}$$

Bending Moment to be taken by cover plates.

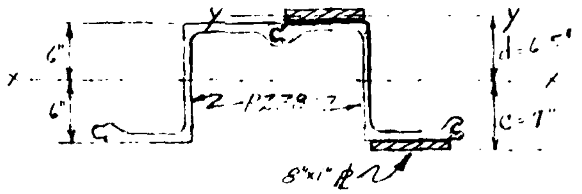
294374 - 136500 = 157874 lb-ft

Additional Section Modulus req'd.

$$S_{Reqd} = \frac{157874(12)}{35000} = 54.13$$

Assume cover plates 8" x 1" (2 per pile) extending from El. 566 to El. 538. (See sketch on page 2E).

Subject: Cleveland Harbor Study - Congestion Study
Computation of: Bulkhead Design for Cut #16 (with surcharge)
Computed by: RCJ 11/6/81 Checked by: ________ Date: ________



I of PZ38 about axis X-X = $421.2\ in^4$

I_{yy} of 8"x1" PL $= \frac{bd^3}{3} = \frac{8(1)^3}{3} = 2.67\ in^4$

Ad^2 of 8"x1" PL $= (8)(1)(6.5)^2 = \underline{338.00}\ in^4$

$I_{yy} + Ad^2$ of one 8"x1" Plate $= 340.67\ in^4$

" " " two " " " $= 681.34\ in^4$ = $\underline{681.34\ in^4}$

I_{xx} of reinforced PZ 38 pile = $1102.54\ in^4$

I_{xx} per foot of wall $= \frac{1102.54(12)}{18} = 735.03\ in^4/ft$

$$S_{xx}/\text{ft of wall} = \frac{I_{xx}}{c} = \frac{735.03}{7} = 105.0\ in^3/ft$$

Check bending stress in piling.

$$f_b = \frac{M}{S} = \frac{294374(12)}{105} = 33643\ psi < 35000\ psi$$

OK!

Deflection - Divide maximum scaled deflection in $lb\text{-}in^3$ by the product of the modulus of elasticity of steel and the moment of inertia of the reinforced PZ38.

$$\text{Max. Deflection} = \frac{6.98 \times 10^{10}}{(2.9\times10^7)(7.3503\times10^2)} = 0.33\times10^1 \text{ inches}$$

or 3.3 inches

Subject: CLEVELAND HARBOR STUDY - CONGESTION STUDY
Computation of: Bulkhead Design for Cut #16 (with surcharge)
Computed by: RCJ 11/6/81 Checked by: ______ Date: ______

Tie Rods

Assume tie rods are level ($\alpha = 0$) and spaced 9' apart ($d = 9'$)

$A_p = \frac{T_x d}{\cos\alpha} = \frac{31893(9)}{1} = 287037$ lb/rod

Increase 30% for design, then $A_p = 1.3(287037) = 373148$ lb

say 373000

Use high strength steel (A-588) $F_y = 50000$ psi

Req'd cross-sectional area of rod $= \frac{373000}{0.6(50000)} = 12.43$ in^2
too large

Decrease spacing to 6'

$A_p = \frac{31893(6)}{1} = 191358$ lb $+ 30\% = 248765$ lb

say 250000 lb

Req'd $A_s = \frac{250000}{30000} = 8.33$ □"

Use 3¼" ⌀ upset to 4" $A_{s\,furn.} = 8.296$ □"
slight overstress
OK

Wales

For Max. moment use $\frac{1}{9} T d^2$

$M_{max} = \frac{31893(6)^2}{9} = 127572$ lb ft

$F_b = 0.6 F_y$, $F_y = 55000$ and $F_b = 33000$ psi

S_{xx} req'd $= \frac{M}{F_b} = \frac{127572(12)}{33000} = 46.39$ in^3
or 23.2 in^3/channel

Use two C12 x 25, $S_{furn} = 48.2$ in^3

or two MC10 x 28.3, $S_{furn} = 47.2$ in^3

Subject CLEVELAND HARBOR STUDY - CONGESTION STUDY
Computation of Bulkhead Design for Cut #16 (with surcharge)
Computed by RCT 11/6/81 Checked by ________ Date ________

Anchor Wall

Based on previous computations for the river deepening, locate a continuous PZ 38 sheet pile anchor wall, 70 feet back from the bulkhead wall, with a vertical height of 12 feet.

Subject CLEVELAND HARBOR STUDY - CONGESTION STUDY
Computation of New Bulkhead Walls for Cut #16 Site #3
Computed by RCJ 11/6/81 Checked by ______ Date ______

NOTE: Use CBP 124 85' long for wales and tension piles.

Anchorage Design Utilizing Battered Tension Piles

Anchor Pull = 31893 lb
Assume 6' spacing for battered piles

Wales $M_{max} = 1/9\, Td^2 = 1/9(31893)(6)^2 = 127{,}572$ lb-ft

$F_t = 0.6 F_y = 0.6(55000) = 33000$ psi

$S = \frac{127572(12)}{33000} = 46.4\ in^3$

Use 10x10x57 (CBP 103)
$S_{furn.} = 58.9$

Extractive Force on Batter Pile

Assume 45° batter

$F = \frac{31893(6)}{\cos 45°} = 270624$ lbs (Axial Load)
increase by 30%, say 352000

$F_T = 0.6 F_y = 33000$

$A_{s\,reqd} \quad \frac{352000}{33000} = 10.67\ in^2 < 16.76\ in^2$ OK

Frictional resistance per S.F. of pile driven into material having a cohesion value of c is given by:

$f = 0.25\, q_u$, where $q = 2c$

$\therefore\ f = 0.25(2c) = 0.5c$

The force exerted on a round pile as resistance to extraction is, $T = \pi d L f$ (Foundation Engineering Handbook, Winterkorn & Fang)

πd = circumference of pile
L = embedded length
$f = 0.5c$

For a bearing pile substitute NP net perimeter for πd

Then $T = NPLf$ or $L = \frac{T}{NPf}$ $f = 2c = 2(2000) = 4000$
$NP = 3.33'$

$L = \frac{352000}{3.33(4000)} = 26.43' + \frac{(EL 571.6 - EL 535.0)}{.7071}$

$= 26.43 + 51.76 = 78.19$ say 80'

```
PROGRAM CHTUAL - DESIGN/ANALYSIS OF ANCHORED
OR CANTILEVER SHEET PILE WALLS BY CLASSICAL METHODS
DATE: 12/22/81                          TIME: 10:30:54

1. INPUT DATA

1.A.--HEADING

CLEVE. HARBOR STUDY - OLD RIVER - BULKHEAD NO.5, DESIGN
IMPROVED CHANNEL BOTTOM, 3 FT. HYDROSTAT. HD. DIFF.
SURCHARGE=1000.0PSF

1.B.--WALL TYPE, MODE, METHOD
     ANCHORED WALL DESIGN   BY EQUIVALENT BEAM METHOD

1.C.--WALL DESCRIPTION
     TOP OF WALL ELEVATION =  579.00 (FT)
     ANCHOR ELEVATION      =  571.60 (FT)
     FACTOR OF SAFETY      =    1.50

1.D.--RIGHT SIDE SOIL DESCRIPTION
     NUMBER OF RIGHT SIDE SURFACE POINTS =  1
     NUMBER OF RIGHT SIDE SOIL LAYERS    =  3

     RIGHT SIDE SURFACE POINT COORDINATES
     POINT      ELEVATION      X-COORD
      NO.         (FT)           (FT)
      1          579.00          0.00
```

RIGHT SIDE SOIL LAYER DATA

LAYER NO.	UNIT WEIGHT (PCF)	INTERNAL FRICTION ANGLE (DEG)	COHESION (PSF)	WALL FRICTION ANGLE (DEG)	BOTTOM ELEV AT WALL (FT)	BOTTOM SLOPE (FT/FT)
1	115.00	35.00	0.00	0.00	571.60	1:0.0
2	125.00	35.00	0.00	0.00	546.00	1:0.0
3	186.00	5.00	1450.00	0.00		

1.E.--LEFT SIDE SOIL DESCRIPTION

NUMBER OF LEFT SIDE SURFACE POINTS = 1
NUMBER OF LEFT SIDE SOIL LAYERS = 1

LEFT SIDE SURFACE POINT COORDINATES

POINT NO.	ELEVATION (FT)	X-COORD (FT)
1	538.63	0.00

LEFT SIDE SOIL LAYER DATA

LAYER NO.	UNIT WEIGHT (PCF)	INTERNAL FRICTION ANGLE (DEG)	COHESION (PSF)	WALL FRICTION ANGLE (DEG)	BOTTOM ELEV AT WALL (FT)	BOTTOM SLOPE (FT/FT)
1	186.00	5.00	1450.00	0.00		

1.F.--WATER DATA

RIGHT SIDE ELEVATION = 571.60 (FT)
LEFT SIDE ELEVATION = 568.60 (FT)
WATER UNIT WEIGHT = 62.40 (PCF)
SEEPAGE GRADIENT = 0.00 (FT/FT)

```
     SEEPAGE GRADIENT                =    0.00 (FT/FT)

  1.G.--SURCHARGE LOADS
     NUMBER OF LINE LOADS           =  0
     DISTRIBUTED LOAD DISTRIBUTION = UNIF


     UNIFORM SURCHARGE LOAD
     LOAD                  = 1000.00 PSF


  1.H.--HORIZONTAL LOADS
     NUMBER OF HORIZONTAL LINE LOADS          =    0
     NUMBER OF HORIZONTAL PRESSURE POINTS     =    0
     EARTHQUAKE ACCELERATION                  =    0.00 (G'S)




   DO YOU WANT INPUT DATA SAVED IN A FILE? ENTER 'YES' OR 'NO'
I>YES
   ENTER FILE NAME IN WHICH INPUT DATA WILL BE SAVED.
    (6 CHARACTERS MAXIMUM)
I>RCJOR5
   DO YOU WANT A PLOT OF INPUT GEOMETRY?
   ENTER 'YES' OR 'NO'
I>NO
   INPUT SEQUENCE COMPLETE.
   DO YOU WANT TO CONTINUE SOLUTION?
   ENTER 'YES' OR 'NO'
I>
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PROGRAM SHTWAL - DESIGN/ANALYSIS OF ANCHORED
OR CANTILEVER SHEET PILE WALLS BY CLASSICAL METHODS
DATE: 12/22/81 TIME: 10:33:37

2. RESULTS

2.A.--HEADING

CLEVE. HARBOR STUDY - OLD RIVER - BULKHEAD NO.5, DESIGN
IMPROVED CHANNEL BOTTOM, 3 FT. HYDROSTAT. HD. DIFF.
SURCHARGE=1000.0PSF

2.B.--SUMMARY OF RESULTS FOR ANCHORED WALL DESIGN

SOIL PRESSURES DETERMINED BY COULOMB
COEFFICIENTS AND THEORY OF ELASTICITY
EQUATIONS FOR SURCHARGE LOADS

METHOD	WALL PEN (FT)	BOTTOM ELEV (FT)	MAXIMUM BENDING MOMENT (LB-FT)	MAX SCALED DEFLECTION (LB-IN3)	ANCHOR FORCE (LB)
EQUIV BEAM :	73.94	464.66	266250.	7.51E+10	29079.

(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)

DO YOU WANT COMPLETE RESULTS OUTPUT?
ENTER 'YES' OR 'NO'
I>YES

2.C.--COMPLETE RESULTS FOR ANCHORED WALL DESIGN
BY EQUIV BEAM METHOD

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
579.00	-0.	0.	-4.26E+10	405.49
578.00	-211.	-429.	-3.68E+10	452.12
577.00	-873.	-904.	-3.11E+10	498.76
576.00	-2035.	-1426.	-2.54E+10	545.39
575.00	-3741.	-1995.	-1.96E+10	592.02
574.00	-6040.	-2610.	-1.39E+10	638.65
573.00	-8978.	-3272.	-8.10E+09	685.28
572.00	-12600.	-3981.	-2.32E+09	731.91
571.60	-14252.	-4277.	0.	750.57
571.60	-14252.	24801.	0.	750.57
571.00	491.	24335.	3.48E+09	803.24
570.00	24410.	23488.	9.28E+09	891.02
569.00	47438.	22553.	1.50E+10	978.81
568.60	56380.	22155.	1.73E+10	1013.92
568.00	69489.	21542.	2.07E+10	1029.15
567.00	90512.	20500.	2.63E+10	1054.53
566.00	110480.	19433.	3.17E+10	1079.92
565.00	129369.	18340.	3.69E+10	110› 30

564.00	147152.	17222.	4.18E+10	1130.68
563.00	163805.	16079.	4.66E+10	1156.07
562.00	179301.	14910.	5.10E+10	1181.45
561.00	193616.	13716.	5.52E+10	1206.84
560.00	206724.	12496.	5.90E+10	1232.22
559.00	218600.	11251.	6.24E+10	1257.60
558.00	229218.	9981.	6.55E+10	1282.99
557.00	238554.	8685.	6.81E+10	1308.37
556.00	246581.	7364.	7.04E+10	1333.76
555.00	253274.	6018.	7.22E+10	1359.14
554.00	258608.	4646.	7.36E+10	1384.52
553.00	262557.	3249.	7.46E+10	1409.91
552.00	265097.	1826.	7.51E+10	1435.29
551.00	266201.	378.	7.51E+10	1460.67
550.74	266250.	0.	7.50E+10	1467.23
550.00	265845.	-1095.	7.47E+10	1486.06
549.00	264003.	-2594.	7.38E+10	1511.44
548.00	260649.	-4118.	7.25E+10	1536.83
547.00	255758.	-5668.	7.07E+10	1562.21
546.00	249305.	-7242.	6.85E+10	1587.59
546.00	249305.	-7242.	6.85E+10	1436.85
545.00	241326.	-8734.	6.58E+10	1546.85
544.00	231800.	-10336.	6.27E+10	1656.85
543.00	220617.	-12048.	5.93E+10	1766.85
542.00	207667.	-13870.	5.54E+10	1876.85
541.00	192841.	-15802.	5.12E+10	1986.85
540.00	176027.	-17844.	4.66E+10	2096.84
539.00	157117!	-19995.	4.18E+10	2206.84
538.60	148941.	-20887.	3.98E+10	2250.84
538.60	148941.	-20887.	3.98E+10	201.46
538.00	136374.	-21003.	3.67E+10	184.13
537.00	115284.	-21172.	3.13E+10	155.24
536.00	94039.	-21313.	2.57E+10	126.36
535.00	72668.	-21425.	2.00E+10	97.47

545.00	241326.	-8734.	6.58E+10	1546.85
544.00	231800.	-10336.	6.27E+10	1656.85
543.00	220617.	-12048.	5.93E+10	1766.85
542.00	207667.	-13870.	5.54E+10	1876.85
541.00	192841.	-15802.	5.12E+10	1986.85
540.00	176027.	-17844.	4.66E+10	2096.84
539.00	157117.	-19995.	4.18E+10	2206.84
538.60	148941.	-20887.	3.98E+10	2250.84
538.60	148941.	-20887.	3.98E+10	201.46
538.00	136374.	-21003.	3.67E+10	184.13
537.00	115284.	-21172.	3.13E+10	155.24
536.00	94039.	-21313.	2.57E+10	126.36
535.00	72668.	-21425.	2.00E+10	97.47
534.00	51199.	-21508.	1.42E+10	68.59
533.00	29661.	-21562.	8.23E+09	39.70
531.63	0.	-21589.	0.	0.00

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS
OF ELASTICITY IN PSI TIMES PILE MOMENT OF
INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES)

(NOTE: OUTPUT TABLE FOR EQUIVALENT BEAM
METHOD ENDS AT ASSUMED POINT OF INFLECTION)

DO YOU WANT GEOMETRY AND/OR RESULTS PLOTTED?
ENTER 'GEOMETRY', 'RESULTS', 'BOTH', OR 'NEITHER'

I>

Subject: CLEVELAND HARBOR STUDY - OLD RIVER DEEPENING
Computation of: Typical Bulkhead Design for Left Bank
Computed by: RCJ 1/15/82 Checked by ______ Date ______

Note that the entire left bank of the Old River where bulkheads are required, except for a stretch of 440 feet between river mile 0.2 and 0.3 calls for a sheet pile penetration of 72 feet to 77 feet. This penetration is due to surcharge loading caused by stockpiled sand and gravel products or salt. Therefore use the design for Bulkhead No. 5 as a typical design.

Required Penetration (below dredge line for F.S.=1.5) = 74.0 ft

Max. Bending Moment (lb-ft) = 266250

Max Deflection (lb-in³) = 7.51×10^{10}

Anchor Force per foot of wall = 29079 lb

The bending moment, bending stress, and resulting deflection are too large to be sustained by the steel sheet piling alone!

∴ It will be necessary to reinforce the piling with high strength steel cover plates.

Maximum moment that can be taken by the piling alone. Assume PZ38 and high strength steel.

Section modulus per foot of wall = 46.8 in³

$f_b = 0.65 F_y$ where $F_y = 55000$ psi
$f_b = 0.65(55000) = 35000$ psi

Resisting Moment of piling $= \frac{(46.8\ in^3)(35000\ lb/in^2)}{12} = 136500$ lb-ft

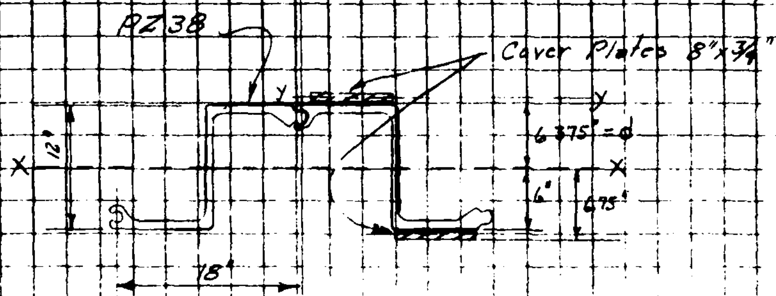
Bending moment to be taken by cover plates.

266250 - 136500 = 129750 lb-ft

Additional Section Modulus Req'd $= \frac{129750(12)}{35000} = 44.5\ in^3$

The additional section modulus req'd will be made up by 8" × 3/4" cover plates (2 per pile) extending from El 565 to El. 538.

Subject CLEVELAND HARBOR STUDY - OLD RIVER DEEPENING
Computation of Typical Bulkhead Design for Left Bank
Computed by RCJ 1/18/82 Checked by ________ Date ________



I of PZ38 about axis X-X = 421.2 in⁴

I of 8"x3/4" PL = $\frac{bd^3}{3} = \frac{8(0.75)^3}{3} = 1.13\ in^4$

Ad^2 of 8"x3/4" PL = $(8)(0.75)(6.38)^2 = 243.84\ in^4$

$I + Ad^2$ of one PL = 244.97 in⁴
$I + Ad^2$ of two PLs = 489.95 in⁴ → 489.95 in⁴

I_{xx} of reinforced piling = 911.15 in⁴

I_{xx} per foot of wall = $\frac{911.15(12)}{18}$ = 607.43 in⁴

$S = \frac{I}{c} = \frac{607.43}{6.75} = 89.99\ in^3$

Check bending stress for reinforced piling

$f_b = \frac{266250(12)}{89.99} = 35504\ psi > 35000$ NG
Use 8"x1" cover plates
or 8"x7/8" " "

I of PZ 38 about axis X-X 421.2 in⁴
I of 8"x7/8" PL = $\frac{bd^3}{3} = \frac{8(0.875)^3}{3} = 2.04\ in^4$

Ad^2 of 8"x7/8" PL = $8(.875)(6.4375)^2 = 290.09\ in^4$
$I + Ad^2$ of one PL = 292.13 in⁴
" " two PLs = 584.26 in⁴ → 584.26 in⁴
I_{xx} of reinforced piling 1005.46 in⁴
I_{xx} per foot of wall = $\frac{1005.46(12)}{18}$ = 670.31 in⁴

$S = I/c = 670.31/6.875 = 97.50\ in^3$

$f_b = \frac{266250(12)}{97.5} = 32770\ psi < 35000\ psi$ OK

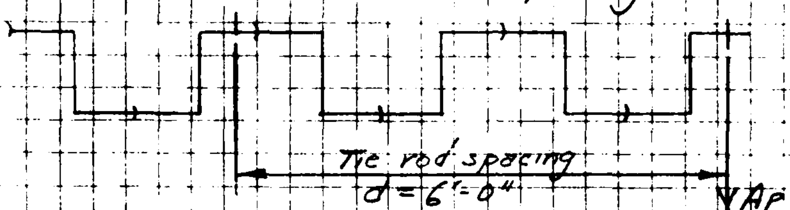
Subject: CLEVELAND HARBOR STUDY - OLD RIVER DEEPENING
Computation of: Typical Bulkhead Design for Left Bank
Computed by: RCJ 1/18/82 Checked by: ________ Date: ________

Deflection: Divide maximum deflection in lb-in³ by the product of the modulus of elasticity of steel and the moment of inertia of the reinforced piling.

$$\text{Defln (inches)} = \frac{7.51 \times 10^{10}}{(2.9 \times 10^{7})(6.0743 \times 10^{2})} = 0.43 \times 10^{1} = 4.3'' \quad \text{O.K.}$$

Design Anchorage System

Tie Rods Use 6-0" spacing



Assume tie rods are level ($\alpha = 0°$ and $\cos\alpha = 1$)

$$A_P = \frac{T \times d}{\cos\alpha} = \frac{29079 \times 6}{1} = 174474 \text{ lbs}$$

Increase by 30% for design. Then $A_p = 227000$ lb

Use high strength steel $F_y = 50{,}000$ (A-588)

$$A_s \text{ req'd} = \frac{227000}{0.6(50000)} = 7.57 \text{ in}^2$$

Use a 3 1/8" Ø bar upset to 4" As furn. = 7.67 □"

Wales

For maximum moment, use $M_{max} = 1/9\, T d^2$

$$M_{max} = \frac{29079 (6)^2}{9} = 116316 \text{ lb-ft}$$

$$F_b = 0.6(55{,}000) = 33000 \text{ psi}$$

$$S_{xx} \text{ req'd} = \frac{116316 (12)}{33000} = 42.3 \text{ in}^3$$

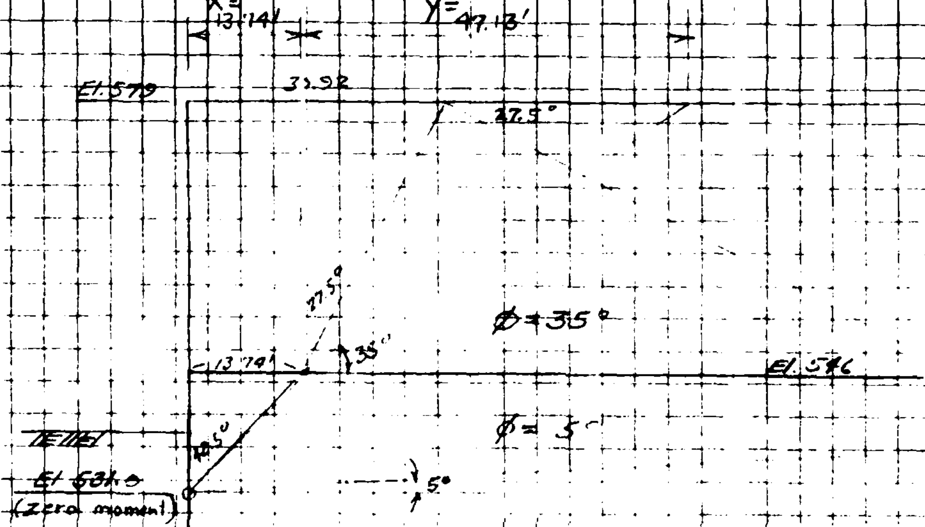
or 21.2 in^3/channel

2 - C12x25 channels furnish 48.2 in³

Use 1" bolts and 1½" pipe sleeves to bolt channels back to back. Assume a clear distance of 3¼".

Subject CLEVELAND HARBOR STUDY - OLD RIVER DEEPENING
Computation of Typical Bulkhead Design for Left Bank
Computed by RCJ 1/18/82 **Checked by** ___ **Date** ___

Location of Anchor Wall.



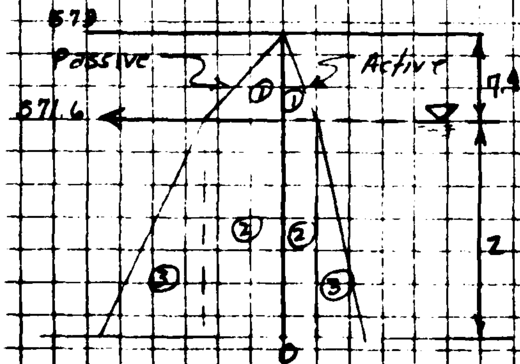
$X = 15\tan(45-\frac{\phi}{2}) + 15\tan(45-\frac{5}{2}) = 15\tan 42.5°$
$X = 15(0.92) = 13.74'$

$Y = 33\cot 35° = 33(1.43) = 47.13$

$Z = 13.74 + 47.13 = 60.87'$ minimum distance of anchor wall from bulkhead

Assume $Z = 70'$

Assume ground water level at El. 571.6, coefficient of wall friction $\delta = 14°$ and $\tan\delta = 0.25$. Pressure diagram for anchor wall shown below.



$\gamma_{mst} = 115$ pcf
$\gamma_{sub} = 63$ pcf
$\phi = 35°$ $\quad K_a = 0.27$
$\delta = 14°$
$\frac{\delta}{\phi} = -0.4$ $\left\{ K_p = 11 \times 0.603 = 6.63 \right.$

$\Sigma F_H = 0 = \frac{(7.4)^2(115)(6.63-0.27)}{2} + (7.4)(115)(6.36)Z + \frac{Z^2(63)(6.36)}{2} - T = 0$

$0 = 20026 + 5413Z + 201Z^2 - T$

$T = 201Z^2 + 5413Z + 20026$ (1)

Subject: CLEVELAND HARBOR STUDY - OLD RIVER DEEPENING
Computation of: Typical Bulkhead Design for Left Bank
Computed by: RCT 1/19/82 Checked by: ____ Date: ____

Anchor Wall Design (cont'd)

$\Sigma M_o = 0 = 20026(z + 2.47) + 5413 z (z/2) + 201 z^2 (z/3) - Tz$

$0 = 20026 z + 49464 + 2707 z^2 + 67 z^3 - Tz$ ②

Combine equations ① and ②

$0 = 20026 z + 49464 + 2707 z^2 + 67 z^3 - z(201 z^2 + 5413 z + 20026)$

$0 = 20026 z + 49464 + 2707 z^2 + 67 z^3 - 201 z^3 - 5413 z^2 - 20026 z$

$0 = 49464 - 2706 z^2 - 134 z^3$

$z^3 + 20.2 z^2 = 369.13$

$z = 3$	$208.8 < 369.13$	
$z = 4$	$387.2 > 369.13$	
$z = 3.9$	$366.56 < 369.13$	
→ $z = 3.91$	$368.60 < 369.13$	diff 0.53
$z = 3.92$	$370.64 > 369.13$	diff 1.51

From Eq. ①

$T = 201(3.92)^2 + 5413(3.92) + 20026$

$T = 3089 + 21219 + 20026$

$T = 44334 > 29079$

$F.S. = \frac{44334}{29079} = 1.52$ OK

Drive anchor wall to depth of 7.4' + 3.9' = 11.3 ft
say 12 ft.

Where battered tension piles are required for anchorage of the bulkhead wall use same design as used for bulkhead type 5-BP in the Congestion Study.

Subject: CLEVELAND HARBOR STUDY - OLD RIVER DEEPENING
Computation of: Typical Bulkhead Design for Left Bank
Computed by: RCJ 1/22/82 Checked by ______ Date ______

Anchorage Design Using Battered Tension Piles

Anchor Pull = 29079 lb/ft of wall
Assume 6' spacing for batter piles

Wales

$M_{max} = 1/9\, Td^2 = 1/9(29079)(6)^2 = 116316$ lb-ft

$F_b = 0.6\,F_y = 0.6(55000) = 33000$ psi

$S_{req'd} = \frac{116316(12)}{33000} = 42.3\ in^3/$wale

CBP 103 (CB10x42) = 43.4 in^3

However use 12x12x53 added factor of safety

Load (extractive force) on batter piles

$29079 \times 6' = 174474$ lb

Pile battered 1 vertical on 1 horizontal

Axial tension on batter pile $= \frac{174474}{\cos 45^\circ} = 246744$ lb

The frictional resistance per square foot of pile driven into material having a cohesion of C is given by the relationship,

$f = 0.25\, q_u$ where $q_u = 2C$

then $f = 1/4(2C) = 0.5C$

The force exerted on a round pile as resistance to extraction is.

$T = \pi d L f$ where πd = circumference, L = length of embedment, f = friction

For a bearing pile πd is replaced by a value NP which is net perimeter

$\therefore L = \frac{T}{NPf} = \frac{246744}{4 \times 0.5(1450)}$ NP = 4.0' for CBP124

$L = 85.08'$ say 85'

BRIDGE No.	TITLE OR NAME	YEAR BUILT	TOTAL USEFUL LIFE	REMAINING LIFE (AFTER 1990)	REMARKS
#23	B&O Railroad	1907	100 yrs.	17 yrs.	Bascule type bridge located in the Old R.
#6	Union Terminal Railroad	1929	100 yrs.	39 yrs.	High level bridge located in the Cuyahoga R.
#7	Columbus Rd. (vehicular)	1940	60 yrs	10 yrs.	Vertical lift bridge located in the Cuyahoga R.
#11	Norfolk & Western Railroad	1957	100 yrs.	67 yrs.	Vertical lift bridge located in the Cuyahoga R

TABLE D-4

REACH No.	AVG. REMAINING LIFE (After 1990)	RIVER	AVG REMAINING LIFE (by River)
1	15 yrs.	Old	15 yrs
2	17 yrs.	Cuya.	12 yrs.
3	8 yrs.	"	
4	10 yrs	"	
5	11 yrs.	"	
6	12 yrs.	"	
7	15 yrs.	"	

Note: For a description of reaches see page D-79.

TABLE D-5

USEFUL LIFE OF EXISTING BULKHEADS

Note: The remaining years of useful life listed for each bulkhead below are based on two assumptions. The first assumption is that the date shown on the permit application precedes the actual construction of the bulkhead by no more than one year. The second assumption is that the total useful life of all bulkheads is fifty (50) years. The linear feet of bulkhead for each permit is also tabulated in order that a weighted average remaining useful life for the bulkheads in each reach can be determined.

OLD RIVER (Reach #1)

REACH NO.	PERMIT NO.	YEAR CONSTRUCTED	REMAINING USEFUL LIFE	LENGTH (FT)	REMARKS
1	952680001	1953	13 years	121	
"	950680001	1951	11 "	111	
"	949680001	1950	10 "	111	
"	948680001	1949	9 "	214	
"	947680001	1948	8 "	151	
"	944680002	1944	4 "	350	
"	944680001	1945	5 "	195	
"	964680001	1964	24 "	386	
"	965680001	1966	26 "	40	
"	971680001	1972	32 "	53	
"	965680002	1966	26 "	619	
"	944210002	1944	4 "	133	
			Total →	2479	Avg Remaining Life - 15 yrs

CUYAHOGA RIVER (Reaches 2 - 7)

REACH NO	PERMIT NO.	YEAR CONSTRUCTED	REMAINING USEFUL LIFE	LENGTH (FT.)	REMARKS
2	960210002	1962	22 years	50	
"	961210002	1961	21 "	30	
"	948210004	1950	10 "	200	
"	943210001	1943	3 "	200	
"	958210001	1961	21 "	225	No plans for replacement No maintenance required
"	960210001	1960	20 "	150	
"	949210001	1949	9 "	113	
"	980210002	1980	40 "	134	Steel plate bulkhead/dock with concrete cap
			Sub-total →	1102	Avg. Remaining Life - 17yrs
3	941210008	1941	1 "	434	
"	953210002	1953	13 "	108	
"	964210001	1954	14 "	250	Sections upstr. & dnstr. are older - may have 10yrs. life
"	959210001	1959	19 "	360	
"	950210003	1950	10 "	40	
"	944210005	1944	4 "	70	
"	941210001	1941	1 "	204	
"	945210002	1944	4 "	270	
			Sub-total →	1736	Avg. Remaining Life - 8yrs
4	960210003	1960	20 "	366	
"	956210002	1957	17 "	224	
"	957210003	1958	18 "	147	
"	955210002	1956	16 "	135	
"	944210001	1945	5 "	1180	
"	957210002	1958	18 "	142	
"	945210001	1945	5 "	116	
"	944210002	1945	5 "	100	
"	94221000[illegible]	1943	3 "	800	
"	944210003	1944	4 "	100	

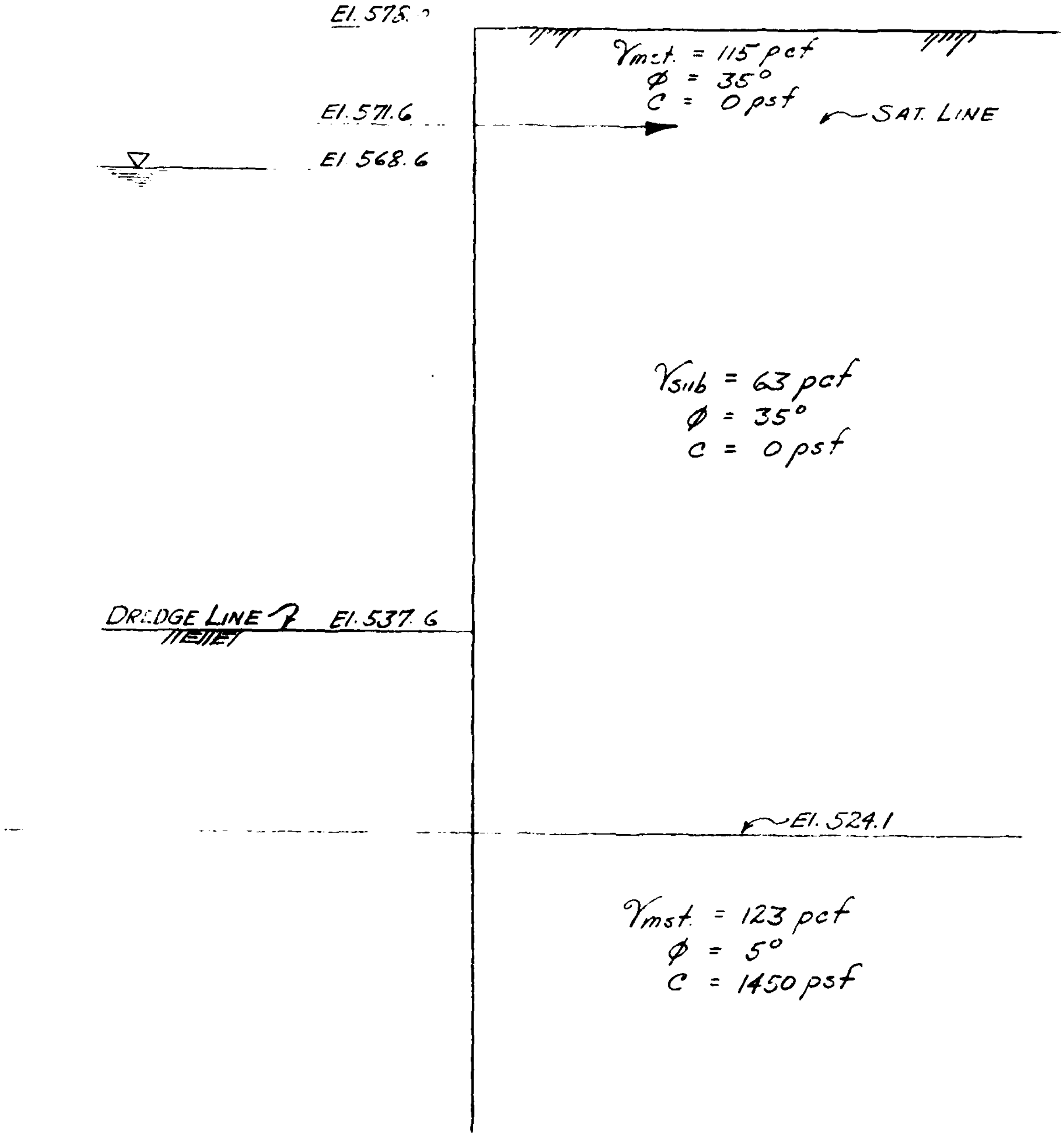
Cuyahoga River (Reaches 2-7)

Reach No.	Permit No	Year Constructed	Remaining Useful Life	Length (FT)	Remarks
4	944210004	1945	5 years	61	
"	940210001	1941	1 "	210	
"	966210001	1967	27 "	341	
"	961210004	1962	22 "	248	
			Sub-total →	4170	Avg Remaining Life - 10 yrs
5	953210001	1954	14 "	400	
"	927210001	1927	0 "	325	
"	943210002	1944	4 "	635	
"	961210001	1961	21 "	537	
"	963210001	1963	23 "	130	
"	954210001	1954	14 "	475	
"	945210005	1946	6 "	289	
			Sub-total →	2791	Avg Remaining Life - 11 yrs
6	950210002	1950	10 "	384	
"	947210001	1947	7 "	385	
"	948210003	1948	8 "	1042	
"	965210001	1965	25 "	754	
"	941210003	1941	1 "	550	Partially in Turning Basin
"	950210001	1950	10 "	50	
"	974210003	1974	34 "	197	
			Sub-total →	3362	Avg Remaining Life - 12 yrs
7	941210006	1941	1 "	155	
"	953210003	1953	13 "	32	
"	950210001	1951	11 "	40	
"	957210004	1958	18 "	976	
"	955210001	1955	15 "	1130	
"	942210002	1942	2 "	87	
			Sub-total →	2420	Avg. Remaining Life - 15 yrs
			Total →	15581	

DESCRIPTION OF RIVER REACHES

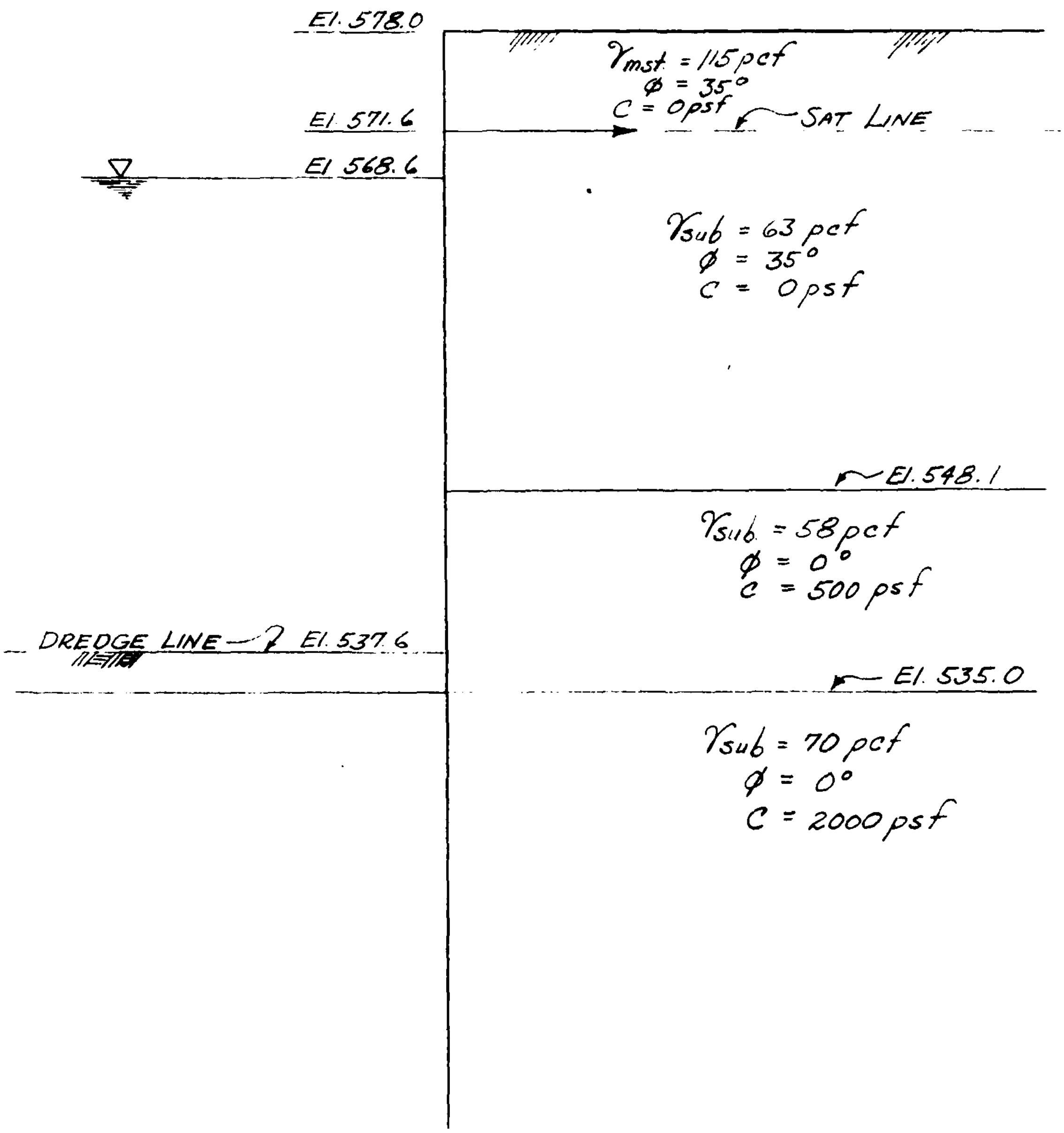
REACH No.	DESCRIPTION	RIVER
1	Cuyahoga R. from Conrail Bridge No 1 to the confluence with the Old R.. Old R. from confluence with the Cuyahoga R. upstream to the limit of contract dredging.	Cuya. R. Rivermile 0.3 to 0.4 Old R. Rivermile 0.4 to 1.5
2	Cuyahoga R. from Conrail Bridge No.1 to British Street NW (Rivermile 0.3 to 1.1)	Cuyahoga River
3	British Street NW to a point upstream of the Carter Road bridge, Bridge No 8 (Rivermile 1.1 to 2.1)	Cuyahoga River
4	From a point upstream of the Carter Road bridge. Bridge No. 8 to a point midway between the Inner Belt Freeway bridge, Bridge No. 12 and the West 3rd St. bridge, Bridge No. 13 (Rivermile 2.1 to 3.1)	Cuyahoga River
5	From a point midway between the Inner Belt Freeway bridge, Bridge No 12 and the West 3rd St. bridge, Bridge No 13 to the slip on the right bank upstream of the Jefferson Ave bridge abutments, Bridge No 15 Rivermile 3.1 to 4.1	Cuyahoga River
6	From the slip on the right bank upstream of the Jefferson Ave. bridge abutments, Bridge No 15, to a point midway between the Turning Basin and the Clark Ave. Viaduct, Bridge No. 19 Rivermile 4.1 to 4.8	Cuyahoga River
7	From a point midway between the Turning Basin and the Clark Ave. Viaduct, Bridge No. 19 To the upstream limit of contract dredging Bridge No. 21 Rivermile 4.8 to 5.6	Cuyahoga River

Incl #1



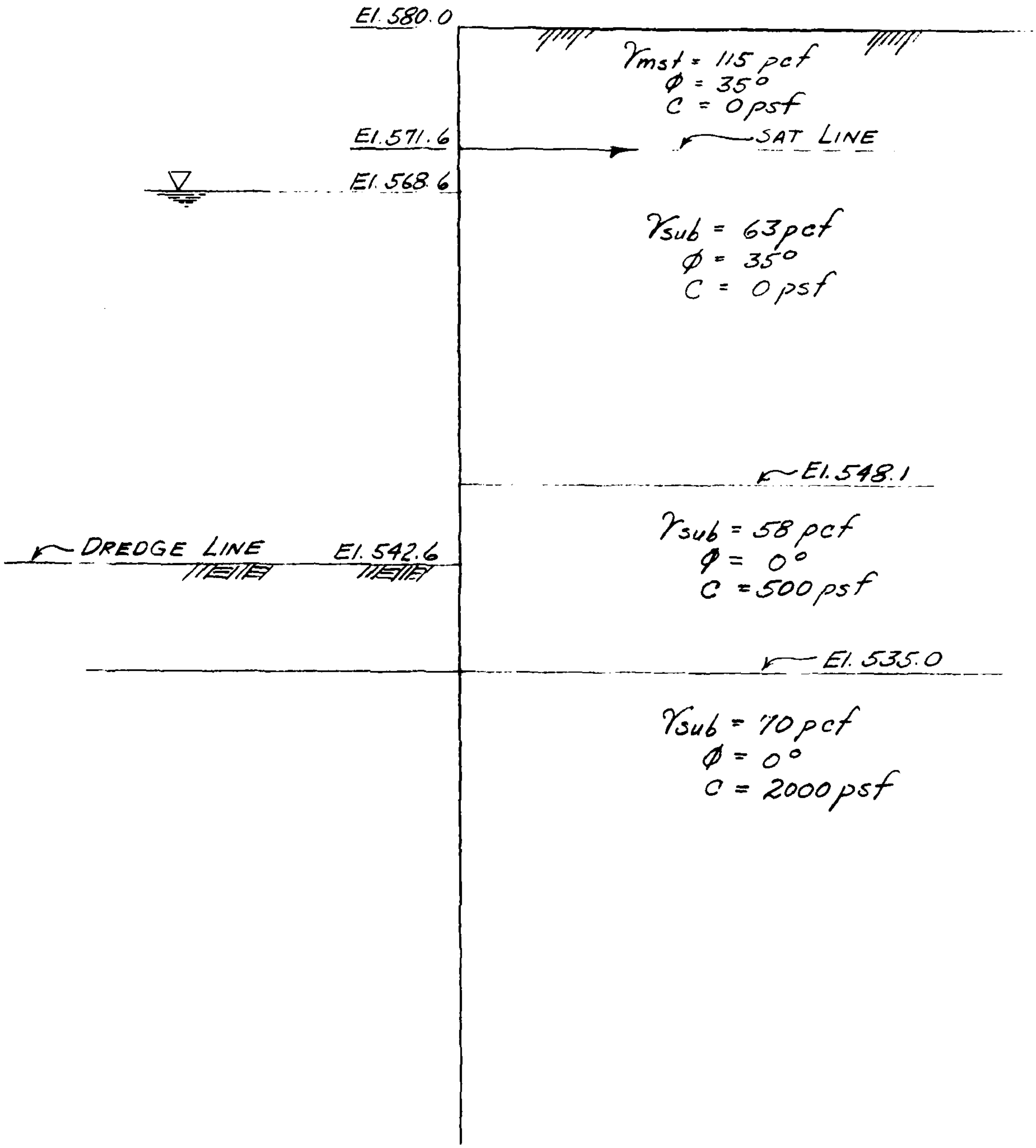
SOIL STRATIGRAPHY & DESIGN PARAMETERS
BULKHEADS A-1 & A-2
ALTERNATIVE 6

Plate No. D1



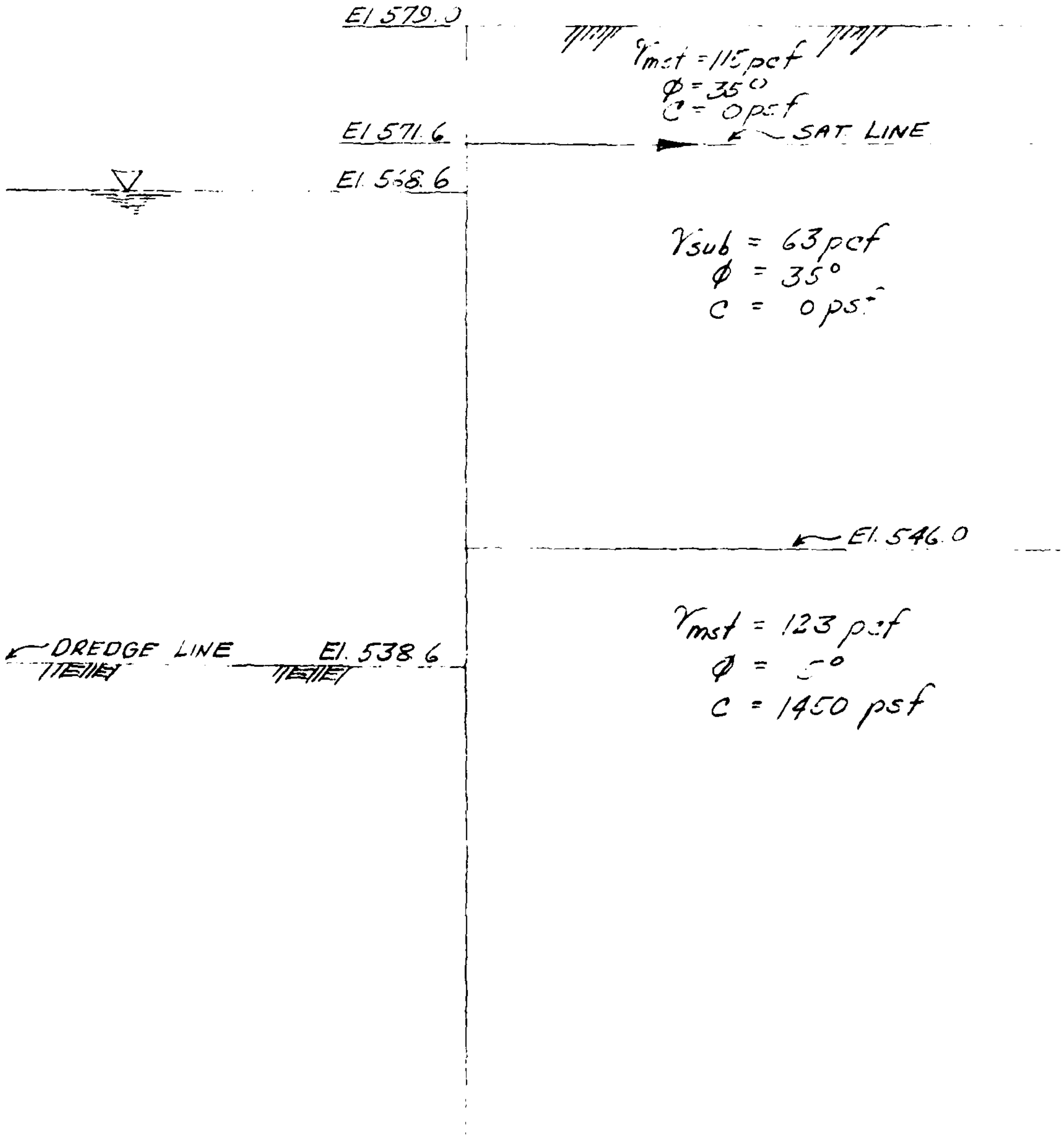
SOIL STRATIGRAPHY & DESIGN PARAMETERS
BULKHEADS B-1 & B-2
ALTERNATIVE 6

Plate No. D2



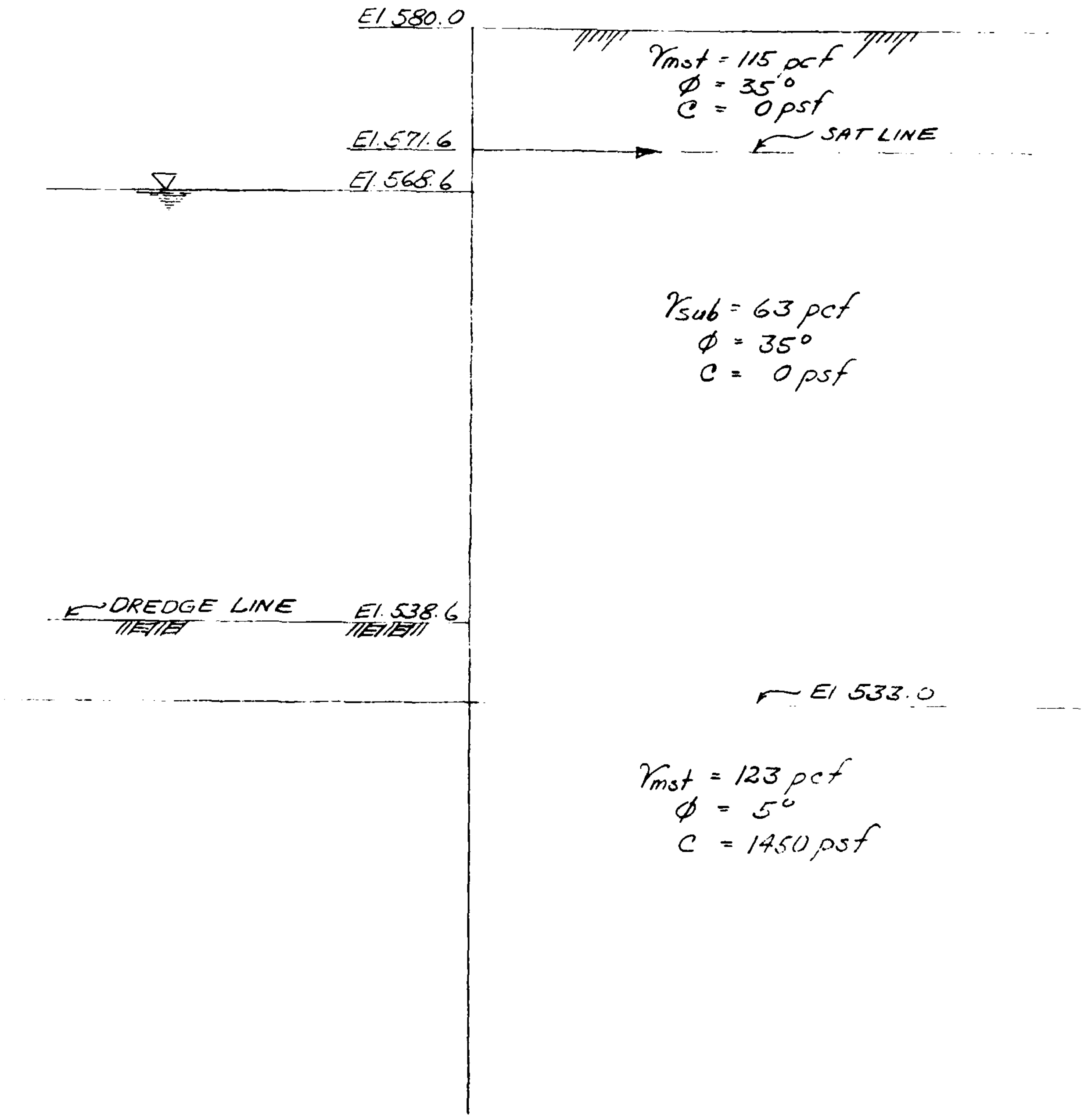
SOIL STRATIGRAPHY & DESIGN PARAMETERS
ALTERNATIVE 7

Plate No. D3



SOIL STRATIGRAPHY & DESIGN PARAMETERS
ALTERNATIVE 5

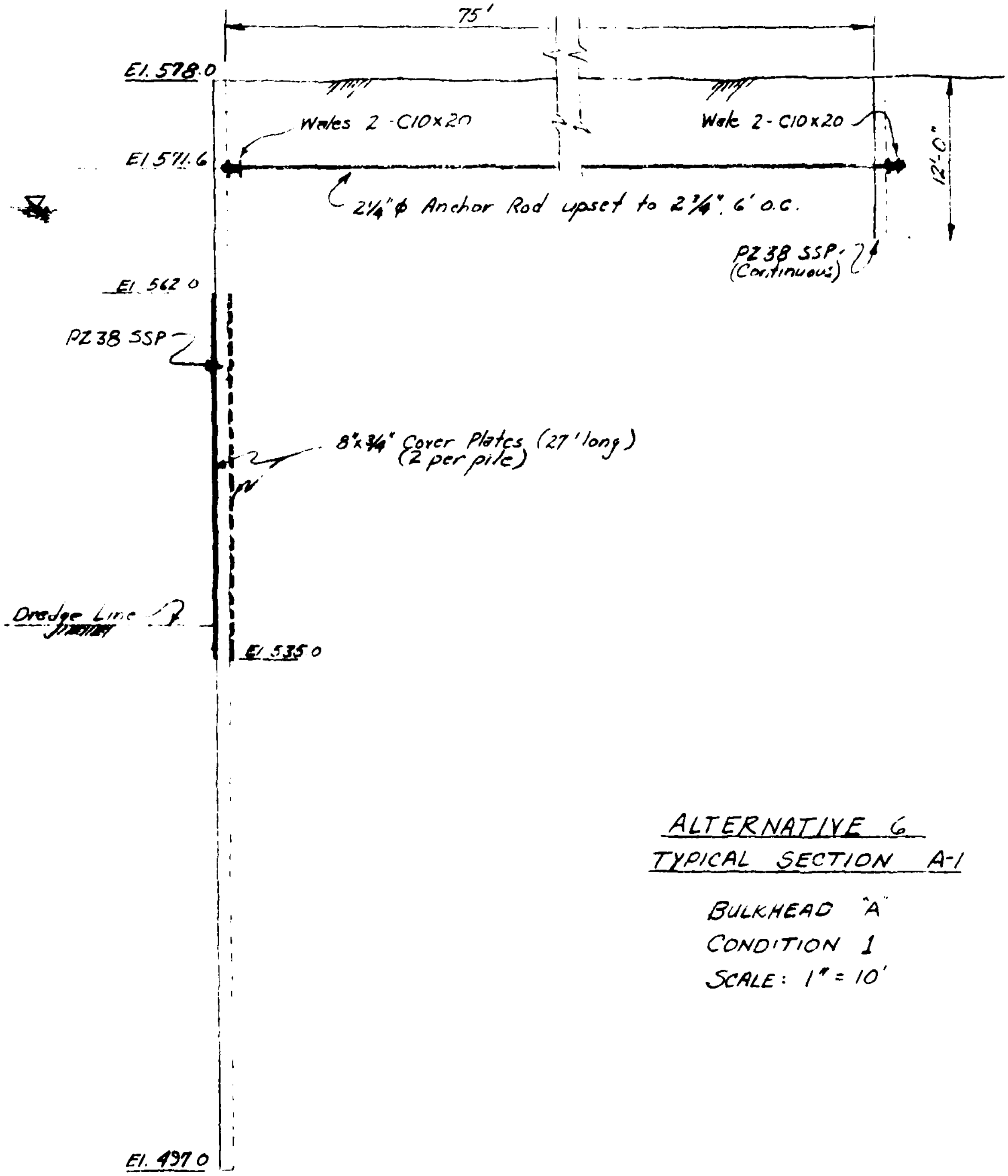
Plate No. D4



SOIL STRATIGRAPHY & DESIGN PARAMETERS
ALTERNATIVE 5 (RIVERMILE 0.0 TO 0.2)

Plate No. D5

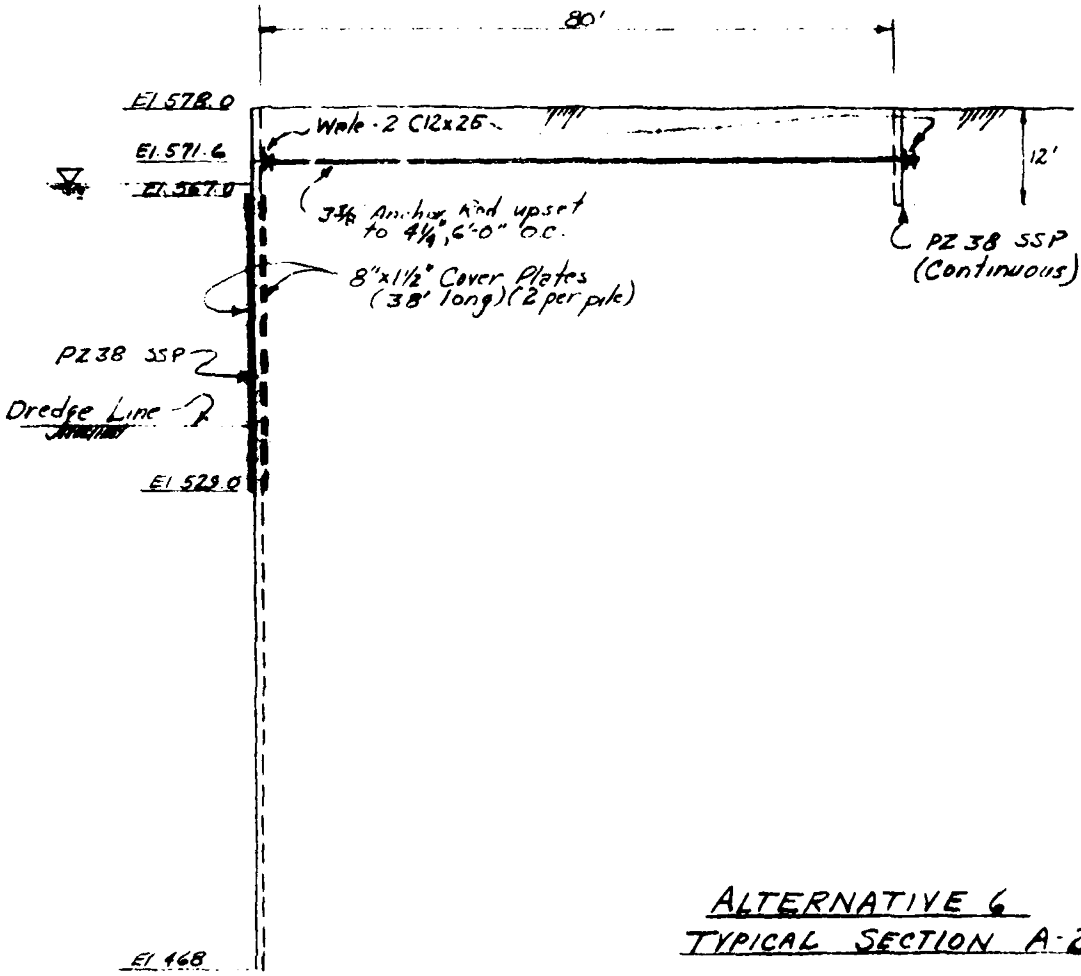
BY RCJ DATE 10/2/81 SUBJECT CLEVELAND HARBOR STUDY SHEET NO. 1 OF
CHKD. BY DATE ANCHORED SSP WALL DESIGN JOB NO.
BULKHEAD "A" COND 1



ALTERNATIVE 6
TYPICAL SECTION A-1

BULKHEAD "A"
CONDITION 1
SCALE: 1" = 10'

BY R.C.J. DATE 10/2/81 SUBJECT CLEVELAND HARBOR STUDY SHEET NO. 2 OF
CHKD. BY DATE ANCHORED SSP WALL DESIGN JOB NO.
BULKHEAD "A" COND. 2

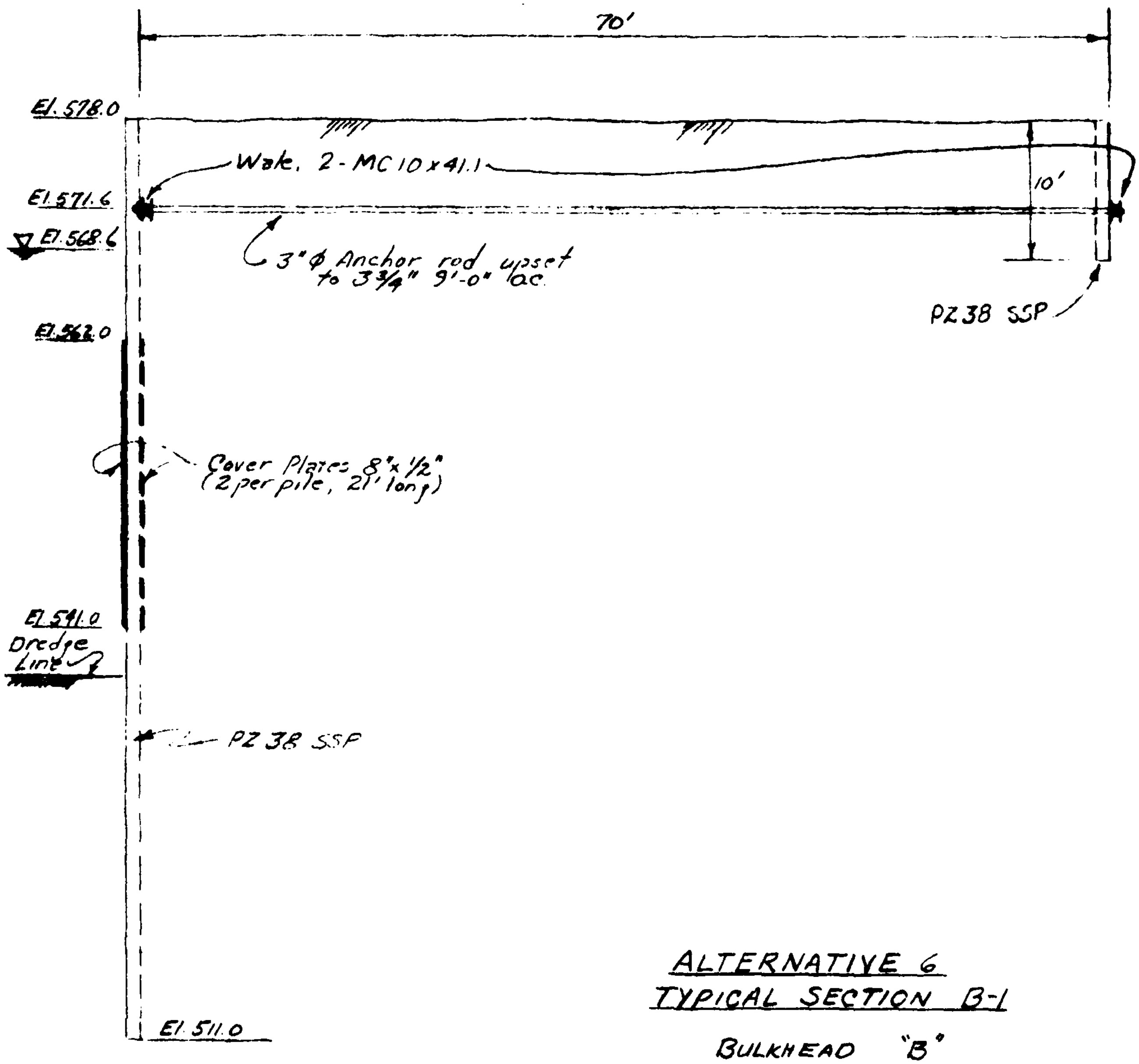


ALTERNATIVE 6
TYPICAL SECTION A-2

BULKHEAD "A"
CONDITION 2
SCALE: 1" = 20'

Plate No. D7

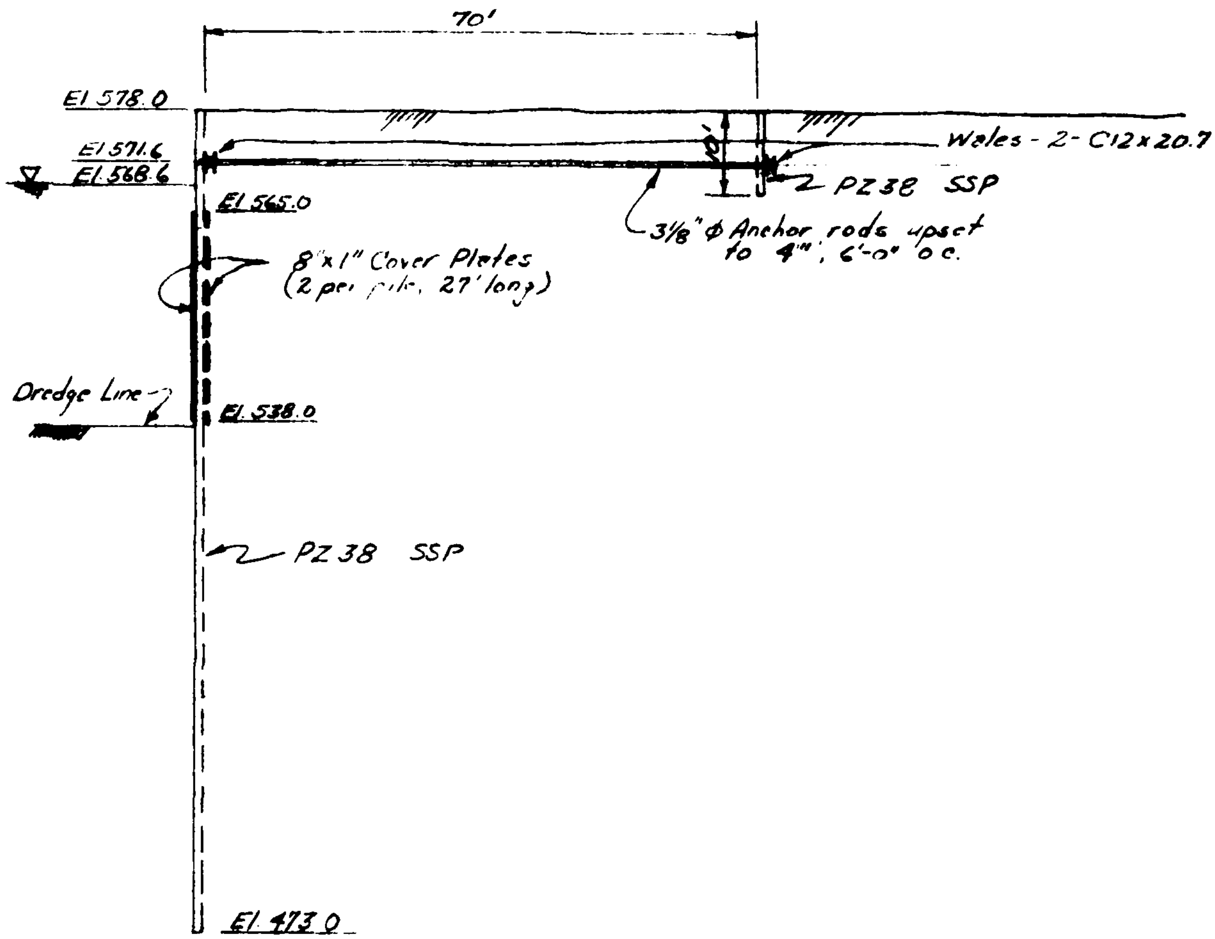
BY KCJ DATE 10/9/81 SUBJECT CLEVELAND HARBOR STUDY SHEET NO. 3 OF
CHKD. BY DATE ANCHORED SSP WALL DESIGN JOB NO.
BULKHEAD "B" COND. 1



ALTERNATIVE 6
TYPICAL SECTION B-1

BULKHEAD "B"
CONDITION 1
SCALE: 1" = 10'

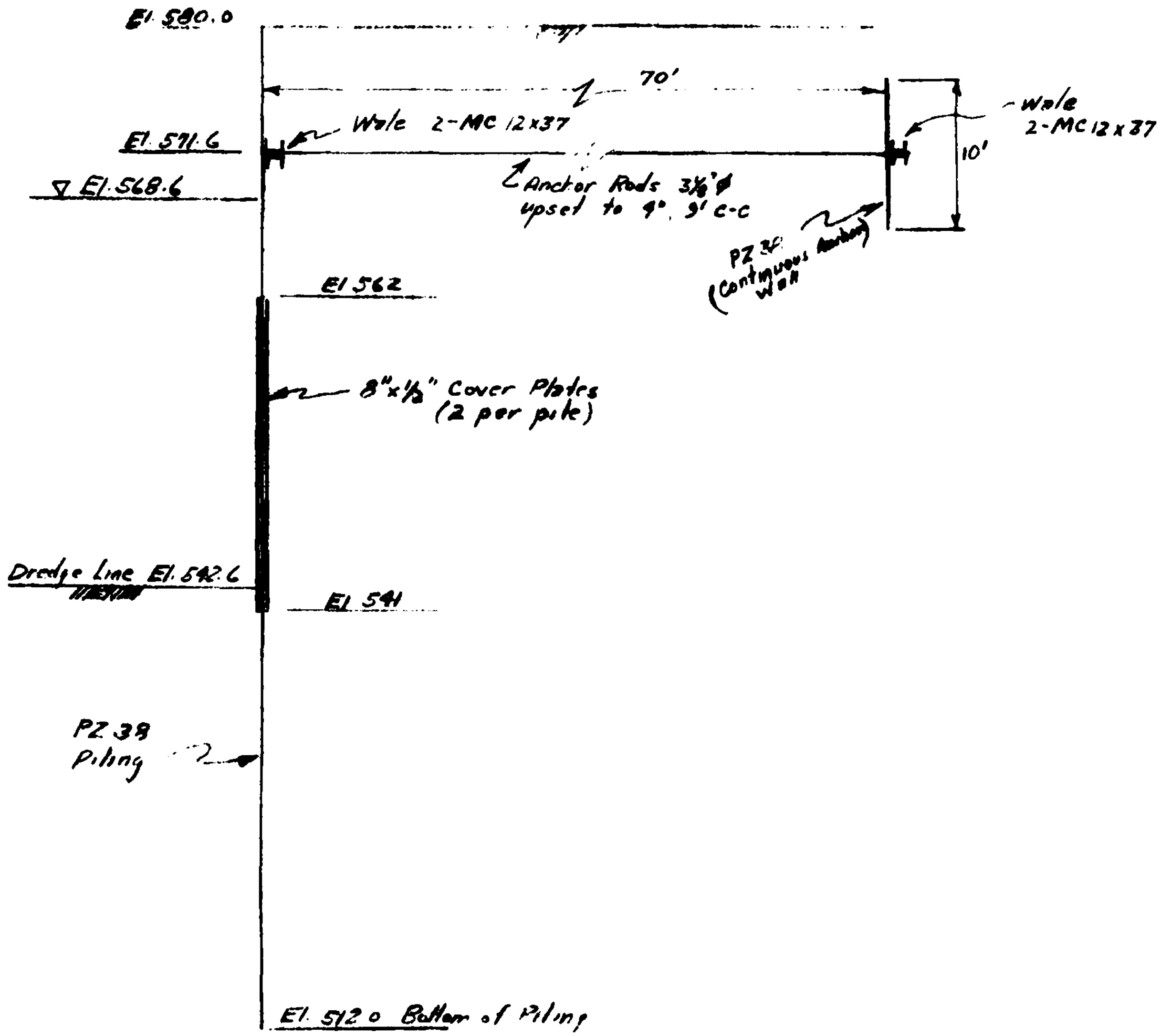
BY RCJ DATE 10/9/81 SUBJECT CLEVELAND HARBOR STUDY SHEET NO. 4 OF
CHKD. BY DATE ANCHORED SSP WALL DESIGN JOB NO.
BULKHEAD "B" COND. 2



ALTERNATIVE 6
TYPICAL SECTION B-2

BULKHEAD "B"
CONDITION 2
SCALE: 1" = 20'

BY RCJ DATE 11/3/81 SUBJECT Cleveland Harbor Study SHEET NO. 1 OF
CHKD. BY DATE Congestion Study - Typical JOB NO.
Bulkhead Design for Sites 2-7

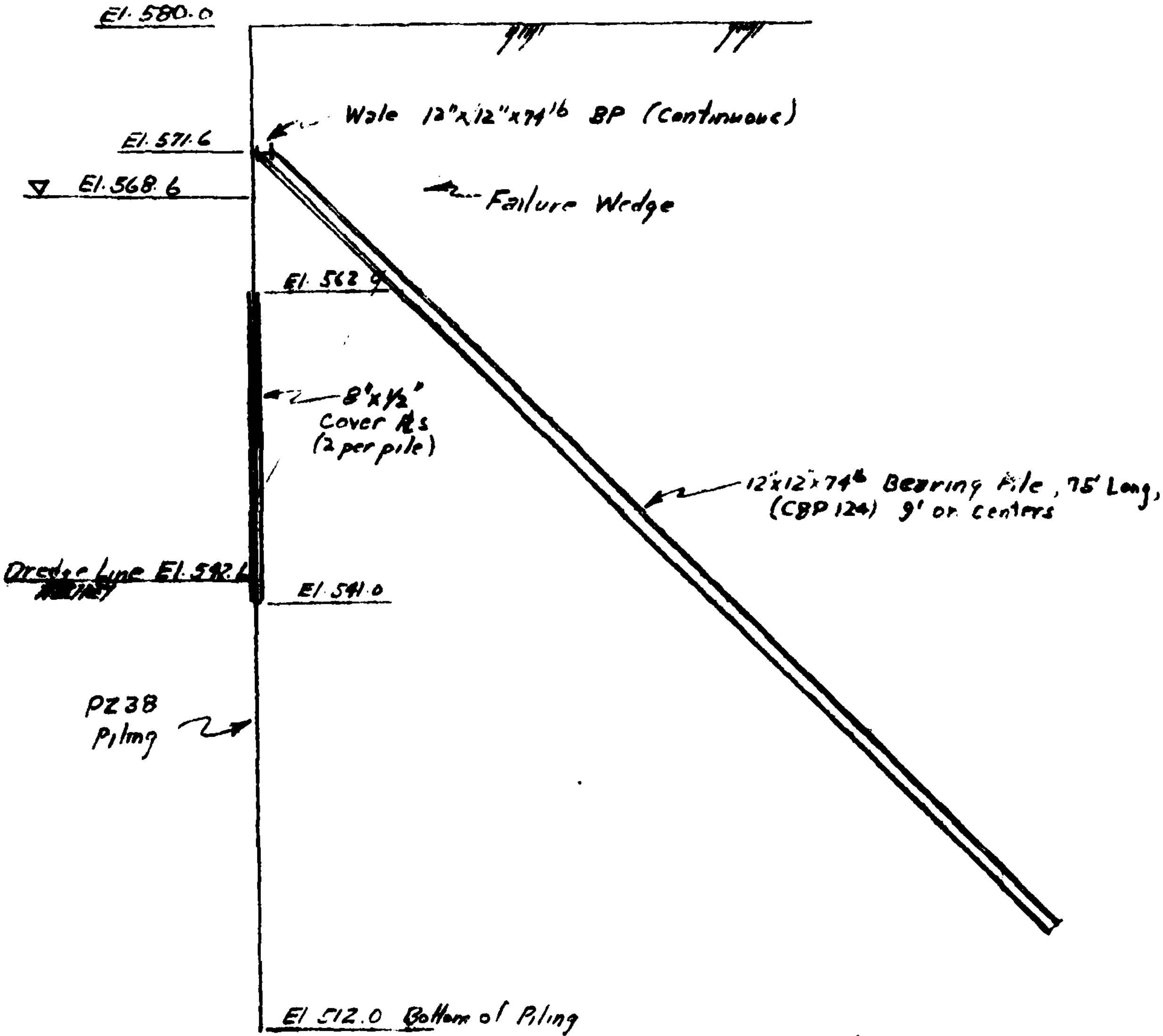


ALTERNATIVE 7
TYPICAL BULKHEAD
TYPE NS-AW

Plate No. D10

BY RCJ DATE 11/10/81 SUBJECT Cleveland Harbor Study SHEET NO. 2 OF

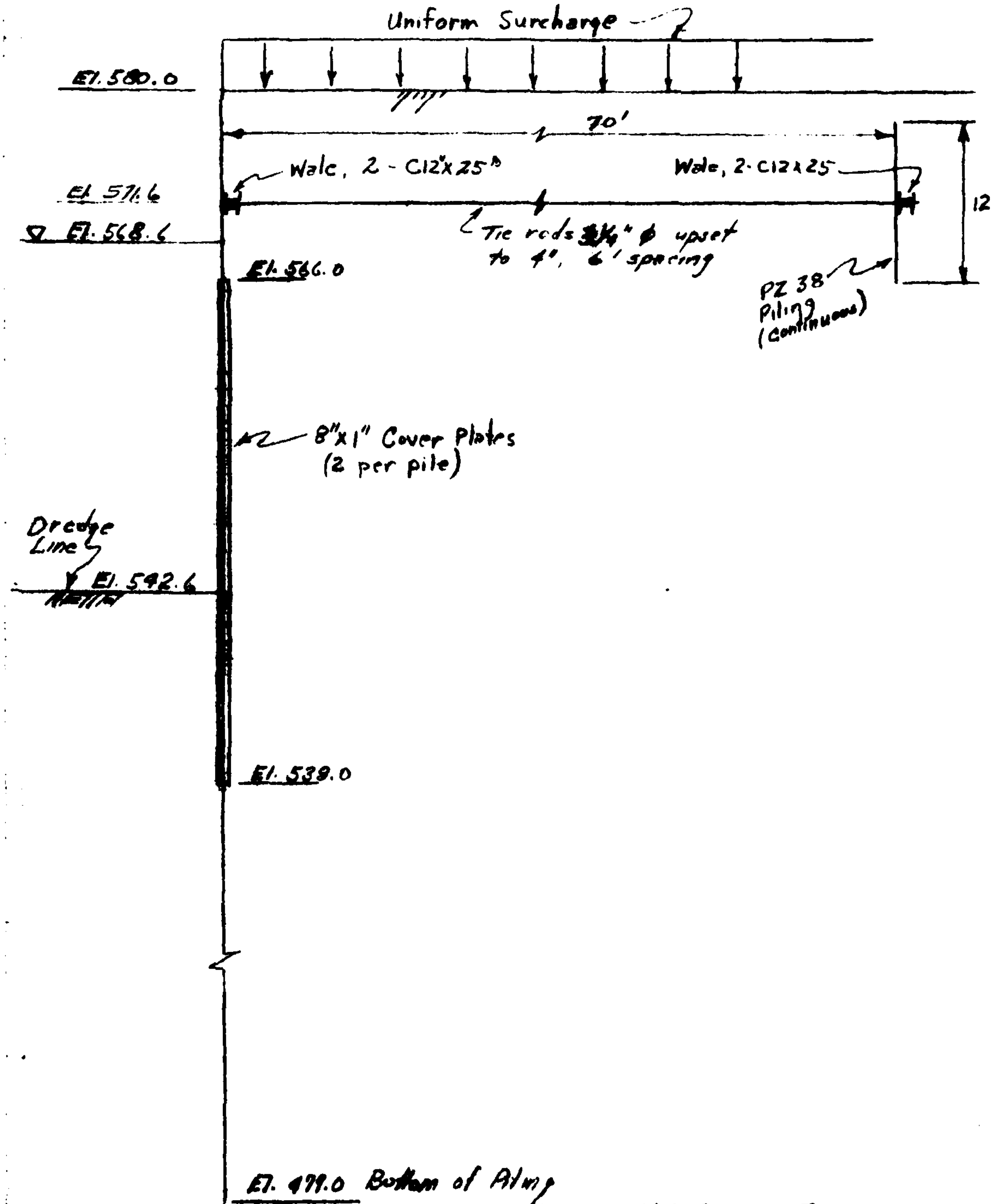
CHKD. BY DATE Congestion Study - Typical Bulkhead Design for Sites #2 - #7 JOB NO.



TYPICAL BULKHEAD ALTERNATIVE 7
TYPE NS-BP

Plate No. D11.

BY RGT DATE 11/10/81 SUBJECT CLEVELAND HARBOR STUDY SHEET NO. 3 OF
CHKD. BY DATE CONGESTION STUDY - Typical Bulkhead Design for Site # 2 - # 7 JOB NO.

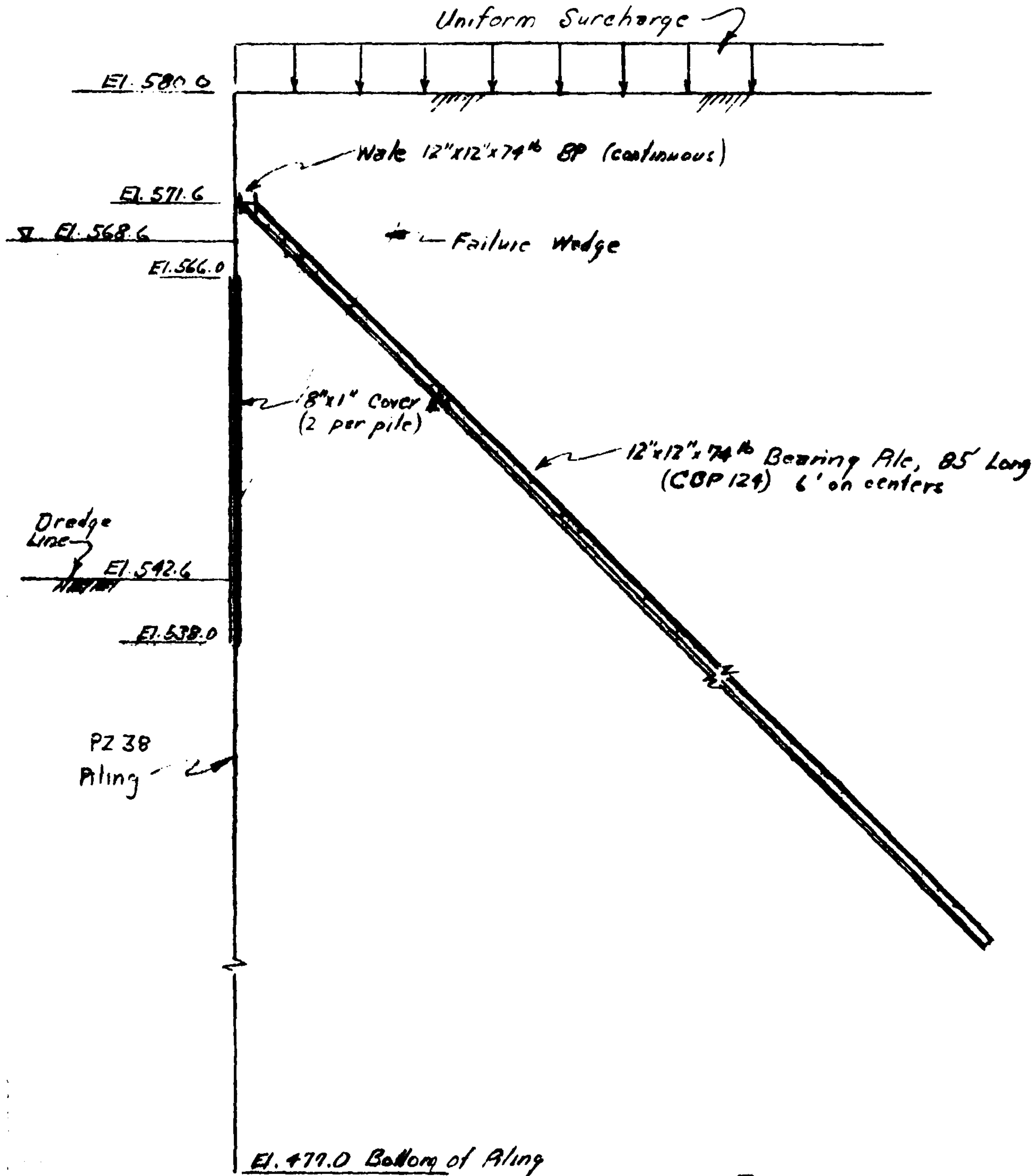


ALTERNATIVE 7
TYPICAL BULKHEAD
TYPE S-AW

Plate No. D12

BY RCT DATE 11/10/81 SUBJECT CLEVELAND HARBOR STUDY SHEET NO. 4 OF

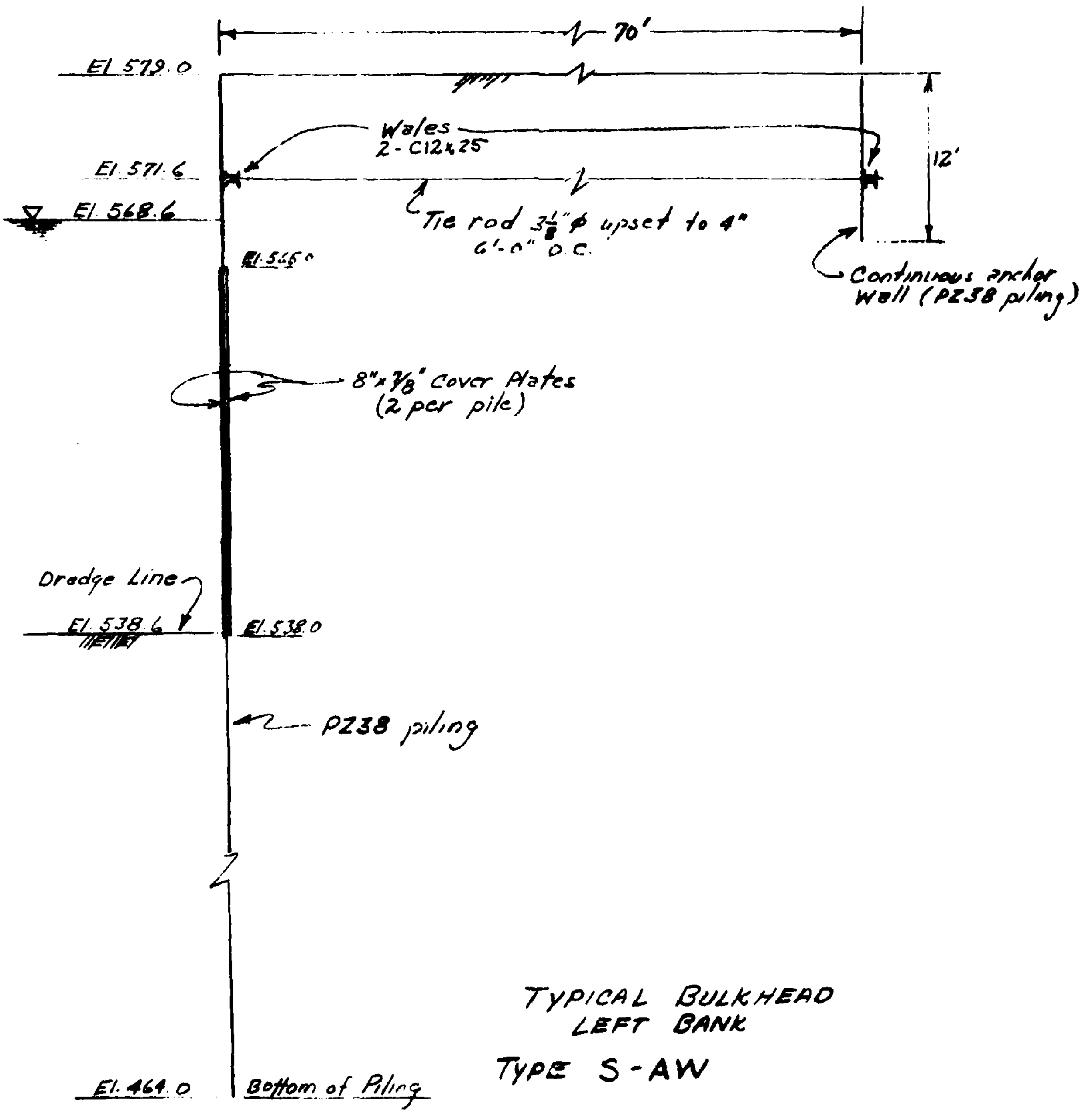
CHKD. BY DATE Congestion Study - Typical Bulkhead Design for Sites #2 - #7 JOB NO.



ALTERNATIVE 7
TYPICAL BULKHEAD
TYPE S-BP

Plate No. D13

BY RCJ DATE 1/21/82 SUBJECT CLEVELAND HARBOR STUDY SHEET NO. 1 OF
CHKD. BY DATE OLD RIVER DEEPENING - TYP. JOB NO.
BULKHEAD S-AW



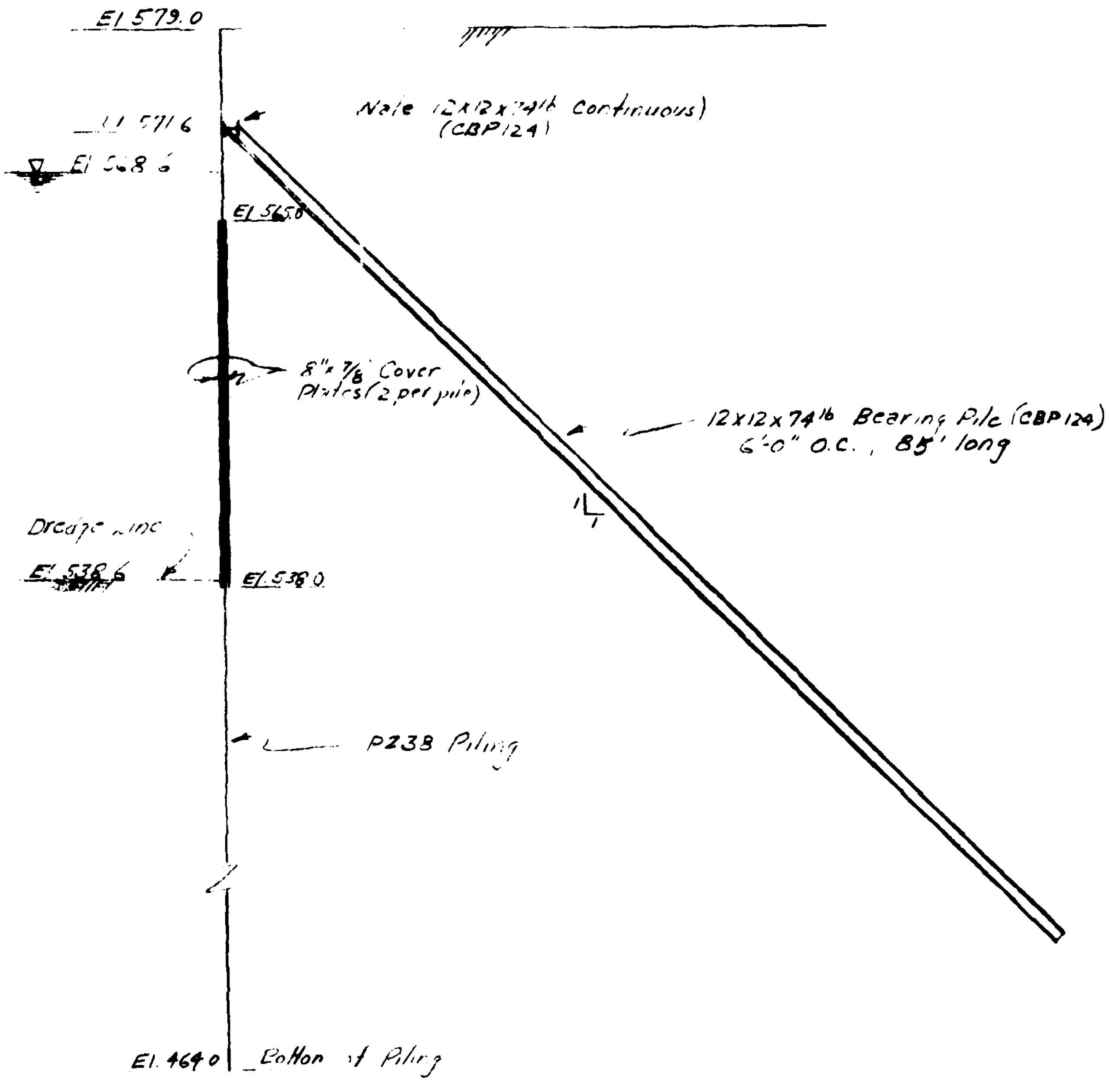
TYPICAL BULKHEAD
LEFT BANK
TYPE S-AW

Plate No. D14
Incl. #3

BY RCJ DATE 1/21/81 SUBJECT CLEVELAND HARBOR STUDY SHEET NO. 2 OF

CHKD. BY DATE OLD RIVER DEEPENING - TYP. JOB NO.

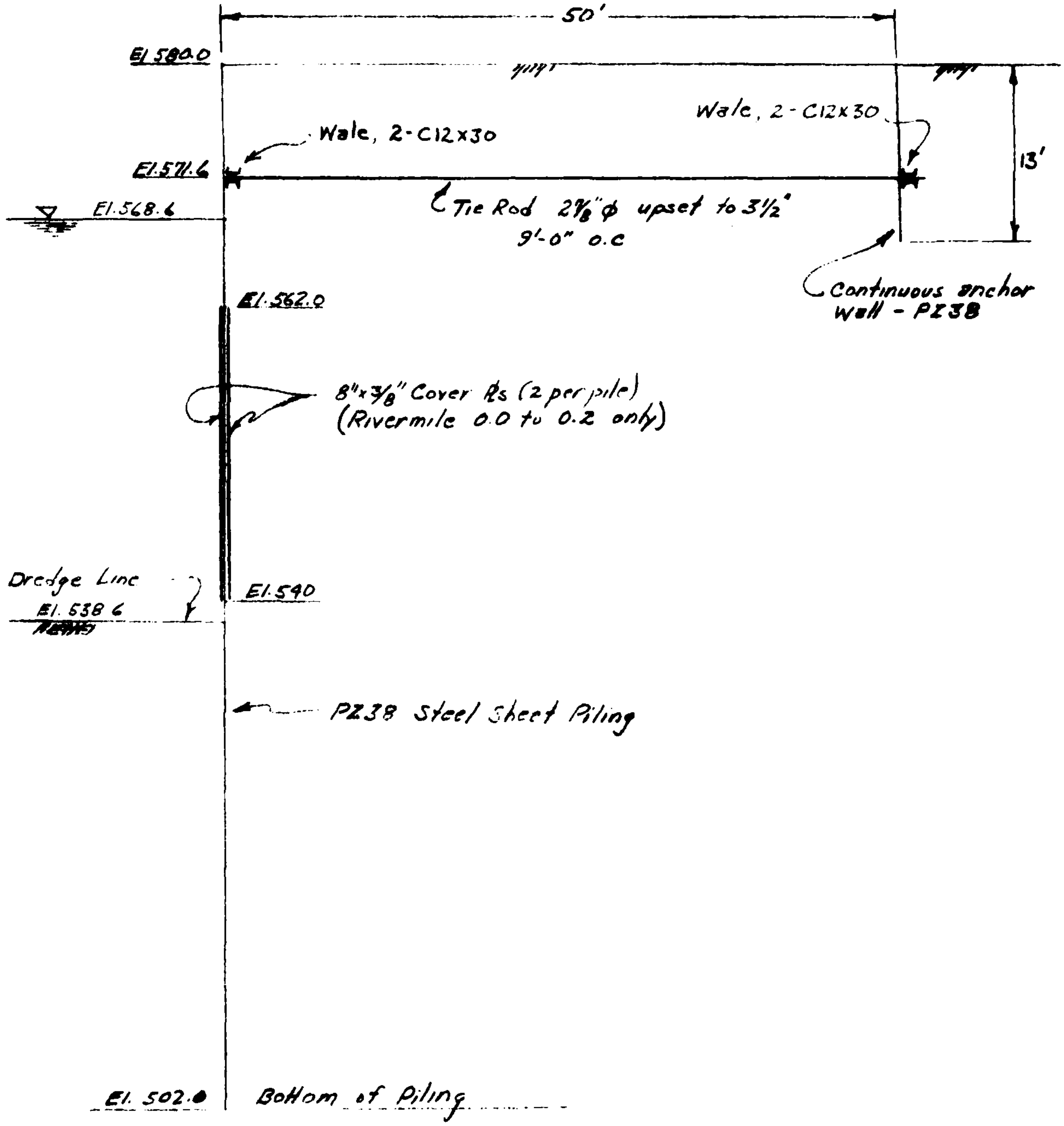
BULKHEAD S-BP



TYPICAL BULKHEAD
LEFT BANK
TYPE S-BP

Plate No. D15
Incl. #4

BY KCJ DATE 1/29/82 SUBJECT CLEVELAND HARBOR STUDY SHEET NO. 3 OF
CHKD. BY DATE OLD RIVER DEEPENING - TYPICAL JOB NO.
BULKHEAD NS-AW



TYPICAL BULKHEAD
RIGHT BANK

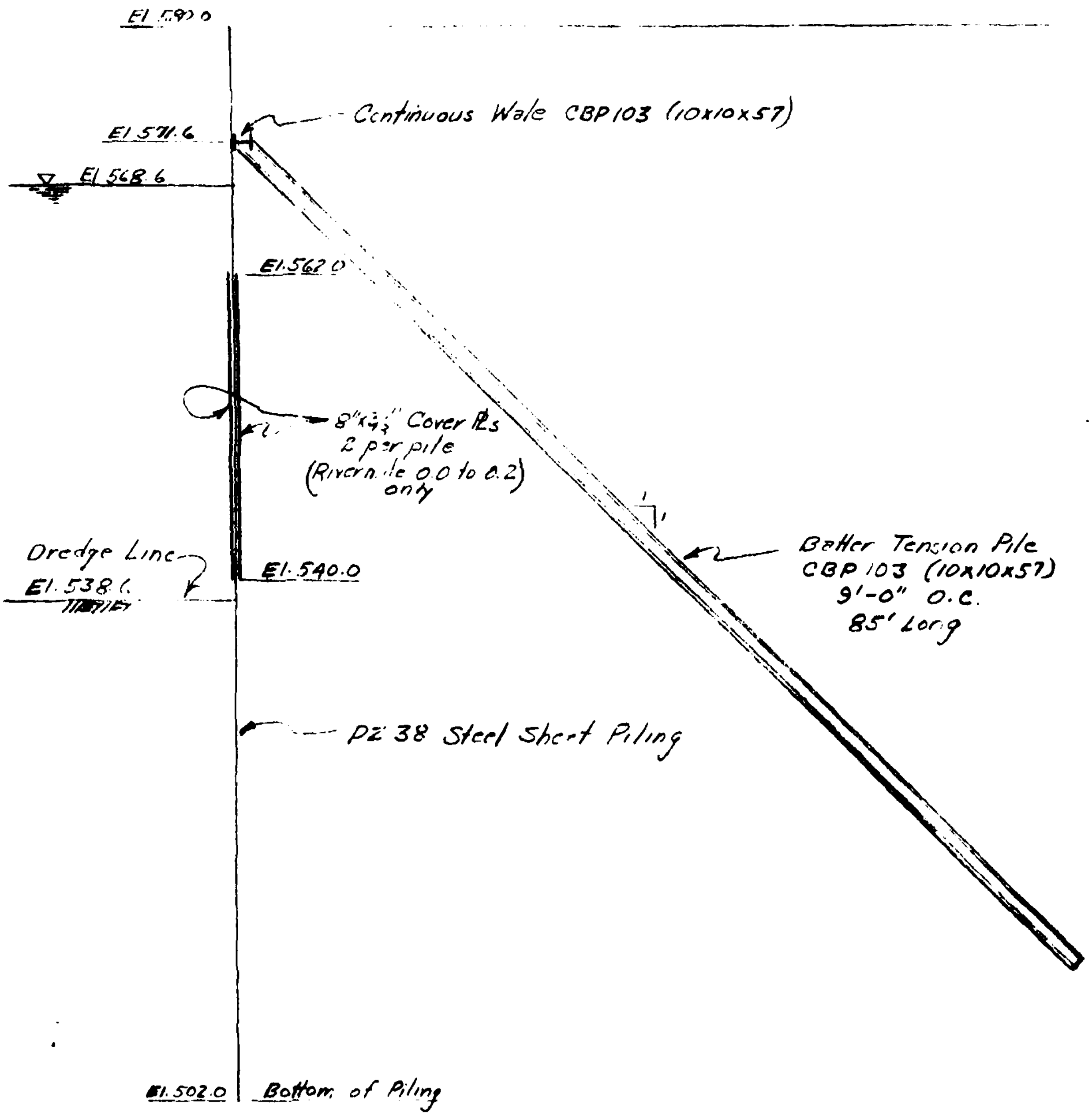
TYPE NS-AW

Plate No. D16
Incl. #5

BY RCJ DATE 1/20/82 SUBJECT CLEVELAND HARBOR STUDY SHEET NO. 4 OF

CHKD. BY DATE OLD RIVER DEEPENING - TYPICAL JOB NO.

BULKHEAD NS-BP



TYPICAL BULKHEAD
RIGHT BANK
TYPE NS-BP

Plate No. D17
Incl. #6

APPENDIX E
COST ESTIMATES

CLEVELAND HARBOR, OH

STAGE 2 REPORT
OF
REFORMULATION PHASE I GENERAL DESIGN MEMORANDUM

U. S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, NY 14207

CLEVELAND HARBOR, OH
STAGE 2 REPORT
OF
REFORMULATION PHASE I

GENERAL DESIGN MEMORANDUM

APPENDIX E
COST ESTIMATES

TABLE OF CONTENTS

TABLES

TABLE OF CONTENTS (Cont'd)

APPENDIX E
COST ESTIMATES

E1. PURPOSE

This appendix presents the detailed estimates of cost for the eight preliminary alternatives considered in detail during Stage 2 planning for the Cleveland Harbor, Ohio, Phase I GDM study.

E2. COST DATA SOURCES

All cost data presented in this appendix are at June 1982 price levels. Unit prices shown in the various alternatives were developed from similar construction projects and updated by use of the Engineering News Record (ENR) Construction Cost Index.

a. Navigation Aids. The costs for the Navigation Aids were supplied by the Ninth Coast Guard District Office in Cleveland, OH (see Appendix G, Exhibit G-7).

b. Bridge Demolition and Replacement. Costs associated with bridge demolition and replacement have been extracted from the following sources:

(1) Alternative No. 5A - Bridge demolition costs were taken from an estimate prepared by the Chessie System Railroad (see Appendix F, Exhibit F-13). Bridge replacement costs were taken from the *Cleveland Harbor 1958 Project Modification Design Memorandum No. 3*.

(2) Alternative No. 7, Site No's 3 and 4 - Bridge demolition and replacement costs addressed at these sites were taken from the 1975 Cleveland Harbor Preliminary Feasibility Report.

(3) Alternative No. 7, Site No. 7 - Bridge demolition costs were extracted from the September 1977 Section 107 Jefferson Avenue Bridge Abutment Removal Reconnaissance Report.

c. Railroad Interchange System. The estimated costs for the Railroad Interchange System in Alternative No. 5B were computed by the Chessie System Railroad (see Appendix F, Exhibit F-13).

d. Lands and Damages. Lands and Damage costs were developed by the North Central Division Real Estate Office. These costs are discussed in Attachments 1,2 and 3 of this appendix.

e. Contingencies. A contingency factor has been applied to the first cost of construction to account for variations in material unit prices, quantities, methods of construction, and material storage and disposal.

E3. TOPOGRAPHIC AND SUBSURFACE INFORMATION

Information available at the District Office to prepare the estimates, consisted of 1978 and 1980 Project Condition Soundings for Cleveland Harbor including the Cuyahoga and Old Rivers, a 1978 Lake Survey Chart provided by the National Oceanic and Atmospheric Administration, and 1978 Aerial Topography conducted by Chicago Aerial Survey and provided by the Cuyahoga County Sanitary Engineer's office. As discussed in Appendix A, "Geotechnical," rock will not be encountered during dredging operations for any of the alternatives considered.

E4. QUANTITY ESTIMATES

a. Dredging. Outer harbor dredged material quantities are based on Spring 1978 Project Condition Soundings for deepening existing channels, and a 1978 Lake Survey Chart for dredging new channels. Cuyahoga and Old River quantities are based on Spring 1980 Project Condition Soundings for deepening existing channels, and 1978 Aerial Photography for new bank cuts. An over-depth allowance of 1 foot and 1V on 2H sideslopes have been incorporated into the dredging quantity calculations. As discussed in the Main Report, it has been assumed that all dredged material will be placed in Cleveland Diked Disposal Area 14.

b. Breakwaters. Breakwater stone quantities have been developed from typical sections shown on Plates 6 through 10. Size of stone has been based on design considerations discussed in Appendix C, "Coastal Engineering Design."

c. Existing Bulkhead Removal/Modifications. Quantities and existing conditions used to determine the cost of removing or modifying existing bulkheads along the Cuyahoga and Old Rivers were developed from Department of Army Permit applications available at the District Office.

d. New Bulkheads. Quantities associated with the new bulkheads have been developed from typical sections shown on Plates 11 through 15.

E5. ESTIMATE OF FIRST COST OF CONSTRUCTION AND ANNUAL OPERTION AND MAINTENANCE COSTS

The estimated first costs of construction and additional annual operation and maintenance costs for the eight alternatives considered in this Phase I study, at June 1982 price levels, are presented in Tables E1 through E17. The operation and maintenance costs are based upon past experience for similar maintenance work performed in the Buffalo District. The annual operation and maintenance costs for the aids to navigation required in Alternative No's 2, 3A, 3B, and 4 were furnished by the Ninth Coast Guard District Office in Cleveland, OH, (see Appendix G, Exhibit G-7).

TABLE E1

REASONABLE CONTRACT ESTIMATE					SHEET 1 OF 1
PROJECT Cleveland Harbor Study - Alternative NO 1					INVITATION NO.
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	ALTERNATIVE NO. 1				
1.	Dredging	1,316,000	C.Y.	$ 2.50	$ 3,290,000
2.	Mobilization and Demobilization	–	L.S	–	8,000
	TOTAL CONTRACTOR'S EARNINGS				3,298,000
	CONTINGENCIES @ 25% ±				832,000
	TOTAL CONTRACTOR'S EARNINGS PLUS CONTINGENCIES				4,130,000
	ENGINEERING & DESIGN				410,000
	SUPERVISION & ADMINISTRATION				520,000
	TOTAL FIRST COST OF CONSTRUCTION				$ 5,060,000

ENG FORM APR 67 1738 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE. Repp / 19 Feb 82

TABLE E2

REASONABLE CONTRACT ESTIMATE					SHEET 1 OF 2
PROJECT Cleveland Harbor Study - Alternative NO. 2					INVITATION NO.
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	ALTERNATIVE NO. 2				
1.	Dredging	190,000	c.y.	# 6.60	# 1,254,000
2.	East Breakwater Spur Demolition	7,400	c.y.	20.50	151,700
3.	West Breakwater Spur Demolition	28,500	c.y.	20.50	584,250
4.	Cellular Pierheads - E.+W. Spur	–	L.S.	–	1,386,000
	a.) Pierhead Core Stone	2,100	TON	23.20	48,720
	b) Pierhead Cover + Toe Stone	3,000	TON	31.20	93,600
	c.) Portland Cement	680	BBL.	14.50	9,860
5.	New West Arrowhead Breakwater				
	a.) Bedding/Core Stone 2-160#	8,800	TON	12.50	110,000
	b) Underlayer Stone 0.5-2 Ton	37,600	TON	34.10	1,282,160
	c) Armor Stone 7-16 Ton	47,200	TON	31.20	1,472,640
6.	New Breakwater Extensions				
	a) Bedding/Core Stone 2-160#	41,800	TON	12.50	522,500
	b) Underlayer Stone 0.5-2 Ton	22,000	TON	34.10	750,200
	c) Armor Stone 7-16 Ton	25,500	TON	31.20	795,600
7.	Cellular Pierheads - Breakwater Ext.	–	L.S.	–	1,386,000
	a) Pierhead Core Stone	2,100	TON	[illegible]	[illegible]
	b) Pierhead Cover + Toe Stone	3,000	TON	31.20	93,600
	c) Portland Cement	680	BBL.	14.[illegible]	9,860
8.	Navigation Aids				
	a) AGA - GRF Light Towers	2	ea.	[illegible]	104,000
	b) Standard Pile Light	2	ea.	21,000	42,000
9.	Mobilization and Demobilization	–	L.S.	–	370,000
	SHEET 1 SUBTOTAL				# 10,515,410

ENG FORM 1738 APR 67 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE.

TABLE E2 (cont'd)

REASONABLE CONTRACT ESTIMATE

SHEET 2 OF 2

INVITATION NO.

PROJECT: Cleveland Harbor Study - Alternative NO. 2

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	ALTERNATIVE NO. 2	Sheet NO 1	SUBTOTAL		10,515,410
	TOTAL CONTRACTOR'S EARNINGS				$ 10,515,410
	CONTINGENCIES @ 20% ±				2,065,590
	TOTAL CONTRACTOR'S EARNINGS PLUS CONTINGENCIES				12,581,000
	ENGINEERING & DESIGN				1,161,000
	SUPERVISION & ADMINISTRATION				1,358,000
	TOTAL FIRST COST OF CONSTRUCTION				$ 15,100,000
	ESTIMATED ADDITIONAL ANNUAL MAINTENANCE COSTS				
	a) Breakwater Extensions				32,000
	b) Navigation Aids				500
	TOTAL				32,500

ENG FORM 1738 APR 67 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE. Repp/MFt82

TABLE E3

REASONABLE CONTRACT ESTIMATE					SHEET 1 OF 2
PROJECT Cleveland Harbor Study - Alternative NO. 3A					INVITATION NO.
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	ALTERNATIVE NO. 3A				
1.	Dredging	336,000	C.Y.	2.50	840,000
2.	East Breakwater Spur Demolition	7,400	C.Y.	20.50	151,700
3.	West Breakwater Spur Demolition	28,500	C.Y.	20.50	584,250
4.	Cellular Pierheads - E. & W. Spur	–	L.S.	–	1,386,000
	a.) Pierhead Core Stone	2,100	TON	23.20	48,720
	b.) Pierhead Cover & Toe Stone	3,000	TON	31.20	93,600
	c.) Portland Cement	680	BBL.	14.50	9,860
5.	W. Arrowhead Breakwater Demolition	47,300	C.Y.	20.50	969,650
6.	West Pierhead Light Demolition	–	L.S.	–	200,000
7.	New Breakwater Extensions				
	a.) Bedding/Core Stone 2-160#	348,000	TON	12.50	4,350,000
	b.) Underlayer Stone 0.5-2 TON	183,600	TON	34.10	6,260,760
	c.) Armor Stone 7-16 TON	212,400	TON	31.20	6,626,880
8.	Cellular Pierheads - Breakwater Ext.	–	L.S.	–	1,386,000
	a) Pierhead Core Stone	2,100	TON	23.20	48,720
	b.) Pierhead Cover + Toe Stone	3,000	TON	31.20	93,600
	c.) Portland Cement	680	BBL.	14.50	9,860
9.	Navigation Aids				
	a.) New Aids to Navigation	–	L.S.	–	360,000
	b.) Standard Pole Light	4	EA.	21,000.00	84,000
10.	Mobilization and Demobilization	–	L.S.	–	8,000
	SHEET 1 SUBTOTAL				23,511,600

ENG FORM 1738 APR 67 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE.

TABLE E 3 (cont'd)

REASONABLE CONTRACT ESTIMATE					SHEET 2 OF 2
PROJECT Cleveland Harbor Study - Alternative No. 3A					INVITATION NO.
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	ALTERNATIVE NO. 3a				
	TOTAL CONTRACTOR'S EARNINGS				23,511,600
	CONTINGENCIES @ 20% ±				4,688,400
	TOTAL CONTRACTOR'S EARNINGS PLUS CONTINGENCIES				28,200,000
	ENGINEERING & DESIGN				2,300,000
	SUPERVISION & ADMINISTRATION				2,700,000
	TOTAL FIRST COST OF CONSTRUCTION			$	33,200,000
	ESTIMATED ADDITIONAL ANNUAL MAINTENANCE COSTS				
	a.) Breakwater Extensions	–	L.S.	–	265,000
	b.) Navigation Aids	–	L.S.	–	500
		TOTAL			$ 265,500

ENG FORM APR 67 1738 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE.

TABLE E4

REASONABLE CONTRACT ESTIMATE

SHEET 1 OF 2

PROJECT: Cleveland Harbor Study - Alternative NO. 3B

INVITATION NO.

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	ALTERNATIVE No. 3 b				
1.	Dredging	915,000	c.y.	2.50	2,287,500
2.	East Breakwater Spur Demolition	7,400	c.y.	20.50	151,700
3.	West Breakwater Spur Demolition	28,500	c.y.	20.50	584,250
4.	Cellular Pierheads - E+W Spur	–	L.S.	–	1,386,000
	a.) Pierhead Core Stone	2,100	TON	23.20	48,720
	b.) Pierhead Cover + Toe Stone	3,000	TON	31.20	93,600
	c.) Portland Cement	680	BBL.	14.50	9,860
5.	New Breakwater Extensions				
	a.) Bedding/Core Stone 2-160#	139,200	TON	12.50	1,740,000
	b.) Underlayer Stone 0.5-2 TON	73,400	TON	34.10	2,502,940
	c.) Armor Stone 7-16 TON	85,000	TON	31.20	2,652,000
6.	Cellular Pierheads - Breakwater Ext	–	L.S.	–	1,386,000
	a.) Pierhead Core Stone	2,100	TON	23.20	48,720
	b.) Pierhead Cover + Toe Stone	3,000	TON	31.20	93,600
	c.) Portland Cement	680	BBL.	14.50	9,860
7.	Navigation Aids				
	a.) AFA-ERP Light Towers?	2	ea.	52,000	104,000
	b) Standard Pole Light	4	ea.	21,000.00	84,000
F.	Mobilization and Demobilization	–	L.S.	–	8,000
	TOTAL CONTRACTOR'S EARNINGS				3,190,750
	CONTINGENCIES @ 20% ±				2,630,250
	TOTAL CONTRACTOR'S EARNINGS PLUS CONTINGENCIES				15,821,000
	ENGINEERING + DESIGN				1,425,000
	SUPERVISION + ADMINISTRATION				1,654,000
	TOTAL FIRST COST OF CONSTRUCTION				$ 18,900,000

ENG FORM APR 67 1738 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE. GPO : 1967 OF—266-653

TABLE E4 (cont'd)

REASONABLE CONTRACT ESTIMATE					SHEET 2 OF 2
PROJECT Cleveland Harbor Study - Alternative NO. 3B					INVITATION NO.
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	ESTIMATED ADDITIONAL ANNUAL MAINTENANCE COSTS				
	a.) Breakwater Extensions	-	L.S.	-	53,000
	b.) Navigation Aids	-	L.S.	-	700
	TOTAL			$	53,700

ENG FORM 1738 APR 67 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE.

GPO : 1967 OF—265-053

TABLE E5

REASONABLE CONTRACT ESTIMATE					SHEET 1 OF 2
PROJECT CLEVELAND Harbor Study - Alternative No 4					INVITATION NO.
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	ALTERNATIVE NO. 4				
1.	DREDGING	1,506,000	C.Y.	$ 3.00	$ 4,518,000
2.	East Breakwater Spur Demo.	7,400	C.Y.	20.50	151,700
3	West Breakwater Spur Demo.	28,500	C.Y.	20.50	584,250
4.	CELLULAR PIERHEADS E&W. Br. water Spur	—	L.S.	—	1,386,000
	a) PIERHEAD Core Stone	2,100	Ton	23.20	48,720
	b) PIERHEAD Cover & Toe Stone	3,000	Ton	31.20	93,600
	c.) Portland Cement	680	BBL	14.50	9,860
5.	New West Arrowhead Breakwater				
	a) Bedding/core stone 2-160#	8800	Ton	12.50	110,000
	b.) Underlayer Stone 0.5-2 Ton	37,600	Ton	34.10	1,282,160
	c.) Armor Stone 7-16 Ton	47,200	Ton	31.20	1,472,640
6.	New Breakwater Extensions				
	a.) Bedding/Core Stone 2-160#	41,800	Ton	12.50	522,500
	b.) Underlayer Stone 0.5-2 Ton	22,000	Ton	34.10	750,200
	C.) Armor Stone 7-16 Ton	25,500	Ton	31.20	795,600
7.	Cellular Pierheads - Breakwater Extensions	—	L.S	—	1,386,000
	a) Pierhead Core Stone	2100	Ton	23.20	48,720
	b) Pierhead Cover & Toe Stone	3000	Ton	31.20	93,600
	c) Portland Cement	680	BBL	14.50	9,860
8.	NAVIGATION AIDS				
	a) AGA-GRP Light Towers	2	EA.	52,000	104,000
	b) STANDARD Pole Light	2	EA.	21,000	42,000
9	MOBILIZATION AND DEMOBILIZATION	—	L.S.	—	378,000
	Sheet No. 1 SUBTOTAL				$ 13,787,410

ENG FORM APR 67 1738 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE.

TABLE E5 (cont'd)

[redacted]

SHEET 2 OF 2

PROJECT: Cleveland Harbor Study - Alternative No. 4

INVITATION NO.

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	ALTERNATIVE NO. 4	Sheet No 1	SUBTOTAL		13,787,410
	TOTAL CONTRACTOR'S EARNINGS				13,787,410
	CONTINGENCIES @ 20% ±				2,795,590
	TOTAL CONTRACTOR'S EARNINGS PLUS CONTINGENCIES				16,583,000
	ENGINEERING AND DESIGN				1,489,000
	SUPERVISION AND ADMINISTRATION				1,728,000
	TOTAL FIRST COST OF CONSTRUCTION				$ 19,800,000
	ESTIMATED ADDITIONAL ANNUAL MAINTENANCE COSTS				
	a.) Breakwater Extensions				32,000
	b.) Navigation Aids				500
	TOTAL				32,500

ENG FORM APR 67 1738 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE. Rgp/21 Nov 81 GPO : 1967 OF—253-053

TABLE E6

REASONABLE CONTRACT ESTIMATE

SHEET OF

INVITATION NO.

PROJECT Cleveland Harbor Study - Alternative NO. 5A

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	ALTERNATIVE NO. 5a				
1.	Dredging	476,600	C.Y.	6.60	3,145,600
2.	Clearing and Grubbing	17	Acre	2,125.00	36,125
3.	Existing Bulkhead Modifications	-	L.S.	-	15,000
4.	Existing Bulkhead Removal	1,370	L.F.	265.00	363,050
5.	Bridge Demolition & Replacement	-	L.S.	-	14,170,000
6.	SSP Bulkhead Replacement				
	a) Excavation	196,000	C.Y.	3.50	686,000
	b) Backfill	196,000	C.Y.	1.35	264,600
	c) SSP PZ-38	918,400	S.F.	17.00	15,612,800
	d) CBP 103 Batter Piles	23,700	L.F.	39.00	924,300
	e) CBP 124 Bearing Piles	5,700	L.F.	51.00	290,700
	f) Wales	805,000	LB.	2.25	1,811,250
	g) Cover Plates	4,667,000	LB.	1.15	5,367,050
	h) Tie Rods	2,559,000	LB.	1.40	3,582,600
7.	Mobilization and Demobilization	-	L.S.	-	370,000
8.	Lands and Damages	-	L.S.	-	403,000
	TOTAL CONTRACTOR'S EARNINGS				47,04[illegible]
	CONTINGENCIES @ 20% ±				9,457,925
	TOTAL CONTRACTOR'S EARNINGS PLUS CONTINGENCIES				56,900,[illegible]
	ENGINEERING & DESIGN				4,500,[illegible]
	SUPERVISION + ADMINISTRATION				5,000,000
	TOTAL FIRST COST OF CONSTRUCTION				$66,000,000
	Private Construction	-	L.S.	-	687,000

ENG FORM APR 67 1738 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE. Copp / [illegible]

TABLE E7

REASONABLE CONTRACT ESTIMATE

SHEET OF

PROJECT: Cleveland Harbor Study - Alternative No. 5B

INVITATION NO.

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	ALTERNATIVE NO. 5b				
1.	Dredging	476,600	c.y.	6.60	3,145,600
2.	Clearing and Grubbing	16	Acre	2,125.00	34,000
3.	Existing Bulkhead Modifications	–	L.S.	–	15,000
4.	Existing Bulkhead Removal	1,370	L.F.	265.00	363,050
5.	Bridge Demolition	–	L.S.	–	870,000
6.	Railroad Interchange System	–	L.S.	–	3,510,000
7.	SSP Bulkhead Replacement				
	a) Excavation	196,000	c.y.	3.50	686,000
	b) Backfill	196,000	c.y.	1.35	264,600
	c) SSP PZ-38	918,400	S.F.	17.00	15,612,800
	d) CBP 103 Batter Piles	23,700	L.F.	39.00	924,300
	e) CBP 124 Bearing Piles	5,700	L.F.	51.00	290,700
	f) Wales	805,000	LB.	2.25	1,811,250
	g) Cover Plates	4,667,000	LB.	1.15	5,367,050
	h) Tie Rods	2,559,000	LB.	1.40	3,582,600
8.	Mobilization and Demobilization	–	L.S.	–	570,000
9.	Lands and Damages	–	L.S.	–	925,000
	TOTAL CONTRACTOR'S EARNINGS				37,771,950
	CONTINGENCIES @ 20% ±				7,528,050
	TOTAL CONTRACTOR'S EARNINGS PLUS CONTINGENCIES				45,300,000
	ENGINEERING & DESIGN				3,900,000
	SUPERVISION & ADMINISTRATION				4,200,000
	TOTAL FIRST COST OF CONSTRUCTION				$ 53,400,000
	Private Construction	–	L.S.	–	[illegible]

ENG FORM 1738 APR 67 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE

AD-A127 218 STAGE 2 REPORT FOR REFORMULATION PHASE I GENERAL DESIGN MEMORANDUM CLEVEL..(U) CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT FEB 83 5/7

UNCLASSIFIED F/G 13/10 NL

1.0
1.1
1.25 1.4 1.6
4.5 5.0 5.6 6.3 7.1 8.0 9.0
2.8 3.2 3.6 4.0
2.5 2.2 2.0 1.8

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE E8

REASONABLE CONTRACT ESTIMATE					SHEET 1 OF 1
PROJECT: Cleveland Harbor Study Alternative No 6A					INVITATION NO.
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	ALTERNATIVE NO 6a.				
	Dredging	993,000	C.Y.	$ 6.60	$ 6,553,800
	Existing Bulkead Modifications	—	L.S.	—	4,238,500
	SSP BULKHEAD Replacement				
	a) Excavation	1,033,000	C.Y.	3.50	3,615,500
	b) Backfill	1,033,000	C.Y.	1.35	1,394,550
	c) SSP PZ-38	3,977,700	SF	17.00	67,620,900
	d) Wales	5,350,000	LB	2.25	12,037,500
	e) Cover Plates	28,313,000	LB	1.15	32,559,950
	f) Tie Rods	16,527,000	LB	1.40	23,137,800
4.	Bridge Fender Replacement				
	a) CBP 124 Piles	48,640	LF	51.00	2,480,640
	b) 12"x12" Timber Wales	8,200	LF	27.00	221,400
	c) Misc. Steel	252,900	LB	2.25	569,025
5.	Utility Relocations	—	L.S.	—	18,480
6.	Mobilization and Demobilization	—	L.S.	—	370,000
7.	Lands and Damages	—	L.S.	—	879,000
	Total Contractor's Earnings				$ 155,697,045
	Contingencies @ 20% ±				30,802,955
	Total Contractor's Earnings plus Contingencies				186,500,000
	Engineering & Design				13,000,000
	Supervision and Administration				13,500,000
	Total First Cost				$ 213,000,000
	Estimated Additional Annual Maintenance Costs				
	a) Dredging	51,000	C.Y.	6.60	336,600

ENG FORM 1738 APR 67 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE.

TABLE E9

REASONABLE CONTRACT ESTIMATE

SHEET 1 OF 1

PROJECT: CLEVELAND HARBOR STUDY - ALTERNATIVE No. 6B

INVITATION NO.

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	Alternative No 6B				
1.	Dredging	1,702,000	C.Y.	6.60	$ 11,233,200
2.	Existing Bulkhead Modification	—	L.S.	—	4,238,500
3.	SSP Bulkhead Replacement.				
	a) Excavation	1,033,000	C.Y.	3.50	3,615,500
	b) Backfill	1,033,000	C.Y.	1.35	1,394,550
	c) SSP PZ-38	3,977,700	S.F.	17.00	67,620,900
	d) Wales	5,350,000	LB	2.25	12,037,500
	e) Cover Plates	28,313,000	LB.	1.15	32,559,950
	f) Tie Rods	16,527,000	LB	1.40	23,137,800
4.	Bridge Fender Replacement				
	a) CBP 124 Piles	48,640	L.F	51.00	2,480640
	b) 12"x12" Timber Wales	8,200	L.F	27.00	221,400
	c) Misc. Steel	252,900	LB.	2.25	569,025
5.	Utility Relocations	—	L.S.	—	86000
6	Mobilization and Demobilization	—	L.S.	—	370,000
7.	Lands and Damages	—	L.S	—	879,000
	Total Contractor's Earnings				$ 160,443,765
	Contingencies @ 20% ±				32,056,035
	Total Contractors Earnings plus Contingencies				192,500,000
	Engineering and Design				13,500,000
	Supervision and Inspection				14,000,000
	Total First Cost.				220,000,000
	Estimated Additional Annual Maintenance Costs				
	a.) Dredging	102,000	cy	6.60	673,200

ENG FORM APR 67 1738 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE.

TABLE E 10

REASONABLE CONTRACT ESTIMATE					SHEET 1 OF 1
PROJECT Cleveland Harbor Study - Alternative NO. 7 - Site No. 2					INVITATION NO.
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	SITE NO. 2				
1.	Dredging	12,000	C.Y.	6.60	79,200
2.	Demolition of Structures	–	L.S.	–	30,000
3.	Clearing and Grubbing	0.75	Acre	2,125.00	1,594
4.	Existing Bulkhead Removal	360	L.F.	200.00	72,000
5.	Existing Bulkhead Modifications	–	L.S.	–	1,000
6.	SSP Bulkhead Replacement				
	a) Excavation	5,200	C.Y.	3.50	18,200
	b) Backfill	5,200	C.Y.	1.35	7,020
	c) SSP PZ-38	55,500	S.F.	17.00	943,500
	d) CBP 124 Bearing Piles	6,000	L.F.	51.00	306,000
	e) Wales	55,500	LB	2.25	124,875
	f) Cover Plates	460,000	LB	1.15	529,000
	g) Tie Rods	47,200	LB	1.40	66,080
7.	Mobilization and Demobilization	–	L.S.	–	130,000
8.	Lands and Damages	–	L.S.	–	70,000
	TOTAL CONTRACTOR'S EARNINGS				2,378,469
	CONTINGENCIES @ 25% ±				596,531
	TOTAL CONTRACTOR'S EARNINGS PLUS CONTINGENCIES				2,975,000
	ENGINEERING & DESIGN				312,000
	SUPERVISION & ADMINISTRATION				383,000
	TOTAL FIRST COST OF CONSTRUCTION				3,670,000

ENG FORM APR 67 1738 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE. Capp/23 Feb 82

TABLE E 11

REASONABLE CONTRACT ESTIMATE					SHEET 1 OF 1
PROJECT Cleveland Harbor Study - Alternative No. 7 - Site No. 3					INVITATION NO.
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	SITE No. 3				
1.	Dredging	137,600	C.Y.	6.60	908,160
2.	Clearing and Grubbing	5	Acre	2,125.00	10,625
3	Existing Bulkhead Removal	1,870	L.F.	235.00	439,450
4.	Bridge Demolition & Replacement	–	L.S.	–	22,400,000
5.	SSP Bulkhead Replacement				
	a) Excavation	30,600	C.Y.	3.50	107,100
	b) Backfill	30,600	C.Y.	1.35	41,310
	c) SSP PZ-38	170,800	S.F.	17.00	2,903,600
	d) CBP 12 4 Bearing Piles	11,900	L.F.	51.00	606,900
	e) Wales	191,000	LB	2.25	429,750
	f) Cover Plates	1,327,000	LB	1.15	1,526,050
	g) Tie Rods	359,000	LB	1.40	502,600
6.	Mobilization and Demobilization	–	L.S.	–	130,000
7.	Lands and Damages	–	L.S.	–	199,000
	TOTAL CONTRACTOR'S EARNINGS				30,204,545
	CONTINGENCIES @ 20% ±				6,095,455
	TOTAL CONTRACTOR'S EARNINGS PLUS CONTINGENCIES				36,300,000
	ENGINEERING & DESIGN				2,900,000
	SUPERVISION & ADMINISTRATION				3,300,000
	TOTAL FIRST COST OF CONSTRUCTION				42,500,000

ENG FORM APR 67 1738 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE. Repp/23 Feb 82

TABLE E12

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	REASONABLE CONTRACT ESTIMATE				SHEET 1 OF 1
	PROJECT: Cleveland Harbor Study - Alternative NO. 7 - Site No. 4				INVITATION NO.
	SITE NO. 4				
1.	Dredging	151,020	c.y.	6.60	996,600
2.	Clearing and Grubbing	8	Acre	2,125.00	17,000
3.	Existing Bulkhead Removal	2,700	L.F.	320.00	864,000
4.	Bridge Demolition & Replacement	–	L.S.	–	16,600,000
5.	SSP Bulkhead Replacement				
	a) Excavation	49,200	c.y.	3.50	172,200
	b) Backfill	49,200	c.y.	1.35	66,420
	c) SSP PZ-38	257,700	S.F.	17.00	4,380,900
	d) CBP 12/4 Bearing Piles	10,925	L.F.	51.00	557,175
	e) Wales	238,300	LB	2.25	536,175
	f) Cover Plates	2,050,000	LB	1.15	2,357,500
	g) Tie Rods	749,000	LB	1.40	1,048,600
6.	Mobilization and Demobilization	–	L.S.	–	130,000
7.	Utility and Railroad Relocations	–	L.S.	–	46,480
8.	Lands and Damages	–	L.S.	–	298,000
	TOTAL CONTRACTOR'S EARNINGS				28,071,050
	CONTINGENCIES @ 20% ±				5,628,950
	TOTAL CONTRACTOR'S EARNINGS PLUS CONTINGENCIES				33,700,000
	ENGINEERING & DESIGN				2,700,000
	SUPERVISION & ADMINISTRATION				3,100,000
	TOTAL FIRST COST OF CONSTRUCTION				39,500,000

ENG FORM APR 67 1738 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE. Rev'd 23 Feb 82

TABLE E13

REASONABLE CONTRACT ESTIMATE					SHEET 1 OF 1
PROJECT Cleveland Harbor Study - Alternative NO. 7 - Site NO. 5					INVITATION NO.
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	SITE NO. 5				
1.	Dredging	106,500	C.Y.	6.60	702,900
2.	Clearing and Grubbing	4.4	Acre	2,125.00	9,350
3	Demolition of Structures	–	L.S.	–	65,000
4.	Existing Bulkhead Removal	1,660	L.F.	270.00	448,200
5.	SSP Bulkhead Replacement				
	a.) Excavation	19,600	C.Y.	3.50	68,600
	b) Backfill	19,600	C.Y.	1.35	26,460
	c.) SSP PZ-38	118,500	SF.	17.00	2,014,500
	d.) CBP 124 Bearing Piles	9,200	L.F.	51.00	469,200
	e.) Wales	164,300	LB.	2.25	369,675
	f.) Cover Plates	632,500	LB.	1.15	727,375
	g.) Tie Rods	188,700	LB.	1.40	264,180
6.	Mobilization and Demobilization	–	L.S.	–	130,000
7.	Lands and Damages	–	L.S.	–	588,000
	TOTAL CONTRACTOR'S EARNINGS				5,883,440
	CONTINGENCIES @ 25% ±				1,471,560
	TOTAL CONTRACTOR'S EARNINGS PLUS CONTINGENCIES				7,355,000
	ENGINEERING & DESIGN				684,000
	SUPERVISION & ADMINISTRATION				821,000
	TOTAL FIRST COST OF CONSTRUCTION			$	8,860,000

ENG FORM APR 67 1738 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE. Repp/24 F-682

TABLE E14

REASONABLE CONTRACT ESTIMATE					SHEET 1 OF 1
PROJECT Cleveland Harbor Study - Alternative NO.7 - Site NO.6					INVITATION NO.
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	Site NO. 6				
1.	Dredging	16,000	C.Y.	6.60	105,600
2.	Clearing and Grubbing	0.5	Acre	2,125.00	1,063
3.	Existing Bulkhead Modifications	-	L.S.	-	41,000
4.	SSP Bulkhead Replacement				
	a.) Excavation	1,200	C.Y.	3.50	4,200
	b.) Backfill	1,200	C.Y.	1.35	1,620
	c.) SSP PZ-38	53,000	S.F.	17.00	901,000
	d.) CBP 12.4 Bearing Piles	6,500	L.F.	51.00	331,500
	e.) Wales	5,700	LB	2.25	12,825
	f.) Cover Plates	297,000	LB	1.15	341,550
5.	Mobilization and Demobilization	-	L.S.	-	130,000
6.	Utility Relocations	-	L.S.	-	25,000
7.	Lands and Damages	-	L.S.	-	3,000
	TOTAL CONTRACTOR'S EARNINGS				1,898,358
	CONTINGENCIES @25%±				476,642
	TOTAL CONTRACTOR'S EARNINGS PLUS CONTINGENCIES				2,375,000
	ENGINEERING & DESIGN				249,000
	SUPERVISION & ADMINISTRATION				306,000
	TOTAL FIRST COST OF CONSTRUCTION				2,930,000

ENG FORM APR 67 1738 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE. Repplied Feb 82

TABLE E 15

REASONABLE CONTRACT ESTIMATE					SHEET 1 OF 1
PROJECT Cleveland Harbor Study - Alternative No. 7 - Site No. 7					INVITATION NO.
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	SITE NO. 7				
1.	Dredging	4,300	C.Y.	6.60	28,380
2.	Clearing and Grubbing	1.1	Acre	2,125.00	2,338
3.	Existing Bulkhead Modifications	–	LS	–	8,300
4.	Bridge Demolition	–	LS	–	546,000
5	SSP Bulkhead Replacement				
	a.) Excavation	17,000	C.Y.	3.50	59,500
	b.) Backfill	17,000	C.Y.	1.35	22,950
	c.) SSP PZ-38	53,800	S.F.	17.00	914,600
	d.) CBP 124 Bearing Piles	1,170	LF	51.00	59,670
	e.) Wales	82,500	LB.	2.25	185,625
	f.) Cover Plates	315,000	LB.	1.15	362,250
	g.) Tie Rods	192,000	LB.	1.40	268,800
6.	Mobilization and Demobilization	–	L.S.	–	130,000
7.	Utility Relocations	–	L.S.	–	11,220
8.	Lands and Damages	–	L.S.	–	13,000
	TOTAL CONTRACTOR'S EARNINGS				2,612,633
	CONTINGENCIES @ 25% ±				657,367
	TOTAL CONTRACTOR'S EARNINGS PLUS CONTINGENCIES				3,270,000
	ENGINEERING & DESIGN				327,000
	SUPERVISION & ADMINISTRATION				403,000
	TOTAL FIRST COST OF CONSTRUCTION				4,000,000

ENG FORM APR 67 1738 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE. Repp/24 Feb 82

TABLE E16

REASONABLE CONTRACT ESTIMATE					SHEET 1 OF 1
PROJECT Cleveland Harbor Study - Alternative NO. 8A					INVITATION NO.
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	ALTERNATIVE NO. 8a				
1.	Edgewater Marina Breakwater Walkway w/Railing	850	LF	260.00	221,000
2.	West Breakwater Railing and Stairway	–	L.S.	–	40,000.
3.	Comfort Station Expansion	–	L.S.	–	65,000
4.	Parking Area				
	a) 6" Crushed Stone Base + Agg	1,300.	S.Y.	2.75	3,575.
	b) 3" Asphalt Base Course	1,300.	S.Y.	6.80	8,840
	c) 1½" Wearing Course	1,300.	S.Y.	3.45	4,485
5.	Lands and Damages	–	L.S.	–	22,000
	TOTAL CONTRACTOR'S EARNINGS				364,900
	CONTINGENCIES @25% ±				91,100
	TOTAL CONTRACTOR'S EARNINGS PLUS CONTINGENCIES				456,000
	ENGINEERING & DESIGN				59,000
	SUPERVISION & ADMINISTRATION				71,000
	TOTAL FIRST COST OF CONSTRUCTION				$ 586,000
6.	Additional Operation & Maintenance Costs				12,000

ENG FORM APR 67 1738 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE.

TABLE E 17

REASONABLE CONTRACT ESTIMATE

SHEET 1 OF 1

PROJECT: Cleveland Harbor Study - Alternative No. 8B

INVITATION NO.

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
	ALTERNATIVE NO. 8B				
1.	West Arrowhead Breakwater Railing	1,275	L.F.	51.00	65,025
2.	West Breakwater Railing	10,900	LF	24.00	261,600
3.	Safety Platform	2	ea.	150,000	300,000
4	Comfort Station Expansion	–	L.S.	–	65,000
5	Pedestrian Bridge	–	L.S.	–	235,000
6.	Parking Area				
	a.) 6" Crushed Stone Base + Prep	4,700	S.Y.	2.75	12,925
	b.) 3" Asphalt Base Course	4,700	S.Y.	6.80	31,960
	c.) 1½" Wearing Course	4,700	S.Y.	3.45	16,215
7.	West Breakwater Stairway	11	ea.	2,100.00	23,100
8.	Lands and Damages	–	L.S.	–	72,000
	TOTAL CONTRACTOR'S EARNINGS				1,082,825
	CONTINGENCIES @ 25%±				267,175
	TOTAL CONTRACTOR'S EARNINGS PLUS CONTINGENCIES				1,350,000
	ENGINEERING & DESIGN				162,000
	SUPERVISION & ADMINISTRATION				188,000
	TOTAL FIRST COST OF CONSTRUCTION				1,700,000
9.	Additional Annual Operation + Maintenance Cost				63,000

ENG FORM 1738 APR 67 SUPERSEDES ENG FORM 1738, 1 APR 54, WHICH IS OBSOLETE. Rev 9 June 82

REAL ESTATE ESTIMATE
OF
CLEVELAND HARBOR CONGESTION
STUDY OF CUYAHOGA RIVER
CLEVELAND, OHIO

1. Description of Project Area:

The project consists of seven sites along the Cuyahoga River which are under consideration for widening and bulkhead improvements to improve navigation within the river to better service the port on Lake Erie.

2. Appraisal Problems:

Six of the seven sites require acquisition of land in fee and all of the sites require temporary work easement areas. The total land to be acquired in fee is approximately 12. 7 acres. The total temporary construction easements required will be from approximately 10 acres to 87 acres depending on the plan selected. Two industrial buildings will also be partially or totally removed by the widening of the river in Alternative Plan No. 7.

3. Valuation Analysis:

Based on an inspection of the subject sites and parcels of similar land which were sold in the Cleveland area, and giving consideration to location, topography, size, utilities, river frontage, access and condition of bulkheads, it is estimated that the fee value of the subject sites would be as listed below on a per acre basis.

The value of the temporary work easements to be estimated as 12 per cent per annum of the fee value for the various sites based on the typical rate of return of investment in the Cleveland area. The annual charge for temporary use of the land is computed below.

a. Alternative Plan No. 7.

Site No. 1 deleted

ATTACHMENT 1

3. VALUATION ANALYSIS: (Cont'd)

Site No. 2 — Land

Land in fee: .2 acre x $63,160 per acre = $12,632 say		$12,600	
Damages	-0-		
Temporary Easement (annual rate)			
.56 acres x $63,160 = $35,370 x 12% =	4,244 say	4,200	
Real estate cost		$16,800	
Contingencies 20%		+ 3,360	
Total land and contingencies		$20,160	
Rounded to			$20,000

Improvements (Excluding Demolition Costs)

An 80 yr. old frame four story and part six story sprinklered industrial storage building 61' x 45'6" x 78' high with 20 wood storage bins (38,000 bushels capacity) river unloading shaft 14' x 15' x 100' high. Total ground floor area is approximately 2,985 sq. ft. (14,700 sq. ft. total floor area)

Estimated value $2.00 per sq. ft. x 14,700 sq. ft.	= $ 29,400	
Unloading shaft $ .60/cu. ft. 21,000 cu. ft. x $60/cu. ft.	= + 12,600	
	$ 42,000	
Contingencies 20% - Imp.	$ 8,400	
Improvements Rounded to		$ 50,000
Total Site No. 2		$ 70,000

Site No. 3 — Land

Land in fee: 2.7 acres x $54,450 per acre = $147,015 say		$147,000	
Damages	-0-		
Temporary Easements (annual rate)			
2.43 acre x $54,450 = $132,313 x 12% = $15,877 say		15,900	
Real estate cost		$162,900	
Contingencies 20%		32,580	
Total real estate and contingencies		$195,480	
Rounded to			$195,000

Improvements

A trailer 47' x 10' high with attached metal storage bin]4' x 8' estimated cost to relocate	4,000
Total Site No. 3	$199,000

3. Valuation Analysis: (cont'd)

Site No. 4

Land in fee: 4.3 acres x $52,270 per acre =	$224,761	say	$225,000	
Damages	-0-		-0-	
Temporary Easement (annual rate)				
3.76 acres x $ 52,270 per acre = $196,535 x 12%=	$ 23,584	say	$ 23,600	
Real estate cost			$248,600	
Contingencies 20%			+49,720	
Total land and contingencies			$298,320	
Rounded to				$298,000

Site No. 5 Land

Land in fee: 2.6 acres x $ 52,270 per acre =	$135,902	say	$135,900	
Damages	-0-		-0-	
Temporary Easement (annual rate)				
1.79 acres x $ 52,270 per acre = $ 93,563 x 12%=	$ 11,227	say	11,200	
Total land cost			$147,100	
Contingencies 20%			+29,420	
Total land and contingencies			$176,520	
Rounded to				$176,500

Improvements (Excluding Demolition Costs)

A 28 yr. old one story masonry constructed industrial building containing 28,575 sq.ft. of ground floor area.

Estimated value $12.00 per sq.ft.	$342,900	
Contingencies 20%	+ 68,580	
Improvement Val.	$411,480	
Rounded to		$411,500
Total land and improvements Site No. 5		$588,000

Site No. 6

Land in fee: None, Navigational Servitude		
Temporary Easement (annual rate)		
.45 acres x $ 50,000 per acre = $ 22,500 X 12%=	$ 2,700	
Contingency 20%	+ 540	
Total Site No. 6.	$ 3,240	
Rounded to		$ 3,000

Site No. 7

Land in fee: .1 acre x $50,000 =	$ 5,000	
Damages	-0-	
Temporary Easement (annual rate)		
1.01 acres x $50,000 per acre = $ 50,500 x 12%=	6,060	
Real estate cost	$ 11,060	
Rounded to	$ 11,100	
Contingency 20%	+ 2,220	
Total Site No. 7	$ 13,320	
Rounded to		$ 13,000

3. VALUATION ANALYSIS: (Cont'd)

b. Alternate Plan No. 6 - Deepening of Cuyahoga River
Option A & B (requirements are the same)
Temporary Easements throughout river (annual rate)
(42,385 lin. ft. x 90 ft. wide)
Approx. 87.6 acres x $ 69,700/acre = $6,105,720
At 12% rental = 732,686
Contingency 20% 146,537
Total each option $879,223
Rounded to $ 879,000

c. Alternative Plan No. 5 - Improving of Old River

Option A

Fee Land 2.5 acres x $78,400 = $176,400		$176,400
Private Slip adjacent to Cut 15		
.3 Acres x $78,400 = $23,520	say	23,500
Damages		-0-
Temporary Easement (annual rate)		
13.68 acres x $78,400/acre = $1,072,512		
at 12% =		$128,700
Fee land for new track and R.R. bridge		
.57 acres x $54,000 per acre = $30,780	say	$ 31,000
Total		$359,600
Contingency 20%		+ 71,920
Total Option A		431,520
	say	431,000

Option B

Fee Land 2.5 acres x $ 78,400 = $176,400		$176,400
Private Slip adjacent to Cut 15		
.3 acres x $78,400 = $23,520	say	23,500
Damages		-0-
Temporary Easement (annual rate)		
13.68 acres x $ 78,400/acre = $1,072,512		
at 12% =		$128,700
Fee land for new B & O R.R. Track		
connection * acres		$ *
Total		$328,600
Contingency 20%		+ 67,720
Total Option B (Excluding R.R. Land Review)		394,320
	say	394,000

*Size, location, and value of parcels are to be provided by B & O Railroad at a later date for review and inclusion in Option B Total.

CERTIFICATION:

I hereby certify that I have carefully examined the properties described and that the estimates as developed in this report represent my unbiased judgment of the present Fair Market Value of the appraised subject only to assumptions and limiting conditions as specifically set forth herein.

Based on the information contained in this report, but not limited thereto, the estimated Acquisition Cost of the Project as of 15 December 1981, is in the amounts of:

Plan No. 7	$1,172,000	
Plan No. 6	879,000	
Plan No. 5-A	431,000	
Plan No. 5-B	394,000	(Excl. R.R. Land)

R.M. Stefanski
ROBERT M. STEFANSKI
Staff Appraiser
Real Estate Division

STATEMENT OF LIMITING CONDITIONS AND ASSUMPTIONS:

In making the appraisal of the subject project, the following assumptions and limiting conditions are presented:

1. That merchantable fee simple titles, free of encumbrances, are vested in the ownerships of record.
2. That all data obtained from the township assessor records and local realtors used in compiling this report are considered reliable, but the appraiser does not guarantee their correctness.
3. That the estimated value is merely a rough estimate and does not constitute a formal appraisal report.
4. That exhibits attached to this report are solely for the purpose of assisting the reader to visualize and understand its contents and are not intended to be exact in scale or detail.
5. That no attempt has been made to render an opinion relative to title or status of easements or any other matter of a legal nature.
6. That I have no present or contemplated future interest in the property.

DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

REFERENCE OR OFFICE SYMBOL	SUBJECT
NCDRE-E	Review of Railroad Cost Estimate, Cleveland Harbor Phase I Study

XX THRU: NCDRE-B (Attn: Mr. R. Dragonette)

FROM NCDRE-E

DATE 1 April 1982 STEFANSKI/eb/3-8041

CMT 1

TO: NCBPD-WB (Attn: Mr. R. Aguglia)

1. The cost estimate provided by the Chessie System Engineering Department for the railroad right-of-way for Alternative Plan No. 5; option B, covering the relocation of Bridge No. 23 has been reviewed and an inspection of the site has been made.

2. The letter from the railroad, dated 4 February 1982, listed a total cost to acquire right-of-way in the amount of $466,000 with no explanation as to how it was estimated. Subsequent telephone calls and correspondence, dated 9 March 1982, with the Manager of the Chessie System Real Estate Department provided additional information sufficient to complete the review.

3. The land portion of the cost estimate is reasonable ($310,000), but additional costs of acquisition (legal, title, exp., etc.) totalling 35-40% have been included ($156,000). This is the standard add on used by the railroad and is based on previous experience in acquisitions of this type. At this stage of the project a contingency and/or relocation expenditure estimate of 20% would be considered in a Corps of Engineers real estate estimate.

R. M. Stefanski

ROBERT M. STEFANSKI
Staff Appraiser
Real Estate Division

ATTACHMENT 2

DA FORM 1 FEB 62 2496 REPLACES DD FORM 96, WHICH IS OBSOLETE.

REAL ESTATE ESTIMATE
OF
EDGEWATER MARINA PLANS 8A AND 8B
CLEVELAND HARBOR PHASE I GDM
CLEVELAND, OHIO

1. DESCRIPTION OF PROJECT AREA:

The project area is south of and adjacent to a paved parking lot in the Edgewater Playfield which is west of the Edgewater Marina between Cleveland Memorial Shoreway (Route 20-2-6) and the shoreline of Lake Erie near West 70th Street. It is a part of the Cleveland Lakefront Park System west of the West Basin Breakwater.

The area surrounding the park area is mainly zoned and used for general industry with some scattered residential use to the southwest.

The subject sites do not have lake frontage but have access to the lake through the existing parking lot.

2. APPRAISAL PROBLEM:

Two areas are being considered as a parking lot for fishermen in the vicinity of the existing parking lot. Plan A requires a site containing .277 acres of land for parking and restroom building. Plan B requires a site containing .979 acres for parking and a restroom building. Both sites will be within the playfield area and will necessitate the removal or relocation of a baseball backstop and a refreshment stand as a part of the construction cost. A permanent easement will be required for the site of the selected parking lot site.

The highest and best use of the property is for recreational boating and fishing purposes.

3. VALUATION ANALYSIS:

Based on an inspection of the subject property, the land sold in the vicinity of the subject sites and giving consideration to time of sale, location, topography, size, water frontage or access, it is estimated that the fee values of the subject sites are $130,000 per acre for Plan A and $122,000 per acre for Plan B. The value of a permanent easement is considered to be less than the fee value. The value of the permanent easement is estimated at 50% of the fee value for both plans. A 20% contingency factor was considered in each site estimate.

ATTACHMENT 3

3. VALUATION ANALYSIS: (cont'd)

The valuation of the plans are as follows:

a. PLAN A

Permanent Easement:

$130,000 per acre x 50% = $65,000 per acre x .277 acre =	$18,005
Say	$18,000
Contingencies at 20%	+ 3,600
Total real estate and contingencies	$21,600
Rounded to	$22,000

b. PLAN B

Permanent Easement:

$122,000 per acre x 50% = $61,000 per acre x .979 acre =	$59,719
Say	$60,000
Contingencies at 20%	+12,000
Total real estate and contingencies	$72,000

CERTIFICATION:

I hereby certify that I have carefully examined the properties described and that the estimates as developed in this report represent my unbiased judgment of the present Fair Market Value of the appraised subject only to assumptions and limiting conditions as specifically set forth herein.

Based on the information contained in this report, but not limited thereto the estimated Acquisition Cost of the Project as of 23 April 1982, is in the amount of:

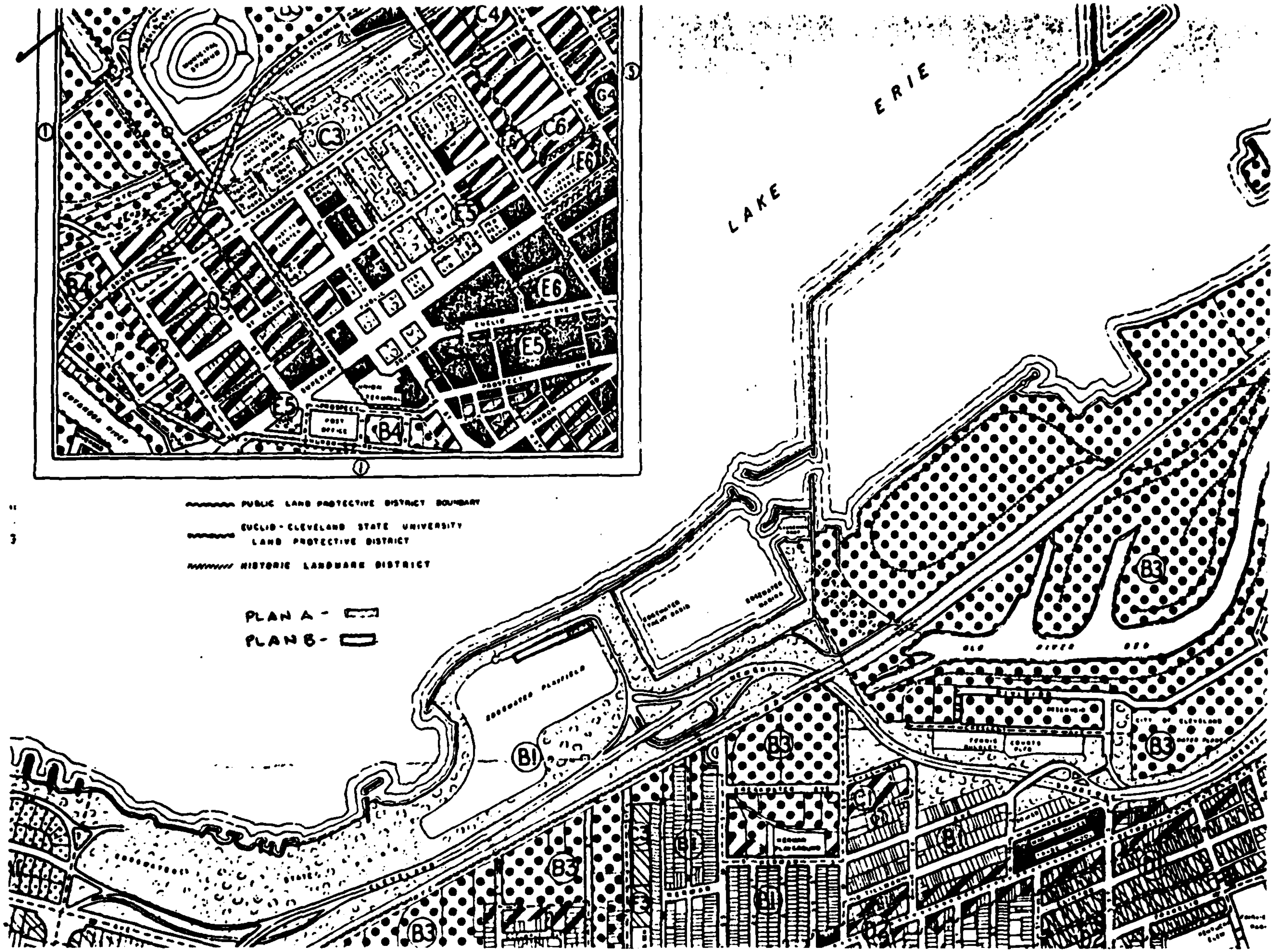
PLAN 8A	$22,000
PLAN 8B	$72,000

R. M. Stefanski
ROBERT M. STEFANSKI
Staff Appraiser
Real Estate Division

STATEMENT OF LIMITING CONDITIONS AND ASSUMPTIONS:

In making the estimate of the subject project, the following assumptions and limiting conditions are presented:

1. That merchantable fee simple titles, free of encumbrances, are vested in the ownerships of record.
2. That all data obtained from the township assessor records and local realtors used in compiling this report are considered reliable, but the appraiser does not guarantee their correctness.
3. That the estimated value is merely a rough estimate and does not constitute a formal appraisal report.
4. That exhibits attached to this report are solely for the purpose of assisting the reader to visualize and understand its contents and are not intended to be exact in scale or detail.
5. That no attempt has been made to render an opinion relative to title or status of easements or any other matter of a legal nature.
6. That I have no present or contemplated future interest in the property.


LAKE ERIE
PUBLIC LAND PROTECTIVE DISTRICT BOUNDARY
EUCLID - CLEVELAND STATE UNIVERSITY LAND PROTECTIVE DISTRICT
HISTORIC LANDMARK DISTRICT
PLAN A -
PLAN B -
EDGEWATER PLAYFIELD
OLD RIVER BED
POST OFFICE
EUCLID
PROSPECT
SUPERIOR
CUYAHOGA RIVER
C3
C4
C6
G4
E6
E5
B4
B1
B3

APPENDIX F
PERTINENT CORRESPONDENCE

CLEVELAND HARBOR, OHIO

STAGE 2 REPORT
OF
REFORMULATION PHASE I GENERAL DESIGN MEMORANDUM

U.S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, NY 14207

APPENDIX F
PERTINENT CORRESPONDENCE

Exhibit	Description
F-1	7 May 1976 Resolution of the Cleveland-Cuyahoga County Port Authority regarding the Port Authority's intent to act as local cooperator for the Cleveland Harbor modifications as outlined in the Draft Feasibility Report for Harbor Modifications, Cleveland, Ohio.
F-2	21 June 1976 Resolution of the Cleveland-Cuyahoga County Port Authority regarding the Port Authority's intent to act as local cooperator for a possible spoil disposal dike, as specified in the 1976 Feasibility Report for Harbor Modifications.
F-3	11 June 1976 letter from Dr. Teater of the Ohio Department of Natural Resources to the Buffalo District Engineer regarding ODNR's intent to be the local cooperator for the proposed West Breakwater fishing access plan at Cleveland Harbor.
F-4	17 February 1982 telephone conversation between Buffalo District and Mr. F. S. Albarano of the Jones and Laughlin Steel Corp. regarding J & L's position on a Lakefront transshipment facility for delivery of iron ore to their upriver steel mill.
F-5a	15 October 1981 letter from Mr. Eric Johannesen, Preservation Officer to Buffalo District regarding the eligibility of the west arrowhead breakwater lighthouse at Cleveland Harbor for the National Register.
F-5b	2 March 1982 letter from Mr. David H. Shank, Chief, Ann Arbor Office, National Park Service to Buffalo District regarding potential impacts of project plans on significant cultural resources in the Cleveland Harbor area.
F-5c	17 March 1982 letter from Mr. W. Ray Luce, State Historic Preservation Officer to Buffalo District regarding potential impacts of project plans on significant cultural resources in the Cleveland Harbor area.
F-6	11 February 1982 letter from Mr. David F. Mattson of Cereal Food Processors, Inc. to Buffalo District regarding their future plans for their ship unloading building adjacent to the Cuyahoga River.
F-7	22 Octover 1981 letter from Mr. Donald E. Yerks of Conrail to Buffalo District regarding Conrail's proposed plans to abandon their Railroad Bridge No. 14 over the Cuyahoga River.

Exhibit	Description
F-8	1 May 1981 letter from Mr. John F. Duink of Conrail to Buffalo District regarding Conrail's sale of the Erie Ore Dock on the Old River.
F-9	7 October 1981 telephone conversation record between Buffalo District and Mr. Hal Mawhey, Cleveland Plain Dealer Publishing Company, regarding their abandonment of plans to develop a newspaper publishing complex adjacent to the Old River.
F-10	11 February 1982 telephone conversation record between Buffalo District and Mr. Robert W. Moore, Ashland Petroleum Company regarding a proposed coal-oil mixing facility on their property adjacent to the Old River currently under consideration.
F-11	19 February 1982 telephone conversation record between Buffalo District and Mr. David Buchanan, Lake Carriers Association regarding the vertical clearance required by a Class VII vessel.
F-12	24 November 1981 letter from Mr. Ronald W. Drucker of the Chessie System regarding their interest in building a connection to Conrail in-lieu-of reconstructing their Baltimore and Ohio Railroad Bridge No. 23 over the Old River.
F-13	4 February 1982 letter from Mr. Ronald Drucker of the Chessie System to the Buffalo District Engineer regarding their preliminary construction cost estimate for the proposed Conrail connection.
F-14	19 May 1982 letter from Mr. Patrick A. Manley of Republic Steel Corporation to Buffalo District regarding their concern about three areas of the Cuyahoga River which inhibit vessel transits.

RESOLUTION NO. 1976-30

A RESOLUTION SUPPORTING THE IMPLEMENTATION OF IMPROVEMENTS RECOMMENDED IN FEASIBILITY REPORT FOR HARBOR MODIFICATIONS, CLEVELAND HARBOR, OHIO; AUTHORIZING THE CLEVELAND-CUYAHOGA COUNTY PORT AUTHORITY TO ACT AS THE LOCAL COOPERATOR FOR SUCH IMPROVEMENTS PROVIDED LOCAL FINANCING IS PROVIDED FROM LOCAL INDUSTRY OR OTHER SOURCES AND AUTHORIZING THE CHAIRMAN TO TRANSMIT THIS INFORMATION TO THE UNITED STATES OF AMERICA THEREFOR.

WHEREAS, the Port Authority has been advised by the United States Army Corps of Engineers by letter dated April 12, 1976 that it will recommend authorization of navigation improvements described in the Feasibility Report for Harbor Modifications, Cleveland Harbor, Ohio; and

WHEREAS, the Port Authority has been further advised by the United States Army Corps of Engineers by such letter that the designation of a Local Cooperator for the Cleveland Harbor navigation improvements is necessary before the improvements can be recommended for authorization;

NOW, THEREFORE, BE IT RESOLVED by the Board of Directors of the Cleveland-Cuyahoga County Port Authority, Cleveland, Ohio:

Section 1. The Cleveland-Cuyahoga County Port Authority will consent and has the legal authority to be the local cooperator for the Cleveland Harbor modifications proposed by the United States Army Corps of Engineers as outlined in the "Draft Feasibility Report for Harbor Modifications,Cleveland, Ohio" as submitted to the Port Authority in March, 1976 and as detailed in a letter from Colonel Bernard Hughes to Chairman Albert Bernstein dated April 12, 1976, provided that the Cleveland-Cuyahoga County Port Authority can obtain financing for the project from local industry or other sources.

Section 2. That this Resolution shall take effect immediately upon its adoption.

ADOPTED: May 7, 1976

CHAIRMAN

ATTEST:

Asst. SECRETARY

Exhibit F-1

RESOLUTION NO. 1976-37

A RESOLUTION SUPPLEMENTING RESOLUTION NO. 1976-30 AUTHORIZING THE CLEVELAND-CUYAHOGA COUNTY PORT AUTHORITY TO ACT AS THE LOCAL COOPERATOR FOR A POSSIBLE SPOIL DISPOSAL DIKE IF SUCH DIKE IS REQUIRED TO COMPLETE THE HARBOR IMPROVEMENTS AS SPECIFIED IN FEASIBILITY REPORT FOR HARBOR MODIFICATIONS.

WHEREAS, the Port Authority Board of Directors has passed Resolution No. 1976-30 supporting the implementation of improvements recommended in Feasibility Report for Harbor Modifications, Cleveland Harbor, Ohio, provided that the Cleveland-Cuyahoga County Port Authority can obtain financing for the project from local industry or other sources; and

WHEREAS, the Port Authority has now received a letter dated June 7, 1976 from Colonel Hughes, District Engineer of the Corps of Engineers, setting forth lifications which he proposes to recommend in the final Feasibi ity Report, which modifications may require construction of a spoil disposal project West of existing Dike #10; and

WHEREAS, it is a requirement that a Local Cooperator of the proposed possible spoil disposal dike be named now for the submission to move forward for approval;

NOW, THEREFORE, BE IT RESOLVED by the Board of Directors of the Cleveland-Cuyahoga County Port Authority, Cleveland, Ohio:

Section 1. The Cleveland-Cuyahoga County Port Authority agrees to be the Local Cooperator for a spoil disposal dike area in accordance with the terms outlined in the letter of Colonel Hughes dated June 7, 1976 provided that the Port Authority continues to be eligible for the waiver of cost of the local share pursuant to the provisions of Section 123 of Public Law 91-611 and provided further, that the City of Cleveland agrees to furnish the Port Authority all lands, easements and rights-of-way required for construction and maintenance of the Harbor improvements and for aids to navigation requested by the Chief of the Corps of Engineers which are not now controlled by the Port Authority.

Section 2. That this Resolution shall take effect immediately upon its adoption.

ADOPTED: June 21, 1976

CHAIRMAN

Exhibit F-2

ODNR
Ohio Department of Natural Resources
Fountain Square · Columbus, Ohio 43224 · (614) 466 3770

June 11, 1976

Colonel Bernard C. Hughes
U.S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, New York 14207

Re: Your 2 June 1976 letter;
Cleveland Harbor fishing access

Dear Colonel Hughes:

This is to assure that this Department is willing and capable of sharing one-half of the estimated $1.3 million cost to construct west breakwater fishing facility. However, we need to look to a local government entity for operation and maintenance. The estimated annual benefit is $945,000.

Our benefit forecast is based on:

(1) fishing access to about 7,000 feet of breakwater,

(2) an estimated annual usage of 150,000 fishing trips, and

(3) $6.30 value per fishing trip based upon the 1970 National Survey of Fishing and Hunting.

Sincerely,

Robert W. Teater

ROBERT W. TEATER
Director

Exhibit F-3

TELEPHONE OR VERBAL CONVERSATION RECORD For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.		DATE 17 February 1982
SUBJECT OF CONVERSATION Cleveland Harbor Study - J&L Steel Corporation's Future Lakefront Transshipment Plans		
INCOMING CALL		
PERSON CALLING	ADDRESS	PHONE NUMBER AND EXTENSION
PERSON CALLED	OFFICE	PHONE NUMBER AND EXTENSION
OUTGOING CALL		
PERSON CALLING Richard Aguglia	OFFICE NCBPD-WB	PHONE NUMBER AND EXTENSION 2263
PERSON CALLED Mr. F.S. Albarano (Shipment Planner)	ADDRESS Pittsburgh, PA	PHONE NUMBER AND EXTENSION 412-227-4305

SUMMARY OF CONVERSATION

1. On 17 February 1982, I called Mr. Albarano about their future lakefront transshipment plans at Cleveland Harbor. Mr. Albarano replied as follows:

a.) J&L Steel Corporation is not interested in building their own iron ore transshipment facility in the Lakefront Harbor. However, if economically justified, they would consider using such a facility if built by others (i.e., Conrail, Cleveland Port Authority, etc.).

b.) They recently stopped feasibility studies by Lake Erie Asphalt Products due to the depressed demand for steel (Note: LEAP was studying the feasibility of building a Lakefront Iron Ore Transshipment facility to serve, among others, J&L Steel.)

c.) They are very interested in using a deepened Cuyahoga River navigation channel.

RICHARD E. AGUGLIA
Project Manager

Exhibit F-4

DA FORM 1 APR 66 751 REPLACES EDITION OF 1 FEB 58 WHICH WILL BE USED.

WRHS
THE WESTERN RESERVE HISTORICAL SOCIETY
10825 EAST BOULEVARD/CLEVELAND, OHIO 44106/(216) 721-5722

October 15, 1981

Mr. Charles E. Gilbert
Buffalo District Corps of Engineers
1776 Niagara Street
Buffalo, NY 14207

Dear Mr. Gilbert:

In response to your letter of October 13, 1981, The West Pierhead Lighthouse in Cleveland Harbor was built in 1909-1910, with additions in 1916. It was included in a survey of lighthouses on the Great Lakes conducted by the U. S. Coast Guard and HAER in 1979. It was subsequently included in a thematic resource nomination to the National Register and submitted to the National Park Service in August, 1980.

I do not know whether this thematic resource group has been listed, and I suggest that you contact the National Register office directly. The State Historic Preservation Officer for Ohio has concurred in the eligibility of the structure for the National Register.

Sincerely,

Eric Johannesen

Eric Johannesen
Preservation Officer

Exhibit F-5a

United States Department of the Interior

NATIONAL PARK SERVICE
MIDWEST REGION
ANN ARBOR OFFICE
FEDERAL BUILDING
ANN ARBOR, MICHIGAN 48107

IN REPLY REFER TO:
March 2, 1982

1201-02(a)

Mr. Charles E. Gilbert
Chief, Engineering Division
Department of the Army
Buffalo District, Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207

Dear Mr. Gilbert:

Thank you for your February 25, 1982, letter concerning the study to provide various navigation improvements to Cleveland Harbor, Ohio.

We are not aware of any significant cultural resources which would be affected by this project, except for the West Pierhead Lighthouse mentioned in the letter by Eric Johannesen, Preservation Officer, The Western Reserve Historical Society.

We suggest you write for the comments of Dr. W. Ray Luce, Ohio State Historic Preservation Officer, The Ohio Historical Society, Interstate 71 at 17th Avenue, Columbus, OH 43211.

Thank you for giving us this opportunity to comment on the project. If you have any questions, call Dr. Harry G. Scheele, FTS 378-2007.

Sincerely,

David H. Shonk

David H. Shonk, Chief
Ann Arbor Office

Exhibit F-5b

Ohio Historic Preservation Office
Ohio Historical Center I-71 & 17th Avenue Columbus, Ohio 43211 (614) 466-1500

March 17, 1982

U.S. Army Corp. of Engineers, Buffalo
Environmental Resources Branch
1776 Niagara Street
Buffalo, New York 14207

Attention: Kathleen McDermott

Re: Navigation Improvements
Cleveland Harbor

Dear Ms. McDermott:

This is in reply to your letter of 25 February 1982, requesting our preliminary comments on various proposed alternative actions to improve navigation at Cleveland Harbor.

Of the different entrance plans, it appears that only Alternative 1 ("All-Weather" East Entrance Plan) will not involve the Cleveland West Pierhead Light, which should be considered eligible for inclusion in the National Register of Historic Places (see enclosed). If this light is involved and adversely affected it will be necessary to prepare a Preliminary Case Report and request the comments of the Advisory Council on Historic Preservation. If Alternative 1 is selected, there will be no effect on cultural resources.

The various improvements for to the Cuyahoga River and the Old River including new bulkheads, deepening, and reducing river congestion must take into consideration the National Register or eligible properties along the river. These properties include the Center Street Swing Bridge, the Old Superior Avenue Viaduct, the Columbus Road Vertical Lift Bridge (currently scheduled for reconstruction by ODOT but indicated for replacement in Alternative 7), The Union Terminal Groups, and the Lorain Carnegie Bridge. As plans for these various proposals progress, you should continue to coordinate with this office. As necessary, you should request determinations of eligibility or determinations of effect and initiate consulation with the National Park Service and the Advisory Council.

Thank you for requesting our early imput on this project and we look forward to continued coordination.

Sincerely,

W. Ray Luce

W. Ray Luce
State Historic Preservation Officer

WRL/BD:vb
Enclosures
X.c: Charlene Dwin, ACHP

Exhibit F-5c

Ohio Historic Preservation Office

Ohio Historical Center I-71 & 17th Avenue Columbus, Ohio 43211 (614) 466-1500

August 5, 1980

U. S. Nichols
Chief, Logistics & Property Branch
Ninth Coast Guard District
1240 East 9th Street
Cleveland, Ohio 44199

Dear Mr. Nichols:

Enclosed is the National Register of Historic Places nomination form you forwarded for the U.S. Coast Guard Lighthouses. I have signed the document at the appropriate place indicating my concurrence in their nomination. I feel these Ohio properties are eminently qualified for the National Register.

We appreciate your initiating these efforts to meet your E.O. 11593 responsibilities, and are pleased to work with you in recognizing these important Ohio landmarks. Please let us know if we can be of any assistance in your future preservation endeavors.

Sincerely,

David L. Brook

David L. Brook
State Historic Preservation Officer

DLB:DAS:cw

X. c: Eric Johannesen
Ted Ligibel

FOR NPS USE ONLY
RECEIVED
DATE ENTERED

NATIONAL REGISTER OF HISTORIC PLACES INVENTORY -- NOMINATION FORM

Illinois

Chicago Harbor Light Station

Michigan

Big Sable Point Light Station
Detroit River Light Station
Eagle Harbor Light Station
Forty Mile Point Light Station
Grand Traverse Light Station

Granite Island Light Station
Gull Rock Light Station
Harbor Beach Light
Isle Royale Light Station
Little Sable Point Light Station

Manitou Island Light Station
Marquette Harbor Lighthouse
Pointe Betsie Light Station
Port Sanilac Light Station
Presque Isle Light Station

Rock of Ages Light Station
Saginaw River Light Station
Seul Choix Point Light Station
Skillagallee (Ile Aux Galets) Light Station
Sturgeon Point Light Station

St. Martin Island Light Station
Tawas Point Light Station
Thunder Bay Island Light Station
Waugoshance Light Station
White Shoal Light Station

Minnesota

Duluth South Breakwater Inner Light
Two Harbors Light Station

New York

Buffalo Main Light
Buffalo North Breakwater South End Light
Dunkirk Light
Fort Niagara Light
Galloo Island Light
South Buffalo North Side Light
Thirty Mile Point Light
Tibbetts Point Light

Ohio

Ashtabula Harbor Light
Cedar Point Light
Cleveland West Pierhead Light
Toledo Harbor Light
West Sister Island Light

Pennsylvania

Presque Isle Light

Wisconsin

Ashland Breakwater Light
LaPointe Light Station
North Point Light Station
Plum Island Rear Range Light
Rawley Point Light Station
Sherwood Point Light Station
Sturgeon Bay Canal Light
Wind Point Light Station

HAER INVENTORY — Department of the Interior, Washington, D.C.

FIELD NO

CLASSIFICATION: ...NS:MARINE:Navigational Aids — 5 5 0 1

ENDANGERED? ☐ YES ☒ NO ☐ UNKNOWN

DATE: 1909-1910; 1916

GOVT SOURCE OF THREAT

OWNER/ADMIN: Department of Transportation, U. S. Coast Guard

NAME OF STRUCTURE: ...veland West Pierhead Light

OWNER'S ADDRESS: Ninth District, 1240 East 9th Street, Cleveland, Ohio 44199 — PHONE: 216/522-2950

STATE / COUNTY: OH — COUNTY NAME: Cuyahoga — CITY/VICINITY: Cleveland — CONG DIST

ADDRESS (STREET & NO): west pierhead at main entrance to Cleveland Harbor, on Lake Erie

12 EXISTING SURVEYS: ☐ HABS ☐ HAER-I ☐ HAER ☐ NPS ☐ CLG ☐ CONF ☐ STATE ☐ COUNTY ☐ LOCAL ☐ OTHER

13 SPECIAL FEATURES (DESCRIBE BELOW): ☒ INTERIOR INTACT ☒ EXTERIOR INTACT ☒ ENVIRONS INTACT

UTM ZONE: 17 — EASTING: 440100 — NORTHING: 4595300

SCALE: ☒ 1:24 ☐ 1:625 — QUAD NAME: Cleveland North

CONDITION: ☐ EXCELLENT ☐ GOOD ☒ FAIR ☐ DETERIORATED ☐ RUINS ☐ UNEXPOSED ☐ ALTERED ☐ DESTROYED ☐ DEMOLISHED

INVENTORIED BY: ...ol Pob Miller — AFFILIATION: HAER-Great Lakes Lighthouse Survey — DATE: May 1979

DESCRIPTION AND BACKGROUND HISTORY, INCLUDING CONSTRUCTION DATE(S), HISTORICAL DATA, PHYSICAL DIMENSIONS, TECHNICAL DATA, EXTANT EQUIPMENT, AND IMPORTANT BUILDERS, ENGINEERS, ETC.

...ether with a small metal beacon on the east breakwater, the Cleveland West Pierhead Light marks ... main entrance to Cleveland Harbor. The arrowhead breakwaters were built 1904-1909 to protect ... harbor from prevailing northerly winds. In 1908, $45,000 was appropriated for two "light-...tions" to mark the channel into the harbor. The West Pierhead Light, erected 1909-1910, consists ... a 4-story brick tower sheathed with wood. The conical tower, painted white, features windows with ...mental architraves and an entrance vestibule with three-part entablature. There is a basement, ...ley on the first floor, and living quarters on the second, third, and fourth floors (no longer ...upied). Above this is a watchroom with a circular gallery supported on brackets. The circular ...tern rises above the watchroom. Although the light was converted to electric lens drive in (CONT OVER)

ORIGINAL USE: ...bor light & fog signal — PRESENT USE: Harbor light & fog signal — ADAPTIVE USE

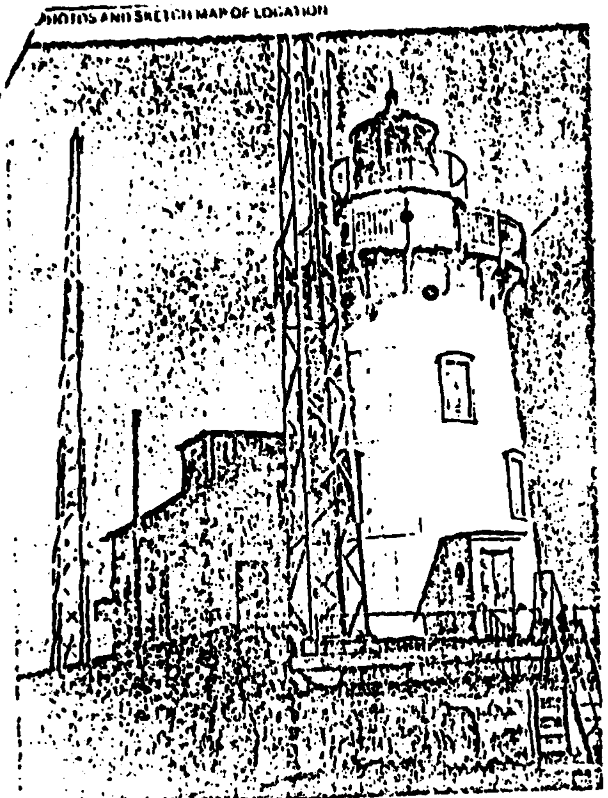
REFERENCES—HISTORICAL REFERENCES, PERSONAL CONTACTS, AND/OR OTHER

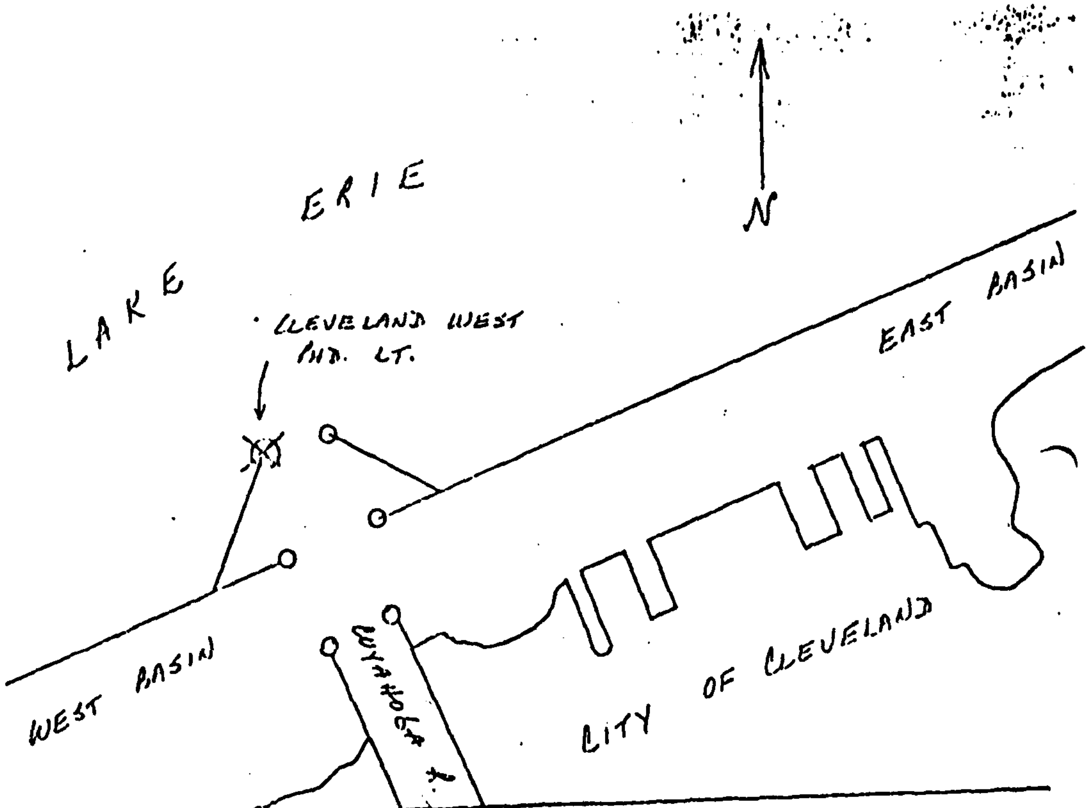
...wing and photograph files, United States Coast Guard Ninth District Headquarters, Cleveland, Ohio.
...ords of the United States Coast Guard, Record Group 26, National Archives, Washington, D.C.
..., Department of Transportation, United States Coast Guard, Light List, vol. 4, Great Lakes (1979), p. 30. (CONT OVER)

...ERAL AND A 50 ... ☒ YES ☐ NO — 21 HCRS REGION — 22 PUBLIC ACCESSIBILITY: ☒ YES, LIMITED ☐ YES UNLIMITED ☐ NO ☐ UNKNOWN — 23 EDITOR / INDEXER

LOCATED IN AN HISTORIC DISTRICT? ☐ YES ☒ NO — NAME — DISTRICT ID NO

PHOTOS AND SKETCH MAP OF LOCATION





DESCRIPTION (CONTINUED)

1960, it is still shone through a 4th-order Fresnel lens bearing the marking of "Barbier & Benard, Paris, 1884." The light, which has a focal plane height of 63' above mean lake level, shows an alternating white and red flash. On the north side of the light, a covered passage connects the tower to a 1½-story steel-framed fog signal house, built in 1916. The gable-roofed building, 29' 31', is clad with ¼" steel plates. New fog signal apparatus was installed in 1964.

INFLUENCES (CONTINUED)

UTD: includes lighthouse and its foundation approx. 25 acres

This lighthouse played an important role in the development of Cleveland harbor.

Cereal Food Processors, Inc.

4901 MAIN ST., SUITE 400
P.O. BOX 11336
KANSAS CITY, MO. 64112

PHONE: (816) 561-4271

February 11, 1982

Mr. Richard Aguglia
Project Manager
Department of the Army
Buffalo District
Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207

Dear Mr. Aguglia:

In reply to the letter of October 7, 1981, and our phone conversation this week, we have, as you indicated, removed the North building as planned. However, the ship unloading building is still very much in use. The discussions we had in 1976 were based on the premise that self unloaders were to be employed in grain transportation. This projection has not taken place.

Therefore, if we were to remove the ship unloading building for implementing the construction of Cut No. 4. The following steps would have to be taken:

a.)	Replace marine leg	$350,000
b.)	Replace tempering bins	250,000
c.)	Install grain conveying equip.	100,000
	Total	$700,000

The costs shown are estimates and not firm prices.

At the present time, we have no plans for carrying out these modifications.

We hope to see you next month at your meeting in Cleveland. In the meantime, if you desire further information, please contact me.

Sincerely,

CEREAL FOOD PROCESSORS, INC.

David F. Mattson
Vice President - Operations

DFM:akk

Exhibit F-6

CONRAIL

October 22, 1981

Mr. Richard Agvglia
Army Corps of Engineers-Buffalo District
1776 Niagara Street
Buffalo, New York 14207

Dear Sir:

This is to confirm our phone conversation of October 16, 1981 regarding Bridge 14 over the Cuyahoga River in Cleveland, Ohio.

Bridge 14 is part of the former Erie Lackawanna main line now known as the River Bed line. The River Bed line is targeted for abandonment. Conrail anticipates filing for abandonment before December 1, 1981.

Conrail will have no further use for a railroad bridge at the location of Bridge 14.

Sincerely,

Donald E. Yerks

Donald E. Yerks

Exhibit F-7

CONRAIL

May 1, 1981

Mr. Donald M. Liddell
Chief, Engineering Section
Department of the Army
Buffalo District, Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207

Dear Sir:

This is in reply to yours of April 24, 1981, concerning Conrail's plans for two sites in the Cleveland area.

I have asked our Mr. G. M. Williams, Assistant Vice President, Regional Market Development, to respond directly to you, regarding the status of our line of track crossing the Cuyahoga River at Bridge 14.

Regarding the Erie Ore Dock in the Old River, we expect title to pass to new owners within the next six months. While we cannot speak for these people, we would imagine that their use of the property will require continued marine activity although not as an iron ore dock.

Very truly yours,

John F. Duink
Director
Coal & Ore Sales

Exhibit F-8

TELEPHONE OR VERBAL CONVERSATION RECORD

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

DATE: 10/7/81

SUBJECT OF CONVERSATION
Proposed Plans of Forest City Publishing Company for Expansion of their facilities in Cleveland, Ohio.

INCOMING CALL

PERSON CALLING	ADDRESS	PHONE NUMBER AND EXTENSION
PERSON CALLED	**OFFICE**	**PHONE NUMBER AND EXTENSION**

OUTGOING CALL

PERSON CALLING	OFFICE	PHONE NUMBER AND EXTENSION
RICHARD AGUGLIA	NCBPD-WB	ext. 2263
PERSON CALLED	**ADDRESS**	**PHONE NUMBER AND EXTENSION**
HAL MAWHEY	CLEVELAND PLAIN DEALER PUBLISHING COMPANY	216-344-4500

SUMMARY OF CONVERSATION

1. On 7 October 1981 I called Mr. Hal Mawhey of the Cleveland Plain Dealer Publishing Company (formerly the Forest City Publishing Company) regarding their proposed plans to develop a newspaper publishing complex on their property adjacent to the Old River. Prospective waterbourne commerce to this facility was used, in part, to justify deepening of the upper portion of the Old River from 21-feet to 27-feet below LWD, as proposed in the "Detailed Project Report on Improvement on Old River Channel - Cleveland Harbor, Ohio", subsequently approved by OCE for construction on 6 December 1966.

2. Mr. Mawhey stated that his company no longer plans on developing this property and, in fact, the property is currently up for sale. Thus there will be no need to deepen the Old River for their use.

RICHARD E. AGUGLIA
Project Manager

Exhibit F-9

DA FORM 1 APR 66 751 REPLACES EDITION OF 1 FEB 58 WHICH WILL BE USED.

TELEPHONE OR VERBAL CONVERSATION RECORD

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

DATE: 11 February 1982

SUBJECT OF CONVERSATION: Cleveland Harbor Study - Ashland Petroleum Company's proposed Oil-Coal Mixing Facility on their Old River Site in Cleveland

INCOMING CALL

PERSON CALLING	ADDRESS	PHONE NUMBER AND EXTENSION
Robert W. Moore, Manager of Facilities of Engineering	Ashland Petroleum Company AT-4 P.O. Box 391 Ashland, KY 41014	606-329-5124
PERSON CALLED	**OFFICE**	**PHONE NUMBER AND EXTENSION**
Richard Aguglia Roger Haberly	NCBPD-WB NCBPD	ext. 2263 ext. 2178

OUTGOING CALL

PERSON CALLING	OFFICE	PHONE NUMBER AND EXTENSION
PERSON CALLED	**ADDRESS**	**PHONE NUMBER AND EXTENSION**

SUMMARY OF CONVERSATION

1. On 11 February 1982, Mr. Robert Moore of the Ashland Petroleum Company called Roger Haberly and myself. The purpose of the call was to discuss their proposed plans to construct an Oil-Coal Mixing Facility on their property in Cleveland adjacent to the Old River.

2. Mr. Moore explained that his company is presently conducting a preliminary investigation to determine if a coal-oil mixing facility is economically feasible. However, until this study is completed, he cannot make a commitment on when or if this facility would actually be constructed. The concept currently under consideration involves receiving coal by rail and oil by vessel on the Old River and mixing the oil and coal together to produce boiler fuel for Republic Steel's operations in Cleveland. The boiler fuel would be delivered to Republic by barge. The proposed plant would require approximately 126,000 gallons of oil per day which would be recieved from either North Tonawanda, NY or from Canada. Mr. Moore also stated that if water rates for coal delivery become competitive with rail rates, they would also consider receiving their coal by ship.

3. Mr. Moore stated that Ashland would probably use their own vessels to deliver the oil to this plant. However, he did not know what size these vessels would be or what draft they could be loaded to. He said he would check on this, and call us back in a day or two with the information. Mr. Moore also stated that he would find out if they would increase the size of their vessel or load to a deeper draft if the authorized but uncompleted improvements on the Old River were constructed (NOTE: These authorized improvements would allow a larger vessel to use the Old River navigation channel (increase in size from a maximum 649-foot long vessel to a 730 foot long vessel) and would allow vessels to load to the systems draft of 25.5 feet versus the restricted draft of 20.5 feet which currently exists). Mr. Moore also stated that the existing Old River navigation Channel is sufficient for the barge they would use to deliver the boiler fuel to Republic.

4. Roger Haberly asked what the current production at their plant on the Old River was. Mr. Moore replied that they currently process about 35 to 40 million gallons of oil per year, however, they are only operating at about 20% capacity.

Exhibit F-10

5. Mr. Moore also expressed an interest in attending the Cleveland Harbor workshop meeting in late March or early April.

RICHARD E. AGUGLIA
Project Manager

(NOTE: Via telephone call on 27 April 1981, Mr. Moore indicated that his company would use a 450-foot vessel to ship oil to their proposed facility and the existing 23-foot channel depth of the Old River navigation channel was sufficient for their needs. Also, they would not increase the size of their vessel if authorized but uncompleted improvements on the Old River were completed.)

TELEPHONE OR VERBAL CONVERSATION RECORD

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

DATE		19 February 1982
SUBJECT OF CONVERSATION		
INCOMING CALL		
PERSON CALLING: Dave Buchanan	ADDRESS: Lake Carriers Association Cleveland, OH	PHONE NUMBER AND EXTENSION: 216-621-1107
PERSON CALLED: Richard Aguglia	OFFICE: NCBPD-WB	PHONE NUMBER AND EXTENSION: Ext. 2263
OUTGOING CALL		
PERSON CALLING	OFFICE	PHONE NUMBER AND EXTENSION
PERSON CALLED	ADDRESS	PHONE NUMBER AND EXTENSION

SUMMARY OF CONVERSATION

1. On 19 February 1982, Mr. Dave Buchanan called me back in regards to my question on the vertical clearance required for a 730-foot vessel. Mr. Buchanan stated that he contacted Olgebay-Norton, who operate a 730-foot vessel. They stated that their 730-foot vessel (which can be considered as a representative American owned 730-foot vessel) is 94 feet in height, as measured from the top of the radar mast to the keel. Since the ship can ballast to 18', they require a minimum of 76 feet of vertical clearance from the water surface. Therefore, since the Conrail vertical lift bridge at the mouth of the Cuyahoga River and the Willow Avenue vertical lift bridge on the Old River at Cleveland Harbor both have 98 feet of vertical clearance above LWD, 730-foot vessels should be able to pass underneath these bridges without any problems.

2. Mr. Buchanan also stated that he believes that some Canadian owned 730-foot vessels are designed based on St. Lawrence Seaway dimensions (maximum vertical height above water of 116.5 feet). Thus, some Canadian vessels may not be able to use the Old River navigation channel if it is improved for 730-foot vessel operation without modifying the bridges.

RICHARD E. AGUGLIA
Project Manager

Exhibit F-11

DA FORM 1 APR 66 751 REPLACES EDITION OF 1 FEB 58 WHICH WILL BE USED.

Engineering Department

Chessie System

Operating Headquarters Building
P. O. Box 1800
Huntington, W. Va. 25718

November 24, 1981 F/94

File: H- 4473
H-10185

Colonel George P. Johnson
District Engineer
Department of the Army
Buffalo District, Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207

Dear Colonel Johnson:

This will acknowledge receipt of your letter of November 12, regarding reactivation of the study of the Old River channel at Cleveland, Ohio as it pertains to possible replacement of Bridge No. 23 (B&O No. 464.)

I am certain that our company is interested in pursuing this study as it pertains to building a connection to Conrail in lieu of reconstructing Bridge No. 464. My office will arrange to progress the development of updated costs in connection with this proposal.

Because of the necessity to handle this matter with Conrail to develop their requirements and estimated cost related thereto, it is difficult at this time to predict exactly when completion of updated cost estimates might be anticipated. However, we can keep you abreast of developments as they occur.

If you have any questions, please contact Mr. P. E. Van Cleve at (304) 522-5471.

Very truly yours,

Ronald W. Drucker

Ronald W. Drucker
Chief Engineer

cc: Messrs. E. R. Lichty
M. E. Good
G. R. Guess
E. M. Cummings
C. L. Bialik

Exhibit F-12

Engineering Department

Chessie System

Operating Headquarters Building
P. O. Box 1800
Huntington, W. Va. 25718

February 4, 1982 FD/94

File: H-4473

Colonel George P. Johnson
District Engineer
Department of the Army
Buffalo District, Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207

Dear Colonel Johnson:

This refers to your letter of November 12 regarding reactivation of the study of the Old River channel at Cleveland, Ohio as it pertains to the possible replacement of Bridge No. 23 (B&O No. 464).

As requested, attached are updated cost estimates for the five specific areas of work for the alternate connection. Due to the short reply time allowed, we made only a cursory site inspection and had only the 1971 Penn Central estimates to rely on for work on Conrail property. We have queried Conrail as to their continued interest in the relocated interchange, but have no reply to date. The estimates are based on current railroad and contract prices, however, some of the quantities involved could only be guessed at due to lack of details. All figures include the current appropriate Federal Aid (FHPM) additives and salvage credits.

(a) Cost of new connection at St. Clair Ave.	$2,447,600
(b) Cost to modify Conrail wye - No costs shown by PC in 1971	
(c) Cost to modify Conrail for new interchange	$1,403,400
(d) Cost to remove Bridge No. 23	$ 842,000
(e) Cost to remove existing interchange	$ 33,400
	$4,726,400

We have no scale plan for work on Conrail property but enclose a Corps print showing locations involved by coloring. Also enclosed are two prints of our new connection Drawing No. 27767-C as revised February 3, 1982.

Very truly yours,

Ronald W. Drucker

Ronald W. Drucker, Chief Engineer

Exhibit F-13

CLEVELAND, OHIO

(A) New B&O-Conrail Connection at St. Clair Avenue

Work by B&O:

(a) Install #8 turnout	$ 20,200
(b) Install Track Connection - 1106 Ft.	$ 111,000
(c) Rubber Grade Crossings - 2 Ea.	$ 43,200
(d) Flashing light signals - 2 sets	$ 210,200
(e) Remove Paving & Walks	$ 45,500
(f) Alter Utilities	$ 287,000
(g) Grading for Track & Roads	$ 230,000
(h) "New" Road Drainage	$ 46,600
(i) "New" Road Paving, Walks & Gutters	$ 159,000
(j) "New" Road Guardrail	$ 17,100
(k) Pump Station Wall & Access	$ 106,700
(l) City "Park" Bulkhead	$ 490,300
(m) Acquire Right-of-Way	$ 466,000
	$2,232,800

Work by Conrail:

(a) Relocate Existing Turnout	$ 16,200
(b) Install #10 Turnout	$ 24,100
(c) Alter Signal System a/c New Turnout	$ 174,500
	$ 214,800

TOTAL	$2,447,600

CLEVELAND, OHIO

(C) Main Line Conrail Changes for B&O Interchange

Work West of Bridge No. 1

(a) Install #20 Crossover	$ 93,200
(b) Alter Signal System	$ 150,100
	$ 243,300

Work East of Bridge No. 1

(a) Install 4 Turnouts & 2 Crossovers	$ 200,100
(b) Install Interchange Track - 5430 Ft.	$ 504,100
(c) Realign Track - 1550 Ft.	$ 15,400
(d) Remove 1 Turnout & 2 Crossovers	$ 30,400
(e) Remove Track - 750 Ft.	$ 2,700
(f) Alter Signal System	$ 407,400
	$1,160,100

TOTAL	$1,403,400

CLEVELAND, OHIO

(D) Remove Bridge No. 23 (B&O No. 464)

(a) Remove Bridge	$ 235,700
(b) Remove West Pier & Fenders	$ 565,700
(c) Remove Bridge Control Building, Signal System & Electric Service	$ 31,700
	$ 833,100
(d) Remove B&O Main Track - Sta. 8+13 to 13+90	$ 3,000
(e) Install Bumping Post at West End of Main Track (Sta. 13+90)	$ 1,900
(f) Remove Sidetracks VOE, VST & VOAB(8)	$ 4,000
	$ 8,900
TOTAL	$ 842,000

CLEVELAND, OHIO

(E) Remove B&O-Conrail Interchange

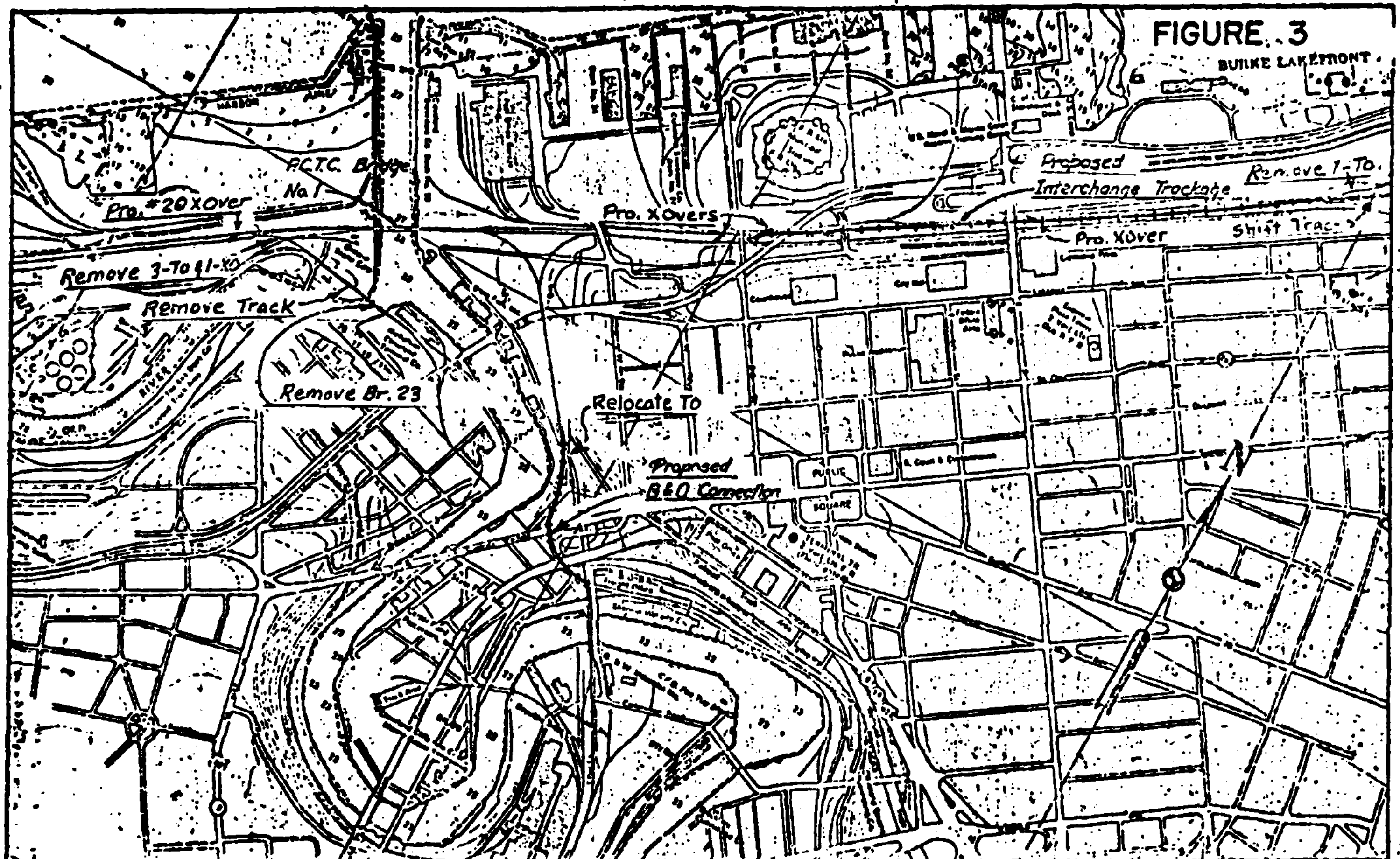
Work by B&O:

(a) Remove Main Track incl. Crossing Frog Sta. -0+02 to 8+13	$ 6,100
(b) Remove Public Grade Crossing	$ 2,400
	$ 8,500

Work by Conrail:

(a) Remove Track - 1900 Ft.	$ 6,800
(b) Remove Crossing Frog & Restore Track	$ 7,700
(c) Remove 3 turnouts and Crossover	$ 10,400
	$ 24,900
TOTAL	$ 33,400

Office of Chief Engineer
Huntington, West Virginia
File: H-4473 FD/94
Drawing No. 27767-C (Rev. 2-3-82)



OLD RIVER IMPROVEMENTS

(PROPOSED RAILROAD CONNECTIONS)
CLEVELAND HARBOR, OHIO
CORPS OF ENGINEERS BUFFALO, N.Y.
OCTOBER 1975

Construction
Removals

2-3-82 FD

Encl 3

Republicsteel

Republic Steel Corporation
General Office: Republic Building
Raw Materials Department
PO Box 6778
Cleveland, OH 44101

May 19, 1982

PA Manley
Manager
Resource Business Development

Charles E. Gilbert
Chief, Planning Division
Department of the Army
Corps of Engineers
1776 Niagara Street
Buffalo, NY 14207

Dear Mr. Gilbert:

Thank you for providing us the opportunity to discuss improvements to the Cleveland Harbor and Cuyahoga River with you and Mr. Richard Aguglia. As you know, our interest in these matters has been quite active for severals years.

We take particular note of your revised plans and estimate for a suitable passage for the 1,000 ft. ships bound for the Cleveland Harbor. You may recall that this was also the recommendation of the consultant that we hired in the late '70's to determine what modifications were necessary in order for the Cleveland Harbor to safely accommodate the transit of the new super-sized ships on the Great Lakes.

We have previously communicated our concerns to you involving three areas of the Cuyahoga River requiring attention in order to provide a safer transit for these vessels serving the Cuyahoga Valley industries

1. Bridge 19 -- the former Erie Lackawana Bridge - Removal of Bridge and Abutments
2. Jefferson Avenue Bridge -- Removal of abutments
3. The deepening of the turning basin to 23 ft draft.

Mr. Gilbert
Page #2

We note these items have been on your agenda for quite some time and we were pleased to learn that some resolutions to the problems may be near at hand. We are hopeful that a sufficient amount of attention and effort will be forcused on this in order to expedite the improvements.

Again, We would like to thank you for your continuing cooperation.

Patrick A. Manley
Manager
Resource Business Development

PAM/sdw

cc: R. R. Hostelley
C. T. Burke

APPENDIX G
PUBLIC INVOLVEMENT

CLEVELAND HARBOR, OHIO

STAGE 2 REPORT
OF
REFORMULATION PHASE I GENERAL DESIGN MEMORANDUM

U.S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, NY 14207

APPENDIX G
PUBLIC INVOLVEMENT

Exhibit	Description
G-1	Summary Minutes of 14 March 1979 Workshop Meeting
G-2	Summary Minutes of 8 April 1981 Workshop Meeting
G-3	Summary Minutes of 29 and 30 October 1981 Workshop Meeting
G-4	Summary Minutes of 16 February 1982 Workshop Meeting with Ontario Stone Corporation
G-5	Summary Minutes of 4 May 1982 Workshop Meeting
G-6	Summary Minutes of 26 February 1980 Workshop Meeting with Cleveland-Cuyahoga County Port Authority
G-7	Summary Minutes of 16 September 1981 Workshop Meeting with U.S. Coast Guard, Ninth Coast Guard District
G-8	Summary Minutes of 15 March 1982 Workshop Meeting

DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

REFERENCE OR OFFICE SYMBOL	SUBJECT
NCBED-PW	Cleveland Harbor, OH - Lorain Harbor, OH, Vessel Masters Meeting, 14 March 1979

TO

FROM J. Henry, Proj. Mgr., Cleveland
R. Simonsen, Proj. Mgr., Lorain

DATE 22 Mar 79 CMT 1

Henry/bb/2263
Simonsen/bb/2276

1. The purpose of the meeting was to obtain expert opinions of experienced vessel masters on needed harbor improvements at Cleveland and Lorain for safe and efficient operation of the 1,000-foot vessel and an 1,100-foot hull. An attendance list is attached (Incl 1). A summary of discussion relative to general vessel operating characteristics and to harbor improvement at Cleveland follows. Separate notes have been prepared for discussion related to Lorain Harbor.

2. Vessel Operating Characteristics.

a. Vertical Ship Movements - Squat, Pitch, Roll, and Heave at Lakefront Harbor Entrance - The vessel masters do not know the extent of vertical vessel movements and have no measuring instruments aboard ship. They agree that 1,000-foot vessels do not squat appreciably, particularly at three or four mile speeds in river channels and there is not much pitch. However, roll is much greater than pitch and is significant when turning into a position parallel to wave troughs. In rough open-lake conditions, masters have experienced up to an estimated 45° of roll in small boats. Captain Allen said even the Steamship Charles M. Beeghly (806 feet X 75 feet) experiences considerable roll in open sea conditions. The broad beam of the 1,000-foot vessel reduces the roll effect. Captain Brabender said that for some reason the Steamship Stewart J. Cort rolls relatively little. Although vertical movements are not quantifiable, the masters concluded the proposed 32-foot depth below LWD would be satisfactory harbor entrance depth at Cleveland to account for vertical movements.

b. Instrumentation of Vertical Ship Movements - The pendulum-type roll meter aboard ship is not sensitive and masters are too busy to read the roll meter. They agreed that any new instrumentation should be self-recording. Captain Brabender commented that the Naval Researach Lab has a wave recorder on the Stewart J. Cort, which measures wave heights.

c. Stopping Distance vs. Speed - Weather, currents, traffic are the primary factors external to the ship which influence stopping distance. The Captains feel that each ship handles differently depending on type of engine and other factors. They have tables which relate stopping distance and speed, under load and ballasted conditions, but these apply only on calm, deep water situations. For example, a twin screw 1,000-footer could stop in 500 feet at a speed of four mph.

d. Turning in Confined Areas - Wind and wave condition affect turning. Although thrusters are effective only at very slow speed of about three or four mph, in a following sea it is difficult to control and turn a vessel at slow speeds. With respect to turning a vessel around, in calm conditions the vessel can turn in a circle with a diameter about equal to the ship length. Turning is made more difficult as wind speeds increase and at about 20 mph the thrusters will not turn the bow into the wind.

Exhibit G-1

e. Tug Assistance - The Captains agreed that Great Lakes tugs are not powerful enough to effectively maneuver a 1,000-foot vessel in most situations where a 1,000-footer could use assistance. Captain Brabender thought that the large tugs such as those at Seven Islands, Quebec, might sometimes be a help. Captain Brabender commented that he did not use a tug last season. The Captains generally feel that because of the size of the 1,000-footer it is difficult to coordinate a tug assistance operation. They also commented a tug assistance operation is expensive and that there are problems with tug crew personnel and labor union requirements. However, foreign general cargo vessels use tugs because the general cargo vessel is not as maneuverable as bulk cargo vessels with twin engines and thrusters.

f. Limiting Wave and Wind Conditions - The Captains feel that 30-mile per hour winds with a full sea condition from northeasterly through north to northwesterly direction prevent entry to all the Lake Erie harbors. They must wait off Canadian shore or hold up above southeast shoals. If the Cleveland east entrance were deepened, they might try Cleveland at wind speeds and full seas up to about 35 mph.

3. Study Background and Review of Alternatives - Cleveland Harbor. Jim Henry explained that the Corps is presently conducting a detailed study of Cleveland following a six-year feasibility study completed in March 1977. The feasibility study included workshops in 1975 with the Lake Carriers Association, the Port Authority, Coast Guard, active and retired vessel masters, and representatives from steamship companies. Jim Henry reviewed the six lakefront harbor improvement alternatives which the workshop participants considered, and the decision to more thoroughly study two of the alternatives:

a. The east entrance alternative involving deepening of the east basin channel and an extension to the east breakwater.

b. The west entrance alternative involving a large "L" shaped breakwater extension from the easterly arrowhead structure and deepening through the new entrance.

The 1975 workshop participants then reevaluated these two alternatives and concluded that the east entrance alternative was the better plan. The Corps March 1977 report proposed a plan involving minor structural changes to the west entrance in combination with these east entrance alternative. However, that report recommended

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that the plan be reformulated. In July of 1977, a meeting of the Lake Carriers Association, the Port Authority, and several representatives from steamship companies and industry concluded: that the east basin channel should be improved as the primary entrance, that the proposed east breakwater extension could be excluded, and that the west entrance should be modified to permit 1,000-foot vessels to exit in relatively calm conditions and to reduce wave transmission into the lakefront harbor. The recent decision by Republic Steel to receive 1,000-foot vessel delivery of ore requirements at Lorain has reduced the urgency for moving rapidly to construction at Cleveland and some interests wish reconsideration of the other harbor entrance alternatives involving the west entrance.

4. Views and Opinion of Masters on Necessary Harbor Improvements at Cleveland. The Captains unanimously favor development of the east basin channel and minor change to the west entrance essentially as agreed to by participants in the July 1977 meeting. They consider it far superior to any of the alternatives involving the west entrance and do not think anything could be done to west entrance to make it a comparable point of entry. They also estimate additional transit time from southeast shoals via east entrance would only be about one-half hour. Seaway traffic could use the east entrance and vessel congestion and delays would be reduced having two optional entrances with Seaway depths. They agreed on the following points related to harbor improvements.

a. Extension of the East Breakwater (Proposed During Previous Study) - They would like a breakwater extension but do not consider it a necessity. They would like this considered if actual 1,000-foot vessel operation proves that it is needed.

b. Depth and Width of East Entrance Channel - They agree with the dimensioning of the 2,900-foot long X 1,000-foot wide entrance and that this section of channel should be located close to the east breakwater as shown in study plan. They also agree that this section of channel should be 32 feet deep below LWD to make the east entrance operational in 30 mph winds and full sea conditions. At a depth of 29 feet below LWD, the east basin would not be operational in storm conditions. A 500-foot wide, 28-foot deep channel through the remainder of the east basin is adequate considering present channel depths in the Great Lakes interconnecting channels.

c. Anchorage - They proposed an anchorage in the east basin for boats to hold while waiting for a dock, particularly when storms are

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forecasted. They also feel that an anchorage is needed as a refuge and safety feature. It was agreed that an anchorage in the Nicholson approach channel at a depth of 28 feet should be considered (assume 90 feet of anchorage chain). A pile cluster mooring east of the breakwater would not be acceptable in foul weather. (However, a similar concept in an area protected by the breakwater should probably be considered).

d. Modification to the West Entrance - The Captains thought that parts of the spur breakwaters inside the arrowhead might be removed but cautioned against any major change to the arrowhead entrance which would adversely effect wave action in the lakefront. They agreed with a model study and suggested that the model study should consider removal of the inner end of the arrowhead arms to create a gap between the arrowhead structures and the main breakwater. The 29-foot depth in arrowhead entrance is sufficient. The 1,000-foot vessel would exit only during fair weather and would be ballasted to a draft of about 24.5 feet.

e. The West Basin - The Captains proposed no change to the west basin and considered the 1,500-foot basin width adequate for a vessel turnaround under its own power in winds up to about 20 mph.

5. Lorain Harbor-Purpose of Meeting. The purpose of the Lorain portion of the meeting was to discuss improvements to be considered for the safe and efficient operation of 1,000-foot vessels within the Lorain Federal project limits. Suggested improvements were discussed in regards to the outer harbor, the lower river channel, and the upper river channel.

6. Outer Harbor. The masters discussed the limiting conditions of the present harbor and suggested two alternative breakwater arrangements. Under the existing breakwater arrangement, the 1,000-foot vessel masters would attempt entry of their ship only under good weather conditions (winds under 25 mph) and would attempt stern entry only under "most ideal" weather conditions. One alternative suggested by the vessel masters included: removing 500 feet from the north end of the west breaker to allow a larger entrance for 1,000-foot vessels (Area 1 of project map), extending the area dredged in outer harbor as shown on project map (Area 2 on project map) and dredge to 25 feet to allow 1,000-foot vessels to turnaround in ballast safely, and dredging the turnaround area in the outer harbor to 28 feet to allow the 1,000-foot vessels to turnaround fully loaded. The second alternative suggested by the vessel masters was

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to reorient the west breaker as shown on the attached project map (Area 3) and again dredge turning area to 28 feet. This alternative would provide the larger entrance and needed turning area for 1,000-foot vessels, plus minimize the amount of dredging needed for a fully loaded 1,000-footer.

7. Lower Black River Channel (from river mouth to just above Norfolk and Western Railroad Bridge). Several points and suggestions were established for the lower Black River Channel.

a. It was established that 1,000-foot vessels could navigate the Federal Channel below Erie Avenue Bridge. (Area 4)

b. It was established that 1,000-foot vessels could not operate through the Erie Avenue Bridge constriction on a regular basis safely if the bridge and channel alignment were left in their existing condition.

c. Two options were presented to improve the Erie Avenue Bridge constriction. One, to realign channel to go through the City Park area (Area 5 on project map) and leave the bridge as it exists now. Two, replace the bridge with a high level bridge or tunnel.

d. A 200-foot wide channel constructed normal to the existing Erie Avenue Bridge through the City Park (Area 5 on project map) and construction of a cut south of the Erie Avenue Bridge (Area 6 on project map) would allow a 1,000-foot vessel to pass through the Erie Avenue Bridge constriction safely on a regular basis.

e. The vessel masters indicated that the maneuverability of a 1,000-foot vessel would be a problem in the Black River because of the size of the 1,000-foot vessels in the narrow channel. As the vessel moves upstream into the turns, it in effect, temporarily "dams" the river flow.

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SUBJECT: *Cleveland Harbor, OH - Lorain Harbor, OH, Vessel Masters Meeting, 14 March 1979*

f. A cut in the river channel (Area 6 on project map) is not only necessary to enable a 1,000-foot vessel through the bridge, but also to maneuver through the next bend. The vessel masters also suggested it would also allow smaller vessels to maneuver through the congestion associated with the American Shipbuilding Company operation more safely.

g. The masters indicated a cut in the river (Area 6 on project map) would be necessary not only for the alternative of a new channel through the park, but also for the alternative of a new high level bridge structure for the Erie Avenue crossing.

h. The vertical clearance of a new high level bridge would need to be Seaway clearance (about 120 feet). Also, the masters indicated Seaway clearance is sufficient to clear a 1,000-foot vessel under the bridge.

i. Seven hundred and thirty-foot vessels presently handle stone deliveries on the Black River.

j. The vessel masters pointed out that the proximity of the ship to the bank greatly affects the control and maneuverability of the ship. Propellor suction draws the stern towards the river bank. The more sharp turns in the channel, the more of a problem control of the ship becomes. Also, the masters indicated that stern thrusters are not that effective in counteracting this effect.

k. The masters indicated that bow and stern thrusters are powerful, that bank erosion could be a major problem. Masters indicated that riprap would probably not stop bank erosion by thrusters, and that sheet piling would be needed all along the riverbanks suspectable to erosion. The only way around the erosion problem with thrusters would be to straighten the channel to the point that you could just float the ship upriver.

l. Vessel masters indicated a need for a cut across from the American Shipbuilding Company operation (Area 7 on project map) to enable 1,000-foot vessels to make the turn and line up the vessel to go through the Norfolk and Western Bridge.

m. Vessel masters mentioned that storage of American Shipbuilding Company hulls encroach on the Federal navigation channel. Existing size vessels have difficulty operating through this area presently. It was indicated that the problem of encroachment along Federal navigation channels is not unique to Lorain, but occurs along the entire Great Lakes System.

n. Corps personnel indicated that the Federal channel is not designed for the purpose of storing vessels, but is designed for the purpose of moving vessels. The vessel masters indicated that generally the Coast Guard does not enforce encroachment violations.

o. The masters indicated that the horizontal clearance (205 feet) and vertical clearance (Seaway height) of the Norfolk and Western Railroad Bridge is sufficient for 1,000-foot vessels.

8. <u>Upper Black River Channel</u> (from just above Norfolk and Western Railroad Bridge to river mile 3). Several points and suggestions were established concerning the upper river channel.

a. Vessel masters indicated additional cuts (Areas 8 and 9 on project map) would have to be made to enable safe passage of 1,000-foot vessels.

b. Vertical clearance of 21st Street Bridge is 98.7 feet above LWD. It was not clearly established whether this vertical clearance would be sufficient for 1,000-foot vessels. Vessel masters indicated that water level fluctuations of the Black River could affect whether a 1,000-foot vessel would be able to pass under the 21st Street Bridge.

c. Two options concerning the 21st Street Bridge were discussed. One, if the vertical clearance was enough. And two, if the vertical clearance was not enough.

d. If the vertical clearance was sufficient for the 21st Street Bridge, the vessel masters indicated additional cuts (Areas 10 and 11 on project map) would be needed for 1,000-foot vessels to navigate to the upstream limit of the Federal project and provide sufficient turning area for the 1,000-foot vessel. The 1,000-foot vessel masters indicated a need for an area approximately 1,200 feet in diameter to turn safely.

e. If the vertical clearance of the 21st Street Bridge is not sufficient, the bridge could be raised or replaced with a new high level bridge.

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f. If the vertical clearance of the 21st Street Bridge is not sufficient, a transshipment facility could be constructed below the 21st Street Bridge. With this alternative, the masters indicated a need for an additional cut in lower turning basin (Area 12 on project map) to provide sufficient area to turn a 1,000-foot vessel.

g. An additional point brought up was that U.S. Steel is the only company which receives iron ore about the 21st Street Bridge. The Corps Division representative then commented that this may be a single user situation requiring local cost-sharing.

h. The Corps indicated that U.S. Steel has expressed an interest in expanding their Lorain facility.

i. Assuming that changes were made to the Black River channel to allow 1,000-foot vessels to navigate up to river mile 3, the masters indicated that all other vessel traffic would have to stop and be clear of the channel to enable 1,000-foot vessels to get up the channel and that it would take at least three hours to navigate from the breakwaters to river mile 3.

9. Miscellaneous.

a. Traffic Control at St. Mary's River Locks - The Captains experience serious congestion problems above the locks because traffic control, split between the Corps of Engineers and the Coast Guard, is ineffective. These problems are resulting in vessel delays and create a major accident potential. This condition is intensifying with the increasing number of boats which must use the new Poe Lock. Dave Buchanan said the Lake Carriers Association is following up on this matter.

b. Ashtabula Harbor - Mr. Allen and Mr. Anderson indicated that the Ashtabula Outer Harbor should be widened for 1,000-foot vessel traffic at Slip No. 1 and Seaway traffic at Slip No. 2. They also indicated that operation in the Ashtabula lakefront is complicated when Coast Guard removes channel markers in the fall. Jim Henry will bring this to the attention of the appropriate persons in the Buffalo District Office.

c. Burns Harbor - Captain Brabender operates the Steamship Stewart J. Cort regularly at Burns Harbor and feels strongly that a breakwater extension similar to the Buffalo south entrance is definitely needed. Jim Henry will bring this to the attention of the appropriate Corps of Engineers Office.

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Masters Meeting, 14 March 1979

d. Charts - Mr. Allen commented that the new NOAA harbor charts are difficult to read. NOAA tabulates recent soundings on the lower left part of the page but a reader cannot correlate these soundings with a map location.

2 Incl
as

FRANK J. HENRY, Project Manager, Cleveland

ROLF SIMONSEN, Project Manager, Lorain

LIST OF ATTENDEES

Name	Representing
Robert A. Brabender	Bethlehem Steel Corporation Vessel Master of STEWART J. CORT
Leonard V. Olsen	Pickands Mather & Co. Vessel Master of JAMES R. BARKER
Eldon Allen	Pickands Mather & Co. Vessel Master of HERBERT C. JACKSON
Victor Anderson	Pilots Association
David Buchanan	Lake Carriers Association
Max Janairo	Michael Baker Jr., Inc.
John Kurgan	Michael Baker Jr., Inc.
William Flick	Michael Baker Jr., Inc.
James Beirs	U.S. Army Corps of Engineers, North Central Division
Frank J. Henry	U.S. Army Corps of Engineers, Buffalo District
Michael Pelone	U.S. Army Corps of Engineers, Buffalo District
Richard Gorecki	U.S. Army Corps of Engineers, Buffalo District
Rolf Simonsen	U.S. Army Corps of Engineers, Buffalo District

Cleveland Harbor Study
Summary Minutes of 8 April 1981
Vessel Masters Workshop Meeting
Cleveland-Cuyahoga County Port Authority Office
Cleveland, Ohio

1. A meeting was held on 8 April 1981, at the Cleveland-Cuyahoga County Port Authority's Office, Cleveland, Ohio, to establish design criteria for an "all-weather" entrance for 1,000-foot vessels at the arrowhead (west) entrance to Cleveland Harbor and to review an "all-weather" east entrance plan and a "fair-weather" west entrance plan for safe and efficient operation of 1,000-foot vessels prepared by the Buffalo District. The names of those persons in attendance are shown on the attached list (Incl 1). Mr. John Zorich opened the meeting at approximately 1:30 p.m. by welcoming all meeting participants. Following introduction of the persons in attendance, Mr. Zorich stated that the purpose of this meeting was to obtain professional and expert information on 1,000-foot vessel operating characteristics with a view towards design of an "all-weather" west (arrowhead) entrance at Cleveland Harbor for such vessels. Another stated objective was the review of an "all-weather" east entrance plan and a "fair-weather" west entrance plan that were developed based on input received from vessel masters and steamship companies at previous workshop meetings. Mr. Zorich then turned the meeting over to Mr. Richard Aguglia.

2. Mr. Aguglia stated that the Cleveland Harbor Study is presently in Stage 2 of the planning process in which a wide array of preliminary alternatives are formulated to meet the water resources needs of the area. Through a process of assessment and evaluation, these preliminary alternatives are then screened down to two or three plans which appear most feasible. These plans are then developed in detail so that a rationale choice can be made among them and, if appropriate, an alternative could be recommended for implementation. Mr. Aguglia also stated that there are four main areas of study in the Cleveland Harbor investigation, however, this meeting is only concerned with the development of a safe and efficient entrance into the Lakefront Harbor for 1,000-foot vessels. It is anticipated that these vessels would dock at either the C & P dock on Whiskey Island and/or at a new Port Authority dock. Mr. Aguglia then stated that the Corps is studying three entrance concepts for 1,000-foot vessels: (1) an "all-weather" east entrance which primarily involves deepening of the existing east entrance and east basin; (2) an "all-weather" west entrance which involves major structural changes to the existing west entrance; and (3) a "fair-weather" west entrance which involves minor structural changes to the west entrance with the realization that vessels would not be able to enter the Lakefront Harbor under storm conditions. An "all-weather" entrance was defined as an entrance that would allow 1,000-foot vessels to enter the Lakefront Harbor under all weather conditions for which they would dock and unload their cargo. Based on discussions during the meeting, this "all-weather" condition was further defined as waves less than 8 feet in height and winds under 30 knots from the west through the northeast.

3. Mr. Aguglia then stated that the first item for discussion was development of an "all-weather" west entrance plan for 1,000-foot vessels. This plan would then be tested in the hydraulic model of the Lakefront Harbor at the Corps Waterways Experiment Station to insure that all design criteria are met. Included in the model tests will be a series of navigation tests using a scale model 1,000-foot vessel. This vessel has been operated by both Captain McSweeney and Captain Chamberlain and they feel that the model ship adequately simulates operating characteristics of the prototype vessel with the exception of roll and stopping response. Mr. Aguglia then briefly reviewed the five "all-weather" west entrance concepts developed by the Buffalo District (see Incls 2-6). The vessel masters did not feel that any of these concepts would provide an adequate entrance and suggested two alternate concepts: (1) an "L" shaped breakwater concept similar to the entrance plan studied during the feasibility study of the early 1970's (see Incl 7); and (2) a detached east arrowhead extension concept similar to the breakwater arrangement at Lorain Harbor (see Incl 8). Because the "L" shaped breakwater concept would require more breakwater than the detached east arrowhead extension concept, and consequently a higher construction cost, the detached east arrowhead extension concept was selected as the preferred concept for development of an "all-weather" west entrance. Mr. Aguglia then led a general discussion to refine this concept. The results of this discussion are as follows:

a. The vessel masters are unanimous in their preference for an east entrance for 1,000-foot vessels and feel it is far superior to any west entrance plan. Their main concern is the potential damage from striking the many obstacles at the west entrance (i.e., pierhead lights, breakwater arms, etc.), especially since they lose sight of an object when it is closer than 300 to 400 feet away. They are then forced to rely on instruments and/or lookouts at the bow of the vessel. This problem is intensified at Cleveland due to the strong cross-currents at the arrowhead entrance.

b. "All-weather" conditions were defined as a maximum 8-foot wave at the entrance and 30-knot winds from the west through northeast. Under these conditions, 1,000-foot vessels would have to enter at 6 mph in order to be under proper control. The required stopping distance at this speed is 1,700-1,800 feet. Captain Anderson stated that smaller vessels (vessels 730 feet in length or less) could probably enter under worse weather conditions. Captain Anderson also stated that, based on his experience in piloting vessels (vessels 730 feet or less in length), the only time he could not enter Cleveland Harbor due to adverse weather conditions was during "Agnes" on 22 June 1972.

c. Captain Anderson asked what the current schedule was for construction at Cleveland Harbor. Mr. Aguglia replied that based on the current schedule, which assumes adequate funding, the earliest construction could start would be 1987 and construction would probably take two construction seasons.

d. Captain Anderson also asked what the possibility was for constructing a dual entrance for 1,000-foot vessels at Cleveland. Mr. Aguglia replied that at the present time it does not appear that a dual entrance would be economically justified because there would not be enough incremental benefits to justify a second entrance once the first entrance was in place. We will, however, investigate a dual entrance plan during Stage 2 planning.

e. Captain Tereki asked if the Corps was taking into account the possibility of 1,200-foot vessels on the Great Lakes. Mr. Aguglia replied that this possibility would be used in assessing each entrance plan. Admiral Trimble stated that he sees no increase in ship size beyond 1,000-footers before the turn of the century and their use would be dependent on the construction of larger locks capable of handling these ships.

4. The "All-Weather" West Entrance-Detached East Arrowhead Extension concept was refined as follows (see Incl 9):

(1) The length of the detached breakwater, parallel to the east arrowhead breakwater, was set at 3,000 feet. This length was selected since it allows adequate room for a 1,000-foot vessel, entering at 6 mph as required under design conditions, to slow down before making the turn into the Lakefront Harbor (Note: Stopping distance at 6 mph is approximately 1,700-1,800 feet after the vessel is completely into the protected entrance). It was also decided that this detached breakwater would be located 300 feet off the existing east arrowhead breakwater.

(2) To facilitate vessel maneuvering, 600 feet of the west arrowhead breakwater, 300 feet of the west spur breakwater, and 200 feet of the east spur breakwater will be removed.

(3) A second detached breakwater will be required to prevent increased wave activity in the Lakefront Harbor as a result of the breakwater removals. The length of the detached breakwater will be determined based on model tests at WES.

(4) The opening between the new detached breakwaters will be 900 feet, which is similar to the entrance at Lorain Harbor.

(5) The new detached breakwaters should be designed to limit wave heights in the entrance channel to 2 to 3 feet during design conditions (8-foot waves and 30-knot winds) at the location of the existing arrowhead entrance. This would allow the masters to slow their vessels down to 2 to 3 mph before making the turn into the Lakefront Harbor. By slowing down to 2 to 3 mph, the masters would also be able to use their thrusters in turning their vessel. (Note: Above 2 to 3 mph, thrusters lose their effectiveness in controlling a vessel).

(6) When entering at 6 mph under design conditions (8-foot waves and 30-knot winds) a roll of 3-5 degrees can be expected in a 1,000-foot vessel. For the determination of required channel depths, use 4 degrees of roll. Captain Anderson stated that roll for smaller vessel (vessels 730 feet in length or less) would be about 1-1/2 times the roll of a 1,000-foot vessel, or between 5 to 7 degrees (use 6 degrees for required depth determinations). The vessel masters also stated that they need sufficient water under their vessel in order to be able to use their engines without rupturing oil and air

lines due to vibrations. The vessel masters feel a 32-foot channel depth would be adequate to prevent this.

5. Mr. Aguglia then reviewed the "all-weather" east entrance plan that was developed based on input received from vessel masters and steamship companies at previous workshop meetings. This plan included (see Incl 10): (1) an entrance channel, varying in width from 2,000 feet to 1,000 feet, and 32-feet deep; and (2) an interior channel, 500-feet wide and 28-feet deep. Mr. Aguglia then led a general discussion on this plan. The results of this discussion are as follows:

a. Captain Tereki stated that he feels a 1,000-foot long breakwater extension, at the end of the east breakwater and parallel to the proposed entrance channel, is required to break up wave action caused by a northwest wind. However, all vessel masters agreed that under the design entrance conditions (8-foot waves and 30-knot winds), this breakwater extension would not be required.

b. Entrance speed and vessel roll under design conditions would be 6 mph and 3-5 degrees (use 4 degrees in determination of required channel depths), respectively.

c. All vessel masters agreed that a 28-foot depth for the interior channel was adequate since their vessels would not roll in the protected channel. However, it was decided that the 500-feet wide interior channel should be extended across the west entrance and dredged to 30 feet. This extra depth is required since a 1,000-foot vessel can be expected to roll up to 2 to 3 degrees as a result of waves entering between the arrowhead breakwater.

d. Mr. Bowser of the city of Cleveland stated that the city is studying the possibility of expanding Burke Lakefront Airport and would be interested in using the dredged material as fill if this plan was implemented. Use of the dredged material as fill would also result in an extra benefit for this plan. The Corps and the city will coordinate on this matter as the study progresses.

6. Mr. Aguglia than reviewed the "fair-weather" west entrance plan which was developed at the Corps Waterways Experiment Station using the scale model 1,000-foot vessel operated by Captain McSweeney. The plan that was developed (see Incl 11) included removal of 300 feet of the west spur breakwater and 200 feet of the east spur breakwater and deepening the approach channel to 30 feet and the interior entrance channel to 29 feet. To compensate for increased wave activity in the Lakefront Harbor due to the spur breakwater removal, the plan also includes two 300-foot parallel piers at the lakeward end of the existing arrowhead breakwaters and raising of the west arrowhead breakwater from +8 LWD to +14 LWD. Mr. Aguglia also showed a short movie of the model at WES illustrating this "fair-weather" west entrance plan and the

scale model 1,000-foot vessel. Mr. Aguglia then led a general discussion on this plan, the results of which are as follows:

a. "Fair-weather" conditions were defined as a maximum 4-foot wave and 20-knot winds from the west through northeast. Under these conditions, 1,000-foot vessels would enter at 2 to 3 mph and would experience no vessel roll. Because there would be no vessel roll under the "fair-weather" design condition, the existing depths in the approach channel and interior entrance channel (29 feet and 28 feet, respectively) are considered adequate.

b. The vessel masters also stated that the two 300-foot parallel piers are required for safe navigation of 1,000-foot vessels in addition to being required to compensate for increased wave activity in the Lakefront Harbor as a result of the spur breakwater removal.

7. Although not on the original agenda, Mr. Aguglia then reviewed the results of the channel depth calculations for 730-foot vessels recently completed by the Buffalo District. Based on a 12 mph entrance speed, 7 degree roll, 25.5-foot draft and 2-foot underkeel clearance, the required channel depth for a 730-foot vessel is 33 feet. This required depth is 4 feet more than the existing entrance depth of 29 feet at the arrowhead entrance. Mr. Aguglia asked the vessel masters if the 33-foot depth appeared excessive and did they experience problems entering Cleveland Harbor under storm conditions during the low water period of the early 60's. The masters replied that the entrance speed should be a maximum of 6 mph and roll would be between 5 to 7 degrees at the entrance (use 6 degrees for depth calculations). Mr. Aguglia replied that even using these new values, the required depth would be 31 to 32 feet which is still more than the existing 29-foot depth. The masters stated that this appeared reasonable since they did come into Cleveland 2 to 3 feet lighter in the early sixties than they currently do.

8. Mr. John Zorich then thanked all the meeting participants and adjourned the meeting at 5:00 p.m.

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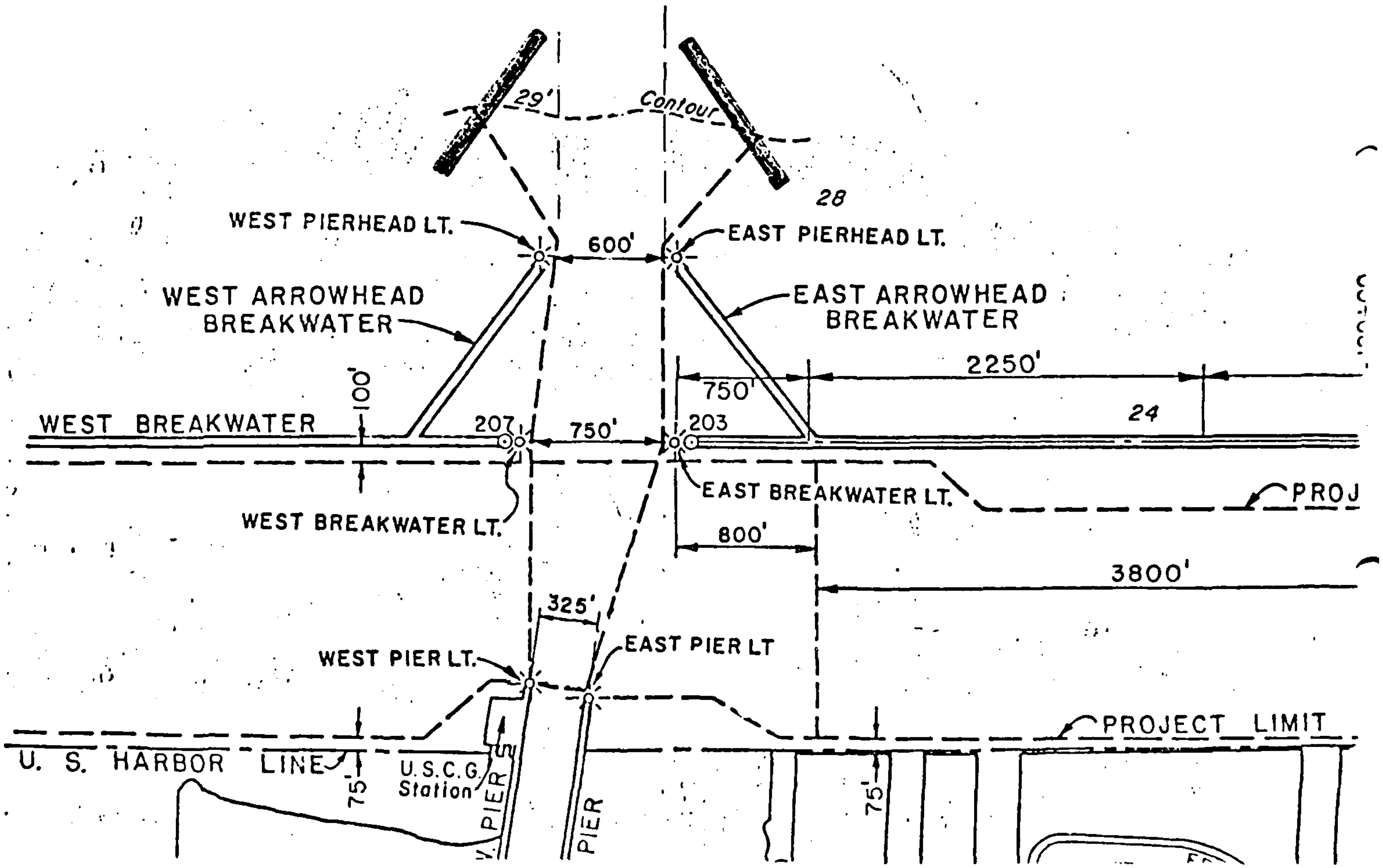
RICHARD AGUGLIA
Project Manager

Cleveland Harbor Study
Summary Minutes of 8 April 1981
Vessel Masters Workshop Meeting
Cleveland-Cuyahoga County Port Authority Office
Cleveland, Ohio

ATTENDANCE

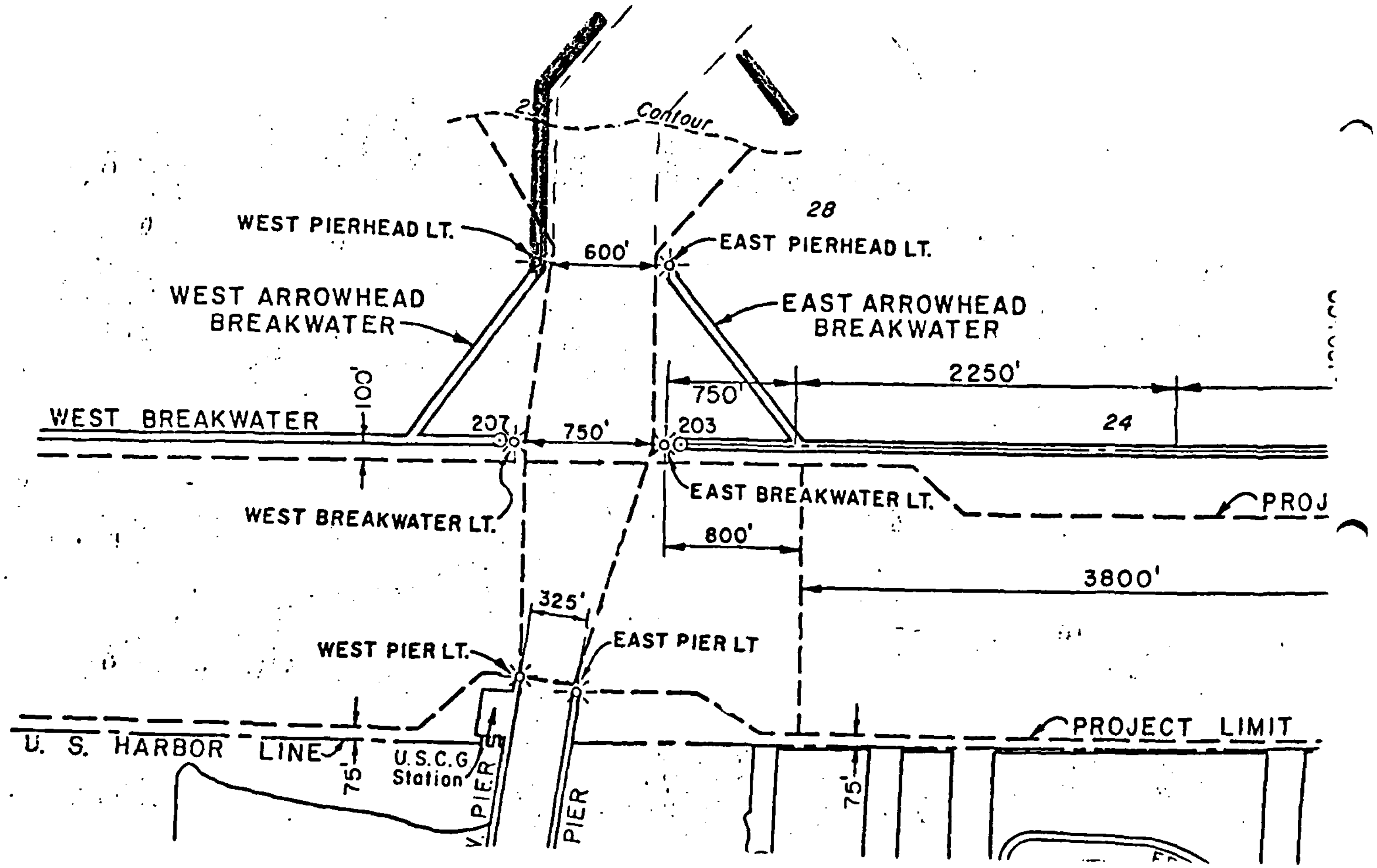
Name	Organization
Anthony Russo	Acting Director, Cleveland-Cuyahoga County Port Authority
Harry Gard	Chief Engineer, Cleveland-Cuyahoga County Port Authority
Captain Alton Hayves	American Steamship Company
Captain Vic Chamberlain	Hanna Mining Company
Captain Paul D. Lyon	American Steamship Company
Captain William McSweeney	Interlake Steamship Company
Captain Joseph J. Tereki	Columbia Transportation Company
Captain Vic Anderson	Lake Pilots Association, Inc.
Captain Edgar M. Jacobsen	Oglebay Norton
Admiral Paul E. Trimble	Lake Carriers Association
John Townley	Cleveland Cliffs Iron Company
John Horton	Cleveland Cliffs Iron Company
John D. Baker	ILA
Brian Bowser	City of Cleveland
John Zorich	Corps of Engineers, Buffalo District
Henry Gartner	Corps of Engineers, Buffalo District
Richard Gorecki	Corps of Engineers, Buffalo District
Mike Pelone	Corps of Engineers, Buffalo District
Robert Webster	Corps of Engineers, Buffalo District
Richard Aguglia	Corps of Engineers, Buffalo District
Charlie Johnson	Corps of Engineers, North Central Division

"All-Weather" West Entrance Concept No 1: Detached Arrowhead
(not to scale)



"All-Weather" West Entrance Concept No. 2 : Dogleg with Detached Breakwa
(not to scale)

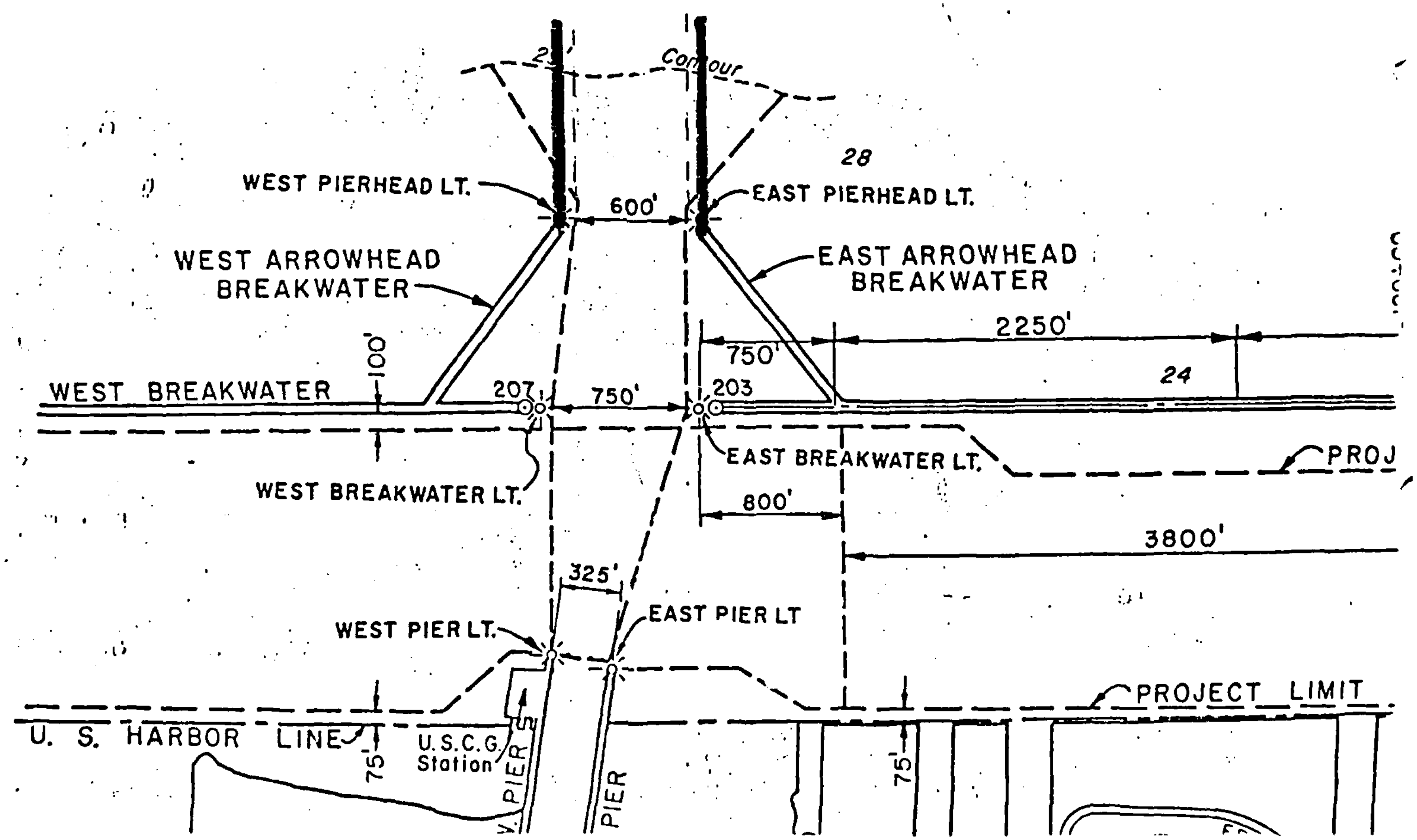
Encl 3



"All-Weather" West Entrance Concept No 3: Parallel Extension

(Not to scale)

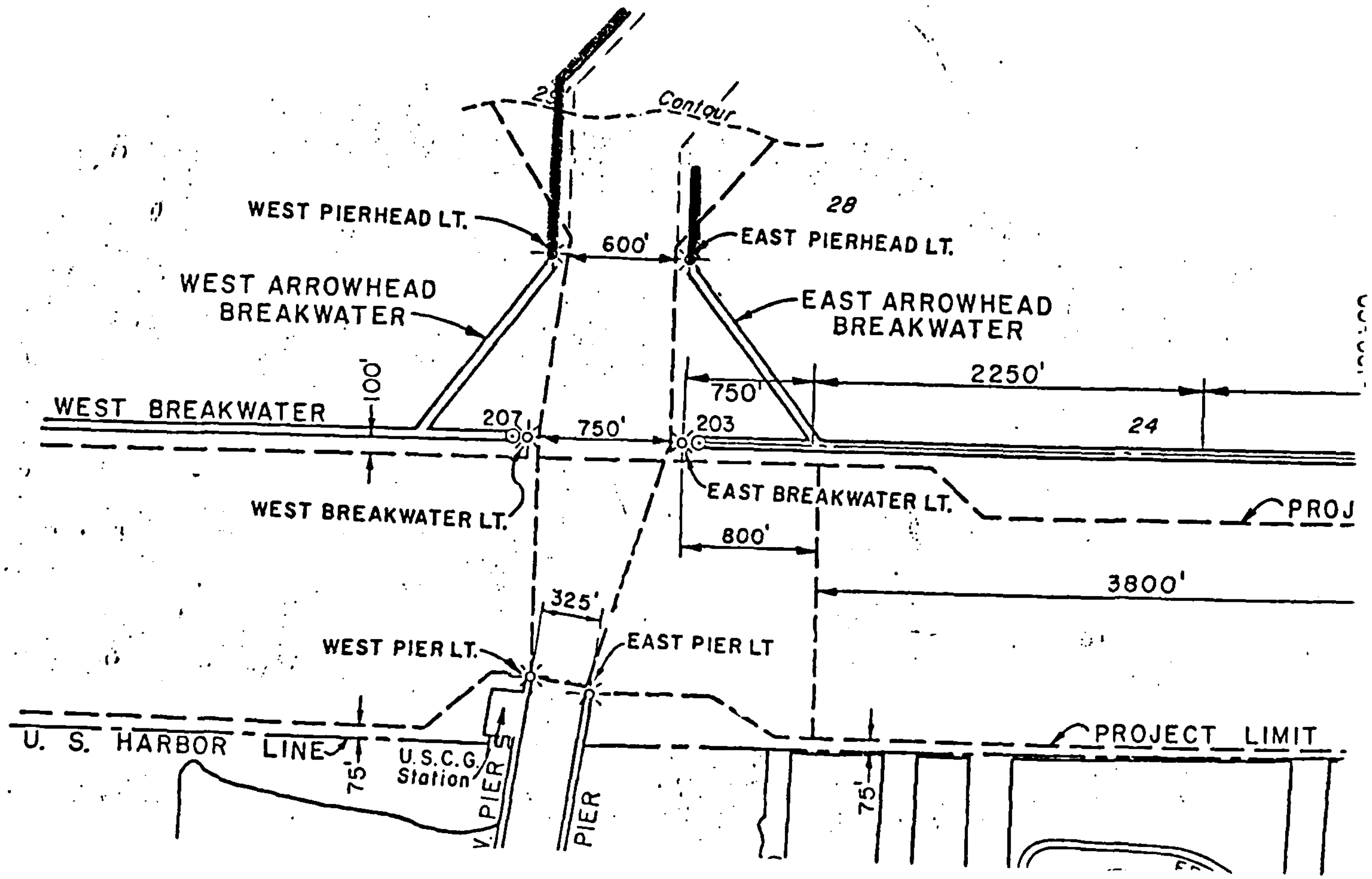
Incl 4



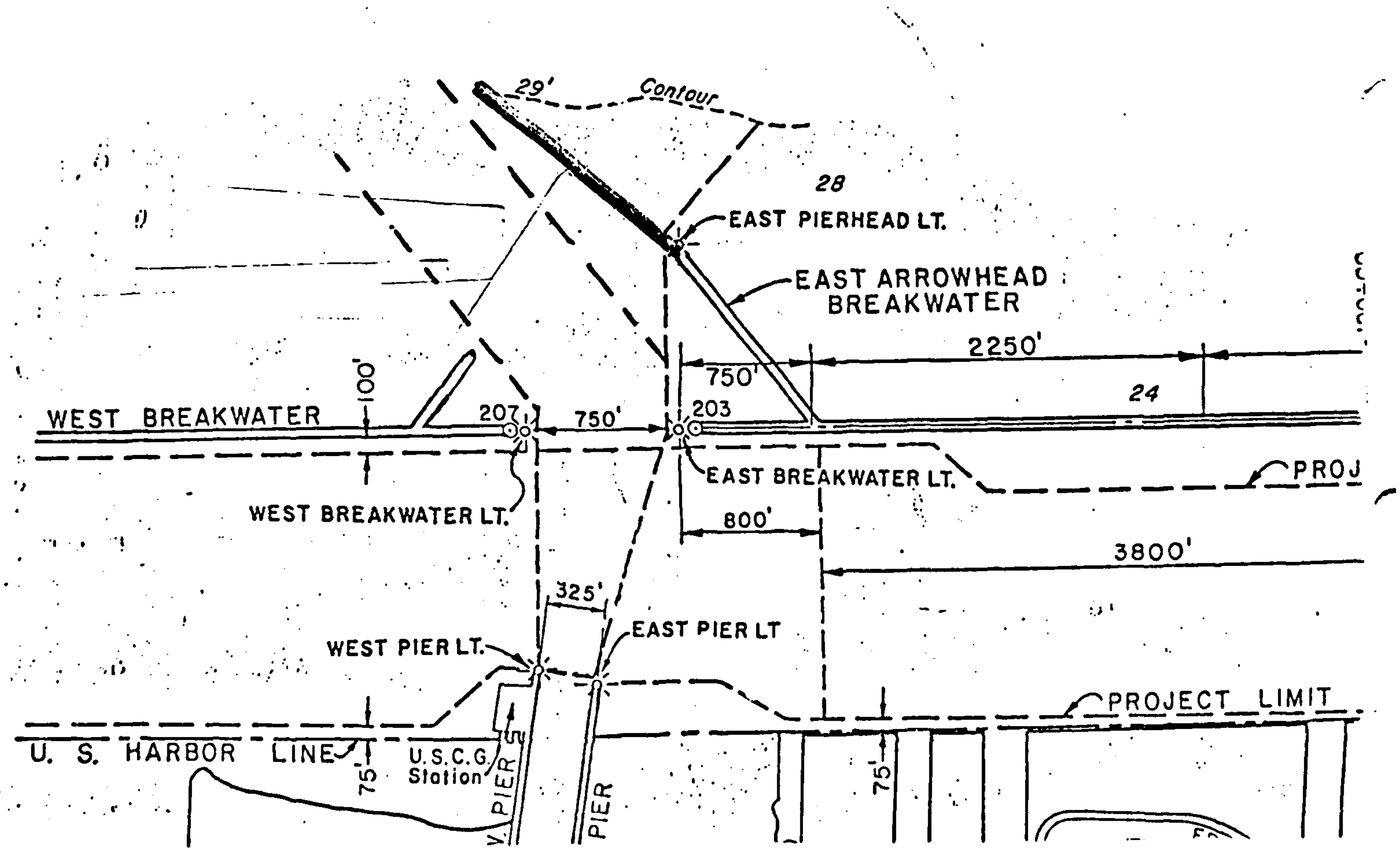
"All-weather" West Entrance Concept No. 4: Dogleg with Parallel Extension

(not to scale)

Encl 5

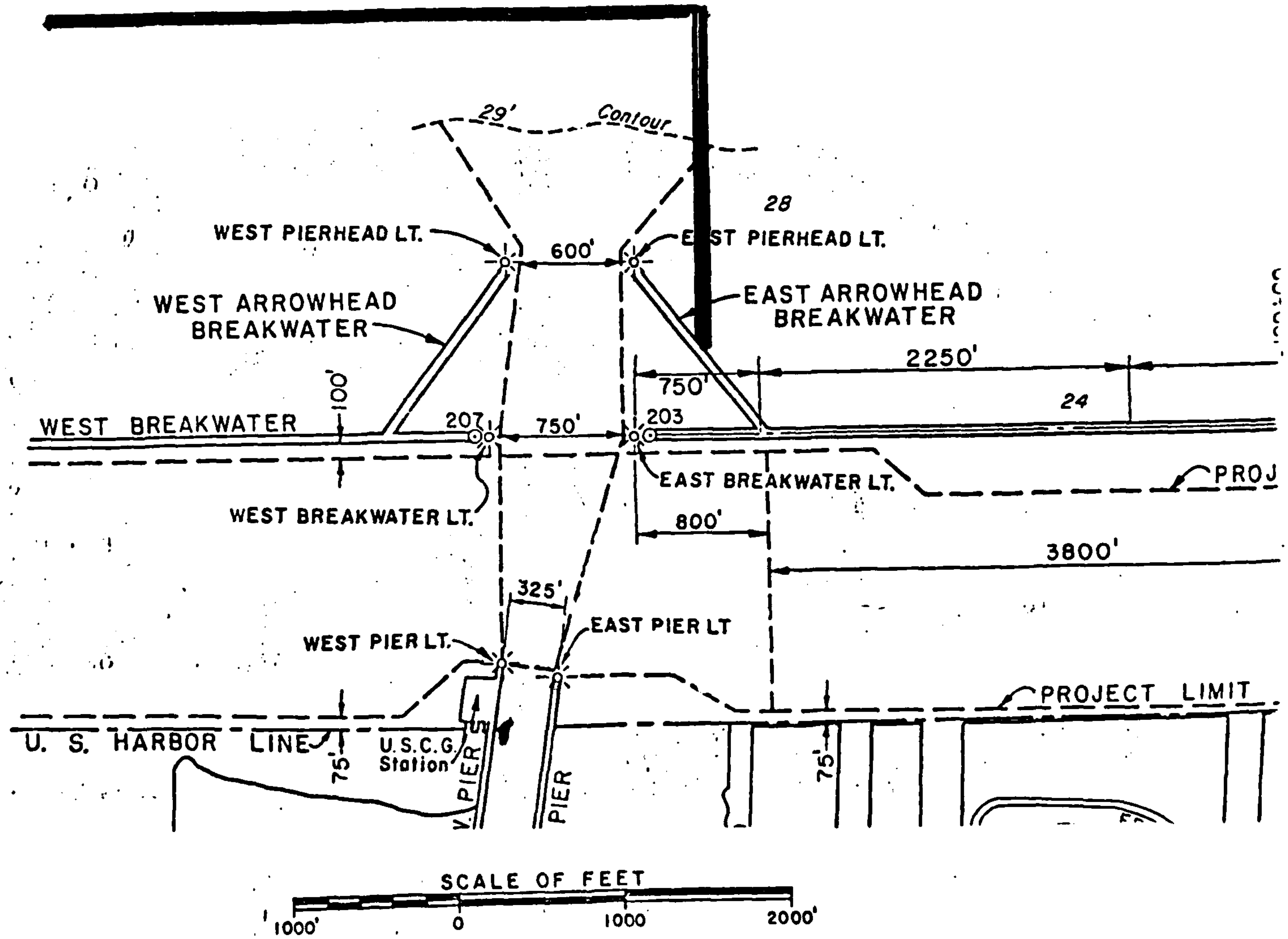


"All-Weather" West Entrance Concept No 5: East Arrowhead Breakwater Extension
(not to scale)



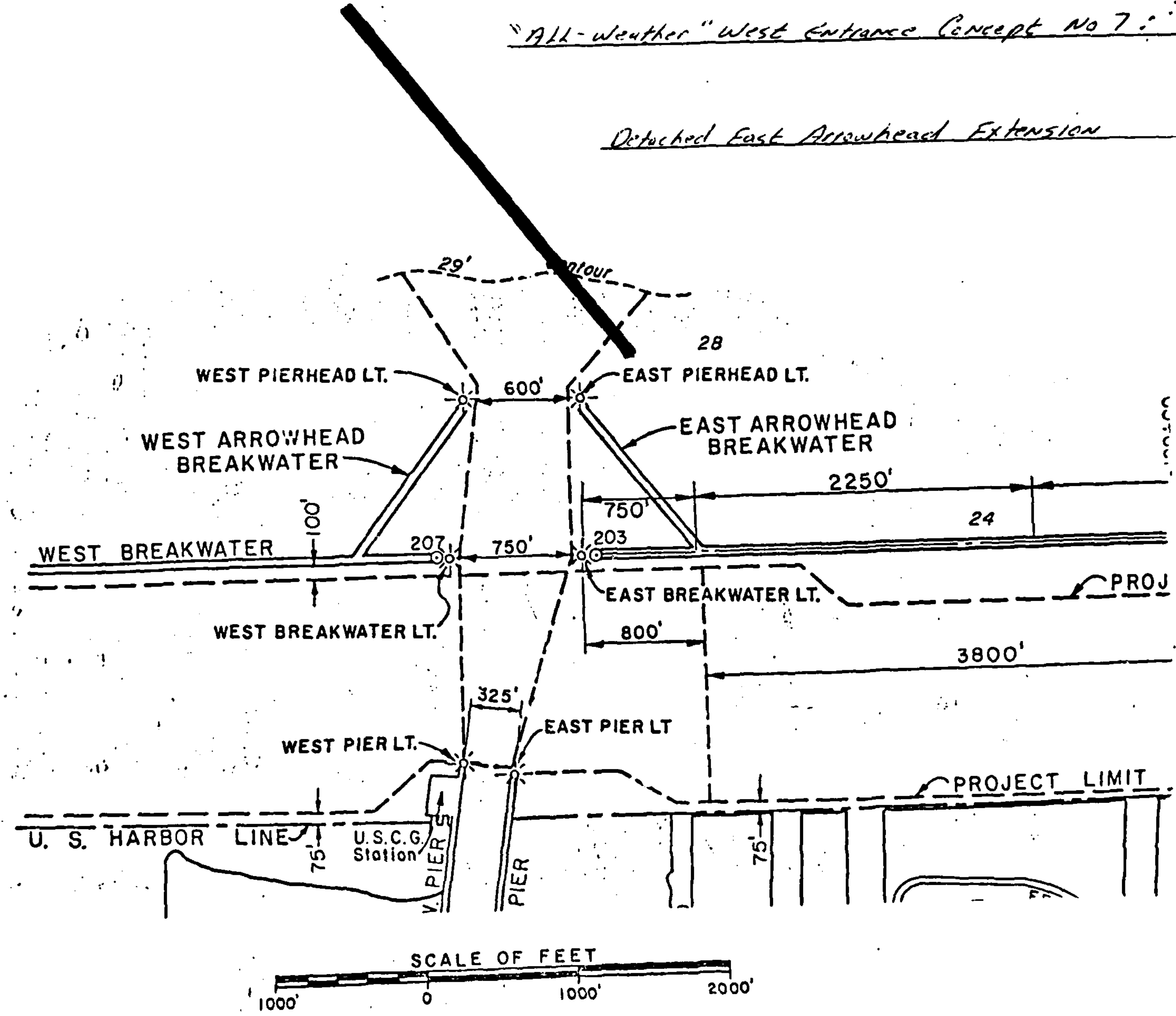
Encl 6

"All-Weather" West Entrance Concept No 6: "L" Shaped Breakwater



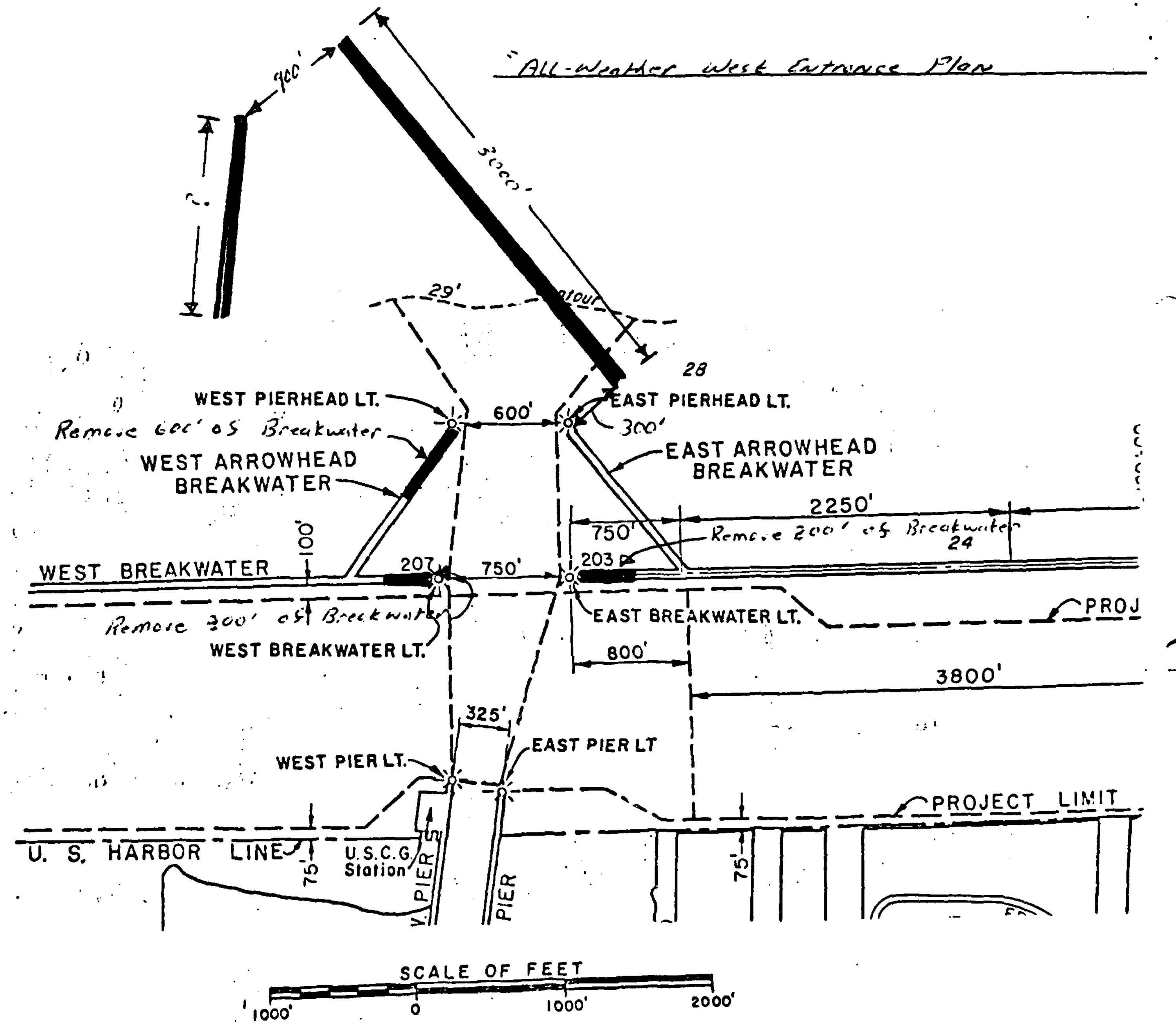
"All-weather" West Entrance Concept No 7:

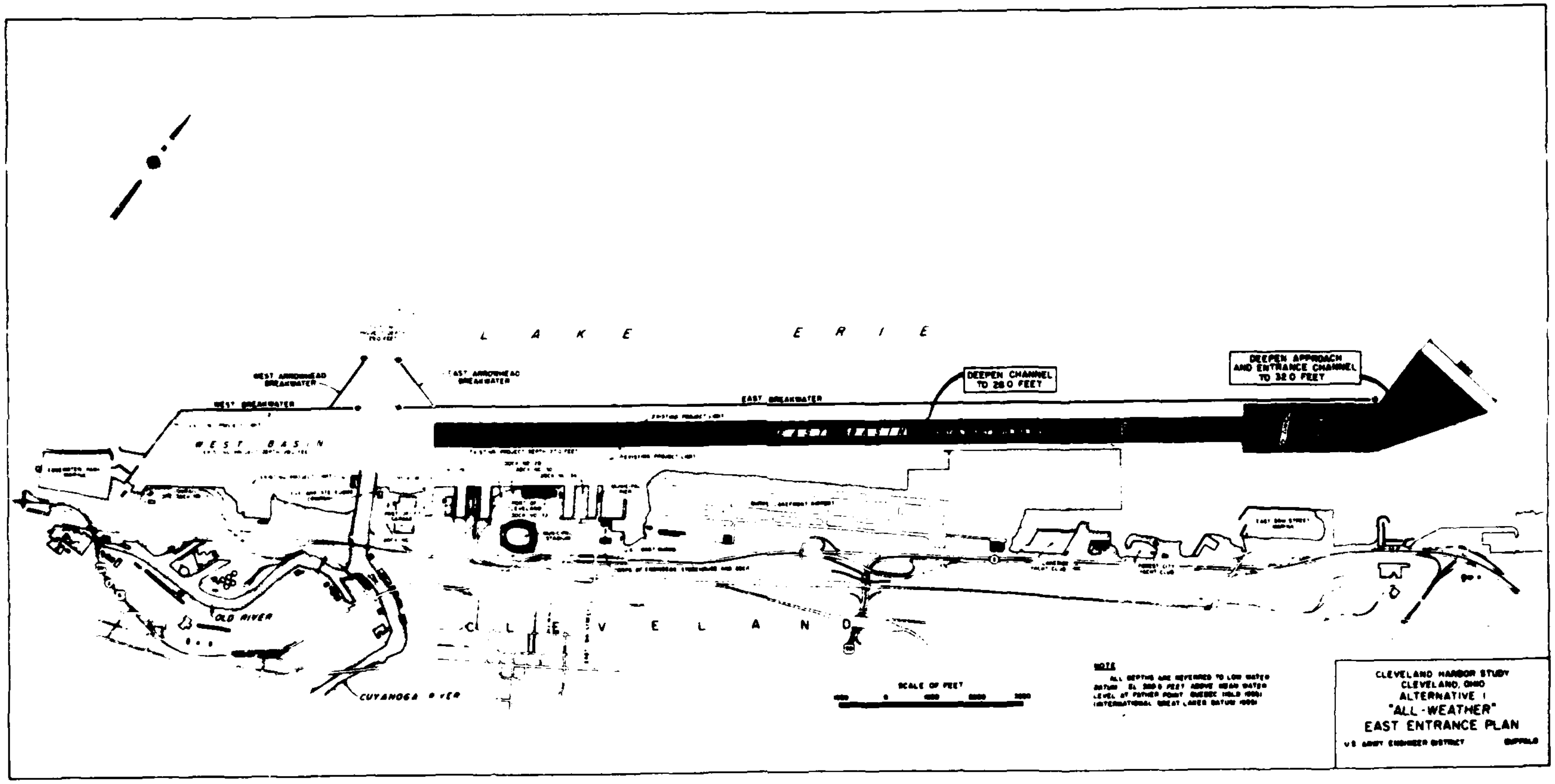
Detached East Arrowhead Extension



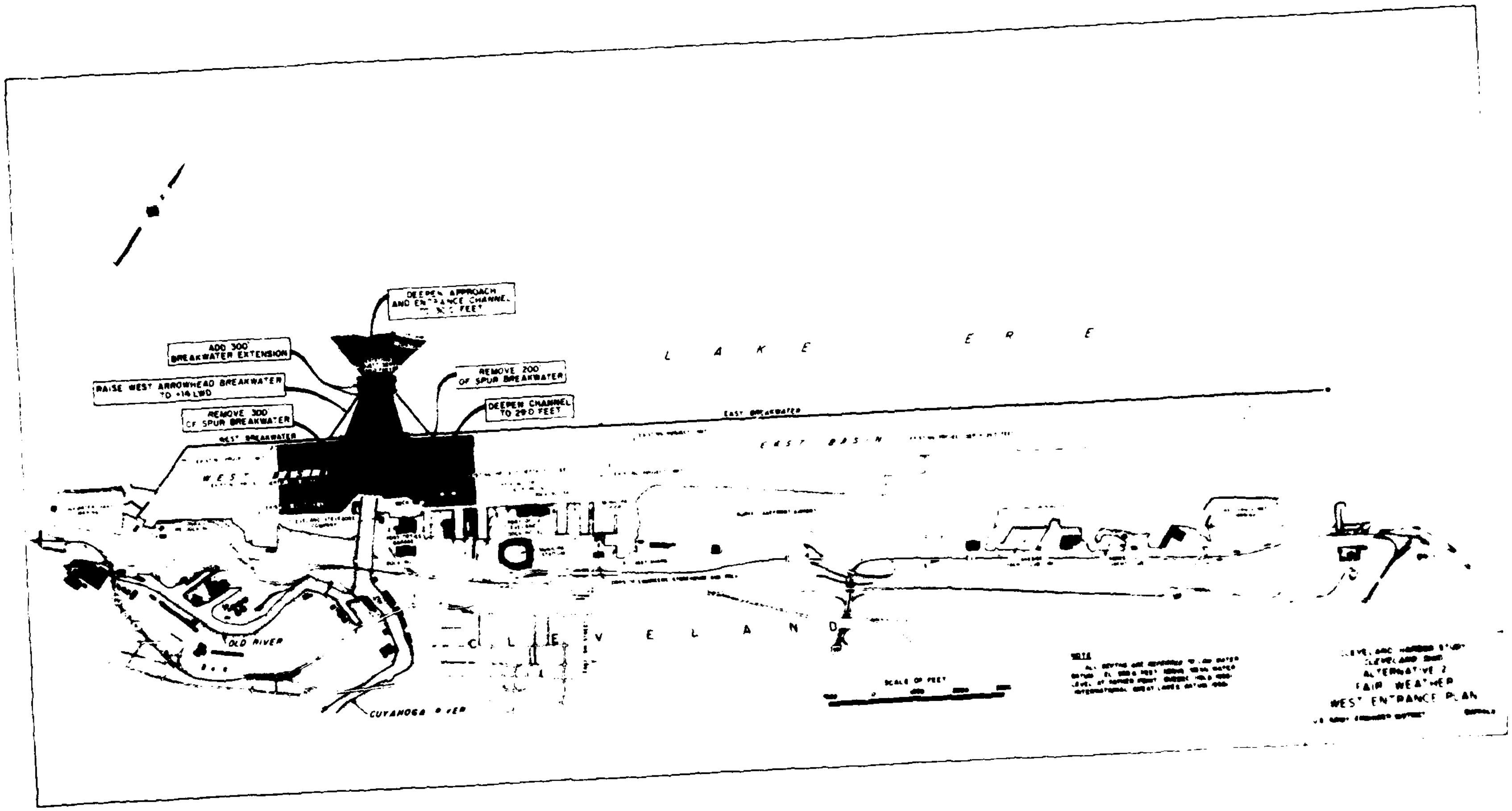
incl 8

"All-Weather West Entrance Plan




LAKE ERIE
WEST ARROWHEAD BREAKWATER
EAST ARROWHEAD BREAKWATER
WEST BREAKWATER
EAST BREAKWATER
WEST BASIN
DEEPEN CHANNEL TO 28.0 FEET
DEEPEN APPROACH AND ENTRANCE CHANNEL TO 32.0 FEET
CLEVELAND
OLD RIVER
CUYAHOGA RIVER
SCALE OF FEET
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE I
"ALL-WEATHER"
EAST ENTRANCE PLAN
U.S. ARMY ENGINEER DISTRICT BUFFALO

Incl. 2


DEEPEN APPROACH AND ENTRANCE CHANNEL
ADD 300' BREAKWATER EXTENSION
RAISE WEST ARROWHEAD BREAKWATER TO +14 LWD
REMOVE 300' OF SPUR BREAKWATER
REMOVE 200' OF SPUR BREAKWATER
DEEPEN CHANNEL TO 29.0 FEET
WEST BREAKWATER
EAST BREAKWATER
EAST BASIN
L A K E E R I E
C L E V E L A N D
OLD RIVER
CUYAHOGA RIVER
NOTE
SCALE OF FEET
ALTERNATIVE 2
FAIR WEATHER
WEST ENTRANCE PLAN

Incl 11

NCBPD-WB 5 January 1982

MEMORANDUM FOR RECORD

SUBJECT: Model Study Review Conference - Cleveland Harbor Study

1. On 29 and 30 October 1981 representatives of NCD, NCB, and the Cleveland Port Authority met with masters of 1,000-foot vessels at the Corps Waterways Experiment Station, Vicksburg, MS. The purpose of this meeting was to obtain input from these vessel masters to be used in the development of an "all-weather" West Entrance plan for safe and efficient operation of 1,000-foot vessels at Cleveland Harbor. (NOTE: "All-weather" conditions are defined as a maximum 30-knot wind and 8-foot wave.) The following people were in attendance:

Captain William McSweeney	- NCB	Chuck Gilbert	- NCB
Captain Al Haynes	- American Steamship Company	Denton Clark	- NCB
		John Zorich	- NCB
Captain Vic Chamberlain	- Hanna Mining Co.	Dick Aguglia	- NCB
Gene Chatham	- WES	Larry Hiipakka	- NCD
Ray Bottin	- WES		
Harry Gard	- Cleveland-Cuyahoga County Port Authority		

2. Gene Chatham opened the conference on 29 October by welcoming all participants and stated that the purpose of the conference was to obtain input from the vessel masters to be used in developing an "all-weather" West Entrance plan for safe and efficient operation of 1,000-foot vessels at Cleveland Harbor. Gene then turned the meeting over to Ray Bottin.

3. Ray presented a short movie which illustrated the proposed "fair-weather" West Entrance plan (see Incl 1) that was previously presented at the 8 April 1981 Vessel Masters' Workshop. (NOTE: "Fair-weather" conditions are defined as a maximum 20-knot wind and 4-foot wave). Components of the "fair-weather" West Entrance plan included the following:

a. Removal of 300 feet of the west spur breakwater and 200 feet of the east spur breakwater; and

b. Compensating works to maintain existing wave conditions inside the Lakefront Harbor with the spur breakwaters removed.

4. Ray then presented a slide show illustrating the evolution of the proposed "all-weather" West Entrance plan, from the plan originally developed at the 8 April 1981 Vessel Masters' Workshop (Incl 2), to the plan currently installed in the Cleveland Harbor model (Incl 3). This plan (Incl 3) was the plan the vessel masters had been running navigation tests on with the scale model of a 1,000-foot vessel. Ray also stated that modifications to the

originally proposed plan (Incl 2) were required in order to meet the design criteria previously established (ie., maximum wave height of 3 feet in the entrance channel under "all-weather" design conditions and no increase in wave activity above existing conditions in the Lakefront Harbor).

5. Dick Aguglia then led a general discussion on the "all-weather" West Entrance plan currently installed in the model (Incl 3). Main points of this discussion are as follows:

a. Although navigation tests have not been run with wind and waves from the north, the vessel masters feel that this plan (Incl 3) is about the best that can be accomplished at the West Entrance. They are unanimous, however, in their preference for an "all-weather" East Entrance plan (see Incl 4) for 1,000-foot vessels and feel it is far superior to any West Entrance plan. With an East Entrance plan, masters would be able to enter Cleveland Harbor under adverse weather conditions with sufficient speed to maintain control of their vessel and still have adequate room to reduce their speed once they were in protected water.

b. Captain Haynes stated that he thinks the waves that are acting against the model ship are being amplified more than in real life. It was postulated that this was because the waves being generated in the model are monochromatic and do not have the same dampening effect when they are reflected off the side of the ship as real life waves, which have different periods and wave heights. It was decided to run a few navigation tests with a 6-foot wave, in addition to an 8-foot wave, to see if this produced a force on the ship that would be closer to that generated by an 8-foot wave in real life. However, it was also noted that this difference was not a critical factor in developing an "all-weather" plan.

c. Captain Haynes also stated that the maximum 8-foot wave criteria established for "all-weather" conditions at the 8 April 1981 Vessel Masters' Workshop meeting may have referred to the wave height as it struck the side of the ship and not the incident wave height. However, it was decided to continue to use the 8-foot incident wave criteria for "all-weather" conditions.

6. Following this discussion, Chuck Gilbert asked the vessel masters if there was a need for a harbor-of-refuge on Lake Erie. The concensus of the vessel masters was that a harbor-of-refuge was not needed since vessels could hug Pelee Island or the north shore of Lake Erie during storms and then proceed into harbor when the weather moderated.

7. Dick Aguglia asked the vessel masters if they thought it would be worthwhile to model the proposed "all-weather" East Entrance plan (see Incl 4) and run ship navigation tests. The purpose of these tests would be to refine the dimensions of the fan-shaped approach and entrance channels. The masters agreed that model testing would be worthwhile, especially since it may be a good idea to widen the approach and entrance channels. This additional widening would give the vessel masters more leeway in making their turn into

the East Basin during rough weather. WES will provide the District with a time and cost estimate for conducting model tests on the East Entrance. (NOTE: Estimate received 24 November 1981.) All participants agreed, however, that the present configuration of the "all-weather" East Entrance plan was sufficient for comparison purposes with the West Entrance plan presently under consideration, since the added cost of any changes would be minor in comparison to the total cost of the plan.

8. Harry Gard asked if it would be possible to test modifications to the east breakwater with a view towards reducing wave action along the Port Authority's docks in the Lakefront Harbor. Dick Aguglia replied that this type of testing could be done, however, Federal participation in any improvement to the east breakwater would not be feasible because of lack of economic justification. (NOTE: Past discussions with the Port Authority indicated that, although existing wave activity in the Lakefront Harbor is high, it does not significantly hinder their operations and thus little or no benefit would be gained by improving the east breakwater.) Harry Gard replied that he understood this, but felt it would still be worthwhile for the Port Authority to have plans to improve the east breakwater "on-the-shelf" in the event that funds became available to the Port Authority for this type of work. Harry also stated that he would send a letter to the District requesting that we do this testing for the Port Authority and the design criteria they would like to meet.

9. Following lunch, the meeting reconvened at the Cleveland Harbor model where the vessel masters ran navigation tests with the "all-weather" West Entrance plan installed (see Incl 3). Weather conditions for these tests were 30-knot winds and 8-foot incident waves from the north-northeast initially, with the incident wave being reduced to 6 feet later on in the afternoon. While conducting the navigation tests, it was obvious that the vessel masters were having trouble making the turn into the arrowhead entrance. It appeared that the main problem was the wind acting on the stern cabin which tended to force the stern of the vessel in the opposite direction of the turn they were trying to make (ie., the vessel was being pushed counterclockwise by the wind when the required turn into the arrowhead entrance was clockwise). In order to neutralize the effect of the wind, the vessel would have to carry too much speed to safely make the turn into the arrowhead entrance. In addition, the vessel masters stated that with this type of plan, once they started the initial turn into the entrance, they were totally committed and would have a difficult time backing out if problems arose. It was, therefore, decided to test a different type of "all-weather" plan composed of the following (see Incl 5);

a. two 1,000-foot long parallel piers (crest elevation +8 LWD) 600 feet apart, extending out from the existing east and west arrowhead breakwaters;

b. removal of 300 feet of the west spur breakwater and 200 feet of the east spur breakwater; and

NCBPD-WB
SUBJECT: Model Study Review Conference - Cleveland Harbor Study

c. any additional compensating works required to maintain existing wave conditions inside the Lakefront Harbor with the spur breakwaters removed.

The meeting then adjourned for the remainder of the day while WES personnel installed the new plan (Incl 5) in the model.

10. The meeting reconvened at the model the following morning (30 Oct) and the vessel masters ran navigation tests with the new parallel pier "all-weather" plan installed (Incl 5). Weather conditions for these tests were 30-knot winds and 8-foot waves from the west, which were considered to be the most difficult conditions for entering the harbor with this type of plan. The vessel masters were unanimous in their preference for this plan over the plan previously installed (Incl 3). Features of this plan that made it preferable were that vessels were not required to make a turn before entering the protected Lakefront Harbor and vessels would have the option of backing out and making a second entrance approach if problems developed during their initial run. In addition, the parallel-pier plan would be considerably cheaper to construct than the previous "all-weather" plan (Incl 3) since the length of new breakwater required would be about 40 percent of the previous plan (2,000 feet of new breakwater required vs 5,000 feet). Therefore, it was decided that the parallel-pier plan would be refined and carried foward as the preferred "all-weather" West Entrance plan. Refinement of this plan would be limited to model tests to determine if there would be an increase in wave activity in the Lakefront Harbor as a result of the spur breakwater removal and, if so, what type of compensating works would be required to reduce it down to existing conditions.

11. Following lunch, the meeting reconvened in the conference room where Gene Chatman summarized the results of the meeting and thanked everyone for their participation. The meeting then adjourned at 1:30 p.m.

(NOTE: Following the meeting, Captain McSweeney stated that 1,000-foot vessels could probably use the existing arrowhead entrance when leaving the harbor if the weather was not too rough. In that case,they could use the existing east entrance with light ballast. Captain McSweeney also stated that he once used the east entrance during rough weather to enter Cleveland Harbor in a 1,000-foot vessel, however, that was only possible because he was light loaded.)

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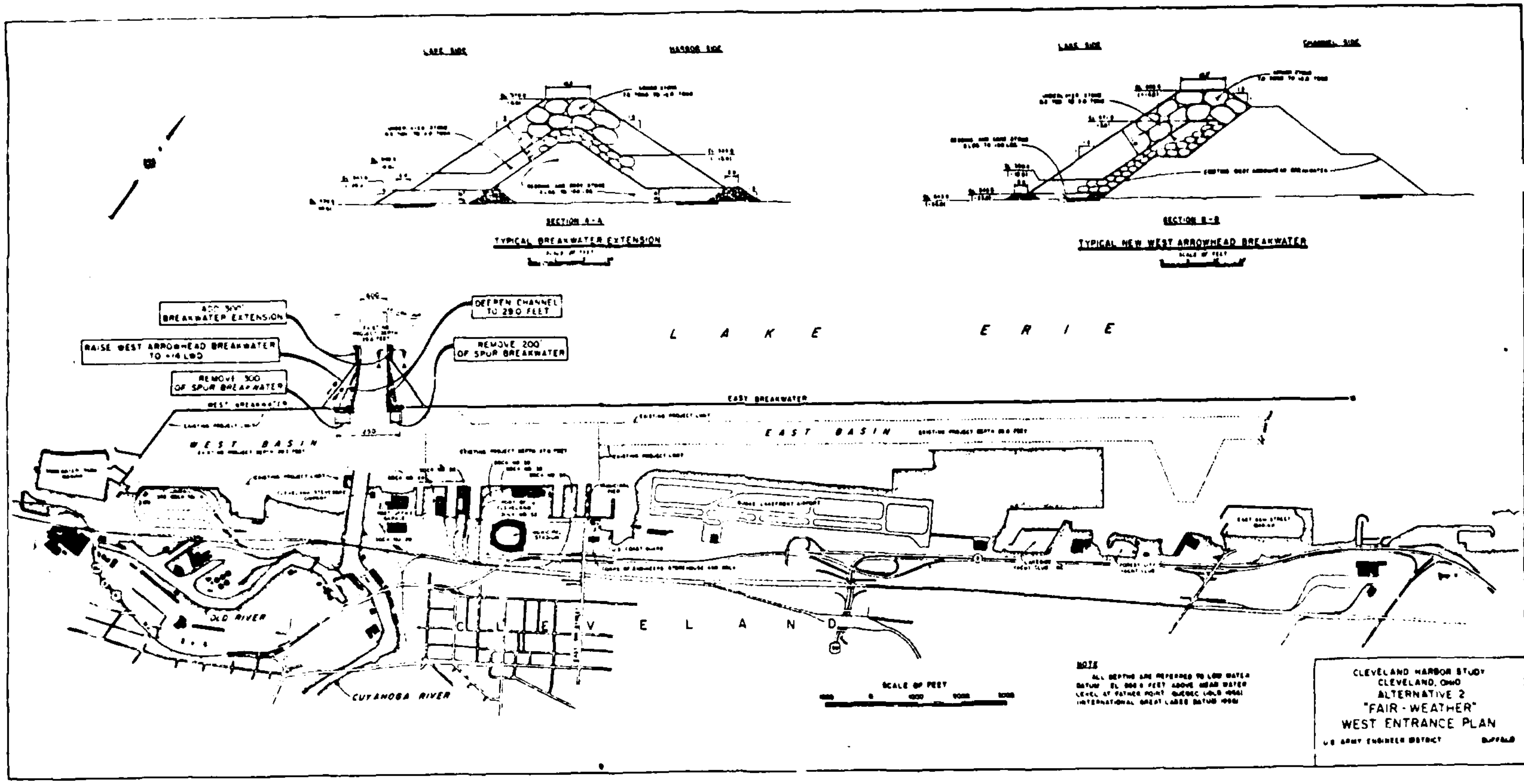
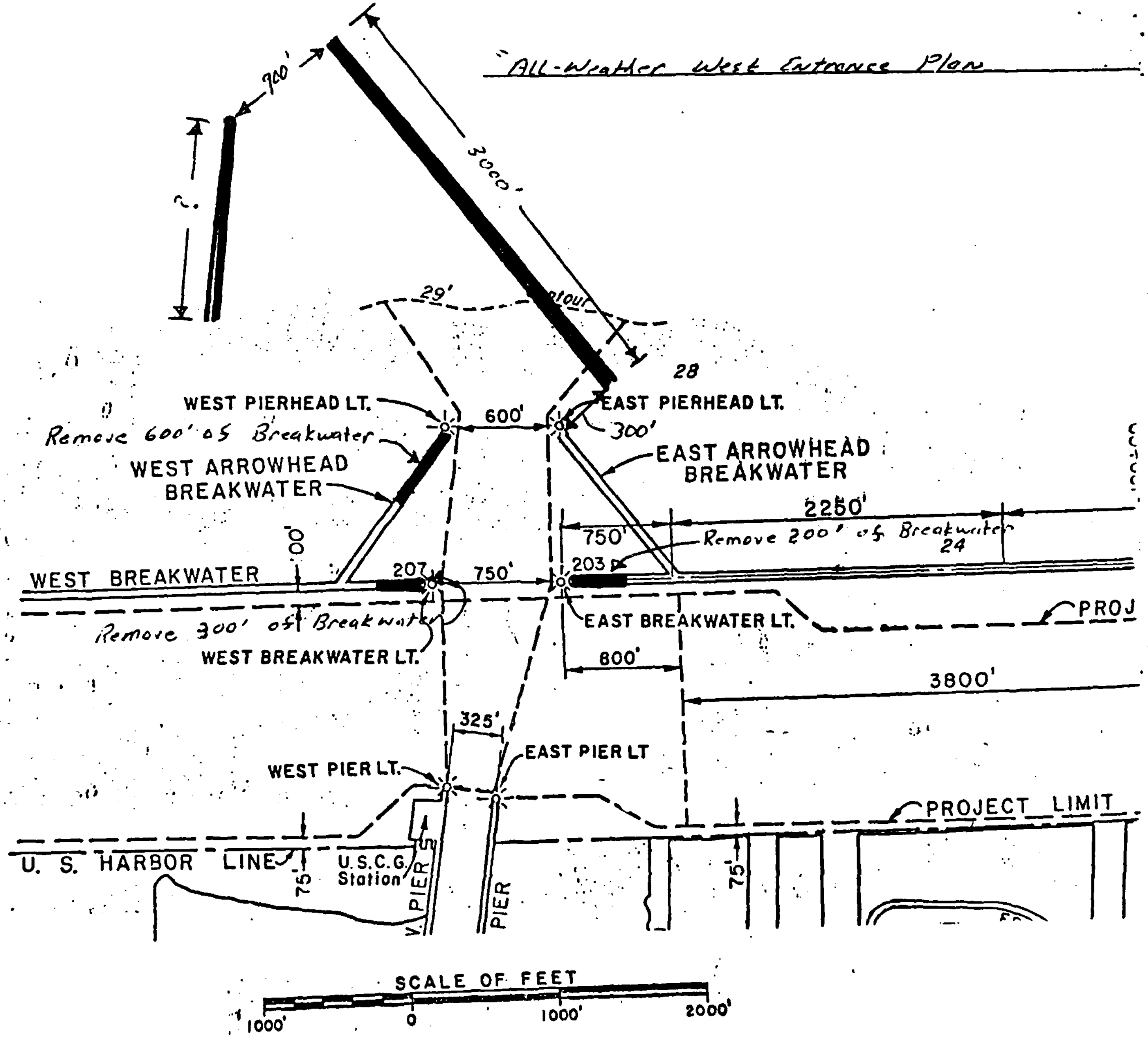
RICHARD AGUGLIA
Project Manager

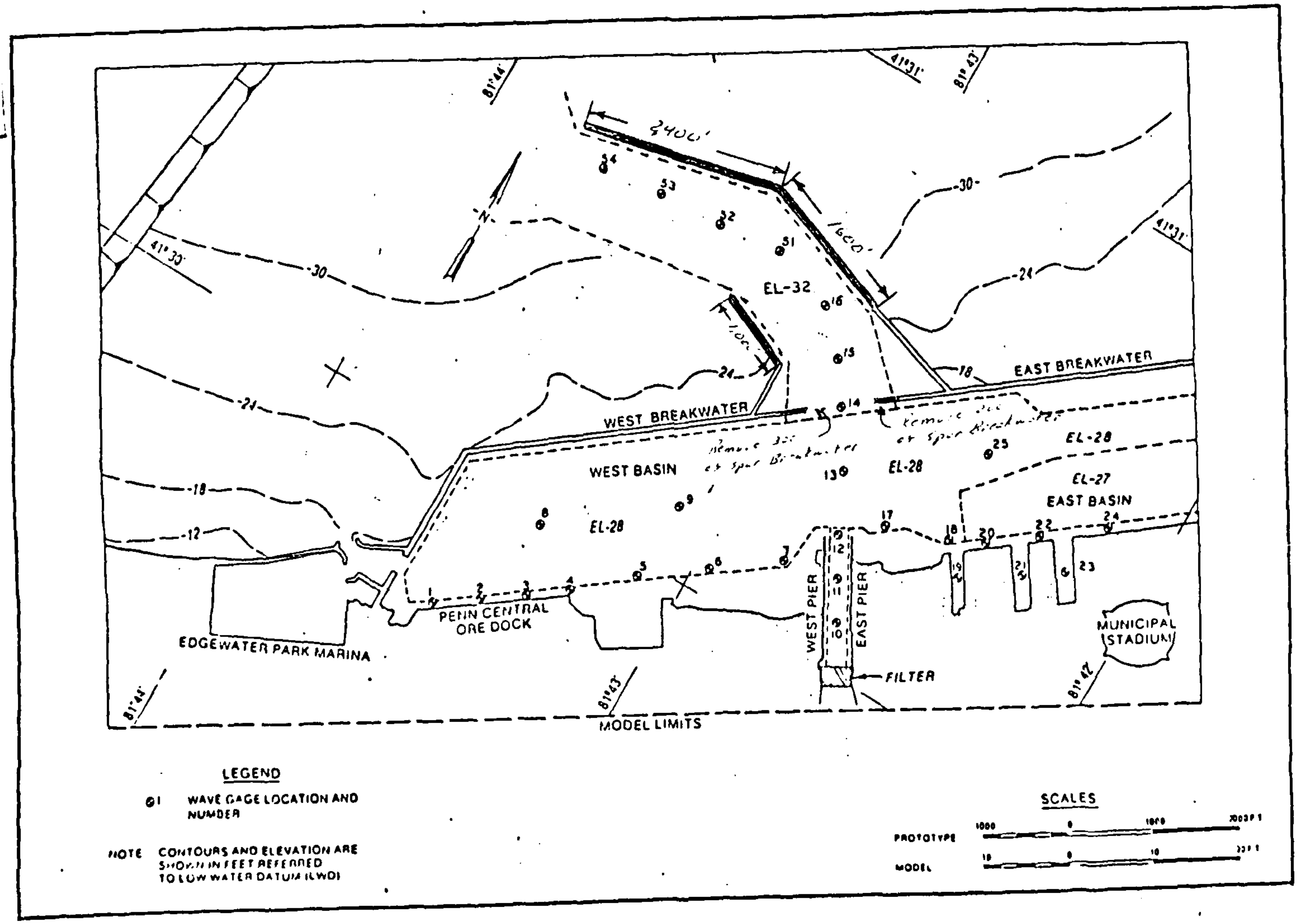

LAKE SIDE
HARBOR SIDE
SECTION A-A
TYPICAL BREAKWATER EXTENSION
LAKE SIDE
CHANNEL SIDE
SECTION B-B
TYPICAL NEW WEST ARROWHEAD BREAKWATER
400-500' BREAKWATER EXTENSION
RAISE WEST ARROWHEAD BREAKWATER TO +14 LWD
REMOVE 300' OF SPUR BREAKWATER
DEEPEN CHANNEL TO 29.0 FEET
REMOVE 200' OF SPUR BREAKWATER
L A K E E R I E
EAST BREAKWATER
WEST BREAKWATER
WEST BASIN
EAST BASIN
OLD RIVER
CUYAHOGA RIVER
C L E V E L A N D
SCALE OF FEET
NOTE
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 2
"FAIR-WEATHER"
WEST ENTRANCE PLAN
U.S. ARMY ENGINEER DISTRICT
BUFFALO

Incl 1

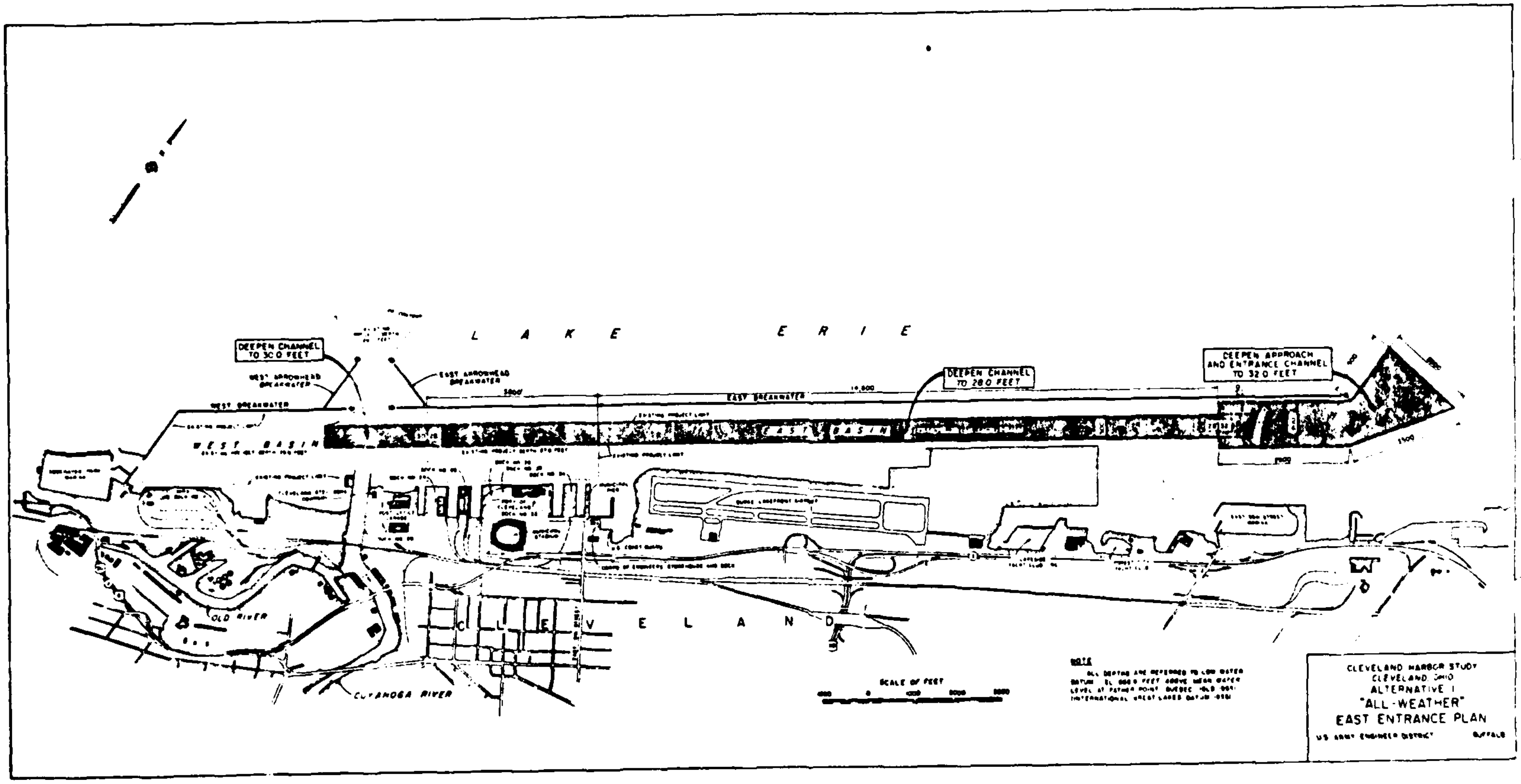
"All-Weather West Entrance Plan

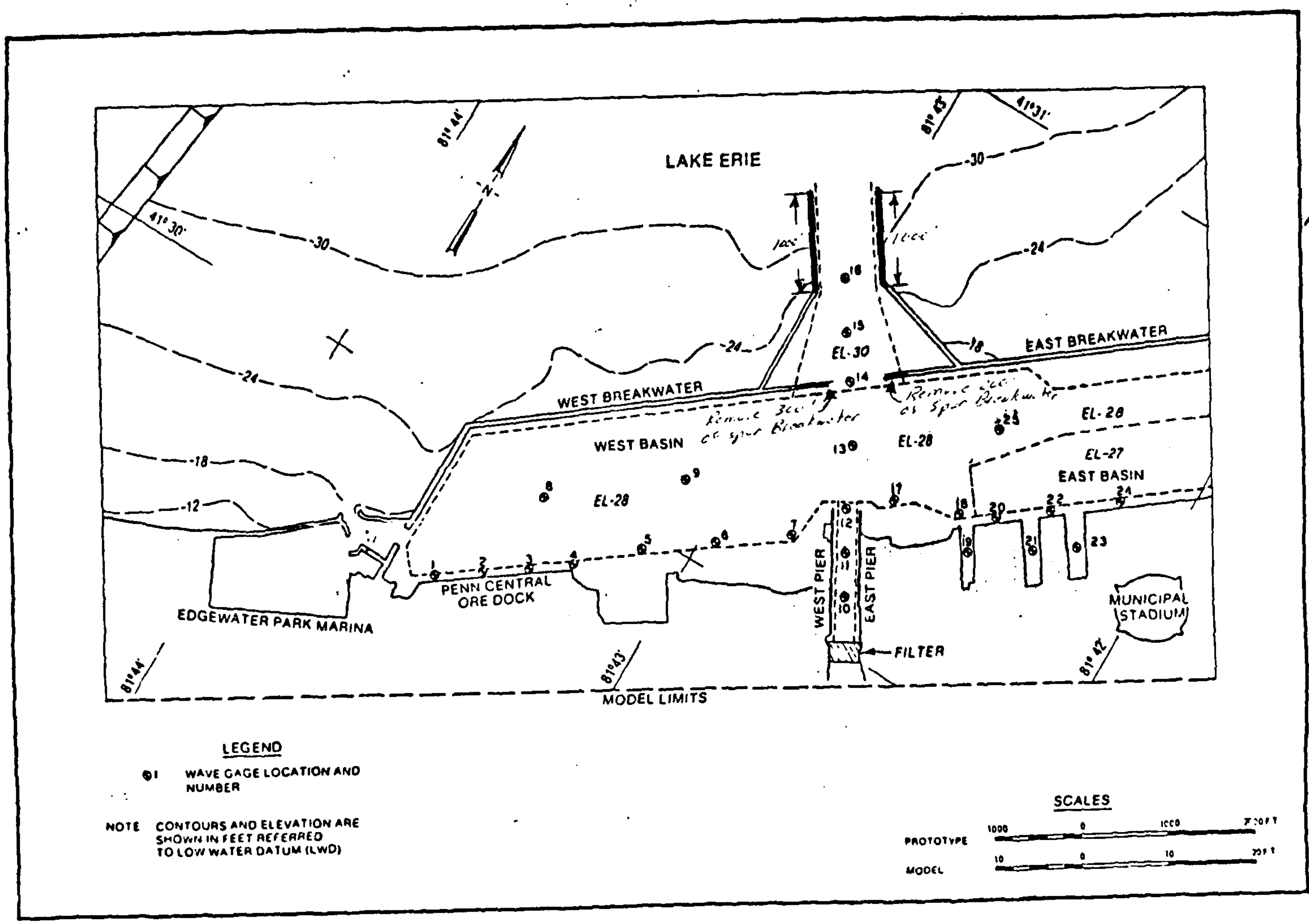


Incl 2



EAST BREAKWATER
WEST BREAKWATER
WEST BASIN
EAST BASIN
EL-32
EL-28
EL-27
2400'
1600'
PENN CENTRAL ORE DOCK
EDGEWATER PARK MARINA
WEST PIER
EAST PIER
FILTER
MUNICIPAL STADIUM
MODEL LIMITS
LEGEND
WAVE GAGE LOCATION AND NUMBER
NOTE CONTOURS AND ELEVATION ARE SHOWN IN FEET REFERRED TO LOW WATER DATUM (LWD)
SCALES
PROTOTYPE
MODEL


LAKE ERIE
DEEPEN CHANNEL TO 30.0 FEET
WEST ARROWHEAD BREAKWATER
EAST ARROWHEAD BREAKWATER
WEST BREAKWATER
EAST BREAKWATER
WEST BASIN
EAST BASIN
DEEPEN CHANNEL TO 28.0 FEET
DEEPEN APPROACH AND ENTRANCE CHANNEL TO 32.0 FEET
OLD RIVER
CUYAHOGA RIVER
CLEVELAND
SCALE OF FEET
NOTE
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE I
"ALL-WEATHER"
EAST ENTRANCE PLAN
U.S. ARMY ENGINEER DISTRICT BUFFALO


LAKE ERIE
WEST BREAKWATER
EAST BREAKWATER
WEST BASIN
EAST BASIN
EL-30
EL-28
EL-27
PENN CENTRAL
ORE DOCK
EDGEWATER PARK MARINA
WEST PIER
EAST PIER
FILTER
MUNICIPAL STADIUM
MODEL LIMITS
41° 30'
41°31'
81° 44'
81°43'
81°42'
-30
-24
-18
-12
LEGEND
WAVE GAGE LOCATION AND NUMBER
NOTE CONTOURS AND ELEVATION ARE SHOWN IN FEET REFERRED TO LOW WATER DATUM (LWD)
SCALES
PROTOTYPE
MODEL

Incl 5

DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

REFERENCE OR OFFICE SYMBOL	SUBJECT
NCBPD-WB	Cleveland Harbor Study - Summary Minutes of 16 Feb. 1982 Meeting with Ontario Stone Corporation

TO PROJECT FILES FROM R. Aguglia DATE 18 February 1982 CMT 1

1. On 16 February 1982, Mr. Carl Barcelli, President, Ontario Stone Corporation, visited the Buffalo District Office. The purpose of this visit was to review the authorized, but uncompleted improvements on the Old River. These improvements include: 1.) bank cuts 12 - 15; 2.) replacement of the B&O Railroad Bridge at the mouth of the Old River; and 3.) deepening the navigation channel to 28-feet below LWD. Persons in attendance were as follows:

Bob Johnson - NCBED-DD	Dick Aguglia - NCBPD-WB
Roger Haberly - NCBPD-EC	Carl Borcelli - Ontario Stone Corporation

2. Mr. Aguglia opened the meeting by reviewing the authorized improvements on the Old River. Mr. Aguglia then stated that, because of the recent closing of the Erie Ore Dock, there does not appear to be sufficient potential transportation benefits available to justify these improvements. Since Ontario Stone Corporation recently purchased the Erie Ore Dock, the Buffalo District would like to review Ontario Stone Corp's future plans for this facility. Mr. Barcelli replied with the following:

a.) Ontario Stone will be reopening the dock this year. They presently have commitments to receive 60,000 tons of coal for use in the Cleveland area and to receive 50,000-60,000 tons of steel scrap for local consumption.

b.) Current improvement plans for the dock include: (1) renovating the three brick buildings on the property; (2) installing a truck scale; (3) removing the 3 existing Hulett unloaders; and (4) replacing 450 feet of damaged timber bulkhead with steel sheet pile bulkhead.

c.) Ontario Stone has received an inquiry for exporting approximately 2,000,000 tons of coal from the Erie Ore Dock. Coal would be received at the dock by rail car and loaded out in 650-foot vessels. Since they are in the preliminary stages of discussion, however, no definite commitment for this activity can be made at the present time.

d.) If the authorized improvements on the Old River are completed, Ontario Stone would tranfer their stone receipts (1,000,000 tons per year) from their Cuyahoga River dock to the Old River. In addition, they would increase the size of the vessels used in this traffic from 630-foot vessels (maximum vessel that can transit the Cuyahoga River) to 730 foot vessels. Stone would continue to be delivered to their customers by truck after receipt at the dock. They would also use a 730-foot vessel for the export of coal, if this potential new business becomes a reality.

e.) Mr. Barcelli does not know at the present time whether or not he would build the 40-foot docking area proposed in the authorized improvements. He will make his decision on this aspect just prior to construction of the authorized improvements.

f.) Mr. Barcelli stated that the B&O makes two trips per day over their bridge at the mouth of the Cuyahoga River.

Exhibit G-4

NCBPD-WB
SUBJECT: Cleveland Harbor Study - Summary Minutes of 16 February 1982 Meeting with Ontario Stone Corporation

3. Mr. Barcelli also stated that the Conrail Bridge at the mouth of the Cuyahoga River and the Willow Avenue Bridge on the Old River do not provide adequate vertical clearance for 730-foot vessels when they are in ballast (Note: Both vertical lift bridges provide 98 feet of vertical clearance at LWD when in the up position). The Buffalo District will look into this potential problem further.

4. The meeting then adjourned at 10:00 a.m.

RICHARD AGUGLIA
Project Manager

CLEVELAND HARBOR STUDY
SUMMARY MINUTES OF 4 MAY 1982 WORKSHOP MEETING
CLEVELAND-CUYAHOGA COUNTY PORT AUTHORITY OFFICE
CLEVELAND, OHIO

1. A workshop meeting was held on 4 May 1982 at the Cleveland Port Authority's office. The purposes of this meeting were to review the commercial navigation alternatives developed during Stage 2 planning (Development of Preliminary Plans) for the Cleveland Harbor Phase I GDM study and to select the most feasible plans(s) to be carried forward into Stage 3 planning (Development of Detailed Plans). The names of those persons in attendance are shown on Inclosure 1. The meeting agenda is shown on Inclosure 2.

2. Mr. Charles Gilbert opened the meeting at 9:00 a.m. by welcoming all meeting participants and reviewing the purposes of the meeting. Following introduction of the meeting participants, Mr. Gilbert then stated that the current schedule for the Cleveland Harbor study calls for submission of the Stage 2 Report to North Central Division (NCD) in July, 1982 with the report being released to the public in October 1982. The submission of the Final Report to NCD is scheduled for July 1984. NCD will then submit the Final Report to the Board of Engineers for Rivers and Harbors for final review and coordination. Following this final review and coordination, the report will be submitted to Congress for construction authorization. Mr. Gilbert also discussed the President's proposed new cost-sharing legislation for commercial navigation projects currently before Congress. This proposed legislation calls for complete recovery of all costs of the Federal Government for commercial navigation projects authorized for construction after 1 October 1981 and for operation and maintenance costs after 1 October 1982.
Mr. Gilbert stressed that this new cost-sharing proposal should be kept in mind when selecting plans to be carried forward into Stage 3 planning.
Mr. Gilbert then turned the meeting over to Mr. Richard Aguglia.

3. Mr. Aguglia stated that Buffalo District developed four sets of plans to improve commercial navigation at Cleveland Harbor: (1) plans to improve the Lakefront Harbor for safe and efficient operation of 1,000-foot vessels; (2) a reevaluation of authorized but uncompleted improvements to the Old River navigation channel in light of current conditions; (3) plans to deepen the Cuyahoga River navigation channel; and (4) plans to reduce congestion on the Cuyahoga River navigation channel. Mr. Aguglia then stated that he would be discussing these plans in sets as shown on the agenda. For each set, he would first review each of the plans formulated, including their costs and benefits, followed by the District's tentative recommendation on which plan(s) to carry forward into Stage 3 planning. The meeting would then be opened for general discussion to answer any questions on the plans and to select the final plan(s) to be carried forward into Stage 3 planning.

4. Mr. Aguglia then reviewed the Lakefront Harbor Improvement Plans (Plans 1-4). A description of these plans, including their costs and benefits, is provided in Inclosure 3. Mr. Aguglia also stated that early in the study, a nonstructural tug assistance plan was formulated but was initially eliminated because such a plan would not provide adequate channel depths for 1,000-foot vessels loaded to the system's draft of 25.5 feet, and tugs would not be able

to control the movements of a 1,000-foot vessel during storm conditions while entering the narrow west entrance. Participants were in agreement on the elimination of this plan. Mr. Aguglia also stated that the purpose of Plans 1-4 is to provide for safe and efficient operation of 1,000-foot vessels in the Lakefront Harbor. Several of the plans would also provide adequate entrance channel depths for operation of Class V through Class X vessels loaded to the Great Lakes System draft of 25.5 feet which presently must lighter during low water conditions. Mr. Aguglia also stated that these plans were developed under the following assumptions: (1) that an iron ore transshipment facility, capable of accommodating 1,000-foot vessels, would be constructed in the Lakefront Harbor; and (2) all dredged material would be placed in Dike Site 14. (NOTE: Dikes 12 and 14 were originally authorized to contain 10 years of maintenance dredging. However, due to reduced dredging at Cleveland Harbor over the last several years, these diked areas will have about 2-3/4 million cubic yards of excess capacity after the authorized 10-year period. This excess capacity will be used to contain dredged material from the alternatives developed for this study.) The assumption to use Dike 14 for containment of dredged material may change, however, since the city of Cleveland is interested in using the dredged material in their proposed expansion of Burke Lakefront Airport. The Port Authority is also interested in using the dredged material for possible plans to fill in Whiskey Island. As long as an adequate diked area is provided, the Corps would be willing to give the dredged material to either agency. Following the presentation of two model study movies illustrating Plan 2 and Plans 3A and 3B, Mr. Aguglia stated that the Buffalo District's tentative recommendation is to carry forward Plan 1 into Stage 3 planning and to eliminate Plans 2-4 from further consideration. This tentative recommendation is based on the following considerations: (1) Plan 1 is the NED Plan (i.e., the plan that provides the greatest net benefits); (2) based on input from vessel masters, Plan 1 would provide safer entrance conditions for 1,000-foot vessels than any of the west entrance plans, especially since the 4-mile east basin channel would allow vessels to enter Cleveland Harbor at adequate entrance speeds to counteract the wind and wave forces acting on the vessel during storm conditions; (3) due to the absence at the east entrance of the many obstacles that are present at the west entrance, the potential for vessel accidents would be less for Plan 1 than for any of the west entrance plans; and (4) the cost to construct Plan 1 is significantly less than for any other plan. A general discussion on Plans 1-4 then ensued. The main points of this discussion are as follows:

a. Mr. Layton Washburn asked what credence was given to ODNR's Lakefront State Park development plan which includes shortening the east basin and increasing the usage of the east basin by recreational small boats. Mr. Aguglia replied that ODNR previously stated that they would be modifying their development plan to eliminate this apparent conflict with commercial navigation. However, shortening the east basin, as proposed by ODNR, would not effect the adequacy of the east entrance plan since an adequatly protected channel length would still be available. In regards to impacting on small boats, Plan 1 would result in increased usage by commercial vessels of the east basin. However, since a 1,000-foot vessel loaded to 25.5 feet static draft can carry about three times the tonnage of a 730-foot vessel presently in use at Cleveland Harbor, an overall reduction in the number of commercial ships using the Lakefront Harbor will occur. It is assumed that this positive benefit will counterbalance the negative impact of increased usage by commercial vessels in the east basin. Another potential conflict is ODNR's proposal to develop Whiskey Island as a recreational complex. As previously stated, it is assumed that a new iron ore transshipment facility will be built in the Lakefront Harbor and any recommendation to modify the Lakefront Harbor would be made contingent upon such a facility actually being built. The most logical location for such a facility is Whiskey Island. It will be up to local interests to decide whether to develop Whiskey Island for recreational use or for use as a transshipment facility.

b. Mr. Ed Jacobson asked why develop the east entrance instead of the west entrance for 1,000-foot vessels. He also expressed his concern about the effects of wind forces acting on a vessel as it travels through the east basin. Mr. Aguglia replied that the east entrance plan (Plan 1) is preferred by vessels masters who feel it is superior to any west entrance plan. They have also stated that they anticipate no trouble traveling through the east basin as long as an adequate entrance channel and adequate channel depths are provided. Also, the east entrance has fewer obstacles than the west entrance which reduces the probability of vessel accidents. The east entrance plan was selected because of those reasons and because Plan 1 provided the greatest net benefits of any of the Lakefront Harbor plans. Mr. Aguglia also noted that the east entrance was originally authorized as a storm entrance for Class V vessels (630-foot vessels) who had difficulty entering the west entrance during rough weather. However, the depth of the east entrance became inadequate when the system's draft was increased to 25.5 feet.

c. The Coast Guard expressed concern that wakes from 1,000-foot vessels using the east entrance would cause an increase in shoreline erosion, especially since they would have to travel at speeds sufficient to maintain vessel control in winds up to 30 knots. Also, will a turning basin for 1,000-foot vessels be provided. Mr. Aguglia replied that the expected 2 to 3 mph speed should not produce a wake greater than the waves that are present in the east basin now, when the east breakwater is overtopped. Also, the shoreline in the east basin is protected with stone riprap. Mr. John Manning replied that based on his observations, small boats make more wake than the larger commercial vessels. He also stated that commercial vessel masters would not speed through the east basin. In regards to providing a turning basin, Mr. Aguglia replied that vessel masters previously stated that the 1,500-foot width of the west basin was sufficient to turn a 1,000-foot vessel and, thus, no consideration was given to providing a separate turning basin.

d. Admiral Trimble asked if the savings of 1 to 1-1/2 hours in vessel transit time from using the west entrance in lieu of the east entrance was included in the benefit analysis for the west entrance plans. Mr. Aguglia replied that since this savings was such a small percentage of the total 5 to 6 day round trip, it did not affect the estimated benefits for the west entrance plans. Admiral Trimble also asked if using the dredged material for the expansion of Burke Lakefront Airport or for development of Whiskey Island would decrease the cost of Plan 1. Mr. Aguglia replied that it would not decrease the cost of the plan. (NOTE: Although not mentioned at the meeting, using dredged material for fill material for either proposed plan may result in an added benefit for Plan 1. This aspect will be investigated in Stage 3, as appropriate.)

e. Admiral Trimble also expressed his objection to the term "all-weather" entrance since "all-weather" conditions are defined as a maximum 8-foot wave and 30-knot wind. His concern is that this term could mislead the public who are not completely familiar with the term as used in the context of this study. It was, therefore, decided to change the name in Stage 3 to eliminate this possible confusion.

f. Mr. Robert Lucas asked what the Corps current schedule was for submission of the Final Report to Congress. Mr. Aguglia replied that the Final Report is scheduled to be sent to the Board of Engineers for Rivers and Harbors in August 1984 for final review and coordination. However, once it gets to Washington, it can take anywhere from 6 months to 2 years before it gets to Congress. Mr. Aguglia also stressed that if the project was authorized for construction, Congress would also have to appropriate sufficient funds for construction before the project could be built.

g. Admiral Trimble asked what benefit the Cleveland Port Authority would realize from construction of any of the Lakefront Harbor modification plans. Mr. Tom Burke replied that the Port Authority would not receive any direct benefit to Port facilities, but they are willing to go along with the wishes of the Lake Carriers Association (LCA).

Following this discussion, Admiral Trimble stated that the LCA concurs with carrying forward Plan 1 into Stage 3 planning and eliminating Plans 2 through 4 from further consideration. However, their final position on whether to support construction of this plan is dependent upon final Congressional legislation on user fees for commercial navigation projects. Thus, only Plan 1 will be carried forward into Stage 3 planning. Mr. Aguglia then stated that one aspect we will be looking at in Stage 3 is the required depth of water under a vessel's keel. For Stage 2, we have assumed 2 feet of underkeel clearance would be required, however, we would like to verify this aspect. Mr. John Manning stated that the LCA recommended 30 inches of underkeel clearance for the Connecting Channels study.

5. Mr. Aguglia then reviewed the authorized but uncompleted improvements to the Old River navigation channel (Plans 5A and 5B). A description of these plans is provided in Inclosure 3. If implemented, these improvements would allow a 730-foot vessel to navigate the Old River navigation channel loaded to a 25.5-foot static draft. (NOTE: Currently, the Old River navigation channel can accommodate a maximum sized vessel of 640-feet loaded at a 21-foot static draft.) A reevaluation of these authorized but uncompleted improvements at this time is required because of the closure of the old Erie Ore Dock, which was recently sold to Ontario Stone Corporation, and the decision by Forest City Publishing Company not to construct a newspaper complex on their property adjacent to the Old River. Since cargo expected to cross these docks was used, in part, to economically justify the authorized

improvements, their continued economic feasibility is in question. Mr. Aguglia also stated that since the economic reevaluation indicated that the new benefit-cost ratio (BCR) for these plans were below 1.0, the initial reaction of the District was to recommend deauthorizing these authorized improvements. However, recent discussions with a dock owner on the Old River indicated that he was in preliminary discussions with a company interested in exporting approximately 2 million tons of coal from their Old River dock. If this new business was to materialize, it could generate a potential additional benefit of about $1.00 per ton, or $2 million annually. This additional benefit would be sufficient to increase the BCR for Plan 5B to about 1.1, indicating the plan would be economically feasible. Therefore, it is the District's final position that the authorized improvements to the Old River navigation channel remain in the inactive category until such time as a final decision has been reached on whether this new business will materialize. If it does, the improvements would then be placed in the active category and construction would procede under their original authorization. If this business does not materialize, then these improvements would become a candidate for deauthorization. All meeting participants were in agreement with this approach.

6. Mr. Aguglia then reviewed the plans to deepen the Cuyahoga River (Plans 6A and 6B). A description of these plans is provided in Inclosure 3. The purposes of these plans are either to partially or totally eliminate the need to navigate the Cuyahoga River light-loaded. However, because the BCR's for these two plans were significantly below 1.0, it was the District's recommendation to eliminate these plans from further consideration. All meeting participants concurred in this recommendation.

7. The final set of plans to be reviewed were the Cuyahoga River congestion plans (Plans 7A through 7G). A description of these plans is provided in Inclosure 3. The purpose of these plans is to eliminate undue vessel delays at seven locations on the Cuyahoga River identified as delay points by shipping companies transiting the river channel. Mr. Aguglia also stated that it was the District's recommendation to eliminate Plans 7A, 7C, 7D, 7E, and 7G from further consideration due to BCR's being less than 1.0. It is also recommended that construction of Plans 7B and 7F, which are also previously authorized but uncompleted improvements to the Cuyahoga River navigation channel, be pursued under their existing construction authority since they still have BCR's greater than 1.0. All meeting participants were in agreement with these recommendations except as noted below:

a. Because of the significant local costs that would be required for Plan 7B, it was recommended that this authorized improvement plan be kept in deferred status until final legislation on user fees is passed by Congress. In addition, it was stated that the mill adjacent to this improvement site is in a state of disrepair and may be closed down in the future. This action would significantly reduce the local cost for this plan. Thus, it was the final recommendation that Plan 7B be kept in the deferred category.

b. It was also decided to change the status of Plan 7F from deferred to active. The first step in preconstruction planning would then be to investigate the possibility of not bulkheading Bank Cut No. 20, but to cut the bank back on a stable slope. This would significantly reduce the cost of this plan.

c. Although Plan 7G has a BCR less than 1.0, it will still be carried forward into Stage 3 planning since shipping companies indicated that numerous minor accidents occur at this site, but are not of sufficient magnitude to be reported to the Coast Guard. Even though each accident involves only minor damage, in total, they represent a significant amount of damage which may be sufficient to increase the BCR for Plan 7G above 1.0. Shipping companies will supply information on these minor accidents to the Buffalo District for Stage 3 analysis.

8. Mr. Gilbert then reviewed the conclusions reached at this meeting and adjourned the meeting at 12:00 noon.

RICHARD AGUGLIA
Project Manager

CLEVELAND HARBOR STUDY
4 May 1982 Workshop Meeting

Attendance

Name	Organization
Charles Gilbert	Chief, Planning Division, COE
Richard Aguglia	Planning Division, COE
Michael Pelone	Economics Branch, COE
Roger Haberly	Economics Branch, COE
Robert Johnston	Design Section, COE
Robert Lucas	Ohio Department of Natural Resources
Ken Alvey	Ohio Department of Natural Resources
Kent E. Kroonemeyer	U. S. Fish and Wildlife Service
Ken Multerer	U. S. Fish and Wildlife Service
John Baker	International Longshoreman's Association
Joe Hayes	Lake Erie Asphalt Products
Edgar M. Jacobsen	Oglebay Norton
Admiral Paul Trimble	Lake Carriers Association
John Manning	Hanna Mining Company
Carl Barcelli	Ontario Stone Corporation
Michael Neylon	International Salt Company
Layton Washburn	Cleveland City Planning Commission
Roual G. Denning	Cereal Food Processors, Inc.
Captain Davies	Kinsman Lines
Dewey Aston	Pickards Mather
Louis Ervin	American Steamship Company
Ed Guffing	U. S. Coast Guard
Gordon Piche	U. S. Coast Guard
Robert W. Gasior	U. S. Coast Guard
Captain Dave Freeborn	U. S. Coast Guard
Bob Spar	Jones & Laughlin Steel Corporation
P. E. VanCleve	Chessie System
Thomas Burke	Cleveland-Cuyahoga County Port Authority
Anthony Russo	Cleveland-Cuyahoga County Port Authority

Inc. 1

AD-A127 216 STAGE 2 REPORT FOR REFORMULATION PHASE I GENERAL DESIGN MEMORANDUM CLEVEL..(U) CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT FEB 83 6/7

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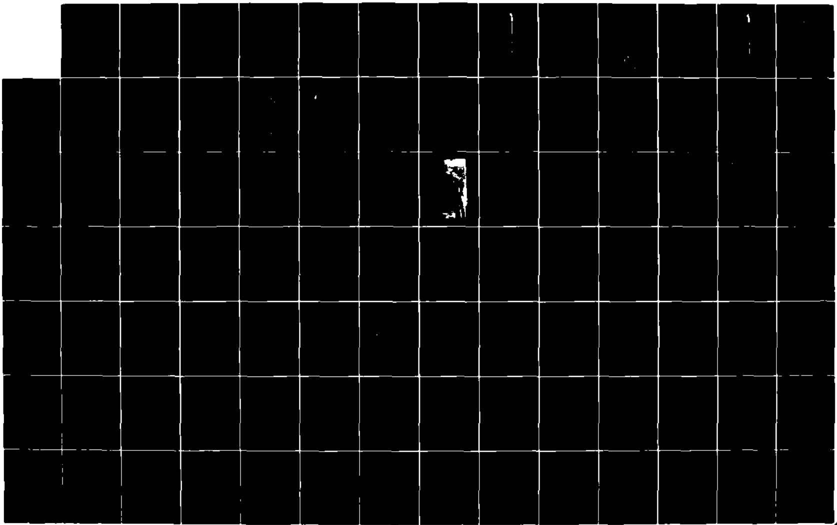
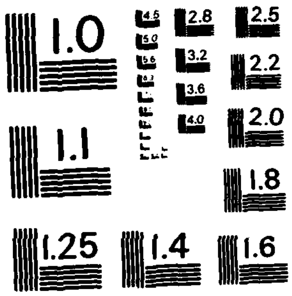




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Agenda
for
Workshop Meeting
on
Cleveland Harbor Study

Tuesday, 4 May 1982
Cleveland-Cuyahoga County Port Authority Office
101 Erieside Avenue, Cleveland, Ohio

9:00 a.m.	WELCOME AND OPENING REMARKS . . . . .Charles E. Gilbert, Chief, Planning Division, COE
9:15 a.m.	OUTER HARBOR ALTERNATIVES - REVIEW OF PLANS 1-4, INCLUDING MODEL STUDY MOVIES ON PLAN 2 AND PLANS 3A and 3B . . . . .Richard Aguglia, COE
10:00 a.m.	OPEN DISCUSSION . . . . . . .All
10:30 a.m.	OLD RIVER ALTERNATIVES - REVIEW OF PLANS 5A, 5B . . . . .Richard Aguglia, COE
10:45 a.m.	OPEN DISCUSSION . . . . . . .All
11:00 a.m.	CUYAHOGA RIVER DEEPENING ALTERNATIVES - REVIEW OF PLANS 6A, 6B . . . . .Richard Aguglia, COE
11:15 a.m.	OPEN DISCUSSION . . . . . . .All
11:30 a.m.	CUYAHOGA RIVER CONGESTION ALTERNATIVES - REIVEW OF PLANS 7A-7G . . . . .Richard Aguglia, COE
11:45 a.m.	OPEN DISCUSSION . . . . . . .All
12:15 p.m.	SUMMARY AND CLOSING REMARKS . . . . .Charles E. Gilbert, COE

Inc. 2

April 1982

Comparison of Commercial Navigation Alternatives (Plans 1-7)(1)

Plan Description	Total Project Cost (2) (June 1982 Price Levels) ($1,000)	Traditional Cost Allocation: Federal ($1,000)	Traditional Cost Allocation: Non-Federal ($1,000)	Proposed Cost Allocation: Federal ($1,000)	Proposed Cost Allocation: Non-Federal ($1,000)	Annual Cost (3) ($1,000)	Annual Benefits (3) ($1,000)	Benefit-Cost Ratio	Average Annual Net Benefits ($1,000)
1. <u>OUTER HARBOR IMPROVEMENT PLANS (PLANS 1-4)</u>: Purpose is to provide for safe and efficient operation of vessels up to 1,000 feet long by 105 feet wide loaded to the Great Lakes System Draft of 25.5-feet in the Lakefront Harbor.									
<u>Alternative Plan No. 1</u> ("All-weather" East Entrance Plan - See Plate 1). This plan includes dredging a fan shaped entrance channel at the existing east entrance and dredging a 500-foot wide channel through the East Basin to the West Basin. Plan is suitable for vessel operation in "all-weather" conditions (maximum 8-foot wave and 30 knot wind from the west through northeast).	5,060	5,060	0	0	5,060	395.9	17,605	44.5	17,209.1
<u>Alternative Plan No. 2</u> ("Fair-weather" West Entrance Plan - See Plate 2). This plan includes removal of sections of the spur breakwaters at the west (main) entrance to promote vessel operation during "fair-weather" conditions (maximum 4-foot wave and 20 knot wind from the west through northeast). Also included are breakwater modifications to prevent increased wave activity in the Lakefront Harbor as a result of the spur breakwater removal.	15,100	15,100	0	0	15,100	(4)	(4)	(4)	(4)
<u>Alternative Plan No. 3A</u> (Modified "L" shaped Breakwater "All-weather" West Entrance Plan - See Plate 3). This plan consists of providing a new modified "L" shaped breakwater protected entrance channel, approximately 4,000 feet long, at the existing west (main) entrance and removing portions of the spur breakwaters to promote vessel operation. Plan is suitable for vessel operation during "all-weather" conditions.	33,200	33,200	0	0	33,200	3,160.2	17,605	5.6	14,444.8
<u>Alternative Plan No. 3B</u> (1,000-foot Parallel Breakwater Extension "All-weather" West Entrance Plan - See Plate 4). This plan consists of extending and deepening the existing west (main) entrance channel and removing portions of the spur breakwaters to promote vessel operation. Extended entrance channel would be protected by two new 1,000-foot long parallel breakwaters. Plan is suitable for vessel operation during "all-weather" conditions.	18,900	18,900	0	0	18,900	1,645.2	17,605	10.7	15,959.8

Incl 3

Comparison of Commercial Navigation Alternatives (Plans 1-7)(1) (Cont'd)

Plan Description	Total Project Cost (2) (June 1982 Price Levels) ($1,000)	Traditional Cost Allocation: Federal ($1,000)	Traditional Cost Allocation: Non-Federal ($1,000)	Proposed Cost Allocation: Federal ($1,000)	Proposed Cost Allocation: Non-Federal ($1,000)	Annual Cost (3) ($1,000)	Annual Benefits (3) ($1,000)	Benefit-Cost Ratio	Average Annual Net Benefits ($1,000)
Alternative Plan No. 4 (Combined "All-weather" East Entrance and "Fair-weather" West Entrance Plan - See Plate 5). This plan combines the features of Plans 1 and 2. The "all-weather" east entrance would be used during rough weather, while the "fair-weather" west entrance would be used during relatively calm conditions. Use of the "fair-weather" west entrance in-lieu-of the "all-weather" east entrance would save 1 hour in vessel transit time each time a vessel entered or left the harbor.	19,800	19,800	0	0	19,800	(5)	(5)	(5)	(5)
2. AUTHORIZED BUT UNCOMPLETED IMPROVEMENTS TO THE OLD RIVER NAVIGATION CHANNEL (PLANS 5A AND 5B). Purpose is to determine if authorized but uncompleted improvements to the Old River navigation channel are still economically justified in-light-of current conditions.									
Alternative Plan No. 5A (Replace Bridge No. 23 - See Plates 6 and 7). This plan consists of four bank cuts (Cuts No. 12-15), replacing the existing B&O Railroad Bridge at the mouth of the Old River (Bridge No. 23) with a new vertical lift bridge spanning the new channel width and deepening the navigation channel to 28 feet below Low Water Datum (LWD). In addition, new bank cuts would be bulkheaded and existing bulkheads that become unstable due to the channel deepening would be replaced. Implementation of these improvements would allow a vessel up to 730 feet in length to navigate the Old River navigation channel loaded to the Great Lakes System Draft of 25.5 feet.	66,687	24,001	42,686	(6)	(6)	6,008.5	2,405.4	0.4	-3,603.1
Alternative Plan No. 5B (Interchange System - See Plates 6 and 7). This plan is similar to Plan 5A, except that in-lieu-of replacing the existing B&O Railroad Bridge, the bridge will be removed and a new connection and interchange system to the Conrail trackage on the east side of the Cuyahoga River will be provided. B&O traffic would reach Whiskey Island via this new connection and interchange system and Conrail Bridge No. 1.	54,087	11,263	42,824	(6)	(6)	3,600.5	2,098.5	0.6	-1,502

Comparison of Commercial Navigation Alternatives (Plans 1-7)(1) (Cont'd)

Plan Description	Total Project Cost (2) (June 1982 Price Levels) ($1,000)	Traditional Cost Allocation: Federal ($1,000)	Traditional Cost Allocation: Non-Federal ($1,000)	Proposed Cost Allocation: Federal ($1,000)	Proposed Cost Allocation: Non-Federal ($1,000)	Annual Cost (3) ($1,000)	Annual Benefits (3) ($1,000)	Benefit-Cost Ratio	Average Annual Net Benefits ($1,000)
3. **CUYAHOGA RIVER DEEPENING PLANS (PLANS 6A AND 6B).** The purpose of these plans is to provide a deeper navigation channel in the Cuyahoga River, partially or totally eliminating the need to traverse the channel light-loaded.									
Alternative Plan No. 6A (Deepen the Cuyahoga River to 25.5 feet - See Plate 8). This plan consists of deepening the Cuyahoga River navigation channel from the existing authorized depth of 23 feet to 25.5 feet below LWD. Even with the proposed deepening, however, vessels would still be required to light-load, although at a reduced level from present practice. In addition, existing bulkheads and bridge fendering systems that become unstable due to the river deepening would be replaced. Also, one utility would be relocated (lowered).	213,000	13,496	199,504	0	213,000	20,165.4	8,915.6	0.4	-11,249.8
Alternative Plan 6B (Deepening Cuyahoga River to 28 feet - See Plate 9). This alternative is similar to Plan 6A, except that the channel would be deepened to 28 feet below LWD instead of 25.5 feet, and four utilities would be relocated. The deepened channel would allow vessels to load to the Great Lakes System Draft of 25.5 feet.	220,000	19,939	200,061	0	220,000	21,154.1	9,745.1	0.5	-11,409
4. **PLANS TO REDUCE RIVER CONGESTION ON THE CUYAHOGA RIVER (PLANS 7A THROUGH 7G).** The purpose of these plans is to eliminate undue vessel delay at seven locations on the Cuyahoga River identified as delay points by shipping companies transiting the river channel.									
Alternative Plan 7A (Site 1 - See Plate 10). This plan was eliminated from further consideration during the early portion of Stage 2 planning due to the high cost of replacing the existing vertical left Conrail Bridge No. 1 with a new high level bridge and the corresponding approach track modifications required for the new high level bridge. If implemented, a savings of 30 minutes in vessel transit time would have occurred.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comparison of Commercial Navigation Alternatives (Plans 1-7)(1) (Cont'd)

Plan Description	Total Project Cost (2) (June 1982 Price Levels) ($1,000)	Traditional Cost Allocation: Federal ($1,000)	Traditional Cost Allocation: Non-Federal ($1,000)	Proposed Cost Allocation: Federal ($1,000)	Proposed Cost Allocation: Non-Federal ($1,000)	Annual Cost (3) ($1,000)	Annual Benefits (3) ($1,000)	Benefit-Cost Ratio	Average Annual Net Benefits ($1,000)
Alternative Plan No. 7B (Site 2 - See Plates 10 and 11). This plan consists of completing the remaining portion of Cut No. 4. In addition, the new bank cut would be bulkheaded and the existing bulkheads immediately downstream of Cut No. 4 would be replaced. A savings in vessel transit time of 20 minutes would result.	3,670	247	3,423	(6)	(6)	287.1	501.2	1.8	214.1
Alternativ Plan No. 7C (Site 3 - See Plates 10 and 11). This plan consists of new bank Cut No. 16 and replacing the existing Cleveland Union Terminal Bridge and Columbus Road Bridge with new bridges spanning the widened channel. In addition, the new bank cut would be bulkheaded. A savings in vessel transit time of 10 minutes would result.	42,500	31,935	10,565	0	42,500	3,703.7	1,251.7	0.3	-2,452
Alternative Plan No. 7D (Site 4 - See Plates 10 and 12). This plan consists of new bank Cuts No. 17 and 18 and replacing the existing N&W Railroad Bridge with a new bridge spanning the widened channel. Again, the new bank cuts would be bulkheaded. A savings in vessel transit time of 10 minutes would result.	39,500	24,912	14,588	0	39,500	3,441.3	708.9	0.2	-2,732.4
Alternative Plan No. 7E (Site 5 - See Plates 10 and 12). This plan consists of new bank Cut No. 19 and bulheading the new bank cut. A savings in vessel transit time of 10 minutes would result.	8,860	1,774	7,086	0	8,860	742.6	436.8	0.6	-305.8
Alternative Plan No. 7F (Site 6 - See Plates 10 and 13). This plan consists of bank Cut No. 20 and bulkheading the new bank cut. A savings in vessel transit time of 15 minutes would result.	2,930	175	2,755	(6)	(6)	229.2	369.1	1.6	139.9
Alternative Plan No. 7G (Site 7 - See Plates 10 and 13). This plan consists of removing the Jefferson Avenue Bridge abutments, new bank Cuts No. 21 and 22, and bulkheading the new bank cuts. A savings in vessel transit time of 10 minutes would result.	4,000	46	3,954	0	4,000	313	225.8	0.7	-87.2

FOOTNOTES:

(1) All costs and benefits stated are preliminary and are subject to change.

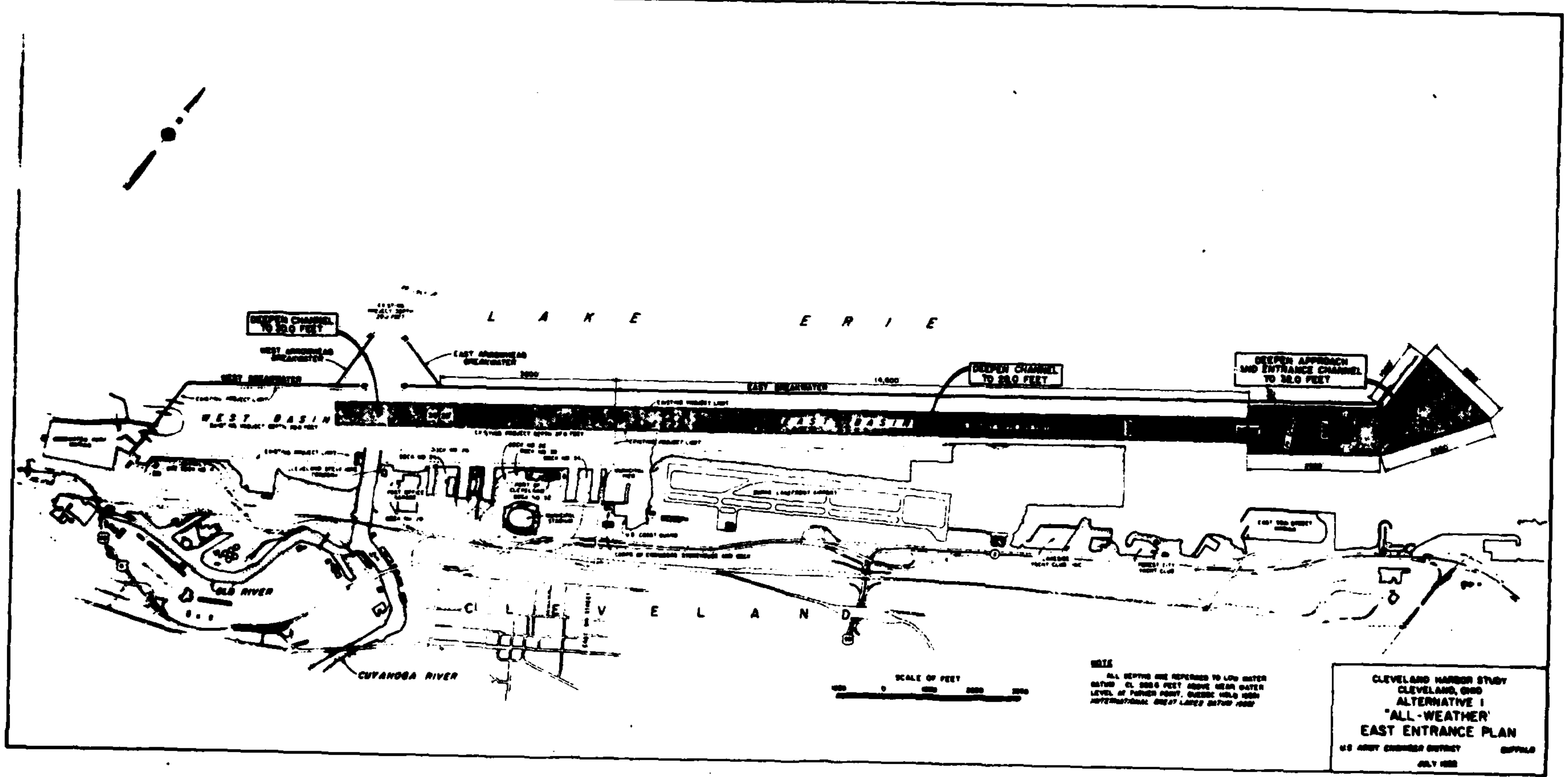
(2) Does not include cost for mitigation of adverse environmental impacts that may be required for each alternative. Mitigation will be evaluated in Stage 3, as appropriate. Also, for all alternatives, it has been assumed that dredged material will be placed in Dike Site 14.

(3) Based on June 1982 price levels, a 50-year economic life, and 7-5/8 percent interest rate.

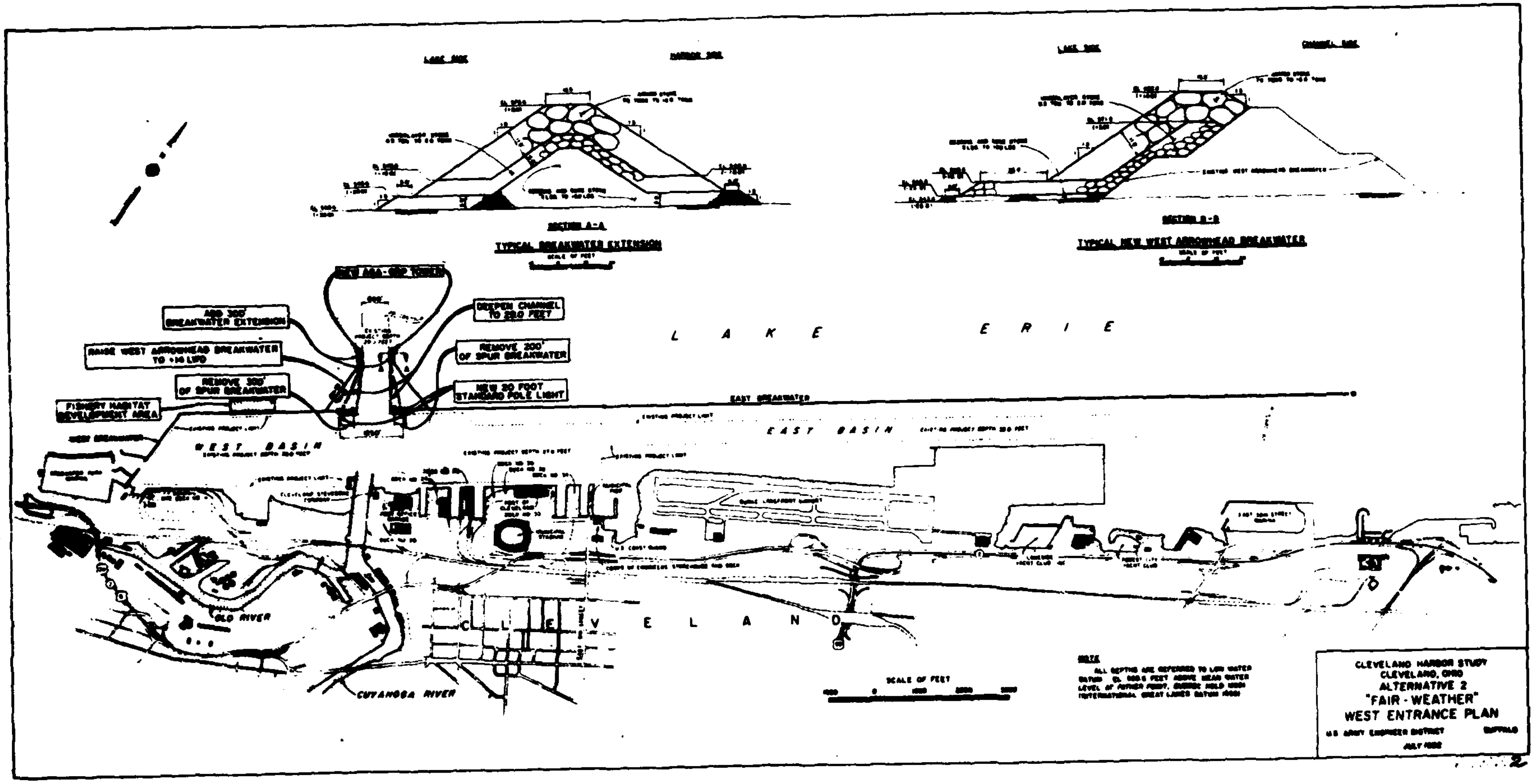
(4) Economic evaluation was not conducted for Alternative Plan No. 2 because Alternative Plan No. 1 provided greater benefits (i.e., vessel operation during "all-weather" conditions versus vessel operation in "fair-weather" conditions only) for one-third the cost. Thus, Plan No. 1 was obviously more economically efficient than Alternative Plan No. 2.

(5) Economic evaluation was not conducted for Atlernative Plan No. 4 since incremental benefits to justify adding the "fair-weather" west entrance component to the "all-weather" east entrance component were obviously insufficient to economically justify the added increment (i.e., the savings in vessel transit time of 1 hour during calm weather conditions would not result in sufficient benefits to justify an expenditure of approximately $15 million).

(6) This alternative was funded for construction prior to 1 October 1981 and, therefore, the President's proposed cost allocation is not applicable.



LAKE ERIE
WEST BREAKWATER
EAST BREAKWATER
WEST BASIN
EAST BASIN
OLD RIVER
CUYAHOGA RIVER
CLEVELAND
SCALE OF FEET
NOTE
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE I
"ALL-WEATHER"
EAST ENTRANCE PLAN


SECTION A-A
TYPICAL BREAKWATER EXTENSION
SECTION B-B
TYPICAL NEW WEST ARROWHEAD BREAKWATER
ADD 300' BREAKWATER EXTENSION
RAISE WEST ARROWHEAD BREAKWATER TO +14 LWD
REMOVE 300' OF SPUR BREAKWATER
FISHERY HABITAT DEVELOPMENT AREA
DEEPEN CHANNEL TO 28.0 FEET
REMOVE 200' OF SPUR BREAKWATER
NEW 20 FOOT STANDARD POLE LIGHT
L A K E E R I E
EAST BREAKWATER
WEST BASIN
EAST BASIN
C L E V E L A N D
OLD RIVER
CUYAHOGA RIVER
SCALE OF FEET
NOTE
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 2
"FAIR - WEATHER"
WEST ENTRANCE PLAN
U.S. ARMY ENGINEER DISTRICT BUFFALO

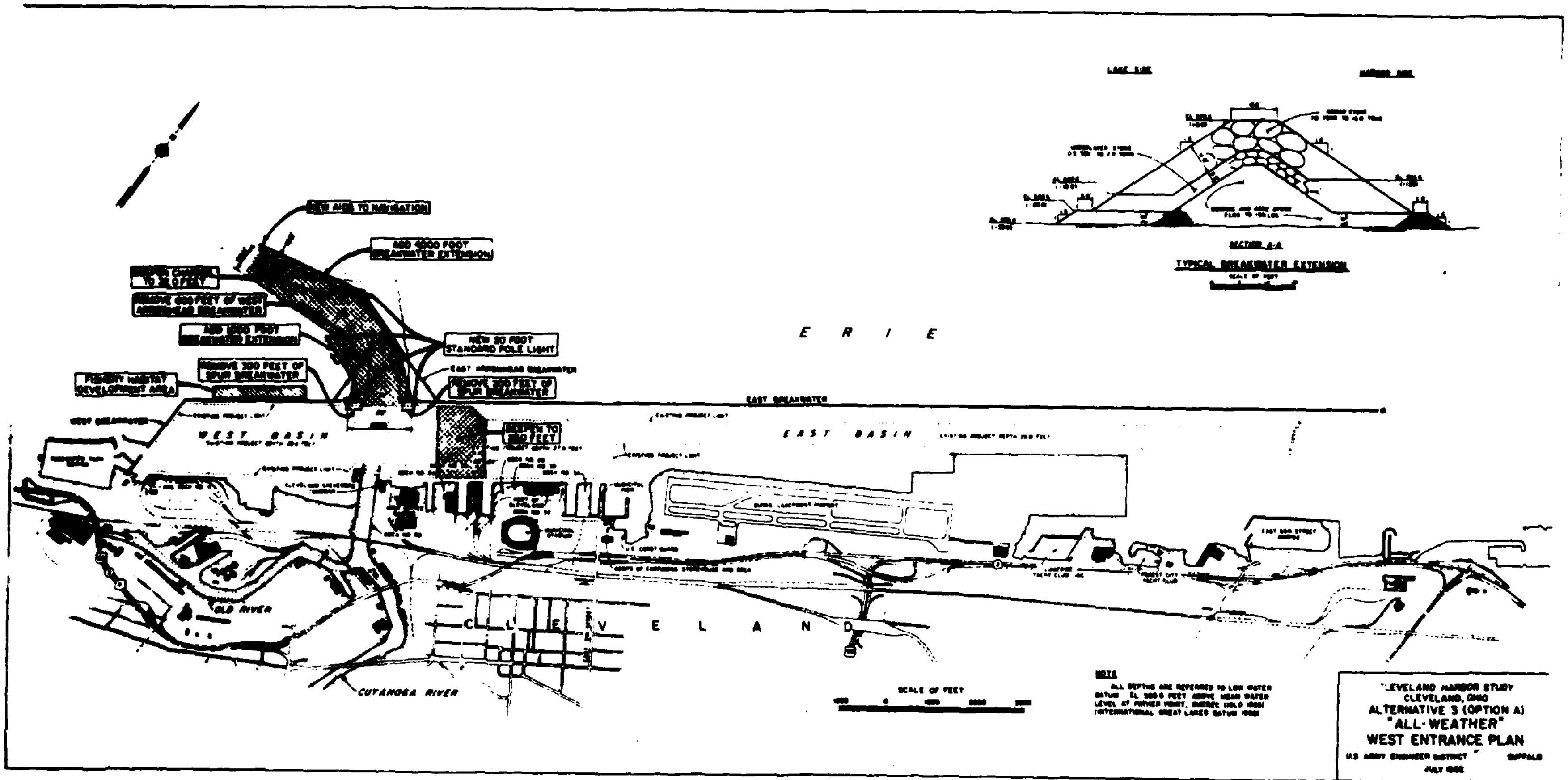

LAKE SIDE
HARBOR SIDE
SECTION A-A
TYPICAL BREAKWATER EXTENSION
NEW AIDS TO NAVIGATION
ADD 4000 FOOT BREAKWATER EXTENSION
NEW 30 FOOT STANDARD POLE LIGHT
EAST ARROWHEAD BREAKWATER
REMOVE 300 FEET OF SPUR BREAKWATER
DEEPEN TO 30.0 FEET
FISHERY HABITAT DEVELOPMENT AREA
WEST BREAKWATER
E R I E
EAST BREAKWATER
WEST BASIN
EAST BASIN
OLD RIVER
CUYAHOGA RIVER
C L E V E L A N D
SCALE OF FEET
NOTE
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 3 (OPTION A)
"ALL-WEATHER"
WEST ENTRANCE PLAN
U.S. ARMY ENGINEER DISTRICT BUFFALO

PLATE 3

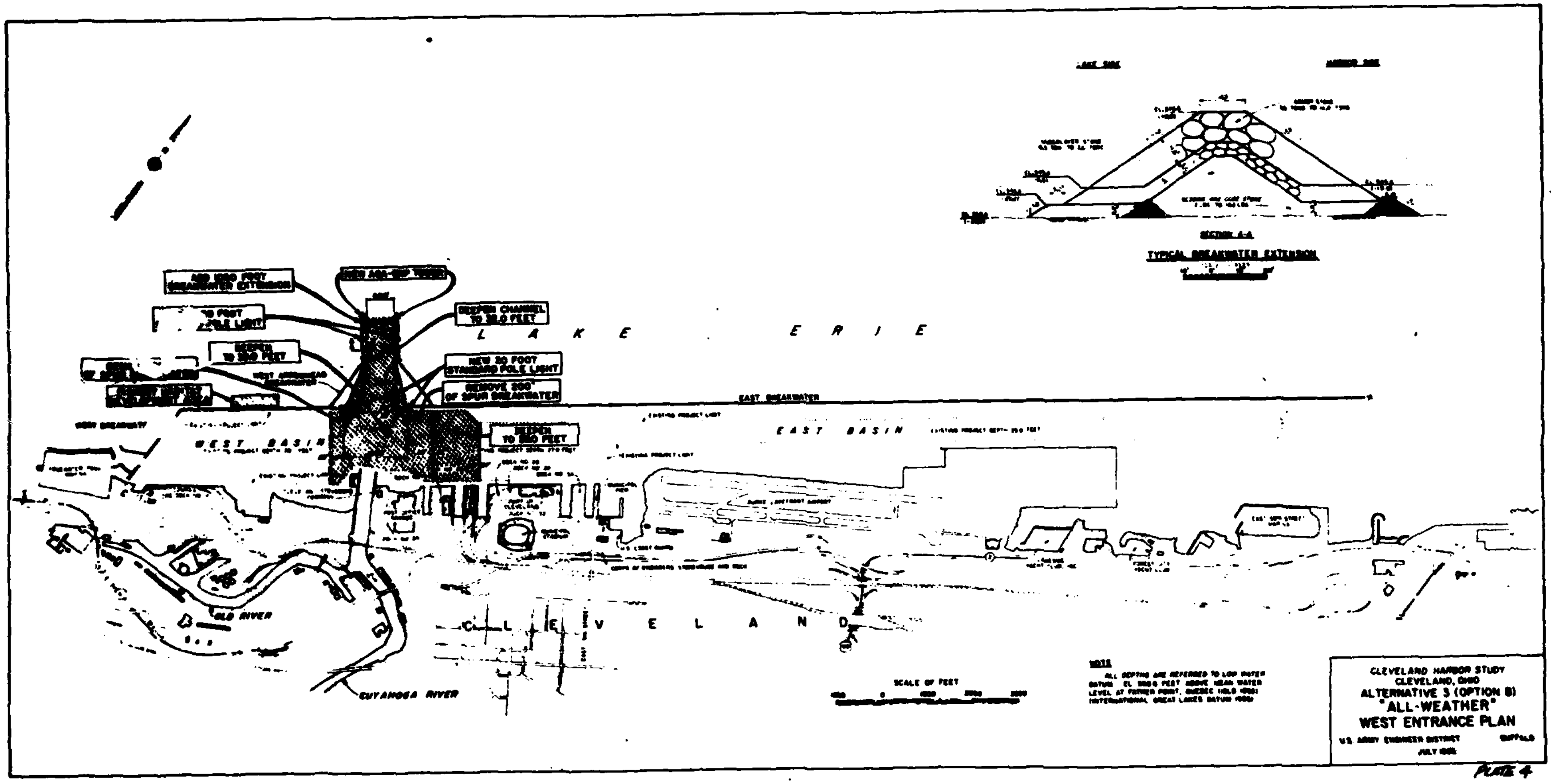
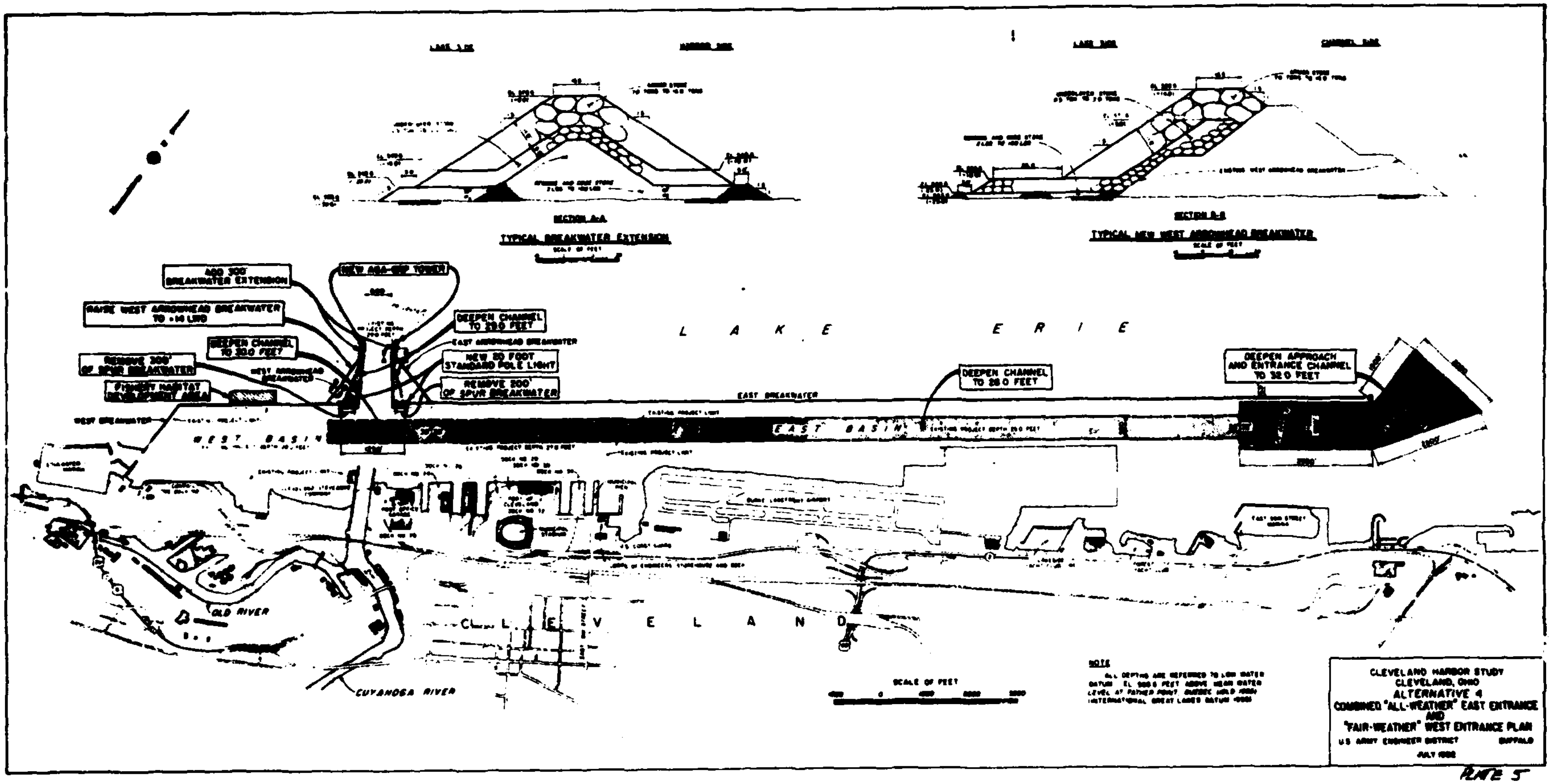
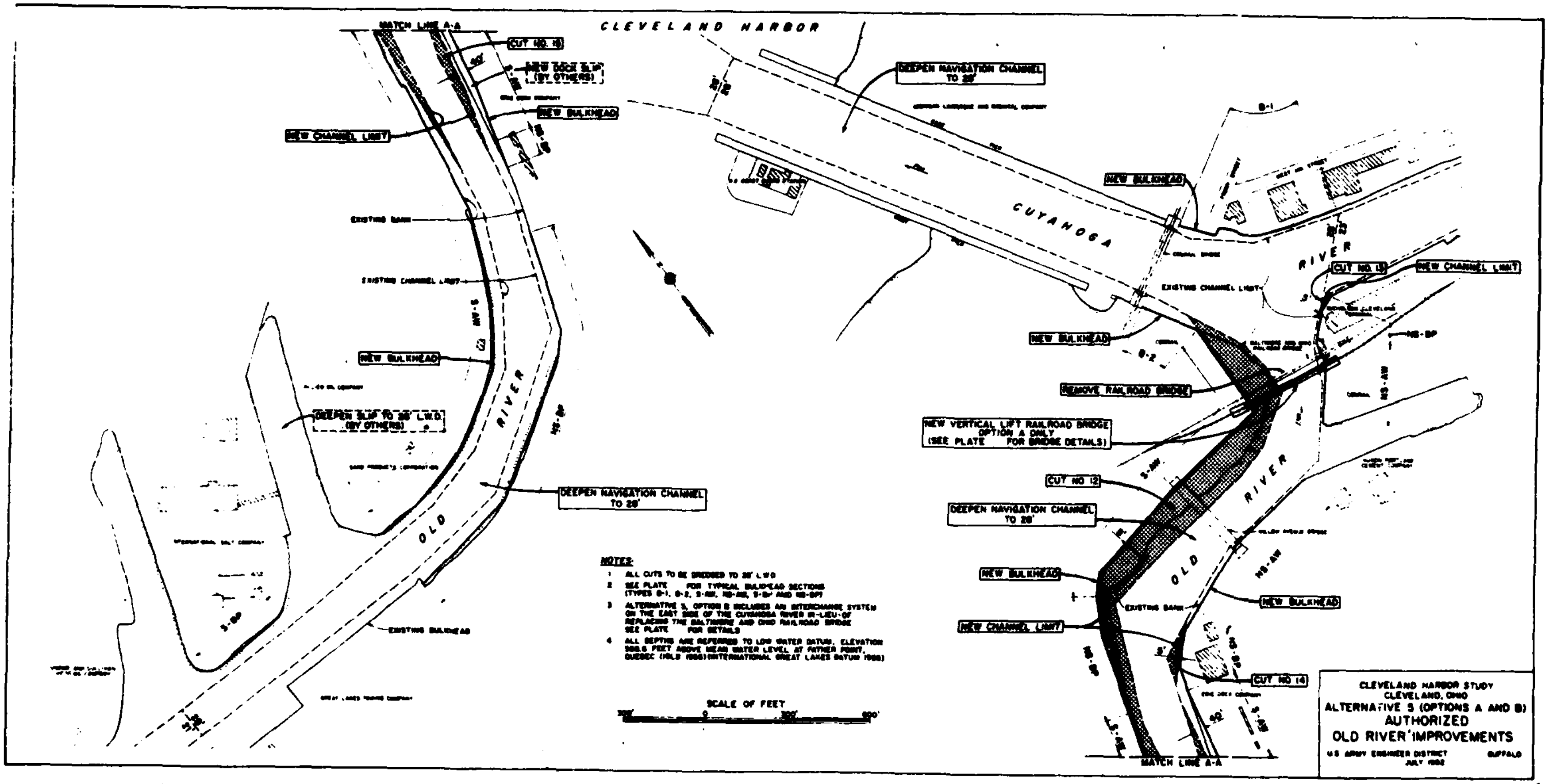

LAKE SIDE
HARBOR SIDE
SECTION A-A
TYPICAL BREAKWATER EXTENSION
DEEPEN CHANNEL TO 30.0 FEET
NEW 20 FOOT STANDARD POLE LIGHT
REMOVE 200' OF SPUR BREAKWATER
DEEPEN TO 30.0 FEET
L A K E E R I E
EAST BREAKWATER
EAST BASIN
WEST BASIN
C L E V E L A N D
OLD RIVER
CUYAHOGA RIVER
SCALE OF FEET
NOTE
ALL DEPTHS ARE REFERRED TO LOW WATER DATUM EL. 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC
INTERNATIONAL GREAT LAKES DATUM
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 3 (OPTION B)
"ALL-WEATHER"
WEST ENTRANCE PLAN
U.S. ARMY ENGINEER DISTRICT BUFFALO

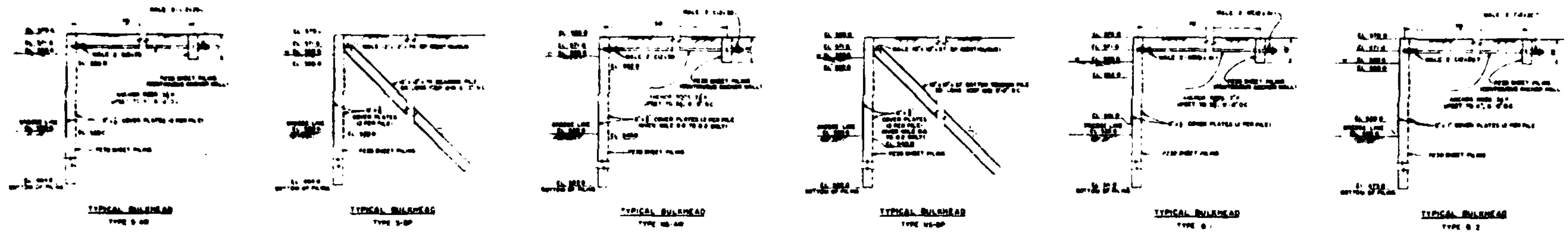
PLATE 4



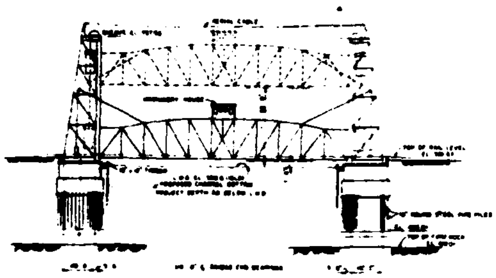
SECTION A-A
TYPICAL BREAKWATER EXTENSION
SECTION B-B
TYPICAL NEW WEST ARROWHEAD BREAKWATER
ADD 300' BREAKWATER EXTENSION
NEW AGA-GSP TOWER
RAISE WEST ARROWHEAD BREAKWATER TO +14 LWD
DEEPEN CHANNEL TO 29.0 FEET
EAST ARROWHEAD BREAKWATER
DEEPEN CHANNEL TO 30.0 FEET
NEW 30 FOOT STANDARD POLE LIGHT
REMOVE 300' OF SPUR BREAKWATER
WEST ARROWHEAD BREAKWATER
REMOVE 200' OF SPUR BREAKWATER
FISHERY HABITAT DEVELOPMENT AREA
WEST BREAKWATER
L A K E   E R I E
EAST BREAKWATER
DEEPEN CHANNEL TO 28.0 FEET
DEEPEN APPROACH AND ENTRANCE CHANNEL TO 32.0 FEET
WEST BASIN
EAST BASIN
C L E V E L A N D
OLD RIVER
CUYAHOGA RIVER
SCALE OF FEET
NOTE
ALL DEPTHS ARE REFERRED TO LOW WATER DATUM EL. 569.2 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD 1955) INTERNATIONAL GREAT LAKES DATUM 1955
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 4
COMBINED "ALL-WEATHER" EAST ENTRANCE AND "FAIR-WEATHER" WEST ENTRANCE PLAN
U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1980

PLATE 5


CLEVELAND HARBOR
CUYAHOGA
RIVER
OLD RIVER
MATCH LINE A-A
CUT NO. 12
CUT NO. 13
CUT NO. 14
CUT NO. 15
NEW DOCK SLIP (BY OTHERS)
NEW BULKHEAD
NEW CHANNEL LIMIT
EXISTING BANK
EXISTING CHANNEL LIMIT
EXISTING BULKHEAD
DEEPEN SLIP TO 28' L.W.D. (BY OTHERS)
DEEPEN NAVIGATION CHANNEL TO 28'
REMOVE RAILROAD BRIDGE
NEW VERTICAL LIFT RAILROAD BRIDGE OPTION A ONLY (SEE PLATE FOR BRIDGE DETAILS)
NOTES:
1 ALL CUTS TO BE DREDGED TO 28' L.W.D.
2 SEE PLATE FOR TYPICAL BULKHEAD SECTIONS
3 ALTERNATIVE 5, OPTION B INCLUDES AN INTERCHANGE SYSTEM ON THE EAST SIDE OF THE CUYAHOGA RIVER IN-LIEU-OF REPLACING THE BALTIMORE AND OHIO RAILROAD BRIDGE SEE PLATE FOR DETAILS
4 ALL DEPTHS ARE REFERRED TO LOW WATER DATUM, ELEVATION
SCALE OF FEET
0
300'
600'
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 5 (OPTIONS A AND B)
AUTHORIZED
OLD RIVER IMPROVEMENTS
U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982
PLATE 6

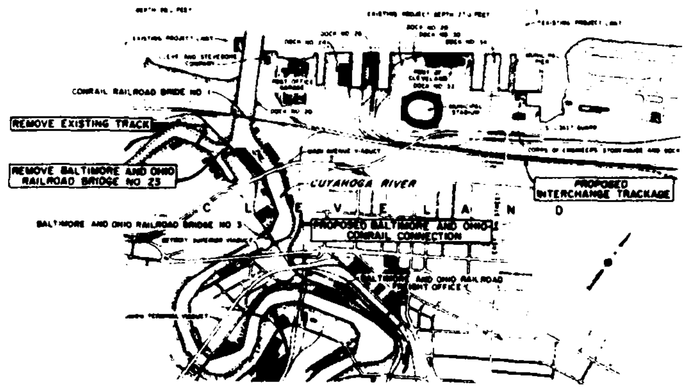


TYPICAL NEW BULKHEAD SECTIONS



ELEVATION OF PROPOSED VERTICAL LIFT RAILROAD BRIDGE
(ALTERNATIVE 5, OPTION A)

SCALE OF FEET



PROPOSED BALTIMORE AND OHIO RAILROAD INTERCHANGE SYSTEM
(ALTERNATIVE 5, OPTION B)

SCALE OF FEET

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

TYPICAL SECTIONS
AND INTERCHANGE SYSTEM
FOR ALTERNATIVE 5

U.S. ARMY ENGINEER DISTRICT, BUFFALO
JULY 1980

PLATE 7

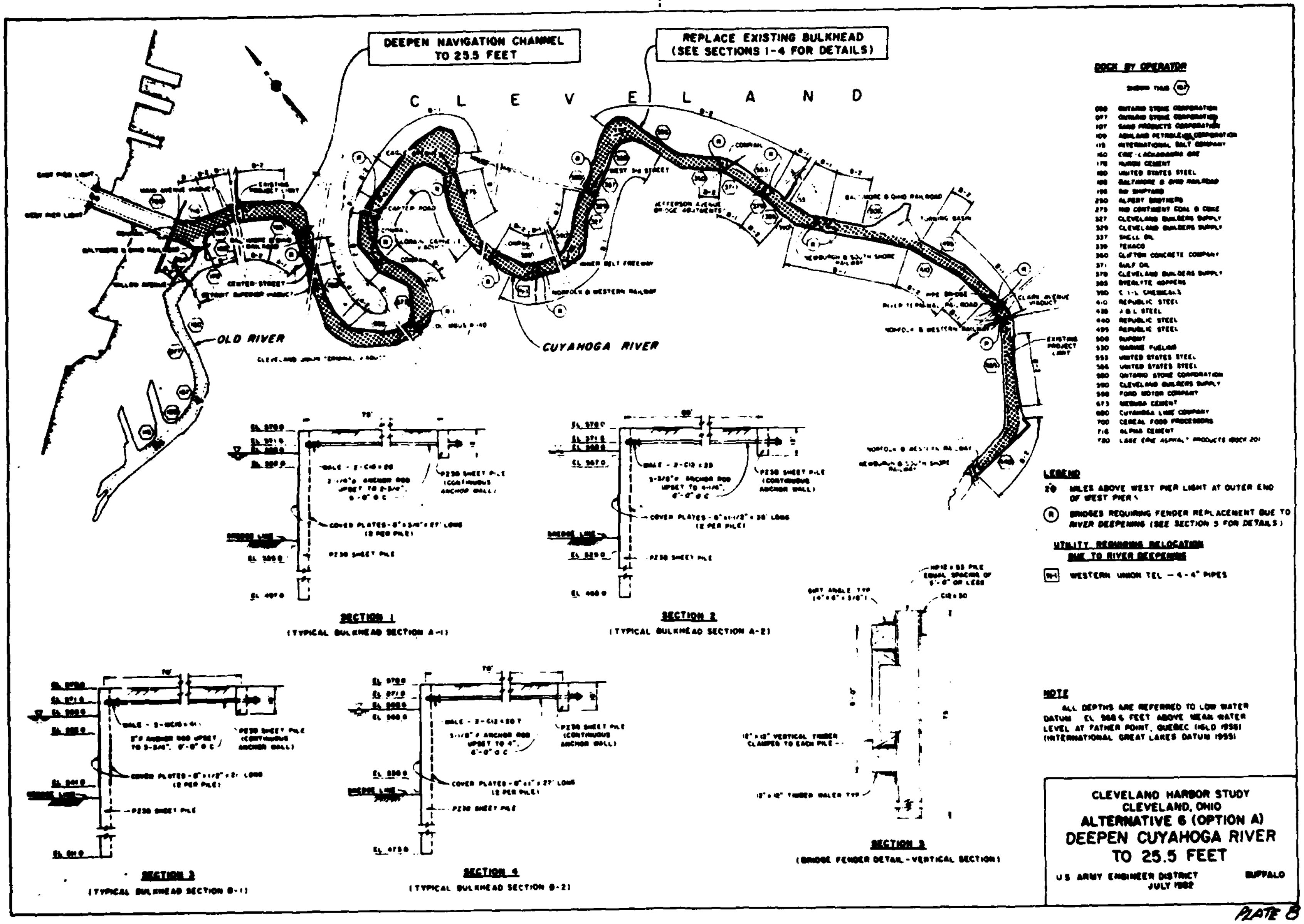

DEEPEN NAVIGATION CHANNEL TO 25.5 FEET
REPLACE EXISTING BULKHEAD (SEE SECTIONS 1-4 FOR DETAILS)
C L E V E L A N D
OLD RIVER
CUYAHOGA RIVER
WEST 3rd STREET
CENTER STREET
DETROIT SUPERIOR VIADUCT
JEFFERSON AVENUE BRIDGE ABUTMENTS
INNER BELT FREEWAY
NORFOLK & WESTERN RAILWAY
BALTIMORE & OHIO RAILROAD
NEWBURGH & SOUTH SHORE RAILWAY
TURNING BASIN
CLARK AVENUE VIADUCT
EXISTING PROJECT LIMIT
DOCK BY OPERATOR
ONTARIO STONE CORPORATION
ONTARIO STONE CORPORATION
SAND PRODUCTS CORPORATION
ASHLAND PETROLEUM CORPORATION
INTERNATIONAL SALT COMPANY
ERIE-LACKAWANNA ORE
HURON CEMENT
UNITED STATES STEEL
BALTIMORE & OHIO RAILROAD
AMERICAN SHIPYARD
ALPERT BROTHERS
MID CONTINENT COAL & COKE
CLEVELAND BUILDERS SUPPLY
CLEVELAND BUILDERS SUPPLY
SHELL OIL
TEXACO
CLIFTON CONCRETE COMPANY
GULF OIL
CLEVELAND BUILDERS SUPPLY
C-I-L CHEMICALS
REPUBLIC STEEL
J & L STEEL
REPUBLIC STEEL
REPUBLIC STEEL
MARINE FUELING
UNITED STATES STEEL
UNITED STATES STEEL
ONTARIO STONE CORPORATION
CLEVELAND BUILDERS SUPPLY
FORD MOTOR COMPANY
CUYAHOGA LIME COMPANY
CEREAL FOOD PROCESSORS
ALPHA CEMENT
LAKE ERIE ASPHALT PRODUCTS (DOCK 20)
LEGEND
MILES ABOVE WEST PIER LIGHT AT OUTER END OF WEST PIER
BRIDGES REQUIRING FENDER REPLACEMENT DUE TO RIVER DEEPENING (SEE SECTION 5 FOR DETAILS)
UTILITY REQUIRING RELOCATION DUE TO RIVER DEEPENING
WESTERN UNION TEL — 4-4" PIPES
NOTE
ALL DEPTHS ARE REFERRED TO LOW WATER DATUM EL 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD 1955) (INTERNATIONAL GREAT LAKES DATUM 1955)
SECTION 1
(TYPICAL BULKHEAD SECTION A-1)
SECTION 2
(TYPICAL BULKHEAD SECTION A-2)
SECTION 3
(TYPICAL BULKHEAD SECTION B-1)
SECTION 4
(TYPICAL BULKHEAD SECTION B-2)
SECTION 5
(BRIDGE FENDER DETAIL - VERTICAL SECTION)
PZ38 SHEET PILE
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 6 (OPTION A)
DEEPEN CUYAHOGA RIVER
TO 25.5 FEET
U S ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE 8

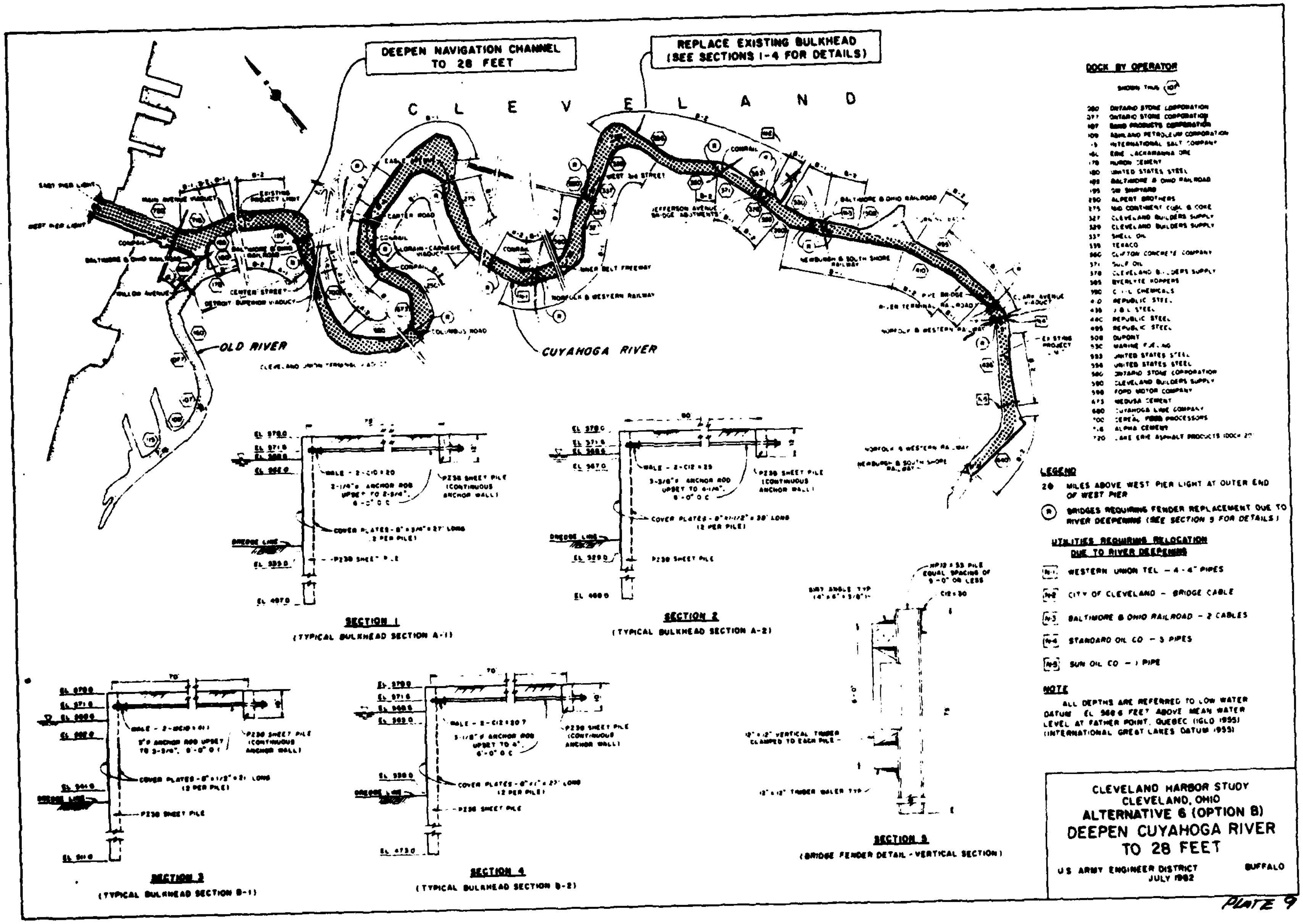
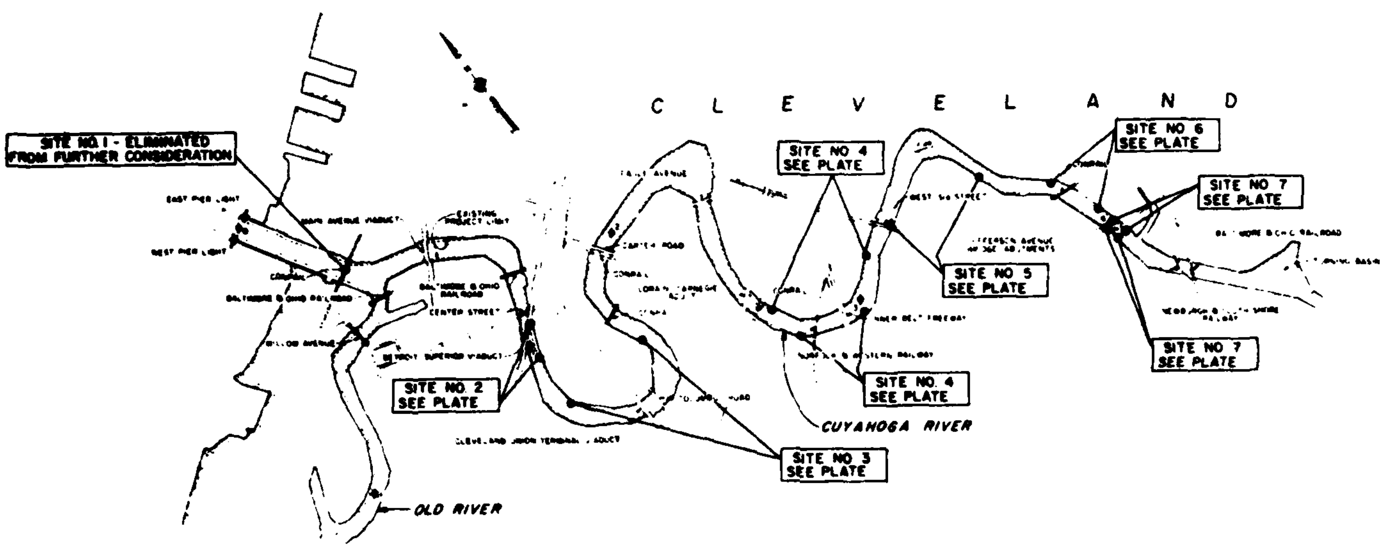
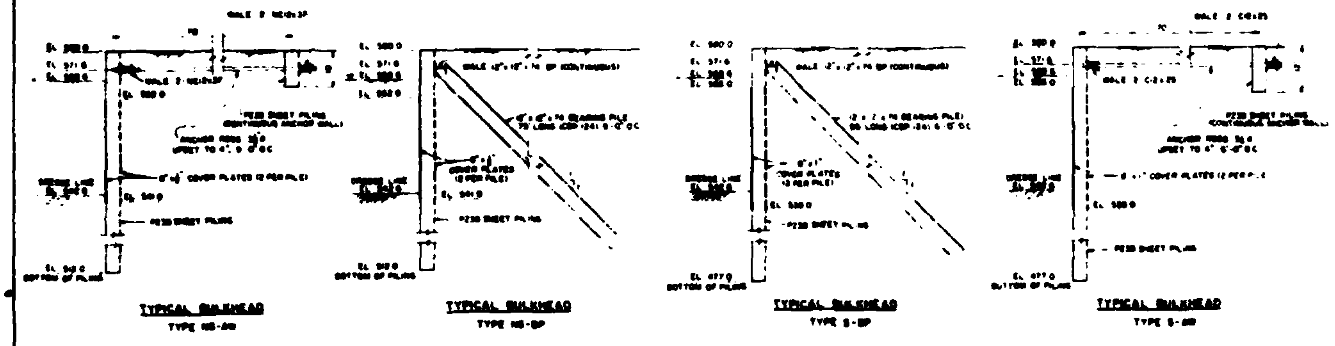

DEEPEN NAVIGATION CHANNEL TO 28 FEET
REPLACE EXISTING BULKHEAD (SEE SECTIONS 1-4 FOR DETAILS)
C L E V E L A N D
CUYAHOGA RIVER
OLD RIVER
EAST PIER LIGHT
WEST PIER LIGHT
CENTER STREET
DETROIT SUPERIOR VIADUCT
CARTER ROAD
LORAIN-CARNEGIE VIADUCT
COLUMBUS ROAD
INNER BELT FREEWAY
NORFOLK & WESTERN RAILWAY
WEST 3rd STREET
JEFFERSON AVENUE BRIDGE ABUTMENTS
BALTIMORE & OHIO RAILROAD
NEWBURGH & SOUTH SHORE RAILWAY
CLARK AVENUE VIADUCT
EXISTING PROJECT LIMIT
DOCK BY OPERATOR
SHOWN THUS
ONTARIO STONE CORPORATION
ASHLAND PETROLEUM CORPORATION
INTERNATIONAL SALT COMPANY
ERIE LACKAWANNA ORE
HURON CEMENT
UNITED STATES STEEL
BALTIMORE & OHIO RAILROAD
GM SHIPYARD
ALPERT BROTHERS
MID CONTINENT COAL & COKE
CLEVELAND BUILDERS SUPPLY
SHELL OIL
TEXACO
CLIFTON CONCRETE COMPANY
GULF OIL
EVERLITE HOPPERS
REPUBLIC STEEL
J & L STEEL
DUPONT
UNITED STATES STEEL
FORD MOTOR COMPANY
MEDUSA CEMENT
CUYAHOGA LIME COMPANY
ALPHA CEMENT
LAKE ERIE ASPHALT PRODUCTS
LEGEND
20 MILES ABOVE WEST PIER LIGHT AT OUTER END OF WEST PIER
BRIDGES REQUIRING FENDER REPLACEMENT DUE TO RIVER DEEPENING (SEE SECTION 5 FOR DETAILS)
UTILITIES REQUIRING RELOCATION DUE TO RIVER DEEPENING
WESTERN UNION TEL - 4-4" PIPES
CITY OF CLEVELAND - BRIDGE CABLE
BALTIMORE & OHIO RAILROAD - 2 CABLES
STANDARD OIL CO - 3 PIPES
SUN OIL CO - 1 PIPE
NOTE
ALL DEPTHS ARE REFERRED TO LOW WATER DATUM EL 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD 1955) (INTERNATIONAL GREAT LAKES DATUM 1955)
SECTION 1
(TYPICAL BULKHEAD SECTION A-1)
SECTION 2
(TYPICAL BULKHEAD SECTION A-2)
SECTION 3
(TYPICAL BULKHEAD SECTION B-1)
SECTION 4
(TYPICAL BULKHEAD SECTION B-2)
SECTION 5
(BRIDGE FENDER DETAIL - VERTICAL SECTION)
DREDGE LINE
PZ38 SHEET PILE
COVER PLATES
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 6 (OPTION B)
DEEPEN CUYAHOGA RIVER
TO 28 FEET
U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE 9



CONGESTION AREAS UNDER CONSIDERATION



TYPICAL NEW BULKHEAD SECTIONS

LEGEND

MILES ABOVE WEST PIER LIGHT AT OUTER END OF WEST PIER SHOWN THUS 20

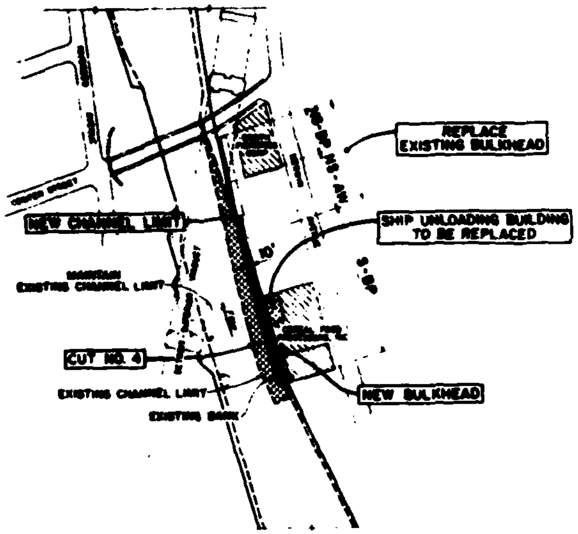
NOTE

ALL DEPTHS ARE REFERRED TO LOW WATER DATUM EL 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD 1955) (INTERNATIONAL GREAT LAKES DATUM 1955)

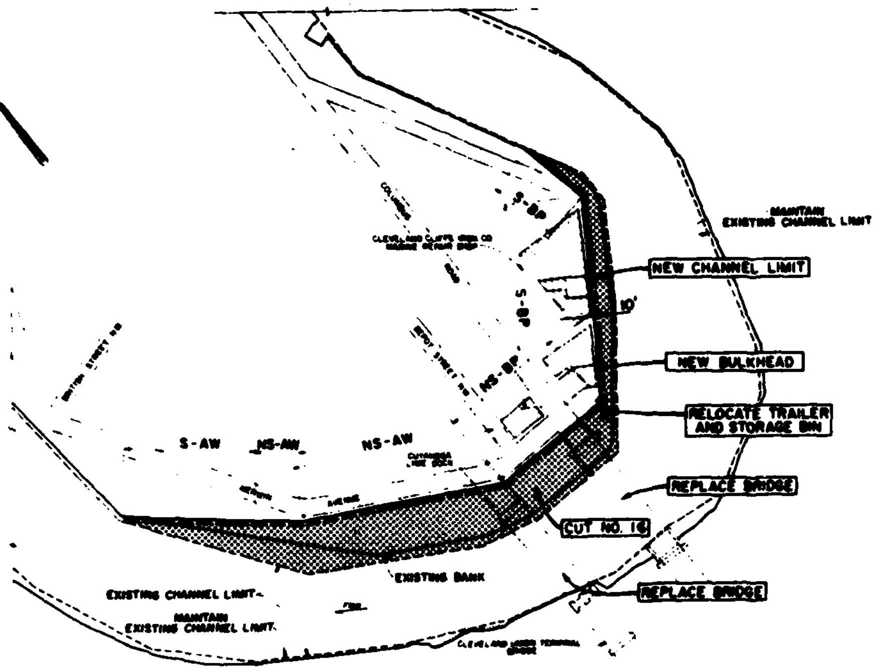
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
INDEX MAP AND
TYPICAL BULKHEAD SECTIONS
FOR ALTERNATIVE 7

U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE 10



SITE NO. 2
(ALTERNATIVE 7, OPTION B)



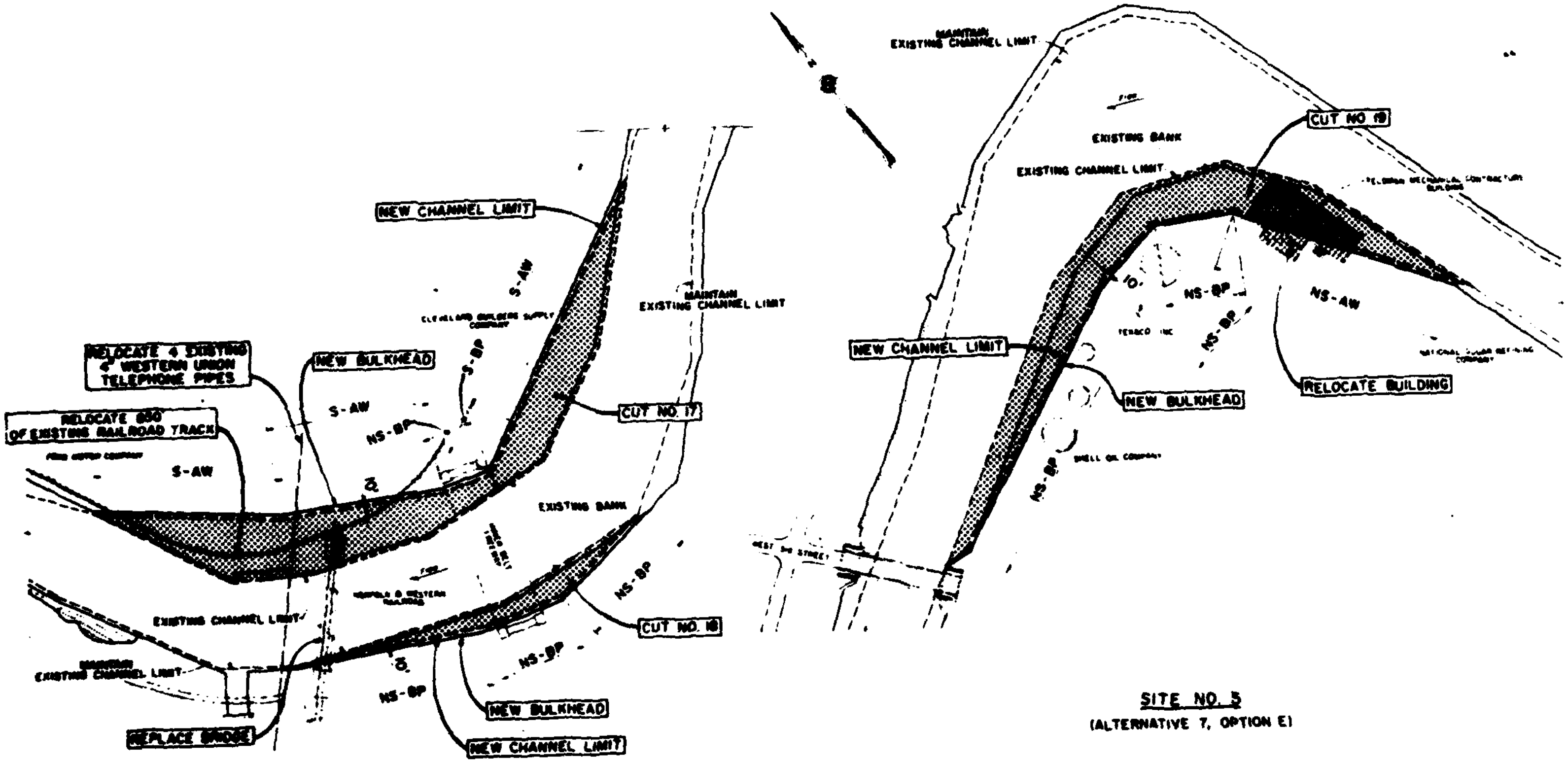
SITE NO. 3
(ALTERNATIVE 7, OPTION C)

NOTES:
1. SEE PLATE FOR TYPICAL BULKHEAD SECTIONS (TYPES S-AW, NS-AW, S-BP AND NS-BP)
2. ALL CUTS TO BE DREDGED TO 23 FEET LWD

SCALE OF FEET
300' 0 300' 600'

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 7 (OPTIONS B AND C)
REDUCE RIVER CONGESTION
U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE 11



SITE NO. 5
(ALTERNATIVE 7, OPTION E)

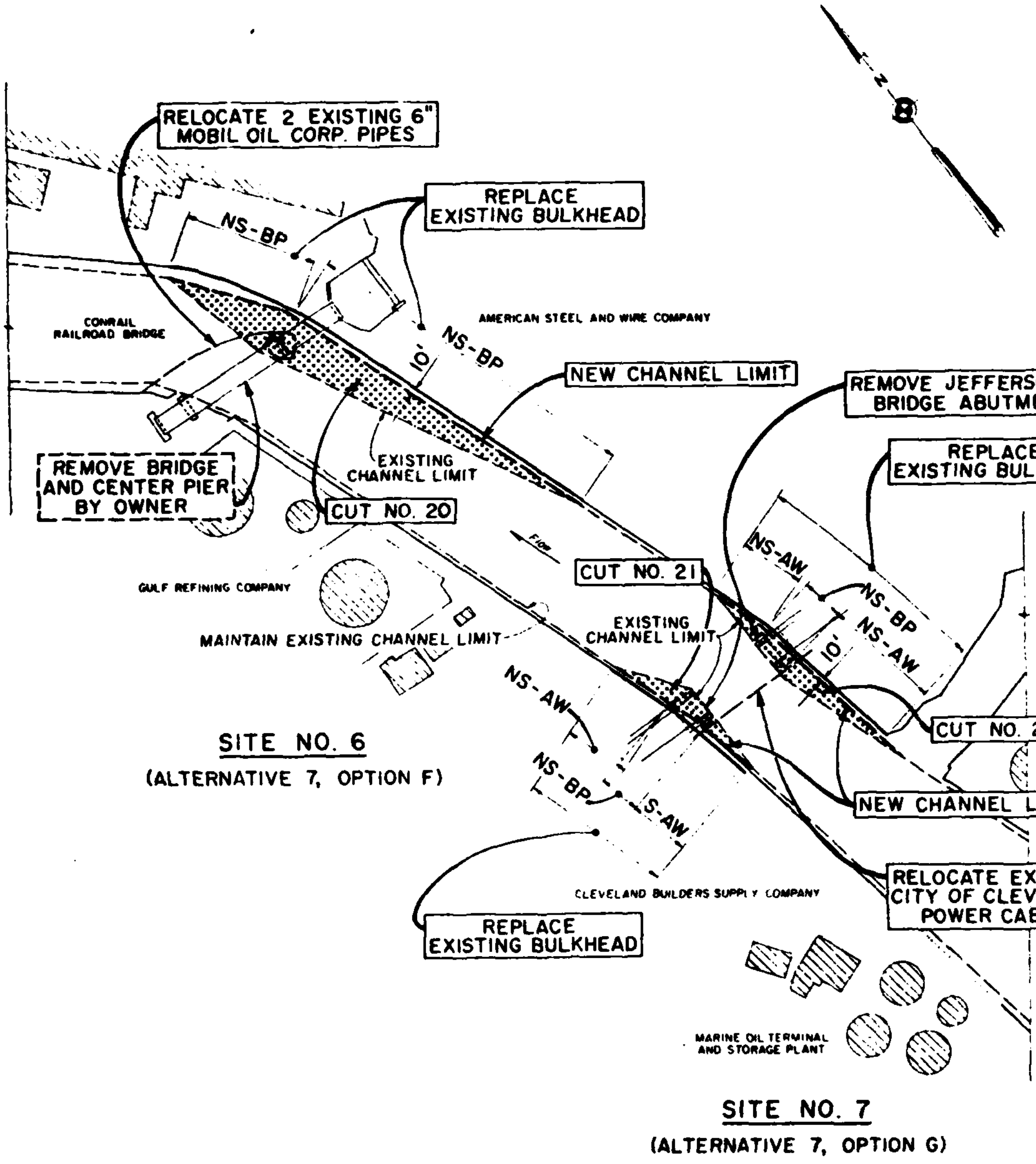
SITE NO. 4
(ALTERNATIVE 7, OPTION D)

NOTES:
1. SEE PLATE FOR TYPICAL BULKHEAD SECTIONS (TYPES S-AW, NS-AW, S-BP AND NS-BP)
2. ALL CUTS TO BE DREDGED TO 23 FEET LWD

SCALE OF FEET
300' 0 300' 600'

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 7 (OPTIONS D AND E)
REDUCE RIVER CONGESTION
U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE 12



NOTES:

1. SEE PLATE FOR TYPICAL BULKHEAD SECTIONS (TYPES S-AW, NS-AW, S-BP AND NS-BP)
2. ALL CUTS TO BE DREDGED TO 23 FEET LWD

SCALE OF FEET

300' 0 300' 600'

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

ALTERNATIVE 7 (OPTIONS F AND G)

REDUCE RIVER CONGESTION

U S ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE 13

DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

REFERENCE OR OFFICE SYMBOL	SUBJECT
NCBED-PW	Cleveland Harbor Phase I GDM - Meeting with Cleveland - Cuyahoga County Port Authority

XX THRU: Ch, Engr Div
District Engr

FROM Chief, Western Basin DATE 5 Mar 80 CMT 1
Zorich/ml/2261

TO: Project Files

1. Subject meeting was held at the offices of the Port Authority on Tuesday 26 February 1980 at the request of Albert Bernstein. A list of meeting attendees is attached.

2. Mr. Bernstein made introductory remarks welcoming and thanking all for their attendance. He stated his interest in establishing the direction the Corps was going with the Cleveland Harbor study and turned the meeting over to Colonel Johnson to brief the group on past and future activities on the study.

3. Colonel Johnson noted we are on schedule with the study according to the 2 - phase authorization from Section 175 of the 1976 WRDA. The major problem with accomplishing our authorizing directive is the controversy that exists between local interests regarding the East or West entrance to Cleveland Harbor as the "main entrance" for the proposed modified harbor project. At the most recent meeting of 19 December 1979 with locals, there was strong concern that we not sacrifice the possibility of improvements to the West Entrance by indiscriminate concentration on improvements to the East Entrance. Considerable discussion at the 19 December meeting centered on various revisions of legislation now in Congress and changes that might be suggested to preclude total concentration on the East Entrance. Colonel Johnson interjected that maybe the group should separate their short-term goals (apparently improvements to the East Harbor because it provides the shortest time-frame to construction) from their long-term goals. What we need to know from local interests are their long-term objectives and futures for Cleveland.

4. Mr. Bernstein noted that when the previous studies were done (Feasibility Study in 1976-77), it seemed that locals were in unanimous agreement for improvements to the East Entrance. Now we're back to various factions opting for East or West Entrance.

5. Bill Calfee, Authority Counsel, stated that we must identify the particular interests at Cleveland Harbor in order to establish specific needs. These interests are:

a. Shippers

b. Lake Carriers

c. Unions - Don't know their position.

d. Port Authority Board - Interested in developing port for steel industry as much as anything. Are interested in having Dock 20 for bulk commodity transshipments.

e. Conrail - Don't know what they have in mind.

f. National Steel (Hanna) - Also don't know what they propose for C & P Dock.

His impression was that the 19 December meeting was on straightening the river and not concerned about the entrance. The meeting centered on the entrance controversy and feels we are now back to point "zero". He also interprets that Corps wants to go with East Entrance and is concerned that we aren't moving ahead with that project.

Exhibit G-6

NCBED-PW
SUBJECT: Cleveland Harbor Phase I GPM - Meeting with Cleveland - Cuyahoga County Port Authority

6. Colonel Johnson stated his surprise that the Port Authority did not state its concern about the entrance question at the 19 December meeting.

7. Jack Hively provided his impression of the 19 December meeting stating that Admiral Trimble noted the changed condition at Dock 20 with Republic's decision to go to Lorain, and with the need for immediate improvements eliminated, we should look at the West Entrance option closer. The Port Authority supported the East Entrance. Mr. Hively stated he didn't know Cleveland Growth Assn. (F. Unger and J. Stanton) position on the entrance.

8. Don Liddell provided his recollection of the 19 December meeting. Corps stated we would probably be oriented toward the plan that provides the greatest net benefits and strongest B/C ratio. The information we have indicates the East Entrance most probably meets these criteria. Corps will look at the most promising West Entrance configurations, but we don't think massive (costly) changes are warranted based on the cost of East Entrance improvements. Colonel Johnson noted that there appeared to be a unanimous preference for the West Entrance option at the 19 December meeting, if there would be no cost constraints. Position seemed to be why move fast for East Entrance when there is no time constraint with Republic opting for Lorain. Jack Hively stated that although there is not a time crunch now, the Port Authority still supports the East Entrance until additional information and considerations changes the situation, and the Port Authority as local cooperator is now involved in coordination with the Corps and industry. Regarding the 19 December meeting, Don Liddell noted that there is a difference of opinion on the preferred entrance among users - apparently the shipper-users and Lake Carriers want the West Entrance because it provides the shortest distance to the docks while the ship masters preferred the East Entrance. The fact four or five 1,000 footers have entered Cleveland Harbor last year can possibly change the "base case" to 1,000 footers, thus reducing the project benefits. Therefore, if we go ahead and construct the East Entrance, it may be that there would be insufficient excess benefits to do much at the West Entrance.

9. Colonel Johnson on Corps Activities. We are proceeding assuming that we don't have authorization to construct the East Basin. This means we're proceeding along the "long route" to construction. If we get construction authorization, the East Basin Entrance could be constructed in 1-1/2 to 2 years, but such action would preclude major modifications to the West. Colonel Johnson further noted that if the construction authorization isn't forthcoming, this would allow the local sponsor (Port Authority) sufficient time to reevaluate the desired Entrance location. Jack Hively said the Port Authority will contact industry and other affected interests with the goal of getting a unified position on Entrance preference from the Port Authority based on input obtained. Colonel Johnson then asked the Port Authority to obtain information from industry on its plans to build transsphipment. This information will be of value on our reevaluation of project benefits. He also stated that if the Port Authority opts for the East Entrance, the Port Authority should provide the rationale for this selection since the development in conjunction with Republic Steel is no longer viable.

10. Sheldon Schecter asked if the Corps prefers the West Entrance at this time. Colonel Johnson responded that we have no preference and we can't decide until we get the Port Authority's position based upon industry input and reevaluate the project economics.

11. Vic Anderson of the Lake Pilots Association stated his concern that the Assn. hadn't been contacted to see if they would be interested in testing the ship model at WES. The

NCBED-PW
SUBJECT: Cleveland Harbor Phase I GDM - Meeting with Cleveland - Cuyahoga County Port Authority

Association would like to be given consideration for assisting with the testing. Don Liddell agreed that this is a worthwhile suggestion and we would be contacting LCA on this matter. The Corps would prefer a Master who has operated 1,000-footers for this work. Don Liddell then briefed the group on the status of the model study at WES.

12. Mr. Bernstein closed the meeting at about noon and thanked all for attending and participating.

1 Incl
as

JOHN ZORICH
Chief, Western Basin

LIST OF ATTENDEES

Jack Saive	Cleveland Builders Supply
Bill McTaggart	Cong. Mary Rose Oakar
Ladd J. Anthony	US Senator Metzenbaum
Barbara J. Perry	US Senator John Glenn
Col. George P. Johnson	U.S. Army Corps of Engineer
Donald M. Liddell	Corps of Engineers, Buffalo
John Zorich	Corps of Engineers, Buffalo
John D. Baker	ILA
Vic H. Anderson	Lake Pilots Assoc.
Robert F. Selgan	ILA
Albert W. Bernstein	CCCPA
Martin J. Hughes	CCCPA
Sheldon D. Schecter	CCCPA
William L. Calfee	CCCPA Legal Counsel (Bakeo & Hastetlec)
John Riley	Charles A. Vanik's Office
Jack R. Hively	CCCPA
Anthony J. Russa	CCCPA
John J. Desmond	CCCPA
Harry D. Gard	CCCPA
Jill J. Hazel	CCCPA
Mary C. Sherman	CCCPA

DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

REFERENCE OR OFFICE SYMBOL	SUBJECT
NCBED-PW	Summary Minutes of Meeting with Ninth Coast Guard District - Cleveland Harbor Phase I GDM Study

TO Project Files FROM R. Aguglia DATE 24 Sep 81 CMT 1
Aguglia/ds/2263

1. On 16 September 1981 representatives of the Buffalo District and Ninth Coast Guard District met to discuss required aids to navigation for the various Outer Harbor improvement plans under consideration in the subject study. These improvement plans would provide for safe and efficient operation of 1,000-foot bulk cargo vessels at Cleveland Harbor. The following people were in attendance:

Lt. Craig Schnappinger - Ninth Coast Guard District
Robert Gasior - Ninth Coast Guard District
Richard Gorecki - Corps of Engineers
Richard Aguglia - Corps of Engineers

2. Based on discussions at this meeting, it was determined that the following aids to navigation would be required for the various plans under consideration. "Ball-park" estimates (on September 1981 price levels) for the first cost of construction and annual operation and maintenance costs were also developed. These estimates are considered reasonable for the current Stage 2 level of study.

a. Alternative Plan No. 1 ("All-Weather" East Entrance Plan - see Incl 1): No additional aids to navigation would be required and there would be no increase in annual operation and maintenance costs.

b. Alternative Plan No. 2 ("Fair-Weather" West Entrance Plan - see Incl 2): The existing aids to navigation on the end of the east and west arrowhead breakwaters will remain. New AGA - GRP Towers will be placed on the end of each new breakwater extension, at a cost of $50,000 each (including foundation). The existing aids to navigation on the ends of the spur breakwaters will be relocated, if the lights are in good shape. If the lights are not in good shape, new 20-foot standard pole lights will be required at the end of each spur, at a cost of $20,000 each (including foundation). For the Stage 2 estimate, assume new lights will be required. The total increase in maintenance and operation costs will be $500/year.

c. Alternative Plan No. 3 ("All-Weather" West Entrance Plan - see Incl 3): The existing aids to navigation on the ends of the spur breakwaters will be relocated, if the lights are in good shape. If not, new 20-foot standard pole lights will be required at the end of each spur, at a cost of $20,000 each (including foundation). For the Stage 2 estimate, assume new lights will be required. The existing lighthouse on the end of the west arrowhead breakwater will be removed - Corps to estimate removal cost. The lighthouse may be listed on the Federal Register of Historic Places - Corps will research this. A new 20-foot standard pole light will be required at the end of the remaining portion of the west arrowhead breakwater, at a cost of $20,000 (including foundation). A new structure will be required at the west end of the "L-shaped" breakwater. This new structure will house a navigation light, fog signal, radio beacon and electrical generator. The total cost (including structure, foundation, and new equipment) is $350,000. A new 20-foot standard light will also be required at the 90° angle of the "L-shaped" breakwater, at an estimated cost of $20,000 (including foundation). Therefore, the total cost for the aids to navigation for Plan No. 3 is $430,000, plus the cost to remove the existing lighthouse on the end of the west arrowhead breakwater. Additional O and M costs

Exhibit G-7

DA FORM 2496 REPLACES DD FORM 96, WHICH IS OBSOLETE.

NCBED-PW
SUBJECT: Summary Minutes of Meeting with Ninth Coast Guard District - Cleveland Harbor Phase I GDM Study

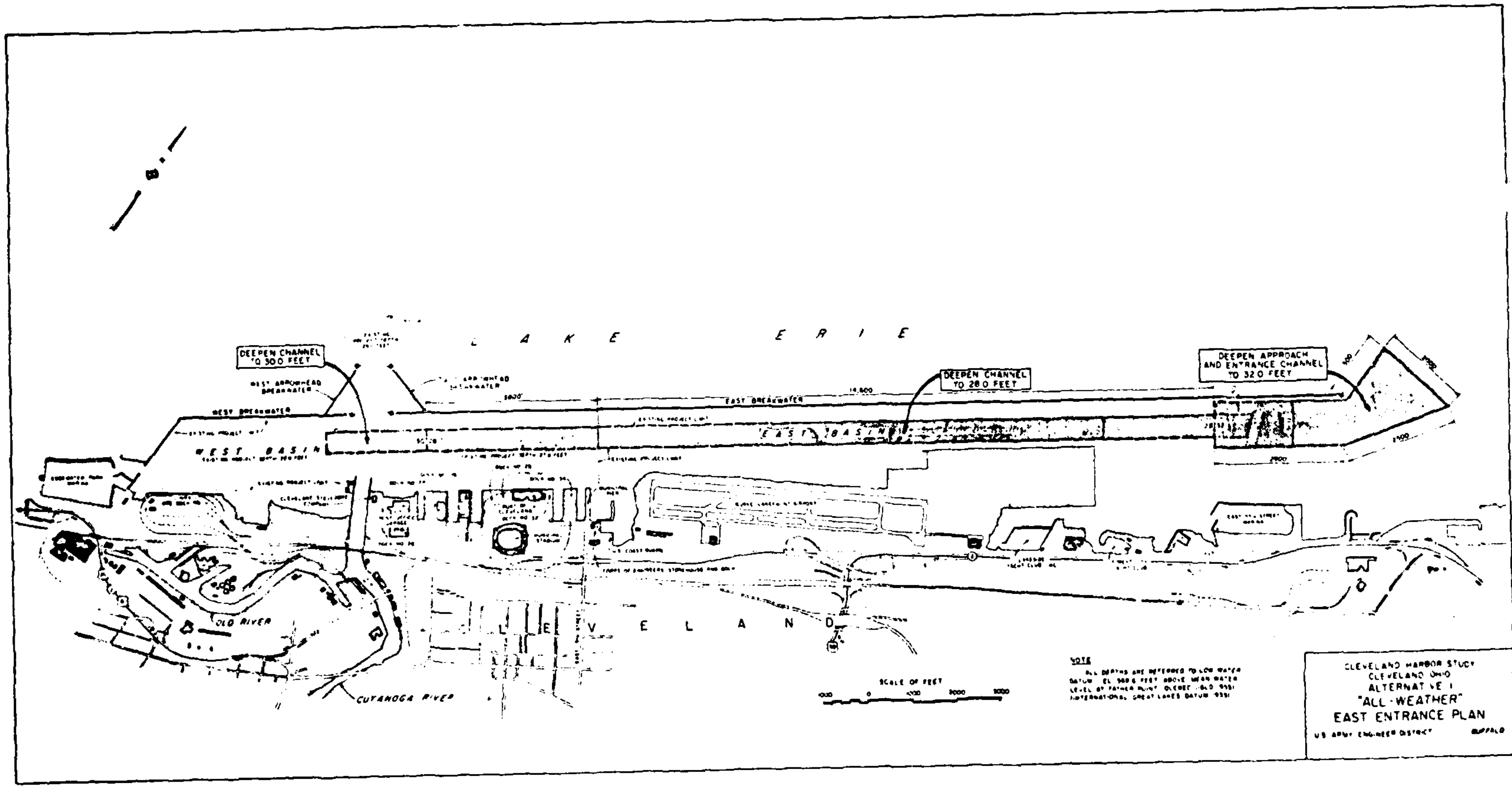
will be $500 per year. It was also stated that if model study tests currently being conducted at the Waterways Experiment Station indicate that the end of the new "L-shaped" breakwater should be offset from the existing east arrowhead breakwater, an additional 20-foot standard pole light will be required at the end of the "L-shaped" breakwater at a cost of $20,000 (including foundation).

3. Lt. Schnappinger and Mr. Gasior also requested copies of the Buffalo District Project Book (mailed 9/22/81) and to be placed on the mailing list to receive future project books.

4. The meeting then adjourned at 2:30 p.m.

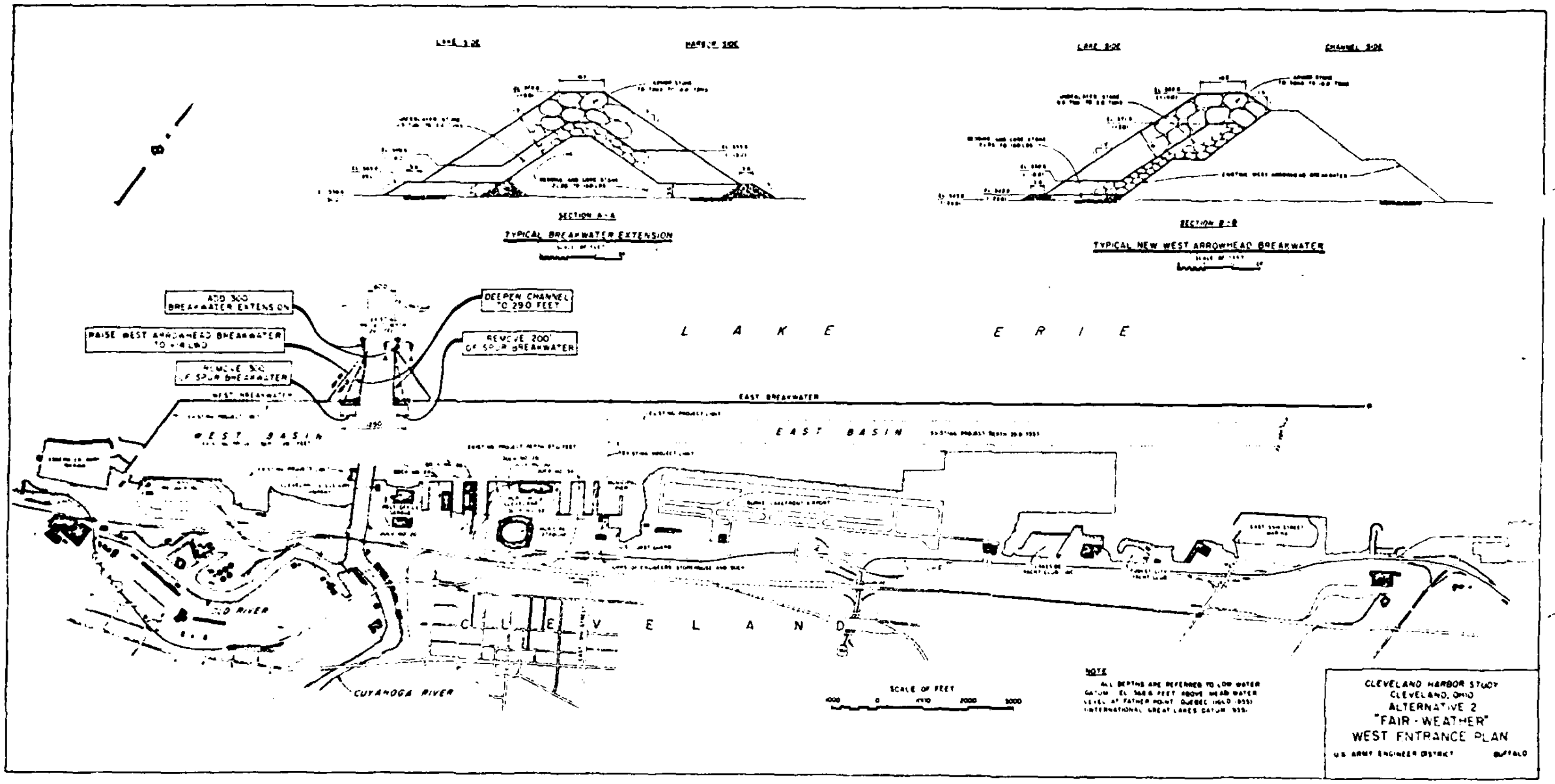
3 Incl
as stated

RICHARD AGUGLIA
Project Manager



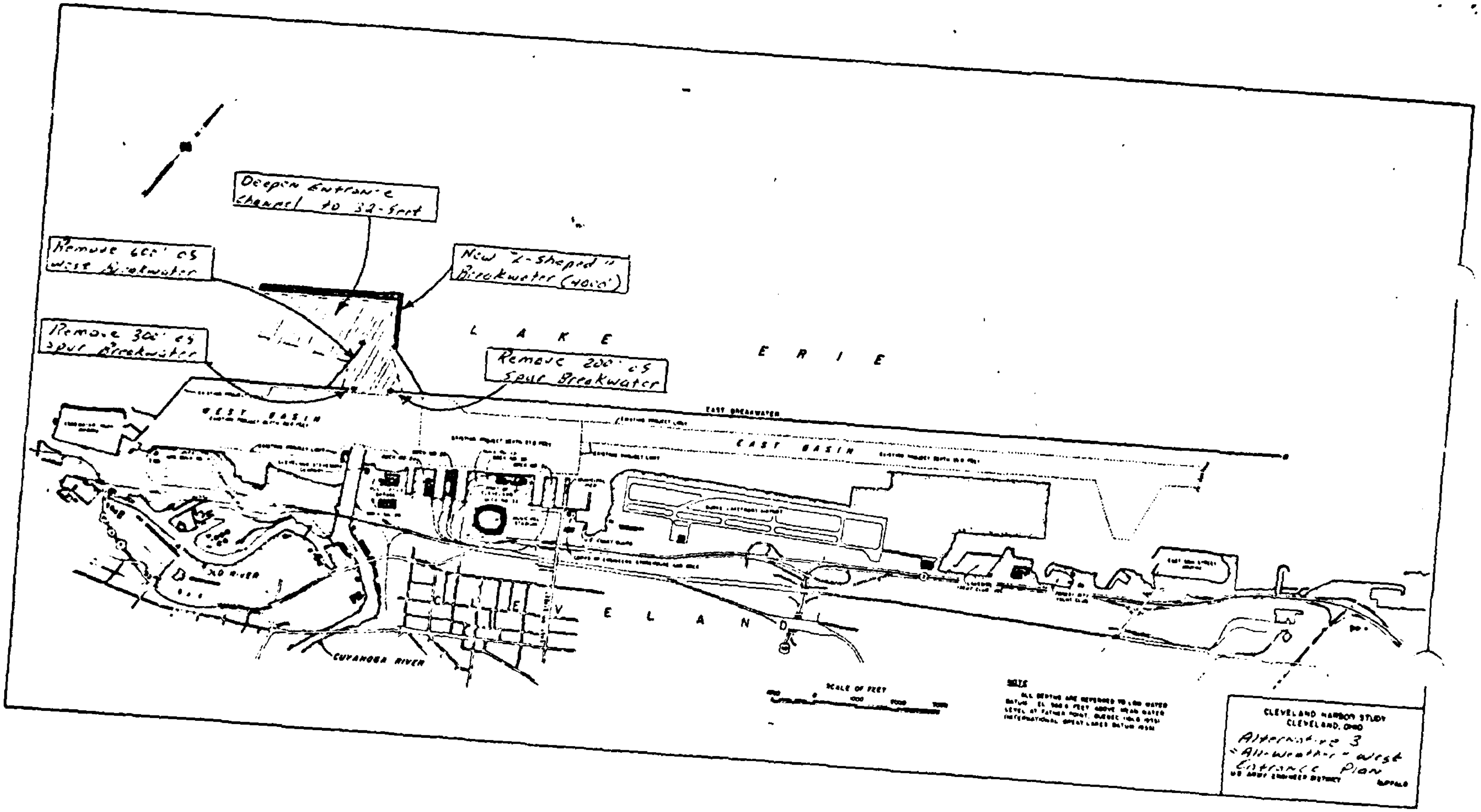
LAKE ERIE
DEEPEN CHANNEL TO 30.0 FEET
WEST ARROWHEAD BREAKWATER
WEST BREAKWATER
WEST BASIN
EAST BREAKWATER
DEEPEN CHANNEL TO 28.0 FEET
EAST BASIN
DEEPEN APPROACH AND ENTRANCE CHANNEL TO 32.0 FEET
CLEVELAND
OLD RIVER
CUYAHOGA RIVER
SCALE OF FEET
NOTE
CLEVELAND HARBOR STUDY
CLEVELAND OHIO
ALTERNATIVE 1
"ALL-WEATHER"
EAST ENTRANCE PLAN
U.S. ARMY ENGINEER DISTRICT BUFFALO

incl 1



SECTION A-A
TYPICAL BREAKWATER EXTENSION
SECTION B-B
TYPICAL NEW WEST ARROWHEAD BREAKWATER
ADD 300' BREAKWATER EXTENSION
RAISE WEST ARROWHEAD BREAKWATER TO +14 LWD
REMOVE 300' OF SPUR BREAKWATER
DEEPEN CHANNEL TO 29.0 FEET
REMOVE 200' OF SPUR BREAKWATER
L A K E E R I E
EAST BREAKWATER
WEST BREAKWATER
WEST BASIN
EAST BASIN
C L E V E L A N D
OLD RIVER
CUYAHOGA RIVER
SCALE OF FEET
1000 0 1000 2000 3000
NOTE
ALL DEPTHS ARE REFERRED TO LOW WATER DATUM, EL. 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD 1955) INTERNATIONAL GREAT LAKES DATUM 1955.
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 2
"FAIR-WEATHER"
WEST ENTRANCE PLAN
U.S. ARMY ENGINEER DISTRICT BUFFALO

Incl 2


Deepen Entrance channel to 32-feet
Remove 600' of west Breakwater
New "Z-shaped" Breakwater (4000')
Remove 300' of spur Breakwater
Remove 200' of spur Breakwater
LAKE ERIE
WEST BASIN
EAST BASIN
EAST BREAKWATER
CLEVELAND
CUYAHOGA RIVER
SCALE OF FEET
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
Alternative 3
"All-weather" west Entrance Plan
US ARMY ENGINEER DISTRICT
BUFFALO

Incl 3

NCBPD-WB 9 April 1982

MEMORANDUM FOR RECORD

SUBJECT: Summary Minutes of 15 March 1982 Workshop Meeting - Cleveland Harbor Phase I GDM Study

1. On 15 March 1982 a workshop meeting was held with the Ohio Department of Natural Resources (ODNR) the US Fish and Wildlife Service (F&WS) and the Buffalo District (NCB) via telephone conference call. The purpose of this meeting was to develop a plan to provide fishermen access to the west breakwater at Cleveland Harbor. The following people were in attendance:

Roger Hubbell - ODNR
Ken Multerer - F&WS
John Zorich - NCB
Roger Haberly - NCB
Robert Johnson - NCB
Dave Heicher - NCB
Dick Aguglia - NCB

2. John Zorich opened the meeting at 9:30 a.m. by welcoming all participants and reviewing the purpose of the meeting. Mr. Zorich then turned the meeting over to Dick Aguglia.

3. Mr. Aguglia reviewed the fisherman access plan that was developed during the Cleveland Harbor Feasibility Study conducted from 1972 to 1976. This plan (see Incl 1) consisted of: (1) 5,900 feet of pedestrian handrail on the west breakwater at Cleveland Harbor; (2) a pedestrian bridge spanning the gap in the west breakwater; and (3) upgrading the existing crushed stone parking area immediately east of Edgewater Marina. The estimated cost of this plan, on October 1981 price levels, is $2,120,000. Mr. Aguglia then stated that he would like to use this plan as the basis for formulating a fisherman access plan(s) to be evaluated in this Phase I Study.

4. Mr. Roger Hubbell stated that the ultimate fisherman access plan to recommend for construction would be dependent on the results of the Section 107 Study for Edgewater Marina. The purpose of this Section 107 Study is to determine the feasibility of modifying Edgewater Marina for wave reduction in the existing small-boat docking area and for expansion of this small-boat docking area. Two alternatives are presently under consideration. The first alternative assumes, among other things, that the existing entrance to Edgewater Marina from Lake Erie (see Fig 2 of Incl 1) is completely blocked off with construction of a new breakwater extending from the east end of the north breakwater of Edgewater Marina to the west breakwater of Cleveland Harbor. A new gap would then be provided in the west breakwater, approximately 500 feet north of this new breakwater. Small boats would enter the west basin of Cleveland Harbor through this new gap and would continue into Edgewater Marina through the existing gap in the west breakwater. The second plan assumes, among other things, that only minor modifications to the existing entrance are required and it continues to serve as the main entance to Edgewater Marina. However, funds to initiate this Section 107 Study have

not been provided and it is not known when this study will begin. Thus, two fisherman access plans will have to be developed during the Cleveland Harbor Phase I Study. The first plan (designated Plan 8A) will assume the existing entrance to Edgewater Marina is completely closed off and a new gap is provided in the west breakwater of Cleveland Harbor. The second plan (Plan 8B) will assume the existing entrance to Edgewater Marina is only slightly modified and continues to serve as the main entrance to the marina. However, selection of the final fisherman access plan to recommend for construction, if justified, must await the results of the Section 107 Study.

5. A general discussion then ensued on the components of each plan. The main points of this discussion follow:

a. Plan 8A.

(1) Fishermen facilities will be provided on the new breakwater which closes off the existing entrance to Edgewater Marina (approximately 1,000 feet) and on the west breakwater of Cleveland Harbor to the new gap (approximately 500 feet). Fishermen facilities will be similar to those currently being provided by ODNR on the north breakwater of Edgewater Marina. (NOTE: ODNR will provide NCB with copies of these plans.)

(2) There will be no need for a predestrian bridge spanning the gap in the west breakwater. Access to the new breakwater will be from the north breakwater of Edgewater Marina which connects into land to the west of Edgewater. (Note: It was also decided not to provide a pedestrian bridge which would span the new gap in the west breakwater and thus allow fisherman access to the remaining west breakwater at Cleveland Harbor. The reason for this decision was that this bridge would have to be about 85 feet high in order to provide sufficient vertical clearance for sailboats entering Edgewater Marina and it was thought that this high of a bridge would present unacceptable safety risks to fishermen.)

(3) Parking and restroom facilities for fishermen will be provided by expanding parking and restroom facilities currently being constructed by ODNR in conjunction with their fishermen access plan for the north breakwater of Edgewater Marina. ODNR will provide NCB with copies of their construction plans.

b. Plan 8B.

(1) Fishermen facilities (pedistrian handrail) will be provided on the west breakwater of Cleveland Harbor out to the lighthouse on the end of the west arrowhead breakwater (approximately 6,000 linear feet). Even though the demand analysis conducted by NCB indicated that there is sufficient demand to completely fill this length of breakwater on peak days, ODNR questioned

whether this full length would be utilized since fishermen would have to walk over a mile to get out to the west arrowhead breakwater. NCB will look into fishermen utilization at other breakwaters in the District that have fisherman access to see if they are used to capacity. ODNR will also check on the results of their creel survey along Lake Erie which they conducted a few years ago to see if this information would answer their concern. For Stage 2, we will assume that the total length will be utilized on peak days.

(2) A pedestrian bridge will be provided to span the gap in the west breakwater. ODNR will check on the vertical clearance that must be provided by this bridge and will provide this information to NCB. It was also noted that since this plan assumes that the existing entrance to Edgewater Marina is only slightly modified and continues to be the main entrance into the marina, it may be possible to construct this pedestrian bridge level with the west breakwater. ODNR will also check on this possibility. (NOTE: Via telephone call on 6 April 1982, ODNR stated that this pedestrian bridge should be constructed level with the west breakwater.)

(3) Based on NCB's experience at other locations where fisherman access is provided on breakwaters, it was decided that safety platforms on the west breakwater would be required. These safety structures would consist of platforms elevated above the west breakwater and would protect fishermen, trapped on the breakwater during stormy weather, from being washed off the breakwater by over-topping waves. The spacing and size of these platforms will depend on such factors as how quickly waves are generated, the frequency of overtopping waves, the cost of the safety platforms, etc. ODNR also stated that they think these platforms should have a total capacity to accomodate about 50 percent of the number of fishermen expected to fish off the breakwaters on a peak day.

(4) ODNR also stated that the area that was to be developed for parking, as formulated in the feasibility study, is no longer available since ODNR does not anticipate closing the launching ramps located immediately north of this area. ODNR will send NCB a plan of the area outlining possible parking sites.

(5) ODNR also stated that the existing restroom facilities for Edgewater Marina are not sufficient for the marina and will have to be replaced and expanded, although they do not presently have plans developed for this expansion. Since the fisherman access plan developed during the feasibility study assumed that these restroom facilities would be sufficient to accommodate increased usage from fishermen, additional restroom facilities will have to be included in Plan 8B. For Stage 2, we will assume that ODNR has replaced the existing restroom facilities for Edgewater Marina at their present location and that we will have to further expand these facilities to accomodate increased usage from fishermen. The cost of this additional expansion would be changed to the fisherman access plan. NCB will check into design criteria for sizing restroom facilities and will provide ODNR with this information.

NCBPD-WB
SUBJECT: Summary Minutes of 15 March 1982 Workshop Meeting - Cleveland Harbor Phase I GDM Study

c. Handicap Access - ODNR stated that for both plans, consideration must be given to providing facilities for the handicapped. However, it was noted that for Plan 8B, which includes a predestrian bridge, this may not be possible. Irregradless, ODNR is planning on providing fishing facilities for the handicapped on the north breakwater at Edgewater Marina.

d. Ken Multerer stated that we may have to provide a fish habitat area off the breakwater where fisherman access is provided in order to attract sufficient numbers of desirable sport fish. This habitat area would consist of dumped stone rubble about 2 feet thick and 50 to 100 feet wide along the entire length of the accessable breakwater. For Stage 2, we will assume that this fish habitat area is not required. We will check this assumption by conducting a four seasons survey in Stage 3. Ken also stated that their fisherman space standard is one fisherman every 10 feet and they would expect fishermen to fish off both sides of the breakwater.

6. Following this discussion, John Zorich thanked all participantss for their input and adjourned the meeting at 11:30 a.m.

1 Incl
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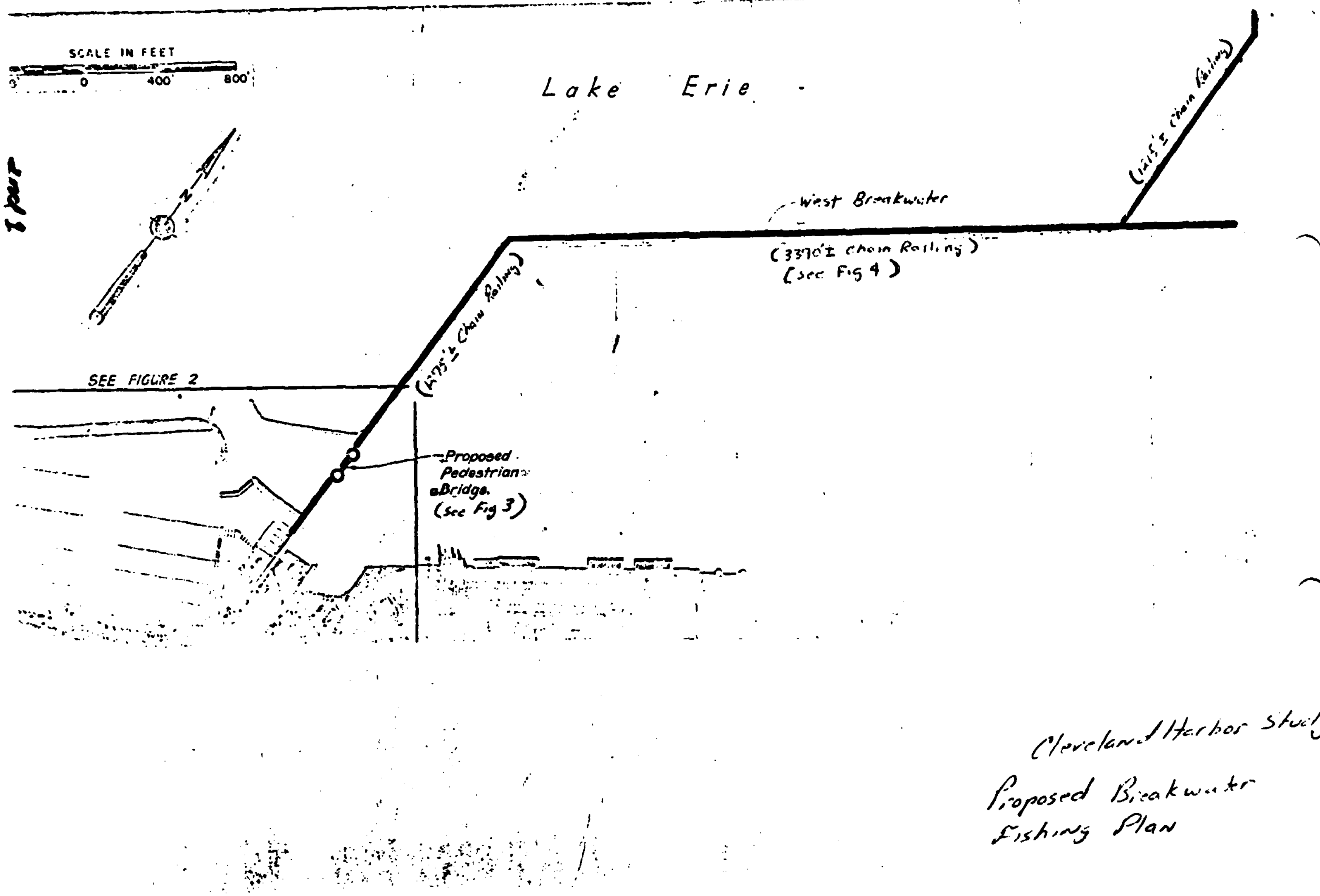
RICHARD AGUGLIA
Project Manager

Figure 1

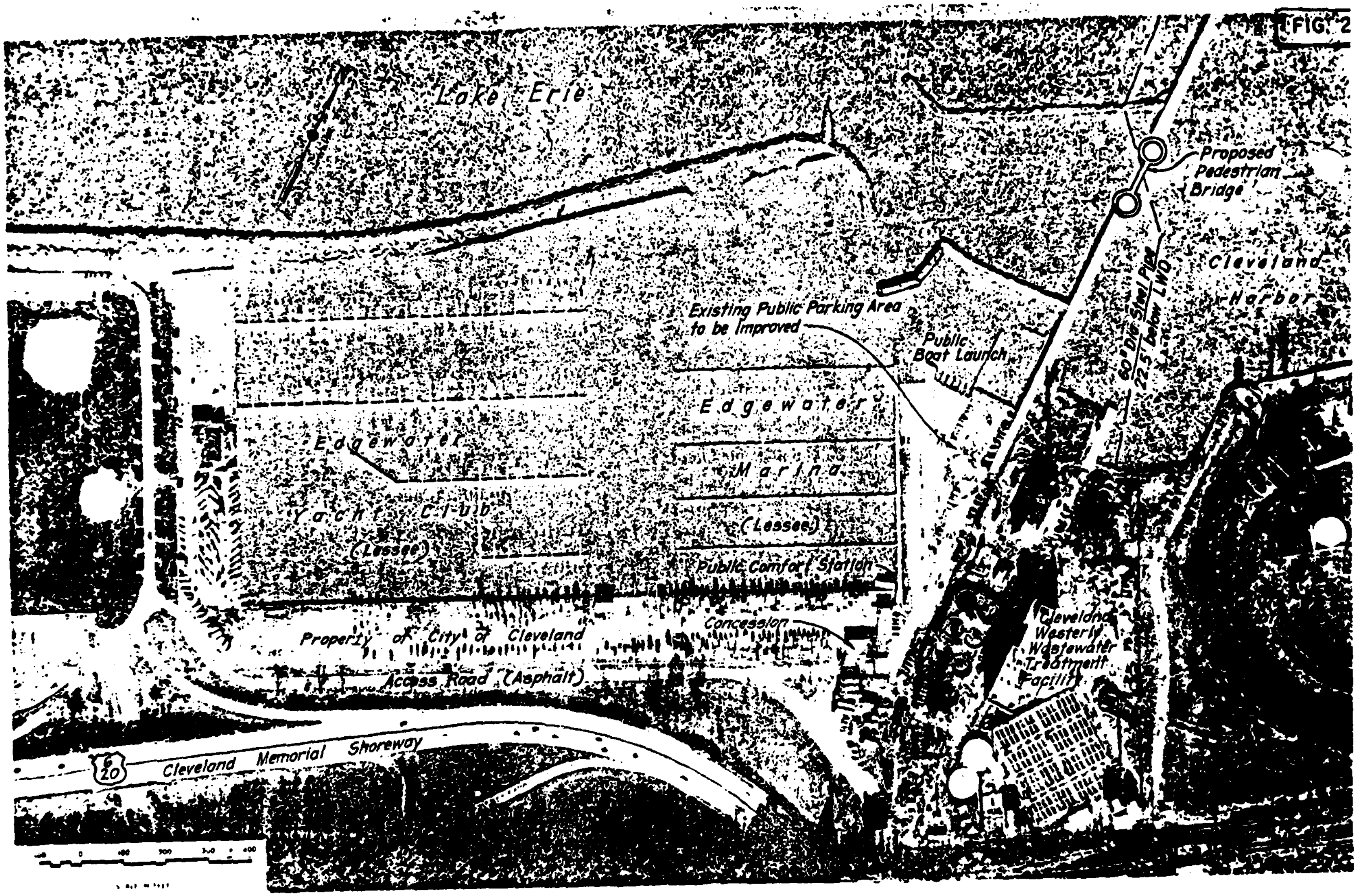


Incl 1

Cleveland Harbor Study

Proposed Breakwater Fishing Plan

FIG. 2



Lake Erie
Proposed Pedestrian Bridge
Cleveland Harbor
60" Dia Steel Pipe 22.5' below LWD
Existing Public Parking Area to be Improved
Public Boat Launch
Edgewater Marina
(Lessee)
Public Comfort Station
Concession
Edgewater Yacht Club
(Lessee)
Property of City of Cleveland
Access Road (Asphalt)
Cleveland Westerly Wastewater Treatment Facility
Cleveland Memorial Shoreway
20

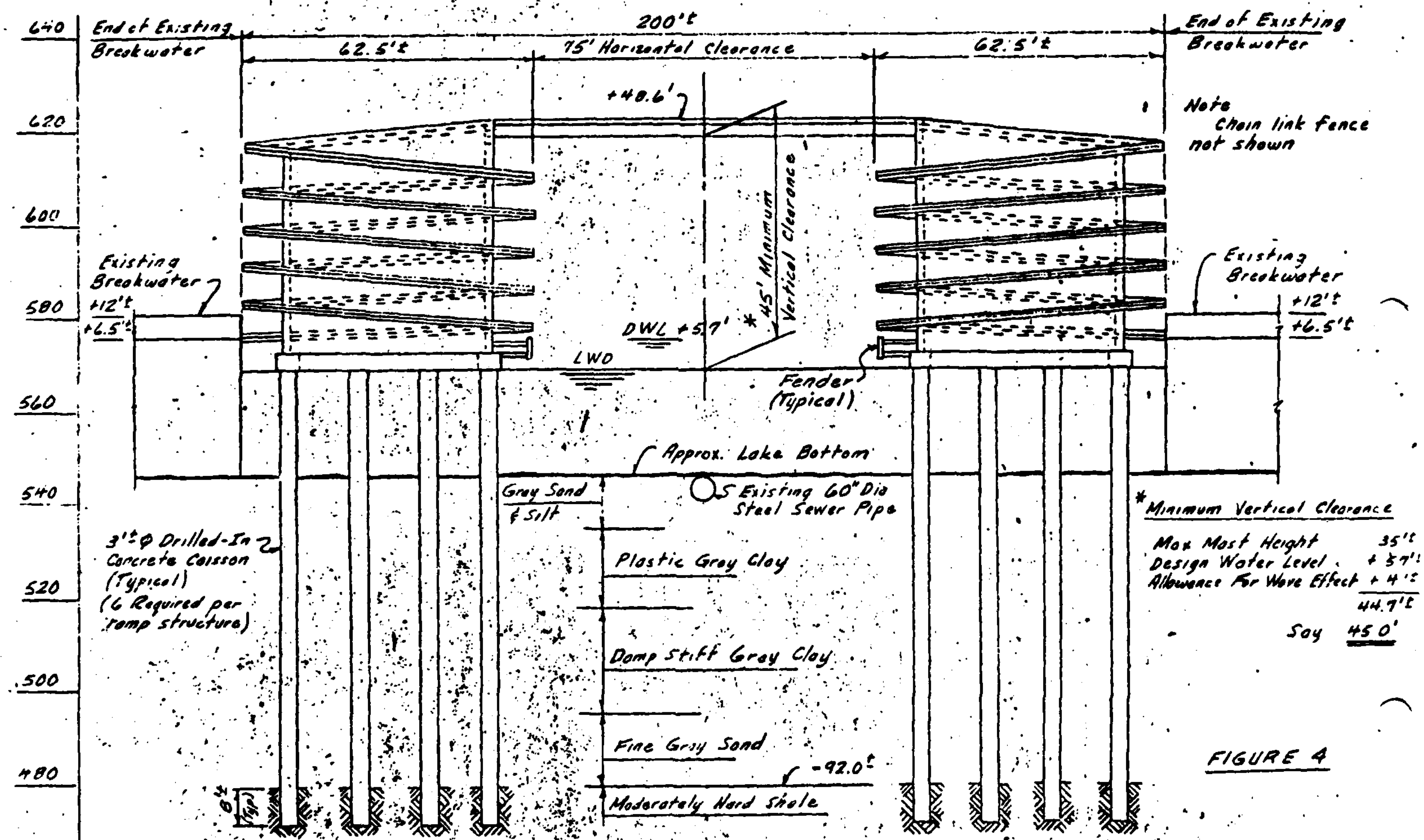
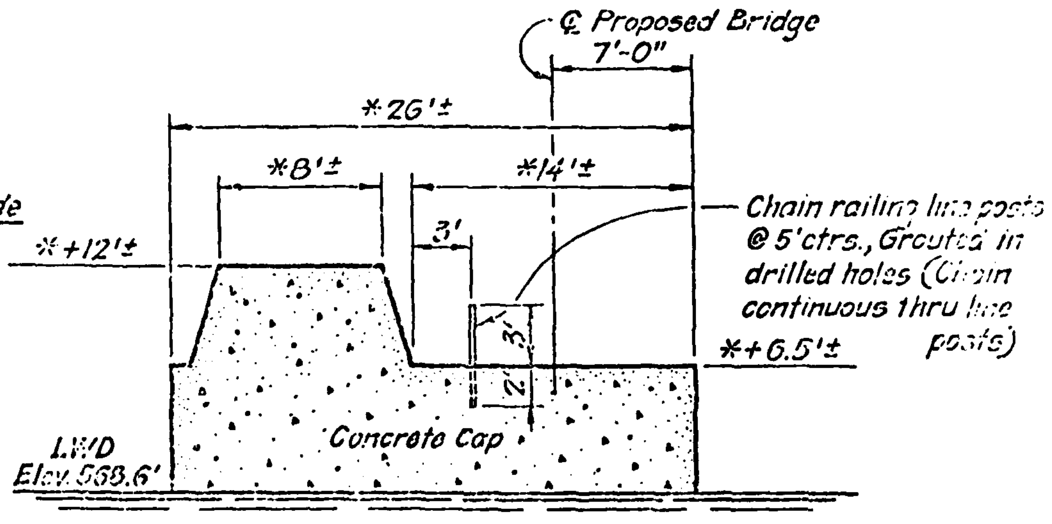


Fig. 3 ELEVATION - PROPOSED PEDESTRIAN BRIDGE
Scale: 1"=20'

FIGURE 4

FIG. 4

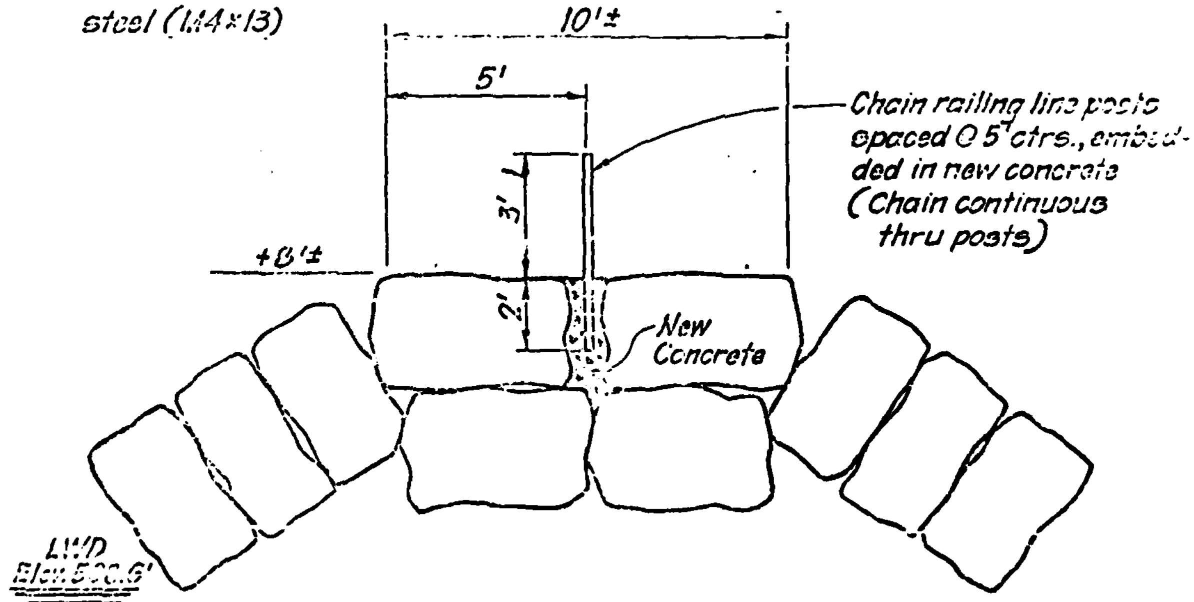


* Based on field measurements

Note: Line posts to be Galv. structural steel (M4×13)

WEST BREAKWATER

Scale: ⅛"=1'-0"



WEST ARROWHEAD BREAKWATER

Scale: ¼"=1'-0"

TYPICAL SECTIONS - EXISTING BREAKWATERS

(SHOWING PROPOSED CHAIN RAILING)

APPENDIX H
REPORTS OF OTHERS

CLEVELAND HARBOR, OHIO

STAGE 2 REPORT
OF
REFORMULATION PHASE I GENERAL DESIGN MEMORANDUM

U.S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, NY 14207

APPENDIX H
REPORTS OF OTHERS

Exhibit	Description
H-1	U.S. Fish and Wildlife Service, 24 June 1981 Planning Aid Letter
H-2	U.S. Fish and Wildlife Service, 3 June 1982 Intermediate Report

United States Department of the Interior

FISH AND WILDLIFE SERVICE

IN REPLY REFER TO:

East Lansing Area Office
Manly Miles Building, Room 202
1405 South Harrison Road
East Lansing, Michigan 48823

JUN 24 1981

Colonel George P. Johnson
District Engineer
U. S. Army Engineer District
Buffalo
1776 Niagara Street
Buffalo, New York 14207

Dear Colonel Johnson:

This planning aid letter on proposed Cleveland Harbor modifications is provided in accordance with obligations of the U. S. Fish and Wildlife Service per the FY-1981 Fish and Wildlife Coordination Act Agreement with the Buffalo District, Corps of Engineers. Section 175 of the Water Resources Development Act of 1976 (PL 587, 94th Congress) authorized the phase I design memorandum stage of advanced engineering and design for harbor modifications at Cleveland, Ohio, in accordance with the District Engineers' June 1976 feasibility report.

This letter has been prepared under the authority of and in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), in compliance with the intent of the National Environmental Policy Act of 1969, and the Endangered Species Act of 1973, as amended.

I. Project Proposal

The proposed Cleveland Harbor modifications recommended in the June 1976 feasibility report as stated in the Classification Report and Plan of Study for Cleveland Harbor (Corps of Engineers, revised October 1979) consist of: (1) extending and deepening lake approach channels at both entrances; (2) deepening the east basin channel and west entrance; (3) removing portions of the west entrance breakwaters; (4) constructing a breakwater extension on the east end of the existing east breakwater; (5) constructing a diked disposal area, if required; and (6) installation of recreational fishing facilities on the west breakwater.

Additional activities under the phase I reformulation investigation will consider: (1) 1,000-foot vessel operation and refuge in the lakefront harbor; (2) deepening the navigation channel to 27 feet in the Old River channel; (3) authorized but incompleted bridge replacements and associated bank cuts on the Cuyahoga River and Old River channel; (4) deepening the lower 5.8 miles of the Cuyahoga River from 23 feet to 27 feet; (5) recreational fishing from harbor structures; and (6) vessel congestion on the Cuyahoga River.

II. Description of Area

The Cleveland Harbor area, protected by the breakwaters, is five miles long and 1,600 to 2,400 feet wide for a total area of approximately 1,300 acres. Improved and dredged channels are maintained in the lower 5.8 miles of the Cuyahoga River and the lower mile of Old River. The lake approach channel is maintained at a depth of 29 feet. The outer harbor is 28 feet deep up to the mouth of the Cuyahoga River. The lower Cuyahoga River channel is 27 feet deep up to the junction of Old River and 23 feet deep upstream to mile 5.8. The maximum flow of the Cuyahoga River is 24,800 cfs and minimum flow is 14.0 cfs.

A. Water Quality

In general, water quality deteriorates from west to east across the harbor area and improves with distance from the shore. The localized areas of water quality degradation are associated with sources of waste discharge near the mouth of the river and near wastewater treatment plants. Another area of depressed water quality is along the lake side of the east breakwater where dredge spoils were dumped until several years ago. During the summer months and other low flow periods, the dissolved oxygen content of the Cuyahoga River in the lower reaches and pooled areas is zero. At that time, over eighty percent of the river's flow is inadequately treated domestic sewage (U.S. Environmental Protection Agency 1976, U. S. Army Corps of Engineers 1978). The pollution in this area is complicated by decreased water velocity which results from the dredging of the channel (Bently et al. 1975).

B. Benthos

Approximately 50 species of benthic macroinvertebrates have been reported in the Cleveland nearshore zone (Table 1). These organisms serve as a food source for many species of fish in the harbor. The majority of the benthic fauna are composed of aquatic oligochaetes (Pliodzinkas 1979). The Army Corps of Engineers (1978) also found abundant populations of mobile macrobenthic invertebrates, including crayfish, amphipods, and isopods in the river channel and harbor. These mobile benthic fauna prefer, and may be restricted to, rocky substrate including breakwalls where abundant growth of the plant, Cladophora, occur. During summer 1975, 1,076 amphipods/M^2 were sampled from the breakwall area (U. S. Army Corps of Engineers 1978).

Phytoplankton crops in Lake Erie have greatly increased in the last 50 years, indicating increased eutrophication. Pronounced spring and fall pulses of phytoplankton occur in the Cleveland Harbor. The dominant species are diatoms, including Asterionella spp., Melosira spp., and Fragilaria spp. Green and blue-green algae also contribute to phytoplankton blooms in the harbor (Hartley and VanVooren 1977, U. S. Army Corps of Engineers 1978).

Zooplankton populations appear to peak with high concentrations in the fall. The most abundant zooplankton in Cleveland Harbor include Rhizopoda, Rotifera, Cladocera, and Copepoda (U. S. Army Corps of Engineers 1978).

C. Terrestrial Vegetation

Upland vegetation in the Cleveland Harbor area is severely limited. There are some trees, vines, and shrubs along the west side of Irishtown Bend on the lower Cuyahoga River, between bridges 5 and 8. The eastern end of Whiskey Island and the filled diked disposal areas are also partially vegetated with grasses, shrubs, and small trees (U. S. Army Corps of Engineers 1978).

D. Fish

Fish populations of the Cleveland area are under great stress from degradation of the ecosystem. Pollution, siltation, and loss of aquatic vegetation are factors that have affected Cleveland fish fauna (White et al. 1978). Table 2 lists those species of fish collected in Cleveland Harbor and adjacent marinas, 1972-1974. Common emerald shiner, eastern gizzard shad, and yellow perch are the most abundant species in the harbor. The yellow perch is the most important species in terms of contribution to the commercial and sport harvest. Both coho and chinook salmon, which occur in the harbor, are stocked in the Chagrin River (White et al. 1975).

White et al. described the following as principal fish nursery zones in the Cleveland area: the mouth, lower one mile, and adjacent shoreline of the Rocky River; the mouth and adjacent shoreline of the Chagrin River; and the Cleveland Harbor and adjacent marinas. Table 3 indicates those species collected as fry or young-of-the-year in Cleveland Harbor. Most of the harbor nursery areas are dominated by a few abundant species.

It is probable that a list of species spawning in the harbor would be similar to Table 3 (White et al. 1975). During 1972-74, goldfish, pumpkinseed sunfish, largemouth blackbass, and yellow perch were observed spawning within Cleveland Harbor (White et al. 1975).

Recreational fishing from harbor structures is an important activity for thousands of residents of the Cleveland area. For the years 1975 to 1977, Baker et al. 1979, reported an average annual harvest of 99,979 fish by shore anglers in the west Cleveland area which includes Cleveland Harbor. The commercial fishery in the Harbor itself has virtually disappeared, resulting in the loss of millions of dollars to the Cleveland economy. The diverse fish fauna and commercial fishery of Cleveland Harbor are restorable if appropriate measures to reduce pollution and restore the environment are implemented (White et al. 1975).

E. Birds

Approximately 260 species of birds have been observed in the Cleveland area (U. S. Army Corps of Engineers 1978). Cleveland Harbor is situated on a migration corridor, located on both Mississippi and Atlantic flyways, which contains a population of over three million ducks and geese (Bellrose 1976).

Migrating waterfowl cross the Cleveland area of Lake Erie on both north-south and east-west routes between breeding and wintering grounds. Birds which occur in the Harbor area include: Bonaparte's gull (Larus philadelphia), ring-billed gull (L. delawarensis), herring gull (L. argentatus), common loon (Gavia immer), horned grebe (Podiceps auritis), great blue heron (Ardea herodias), mallard (Anas platyrhyhchos), black duck (Anas rubripes), canvasback (Aythya valisineria), goldeneye (Bucephola clangula), bufflehead (Bucephala akeola), oldsquaw (Claugula hyemalis),and common merganser (Megus merganser) (U. S. Army Corps of Engineers 1978). Waterfowl are often attracted to the warm, open water areas of the power plant effluents in Cleveland Harbor.

Table 4 shows results of Christmas bird counts for the years 1968-1978 in the Cleveland area.

F. Mammals

At one time, the harbor area supported a diverse fauna of terrestrial and wetland mammals (Burt 1972). Habitat loss has probably eliminated most mammals from the area.

G. Reptiles and Amphibians

The following reptiles have been reported in the Cleveland Harbor area: northern ring-necked snake (Diadophis punctatus edwardsii), racers (Coluber constrictor spp.), eastern milk snake (Lampropeltis doliata triangulum), DeKay's snake (Storeria dekayi), and eastern garter snake (Thamnophis sirtalis sirtalis) (Conant 1951). Other reptiles and amphibians that have been recorded in the area are listed in Table 5.

III. Discussion

The major impacts to fish and wildlife resources will result from the extensive dredging that will be required to increase and maintain navigational channel and harbor depths. Deepening the navigational channel in the Old River channel and lower Cuyahoga River has the potential of resuspending significant quantities of toxic material. This resuspension of toxic material could affect all aquatic organisms in the Cleveland Harbor area. Thus, all sediments to be dredged should be sampled prior to dredging commencement in order to identify the qualitative and quantitative properties of any toxic material. Also, the sampling program should identify any "hot spots" of toxic material which would require special dredging and disposal procedures.

Since the breakwaters provide an excellent benthic substrate, removal of the arrow head spurs of the west channel entrance would reduce benthos production and thus a reduction of fish food organisms. However, proposed breakwater construction at the east and west channel entrances should provide suitable replacement substrate. Since more breakwater is proposed for construction than will be removed, a net loss of available lake-bottom benthic habitat will result. However, the breakwater substrate should compensate for this additional loss of benthic habitat.

The bank cuts on the Cuyahoga River and Old River channel create an additional disposal problem. We assume that most of this material will be of an unpolluted nature and thus, should have a useful purpose. Due to negative aquatic impacts, we would object to placement of the material in any wetland area. If the bank cuts under study are deemed necessary, the exact locations and volume of material to be removed should be discussed in the phase I General Design Memorandum.

Cleveland Harbor and adjacent areas provide local residents an excellent opportunity for recreational fishing. The harbor structures (especially breakwaters) would provide access to varying water depths for shore fishing. The existing City of Cleveland breakwater at Edgewater Park, with its pedestrian walkway, provides public fishing access to both Lake Erie and the marina basin. Access to the west breakwater would greatly expand public fishing access in the Cleveland area.

The proposed recreational fishing access consists primarily of: (1) a pedestrian bridge spanning the 200-foot opening in the shore arm of the existing west breakwater, (2) a pedestrian handrail along the top of the west breakwater, and (3) upgrading of the existing public parking area located east of the Edgewater Marina.

The Cleveland Harbor area and lower Cuyahoga River have undergone major modifications over the years. The fish and wildlife resources and their habitats have been gradually diminished to the point that many species of plants and animals have been extricated from the area and only remnant populations of other species exist. Thus the opportunity to mitigate (replace in kind, restore) project caused loss of habitat is precluded. As stated earlier, the construction of rubble mound breakwaters would create benthic habitat to replace benthic habitat lost due to additional breakwater construction. However, no mitigation is planned for other project caused losses (benthic community destruction, water quality degradation, and loss of fish spawning and nursery areas) due to enlarging and deepening the navigational channels. The recreational fishing access will provide a greater opportunity for the public to utilize the remaining aquatic resources. Some mitigation could be provided by developing artificial spawning areas for specific species which can be enticed to use artificial substrates.

Other than the work conducted by White on the Old River channel and near the mouth of the Cuyahoga River, little is known of the fish and wildlife values of the lower 5.8 miles of the Cuyahoga River. Historic records indicate that this reach of the river has been severely degraded and that aquatic life has been greatly diminished. The Ohio Division of Wildlife has not conducted a fishery survey on the lower Cuyahoga River for at least seven years (LaConte, personal communication). Therefore, if engineering studies indicate that additional dredging and bank cuts are necessary on the lower 5.8 miles of the Cuyahoga River, fishery and benthic surveys should be conducted in the area affected. Also, a survey of riparian habitat and wildlife use of the habitat should be conducted along the lower 5.8 miles of the Cuyahoga River.

IV. Endangered Species

To facilitate compliance with Section 7(c) of the Endangered Species Act of 1973 as amended, Federal agencies are required to obtain from the Fish and Widllife Service information concerning any endangered or threatened species, listed or proposed to be listed, which may be present in the area of a proposed action. Therefore, we are providing you with the following list of species which may be present in the concerned area.

Common Name	Scientific Name	Classification	Habitat
Indiana bat	Myotis sodalis	Endangered	Caves and riparian
Peregrine falcon	Falco peregrinus	Endangered	Migratory
Kirtland's warbler	Dendroica kirtlandii	Endangered	Migratory
Bald eagle	Haliaeetus leucocephalus	Endangered	Breeds in Lucas, Ottawa, Sandusky, and Erie Counties, Ohio
Blue pike	Stizostedion vitreum glaucum	Endangered	Lake Erie

Also, Section 7(c) requires that the Federal agency responsible for actions authorized, funded or carried out in furtherance of the project to conduct a biological assessment for the purpose of identifying endangered, threatened or proposed species likely to be affected by the action. If the biological assessment indicates the presence of such a species, the formal consultation process should be initiated. This can be done by writing to the Area Manager, U. S. Fish and Wildlife Service, Room 202, Manly Miles Building, 1405 S. Harrison Road, East Lansing, Michigan 48823.

V. Recommendations

Based on the above information and discussion, we recommend that:

1. The recreational fishing access (pedestrian bridge, breakwater handrail, and upgraded parking area) be completed at the same time as other project measures.

2. If engineering and economic studies indicate that additional dredging and bank cuts are necessary on the lower 5.8 miles of the Cuyahoga River, benthic and fishery surveys of the area be conducted along with a survey of riparian habitat and wildlife use of this habitat.

3. The use of artificial spawning substrate (placement of tires, gravel, drain tiles, etc.) for selected fish species be investigated as potential mitigation measures.

4. Useful purposes (i.e. road construction, building sites) be investigated for spoiling of excess unpolluted dredged material and bank cut material.

5. Upland disposal sites be investigated to receive unpolluted dredged material and bank cut material.

6. All sediments to be dredged be sampled, prior to dredging commencement, to determine their "polluted" status.

We would appreciate notification of any major alterations in project plans in order that related revisions may be made in our future Fish and Wildlife Coordination Act report. Please advise us of your proposed actions regarding our recommendations.

Sincerely yours,

Acting Area Manager

Table 1. Benthic Macroinvertebrate Taxa Reported in the Lake Erie Nearshore Zone in the Vicinity of Cleveland, Ohio*

Phylum Coelenterata	Class	Hydrozoa
		Hydra sp.
Phylum Aschelminthes	Class	Nematoda
		Alaimus sp.
		Dorylaimus sp.
		Mesodorylaimus sp.
Phylum Annelida	Class	Polychaeta
		Manayunkia speciosa
	Class	Oligochaeta
		Aulodrilus piqueti
		A. pluriseta
		Branchiura sowerbyi
		Ilyodrilus templetoni
		Limnodrilus angustipenis
		L. cervix
		L. claperedeianus
		L. hoffmeisteri
		L. profundicola
		L. udekemianus
		Peloscolex ferox
		P. multisetosus
		Potamothrix moldaviensis
		P. vejdovskyi
		Tubifex tubifex
		Dero digitata
		Nais communis
		N. pseudobtusa
		N. variabilis
		Ophidonais serpentina
		Stylria fossularis
	Class	Hirudinea
		Illinobdella sp.
		Helobdella stagnalis
Phylum Mollusca	Class	Pelecypoda
		Pisidium sp.
		P. casertanum
		P. henslowanum
		P. lilljeborgi
		Sphaerium sp.
	Class	Gastropoda
		Amnicola sp.
		Physa sp.
		Valvata sincera

Table 1. (continued) Benthic Macroinvertebrate Taxa Reported in the Lake Erie Nearshore Zone in the Vicinity of Cleveland, Ohio*

Phylum Arthropoda	Class Crustacea
	Lirceus sp.
	Cypricercus sp.
	Asellus intermedius
	Gammarus fasciatus
	Pontoporeia affinis
	Class Insecta
	Order Diptera
	Chironomus sp.
	C. plumosus
	C. riparius
	Tanytarsini (Tribe)
	Procladius sp.
	P. adumbratus
	P. attenuatus
	P. euliciformes
	P. riparius

Source: Rolan, 1973
Nacht, 1977

*From Pliodzinkas 1979

Table 2. The Relative Abundance of Fishes Collected in the Cleveland Harbor and Adjacent Marinas (Revised July 1974)*

Species	No. Collected	% of Total
Longnose gar	1	0.01 %
Alewife	92	0.85
Eastern gizzard shad	2,525	23.43
Chinook salmon	9	0.08
Coho salmon	42	0.39
Rainbow trout	2	0.02
Rainbow smelt	323	3.00
Northern pike	15	0.14
Carp	64	0.59
Goldfish	97	0.90
Golden shiner	393	3.65
Longnose dace	1	0.01
Creek chub	1	0.01
Western blacknose dace	1	0.01
Common emerald shiner	4,092	37.97
Striped shiner	1	0.01
Spottail shiner	903	8.38
Spotfin shiner	6	0.06
Northern sand shiner	33	0.31
Northern mimic shiner	6	0.06
Northern fathead minnow	1	0.01
Bluntnose minnow	74	0.69
Stoneroller minnow	2	0.02
Eastern quillback	1	0.01
Black redhorse	1	0.01
Golden redhorse	2	0.02
Northern shorthead redhorse	1	0.01
Common white sucker	89	0.83
Channel catfish	2	0.02
Brown bullhead	23	0.21
Black bullhead	14	0.13

Table 2. (continued) The Relative Abundance of Fishes Collected in the Cleveland Harbor and Adjacent Marinas (Revised July 1974)*

Species	No. Collected	% of Total
Stonecat madtom	13	0.12 %
Trout-perch	153	1.42
Brook silverside	3	0.03
White bass	223	2.07
White crappie	80	0.74
Black crappie	11	0.10
Northern rockbass	5	0.05
Northern largemouth blackbass	3	0.03
Warmouth sunfish	1	0.01
Green sunfish	3	0.03
Bluegill sunfish	4	0.04
Pumpkinseed sunfish	34	0.32
Yellow walleye	2	0.02
Yellow perch	1,254	11.64
Northern logperch darter	1	0.01
Freshwater drum (sheepshead)	170	1.58
TOTALS	10,777	100.05 %

47 Species

* from White et al. 1975

Table 3. Species of Fishes Collected as Fry or Young-of-the-Year in the Cleveland Harbor, 1972-1974*

Species	Abundance**
Alewife	Abundant
Eastern gizzard shad	Abundant
Rainbow smelt	Abundant
Eastern quillback	Rare
Common white sucker	Uncommon
Carp	Common
Goldfish	Common
Golden shiner	Abundant
Longnose dace	Rare
Common emerald shiner	Abundant
Spottail shiner	Uncommon
Fathead minnow	Rare
Bluntnose minnow	Common
Trout-perch	Rare
Brook silverside	Rare
White bass	Uncommon
Rockbass	Uncommon
Largemouth blackbass	Rare
Green sunfish	Uncommon
Bluegill sunfish	Common
Pumpkinseed sunfish	Abundant
Yellow perch	Common
Northern logperch darter	Rare
White crappie	Uncommon

* From White et al. 1975

** Abundance of each species is depicted as a relative term

Table 4. *Summary of Data from Christmas Bird Counts at Cleveland, Ohio, 1968-1978***

Species	No. Years Recorded Out of 10 Years	Average Per Year in Years Recorded
Ring-billed gull*	10	14,104
Bonaparte's gull*	10	5,480
Herring gull*	10	4,212
Starling	10	1,302
House sparrow	10	872
Mallard*	10	703
Common crow	10	363
Black-capped chickadee	10	347
Black duck*	10	307
Dark-eyed junco	10	294
Cardinal	10	278
Tree sparrow	10	262
Common goldeneye*	10	212
Tufted titmouse	10	183
Blue jay	10	181
American goldfinch	10	121
Red-breasted merganser*	10	117
Downy woodpecker	10	98
Cedar waxwing	10	98
Mourning dove	10	92
White-breasted nuthatch	10	80
Song sparrow	10	56
Lesser scaup*	10	39
American robin	10	38
Hairy woodpecker	10	32
Redhead*	10	17
Red-bellied woodpecker	10	17
Bufflehead*	10	16
White-throated sparrow	10	15
Eastern bluebird	10	12
Red-tailed hawk	10	6
Belted kingfisher	10	5
Pileated woodpecker	10	5
Brown creeper	10	5
Golden-crowned kinglet	10	5
American kestrel	10	4
Canada goose*	9	719
Snow bunting	9	48
Red-breasted nuthatch	9	22
Ruddy duck*	9	21
Ring-necked pheasant	9	10
Common flicker	9	7
Rufous-sided towhee	9	6
Wood duck	9	5
American wigeon*	9	4

Table 4. (continued) Summary of Data from Christmas Bird Counts at Cleveland, Ohio, 1968-1978**

Species	No. Years Recorded Out of 10 Years	Average Per Year in Years Recorded
Barred owl	9	2
Carolina wren	9	2
Greater scaup*	8	144
Common merganser*	8	85
Field sparrow	8	5
Winter wren	8	2
Pine siskin	7	20
American coot*	7	8
Great black-backed gull*	7	7
Horned grebe*	7	3
Swamp sparrow	7	3
Hooded merganser*	7	2
Yellow-bellied sapsucker	7	2
Evening grosbeak	6	9
Horned lark	6	5
Purple finch	6	4
Pied-billed grebe*	6	3
Red-shouldered hawk	6	2
Mockingbird	6	2
Brown-headed cowbird	6	2
Common grackle	6	1
Great horned owl	6	1
Canvasback*	5	36
Red-winged blackbird	5	3
Pintail*	5	2
Rough-legged hawk	5	2
Common redpoll	4	65
Killdeer	4	6
Gadwall*	4	3
Ruby-crowned kinglet	4	3
Great blue heron	4	2
Green-winged teal*	4	2
Cooper's hawk	4	2
Red-headed woodpecker	4	2
Common snipe	4	1
Bobwhite	3	24
Yellow-rumped warbler	3	7
White-winged scoter*	3	3
Ruffed grouse	3	3
Hermit thrush	3	3
Surf scoter*	3	2
White-crowned sparrow	3	2
Brown thrasher	3	1
White-winged crossbill	2	32
Red crossbill	2	7
Whistling swan*	2	3

Table 4. (continued) Summary of Data from Christmas Bird Counts at Cleveland, Ohio, 1968-1978**

Species	No. Years Recorded Out of 10 Years	Average Per Year in Years Recorded
Oldsquaw*	2	2
Marsh hawk	2	2
Northern shrike	2	2
Eastern meadowlark	2	2
Lapland longspur	2	2
Double-crested cormorant*	2	1
Sharp-shinned hawk	2	1
American woodcock	2	1
Glaucous gull*	2	1
Gray catbird	2	1
White-fronted goose*	1	5
Common loon*	1	1
Snow goose (Blue morph)*	1	1
Shoveler*	1	1
Ring-necked duck*	1	1
King eider*	1	1
Common scoter*	1	1
Franklin's gull*	1	1
Screech owl	1	1
Eastern phoebe	1	1
Boreal chickadee	1	1
Swainson's thrush	1	1
Northern oriole	1	1

Average number of species recorded per census = 72

Average number of individuals recorded per census = 30,569

* Species of birds likely to utilize the waters off the Municipal Light Plant for feeding or resting.

** From U. S. Army Corps of Engineers 1978

Table 5. Published Records of Reptiles and Amphibians with Wetland Affinities from Ohio Counties Bordering Lake Erie*

	County							
Species	Ashtabula	Lake	Cuyahoga	Lorain	Erie	Sandusky	Ottawa	Lucas
Mudpuppy					X			X
Jefferson salamander				X				
Red-backed salamander				X				
Red-spotted newt				X				
American toad					X			
Northern spring peeper				X				
Green frog					X			
Bullfrog	X	X	X	X	X	X	X	X
Northern ringneck snake	X	X	X	X	X		X	X
Eastern fox snake					X	X	X	X
Eastern milk snake	X	X	X	X	X		X	X
Kirtland's water snake					X	X		X
Queen snake	X	X	X	X	X	X	X	X
Northern water snake	X	X	X	X	X	X	X	X
Northern brown snake	X	X	X	X	X		X	X
Northern red-bellied snake	X	X						
Butler's garter snake			X		X		X	X
Northern ribbon snake	X	X	X	X	X			X
Eastern garter snake	X	X	X	X	X	X	X	X
Stinkpot					X		X	X
Snapping turtle	X	X	X	X	X		X	X
Spotted turtle	X	X		X	X			X
Blanding's turtle	X	X		X	X	X	X	X
Map turtle	X			X	X	X	X	X
Midland painted turtle	X	X	X	X	X	X	X	X
Eastern spiny softshell		X		X	X		X	X

* Conant 1951, Morse 1904, from CLEAR 1979

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United States Department of the Interior

FISH AND WILDLIFE SERVICE

IN REPLY REFER TO

Columbus Field Office
3990 East Broad Street
Columbus, Ohio 43215

June 3, 1982

Colonel George P. Johnson
District Engineer
U. S. Army Engineer District
Buffalo
1776 Niagara Street
Buffalo, New York 14207

Dear Colonel Johnson:

This planning aid letter on proposed Cleveland Harbor modifications is provided for inclusion in your Stage 2 Report in accordance with obligations of the U. S. Fish and Wildlife Service per the FY-1982 Fish and Wildlife Coordination Act Agreement with the Buffalo District, Corps of Engineers. This letter has been prepared under the authority of and in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and in compliance with the intent of the National Environmental Policy Act of 1969.

The Cleveland Harbor area, protected by breakwaters, is five miles long and 1,600 to 2,400 feet wide for a total area of approximately 1,300 acres. The lake approach channel is maintained at a depth of 29 feet. The outer harbor area up to the mouth of the Cuyahoga River is maintained at various depths, ranging from 25 to 28 feet. A description of fish and wildlife resources of the Cleveland Harbor area is contained in our June 24, 1981 Planning Aid Letter.

Proposed commercial navigation improvements were considered under four broad areas: (1) outer Harbor Improvements; plans 1, 2, 3A, 3b, and 4; (2) Authorized But Uncompleted Improvements to Old River Navigation Channel: plans 5A and 5B; (3) Cuyahoga River Deepening: plans 6A and 6B; and (4) Plans to Reduce River Congestion on the Cuyahoga River, plan 7A, 7B, 7C, 7D, 7E, 7F, and 7G. Since many of the plans did not have a positive B/C ratio or other plans had a higher B/C ratio, only plans 1 and 7G will be carried into stage three for further evaluation. Alternatives 5A and 5B were placed in an inactive status for the time being. All other plans have been eliminated from further consideration during the stage three planning or will be pursued under their existing construction authority.

We are in agreement that alternative plan No. 1 ("All-weather" East Entrance Plan) should be carried into stage 3 planning since it has the same benefits as the other outer harbor alternatives, but at less cost. This plan includes the dredging of a 32-foot deep fan-shaped entrance channel at the existing east entrance and dredging of a 500-foot wide, 27 feet deep channel through the East Basin to the West Basin. This plan would allow 1,000-foot vessels to operate in "all-weather" conditions (maximum 8-foot waves and 30 knot winds from the west through northeast). It is currently proposed to place all of the dredged material in contained Disposal Area 14. Also, analysis of samples from the project area will be conducted during the summer of 1982. We also concur that plans 7F and 7B should be pursued under their existing construction authority.

We understand that mitigation measures, primarily in-water fishery habitat development in the vicinity of the west breakwater, and increased fishermen access will be developed further in stage 3. We further understand that the ultimate fisherman access plan to recommend for construction will be dependent on the results of the Section 107 Study for Edgewater Marina. The purpose of the Section 107 Study is to determine the feasibility of modifying the entrance to Edgewater Marina for wave reduction and expansion of the small boat docking area.

We appreciate this opportunity to comment on the proposed Cleveland Harbor improvements and request that we be notified of alterations in project plans and kept informed of planning activities.

Sincerely yours,

Kent E. Kroonemeyer
Kent E. Kroonemeyer
Supervisor

cc: Chief, Ohio Division of Wildlife, Columbus, OH
ODNR, Outdoor Recreation Serv, M. Colvin, Columbus, OH
U.S.EPA, Office of Environmental Review, Chicago, IL
Ohio EPA, Attn: J. Albrecht, Columbus, OH

APPENDIX I
STUDY MANAGEMENT

CLEVELAND HARBOR, OHIO

STAGE 2 REPORT
OF
REFORMULATION PHASE I GENERAL DESIGN MEMORANDUM

U.S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, NY 14207

APPENDIX I
STUDY MANAGEMENT

Exhibit	Description
I-1	CPM
I-2	Proposed Schedule of Major Activities

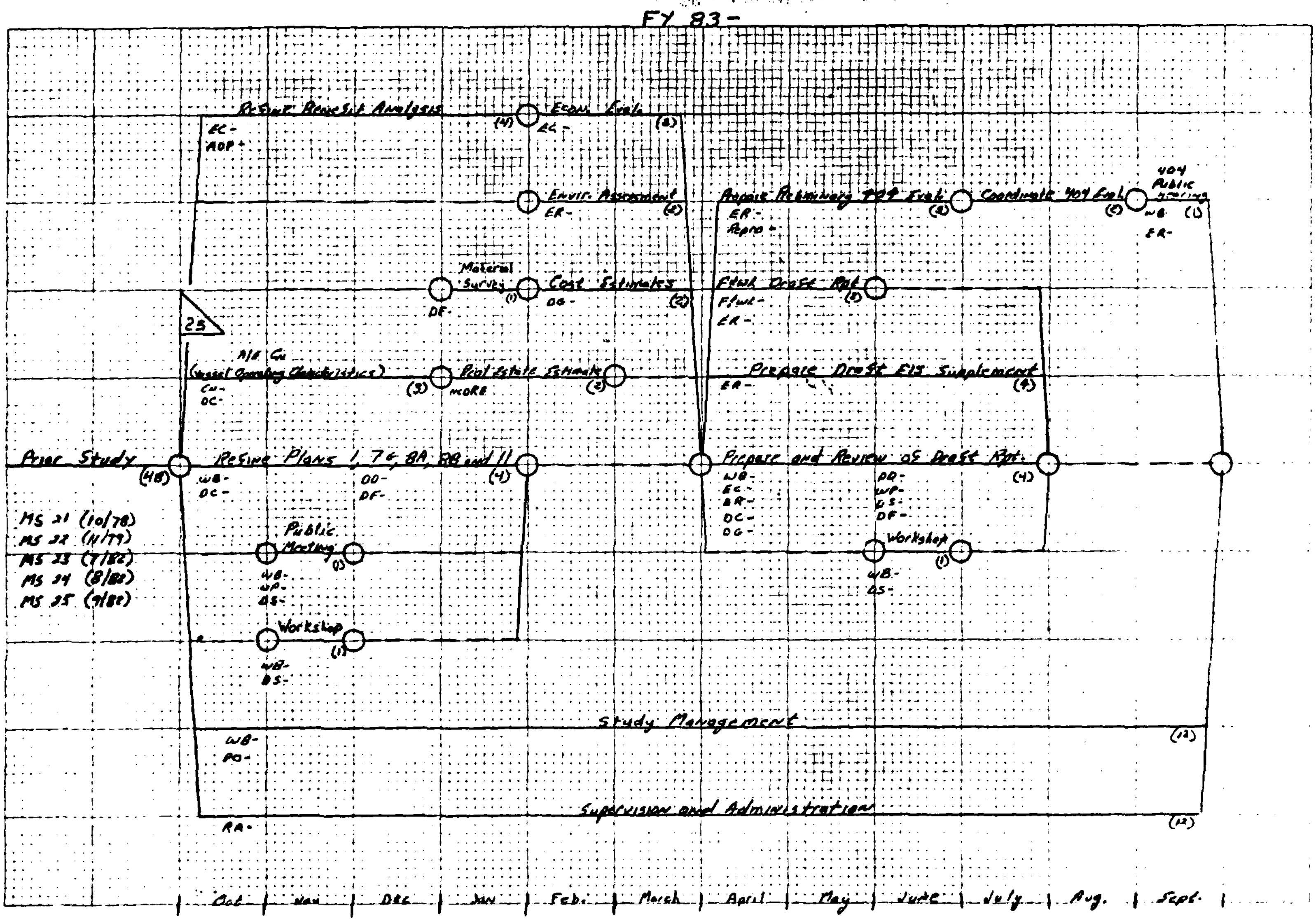
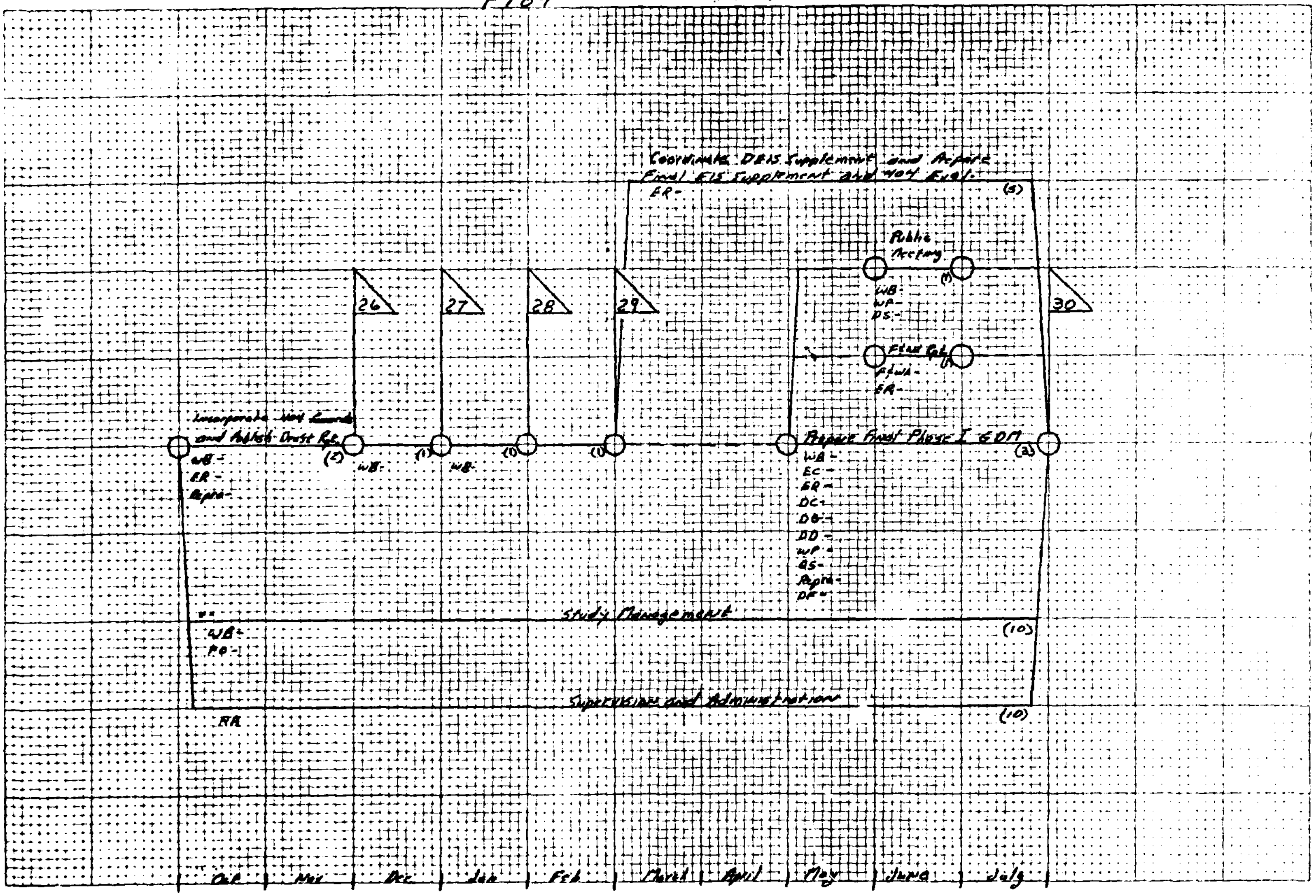

FY 83-
Refine Benefit Analysis
Econ. Eval.
Envir. Assessment
Prepare Preliminary 404 Eval.
Coordinate 404 Eval.
404 Public Hearing
Material Survey
Cost Estimates
Final Draft Rpt.
A/E Contract (Vessel Operating Characteristics)
Real Estate Estimate
Prepare Draft EIS Supplement
Prior Study
Refine Plans 1, 7C, 8A, 8B and 11
Prepare and Review of Draft Rpt.
MS 21 (10/78)
MS 22 (11/79)
MS 23 (7/82)
MS 24 (8/82)
MS 25 (9/82)
Public Meeting
Workshop
Study Management
Supervision and Administration
Oct. Nov. Dec. Jan. Feb. March April May June July Aug. Sept.

EXHIBIT I-1

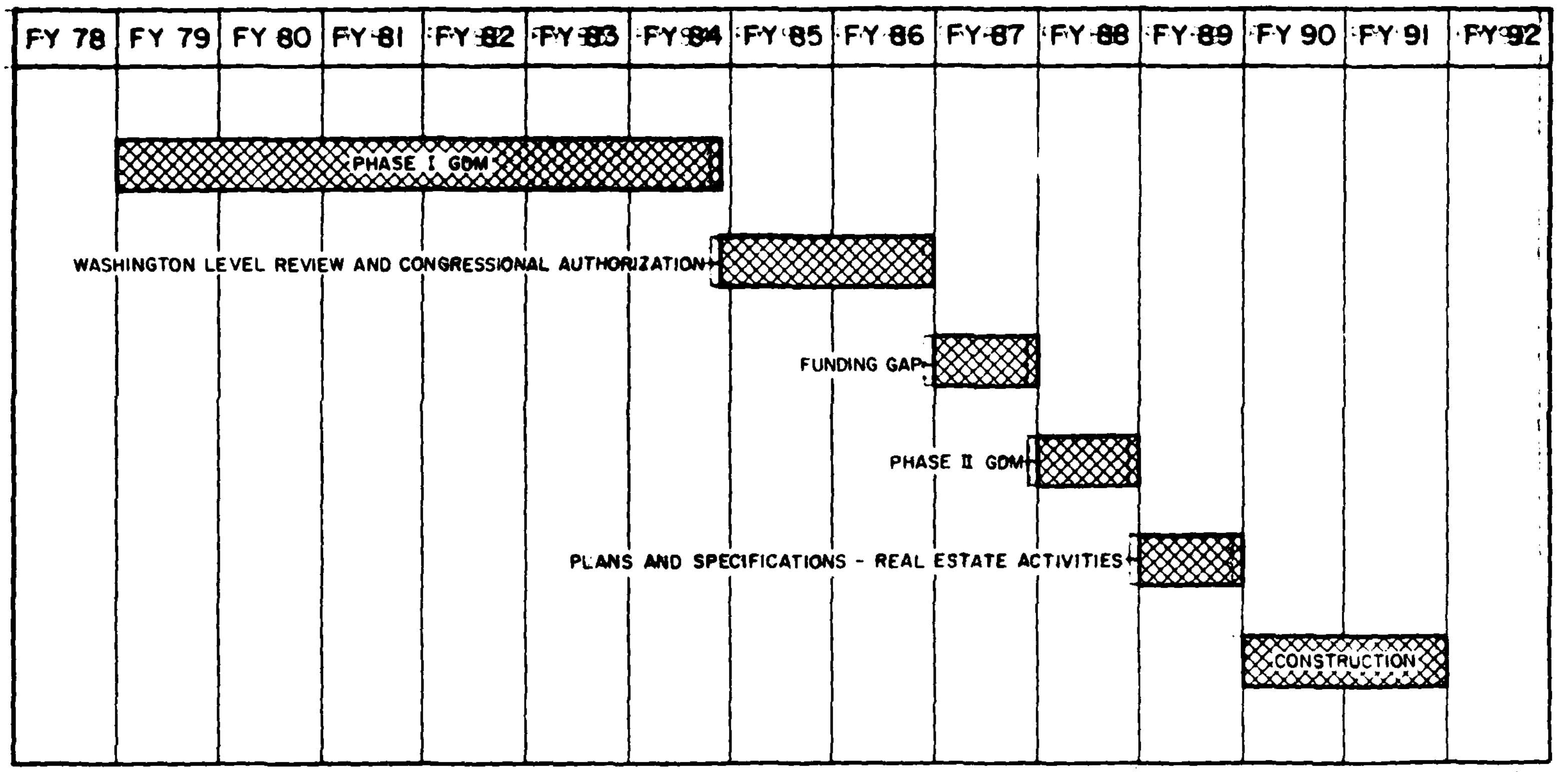
F184-



Coordinate DEIS Supplement and Prepare Final EIS Supplement and 404 Eval.
ER-
Public Meeting
WB-
WP-
PS-
ER-
Incorporate 404 Comments and Publish Draft Re.
WB-
ER-
WB-
WB-
26
27
28
29
30
Prepare Final Phase I GDM
WB-
EC-
ER-
DC-
DD-
WP-
RS-
DF-
Study Management
WB-
Supervision and Administration
RA
(10)
(10)
(5)
Oct
Nov
Dec
Jan
Feb
March
April
May
June
July

Sheet 2

PROPOSED SCHEDULE OF MAJOR ACTIVITIES
CLEVELAND HARBOR



PREPARED JULY 1982

EXHIBIT I-2

EXHIBIT I-2

APPENDIX J
PLATES

CLEVELAND HARBOR, OHIO

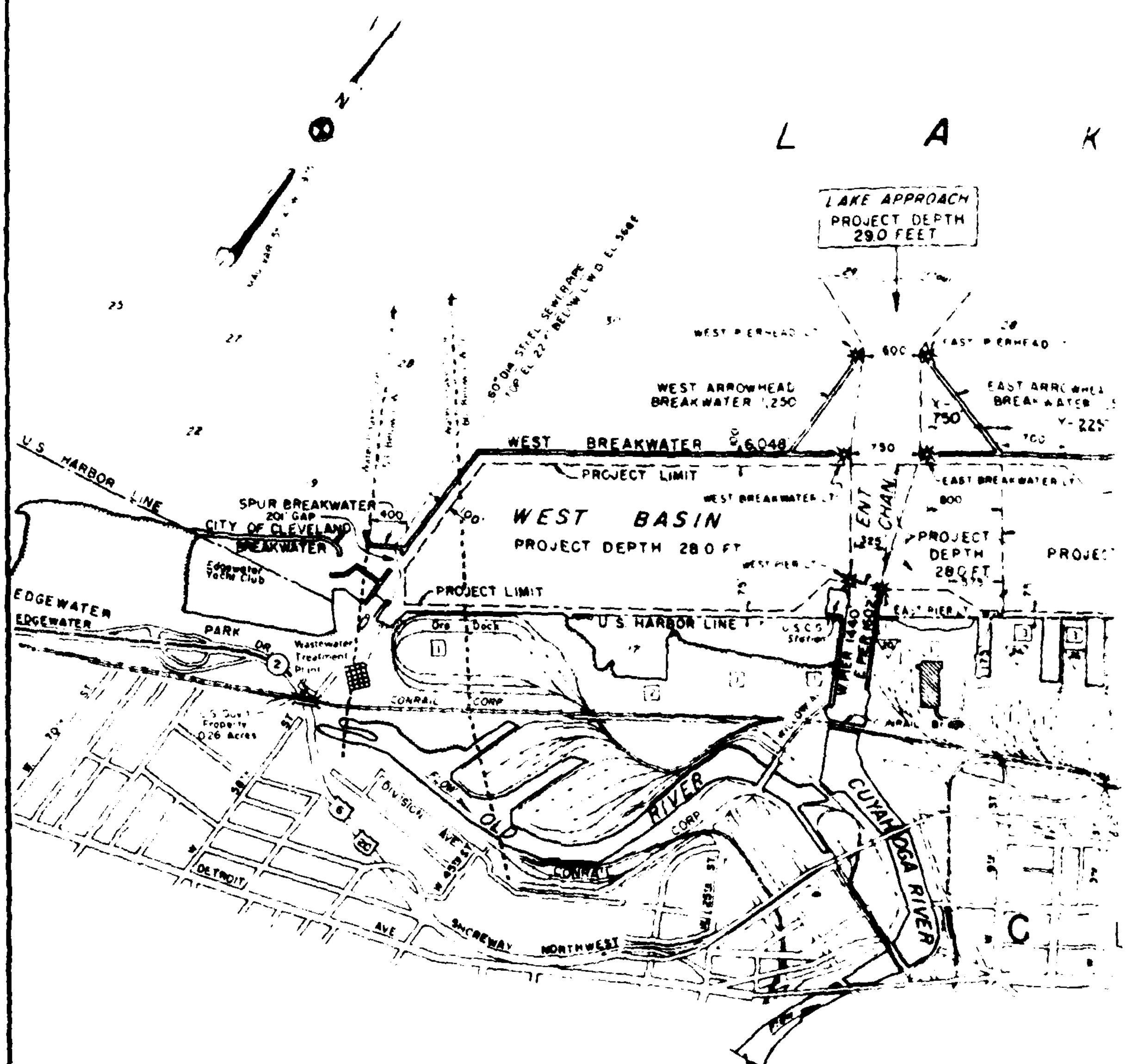
STAGE 2 REPORT
OF
REFORMULATION PHASE I GENERAL DESIGN MEMORANDUM

U.S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, NY 14207

APPENDIX J
PLATES

Plate Number	Description
1	Cleveland Harbor, Ohio
2	Cleveland Harbor, Ohio
3	The Selected Plan
4	Results of 1977 Sediment Sampling
5	Cleveland Lakefront State Park
6	Alternative 1 - "All-Weather" East Entrance Plan
7	Alternative 2 - "Fair-Weather" West Entrance Plan
8	Alternative 3A - "All-Weather" West Entrance Plan
9	Alternative 3B - "All-Weather" West Entrance Plan
10	Alternative 4 - Combined "All-Weather" East Entrance and "Fair-Weather" West Entrance Plan
11	Alternative 5 - (Options A & B) - Authorized Old River Improvements
12	Typical Sections and Interchange System for Alternative 5
13	Alternative 6A - Deepen Cuyahoga River to 25.5 Feet
14	Alternative 6B - Deepen Cuyahoga River to 28 Feet
15	Index Map and Typical Bulkhead Sections for Alternative 7
16	Alternative 7 - (Options B & C) - Reduce River Congestion
17	Alternative 7 - (Options D & E) - Reduce River Congestion
18	Alternative 7 - (Options F & G) - Reduce River Congestion
19	Alternative 8A - Edgewater Marina Fishing Plan
20	Alternative 8B - Cleveland Harbor Fishing Plan

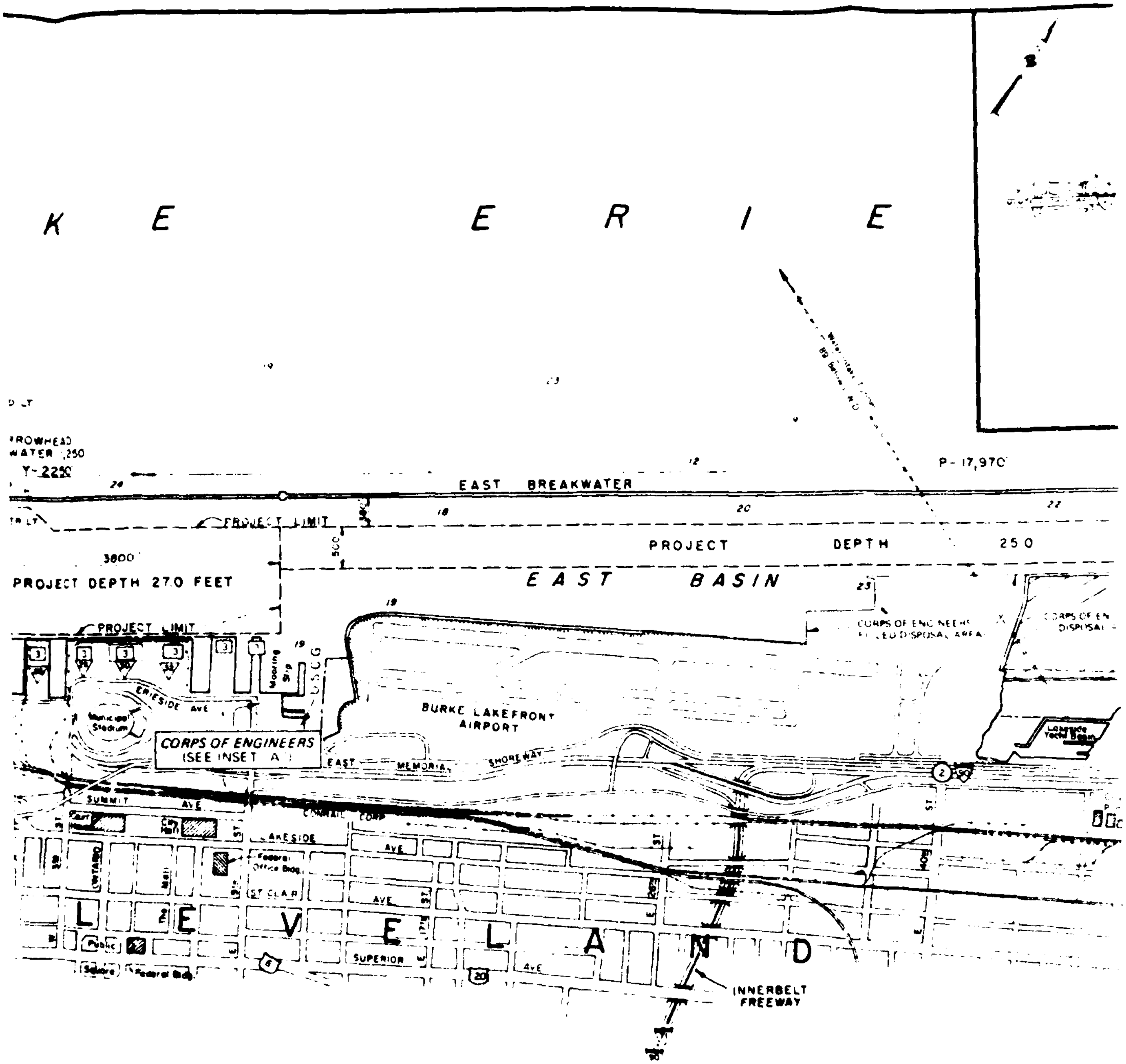
CORPS OF ENGINEERS



THIS IS
(For Cuy

WATERFRONT OWNERSHIP

1. CONRAIL
2. GREAT LAKES DREDGE AND DOCK CO (L) CONRAIL (O)
3. CITY OF CLEVELAND (O)
4. NICHOLSON CLEVELAND TERMINAL CO (O)
5. EAST 55th ST. MARINA, CITY OF CLEVELAND (O)
6. CLEVELAND ELECTRIC ILLUMINATING CO (O)



HIS IS OUTER HARBOR SECTION
(or Cuyahoga River section, see Map 6 A)

NOTES

PROJECT DEPTHS AND SOUNDINGS ARE REFERRED TO LOW WATER DATUM, EL. 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD 1955) (INTERNATIONAL GREAT LAKES DATUM

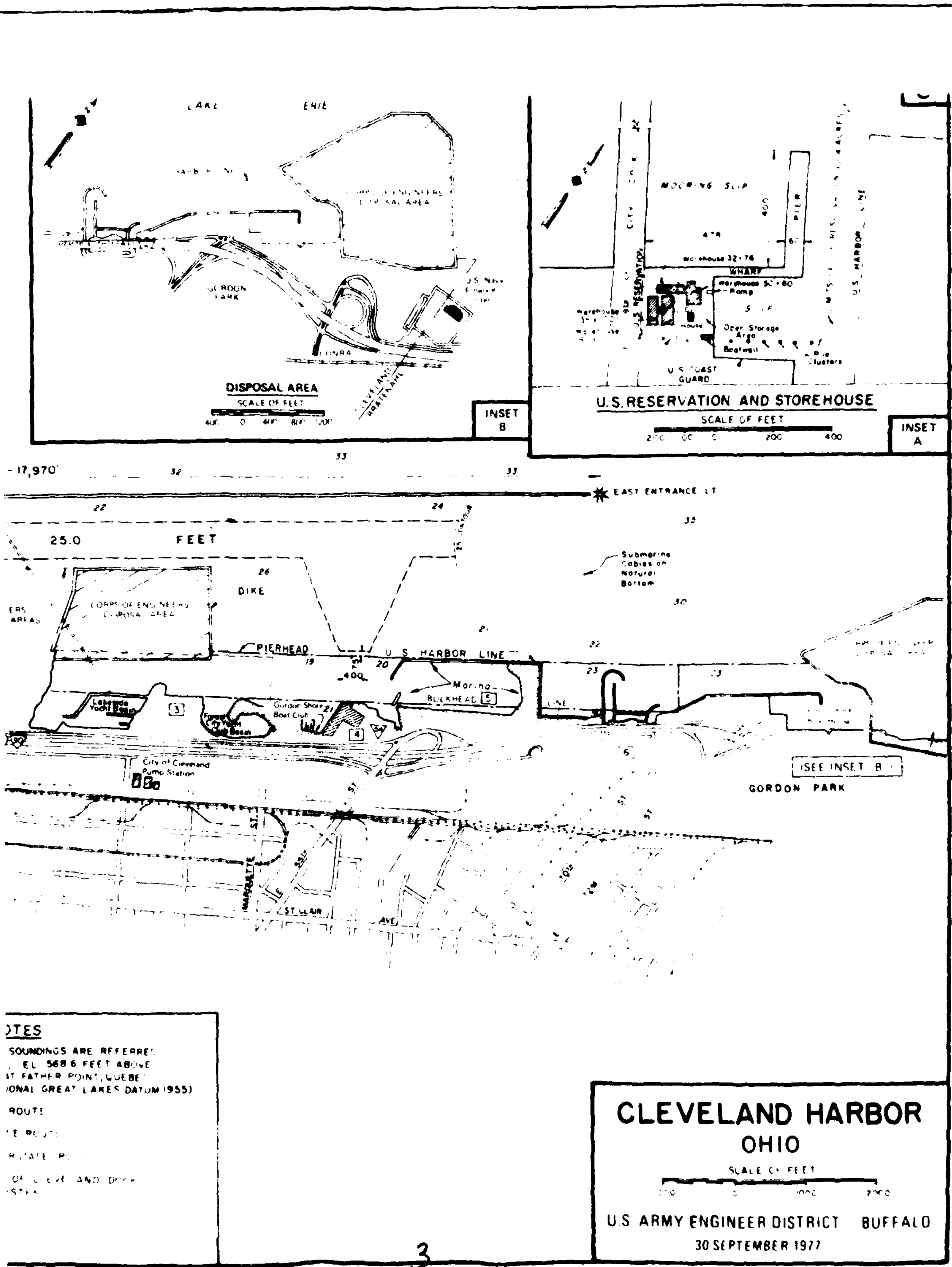
(6) INDICATES U.S. ROUTE

(2) INDICATES STATE ROUTE

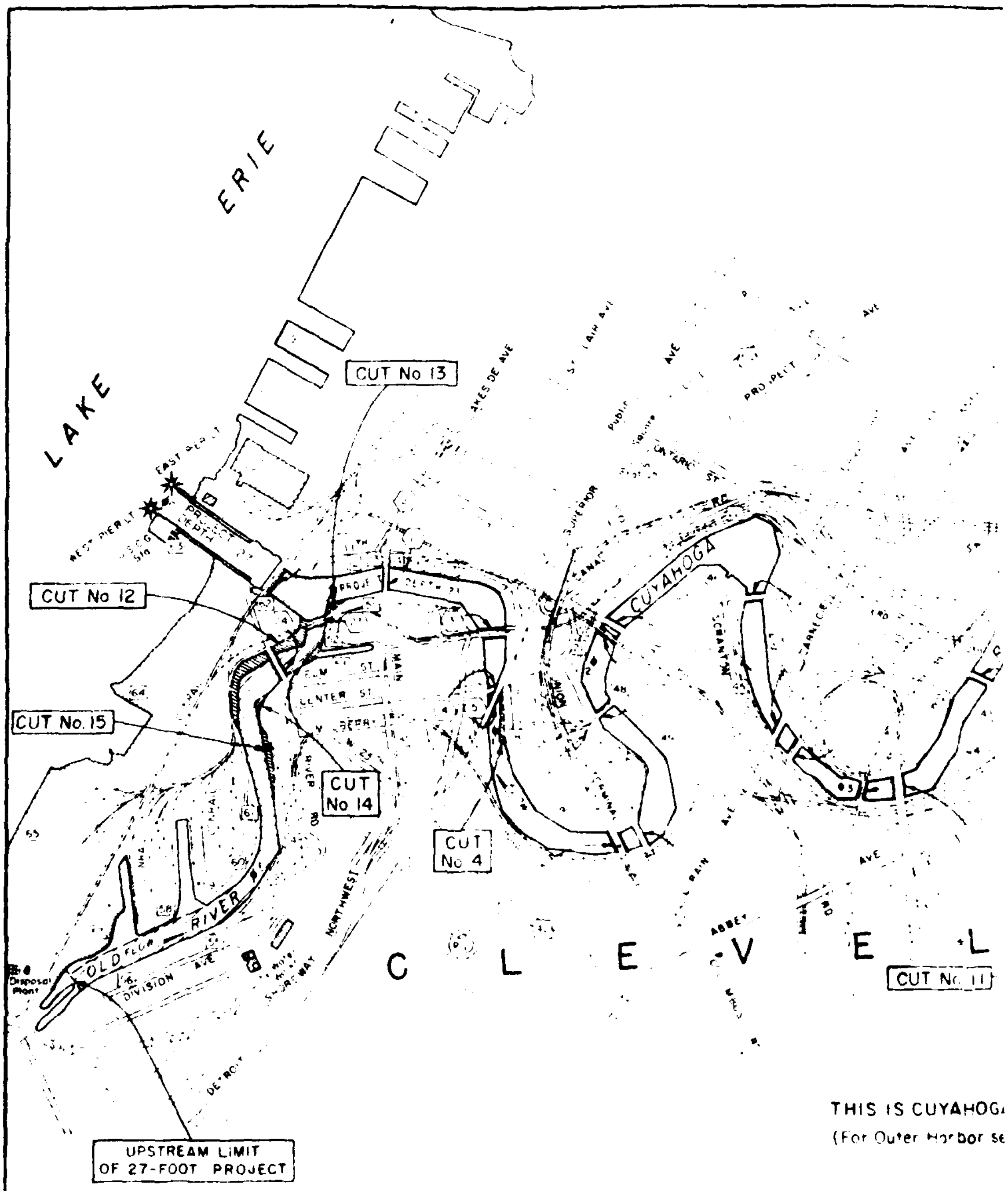
INDICATES INTERSTATE ROUTE

INDICATES CITY OF CLEVELAND DOCK NUMBERING SYSTEM

2


DISPOSAL AREA
SCALE OF FEET
INSET B
GORDON PARK
U.S. RESERVATION AND STOREHOUSE
SCALE OF FEET
INSET A
MOORING SLIP
PIER
WHARF
Open Storage Area
Boatwell
U.S. COAST GUARD
Pile Clusters
U.S. HARBOR LINE
EAST ENTRANCE LT
25.0 FEET
Submarine Cables on Natural Bottom
DIKE
CORPS OF ENGINEERS DISPOSAL AREA
PIERHEAD
Marina
BULKHEAD
Lakeside Yacht Basin
Gordon Shores Boat Club
City of Cleveland Pump Station
(SEE INSET B)
GORDON PARK
MARQUETTE ST.
ST. CLAIR AVE.
NOTES
SOUNDINGS ARE REFERRED
EL. 568.6 FEET ABOVE
FATHER POINT, QUEBEC
GREAT LAKES DATUM 1955)
CLEVELAND HARBOR
OHIO
SCALE OF FEET
U.S. ARMY ENGINEER DISTRICT BUFFALO
30 SEPTEMBER 1977

CORPS OF ENGINEERS



NOTES

[illegible]
[illegible] FEET IN TURNING BASIN AT MILE [illegible]
[illegible] FEET IN OLD RIVER

PROJECT DEPTHS AND SOUNDINGS ARE REFERRED TO LOW WATER DATUM, ELEVATION [illegible] FEET [illegible]

MILES ABOVE WEST PIER LIGHT AT [illegible] WEST PIER [illegible]

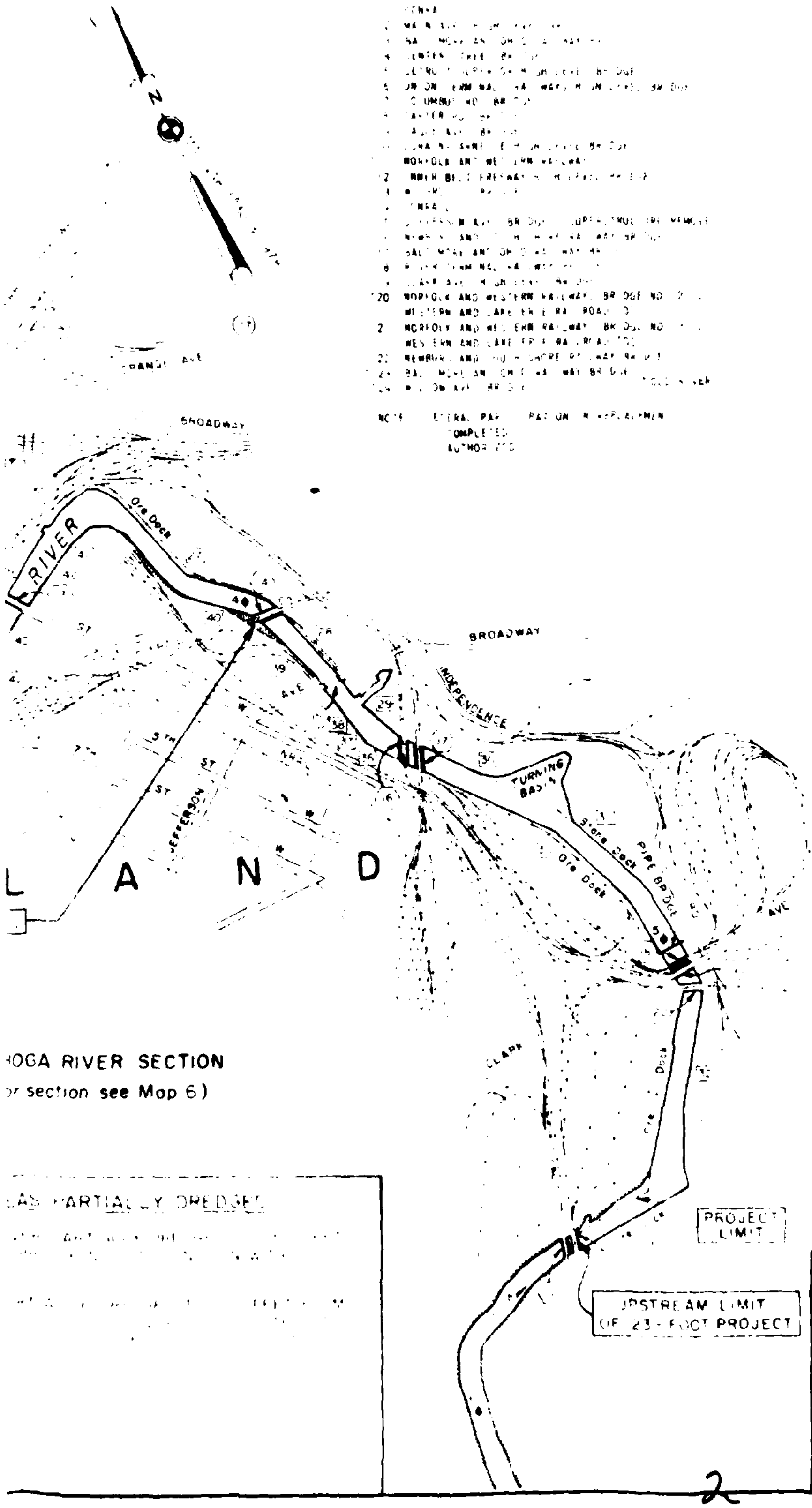
[illegible] INDICATES U.S. ROUTES

[illegible] INDICATES STATE ROUTES

/

INDEX TO BRIDGES

WATERFRONT OWNERSHIP



HOGA RIVER SECTION

(or section see Map 6)

CLEVELAND HARBOR
OHIO

SCALE OF FEET

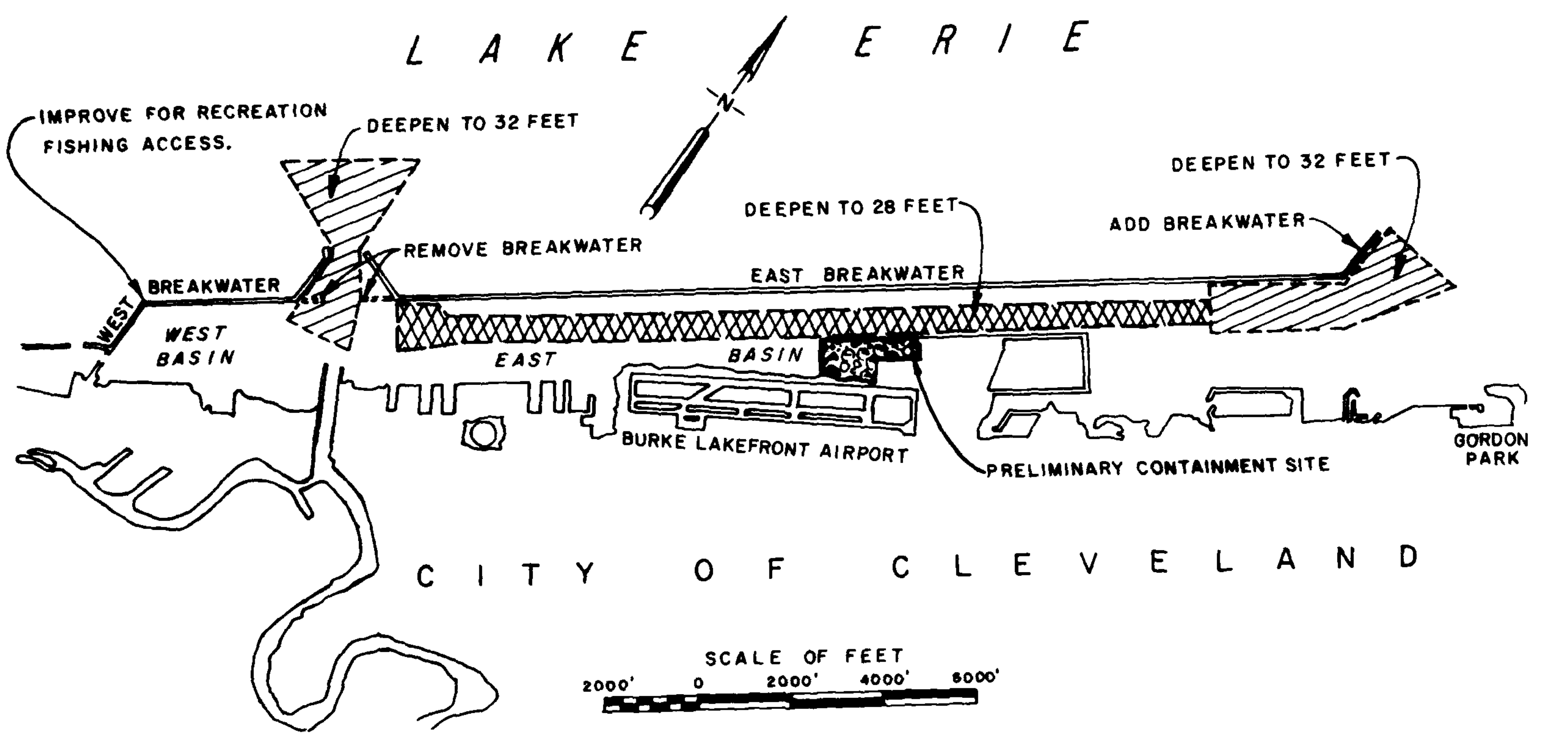
2000

U.S. ARMY ENGINEER DISTRICT, BUFFALO

30 SEPTEMBER 1982

PLATE 2

2



NOTES:

1. THE SELECTED PLAN ALSO INCLUDES TRANSSHIPMENT FACILITIES, WHICH ARE A NON-FEDERAL RESPONSIBILITY.
2. DEPTHS REFERRED TO LOW WATER DATUM, WHICH IS 568.6 FEET ABOVE MEAN SEA LEVEL AT FATHER POINT, QUEBEC ON INTERNATIONAL GREAT LAKES DATUM - 1955.

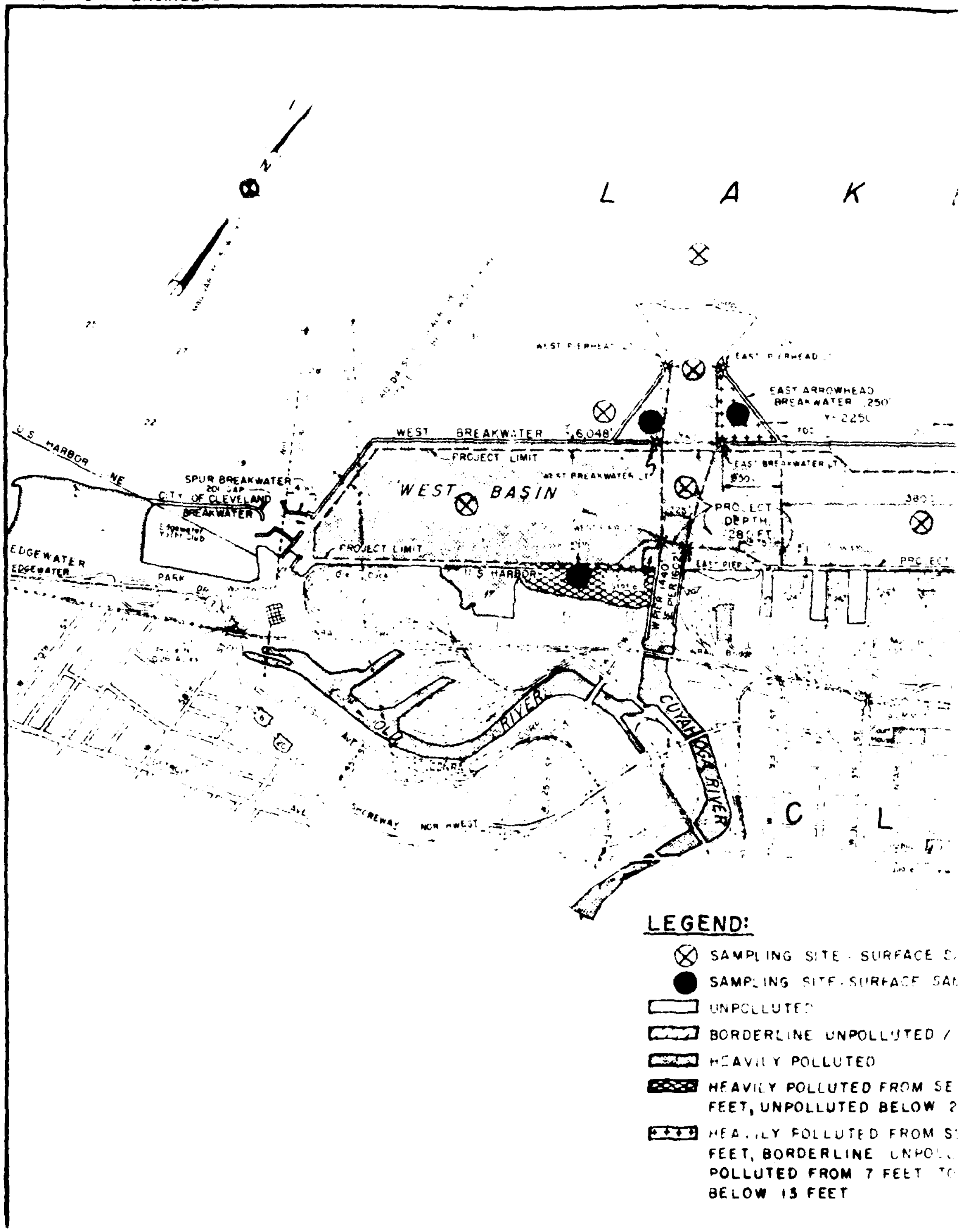
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

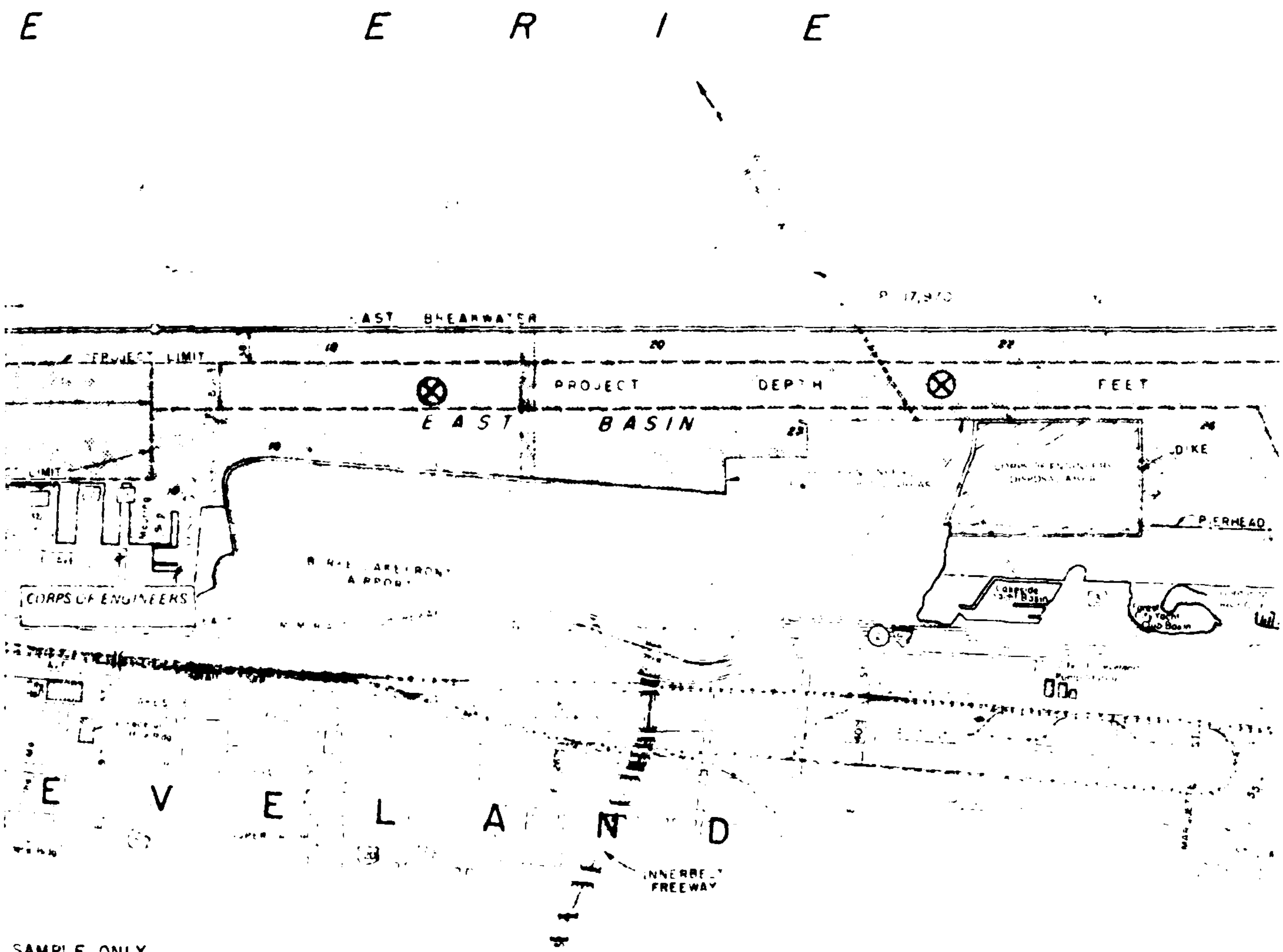
THE SELECTED PLAN

US ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

PLATE 3

CORPS OF ENGINEERS





SAMPLE ONLY

SAMPLE PLUS CORE SAMPLES

/ MODERATELY POLLUTED

SEDIMENT SURFACE TO 2.5
2.5 FEET

SEDIMENT SURFACE TO 7
LLUTED / MODERATELY
TO 13 FEET. UNPOLLUTED

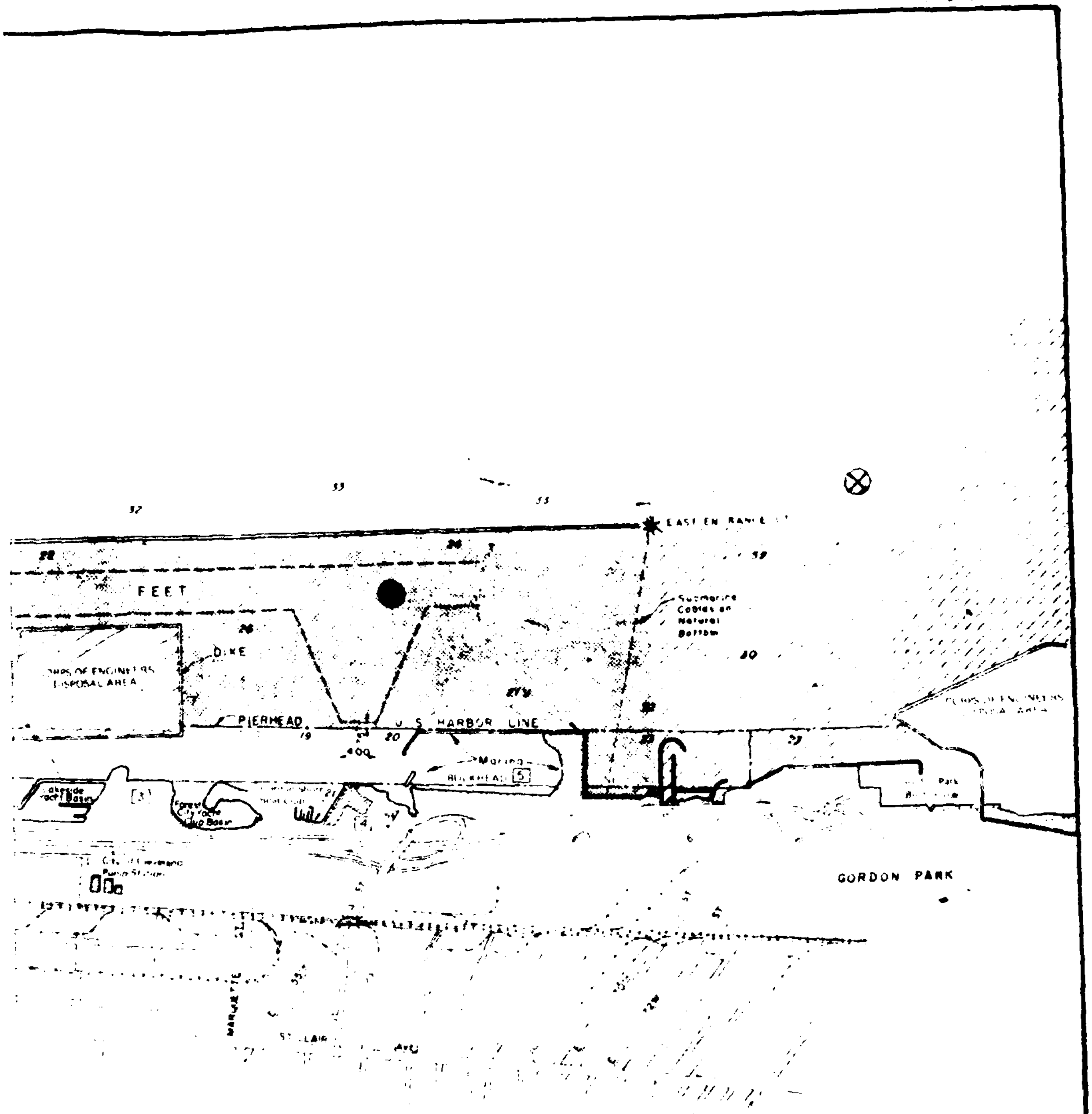
NOTE:

ADDITIONAL SAMPLE SITES WERE LOCATED ON THE CUYAHOGA AND OLD RIVERS.

SOURCE:

U.S. ENVIRONMENTAL PROTECTION AGENCY

U.S. ARMY



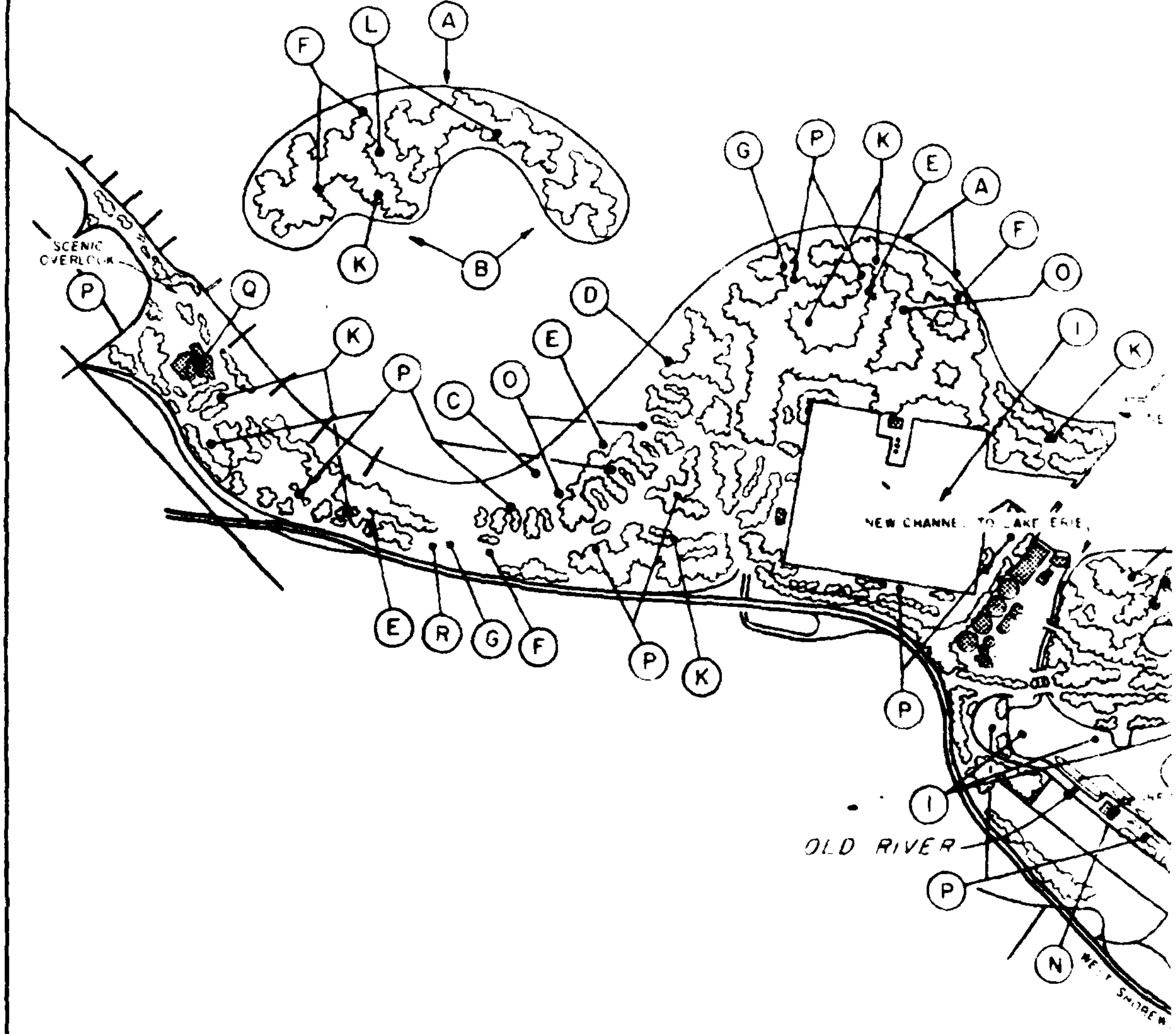
'TES WERE LOCATED
I OLD RIVERS.

PROTECTION

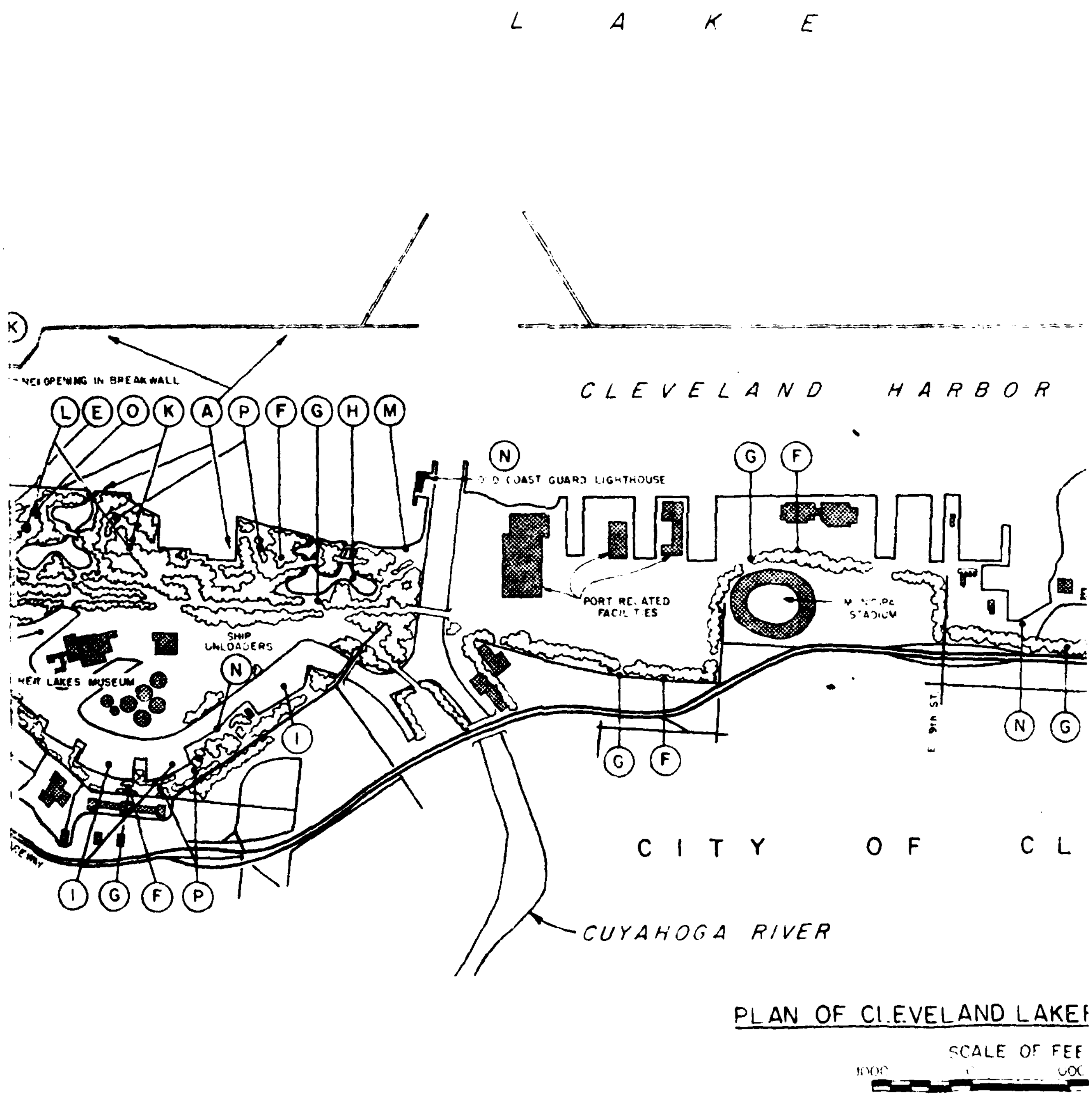
HARBOR STUDY
AND OHIO

RESULTS OF 1977
SEDIMENT SAMPLING

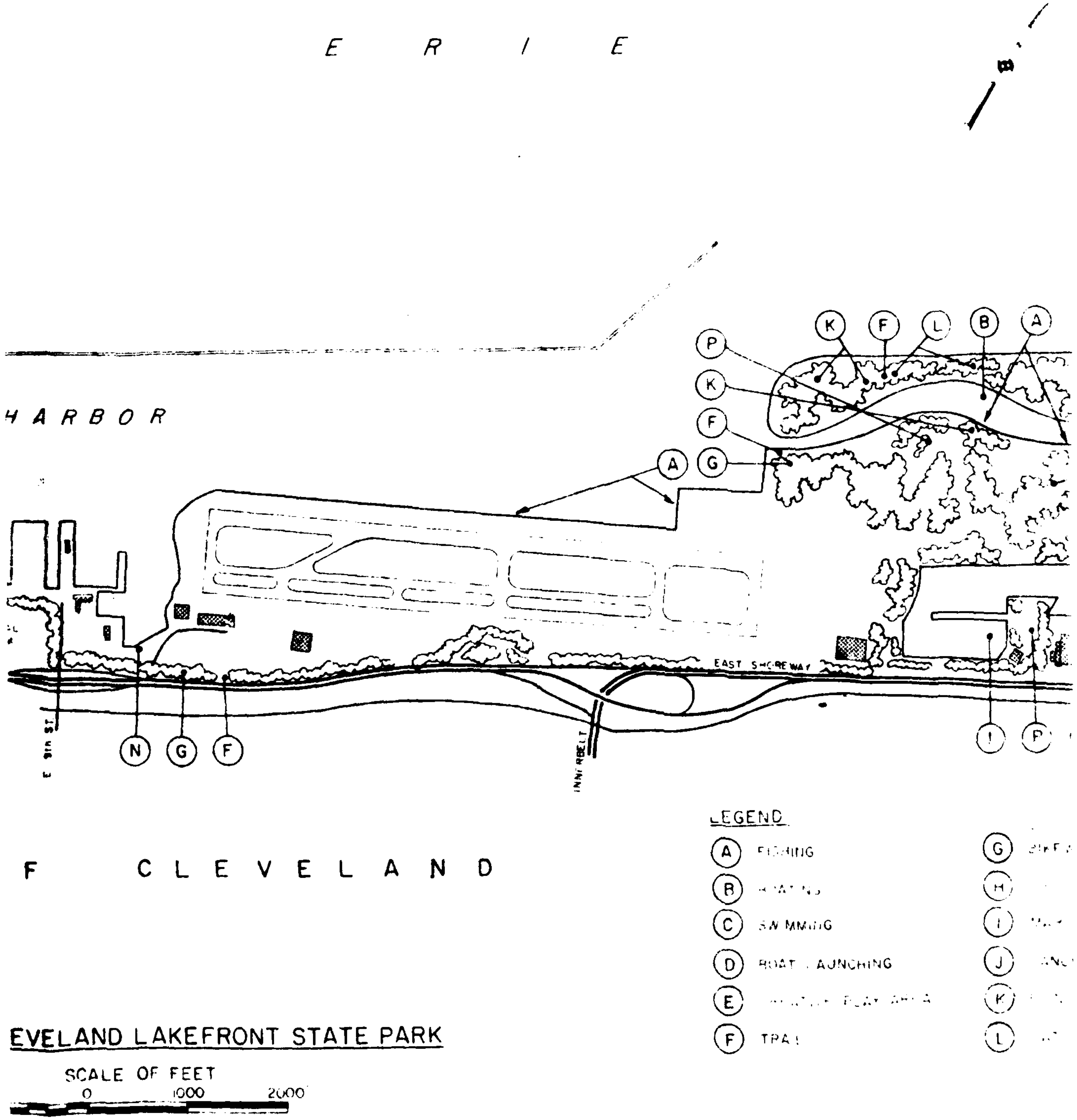
U.S. ARMY ENGINEER DISTRICT BUFFALO

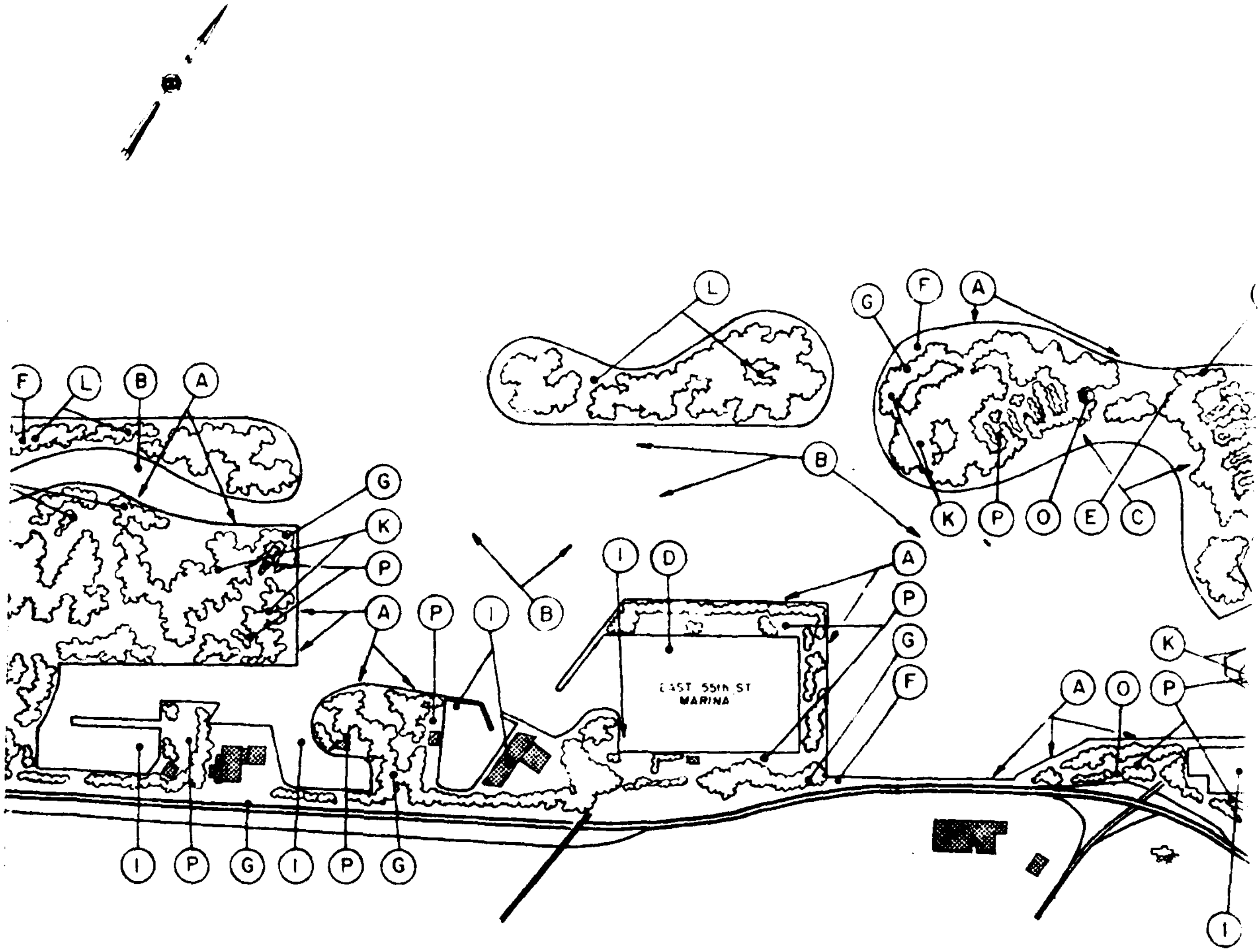


SOURCE: CLEVE AND LAKEFRONT STATE PARK (1979)


L A K E
OPENING IN BREAKWALL
CLEVELAND HARBOR
OLD COAST GUARD LIGHTHOUSE
PORT RELATED FACILITIES
SHIP UNLOADERS
LAKES MUSEUM
CITY OF CL
CUYAHOGA RIVER
E 9th ST
PLAN OF CLEVELAND LAKEF
SCALE OF FEE
L E O K A P F G H M
N G F I P

2

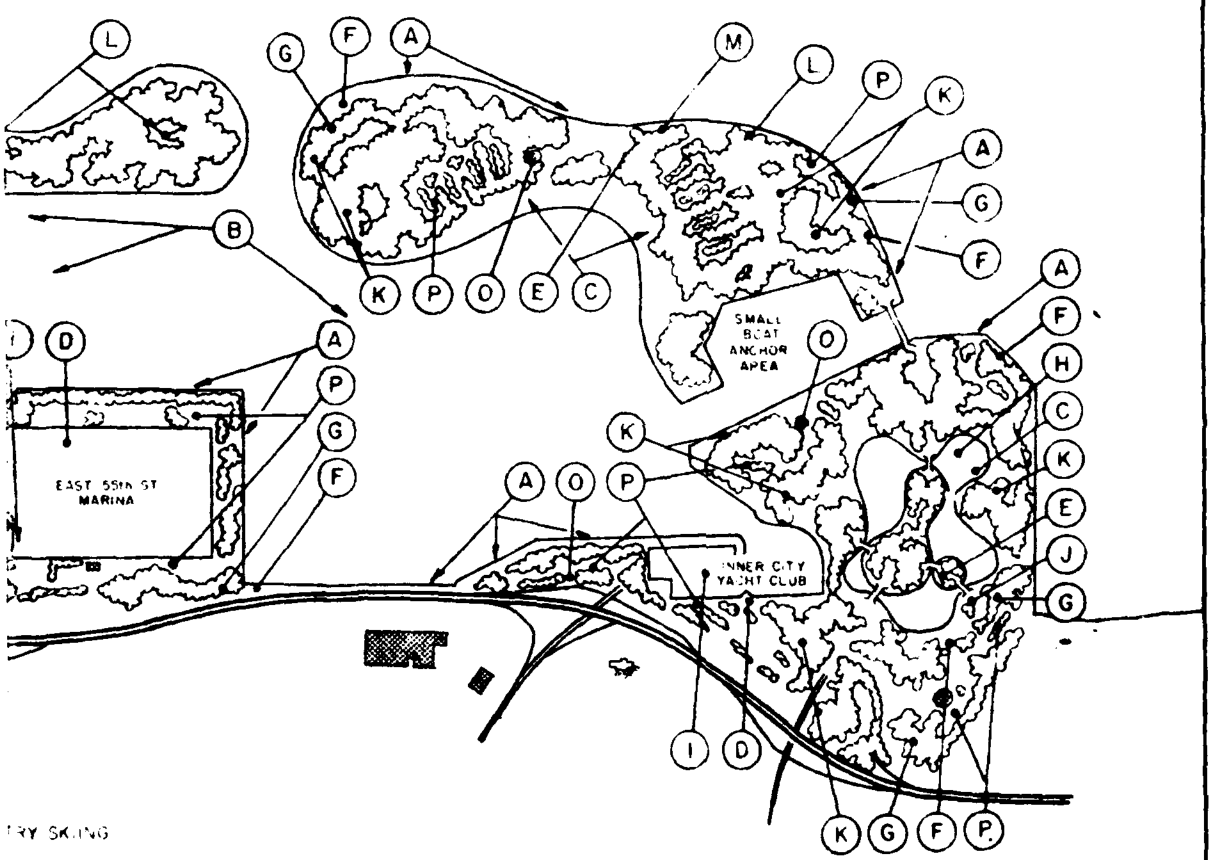

E R I E
HARBOR
EAST SHOREWAY
E 9th ST.
INNERBELT
F CLEVELAND
LEGEND
A FISHING
B BOATING
C SWIMMING
D BOAT LAUNCHING
F TRAIL
EVELAND LAKEFRONT STATE PARK
SCALE OF FEET
0 1000 2000



iG

AREA

G	BIKEWAY	M	CROSS COUNTRY SKIING
H	ICE SKATING	N	HISTORICAL INTEREST
I	MARINA	O	CONCESSION
J	CANOE LIVERY	P	PARKING
K	PICNICKING	Q	SHAKESPEARE THEATRE
L	NATURAL AREA	R	SLEDDING



RY SKIING

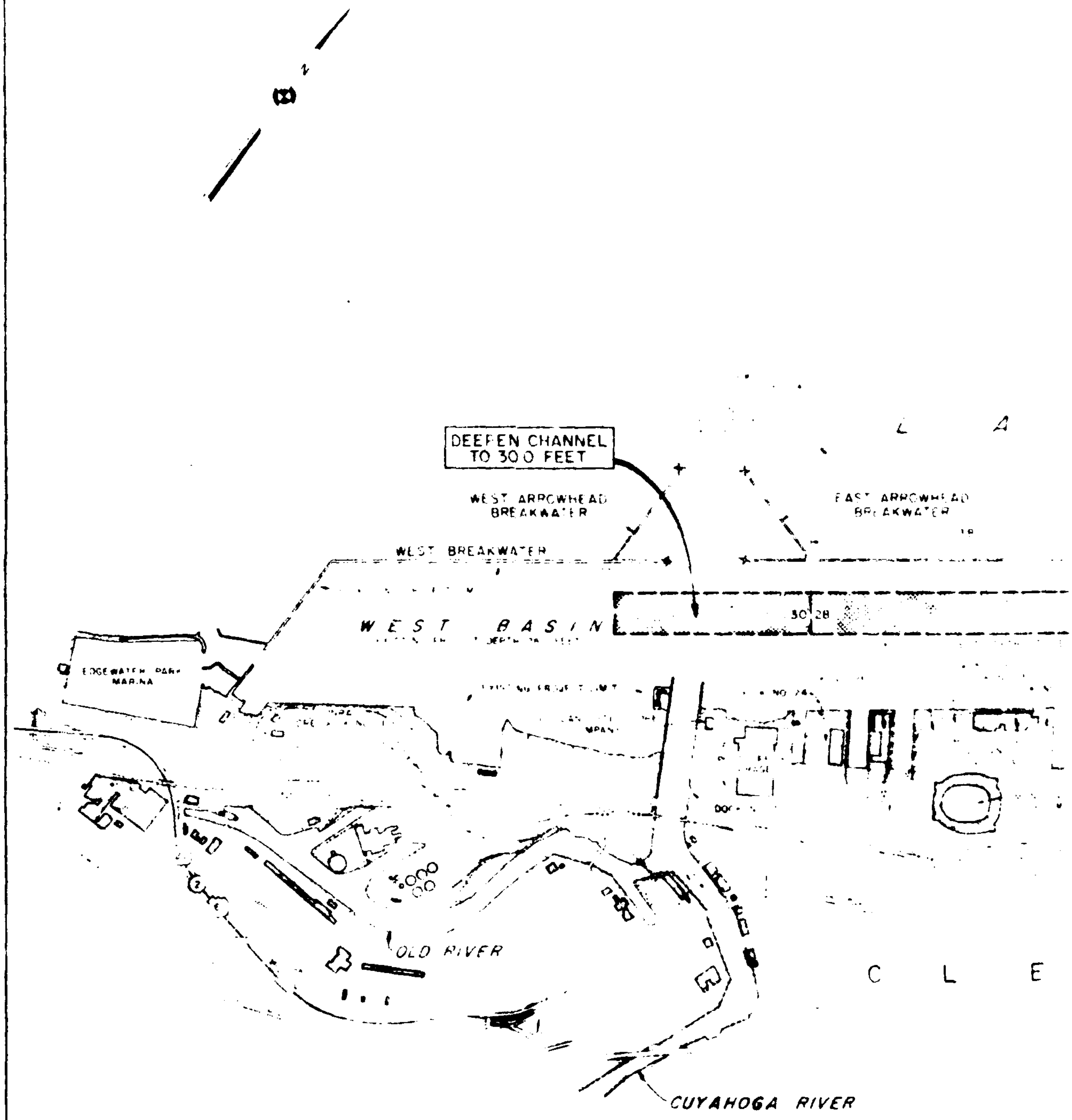
TEREST

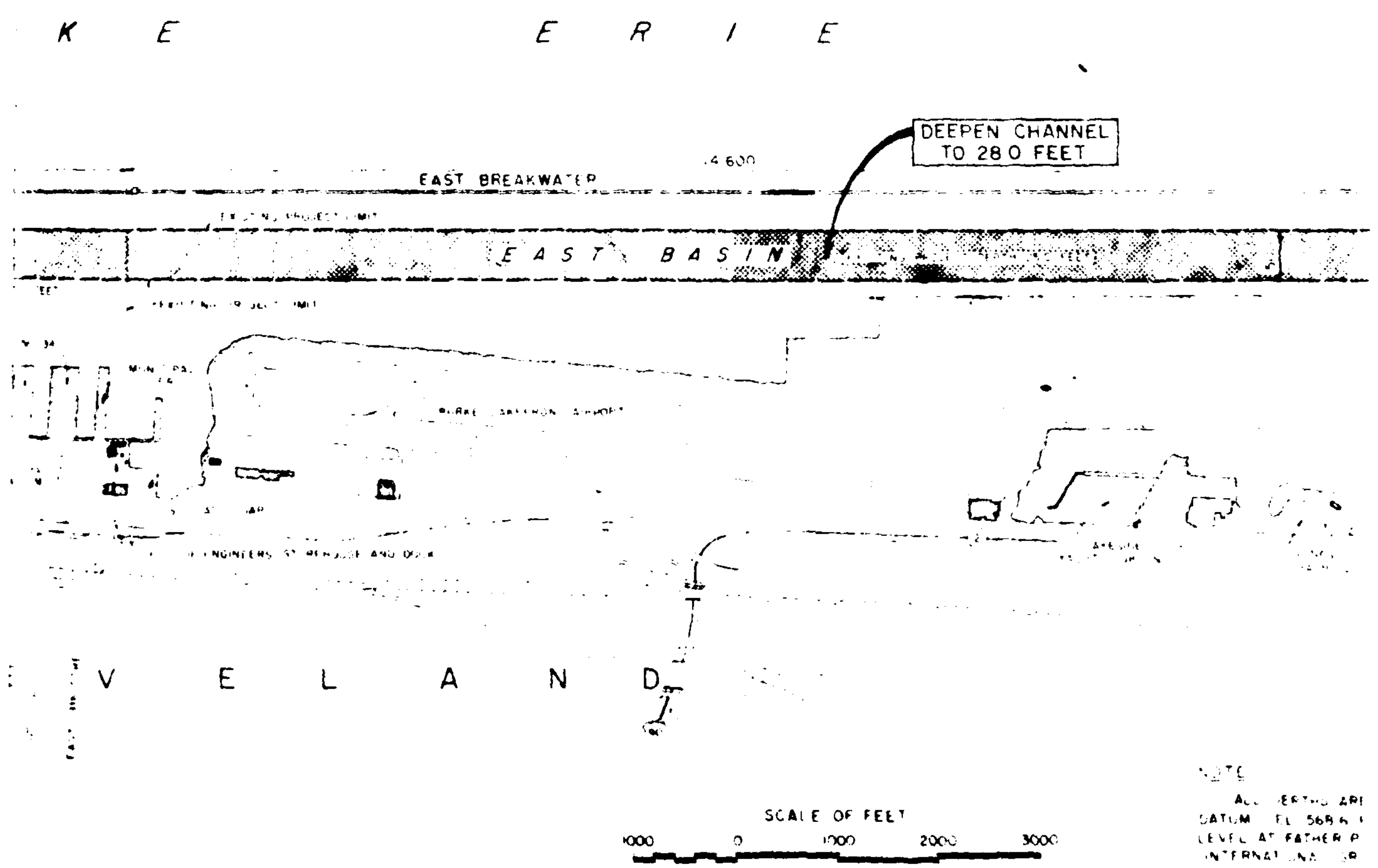
THEATRE

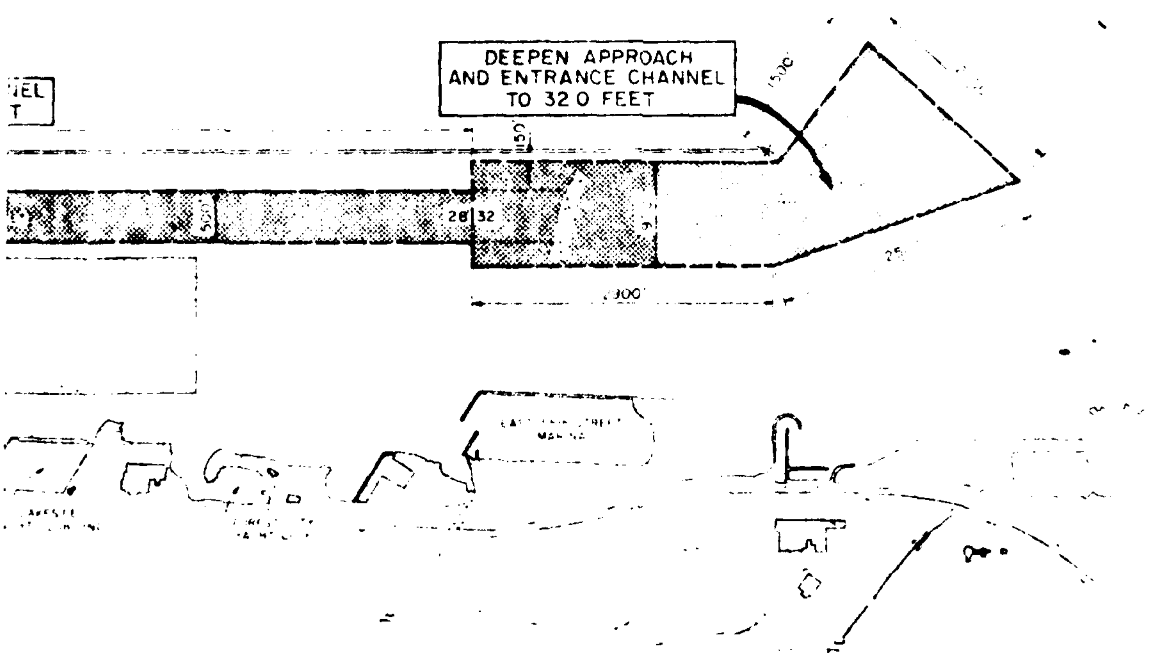
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

**PROPOSED
CLEVELAND LAKEFRONT
STATE PARK**

ARMY ENGINEER DISTRICT BUFFALO
982


DEEPEN CHANNEL
TO 30.0 FEET
WEST ARROWHEAD
BREAKWATER
EAST ARROWHEAD
BREAKWATER
WEST BREAKWATER
W E S T   B A S I N
30
28
EDGEWATER PARK
MARINA
OLD RIVER
CUYAHOGA RIVER
L   A
C   L   E


DEEPEN CHANNEL
TO 28.0 FEET
EAST BREAKWATER
EAST BASIN
SCALE OF FEET
1000 0 1000 2000 3000

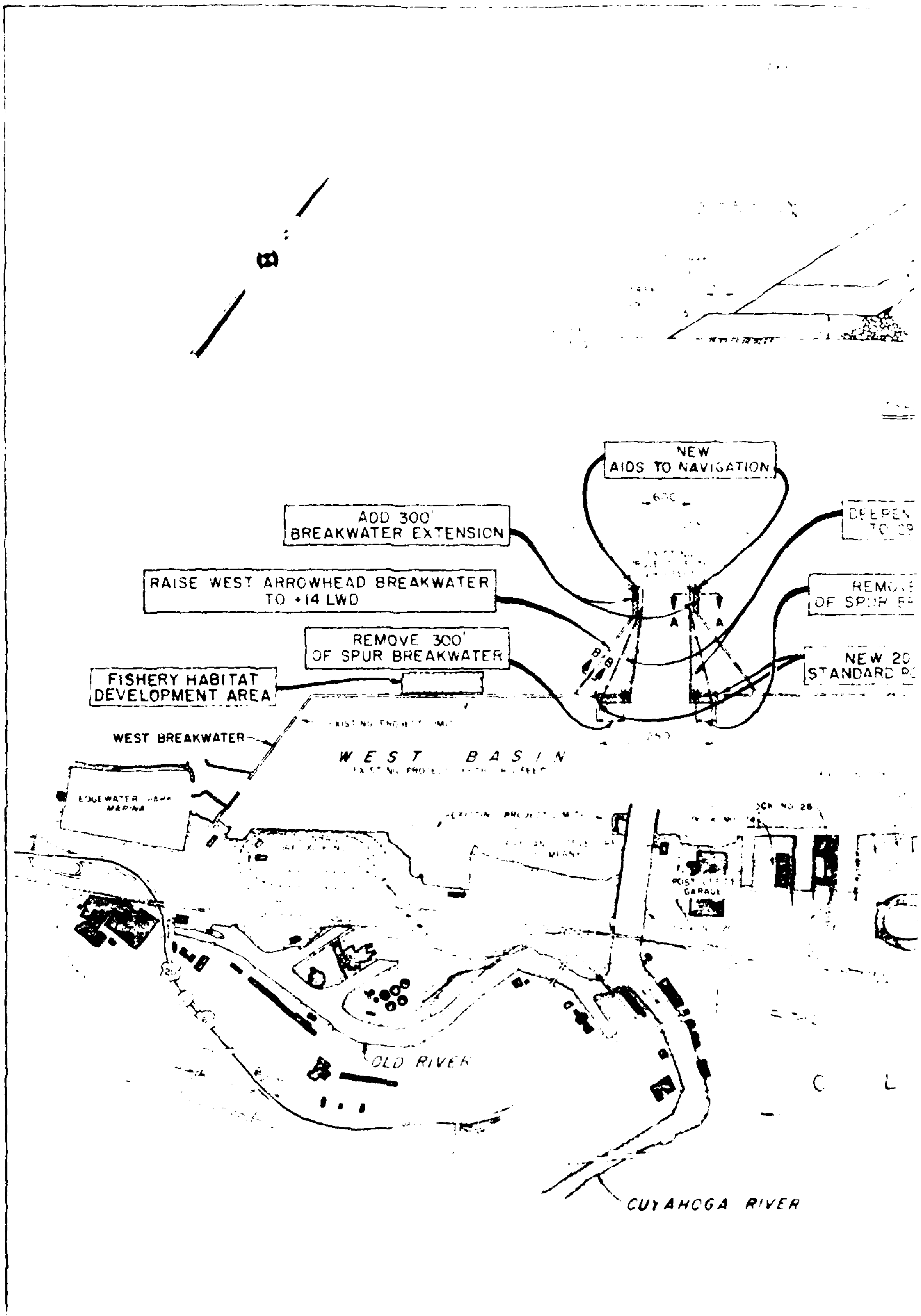


NOTE

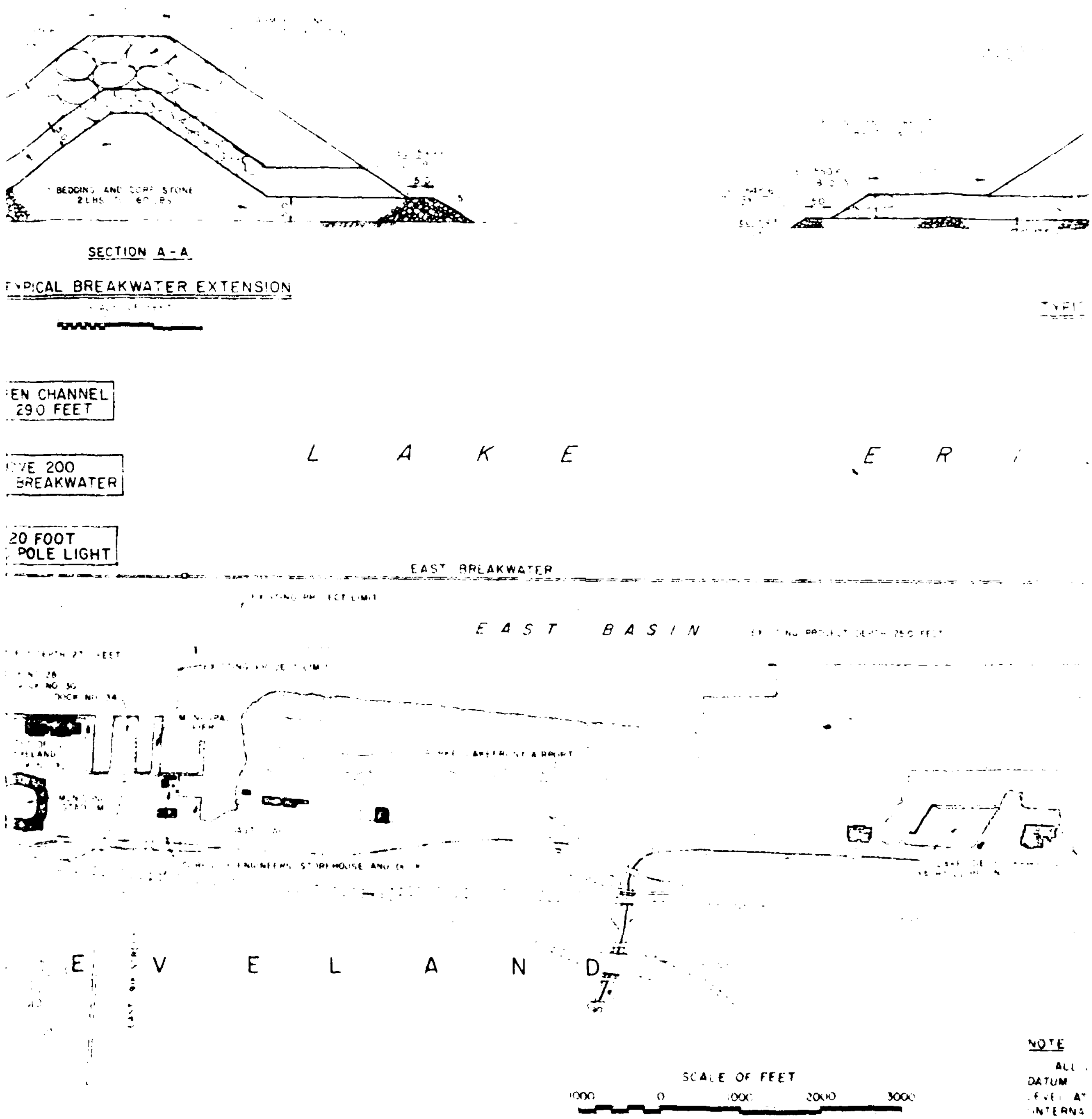
ALL DEPTHS ARE REFERRED TO LOW WATER DATUM, EL 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD 1955) (INTERNATIONAL GREAT LAKES DATUM 1955)

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE I
"ALL-WEATHER"
EAST ENTRANCE PLAN

U.S. ARMY ENGINEER DISTRICT BUFFALO

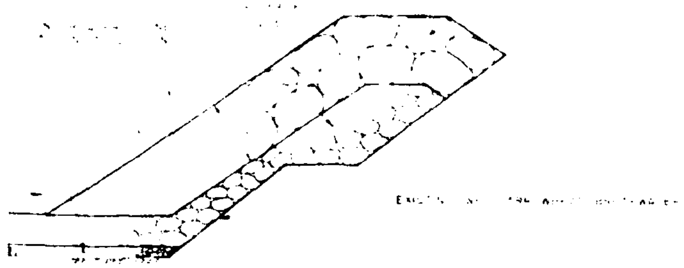


NEW
AIDS TO NAVIGATION
ADD 300'
BREAKWATER EXTENSION
RAISE WEST ARROWHEAD BREAKWATER
TO +14 LWD
REMOVE 300'
OF SPUR BREAKWATER
FISHERY HABITAT
DEVELOPMENT AREA
WEST BREAKWATER
W E S T B A S I N
OLD RIVER
CUYAHOGA RIVER



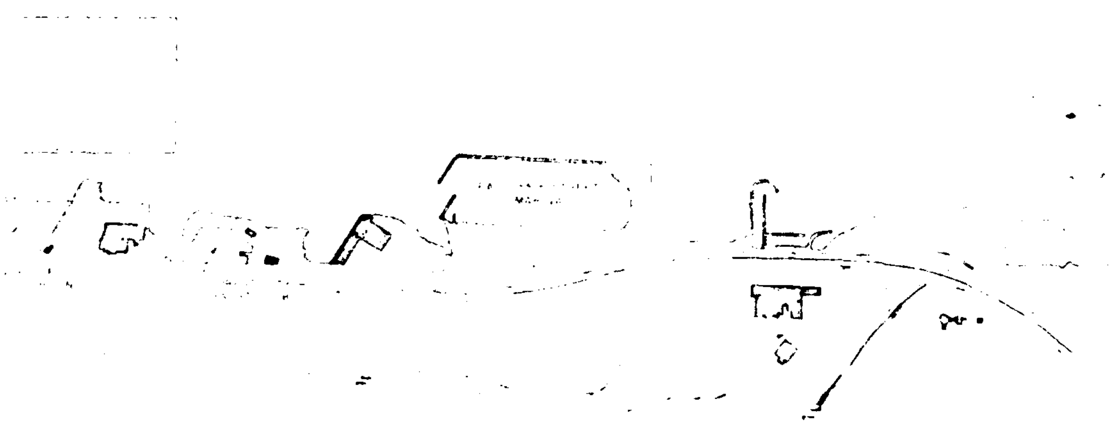
SECTION A-A
TYPICAL BREAKWATER EXTENSION
EN CHANNEL
29.0 FEET
VE 200
BREAKWATER
20 FOOT
POLE LIGHT
L A K E E R I
EAST BREAKWATER
E A S T B A S I N
E V E L A N D
NOTE
ALL
DATUM
INTERNA
SCALE OF FEET
1000 0 1000 2000 3000

2



SECTION B-B

TYPICAL NEW WEST ARROWHEAD BREAKWATER

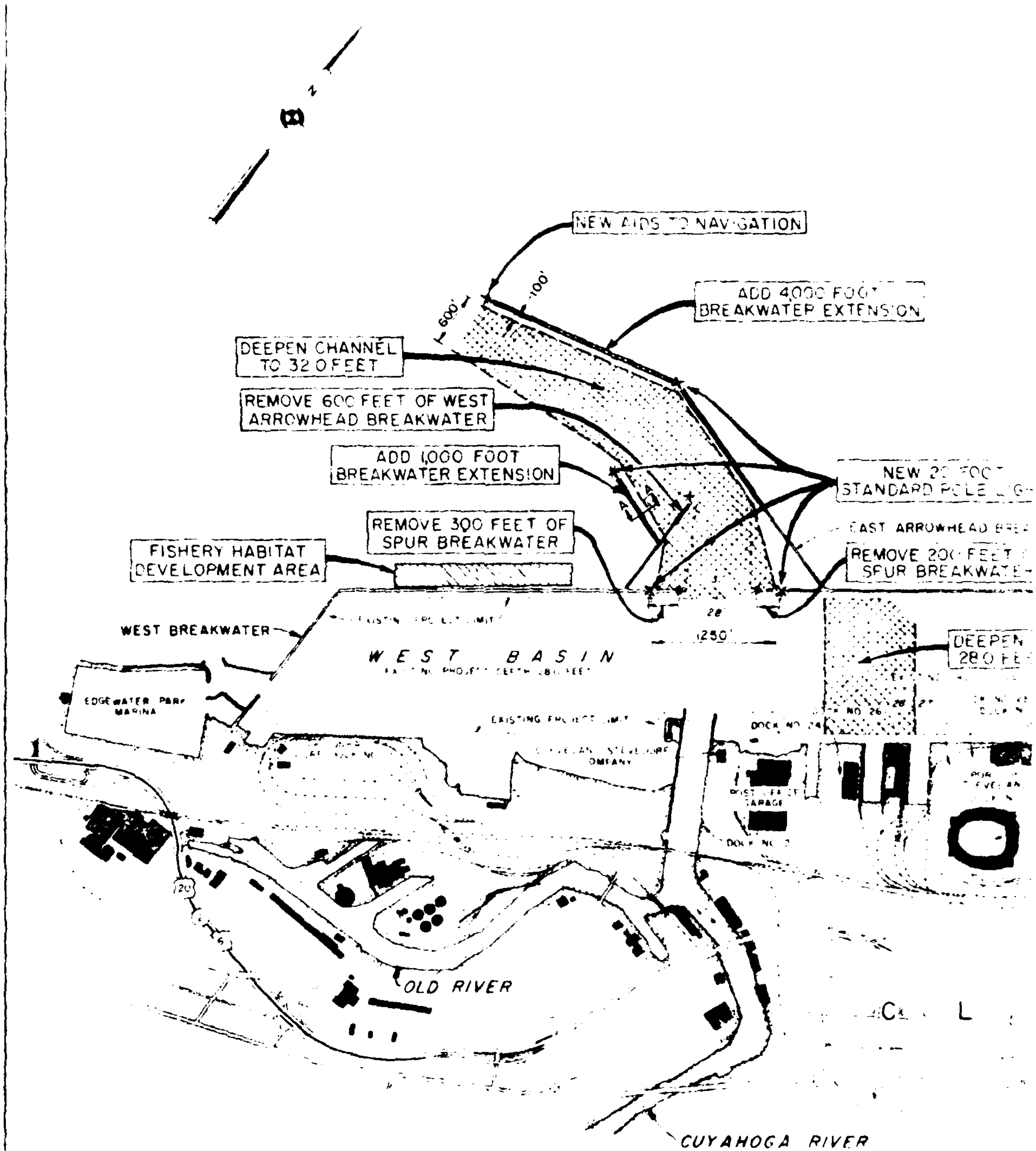


NOTE

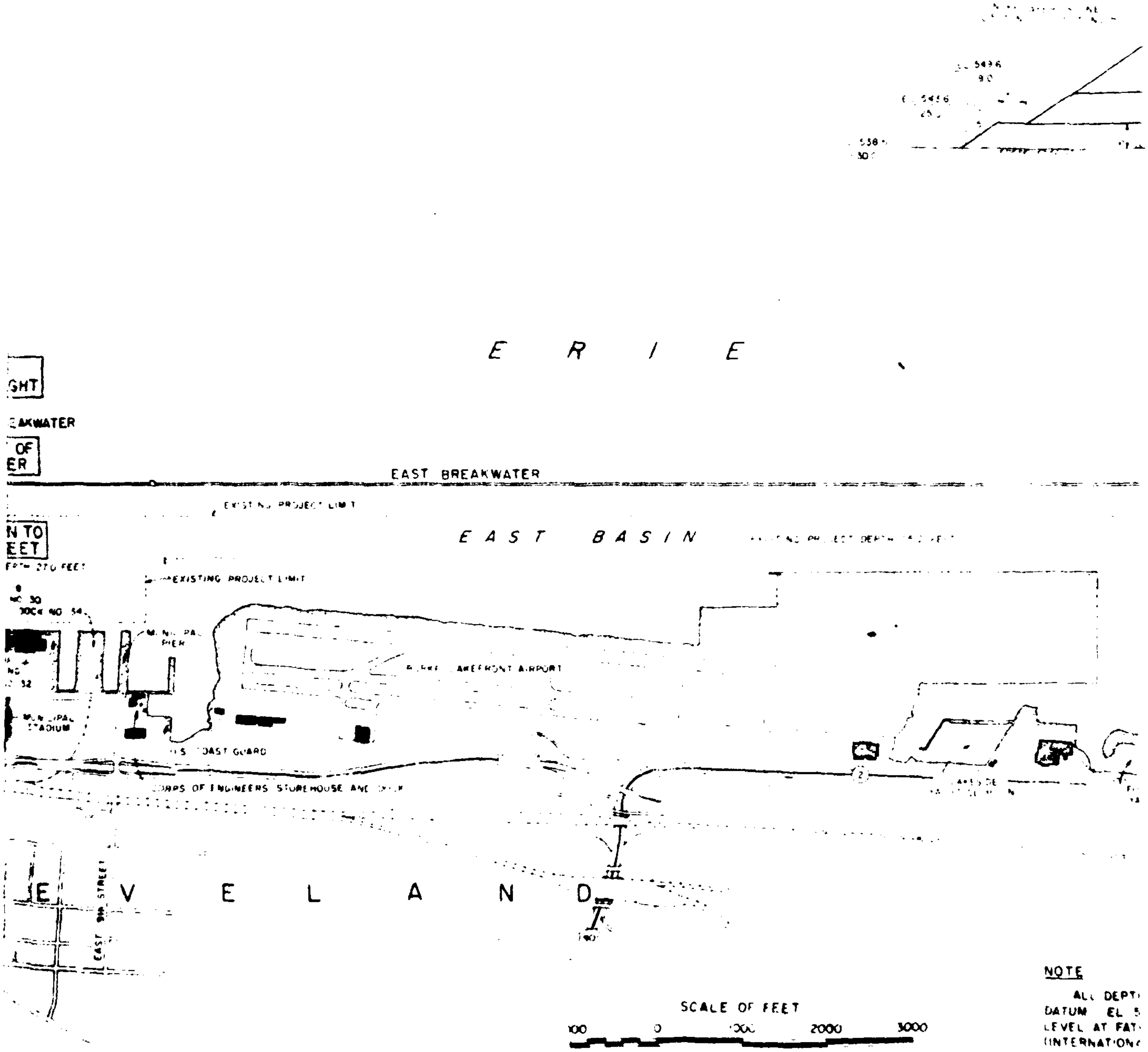
ALL DEPTHS ARE REFERRED TO LOW WATER DATUM EL 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT QUEBEC (IGLD 1955) INTERNATIONAL GREAT LAKES DATUM 1955)

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 2
"FAIR-WEATHER"
WEST ENTRANCE PLAN

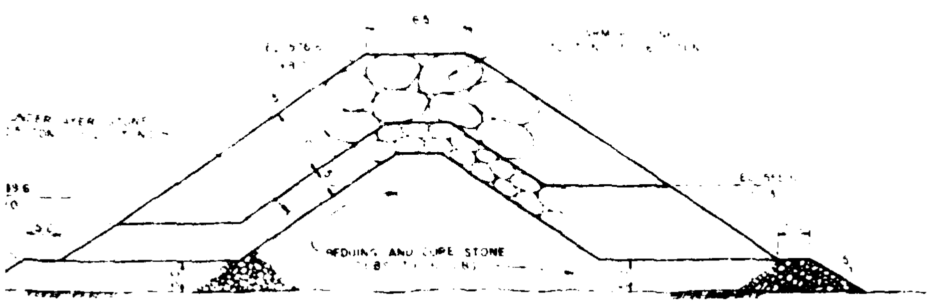
U.S. ARMY ENGINEER DISTRICT BUFFALO



NEW AIDS TO NAVIGATION
ADD 4,000 FOOT BREAKWATER EXTENSION
DEEPEN CHANNEL TO 32.0 FEET
REMOVE 600 FEET OF WEST ARROWHEAD BREAKWATER
ADD 1,000 FOOT BREAKWATER EXTENSION
REMOVE 300 FEET OF SPUR BREAKWATER
FISHERY HABITAT DEVELOPMENT AREA
WEST BREAKWATER
WEST BASIN
EDGEWATER PARK MARINA
EXISTING PROJECT LIMIT
OLD RIVER
CUYAHOGA RIVER

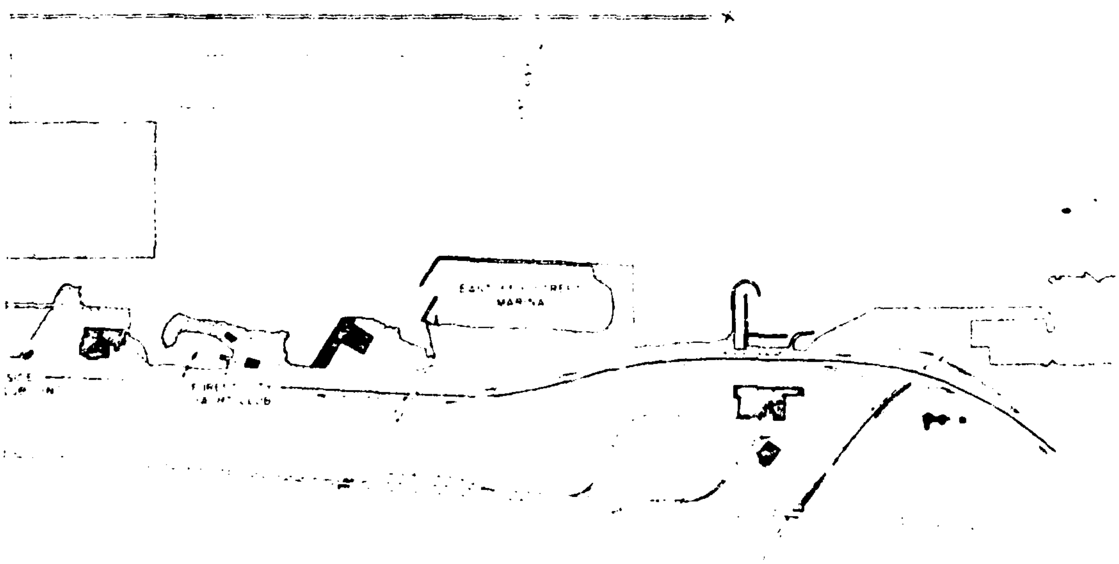


E R I E
EAST BREAKWATER
EAST BASIN
EXISTING PROJECT LIMIT
CORPS OF ENGINEERS STOREHOUSE AND
E V E L A N D
SCALE OF FEET
0
2000
3000
NOTE



SECTION A-A

TYPICAL BREAKWATER EXTENSION

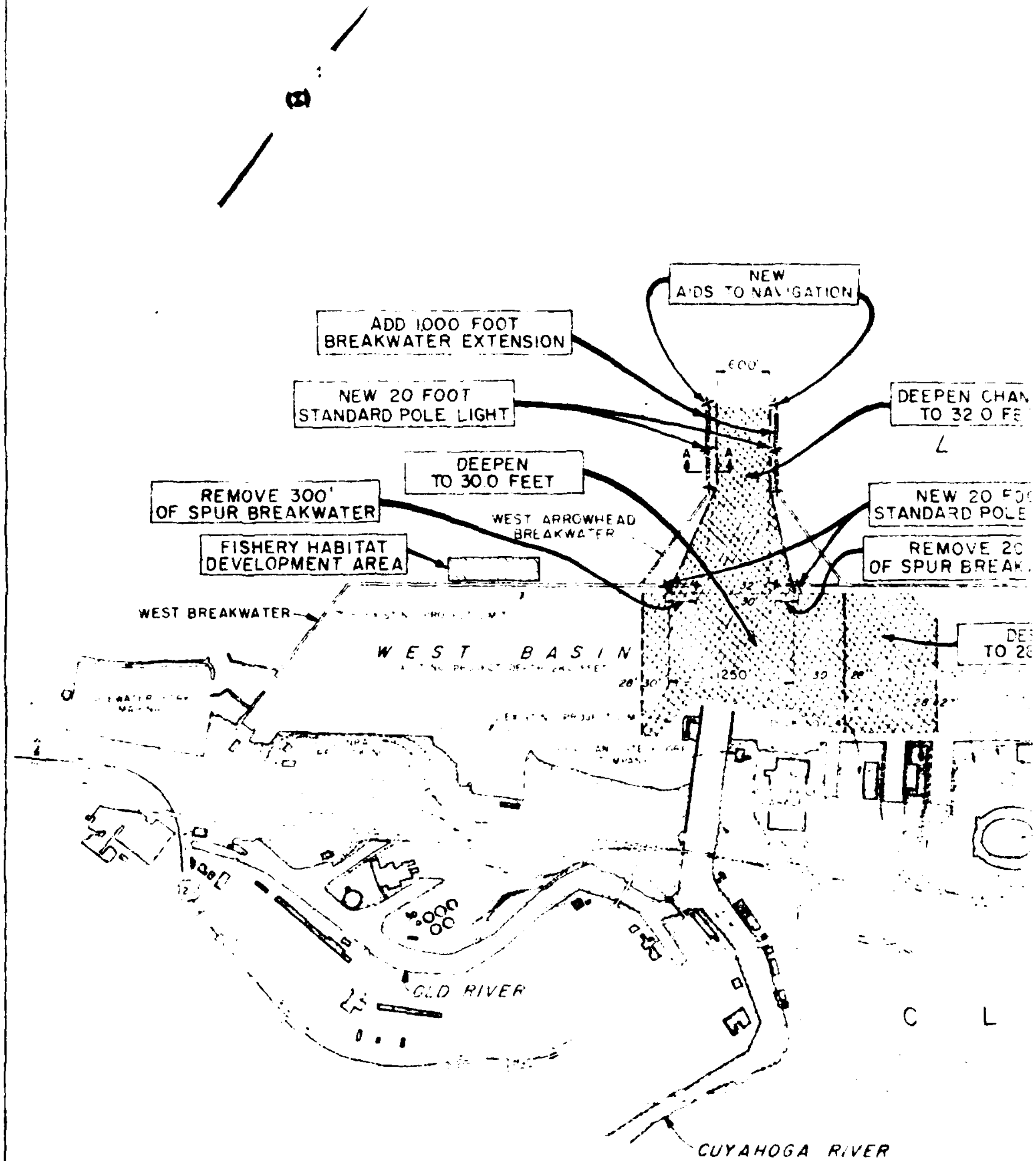


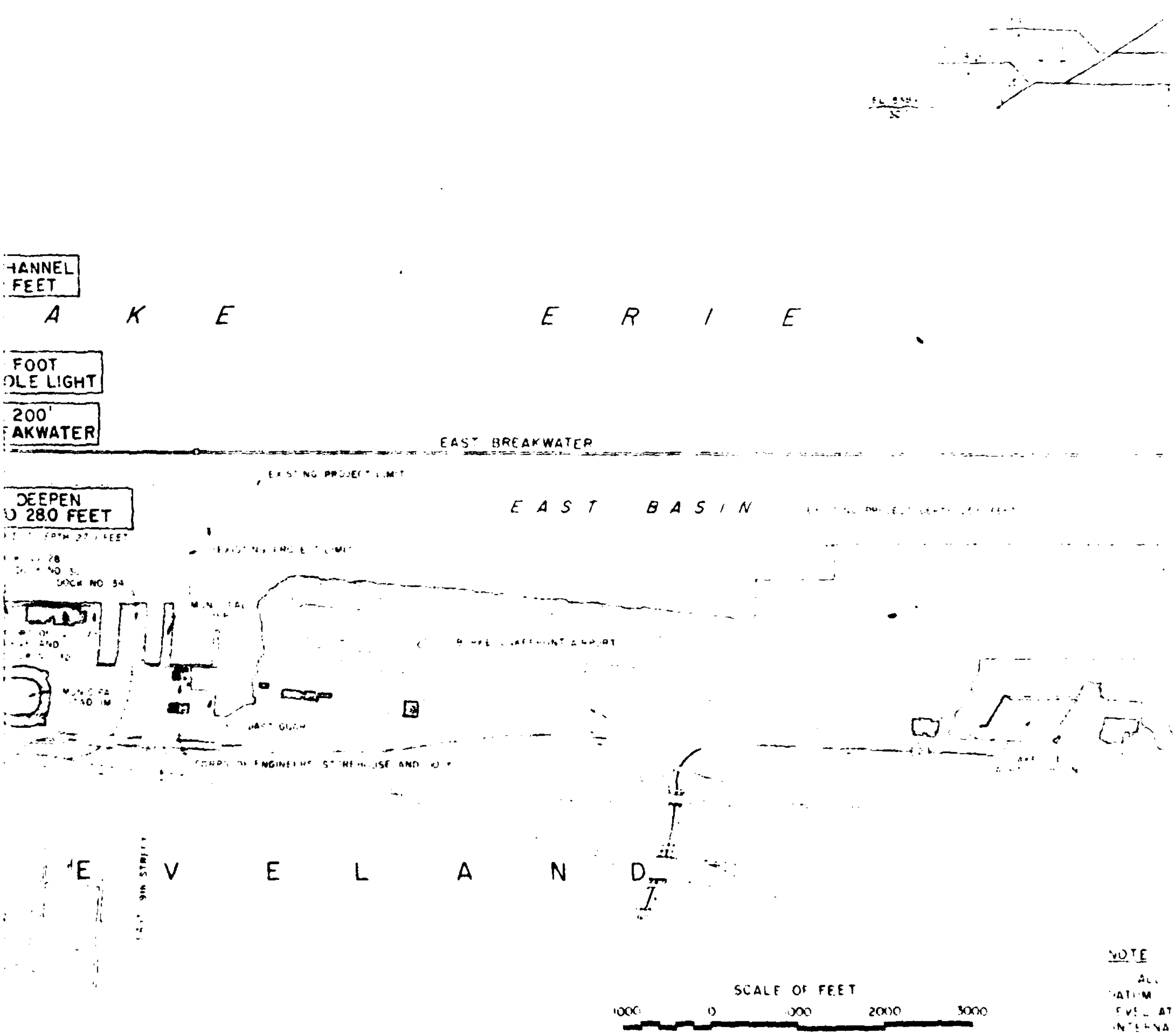
NOTE

ALL DEPTHS ARE REFERRED TO LOW WATER DATUM EL 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD 1955) (INTERNATIONAL GREAT LAKES DATUM 1955)

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 3 (OPTION A)
"ALL-WEATHER"
WEST ENTRANCE PLAN

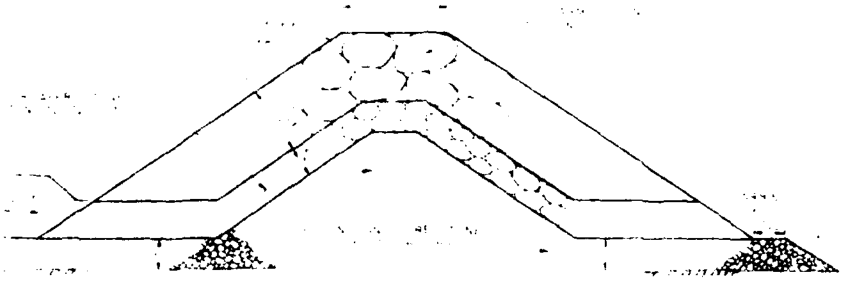
U.S. ARMY ENGINEER DISTRICT BUFFALO


NEW
AIDS TO NAVIGATION
ADD 1000 FOOT
BREAKWATER EXTENSION
600'
NEW 20 FOOT
STANDARD POLE LIGHT
DEEPEN
TO 30.0 FEET
REMOVE 300'
OF SPUR BREAKWATER
WEST ARROWHEAD
BREAKWATER
FISHERY HABITAT
DEVELOPMENT AREA
WEST BREAKWATER
WEST BASIN
1250'
OLD RIVER
CUYAHOGA RIVER
C L



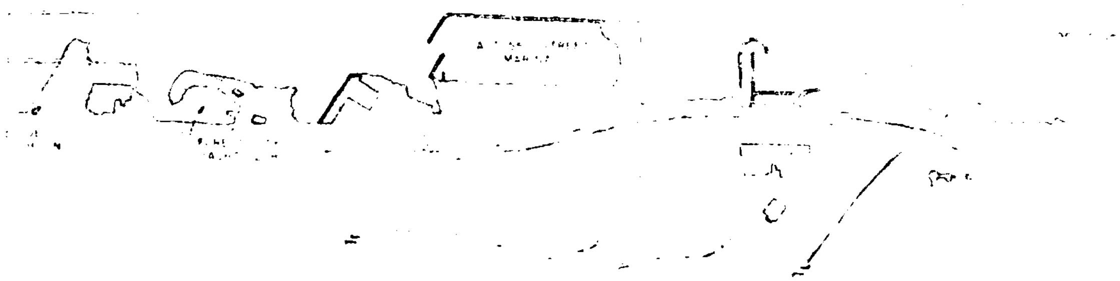
HANNEL
FEET
A K E E R I E
FOOT
OLE LIGHT
200'
AKWATER
EAST BREAKWATER
EXISTING PROJECT LIMIT
EAST BASIN
DEEPEN
0 28.0 FEET
DOCK NO. 34
E V E L A N D
SCALE OF FEET
1000 0 1000 2000 3000
NOTE

2



SECTION A-A

TYPICAL BREAKWATER EXTENSION



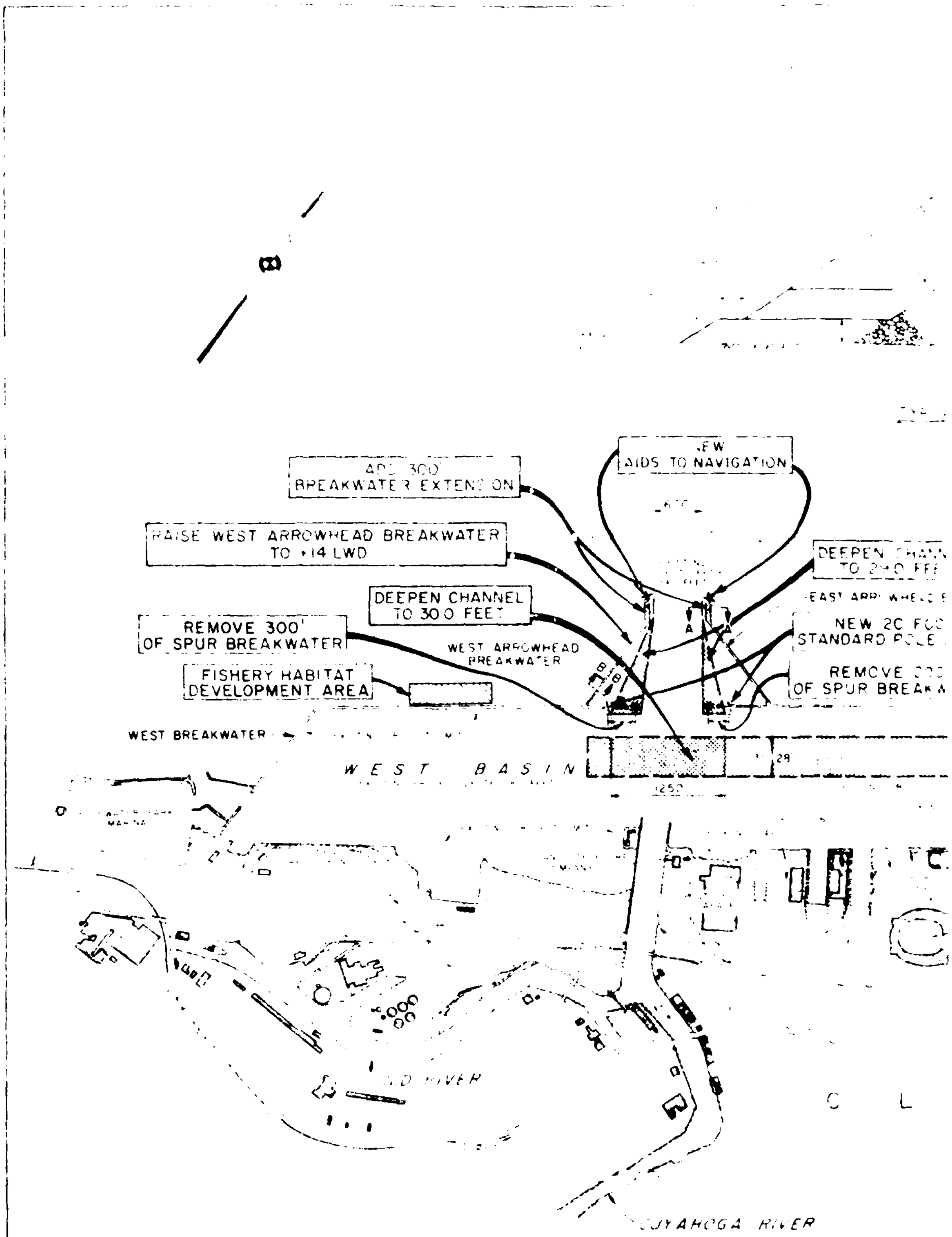
NOTE

ALL DEPTHS ARE REFERRED TO LOW WATER DATUM EL 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT QUEBEC (IGLD 1955) (INTERNATIONAL GREAT LAKES DATUM 1955)

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 3 (OPTION B)
"ALL-WEATHER"
WEST ENTRANCE PLAN

U.S. ARMY ENGINEER DISTRICT BUFFALO

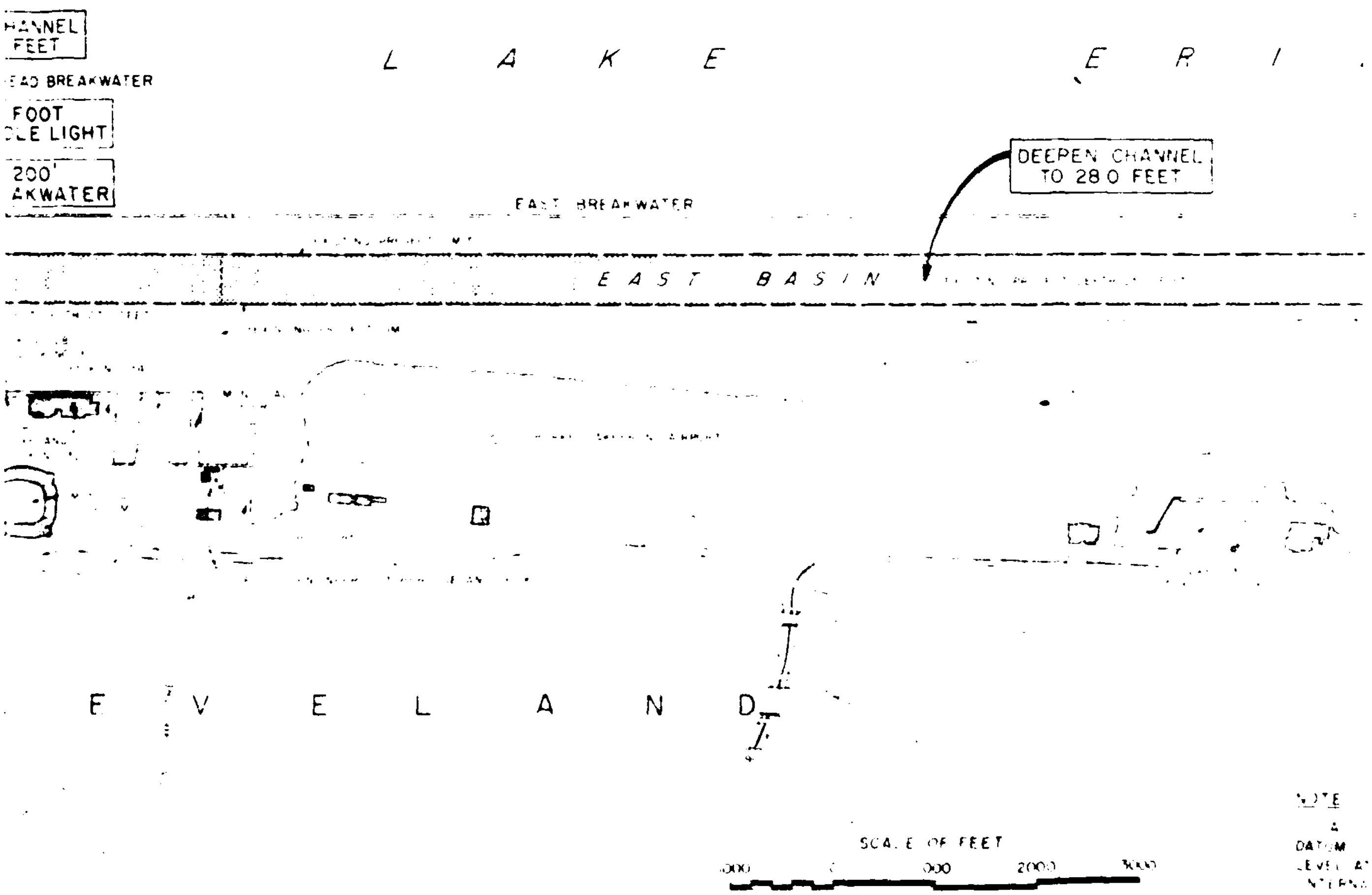
3

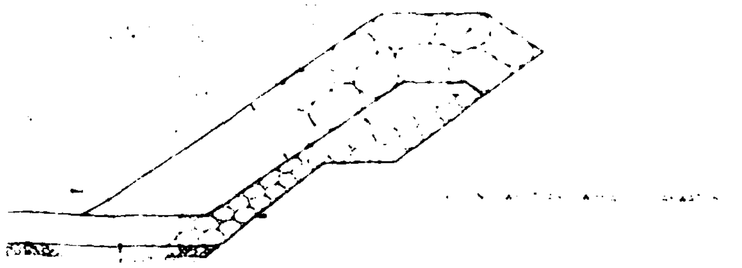


AIDS TO NAVIGATION
BREAKWATER EXTENSION
RAISE WEST ARROWHEAD BREAKWATER
TO +14 LWD
DEEPEN CHANNEL
TO 30.0 FEET
REMOVE 300'
OF SPUR BREAKWATER
FISHERY HABITAT
DEVELOPMENT AREA
WEST ARROWHEAD
BREAKWATER
WEST BREAKWATER
W E S T   B A S I N
28
1250
NEW
STANDARD
REMOVE
OF SPUR
A
B

SECTION A-A

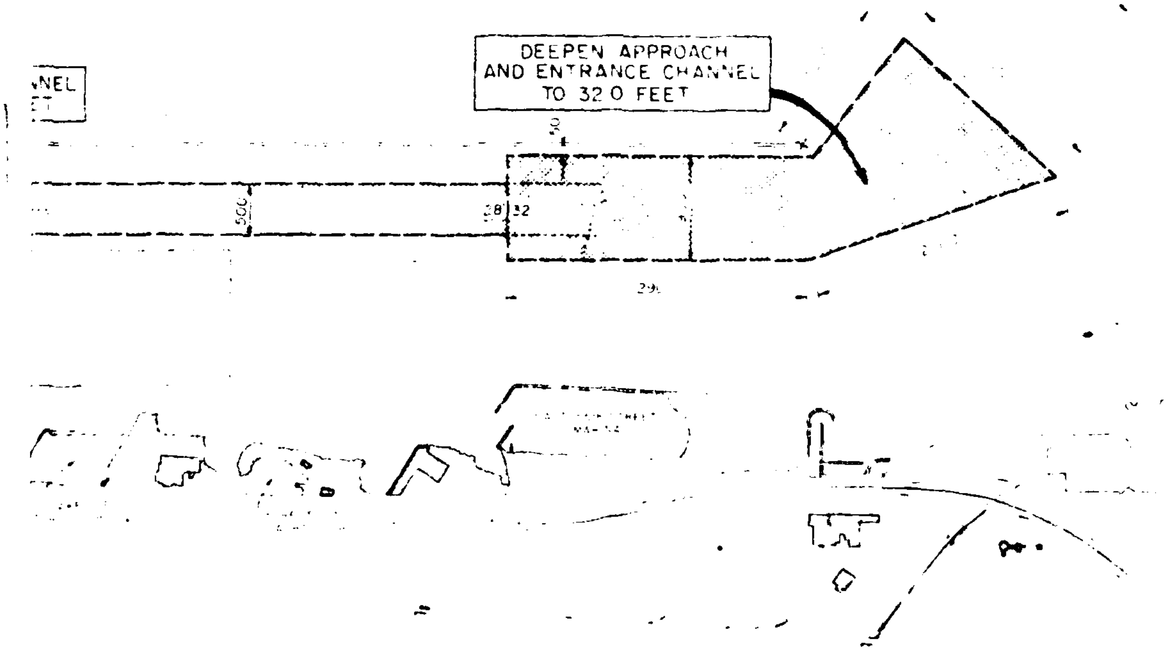
YPICAL BREAKWATER EXTENSION





SECTION B-B

TYPICAL NEW WEST ARROWHEAD BREAKWATER

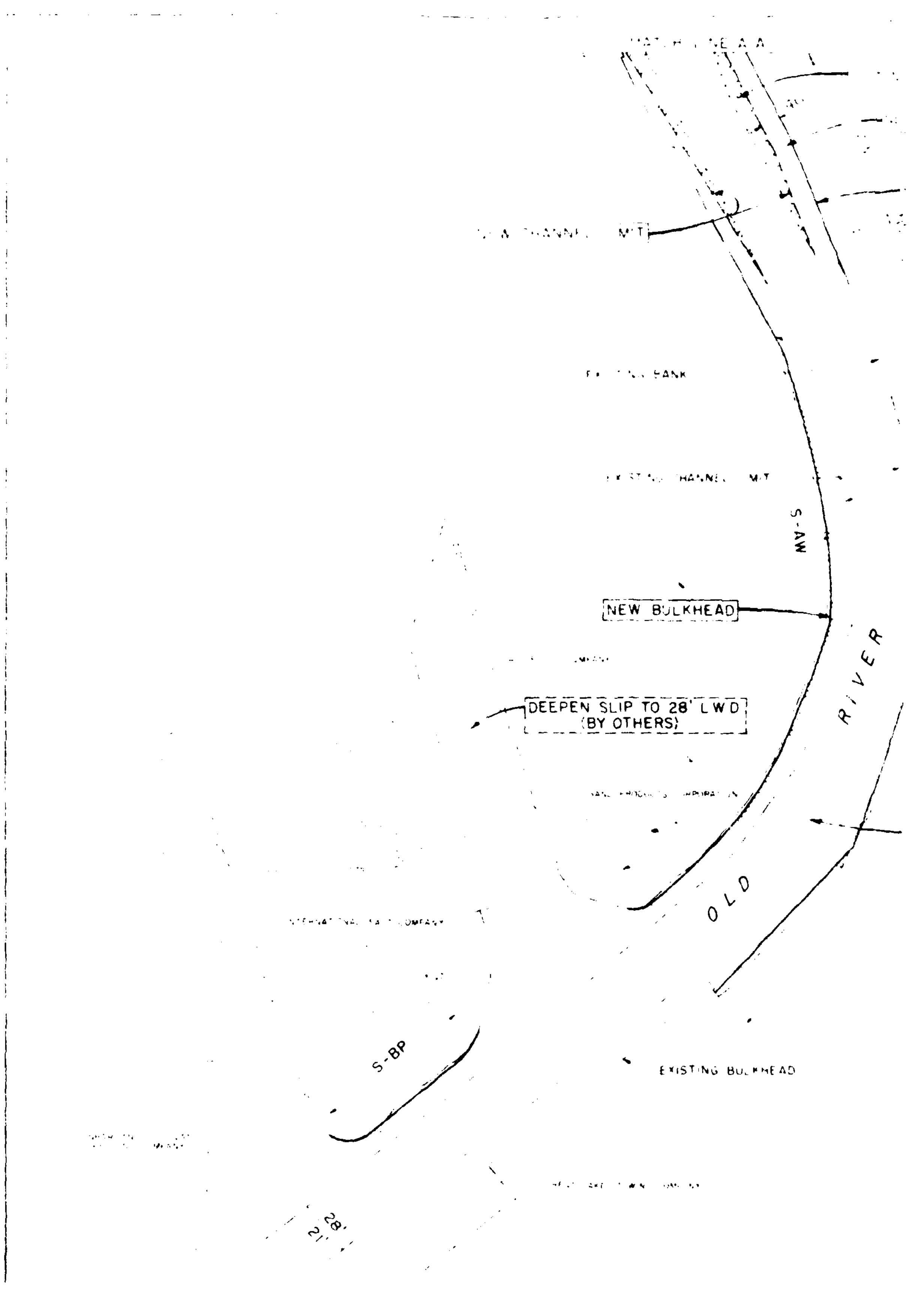


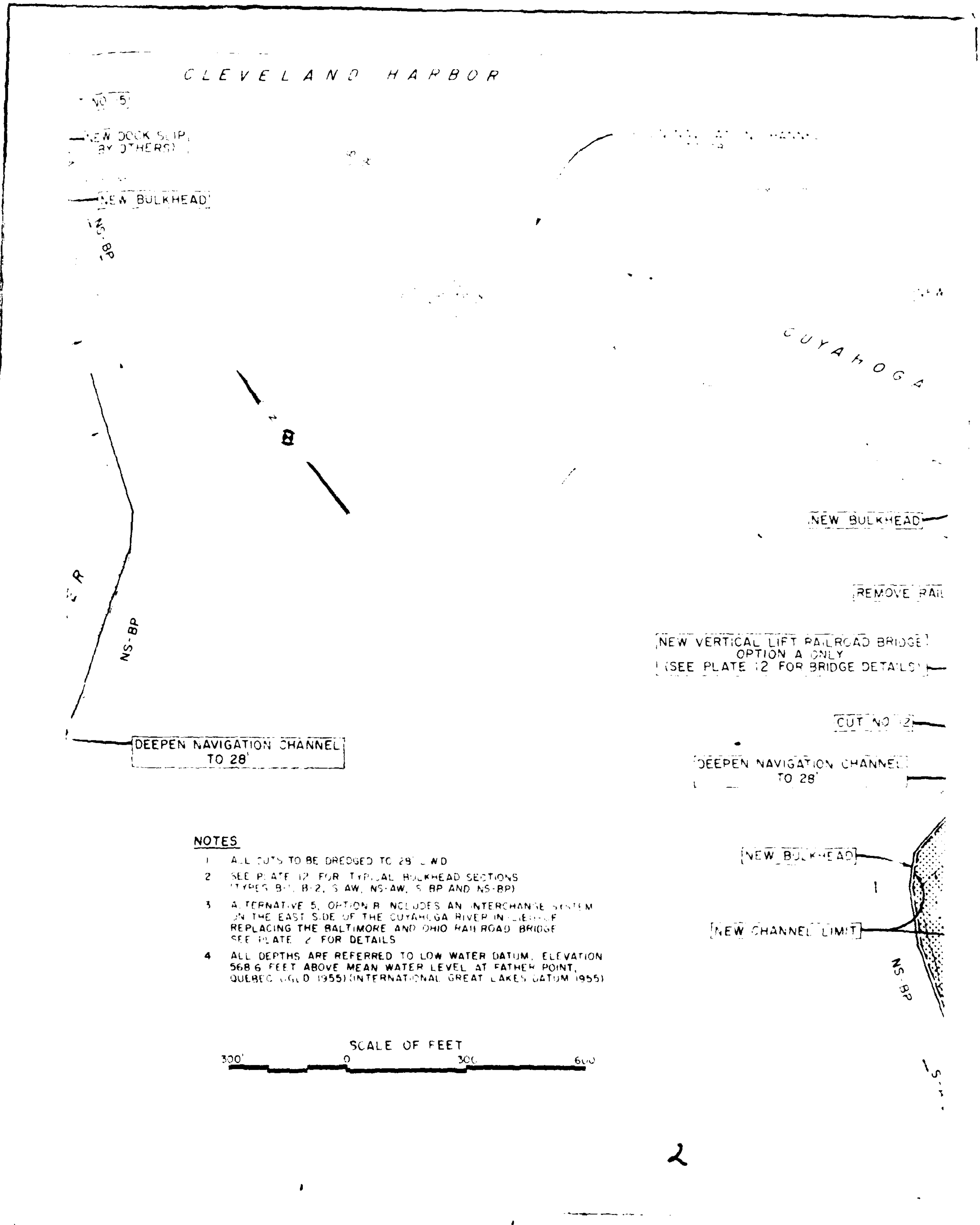
NOTE

ALL DEPTHS ARE REFERRED TO LOW WATER DATUM EL. 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD 1955) (INTERNATIONAL GREAT LAKES DATUM 1955)

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 4
COMBINED "ALL-WEATHER" EAST ENTRANCE
AND
"FAIR-WEATHER" WEST ENTRANCE PLAN

U.S. ARMY ENGINEER DISTRICT BUFFALO

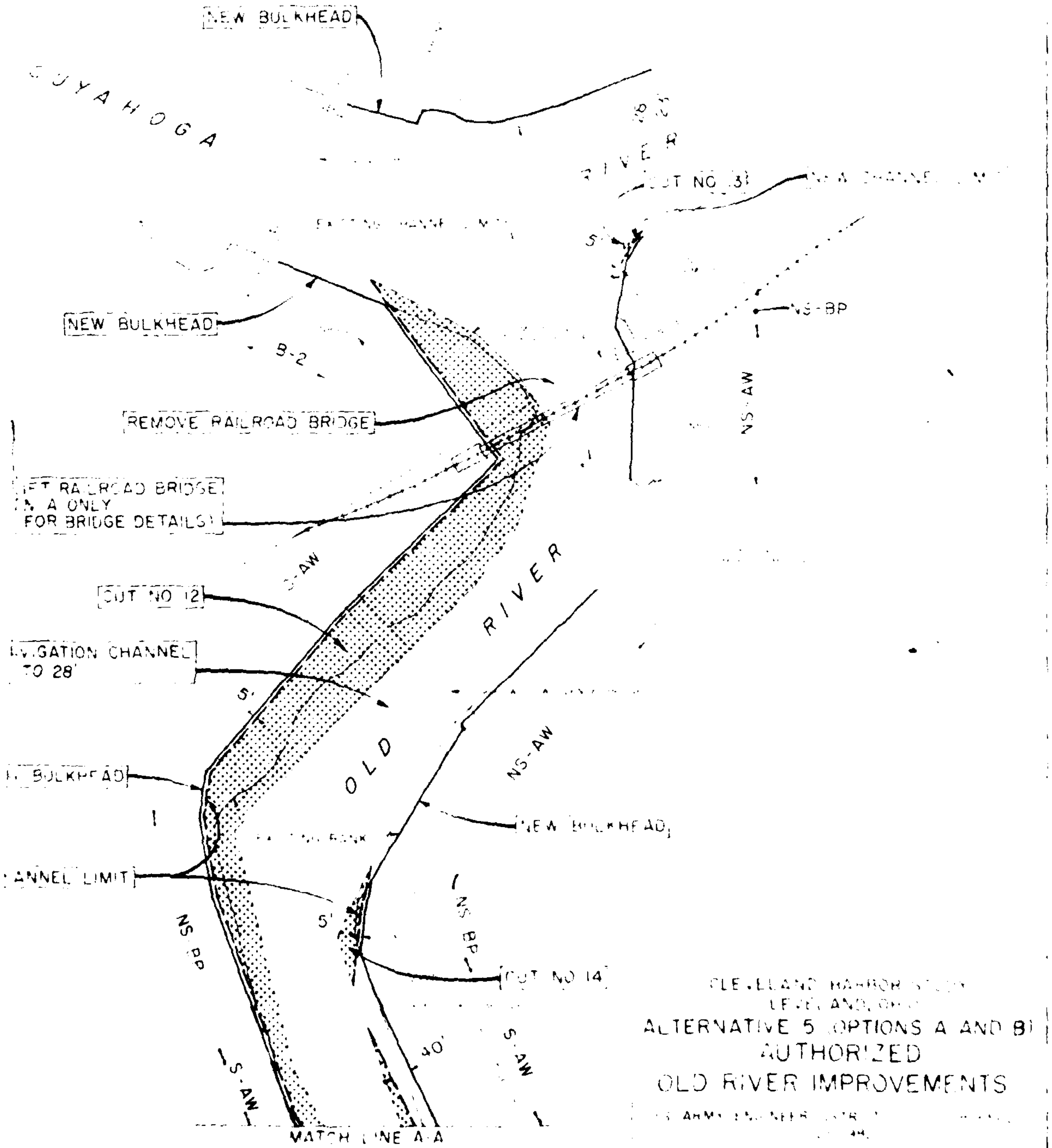

NEW BULKHEAD
DEEPEN SLIP TO 28' LWD
(BY OTHERS)
S-AW
OLD
RIVER
S-BP
EXISTING BULKHEAD
28'
21'



NOTES

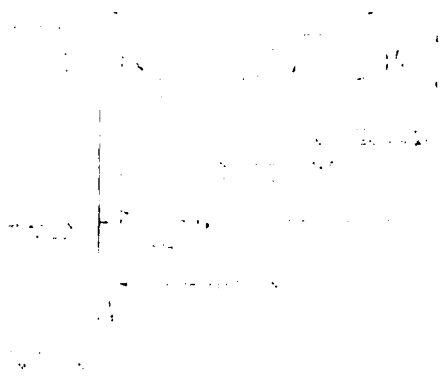
1. ALL CUTS TO BE DREDGED TO 28' LWD
2. SEE PLATE 12 FOR TYPICAL BULKHEAD SECTIONS (TYPES B-1, B-2, S-AW, NS-AW, S-BP AND NS-BP)
3. ALTERNATIVE 5, OPTION B INCLUDES AN INTERCHANGE SYSTEM ON THE EAST SIDE OF THE CUYAHOGA RIVER IN LIEU OF REPLACING THE BALTIMORE AND OHIO RAILROAD BRIDGE SEE PLATE 12 FOR DETAILS
4. ALL DEPTHS ARE REFERRED TO LOW WATER DATUM, ELEVATION 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (I.G.L.D. 1955) (INTERNATIONAL GREAT LAKES DATUM 1955)

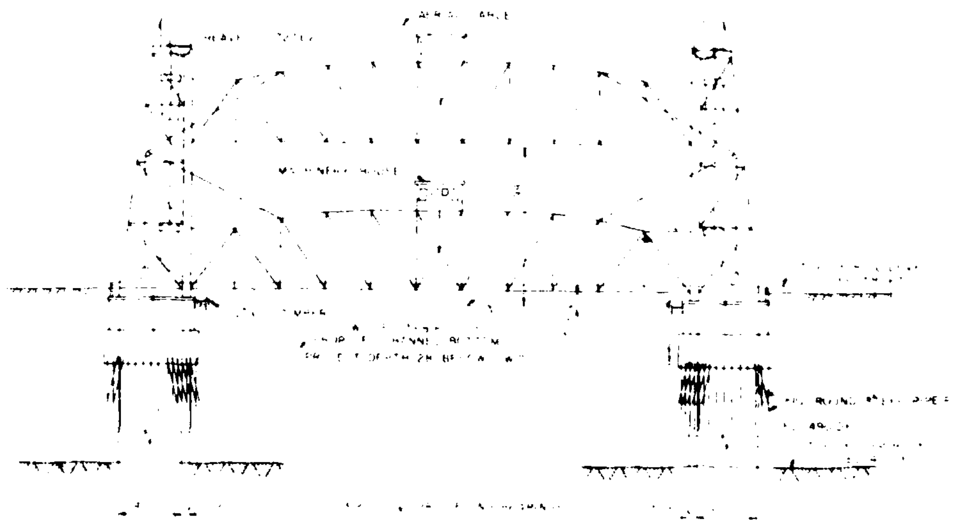
2



NEW BULKHEAD
CUYAHOGA
RIVER
CUT NO. 13
NEW BULKHEAD
B-2
NS-BP
NS-AW
REMOVE RAILROAD BRIDGE
FOR BRIDGE DETAILS
S-AW
RIVER
CUT NO. 12
TO 28'
5'
OLD
NS-AW
NEW BULKHEAD
ANNEL LIMIT
5'
NS-BP
NS-BP
CUT NO. 14
40'
S-AW
S-AW
MATCH LINE A-A
ALTERNATIVE 5 (OPTIONS A AND B)
AUTHORIZED
OLD RIVER IMPROVEMENTS

3





ELEVATION OF PROPOSED VERTICAL LIFT RAILROAD BRIDGE

ALTERNATIVE 5, (OPTION A)

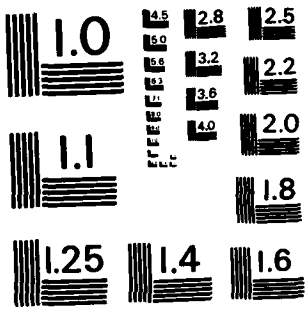
SCALE OF FEET

100 0 100 200

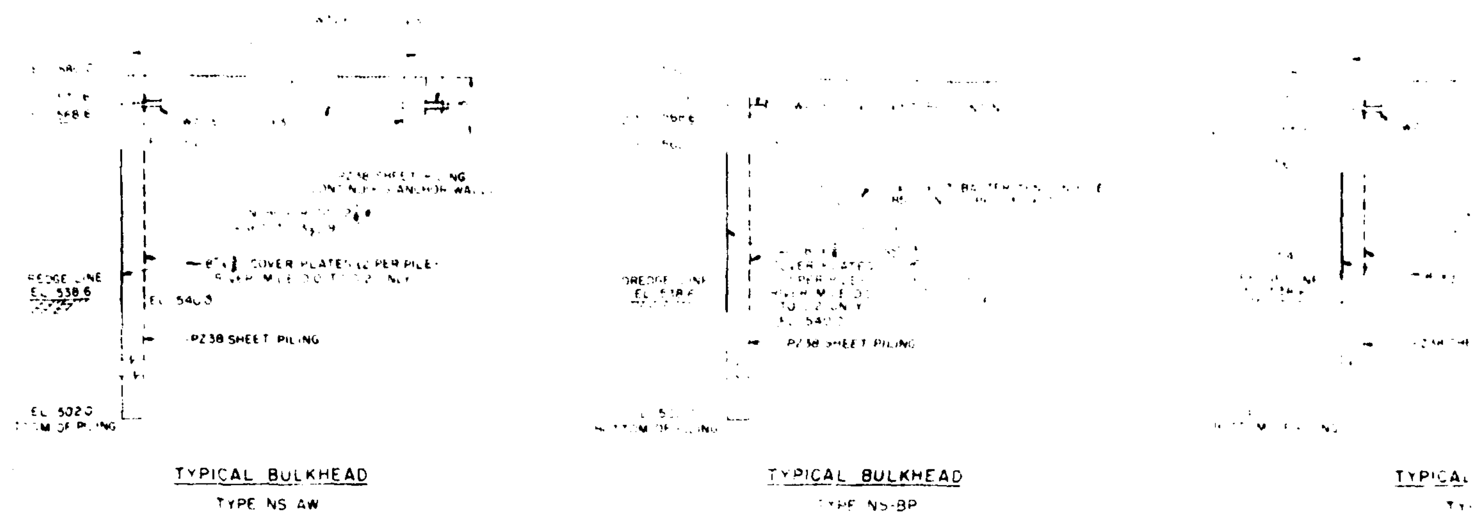
AD-A127 216 STAGE 2 REPORT FOR REFORMULATION PHASE I GENERAL DESIGN MEMORANDUM CLEVEL..(U) CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT FEB 83 7/7

UNCLASSIFIED F/G 13/10 NL

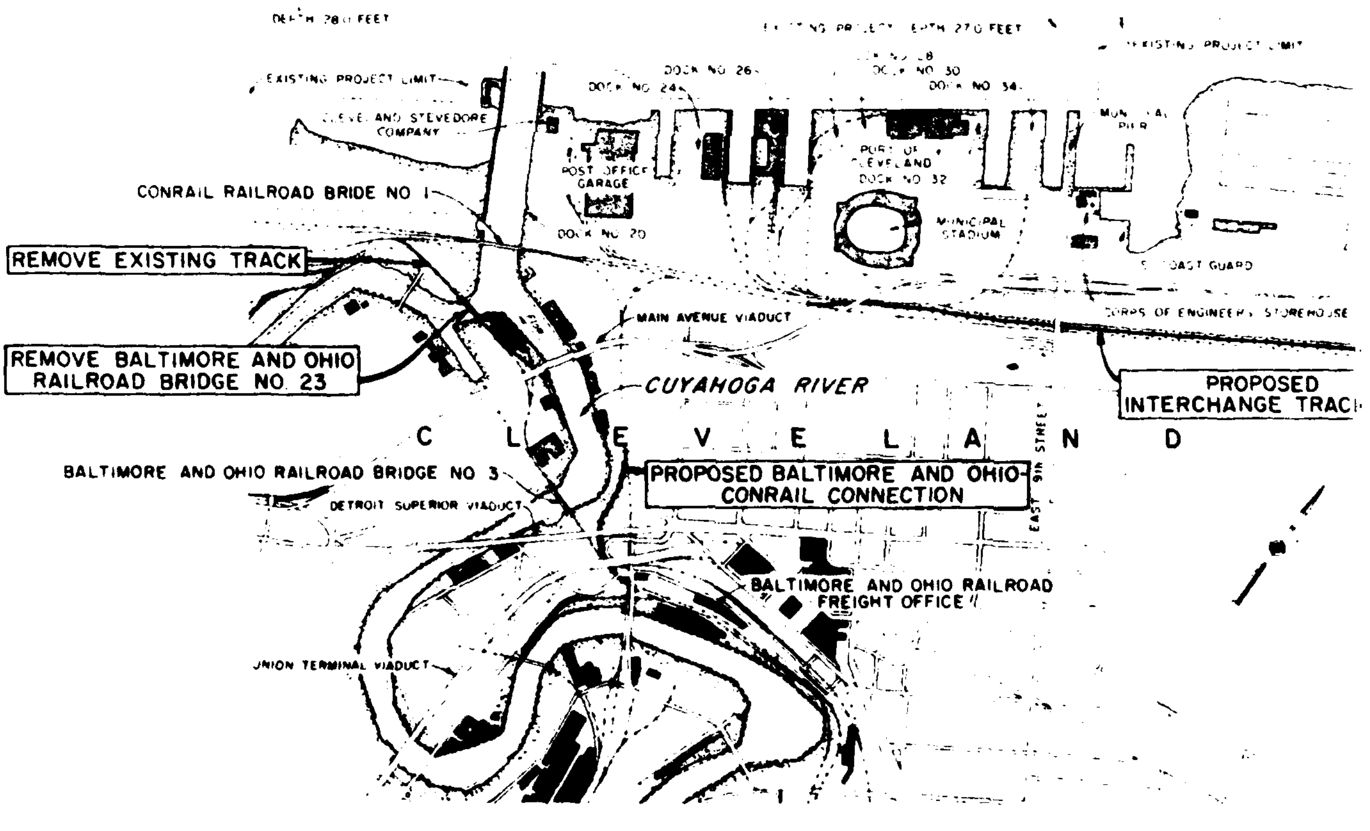
END
DATE
FILMED
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



TYPICAL NEW BULKHEAD SECTIONS

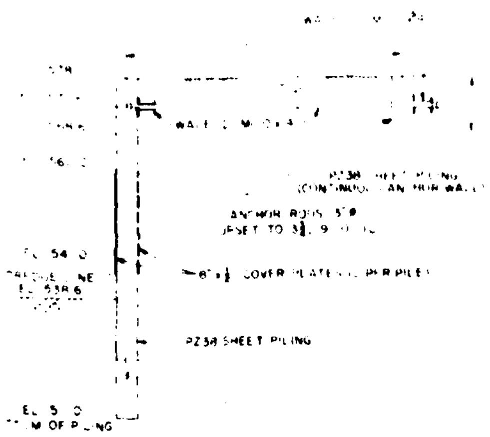


PROPOSED BALTIMORE AND OHIO RAILROAD INTERCHANGE SYSTEM

(ALTERNATIVE 5, OPTION B)

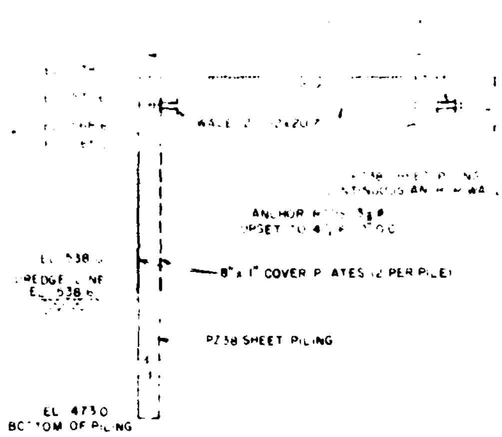
SCALE OF FEET

1000' 0 1000' 2000' 3000'



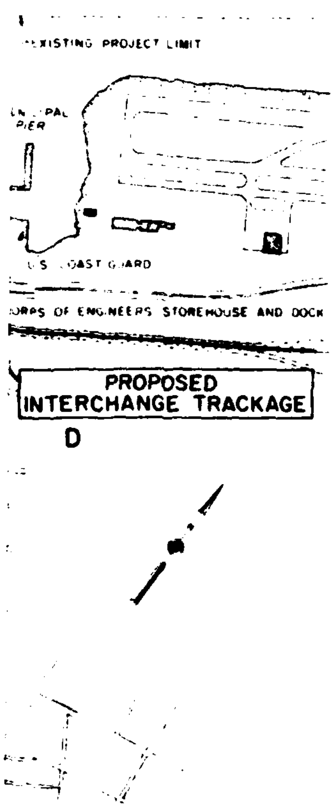
TYPICAL BULKHEAD

TYPE B-1



TYPICAL BULKHEAD

TYPE B-2

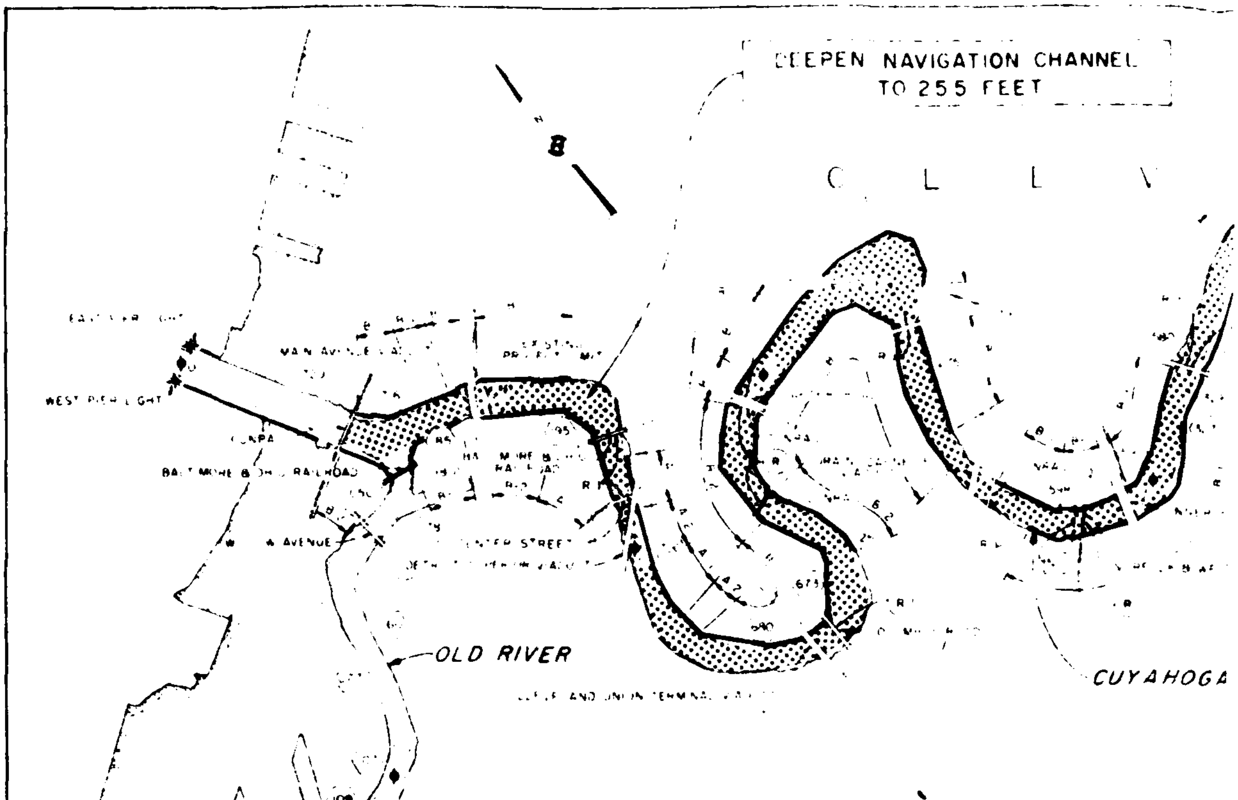


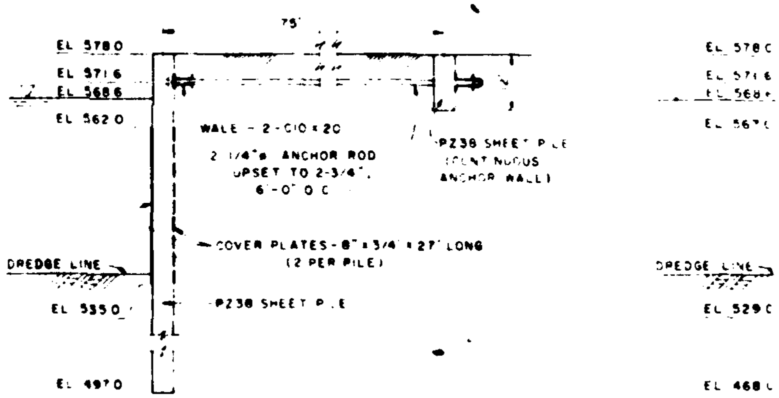
GE SYSTEM

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

TYPICAL SECTIONS AND INTERCHANGE SYSTEM FOR ALTERNATIVE 5

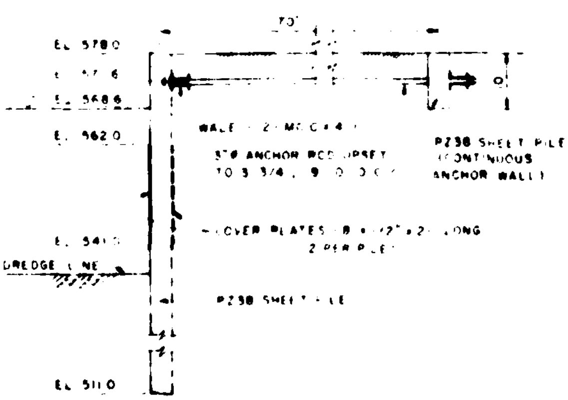
U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982





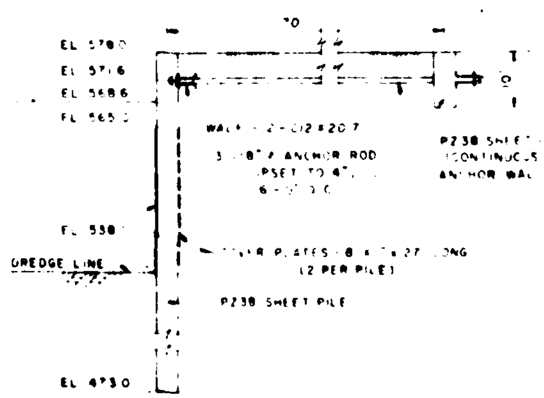
SECTION 1

(TYPICAL BULKHEAD SECTION A-1)



SECTION 3

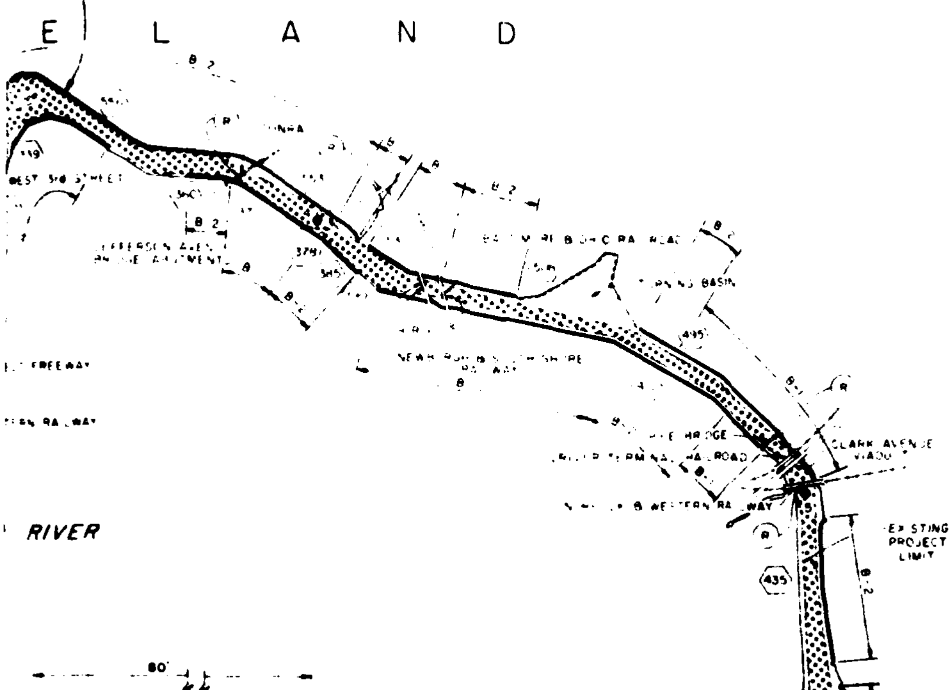
(TYPICAL BULKHEAD SECTION B-1)



SECTION 4

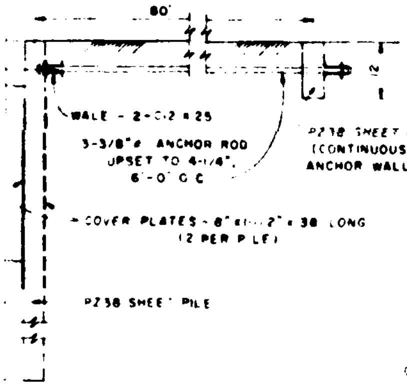
(TYPICAL BULKHEAD SECTION B-2)

REPLACE EXISTING BULKHEAD
(SEE SECTIONS 1-4 FOR DETAILS)



DOCK BY OPERATOR

[illegible]	[illegible] STONE CORPORATION
[illegible]	[illegible] STONE CORPORATION
[illegible]	SAND PRODUCTS CORPORATION
[illegible]	ASHLAND PETROLEUM CORPORATION
[illegible]	INTERNATIONAL SALT COMPANY
[illegible]	ERIE LACKAWANNA ORE
[illegible]	[illegible] CEMENT
180	UNITED STATES STEEL
185	BALTIMORE & OHIO RAILROAD
195	[illegible] SHIPYARD
250	ALPERT BROTHERS
275	MID CONTINENT COAL & COKE
327	CLEVELAND BUILDERS SUPPLY
329	CLEVELAND BUILDERS SUPPLY
337	SHELL OIL
339	TEXACO
360	CLIFTON CONCRETE COMPANY
371	GULF OIL
378	CLEVELAND BUILDERS SUPPLY
385	BYERLYTE KOPPERS
390	[illegible] CHEMICALS
4[illegible]	REPUBLIC STEEL
435	J & L STEEL
440	REPUBLIC STEEL
495	REPUBLIC STEEL
508	DUPONT
530	MARINE FUELING
553	UNITED STATES STEEL
556	UNITED STATES STEEL
580	ONTARIO STONE CORPORATION
590	CLEVELAND BUILDERS SUPPLY
598	FORD MOTOR COMPANY
675	MEDUSA CEMENT
680	CUYAHOGA LIME COMPANY
700	CEREAL FOOD PROCESSORS
716	ALPHA CEMENT
720	LAKE ERIE ASPHALT PRODUCTS (DOCK 20)



SECTION 2

TYPICAL BULKHEAD SECTION A-2)

SECTION 5

(BRIDGE FENDER DETAIL - VERTICAL SECTION)

LEGEND

2● MILES ABOVE WEST PIER LIGHT AT OUTER END OF WEST PIER

(R) BRIDGES REQUIRING FENDER REPLACEMENT DUE TO RIVER DEEPENING (SEE SECTION 5 FOR DETAILS)

UTILITY REQUIRING RELOCATION DUE TO RIVER DEEPENING

N-1 WESTERN UNION TEL - 4-4" PIPES

NOTE

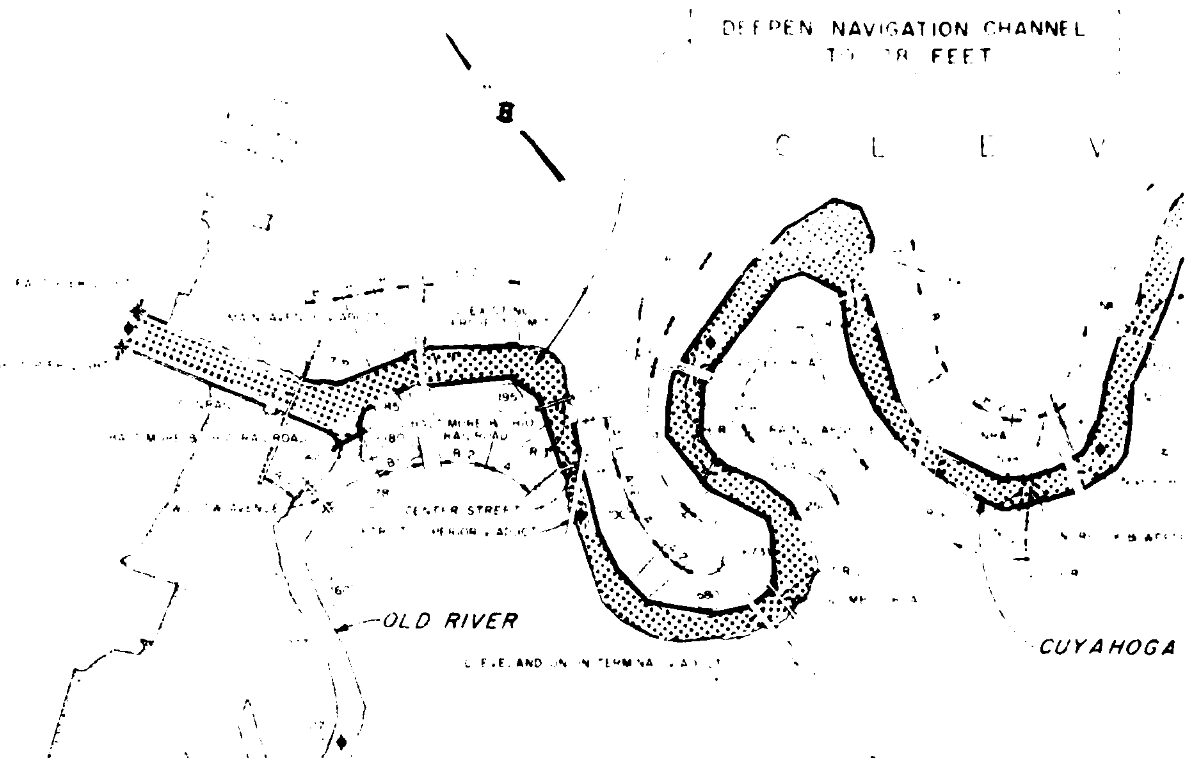
ALL DEPTHS ARE REFERRED TO LOW WATER DATUM EL 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD 1955) (INTERNATIONAL GREAT LAKES DATUM 1955)

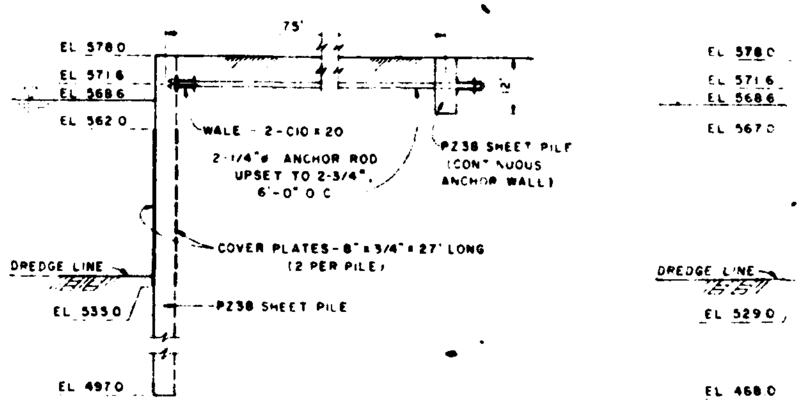
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

ALTERNATIVE 6 (OPTION A)
DEEPEN CUYAHOGA RIVER TO 25.5 FEET

U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

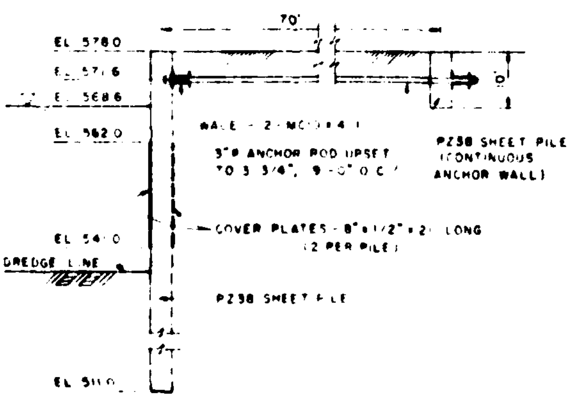
2





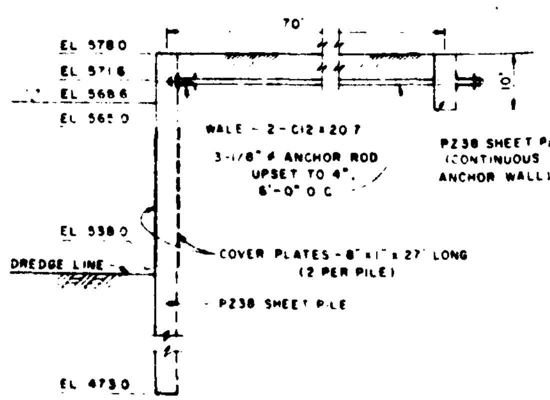
SECTION 1

(TYPICAL BULKHEAD SECTION A-1)



SECTION 3

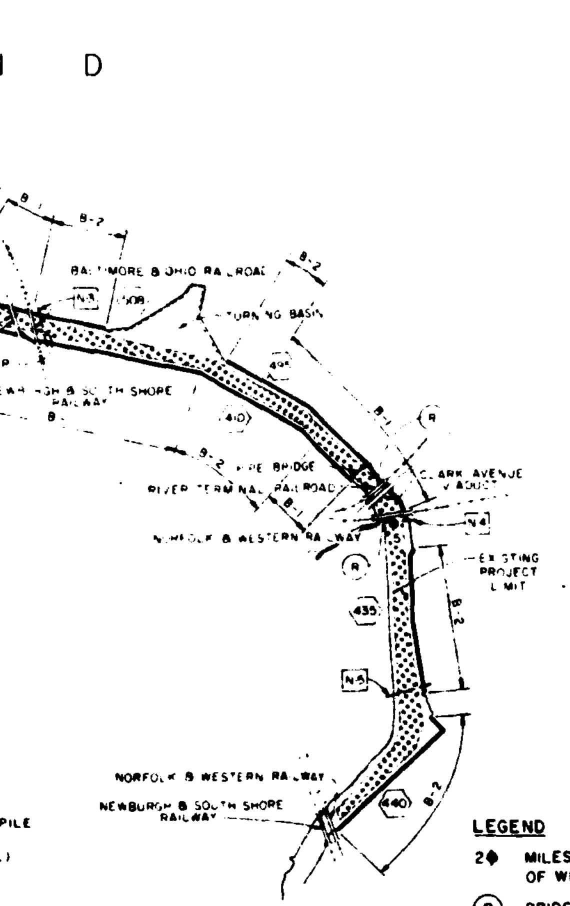
(TYPICAL BULKHEAD SECTION B-1)



SECTION 4

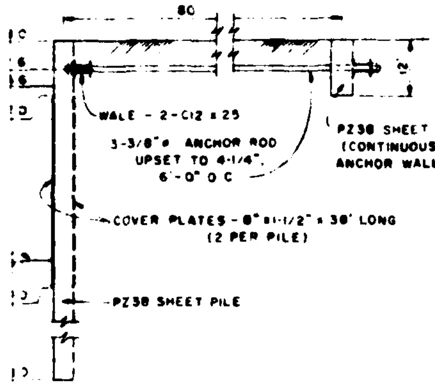
(TYPICAL BULKHEAD SECTION B-2)

REPLACE EXISTING BULKHEAD
(SEE SECTIONS 1-4 FOR DETAILS)



DOCK BY OPERATOR

[illegible]	[illegible]
[illegible]	[illegible]
107	SAND PRODUCTS CORPORATION
[illegible]	[illegible]
	[illegible]
[illegible]	[illegible]
[illegible]8	[illegible] CEMENT
18	UNITED STATES STEEL
95	BALTIMORE & OHIO RAILROAD
95	[illegible] SHIPYARD
250	ALPERT BROTHERS
275	MID CONTINENT COAL & COKE
327	CLEVELAND BUILDERS SUPPLY
329	CLEVELAND BUILDERS SUPPLY
337	SHELL OIL
339	TEXACO
360	CLIFTON CONCRETE COMPANY
37[illegible]	GULF OIL
[illegible]78	CLEVELAND BUILDERS SUPPLY
385	RIVERLYTE KOPPERS
390	[illegible] CHEMICALS
4[illegible]0	REPUBLIC STEEL
435	J & L STEEL
440	REPUBLIC STEEL
495	REPUBLIC STEEL
508	DUPONT
530	MARINE FUELING
553	UNITED STATES STEEL
556	UNITED STATES STEEL
580	ONTARIO STONE CORPORATION
590	CLEVELAND BUILDERS SUPPLY
598	FORD MOTOR COMPANY
673	MEDUSA CEMENT
680	CUYAHOGA LIME COMPANY
700	CEREAL FOOD PROCESSORS
[illegible]6	ALPHA CEMENT
720	LAKE ERIE ASPHALT PRODUCTS (DOCK 2)



SECTION 2

(TYPICAL BULKHEAD SECTION A-2)

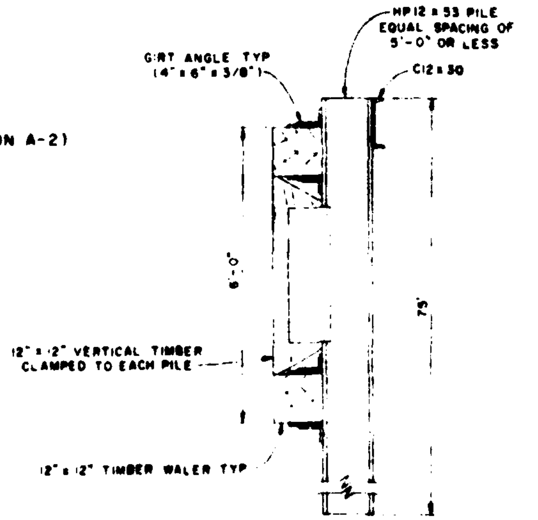
LEGEND

2◆ MILES ABOVE WEST PIER LIGHT AT OUTER END OF WEST PIER

(R) BRIDGES REQUIRING FENDER REPLACEMENT DUE TO RIVER DEEPENING (SEE SECTION 5 FOR DETAILS)

UTILITIES REQUIRING RELOCATION DUE TO RIVER DEEPENING

- N-1 WESTERN UNION TEL — 4 - 4" PIPES
- N-2 CITY OF CLEVELAND — BRIDGE CABLE
- N-3 BALTIMORE & OHIO RAILROAD — 2 CABLES
- N-4 STANDARD OIL CO — 5 PIPES
- N-5 SUN OIL CO — 1 PIPE



SECTION 5

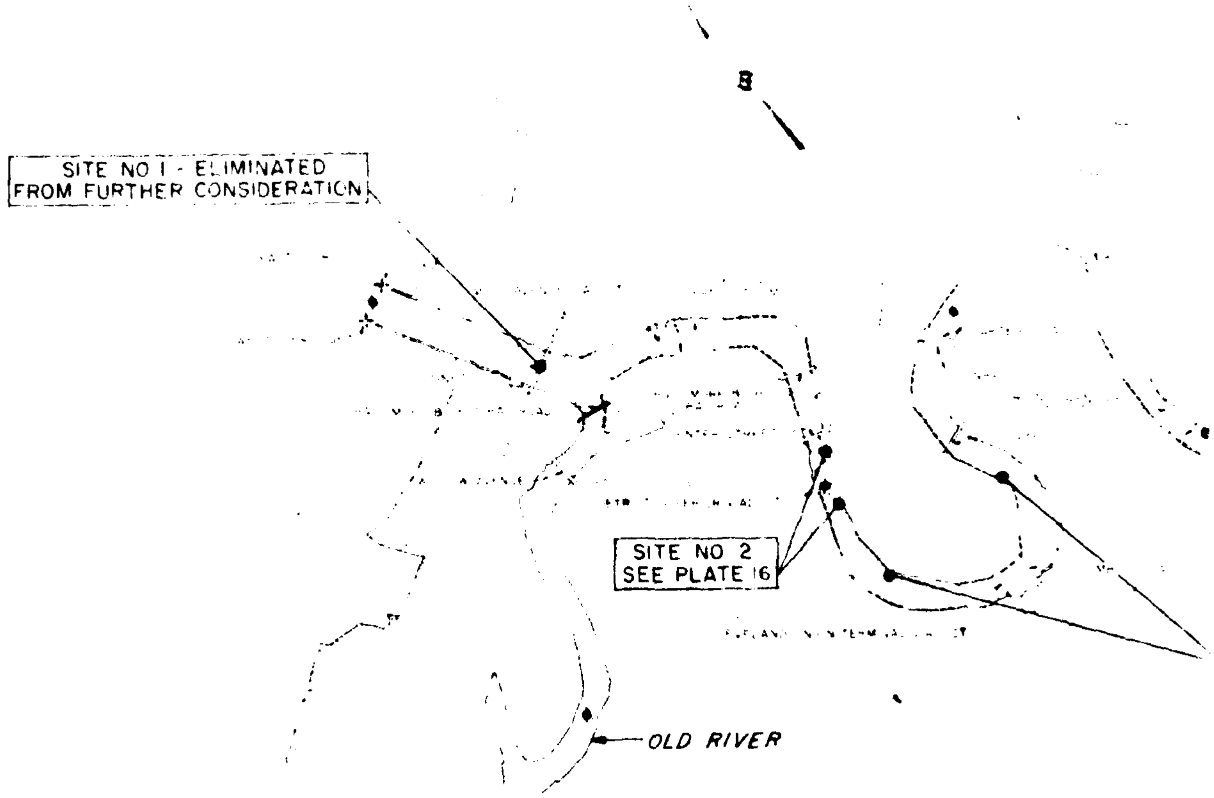
(BRIDGE FENDER DETAIL - VERTICAL SECTION)

NOTE

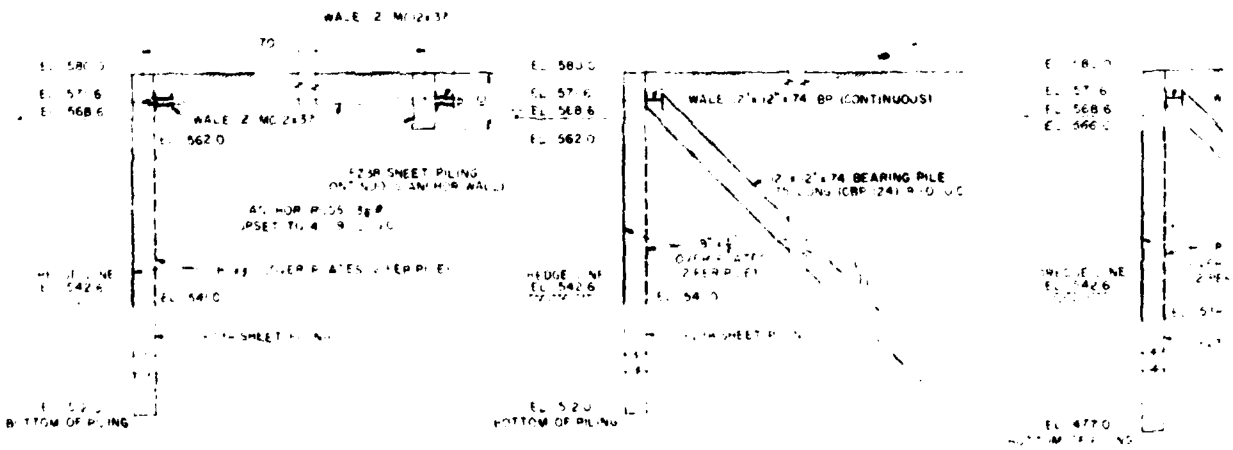
ALL DEPTHS ARE REFERRED TO LOW WATER DATUM EL 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD 1955) (INTERNATIONAL GREAT LAKES DATUM 1955)

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 6 (OPTION B)
DEEPEN CUYAHOGA RIVER
TO 28 FEET

U.S. ARMY ENGINEER DISTRICT BUFFALO



CONGESTION AREAS UNDER CO

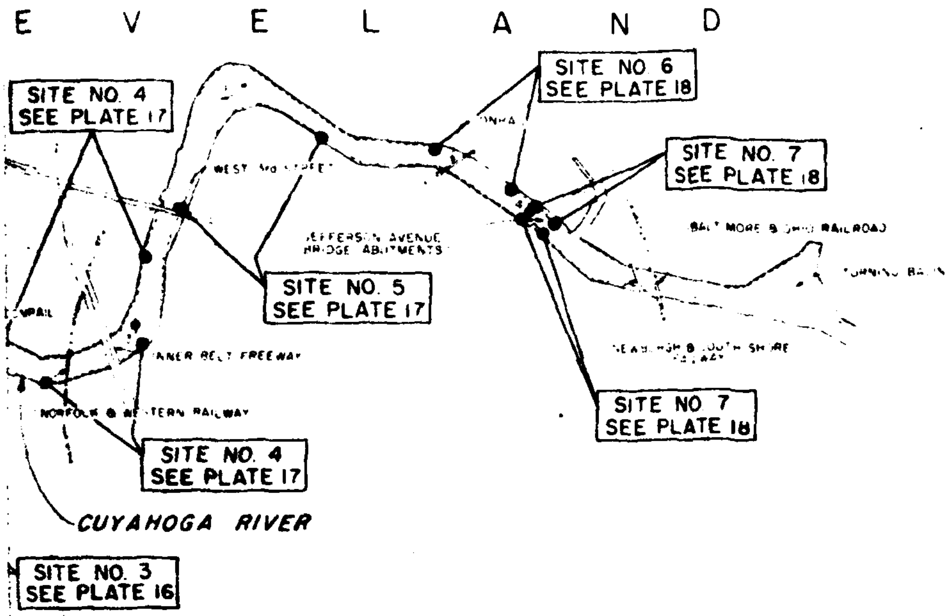


TYPICAL BULKHEAD
TYPE NS-AW

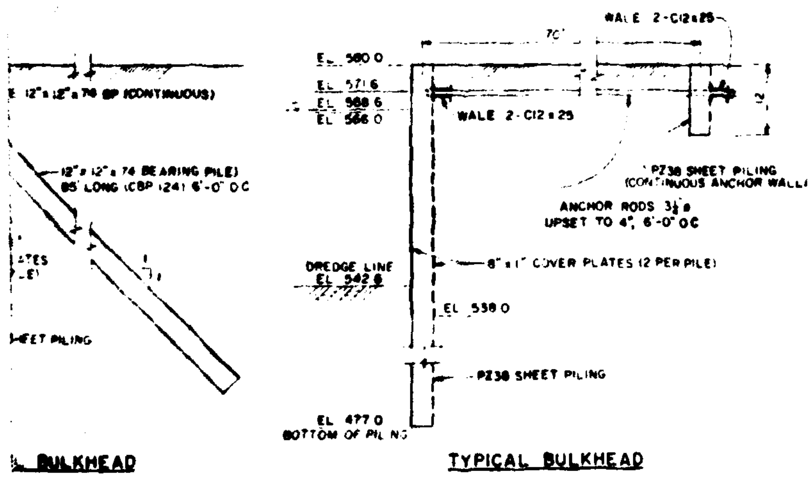
TYPICAL BULKHEAD
TYPE NS-BP

TYPICA

TYPICAL NEW BULKHEAD S



NSIDERATION



L BULKHEAD
TYPE S-BP

TYPICAL BULKHEAD
TYPE S-AW

SECTIONS

LEGEND

MILES ABOVE WEST PIER LIGHT AT OUTER END OF WEST PIER SHOWN THUS 2●

NOTE

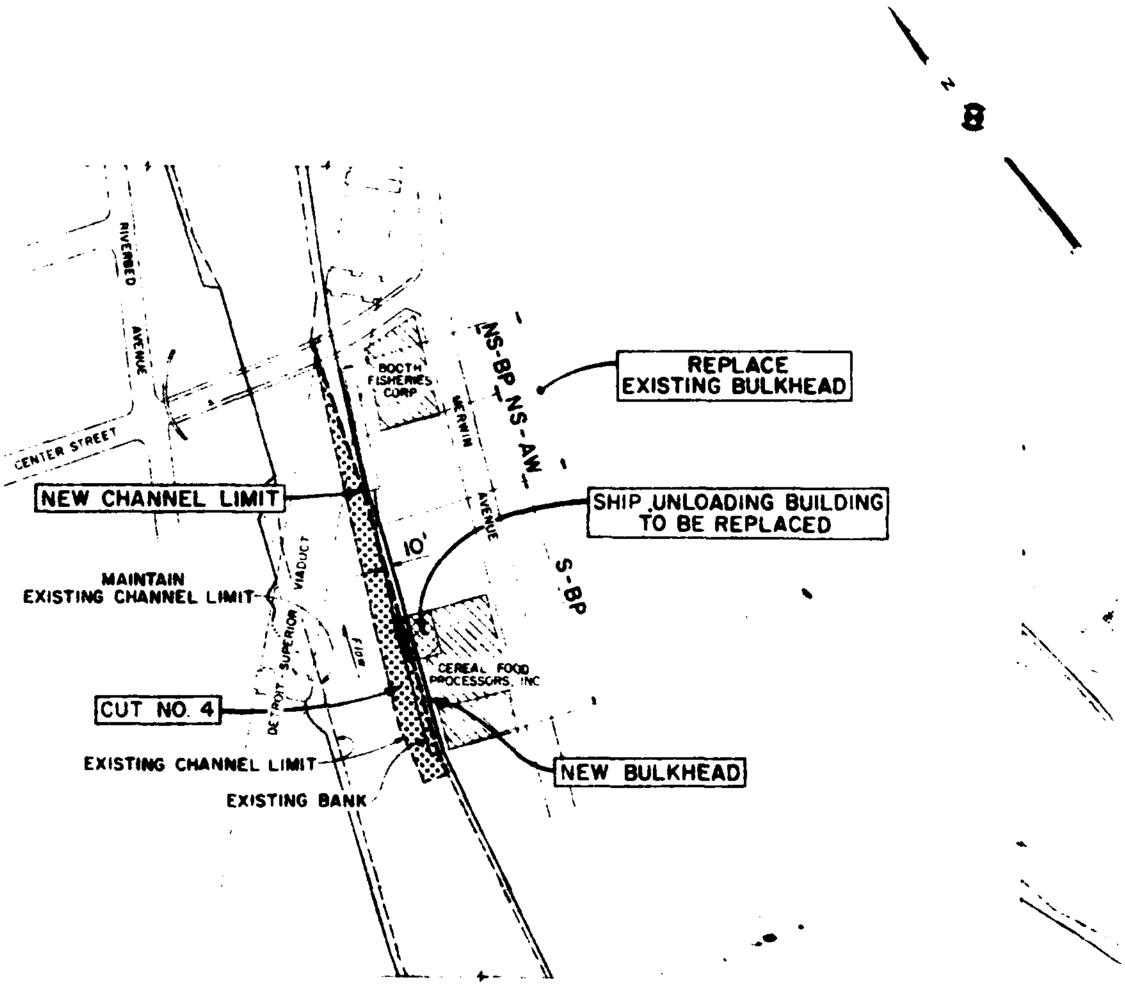
ALL DEPTHS ARE REFERRED TO LOW WATER DATUM EL 568 6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD 1955) (INTERNATIONAL GREAT LAKES DATUM 1955)

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

INDEX MAP AND
TYPICAL BULKHEAD SECTIONS
FOR ALTERNATIVE 7

U S ARMY ENGINEER DISTRICT BUFFALO

2



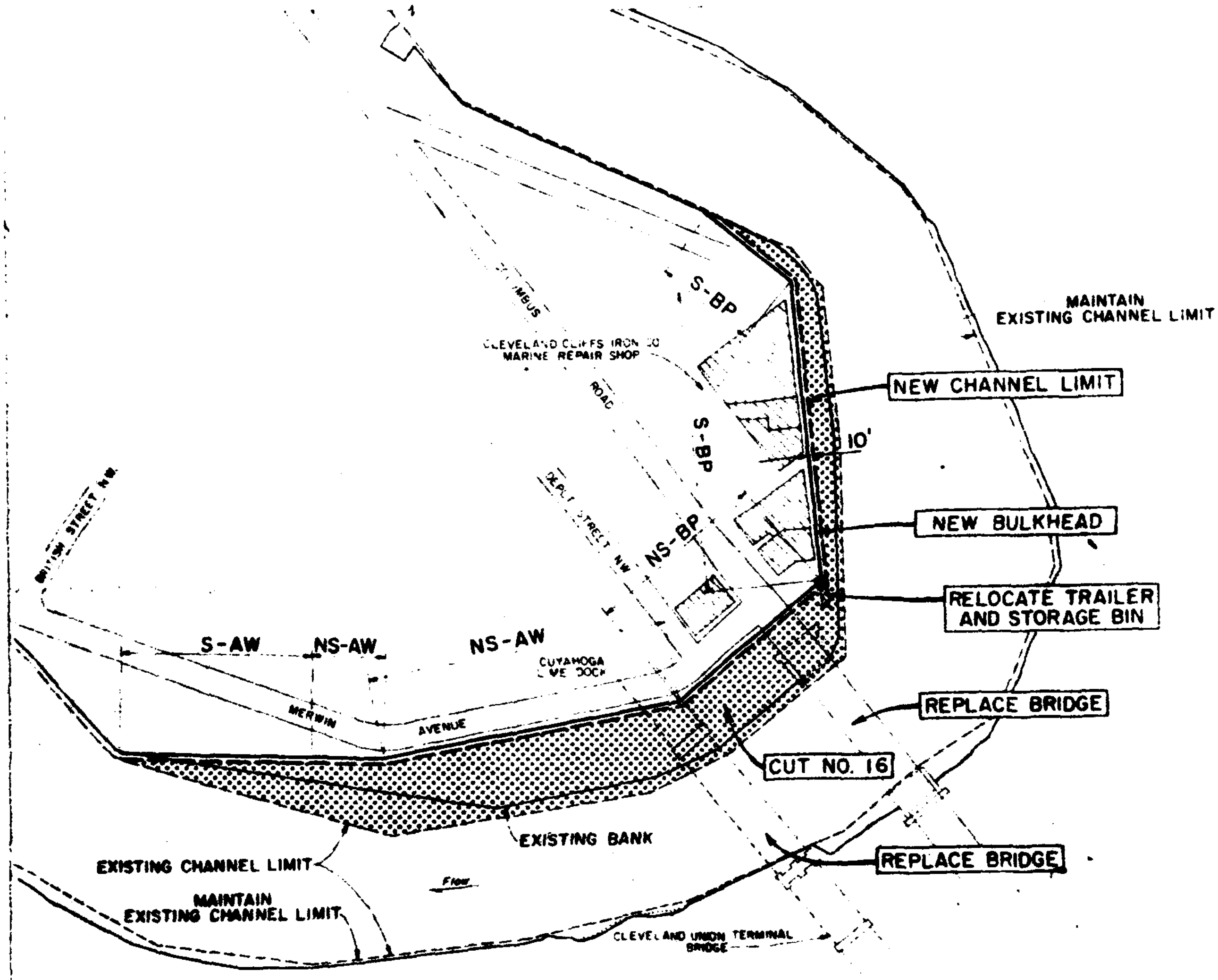
SITE NO. 2

(ALTERNATIVE 7, OPTION B)

NOTES:

1 SEE PLATE 15 FOR TYPICAL BULKHEAD SECTIONS (TYPES S-AW, NS-AW, S-BP AND NS-BP)

2. ALL CUTS TO BE DREDGED TO 23 FEET LWD



SITE NO. 3
(ALTERNATIVE 7, OPTION C)

SCALE OF FEET

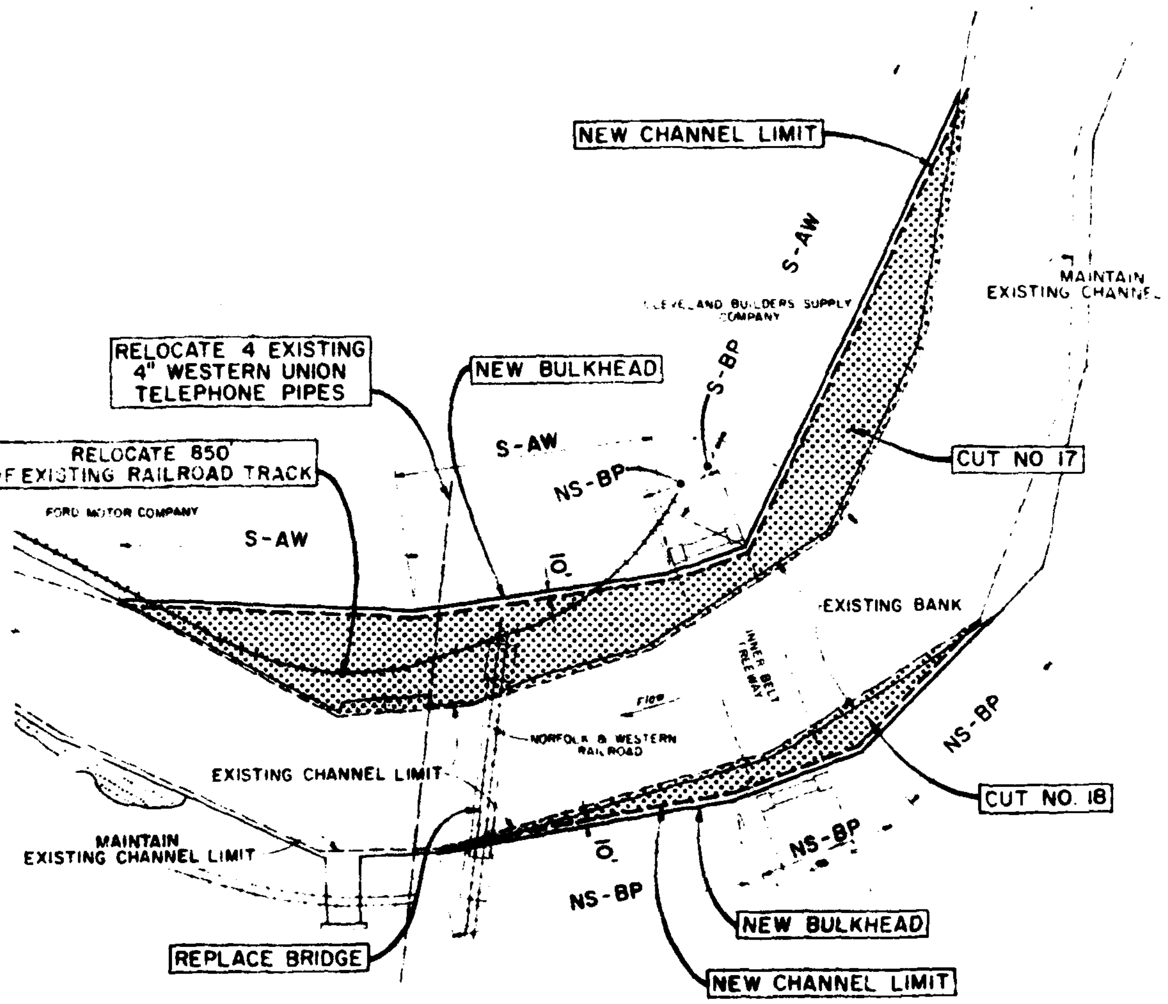
300' 0 300' 600'

CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

ALTERNATIVE 7 (OPTIONS B AND C)

REDUCE RIVER CONGESTION

U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

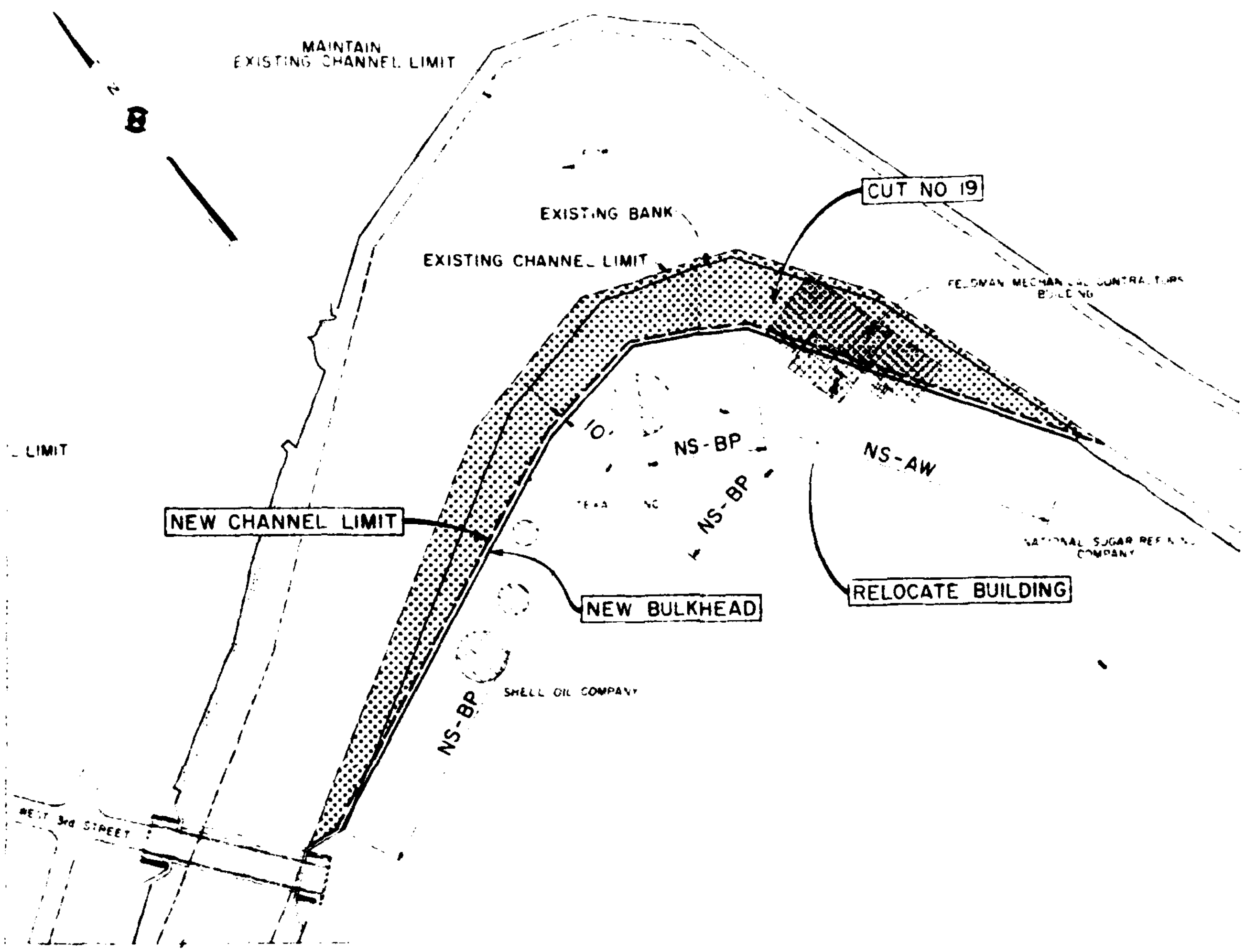


SITE NO. 4

(ALTERNATIVE 7, OPTION D)

NOTES

1. SEE PLATE 15 FOR TYPICAL BULKHEAD SECTIONS (TYPES S-AW, NS-AW, S-BP AND NS-BP)
2. ALL CUTS TO BE DREDGED TO 23 FEET LWD



SITE NO. 5

(ALTERNATIVE 7, OPTION E)

SCALE OF FEET

300' 0 300' 600'

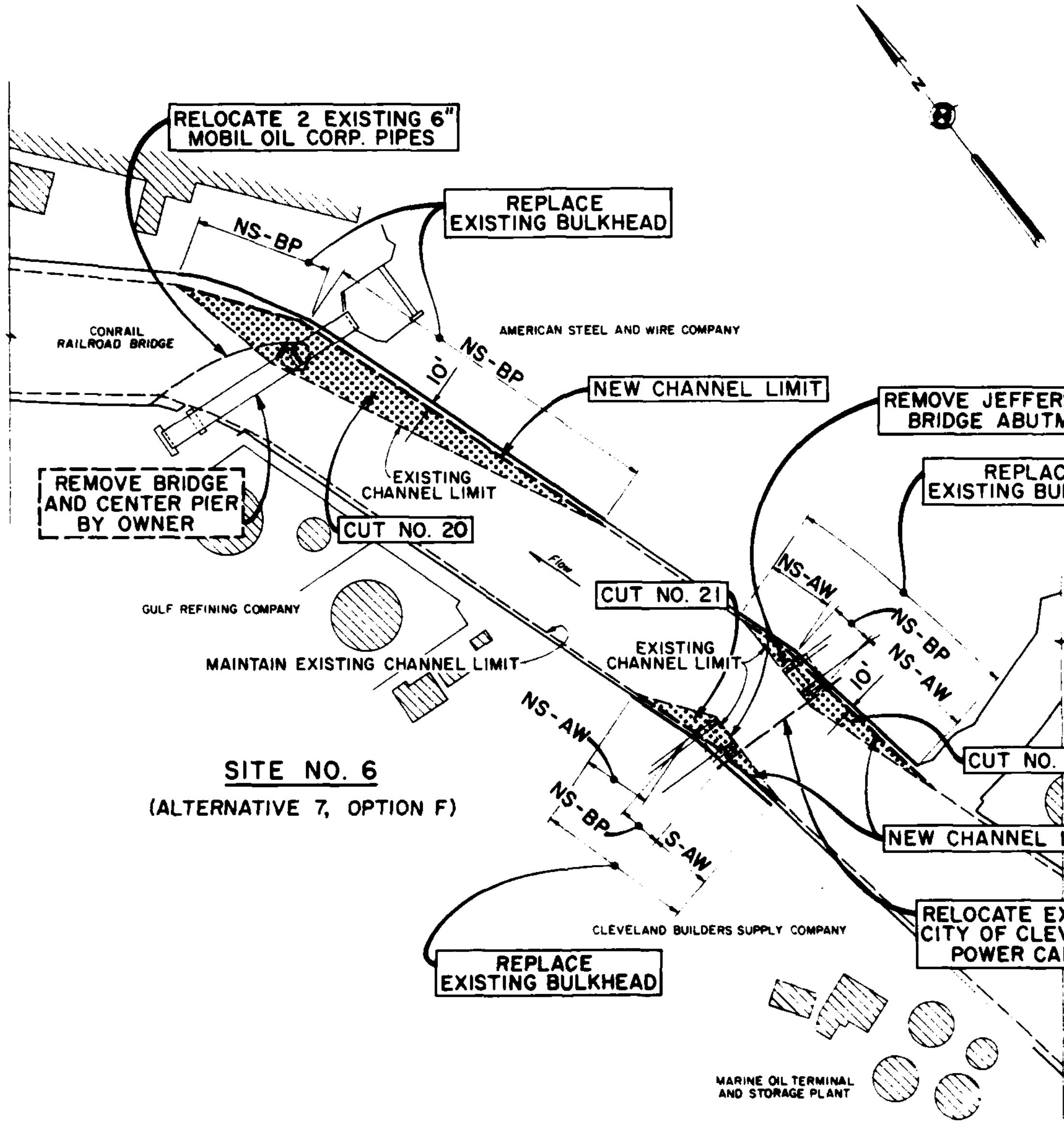
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

ALTERNATIVE 7 (OPTIONS D AND E)

REDUCE RIVER CONGESTION

U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

2



SITE NO. 6

(ALTERNATIVE 7, OPTION F)

SITE NO. 7

(ALTERNATIVE 7, OPTION G)

NOTES:

1. SEE PLATE 15 FOR TYPICAL BULKHEAD SECTIONS (TYPES S-AW, NS-AW, S-BP AND NS-BP)
2. ALL CUTS TO BE DREDGED TO 23 FEET LWD

SCALE OF FEET

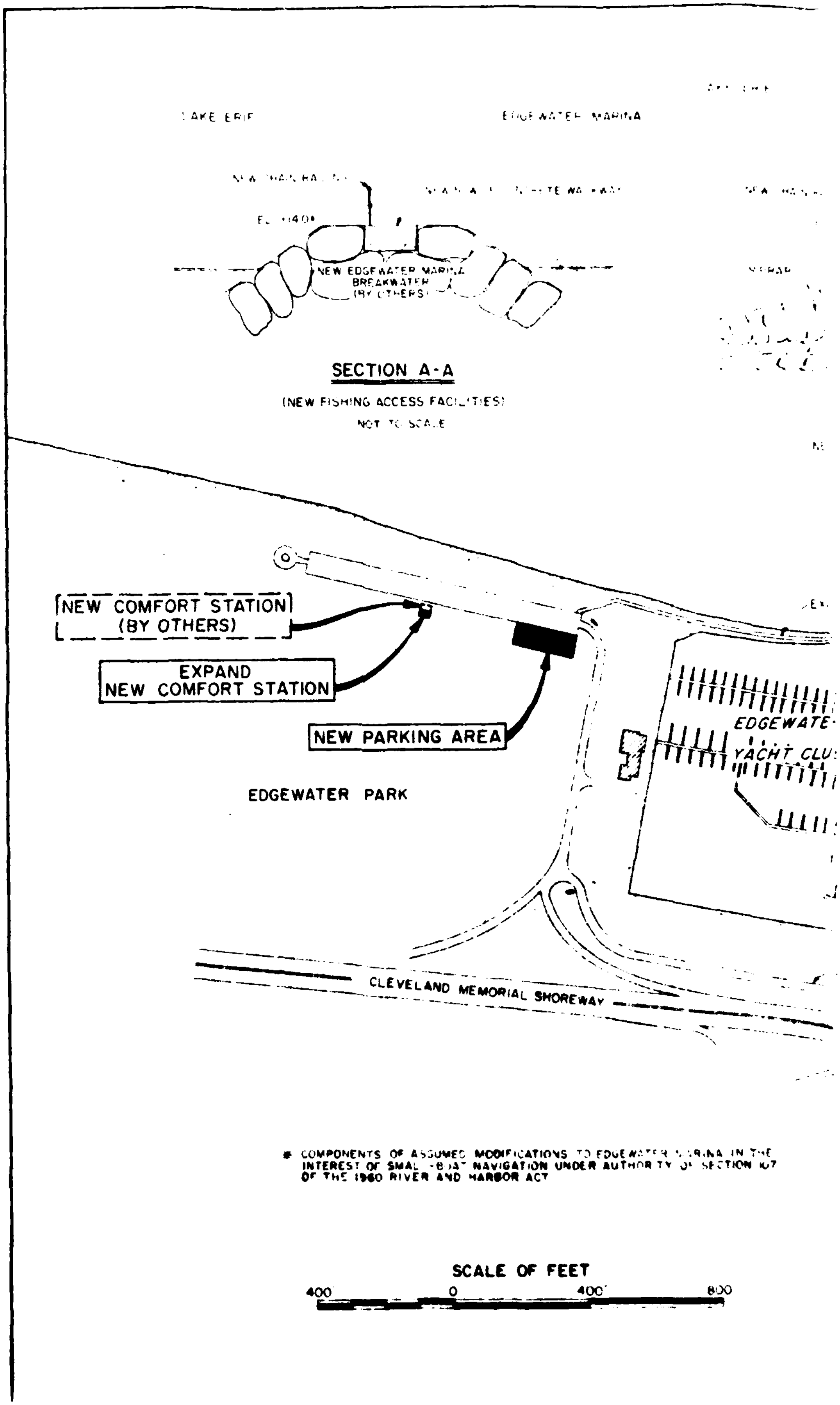
300' 0 300' 600'

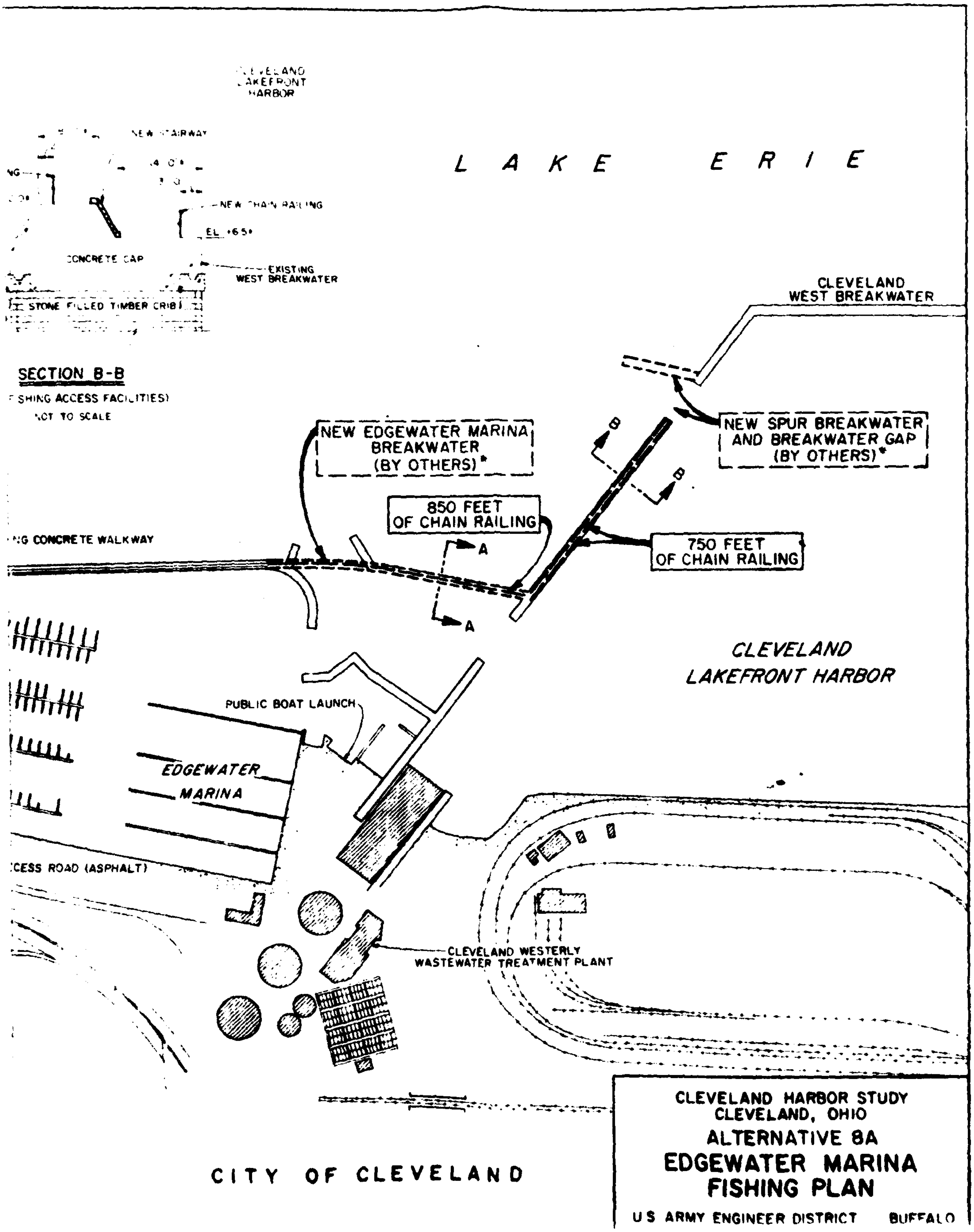
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

ALTERNATIVE 7 (OPTIONS F AND G)

REDUCE RIVER CONGESTION

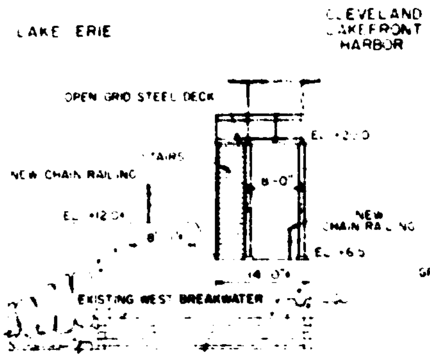
U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982


SECTION A-A
(NEW FISHING ACCESS FACILITIES)
NOT TO SCALE
NEW EDGEWATER MARINA BREAKWATER (BY OTHERS)
NEW COMFORT STATION (BY OTHERS)
EXPAND NEW COMFORT STATION
NEW PARKING AREA
EDGEWATER PARK
EDGEWATE
YACHT CLU
CLEVELAND MEMORIAL SHOREWAY
* COMPONENTS OF ASSUMED MODIFICATIONS TO EDGEWATER MARINA IN THE INTEREST OF SMALL-BOAT NAVIGATION UNDER AUTHORITY OF SECTION 107 OF THE 1960 RIVER AND HARBOR ACT
SCALE OF FEET
400
0
400
800

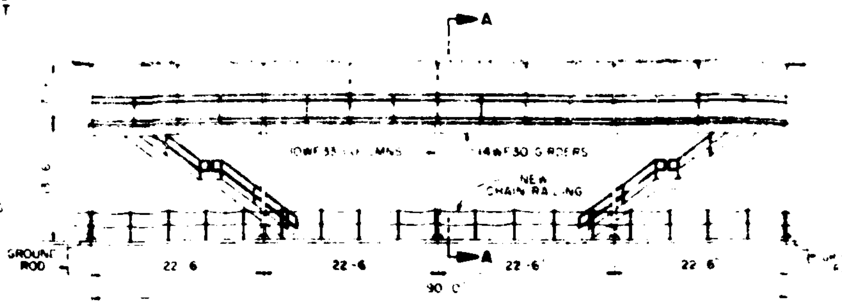


NEW STAIRWAY
NEW CHAIN RAILING
EL +6.5
CONCRETE CAP
EXISTING
WEST BREAKWATER
STONE FILLED TIMBER CRIB
SECTION B-B
NOT TO SCALE
LAKE ERIE
CLEVELAND
WEST BREAKWATER
NEW EDGEWATER MARINA
BREAKWATER
(BY OTHERS)*
NEW SPUR BREAKWATER
AND BREAKWATER GAP
(BY OTHERS)*
850 FEET
OF CHAIN RAILING
750 FEET
OF CHAIN RAILING
CONCRETE WALKWAY
CLEVELAND
LAKEFRONT HARBOR
PUBLIC BOAT LAUNCH
EDGEWATER
MARINA
ACCESS ROAD (ASPHALT)
CLEVELAND WESTERLY
WASTEWATER TREATMENT PLANT
CITY OF CLEVELAND
CLEVELAND HARBOR STUDY
CLEVELAND, OHIO
ALTERNATIVE 8A
EDGEWATER MARINA
FISHING PLAN
U S ARMY ENGINEER DISTRICT BUFFALO

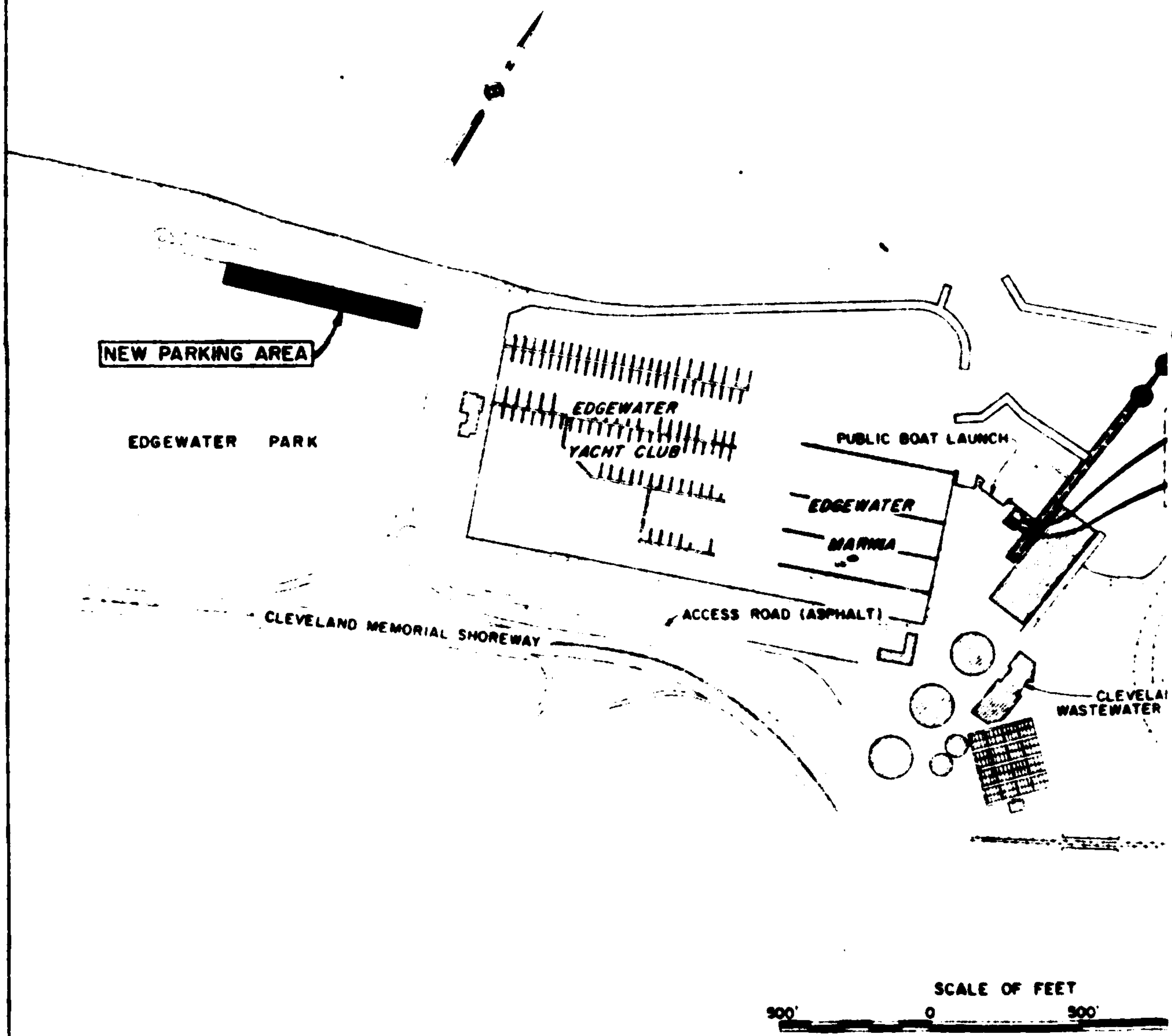
2

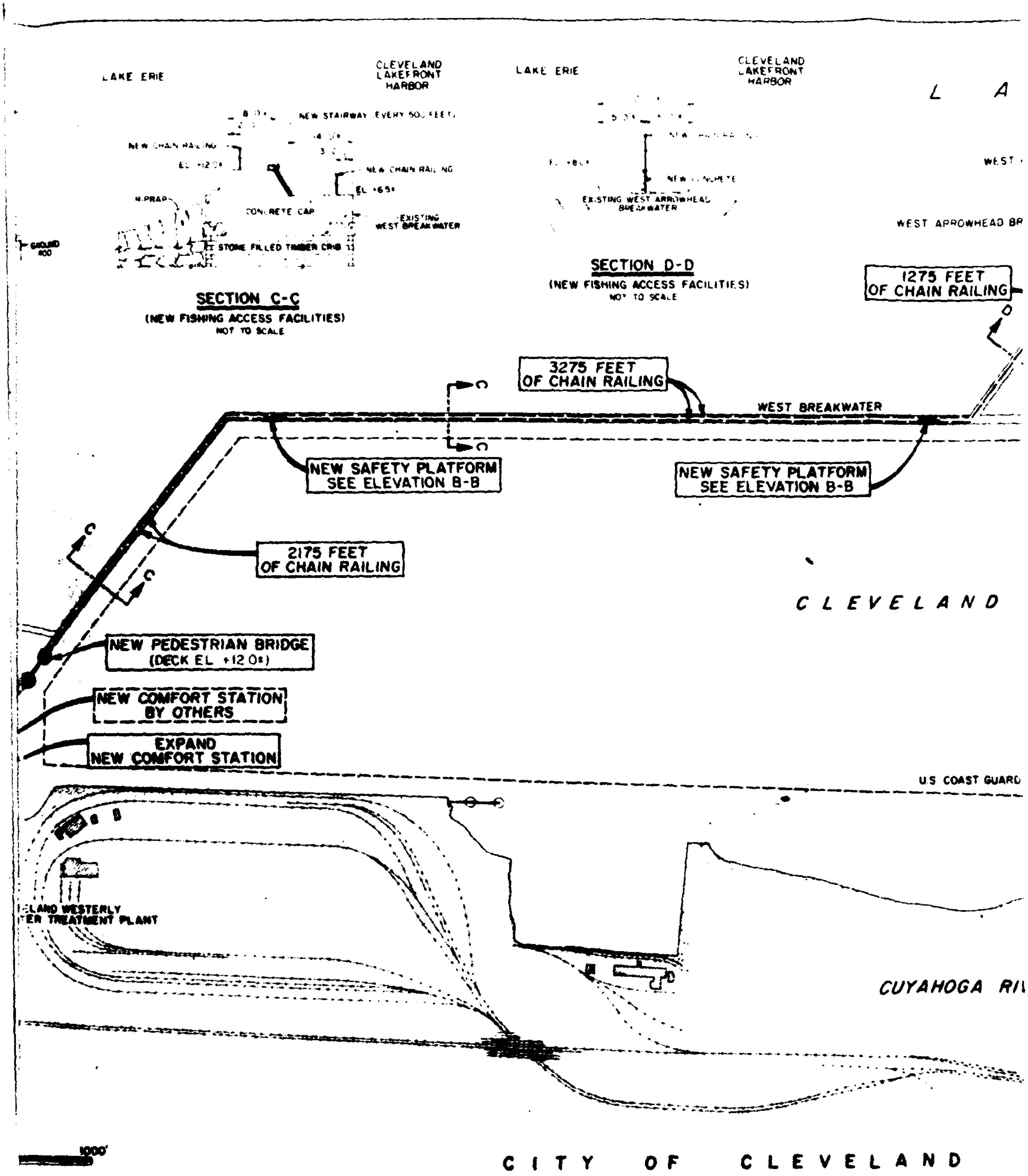


SECTION A-A
(SAFETY PLATFORM)
NOT TO SCALE

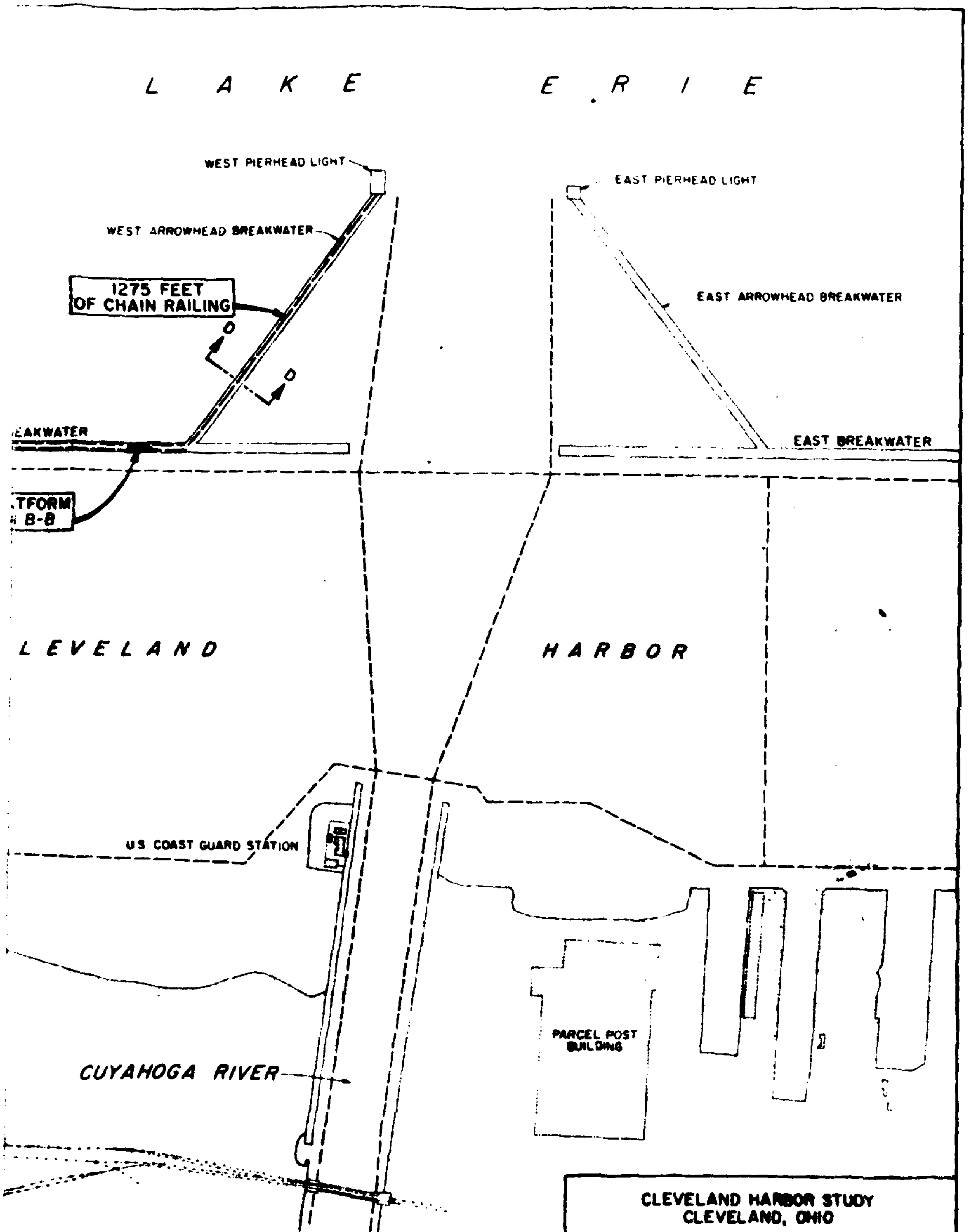


ELEVATION B-B
(SAFETY PLATFORM)
NOT TO SCALE




LAKE ERIE
CLEVELAND LAKEFRONT HARBOR
NEW STAIRWAY (EVERY 500 FEET)
NEW CHAIN RAILING
CONCRETE CAP
EXISTING WEST BREAKWATER
STONE FILLED TIMBER CRIB
SECTION C-C
(NEW FISHING ACCESS FACILITIES)
NOT TO SCALE
LAKE ERIE
CLEVELAND LAKEFRONT HARBOR
EXISTING WEST ARROWHEAD BREAKWATER
SECTION D-D
(NEW FISHING ACCESS FACILITIES)
NOT TO SCALE
L A
WEST ARROWHEAD BR
1275 FEET OF CHAIN RAILING
3275 FEET OF CHAIN RAILING
WEST BREAKWATER
NEW SAFETY PLATFORM SEE ELEVATION B-B
NEW SAFETY PLATFORM SEE ELEVATION B-B
2175 FEET OF CHAIN RAILING
C L E V E L A N D
NEW PEDESTRIAN BRIDGE (DECK EL +12.0±)
NEW COMFORT STATION BY OTHERS
EXPAND NEW COMFORT STATION
U.S. COAST GUARD
LAND WESTERLY
ER TREATMENT PLANT
CUYAHOGA RI
1000'
C I T Y O F C L E V E L A N D

2



CLEVELAND HARBOR STUDY
CLEVELAND, OHIO

ALTERNATIVE 8B

CLEVELAND HARBOR
FISHING PLAN

U.S. ARMY ENGINEER DISTRICT BUFFALO
JULY 1982

3

DATE

ILME

8