LMVED-TD (NOD 20 Jul 73) 5th Ind
SUBJECT: Mississippi River-Gulf Outlet, Design Memorandum No. 1 - General Design, Michoud Canal

DA, Lower Mississippi Valley Division, Corps of Engineers, Vicksburg, Miss. 39180 8 May 74

TO: District Engineer, New Orleans, ATTN: LMNED-MP

1. The information furnished and actions described in the 4th Indorsement are satisfactory.

2. Para 2, 4th Ind. We concur that riprap protection is not warranted along the entire length of the east bank of the Michoud Canal. However, the southern terminus along the east bank will be subjected to waves generated by boat traffic on the Gulf Intracoastal Waterway and also hurricane surges in the Mississippi River Gulf Outlet (MR-GO). To insure protection of this area, the protection described in the Lake Pontchartrain, Louisiana, and Vicinity, Lake Pontchartrain Barrier Plan, General Design Memorandum No. 2, Supplement No. 4, New Orleans East Back Levee should be extended and terminate at levee station 746+00 on the east bank of the Michoud Canal in lieu of station 755+00.

FOR THE DIVISION ENGINEER:

for Robert J Kaufman
R. H. RESTA
Chief, Engineering Division

wd all incl

CF:
DAEN-CWE-B w 14 cy
4th Ind

LMNED-MP (20 Jul 73) 4th Ind 1 April 1974
SUBJECT: Mississippi River-Gulf Outlet, Design Memorandum No. 1, General Design, Michoud Canal

Engineers in Coastal Louisiana with the cooperation of the Bureau of Sports Fisheries and Wildlife, Bureau of Commercial Fisheries, and the Louisiana Wild Life and Fisheries Commission. The underlying rationale for computing marsh values is outlined in the GDM and discussed in the response to comment in para 3, 2d Ind. The numerical calculations are shown in the GDM.

20. Ref para c, 3d Ind. The corrections in arithmetic are appropriate. This correction results in an annual loss of $1,789 in lieu of $1,887 as shown in the GDM. This small change will make no significant change in the B/C ratio.

21. It is recommended that the proposed disposition of comments presented above be approved.

FOR THE DISTRICT ENGINEER:

Walter B Mask
for JEROME C. BAEHR
Chief, Engineering Division

9 Incl (16 cys)
Added 9 incl
2 thru 10
Plates 8, 10, 11, 12, 13, 14, 15,
16 and 17, file no. H-2-25340

b. Other fertilizer movements.

(1) We concur that the "Other Fertilizer" movements do, in fact, represent induced movements comprising net additions to the total consumption. On this basis, the benefits creditable to the project should be $90,500 rather than $181,000, as in the GDM.

(2) The revised total benefits are as follows:

Imported Vehicles	246,600
Anhydrous Ammonia	207,500
Other Fertilizers	90,500
Econ. Development	56,400
	$601,000

18. Ref para a, 3d Ind. The $6.85 figure is the aggregate of the unit losses for commercial fish, commercial wildlife and recreation, without regard to the period over which the loss will be sustained. It does not accurately reflect the project-induced loss because it fails to reflect the fact that the marshlands in question are expected to be lost within 25 years even in the absence of the project.

19. Ref para b(1), b(2), and b(3), 3d Ind.

a. Para b(1). The $6.50 figure referred to in the comment is based on the average annual value of the commercial fisheries harvest for the period 1963-1967, divided by the area of estuarine water area. As set forth in the GDM, the unit value for commercial fisheries utilized was based on an estimate by the Louisiana Wild Life and Fisheries Commission that the estuarine marsh in that area produced 46 pounds of commercial fish per acre. As set forth in the response to comment in paragraph 3, 2d indorsement, the figure used is probably conservative.

b. Para b(2). Studies made by the Bureau of Sports Fisheries and Wild Life in connection with the Coastal Louisiana Studies indicate that the existing sports fisheries supply far exceeds the demand in the year 2020. Possible exceptions are in the areas of shrimping and crabbing. The demand in these two species will exceed the supply earlier. However, as indicated in the GDM and in reference to paragraph 3 of 2d Ind, it is unlikely that the very minor reduction in supply inherent in the conversion of 380 acres of marsh will engender any measurable reduction in the recreational usage of the area.

c. Para b(3). All data used in the evaluation are based on (1) letter dated 20 April 1972 from Louisiana Wild Life and Fisheries Commission for Commercial Fisheries (2) studies made by the Corps of

h. In the final analysis, it does not appear likely that unanimity of informed opinion as to the value of marshlands--beyond what is represented in the sale price between an interested buyer and a willing seller--is an early prospect. We believe it prudent to move with careful deliberation in adopting evaluation procedures for generating dollar expressions for those values of the marsh for use in B/C analysis, which are not adequately reflected in the purchase price. The evaluation procedures suggested by GO&P, and others are useful in overall project evaluation since they do provide insights into the function and value of marshlands to society, but we do not believe that they are now appropriate for use in B/C analysis. The methodology we employ provides an estimate of those intrinsic values of estuarine marshlands which can be related satisfactorily to the market, e.g., commercial fish, commercial wildlife and recreation. It utilizes readily available data, is simple to apply, and, as knowledge of the relationship between the marsh and the production of estuarine-dependent species increases, it is subject to increasing refinement. Despite obvious inadequacies, it is probably as reasonable an approach as is available at this time.

17. Ref para 4, 2d Ind. Additional information relative to the estimate or benefits for anhydrous ammonia and other fertilizers follows:

a. Anhydrous ammonia movements.

(1) The vessels employed in transport of the anhydrous ammonia are specially designed small-lot carriers of 10-11,000 dwt capacity. These vessels have full load drafts which are compatible with a 36-foot channel. Since these ships are destined for European ports, Texas City represents a voyage of an additional 260 miles one-way as compared to N.O. (via the MR-GO). There thus exists an economic incentive for use of the 36-foot Michoud Canal when it is constructed.

(2) As discussed in paragraph 61c(1) of the GDM, the 45,000 tons/yr. of anhydrous ammonia supplied by the Texas City plant to overseas customers of the New Orleans concern is matched by 45,000 tons shipped from the New Orleans plant to inland customers of the Texas City firm. In the absence of this trade-off, the Texas City plant would simply revert to supplying its own customers and thus no net regional transfer would occur.

(3) The trade-out agreement with the Texas City plant is a temporary arrangement, which, when terminated, will require the New Orleans firm to employ the lightering procedure discussed in the DM. Thus, the differential cost of that procedure as compared to direct loading at the plant wharf with the project in place is the appropriate savings attributable to the project.

e. With respect to method b(1) the conceptual difficulties inherent in the other three methods do not arise. A reduction in commercial harvests and recreational opportunities translates readily into market terms. The difficulty here, as GO&P observe, is that "...one cannot prove that all the fishing would be destroyed if the marshes were; nor can one say exactly how many acres of marsh are necessary to support the present level of fishery activity in estuarine and offshore waters...." In our view, however, this difficulty is of far less significance than those associated with methods b(2), b(3), and b(4).

f. The marketable end products supported by Louisiana's estuarine marshes are commercial fish, commercial wildlife, and recreational opportunity oriented around fish and wildlife. The value of those marshes to these three items, expressed in dollars, is compatible with other market-value items utilized in B/C analysis. As implied previously, the state of the art will not permit the determination of a precise relationship between the marsh and the commercial harvest, or, in the case of recreation, utilization of the resource. However, it is reasonable to assume that in the absence of all marsh, commercial fishing and wildlife would cease to exist, as would the recreation potential associated with fish and wildlife; or, as a minimum, populations would fall to levels precluding economical harvest and recreational use, which amounts to the same thing. We have, as a workable approach, chosen to assume that each acre of marsh within a given area contributes equally to the resources. The value of the marsh to be committed by the project is then in the same ratio to the total harvest (total opportunity in the case of recreation) as the marsh acreage to be committed is to the total marsh area. The value of the commercial harvest is available in published statistics, while the marsh acreage has been developed for all segments of coastal Louisiana in studies conducted by the Corps of Engineers in cooperation with other agencies. Data on fish and wildlife-oriented recreation are available from these same studies.

g. We have, in the GDM, followed the above approach, except that the unit value of marshlands in terms of the contribution of those lands to the commercial fisheries resources, has been based on an estimate provided by the Louisiana Wild Life and Fisheries Commission. The basic value furnished was 46 pounds of commercial fish per acre per year, to which we applied a unit value of $.06 per pound to derive an acreage value of $2.75 per acre per year. By comparison with our own studies which, however, are more generalized with respect to area (and which, conceptually, are in reasonable accord with values derived by GO&P, using the Louisiana harvest of commercial fish in 1970), this value is conservative. Since the area of application is, however, quite limited in the Michoud Canal case, we elected to use the figure furnished by the Wild Life and Fisheries Commission.

(3) Waste treatment work, in which the marsh is cast in the role of a tertiary treatment plant and its values computed as the costs of providing equivalent tertiary treatment through current technology.

(4) Life support value as a function of productive energy flow, in which the primary production of the marsh is converted to a dollar value by applying the ratio of the GNP to National Energy Consumption. GO&P opt for use of this approach on the basis that, on the one hand, the other three approaches tend to be mutually conflicting, e.g., aquaculture tends to reduce the value of commercial fishing and recreation; and, on the other, even in combination they fail to encompass the full range of known beneficial functions of the marsh.

c. The central difficulty in attempts to utilize estimates of marsh value such as those developed by the approaches other than b(1), above, derives from the fact that these values relate imperfectly to the other market-value terms used in B/C analysis. The difficulty is illustrated by an exchange at a recent public meeting on a permit, as follows: First speaker (in arguing against granting the permit): "Some investigators have derived values for marshes of as high as $45,000 per acre (capitalized value.)" Permittee: "Find a buyer for me at that price and I'll sell all I own to him." Odom dismisses any such difficulty as mere confusion of the terms "price" and "value," but in point of fact, the concept of interchangeability between "price" and "value" is pretty basic to B/C analysis as currently practiced, and the injection of "values" which cannot be rationally related to the market implies a distortion of the results of such analysis.

d. Benefits and costs used in B/C analysis as practiced by the Corps relate--sometimes tenuously, but most often rather directly--to market values. The benefit for flood control works, for example, is derived by evaluating the increased earnings the works will produce. Navigation benefits are derived by computing the reduction in transportation costs. Even recreation benefits, while subject to certain artificialities which need not be discussed here, are intended to reflect values in terms of what the opportunity is objectively worth to the user. In each case there is an end product or service involved, and a customer or client who will buy it. The values derived under b(2), b(3), and b(4), above, on the other hand, for the most part lack any real connection with the market. For example, the current or potential economic feasibility of oyster aquaculture is by no means established, nor can it be assumed that the expensive treatment procedures referred to under method b(3) would be utilized in the absence of marshes. With respect to the life support approach, it seems to be more a suggested area for investigation rather than a solid proposal for use. This is not to say that those values are "wrong" in any objective sense, but rather they are incompatible with the other costs and benefits used in B/C analysis as is now practiced by the Corps.

12. Ref para k, 1st Ind. Plates 11 through 14 have been revised and are inclosed as inclosures 4, 5, 6 and 7, respectively.

13. Ref para l, 1st Ind. The project cut line has been relocated because of operational requirements and is shown on revised plates 13, 14, and 15, inclosures 6, 7, and 8, respectively. The revised project cut line shown on revised plate 13 does not violate the 1.5 control line; as shown on revised plate 14 results in a minimum factor of safety for the levee and wall of 1.42 which is considered adequate; and as shown on revised plate 15, results in a minimum factor of safety of 1.46 for the new cut which is considered adequate.

14. Ref para m, 1st Ind. Minor comments in red on plates 6, 12, 13, 17, 24 and 25 are noted.

15. Ref para 2, 2d Ind. Spoil area number 1 as shown on plates 1 and 4 comprises 460 acres. The total area diked and used previously for spoil disposal comprises 520 acres; however, 60 acres are being used for the Bayou Bienvenue control structure and approach channel spoil area.

16. Ref para 3, 2d Ind.

a. The comment implies the existence of an objective, generally accepted standard to which the planner may repair in deriving intrinsic marsh values expressed in dollar terms for use in B/C analysis as currently practiced by the Corps. In point of fact, the implication is unwarranted, as is suggested by the extremely wide range of values produced by various researchers and investigators. Even within the work of the same investigators one finds varying methodology for deriving marsh values, with wide variation in the results produced. Gosselink, Odom, and Pope (GO&P) in a very recent paper suggest four possible approaches yielding values ranging from a low of $100 to a high of $4,150 per acre per year.

b. The four approaches referred to above include:

(1) By-product production in which it is assumed that the marsh is a sine qua non to the commercial fisheries harvest and to recreational opportunity associated with fishing; and that each acre of marsh contributes uniformly to the value.

(2) Aquaculture based on utilization of natural primary production, in which the marsh value is computed as the income based on use for controlled culture and harvest of oysters.

7. Ref para f, 1st Ind. The pipelines will be flushed before removal to insure that any residual contaminants in the lines are not spilled.

8. Ref para g, 1st Ind. The LWLFC will be contacted on the advisability of planting wildlife foods instead of allowing the natural regrowth of plants on disposal areas.

9. Ref para h, 1st Ind. A comparison of benefits presented in the project document with benefits presented in the GDM and reasons for the difference is shown below:

a. Comparison of benefits.

Source of Benefit	Review Report (1967 Prices)	DM #1-General Design (1973 Prices)	Difference
Imported Vehicles	$188,000	$246,600	$58,600
Anhydrous Ammonia	176,000	207,500	31,500
Other Fertilizers	131,000	90,500*	-40,500
Economic Development	-0-	56,400	56,400
Total	$495,000	$601,000	$106,000

*Revised based on comments presented in paragraph 4 of 2d Ind. Refer to paragraph 17b(1) and paragraph 17b(2) of this indorsement.

b. Reason for difference. With the exception of the economic development benefits, which were not included in the December 1967 review report, all increases in benefits are attributable to increased price levels which have occurred since publication of the review report. Except for a minor downward revision of the anhydrous ammonia base year tonnage, the supporting rationale contained in the review report remains unchanged. The "Other Fertilizer" movements described in the review of reports represent net additions to supply induced by project implementation. As such, only 50 percent of the $131,000 savings, or $65,000, attributable to these movements is, under current Corps of Engineers policy, creditable to the project as a benefit. When escalated to current price levels, this benefit amounts to $90,500, as shown in the table.

10. Ref para i, 1st Ind. Plate 8 has been revised and is inclosed as inclosure 2. It is noted that the channel slope was not affected by the recommended change.

11. Ref para j, 1st Ind. Plate 10 has been revised and is inclosed as inclosure 3. Note that there is a significant increase in underwater berm required.

These analyses are presented on plates 9 thru 15 of the GDM. The stratifications and shear strength trends used in each analysis are presented on the respective analysis plate, except where otherwise noted.

5. Ref para d, 1st Ind. Concur. Paragraphs 31c(1) and 31c(2) have been revised as noted below. Plates 16 and 17 have been revised and are inclosed as inclosures 9 and 10, respectively. The two borings used for the information presented on revised plates 16 and 17 represent the best available and are considered representative for their respective areas.

a. Para 31c(1).

Spoil area no. 6. The dike stability for this spoil area was analyzed based on the shear strengths and stratifications from boring 17 made by a private drilling and testing company (Eustis) in the vicinity of this spoil area. The results of this boring were correlated with the boring and test results accomplished in connection with DM No. 2--Supplement No. 4, "New Orleans East Back Levees." The analyses were made for top of dike at elevation 6.0 m.s.l., side slopes 1V on 4H, spoil to elevation 5.0 m.s.l. with assumed failure toward each side of the dike, and for a minimum factor of safety of 1.3. All of the dikes in this area will be newly constructed. This analysis is shown on revised plate 17, incl 10.

b. Para 31c(2).

Spoil areas no. 1, 7, and maintenance spoil area. The dike stability for spoil areas no. 1, 7, and the maintenance spoil area was analyzed based on shear strengths and stratifications from boring U-2 taken in this area in connection with DM No. 3, "Chalmette Area Plan, GDM." The analysis was made for top of dike at elevation 7.0 m.s.l., side slopes 1V on 5.5H, spoil elevation varying from elevation 6.0 m.s.l. at the dike to a maximum spoil elevation of 10.0 m.s.l. with assumed failure to the outside of the spoil area and for a minimum factor of safety of 1.3. Practically all of the dikes in spoil area 1 are existing and will be used or rebuilt where necessary. Approximately one-half of the necessary dikes for spoil area 7 now exist with the remaining dikes to be constructed. No dikes exist in the maintenance spoil area and new dikes will be constructed. The stability analysis pertinent to the new dike construction for these areas is shown on revised plate 16, incl 9.

6. Ref para e, 1st Ind. Local interests are responsible for providing maintenance spoil areas and retaining dikes. Maintenance dikes will be constructed or restored as necessary during maintenance dredging work contracted by the Government. Provisions will be made for local interests to reimburse the Government for the cost of this dike work.

LMNED-MP (20 Jul 73) 4th Ind
SUBJECT: Mississippi River-Gulf Outlet, Design Memorandum No. 1, General Design, Michoud Canal

DA, New Orleans District, Corps of Engineers, PO Box 60267, New Orleans, LA 70160 1 April 1974

TO: Division Engineer, Lower Mississippi Valley, ATTN: LMVED-TD

1. The comments of the 1st, 2d, and 3d indorsements to the subject design memorandum have been noted. The proposed disposition of the comments is presented in the following paragraphs.

2. Ref para a, 1st Ind. The plans and specifications for Michoud Canal submitted by letter dated 5 Dec 73, subject "Michoud Canal, La., Initial Dredging, Orleans and St. Bernard Parishes, La., Station 0+00 to Station 169+38" provided for foreshore protection from Citrus back levee station 625+00 to the New Orleans East back levee station 692+00. Foreshore protection from Citrus back levee station 507+45 to 625+00 will be provided by the Lake Pontchartrain, La., and Vicinity, hurricane protection project, specifically as shown in the general design memorandum entitled, "Lake Pontchartrain, Louisiana and Vicinity, Lake Pontchartrain Barrier Plan, Design Memorandum No. 2--General, Citrus Back Levee." Because of the distance between Michoud Canal and the New Orleans East back levee, riprap along the east bank of Michoud Canal is not considered necessary.

3. Ref para b, 1st Ind. Concur with the information presented in the referenced paragraph. Paragraph 31a, page 12, of the GDM has been revised as follows:

Channel stability analysis. The stability of the channel was analyzed using the following conservative assumptions: top of bank at elevation 4.0 m.s.l. and bottom of channel at elevation -40 m.l.g. with side slopes of 1V on 3H. The stratification and shear strengths were developed from boring 2-EUT (see plate 23 of GDM). The stability of the channel was analyzed by applying a minimum factor of safety with respect to shear strength of 1.3. This analysis is presented on revised plate 8, inclosed as inclosure 2.

4. Ref para c, 1st Ind. Concur. Paragraph 31b, page 12 of the GDM has been revised as follows:

Levee and I-wall stability analyses. In order to analyze the stability of the I-walls and levees adjacent to the proposed improvement, stability control lines using a factor of safety of 1.5 were developed. The sections were analyzed for failure toward the canal.

LMVED-TD (NOD 20 Jul 73) 3d Ind
SUBJECT: Mississippi River-Gulf Outlet, Design Memorandum No. 1 - General Design, Michoud Canal

DA, Lower Mississippi Valley Division, Corps of Engineers, Vicksburg, Miss. 39180 4 Jan 74

TO: District Engineer, New Orleans, ATTN: LMNED-MP

Referred to note approval subject to comments in previous indorsements and to the following:

a. 2d Ind, Para 3. The present value of losses to fish and wildlife resources indicated in para 50d of the DM amount to $6.85 per acre ($2.75 + $2.00 + $2.10). The $4.75 per acre value stated in the 2d Ind is the "average annual equivalent of the loss over the first 25 years of project life" and is not considered applicable.

b. Response to comments in the 2d Ind should include:

(1) The Louisiana Coastal Zone Study, prepared for the New Orleans District by the National Marine Fisheries Service, states a value of $6.50 per acre for commercial fisheries in the project area. The difference between this figure and the one used in the DM ($2.75 per acre) should be explained.

(2) Subparagraph 50d(3) implies that, if sport fishing pressure and harvest are less than could be supported by the resource, losses become insignificant. This may not be true. Sustainable harvest rates have not generally been established for marine species, but available data suggest that existing harvests may already be too high for some species. You should reconsider and document your position in this regard.

(3) Adequate documentation should be provided for all data used in the calculations.

c. Design Memorandum, Subpara 50d(5), Page 22. The calculations shown in the last sentence are incorrect. The dollar loss should be 0.7 x $3.00 x 380 x 16.93786 x 0.04073 = $550 per year. This results in an average annual loss of $1,789 per year instead of $1,887 as shown in subpara 50d(6).

FOR THE DIVISION ENGINEER:

R. H. RESTA
Chief, Engineering Division

CF:
DAEN-CWE-B

DAEN-CWE-B (LMNED-MP, 20 Jul 73) 2d Ind
SUBJECT: Mississippi River-Gulf Outlet, Design Memorandum No. 1 - General Design, Michoud Canal

DA, Office of the Chief of Engineers, Washington, D.C. 20314 6 December 1973

TO: Division Engineer, Lower Mississippi Valley, ATTN: LMVED-TD

1. Approved, subject to the comments of the Division Engineer, and to the comments furnished in the following paragraphs.

2. Paragraph 35a. This paragraph describes an area of about 520 acres for Spoil Area No. 1, whereas Table 1, page 31, indicates a construction easement of 460 acres for that area. This difference in area should be reconciled.

3. Paragraph 50d. The estimated aggregate average annual loss of fish and wildlife resources for 380 acres is stated as $1,887, which amounts to about $4.97 per acre. This appears low when compared with the $75.00 to $525.00 per acre per year loss estimated for Virginia marshes, the $250.00 to $525.00 per acre per year loss estimated for North Carolina marshes and the values sometimes ranging up to $1,000.00 per acre per year for Georgia marshes as reported by Odum. It seems that there should be more uniformity between the values associated with Louisiana marshes and those of other southern coastal states. Accordingly, the value of about $4.97 per acre should be further documented by defendable scientific findings.

4. Paragraph 61. The benefits claimed for the imported vehicles appear to be reasonable. The benefits attributed to the export of anhydrous ammonia are questioned in view of the rationale and methodology apparently applied in paragraph 61c(1). The established Corps methodology for evaluating such benefits is based on the estimated transportation savings resulting from operations expected with and without the proposed improvement. Since the improved navigation channel at Texas City is at least 40 feet in depth, there does not seem to be a substantial economic incentive for foreign-bound deep-draft vessels to utilize the proposed 36-foot navigation improvement on the Michoud Canal. It is suggested that the benefits attributed to the movement of anhydrous ammonia be predicated on a regional transfer rather than a national efficiency gain. The third category of benefits derived from shipment of other fertilizers is considered to be basically an induced benefit as discussed in paragraph 61c(2). Induced benefits should be credited to the project on less than a 100 percent basis; therefore, the $181,000 of benefits claimed should be reduced to a lesser amount. A recent example of counting induced benefits was the survey report on the Southern Branch of the Elizabeth River, Virginia, where 50 percent of the induced benefits were credited to the project.

FOR THE CHIEF OF ENGINEERS:

for R. L. Thompson
HOMER B. WILLIS
Chief, Engineering Division
Directorate of Civil Works

1 Incl
wd

LMVED-TD (NOD 20 Jul 73) 1st Ind 24 Aug 73
SUBJECT: Mississippi River-Gulf Outlet, Design Memorandum No. 1 - General Design, Michoud Canal

k. Plates 11 thru 14. Based on boring logs presented on Plates 23, 24, 27, and 28, the soil stratum between els -20 and -35 (stratums 6, 8, 6, 9 on Plates 11, 12, 13, and 14, respectively), should be designated as SP and an appropriate design shear strength of $\phi = 30°$, $c = 0$ tsf assigned for use in the stability analyses. The stability analyses on these plates should be checked considering the above to determine if the stability control line presented is still adequate for a factor of safety of about 1.5.

l. Plates 13 and 14. Prior to preparation of plans and specifications, NOD should carefully check the proposed project cut with respect to the stability control line to assure that the stability control line is not violated.

m. Refer to minor comments in red on Plates 6, 12, 13, 17, 24, and 25.

FOR THE DIVISION ENGINEER:

Robert I Kaufman

ROBERT I. KAUFMAN
Acting Chief, Engineering Division

1 Incl (14 cy)
wd 2 cy

CF:
LMNED-MP w
marked cy DM

were correlated with the boring and test results accomplished in connection with DM No. 2 - Supplement No. 4, "New Orleans East Back Levees" to form a basis for the stability analyses presented on Plate 17. This procedure is considered satisfactory if the District considers the stratification and strengths selected are representative of the conditions and strengths which will be encountered during construction of these dikes.

e. Para 31c(2), page 12. Paras 3 and 35d, pages 2 and 16, indicate that local interests are to be responsible for providing maintenance spoil areas and necessary retaining dikes. It is not clear whether local interests will construct these spoil retention dikes or if they will be included in the Government's construction contracts for channel maintenance excavation with provision for reimbursement by local interests. If local interests are to contract for construction of these dikes, they should be furnished the results of the stability analyses discussed in this paragraph to insure that an adequate spoil retention system is provided.

f. Para 36, page 16. Care should be taken in the removal of the pipelines to insure that any residual contaminants in the lines are not spilled, and are disposed of properly.

g. Subpara 50b, page 20. Further coordination with Louisiana Wildlife and Fisheries Commission should be accomplished to determine if there are desirable wildlife foods that could be established on spoil areas in lieu of natural plant successions.

h. Para 61, pages 35, 36, and 37. A comparison of current benefits should be made with benefits as shown in the project document and all differences explained. The types of navigation benefits are the same as those shown in the review report; however, since all types of benefits have increased substantially, they should be discussed and supported in at least the same detail as shown in the review report.

i. Plates 8 and 21. Boring 2-EUT on Plate 21 indicates clay CH, silt and silty sand between els. -22 to -32. The design shear strength of $\phi = 15^\circ$, c = 200 psf should have extended from el -14 to el -32. Use of this design shear strength between these depths will result in slightly lower factors of safety which may not reduce them to the extent of requiring a flatter slope. However, this should be investigated during preparation of plans and specifications.

j. Plate 10. The factor of safety for assumed failure surface A-1 at el -14 is less than the 1.5 indicated for the stability control line. The stability control line should be adjusted so as to provide a factor of safety of 1.5 for this assumed failure surface.

LMVED-TD (NOD 20 Jul 73) 1st Ind
SUBJECT: Mississippi River-Gulf Outlet, Design Memorandum No. 1 - General Design, Michoud Canal

DA, Lower Mississippi Valley Division, Corps of Engineers, Vicksburg, Miss. 39180 24 Aug 73

TO: HQDA (DAEN-CWE-B) WASH DC 20314

The subject general design memorandum is forwarded for review pursuant to para 21a, ER 1110-2-1150. Approval is recommended subject to the following comments:

a. Para 17, page 8. A discussion of the need for foreshore protection along the channel should be presented.

b. Para 31a, page 12, and Plate 8. The second sentence of the paragraph does not agree with information presented on Plate 8 regarding stratification and shear strengths used in the channel stability analyses. However, telecon with NOD F&M Br personnel indicates the stratification and shear strengths from all pertinent borings were considered and the data from boring 2-EUT found to be the most critical. The channel stability analyses were therefore performed using the stratification and shear strengths from boring 2-EUT rather than as indicated in the second sentence of the paragraph. This procedure is considered satisfactory and no change to the design memorandum is required.

c. Para 31b, page 12. The third sentence of the paragraph is incorrect and misleading. The analyses presented on Plates 9 thru 15 were not previously presented nor approved in the referenced GDMs. The referenced GDM analyses developed the design of the levee and I-wall levee sections without consideration of the proposed channel excavation presented in this GDM. The analyses presented in this GDM check the stability of the referenced GDM levee and I-wall sections with respect to the proposed MR-GO-GIWW-Michoud Canal excavation.

d. Para 31c, page 12, and Plates 16 and 17. The basis for the stratification and design shear strengths used in these stability analyses should have been presented. However, telecon with NOD F&M Br personnel reveals the following:

(1) The spoil dike stability analyses for spoil areas 1, 7, and the maintenance spoil area shown on Plate 16 are based on boring U-2 taken in this area in connection with DM No. 3 "Chalmette Area Plan, GDM." This is considered satisfactory if this boring accurately reflects the foundation conditions and strengths which will be encountered during the construction of these spoil dikes.

(2) The New Orleans District did not make borings in spoil area 6. However, results from general type borings made by a private drilling and testing company (Eustis) in the vicinity of the proposed spoil area 6 location were secured from the New Orleans East Co. Inc. The results of these borings

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P. O. BOX 60267
NEW ORLEANS, LOUISIANA 70160

IN REPLY REFER TO
LMNED-MP

20 July 1973

SUBJECT: Mississippi River-Gulf Outlet, Design Memorandum No. 1 - General Design, Michoud Canal

Division Engineer, Lower Mississippi Valley
ATTN: LMVED-TD

1. The subject general design memorandum is submitted herewith for review and approval, and has been prepared generally in accordance with the provisions of ER 1110-2-1150 exclusive of the Phase I--Phase II planning procedure.

2. In order for the construction contract for this work to be awarded in December 1973, this design memorandum must be approved by 5 September 1973.

3. Approval of this design memorandum is recommended.

Maj CE Acting DE

1 Incl (16 cys) fwd sep
GDM No. 1

for RICHARD L. HUNT
Colonel, CE
District Engineer

MISSISSIPPI RIVER-GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

STATUS OF DESIGN MEMORANDUMS

Design Memo No.	Title	Status
1	Mississippi River-Gulf Outlet, GDM, Michoud Canal	Submitted 20 Jul 73

MISSISSIPPI RIVER-GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

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PLATES

PERTINENT DATA

Location of project		Southeastern Louisiana in Orleans and St. Bernard Parishes
Hydrologic data:		
Temperature:	maximum monthly	87.1° Fahrenheit
	minimum monthly	43.0° Fahrenheit
	average	69.7° Fahrenheit
Annual precipitation:	maximum	85.73 inches
	minimum	31.07 inches
	average	60.58 inches
Channels		
Method of construction		Hydraulic dredging
MR-GO to Michoud Canal		
Length of channel		1.2 miles
Bottom width		250 feet
Bottom elevation		-36.0 m.l.g.
Side slopes		1V on 3H
Excavation		2,186,000 yd^3
Advanced maintenance excavation		2 feet (157,000 yd^3)
Allowable overdepth		2 feet (157,000 yd^3)
Michoud Canal, GIWW to turning basin		
Length of channel		1.7 miles
Bottom width		250 feet
Bottom elevation		-36.0 m.l.g.
Side slopes		1V on 3H
Excavation		1,140,000 yd^3
Advanced maintenance excavation		2 feet (180,000 yd^3)
Allowable overdepth		2 feet (180,000 yd^3)
Turning basin		
Bottom dimensions		800 feet x 800 feet
Bottom elevation		-36.0 m.l.g.
Side slopes		1V on 3H
Excavation		904,000 yd^3
Advanced maintenance excavation		2 feet (48,000 yd^3)
Allowable overdepth		2 feet (48,000 yd^3)

Rights-of-way	
Permanent rights-of-way	
Channel and turning basin	12.3 acres
Maintenance spoil area	380 acres
Pipeline rights-of-way	3.6 acres
Construction easements	
Pipeline easements	2.0 acres
Disposal area easements	1,034 acres
Estimated first costs	
Channels and canals	$3,222,000
Engineering and design	203,000
Supervision and administration	245,000
Lands and improvements	1,035,000
Relocations	25,000
Aids to navigation	9,000
Summary of costs and benefits	
First costs: Federal	$3,679,000
Non-Federal	1,060,000
Total	4,739,000
Annual charges:	291,400
Annual benefits:	691,500
Benefit-to-cost ratio	2.38 to 1

Project purpose: To provide a deep-draft navigation channel from the MR-GO into Michoud Canal

MISSISSIPPI RIVER-GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

PROJECT AUTHORIZATION

1. Authority.

a. Public law. Public Law 90-483, 90th Congress, Second Session, approved 13 August 1968, authorized the Mississippi River-Gulf Outlet, Michoud Canal navigation project. The authorization was substantially in accordance with the recommendations of the Chief of Engineers in Senate Document No. 97, 90th Congress, Second Session, except that the recommendations of the Board of Engineers for Rivers and Harbors shall apply. The Board recommended the requirement that local interests must furnish, without cost to the United States, retaining dikes for disposal areas for maintenance dredging, if required.

b. Senate document. The report of the Chief of Engineers in Senate Document No. 97, 90th Congress, Second Session, submitted for transmission to Congress the report of the Board of Engineers for Rivers and Harbors, accompanied by the reports of the District and Division Engineers. The report of the Board of Engineers for Rivers and Harbors stated: "The Board of Engineers for Rivers and Harbors concurs in general in the views and recommendations of the reporting officers. The Board notes that the District Engineer has planned adequately for disposal of spoil from construction in a manner acceptable to fish and wildlife and other conservation interests in the area. However, for disposal of spoil from maintenance dredging, the Board believes local interests should be required to furnish the necessary retaining dikes, bulkheads, and embankments or the cost of such retaining works in event that such works are determined by the Chief of Engineers to be required. The improvements proposed are suitable and economically justified."

c. BERH recommendation. The report of the Chief of Engineers stated: "The Board of Engineers for Rivers and Harbors concurs in general in the findings of the reporting officers and recommends the modification, generally in accordance with the plan of the District Engineer, subject to local cooperation, including the additional requirement that local interests agree to provide without cost to the United States retaining dikes for disposal of spoil from maintenance dredging, if required...I concur in the views and recommendations of the Board."

2. Purpose and scope. This memorandum presents the essential data, assumptions, and criteria for plan, design, and cost for the enlargement of the Michoud Canal, Louisiana. Its purpose is to present sufficient detail to provide an adequate basis for

preparing plans and specifications for the canal enlargement construction without additional design analysis.

3. Local cooperation. The conditions of local cooperation pertinent to this memorandum and as specified in the report of the Board of Engineers for Rivers and Harbors and concurred in by the report of the Chief of Engineers are that prior to construction local interests agree to:

"a. Provide without cost to the United States all lands, easements, and rights-of-way required for construction and subsequent maintenance of the project and for aids to navigation upon the request of the Chief of Engineers, including suitable areas determined by the Chief of Engineers, to be required in the general public interest for initial and subsequent disposal of spoil, and also retaining dikes for disposal of spoil from maintenance dredging, if required;

"b. Accomplish without cost to the United States such utility or other relocations or alterations as necessary for project purposes;

"c. Hold and save the United States free from damages due to the construction and subsequent maintenance of the project, including any erosion beyond the rights-of-way furnished;

"d. Provide, maintain, and operate without cost to the United States adequate public wharf facilities on the Michoud Canal open to all on equal terms."

4. Existing project. This project is a modification of the existing Mississippi River-Gulf Outlet (MR-GO) project. The MR-GO project provides for construction of a ship channel 36 feet deep and 500 feet wide from the Inner Harbor Navigation Canal (IHNC) through a portion of the Gulf Intracoastal Waterway (GIWW), and thence through the coastal marshes along the south edge of Lake Borgne, and a diked channel across Breton Sound to the Gulf of Mexico. The project further provides for the replacement of the existing lock or the construction of a new lock and connecting channels in the vicinity of Meraux, La., when justified by obsolescence of the existing lock or by increased traffic; the construction of a bridge over the ship channel at the Louisiana Highway 47 crossing; and the operation and maintenance of the Seabrook lock at the Lake Pontchartrain terminus of the IHNC. The Seabrook lock will be constructed under the Lake Pontchartrain, La. and Vicinity, project as authorized by the Flood Control Act of 1965 (Public Law 89-298, approved 27 October 1965). The ship channel was opened to traffic in 1963 and was completed in 1968 except for foreshore protection and the dike across Breton Sound. The project is approximately 58 percent complete with construction

continuing on foreshore protection and stone dikes. Planning is continuing for replacement of the IHNC lock with a new ship lock.

INVESTIGATIONS

5. Project document investigations. Studies and investigations made in conjunction with the project document consisted of research of information which was available from the existing federally constructed GIWW and MR-GO projects, records of traffic over the existing Federal waterways, and previous reports. Specific investigations included field reconnaissance and surveys, economic studies, and preliminary design of improvements considered. Economic studies included cost studies and the determination of potential traffic and transportation savings which would accrue from the proposed channel. This was accomplished by a field canvass of the industries and shippers operating within the area and landowners along the proposed improvement.

6. Investigations made subsequent to project authorization. Studies and investigations made subsequent to project authorization include:

a. Field and aerial surveys of the project area;

b. Geologic and soils studies, including borings and stability analyses;

c. Hydrology and sedimentation studies;

d. Field surveys to locate a derelict barge;

e. Detailed design studies for channel and turning basin;

f. Determination of real estate requirements and costs;

g. Cost estimates for construction of the channel and turning basin;

h. Economic studies evaluating the justification for recommended improvements;

i. Studies of the acceptability of alternate spoil disposal areas; and

j. Environmental impact studies.

A substantial amount of basic data was available from that collected for the "Lake Pontchartrain, Louisiana and Vicinity," project, including soil borings, aerial photos, field surveys, and base maps.

Basic data were also available from various studies under the General Investigations program. Among the more pertinent of these are the Louisiana Coastal Area study and the West Texas and Eastern New Mexico Import study. A special study, conducted by an interagency group under the chairmanship of the Corps of Engineers, "The Fish and Wildlife Study of Coastal Louisiana and the Atchafalaya Basin Floodway," was also a major source of environmental data.

7. Investigations planned in the future. Surveys of the channel to determine the necessity for maintenance dredging will be accomplished at periodic intervals throughout the project life.

LOCAL COOPERATION

8. Local cooperation specified by legislation subsequent to project authorization. In addition to the items of local cooperation specified in paragraph 3 above, local interests must also comply with the following:

a. Public Law 91-611, Section 221. This section states that no water resource project shall be constructed until each non-Federal interest has entered into a written agreement with the Secretary of the Army for furnishing required cooperation for the project. The agreement is enforceable in the appropriate District Court of the United States.

b. Public Law 91-646 (The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970). This law provides for uniform and equitable treatment of persons displaced from their homes, businesses, or farms by Federal and federally assisted programs, and to establish uniform and equitable land acquisition policies for Federal and federally assisted programs.

9. Status of local cooperation.

a. The Board of Commissioners of the Port of New Orleans (Dock Board) is the agency designated as local coordinator for the Michoud Canal project. The U. S. Army Corps of Engineers, on behalf of the United States Government, requested formal assurances for local cooperation from the Dock Board on 10 January 1969. Formal assurances have been received and were accepted on behalf of the United States on 24 February 1969. These assurances included the items of local cooperation described in paragraph 3 above.

b. Agreements of local cooperation covering the requirements of Public Law 91-646 (The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970) and Section 221 of Public Law 91-611 were requested from the Dock Board on 22 June 1972, but have not been received to date.

c. The Dock Board is an official agency of the State of Louisiana whose members are appointed by the Governor. The current principal officers of the Board are as follows:

The Board of Commissioners of the Port of New Orleans
P. O. Box 60046, New Orleans, Louisiana 70160
Eads Poitevent, President
James E. Smith, Vice-President
Frank G. Strachan, Secretary
John Meghrian, Treasurer
Richard B. Montgomery, Chairman, Finance Committee

10. Views of local interests.

a. The Dock Board is sole agency responsible for providing local interest assurances for this project. The plan presented herein has been coordinated in detail with the Dock Board and bears the approval of that agency. The intention and capability of this sponsor to provide the required non-Federal contribution for this construction have been amply demonstrated in its planning activities for this project, and in its previous contributions to the overall MR-GO project.

b. Local interests are also required to provide, maintain, and operate public wharf facilities on the Michoud Canal. To satisfy this requirement, the Dock Board has reserved a tract of land at the extreme northern end of the Michoud Canal turning basin for construction of a public general cargo facility.

c. Because of the foregoing considerations, the prospects of the Dock Board fulfilling its obligations of local cooperation are considered extremely favorable.

11. Required non-Federal cost. The total estimated first cost to local interests is $1,060,000 to include lands, damages, and relocations. This amount includes the cost of the maintenance spoil area which will be acquired prior to initiation of construction. Annual costs to local interests are estimated to be $49,400 for maintenance spoil area dike construction.

LOCATION OF PROJECT AND TRIBUTARY AREA

12. Project location. The project is located in an industrial area in the eastern part of New Orleans as shown on plate 1.

13. Tributary area. The project is tributary to a 32,000-acre tract called New Orleans East and to the 875-acre National Aeronautics and Space Administration (NASA) tract. New Orleans East includes residential, recreational, commercial, and industrial areas. Of this, approximately 4,300 acres are designated heavy industrial property which is considered to be the area from which

commercial cargo tonnage will be drawn. Immediately abutting Michoud Canal are about 423 acres of land presently used as follows:

a. Approximately 76 acres are used by International Auto Sales and Services, Inc., to import, service, and store motor vehicles. Deep-draft unloading is planned as soon as the project channel is excavated and suitable wharf facilities can be constructed;

b. Approximately 84 acres are used by Air Products and Chemicals, Inc., as a plant site for manufacture of commercial fertilizer and industrial gases. Bulk loading of the fertilizer onto deep-draft vessels is anticipated soon after project completion;

c. Louisiana Cement Company occupies a site of approximately 51 acres on which Portland cement is manufactured. At present, raw materials are barged to the plant and bulk cement is barged and trucked away. No change in the operations is known to be planned and no need for deep-draft transport is presently envisioned;

d. Dundee Cement Company operates a Portland cement storage facility occupying approximately 14 acres. Bulk cement is received by barge, stored in silos, and later transported, by truck, to a local distribution area. This company currently intends to expand their plant operations and to utilize deep-draft transport of materials;

e. Pratt-Farnsworth uses a 5-acre tract for its construction business operations. Deep-draft navigation facilities are unlikely to be required for this company's operation in the foreseeable future;

f. Approximately 18 acres have been made available to the Board of Commissioners of the Port of New Orleans to provide public wharf facilities. Deep-draft navigation will, of course, be the principal focus of this future facility;

g. The remaining 175 acres are presently available for development of port facilities any or all of which could be for deep-draft usage.

The NASA facility contains approximately 875 acres abutting the western side of the Michoud Canal north of the GIWW. The agency uses the channels of the GIWW and the Michoud slip for shallow-draft vessels, and has expressed no anticipated need for deep-draft facilities along Michoud Canal.

PROJECT PLAN

14. General. The plan presented herein is essentially the same plan presented in the project document. The plan consists of providing a new ship channel from the junction of the MR-GO and the GIWW eastward along the GIWW to its junction with Michoud Canal; thence northerly along the canal terminating at a newly constructed turning basin at the extreme northern end of the canal. The construction will be confined almost entirely within existing bank lines. Refer to plate 1 for the location and general plan of improvement.

15. Plan of improvement. The plan presented herein provides for construction of a new ship channel 250 feet wide to elevation -36.0 feet m.l.g. (mean low gulf)[1] from the MR-GO to and along the Michoud Canal. The channel will include an additional 2 feet of dredging for advance maintenance (el. -38.0) and 2 feet more for allowable overdepth (el. -40.0) as specified in the project document. Essentially all of this construction will be within existing bank lines as shown on plates 2 and 3. The project also provides for construction of a turning basin (800 feet by 800 feet) at the northern terminus of the Michoud Canal as shown on plate 3. Dredged material from initial construction will be deposited in three disposal areas (areas nos. 1, 6, and 7). Area no. 6 is located just eastward of the turning basin and areas nos. 1 and 7 are located just south of the MR-GO in existing disposal areas. (See plates 3 and 4.) Spoil from maintenance dredging subsequent to initial construction will be deposited in another area south of the MR-GO reserved specifically for this purpose. This area has not been used previously for spoil disposal (see plate 4). Spoil retention dikes existing in the spoil areas will be used or rebuilt whenever possible and new dikes will be constructed where necessary. Typical cross sections are shown on plates 5 and 6.

16. Departures from project document plan. No changes of alinement and depths of channel have occurred since the authorizing document. The only significant departure has been the partial revision of the spoil-disposal plan. The project document plan contemplated the use of some of the dredged material for hurricane protection levee fill adjacent to the MR-GO, and for the disposal of additional material into the leveed area immediately east of the Michoud Canal. The project document did not provide a specific area for the disposal of dredged maintenance spoil. Studies performed in conjunction with this report revealed that the materials to be excavated were not suitable for use as levee fill and consequently

[1] Elevations contained herein are in feet referred to mean low gulf datum unless otherwise noted. Zero m.l.g. (mean low gulf) equals -0.78 foot m.s.l. (mean sea level).

it was deemed necessary to dispose of all of the excavated materials. This determination resulted in the need for more spoil-disposal areas than considered in the authorizing document. Additionally, since the preparation of the project document, many of the tracts of land just east of the canal have become significantly more valuable from a developmental standpoint. This increase in value precluded the extensive use of this area for spoil disposal in combination with the refusal of the landholders granting the necessary construction easements. Accordingly, only a portion of this area is still economically feasible for use as a disposal site (see spoil area 6, plate 3). The remaining disposal area necessary for construction is located south of the MR-GO. Additionally, one area has been reserved specifically for subsequent maintenance dredging of the channel. This area is also located south of the MR-GO and will be provided by local interests prior to initiation of construction.

HYDROLOGY AND HYDRAULICS

17. General. The Michoud Canal is bordered on the north, east, and west by leveed and drained lands and on the south by manmade waterways and open marsh. The canal is connected to Lake Borgne, Breton Sound, and the Mississippi River via the GIWW, the MR-GO, and numerous natural outlets. The depth of the canal varies greatly over the existing water bottom since portions of the canal have been used previously for borrow materials. Data essential to the design and formulation of this project are contained in appendix A of this memorandum.

18. Sedimentation. The Michoud Canal and adjacent reaches of the GIWW were excavated in 1942 to provide a working harbor, marine access, and fill material for what is now the NASA facility and previously a shipbuilding yard. Subsequent to this initial excavation, these areas were again excavated for borrow materials to provide levee fill. However, no known records are available which indicate the locations and depths of borrow pits or the quantities taken therefrom. Similarly, records are not available which yield year-to-year channel sedimentation. Therefore, estimates of expected sedimentation have been derived from the field exploration and analyses made in conjunction with this report.

19. Sources of sedimentation. The soil borings contained in this report indicate that the existing channels have been refilled. This new filling can best be observed on the soil and geologic profile, plate 7. This channel fill is believed to have resulted from:

a. Tidal action continuously eroding the adjacent marshlands and then depositing released solids in the deeper channel reaches;

b. Bank caving and channel erosion due to wave and prop wash with the freed solids being deposited in the deeper reaches;

c. Transport of marsh materials and rearrangement of the channel bottom materials caused by hurricane and storm-generated surges.

20. Estimate of sedimentation. Although the present sedimentation rate cannot be precisely verified, reasonable estimates of expected sedimentation have been computed based on experience with similar channels in coastal Louisiana and by studying the field investigations described above. It is currently estimated that approximately 840,000 cubic yards of channel fill material will have to be removed at each maintenance operation, and that maintenance will be required at 5, 10, 20, 30, and 40 years after initial project construction. The estimate considers the effects of increased shoaling resulting from the anticipated increase in barge and ship traffic induced by the new construction.

GEOLOGY

21. Physiography. The project area is located within the Central Gulf Coastal Plain on the eastern flank of the Mississippi River Deltaic Plain. The dominant physiographic features of the project site and surrounding area include Lake Pontchartrain, Lake Borgne, many smaller lakes and ponds, lagoons, bayous, canals, marshes, abandoned distributaries, and small natural levee ridges. Relief in the area is very slight with elevations ranging from a few feet above mean sea level along the natural levee crests to a few feet below mean sea level in some of the marshlands.

22. General geology. Only the geologic history since the end of the Pleistocene epoch is relevant to this project. At that time, with sea level about 400 to 450 feet below its present level, the Mississippi River began to migrate laterally back and forth across the alluvial valley to the west. About 4,700 years ago, the St. Bernard delta complex was initiated and delta lobes of the Mississippi River system began a series of progradations to the south of the project area. About 1,900 years ago, as the river continued to shift to steeper gradient courses, the Bayou Sauvage delta was formed and the Metairie Bayou-Bayou Sauvage distributary diverted flow northeastward from the existing Mississippi River course, becoming the primary source of sediments in the project area. At first deposition was concentrated in the depression between the older St. Bernard delta lobes to the south and Pine Island, an east-west trending relict beach located immediately north of Bayou Sauvage. Pine Island was ultimately overtopped and buried by deltaic deposits of Bayou Sauvage and its minor distributaries which finally crossed the beach to the north and deposited sediments along the southeast shore of Lake Pontchartrain. Deposition from this source continued until about 700 years ago

at which time the major stream course shifted south and west to the Plaquemines-Modern and Lafourche delta complexes. Since construction of the levee systems along the Mississippi River, seasonal flooding of lands adjacent to the river has been eliminated and the sediment supply into the project area halted. As a result, the land masses within the general project area are in a state of retreat and deterioration.

23. Investigations performed. No borings were taken specifically for this project. However, extensive data from borings taken in conjunction with other projects in the immediate vicinity of the canal and borings taken along the canal are available and included in this report. These borings were performed in conjunction with the Citrus Back Levee and New Orleans East Back Levee features of the Lake Pontchartrain hurricane protection project. These data as well as previously compiled geologic information were available for the interpretation of the subsurface geology and foundation conditions of the area.

24. Foundation conditions. The subsurface below the existing canal bottom consists of Recent deposits varying in thickness from about 12 feet near the north end of Michoud Canal to about 40 feet along the GIWW reach from the canal to the MR-GO. Underlying the Recent are deposits of Pleistocene age. Generally, between stations 0+00 and 140+00, the Recent consists of a 6- to 20-foot layer of very soft channel fill clays with organic matter, underlain by an 8- to 30-foot layer of soft alternating intradelta clays and silt containing numerous layers of silty sand and sand. The channel fill and intradelta deposits are underlain by a thin 3- to 8-foot layer of nearshore sediments consisting principally of sands with shell and shell fragments, except in the section between stations 100+00 and 140+00 where the sands are interfingered with medium clays containing shell and shell fragments. Between stations 140+00 and 170+20, the Recent consists generally of a 6- to 14-foot layer of very soft channel fill clays with organic matter underlain by a thin 1- to 5-foot layer of soft intradelta clays. An exception is in the vicinity of station 148+00 where the intradelta material is absent and only Recent channel fill material is present. The Pleistocene materials which underlie the Recent consist principally of stiff to very stiff clays except between stations 55+00 and 120+00 and between stations 135+00 and 170+20 where layers of silt, silty sand, and sand are encountered. See plate 7.

25. Mineral resources. Oil and gas production are found to the southwest of the project area. However, future exploration or production of oil and gas resources will not be adversely affected by the project, nor will the project be adversely affected by the exploration and production of these natural resources.

26. Conclusions. The subsurface investigations and analyses of all existing data indicate that geologic conditions for enlarging the existing canal and adjacent reach are generally favorable. Practically all of the channel fill layer now forming the existing canal bottom will be removed by the proposed excavation.

SOILS INVESTIGATIONS AND ANALYSES

27. General. This section covers the soils investigation and design analyses for the proposed channel construction over the entire reach of the project enlargement.

28. Field investigations. All soil borings necessary for the design and analysis of the channel enlargement were available from the Lake Pontchartrain hurricane protection project. Borings taken in conjunction with the Citrus Back Levee feature of that project include general-type borings B-13 through B-19 shown on plate 18, general-type borings 2-M, 3-M, 5-M, 6-M, and 7-M shown on plate 19, and undisturbed borings 4-MU, 4-MUT, 8-MU, 8-MUT, 9-MU, and 9-MUT shown on plates 23, 24, 25, 26, 27, and 28, respectively. Borings taken in conjunction with the New Orleans East Back Levee feature of the hurricane protection project include general-type borings 1-B thru 5-B shown on plate 18, general-type borings 1-E, 2-E, 3-ET, 4-ET, and 5-E are shown on plate 20, and undisturbed borings 2-EUT and 3-EU are shown on plates 21 and 22, respectively. The general-type borings were made with a 1 7/8-inch I.D. core barrel sampler and varied in depths from about -45.0 to -83.0 feet m.s.l. The undisturbed borings were made with a 5-inch I.D. steel tube piston-type sampler and varied in depths from about -54.0 to -98.0 feet m.s.l. The locations of all borings are shown on plates 2 and 3.

29. Laboratory tests. Visual classifications were made on all samples obtained and water content determinations were made on all cohesive soil samples. Consolidation (C) tests, unconfined compression (UC), unconsolidated-undrained (Q), consolidated-undrained (R), and consolidated-drained (S) shear tests were performed on representative soil samples from the undisturbed borings.

30. Soil conditions. The subsurface along the project alinement consists generally of 6 to 22 feet of channel fill sediments, partially filling the bottom of a deeper channel excavated about 30 years ago. The fill sediments are composed of very soft fat clay, organic fat clay and peat, with moisture contents ranging between 61 and 130 percent in the fat clay, 120 and 225 percent in the organic fat clay, and 436 to 657 percent in the peat. The top of the Pleistocene varies from about elevation -40 to -60 m.s.l. The Pleistocene is predominantly medium to very stiff fat clay with moisture contents ranging between 31 and 54 percent with alternate layers of silty sand, fine sand, silt, and lean

clay. Between the channel fill sediments and the Pleistocene are Recent deposits of predominantly very soft to medium fat clay with layers of fine sand, silty sand, and lean clay. Moisture contents in the fat clay vary between 36 and 81 percent. The soil along the adjacent levee alinements is generally a soft to medium fat clay with organic fat clay, silt, and sand layers. See plate 7 for a geologic interpretation of the stratification.

31. Stability. The stability analyses of the I-walls and levees, channels, and spoil dikes were determined by the method of planes using design (Q) shear strengths and applying applicable factors of safety with respect to strength.

a. Channel stability analysis. The stability of the channel was analyzed using the following conservative assumptions: top of bank at elevation 4.0 m.s.l. and bottom of channel at elevation -40.0 m.l.g. with side slopes of 1V on 3H. The stratification and shear strengths were developed from all borings in the project area. The stability of the channel was analyzed by applying a minimum factor of safety with respect to shear strength of 1.3. This analysis is presented on plate 8.

b. Levee and I-wall stability analyses. In order to analyze the stability of the I-walls and levees adjacent to the proposed improvement, stability control lines using a factor of safety of 1.5 were developed. The sections were analyzed for failure toward the canal. These analyses are presented on plates 9 thru 15, and were previously presented and approved in the Citrus Back Levee and New Orleans East Back Levee GDM's of the Lake Pontchartrain hurricane protection project. The stratifications and shear strength trends used in each analysis are presented on the respective analysis plate.

c. Spoil retention dike stability analysis. The stability of the spoil retention dikes was analyzed as follows:

(1) Spoil area no. 6. The dike stability for this spoil area was analyzed for top of dike at elevation 6.0 m.s.l., side slopes 1V on 4H, spoil to elevation 5.0 m.s.l. with assumed failure toward each side of the dike, and for a minimum factor of safety of 1.3. All of the dikes in this area will be newly constructed. This analysis is presented on plate 17.

(2) Spoil areas nos. 1, 7, and maintenance spoil area. The dike stability for spoil areas nos. 1, 7, and the maintenance spoil area was analyzed for top of dike at elevation 7.0 m.s.l., side slopes 1V on 5.5H, spoil elevation varying from elevation 6.0 m.s.l. at the dike to a maximum spoil elevation of 10.0 m.s.l. with assumed failure to the outside of the spoil area and for a minimum factor of safety of 1.3. Practically all of the dikes in spoil area 1 are existing and will be used or rebuilt where

necessary. Approximately one-half of the necessary dikes for spoil area 7 now exist with the remaining dikes to be constructed. No dikes exist in the maintenance spoil area and new dikes will be constructed. The stability analysis pertinent to the new dike construction for these areas is shown on plate 16.

32. Design and construction problems. The required enlargement of the Michoud Canal and adjacent waterways produces design and construction problems in the following areas:

a. Channel enlargement. The required channel enlargement will be performed by hydraulic dredging. This construction must be accomplished over a section which will not affect the stability of the channel, adjacent levees and floodwalls, and bankline industries. The design presented is considered to be adequate with respect to these stabilities.

b. Spoil dike construction. Although many of the dikes required for construction spoil confinement are already existing, some new dike construction will be required for the disposal areas. The dike designs must assure that the dikes will not fail under service with the resulting detrimental effects of environmental degradation. The dike designs presented are considered adequate with respect to safety and will suffice the construction needs for the spoil retention.

c. Methods of construction. Since the dredged material will be placed in selected areas, construction controls must be implemented to assure maximum efficient usage of these areas. Construction controls must consider appropriate pipeline discharges to assure environmental quality as well as controls for the discharge of the clarified spoil effluents into the adjacent watercourses. Additionally, since some spoil area is located below the MR-GO, it is necessary for the dredge discharge lines to cross this navigation channel. Accordingly, it will be necessary to provide construction control so that these lines will not interfere with marine traffic or impair vessel safety. The construction specifications will stipulate the appropriate control methods and guidelines for these facets of the construction. Strict adherence to these specifications will be enforced by construction inspectors and supervisors acting in behalf of the United States Government.

DESCRIPTION OF PROPOSED WORKS AND IMPROVEMENTS

33. Channel. New channel construction originates at the MR-GO, where two new theoretical channels will be constructed. One channel centerline (origin at sta. 0+00 centerline west) will connect with the MR-GO centerline to the west and one channel centerline (origin at sta. 0+00 centerline south) connects with the MR-GO centerline to the south (see plate 2). The existing bottom materials between each of these new channels will be

excavated to provide a large intersection area for maneuvering vessels. This entire area will be excavated to elevation -36.0 plus 2 feet more for advance maintenance (elevation -38.0) plus 2 feet more allowable overdepth (elevation -40.0). Refer to plate 5 for the cross section at this intersection area. At station 36+33 centerline west = station 18+60 centerline south, the two theoretical channels unite to form one channel over the entire project reach to the turning basin. The channel dimensions over this segment of the full reach are 250 feet wide by -36.0 with 1V on 3H side slopes, except in the curve at the canal intersection with the GIWW (see plates 5 & 6 for typical section). The channel has been widened at the outside of this curve (see curves nos. 5 & 6) to compensate for a vessels stern drift as it enters the canal. A vessel mooring area 175 feet wide is provided at each immediate side of the new channel from approximate station 90+00 to approximate station 140+00. Beginning at station 140+00 and continuing through the turning basin, the mooring area varies in width from 150 feet to about 225 feet. To the immediate outside of each mooring area, a structure area is available. This area is generally 110 feet in width, but in some instances is greater or lesser in width and in such instances extends from the mooring area limit line to the bankline (see plates 2 & 3 for the channel plan and profile). In order to derive a realistic cost estimate for the channel construction, the channel was separated into three separate reaches; namely, the reach from the MR-GO along the GIWW to the beginning of the Michoud Canal, the reach from the GIWW along the canal to the turning basin, and lastly the turning basin which is discussed in the following paragraph. The reach from the MR-GO to the canal requires a total excavation of about 2,500,000 cubic yards comprised of 2,186,000 cubic yards of excavation to project depth, elevation -36.0, 157,000 cubic yards of excavation for advance maintenance to elevation -38.0, and 157,000 cubic yards of excavation for allowable overdepth to elevation -40.0. For estimating purposes, it was assumed that all of this material would be wasted in spoil area no. 1, south of the MR-GO. The reach from the GIWW to the turning basin requires a total excavation of about 1,500,000 cubic yards comprised of 1,140,000 cubic yards to project depth, elevation -36.0, and 180,000 cubic yards each for 2 feet of advance maintenance and 2 feet of allowable overdepth. For estimating purposes, it was assumed that this material would be wasted in spoil area no. 7, south of the MR-GO. The turning basin is fully described in the following paragraph.

34. Turning basin. At the extreme northern end of the Michoud Canal, a new turning basin will be constructed. The basin will be 800 feet by 800 feet at its bottom and will be constructed to a depth of -36.0 plus an additional 2 feet of advance maintenance to elevation -38.0 plus 2 feet of allowable overdepth to elevation -40.0. The basin side slopes will be 1V on 3H (see plate 5 for a section across the turning basin). A total of about 1 million

cubic yards of material will be excavated to form the turning basin. This quantity is comprised of about 904,000 cubic yards of excavation to project depth, elevation -36.0, and about 48,000 cubic yards each of excavation for 2 feet of advance maintenance, elevation -38.0, and for 2 feet of allowable overdepth, elevation -40.0. For estimating purposes, it was assumed that all of this material would be wasted in spoil area no. 6. This area is described below.

35. Spoil-disposal areas. Since the excavated materials are not suitable for use as levee fill, all of the material will be wasted in designated spoil-disposal areas as follows:

a. Spoil area no. 1. This area is located south of the MR-GO and is shown in plan on plate 4. The area consists of approximately 520 acres and has been used previously for spoil disposal. The area is practically completely diked, and these existing dikes will be reused or rebuilt as necessary. The elevation of the dikes in this area is 7.0 m.s.l. Overflow weirs will be located in the retention dikes such that the clarified effluent will be discharged into Bayou Bienvenue after the solids have settled out. It is estimated that a 5-year construction easement will be required for spoil drying and consolidation since this area is not drained.

b. Spoil area no. 6. This area is located just east of the proposed turning basin and is shown in plan on plate 3. This area contains approximately 174 acres and has not been previously used for spoil disposal. It will be necessary to build new dikes to elevation 6.0 m.s.l. to confine this area. Overflow weirs will be located in these dikes such that the clarified waters will be discharged into the drainage canal just south of the area which connects to a pumping station via a pipeline canal. The clarified waters will ultimately be discharged into the GIWW by the pumping station. Since this spoil area is located in a leveed and drained area, it is estimated that a 3-year easement will be required to drain and consolidate the spoil. Since this area has considerable development potential, local private interests intend to accelerate this drainage time by tilling, etc., after the area has been fully used for spoiling and the material has crusted. A 30-foot wide pipeline easement (approx. 2.0 acres) will be provided from the southeastern corner of the turning basin to this area.

c. Spoil area no. 7. This area is located south of the MR-GO and east of Bayou Bienvenue as shown in plan on plate 4. This area contains approximately 400 acres and has been used previously for spoil disposal. About one-half of this area is already diked. The remaining dikes will be constructed to elevation 7.0 m.s.l. Overflow weirs will be located in the dikes on the south side of the area. The clarified waters will be discharged into

the drainage canal south of the area which in turn discharges into Bayou Bienvenue. This area is located in an undrained area and a 5-year easement will be required for drying and consolidation of the spoil.

d. Maintenance spoil area. It has been estimated that channel maintenance will be required at periodic intervals throughout project life. Accordingly, a disposal area for the maintenance spoil will be required. This area consists of approximately 380 acres and is located south of the MR-GO and east of Bayou Bienvenue as shown on plate 4. This area is currently marshland and has not been previously used for spoil disposal. New dikes will be constructed to confine this area. The dikes will be constructed to elevation 7.0 m.s.l. Since maintenance will be required throughout the life of the project, this area will be acquired for perpetual use. The costs of this acquisition and diking costs will be borne entirely by local interests. This acquisition will be prior to initiation of construction. Permanent rights-of-way 30 feet wide will be acquired for dredge pipeline access from the MR-GO to this area.

36. Relocations. A cluster of three nitrogen pipelines crosses the canal at about station 140+00 (from Citrus Back Levee baseline station 626+69). The lines are 10 inches, 2 1/2 inches, and 1 inch in size. As of July 1970, the lines are no longer in service. Air Products and Chemicals Co., owner of the lines, has been contacted and has expressed its desire that the lines be removed. Accordingly, these lines will be removed prior to or during construction with the cost of the removal to be borne by local interests.

OTHER PLANS CONSIDERED

37. Recommended construction plan. The plan recommended for construction consists of enlarging the Michoud Canal and a segment of the GIWW from the canal to the MR-GO. This construction can be performed feasibly by hydraulic excavation, with all of the excavated materials being wasted in designated spoil-disposal areas. The plan also includes the removal of some abandoned pipelines which now cross the canal.

38. Alternate alinement plan. One plan was developed for an alternate alinement. This plan contemplated the extension of Michoud Canal southward across a natural marsh to the MR-GO channel. This plan necessitated additional excavation and costs were excessive. This plan is discussed in greater detail in appendix B, Comparison of Alternate Plans.

39. Alternate spoil-disposal plans. Nine different spoil plans were evaluated in project planning studies. These plans contemplated several different spoil-disposal area locations and sizes. The results of these studies, to include comparative costs, environmental effects, acreage descriptions, problems, and benefit-to-cost ratios, are presented in appendix B of this memorandum.

ACCESS ROADS

40. General. The construction site may be reached via local heavy duty roads with connections to U. S. Highway 90, thence to Interstate Highway 10 via Louisiana Highway 47. No additional access roads or improvements to existing roads are anticipated for construction of this project.

SOURCES OF CONSTRUCTION MATERIALS

41. Sources of construction materials. The work involved consists exclusively of channel excavation and disposal of excavated materials. No work requiring the use of cement, concrete, aggregate, stone, steel, or other construction materials is involved.

REAL ESTATE REQUIREMENTS

42. General. All rights-of-way and construction easements required for the construction of this project will be acquired by the Dock Board and furnished without cost to the United States. Rights-of-way requirements and easement limits are shown on plates 2, 3, and 4. The United States will be held free from damages due to any erosion of the bed, bottom, or banks beyond the limits of the rights-of-way furnished. Local interests are required to assume the cost of relocation assistance to persons and businesses displaced by such acquisition pursuant to the requirements of Public Law 91-646.

RELOCATIONS

43. General. At approximate channel centerline station 140+00, a cluster of three nitrogen pipelines crosses the canal from the Citrus Back Levee baseline station 626+69. These lines are 10 inches, 2 1/2 inches, and 1 inch in size. These lines have been out of service since July 1970. Air Products and Chemicals Company, owner of the lines, has been contacted and has expressed its desire that the lines be removed. Accordingly, the pipelines will be removed prior to or during construction with the cost of this removal to be wholly borne by local interests.

COORDINATION WITH OTHER AGENCIES

44. General. As previously mentioned, the Dock Board is the agency appointed to provide local coordination in behalf of the State of Louisiana. This agency has functioned to coordinate the needs, desires, and interests of the State and the Corps of Engineers. The plan presented herein is acceptable to the Dock Board.

45. U. S. Department of the Interior, Fish and Wildlife Service. Extensive coordination with the U. S. Fish and Wildlife Service was accomplished during both preauthorization and post-authorization studies. By letter dated 18 August 1972, the Regional Director, U. S. Fish and Wildlife Service, Atlanta, Georgia, was informed of the current viable alternatives for the proposed enlargement and was requested to provide comments on the plans. By letter dated 24 October 1972, the Acting Regional Director states, "Plan VII [the recommended plan] provides for using an existing spoil area, now being used for maintenance of the MR-GO, for placement of construction spoil from enlargement of the Michoud Canal. An additional 2,000 feet of marsh area lying between Bayous Bienvenue and Villere and adjacent to the MR-GO spoil area would be required for maintenance spoil. Therefore, we recommend the adoption of plan VII as being the most acceptable from a fish and wildlife standpoint." Any significant modifications to the current plan will be forwarded to the Regional Director for further review and comment. Copies of the above letter and the responses of the Acting Regional Director are included in appendix C.

46. U. S. Department of the Interior, Federal Water Pollution Control Administration (now Environmental Protection Agency).

a. Review and recommendations. By letter dated 3 September 1970 the Regional Director, Federal Water Pollution Control Administration was informed of the plan to enlarge the Michoud Canal and was requested to furnish views and comments on the project. In his letter of response dated 6 October 1970, the Director recommended that construction specifications require the contractor to:

(1) Take precautions in the handling and storage of hazardous materials to prevent spillages that would result in degradation of the water quality.

(2) Provide and operate sanitation facilities that will adequately treat domestic wastes to conform with Federal, State, and local regulations.

b. Project incorporation of recommendations. Provisions relative to water quality degradation during construction, control of accidental spillages, and maintenance of adequate sanitary

facilities by construction contractors will be incorporated into the construction plans and specifications.

47. Louisiana Wild Life and Fisheries Commission. By letter dated 2 March 1972, the Director, Louisiana Wild Life and Fisheries Commission, was informed of the plan to enlarge Michoud Canal, and was requested to furnish views and comments on the project. By letter dated 20 April 1972 he advised that his agency had no objection to the construction as long as no spoil was deposited in the natural marsh lying just south of the GIWW and east of the MR-GO. The recommended plan does not include this marsh area for spoil and is accordingly acceptable to that agency. Copies of the above letters are included in appendix C.

48. Board of Commissioners of the Port of New Orleans (Dock Board). By letter dated 17 January 1973, the Executive Director of the Dock Board was informed of the recommended plan of construction and was requested to provide his views and comments thereon. In his letter dated 24 January 1973, the Executive Director states, "Please be informed that this Board concurs with your recommendation of Plan VII as being a viable plan of action and one which is acceptable to fish and wildlife interests. We understand that with this concurrence you will be enabled to finalize your environmental statement for this project, as well as to complete the general design memorandum recommending a suitable plan of action." Copies of these letters are included in appendix C.

49. Public coordination. A public meeting concerning the proposed construction was held by the New Orleans District Engineer in New Orleans, La., on 16 December 1964. Notice of the meeting was given wide distribution among Federal, State, and local agencies, and interested groups and individuals. Those attending the meeting represented Federal, State, and city agencies and businesses, industries, and civic groups. There was no opposition to any of the proposed improvements. Since project authorization, numerous meetings have been held to discuss the project. Such meetings have been held before state, regional, and local organizations, and have served generally to inform the public of the proposed works and to coordinate various aspects of the project. The project has also been discussed in the press and by other communication media, as well as by organizational and individual correspondence.

ENVIRONMENTAL ANALYSIS

50. Environmental quality.

a. General. The engineering treatment required for preserving and maintaining the environmental quality of the project has been considered during preparation of this memorandum. As indicated previously, extensive coordination has been accomplished

with the appropriate agencies relative to effects of the project on fish and wildlife resources and water quality control during and subsequent to construction.

b. Enhancement. Construction of the channel enlargement covered herein will modify the existing terrain only to the extent that two tracts of land not previously used for the disposal of excavated spoil will be used for that purpose and further that two other tracts previously used for spoil disposal will be reused. The actual channel enlargement will be confined almost entirely within the existing bank lines and, accordingly, will not result in any appreciable physical land changes. In consideration of the foregoing, beautification measures will not be applied to this work. However, the construction contractor will be required to implement procedures which will prohibit environmental degradation to the greatest possible extent.

c. Water quality control.

(1) General standards and criteria. Standards cited in the report "Water Quality Criteria and Plan for Implementation, State of Louisiana," have been approved by the EPA (Environmental Protection Agency) except that, for those streams and water in which a minimum of 50 percent saturation of dissolved oxygen is specified (as in the coastal waters), the EPA has propsed 4 milligrams per liter (mg/l) as a minimum standard. General water quality criteria require that no wastes after discharge into coastal waters shall create conditions which will adversely affect public health or the use of the waters for propagation of aquatic life, recreation, navigation, or other legitimate uses not prohibited by high mineral content.

(2) Specific criteria. The specific water quality criteria are:

(a) pH--within the ranges of 6.5-9.5

(b) Dissolved oxygen--not less than 50 percent of saturation at the existing water temperature (EPA minimum 4 mg/l)

(c) Temperature--not to be raised more than 3° C.

(d) Oils--there shall be no slicks of free or floating oil present in sufficient quantities to interfere with the designated uses, nor shall emulsified oils be present in sufficient quantities to interfere with the designated uses.

(e) Toxic materials--none present in quantities that alone or in combination will be toxic to animal or plant life.

(f) Foaming and frothing materials--none of a persistent nature.

(3) Effect on water quality during construction. Channel materials are expected to be excavated using a cutter head hydraulic dredge. The soil-water mixture will be pumped to spoil areas for retention where the solids will settle out. Clarified water will be released from the spoil areas through waste-water control structures (adjustable weirs). Discharges from spoil area no. 1 will pass into Bayou Bienvenue; from spoil area no. 7 into an adjacent drainage canal and then into Bayou Bienvenue; and from spoil area no. 6 into an interior drainage canal, thence through an existing pumping plant and into the GIWW. At the points where the liquids are released into surface waters, adverse effects on quality are expected to be negligible because of the retention and clarification process. A small amount of increased turbidity normally occurs in the immediate vicinity of the dredge resulting from action by the cutter head. The extent of this turbidity will depend on the particular dredge, its operation, and the material being excavated. Based on previous dredging experience in the GIWW and MR-GO, visible water surface "clouding" may vary from none at "slack water" to about 1,000 feet from the dredge at normal maximum tide velocities. This turbidity is expected to dissipate in 24 to 48 hours after dredging is stopped. These effects on water quality are expected to be of limited scope and of short duration. The specifications governing the construction contractor will assure that the general criteria of water quality standards will not be exceeded and that the construction activities will not produce any results not in compliance with the specific criteria.

d. Fish and wildlife values.

(1) The placement of dredged material on 380 acres of estuarine marsh will modify both the wildlife habitat and the basic estuarine productivity. These modifications will be reflected in losses to the fish and wildlife resource.

(2) The Louisiana Wild Life and Fisheries Commission (letter dated 20 April 1972, appendix C) has indicated that estuarine marsh in the project area is capable of producing marketable fish and shellfish at the rate of 46 pounds per acre per year. Studies made by the Corps of Engineers in coastal Louisiana suggest that this is a conservative value. The level of commercial fishing pressure on the Louisiana coast is such that it is reasonable to assume that any reduction in productivity will be reflected

in a corresponding reduction in harvest. The average value, per pound, of marketable species taken in the area of project influence, is about $0.06. The modification of 380 acres of estuarine marsh through filling with dredged material will then engender a loss in commercial fishery of $1,045 per year on the average ($2.75 per acre). The 380-acre parcel involved is located within the area to be protected by the Chalmette Area Plan of the Lake Pontchartrain, La. and Vicinity, hurricane protection project now under construction. A substantial portion of the entire protected area will likely be converted to urban-type uses in the future. The parcel in question is very favorably situated within the protected area insofar as potential for development is concerned. It is estimated that its future existence as a viable estuarine marsh would, in the absence of the Michoud Canal project, be limited to 25 years. Thus the loss chargeable to the project over its 50-year life will be limited to the average annual equivalent of the aggregate loss over the first 25 years of project life, or $716 per year ($2.75 x 380 x 16.93786 x 0.04073 = $716).

(3) The reduction in productivity in the fisheries resource has implications in the area of recreation. Reduced production of sports species will be reflected in reduced sports catches. However, since the size of the catch is only part of the attraction, and in view of the small percentage reduction that modification of one small part of the total available estuarine marsh would produce, it is unlikely that any measurable reduction in the recreation potential of the area would be engendered by the project.

(4) The 380 acres of marsh which would be modified supports a variety of commercial wildlife, including, importantly, nutria and muskrat. These animals are harvested for fur and the carcasses are processed into animal feeds. The average annual production of the entire coastal area, on a per-acre basis, has a value of about $2 per acre per year. The modification of the 380 acres of marsh would destroy its productivity insofar as this resource is concerned. Applying the methodology outlined for determining the loss in commercial fisheries, the loss in the commercial wildlife resource attributable to the project would be $523 per year ($2 x 380 x 16.93786 x 0.04073 = $523).

(5) The estuarine marsh supports numerous species in the sport wildlife category. Based on the studies of coastal Louisiana, the marsh area is capable of supporting recreation relating to sport wildlife at a rate of seven-tenths of a man-day per acre per year. The estimated average unit value of this recreational opportunity is $3 per man-day. This recreational opportunity would be lost as a result of the project. The dollar loss chargeable to the project would be $648 ($2.10 x 380 x 19.93786 x 0.04073 = $648 per year).

(6) The aggregate average annual loss, in the fish and wildlife resource, as developed above, amounts to $1,887 per year.

51. Environmental statement. The draft environmental statement for the Michoud Canal project has been prepared and has been widely circulated to the public for review and comment. Such comments have been incorporated into a final statement which was forwarded to LMVD on 2 July 1973 for ultimate transmission to the President, Council on Environmental Quality. This statement describes the effects of the proposed construction essentially as follows:

a. Environmental impact of the proposed plan. The authorized deepwater navigation channel will provide for direct ship access to existing and future industries along Michoud Canal, stimulate industrial development, and reduce the costs of handling cargoes. During construction and maintenance dredging, a small amount of temporary turbidity will be induced into the water column. Placement of maintenance dredging material on 380 acres of marshland will modify wildlife habitat, cause a loss of a proportionate amount of wildlife and will result in unbalanced food chains in the surrounding waters.

b. Adverse environmental effects which cannot be avoided. Temporary turbidity will cause an unavoidable adverse impact on the quality of the water during construction and maintenance. The project will result in the modification of 380 acres of natural marshland that is part of a large sparsely developed area inclosed within protection levees, its wildlife habitat, and the associated wildlife. Reduction of detrital releases from these marshes will cause a proportionate reduction in organisms which feed on detritus. Deepening the existing channel will destroy or displace the present benthic inhabitants. The productivity of the channel area for both fish and shellfish will be decreased.

c. Alternatives to the proposed action. Nine alternative plans for disposal of dredged material were considered during project planning. Appendix B of this memorandum discusses each of the alternatives fully to include environmental effects. An alternate channel alinement was also considered and is discussed in appendix B. The "no-action" alternative was also considered. The course of inaction would have a serious adverse effect on the existing potential industrial development of the project area. Based on an analysis of benefits and cost, an inaction alternative would have a net economic cost of approximately $400,100 annually in foregone benefits.

d. Relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity. The minor but permanent change in the geographic makeup of the channels in the area will not change the short-term uses.

The temporary obstruction of traffic during construction is not expected to significantly alter the short-term uses. The plan will substantially enhance the long-term productivity in terms of industry, job opportunities, transportation, and other uses of land resources in the area.

e. Irreversible or irretrievable commitment of resources which would be involved in the proposed action should it be implemented. The proposed plan involves the enlargement of existing channels and maintenance of the same; therefore, the nature of the resource is not being changed; only additional value is being added through enlargement to proper dimensions. Irretrievable commitments of a minor nature will be experienced by the water quality and aquatic life in the immediate area due to the dredging and associated activities. These effects are temporary and local and are too minor for quantitative evaluation. The construction spoil-disposal areas are designated for future industrial use and require filling before industrial construction can commence. The change in the 380 acres of marsh used for maintenance spoil disposal, along with its related wildlife and wildlife habitat, is irreversible and irretrievable. Other resources that are irreversible and irretrievable are the manpower and costs required to build and maintain the project.

52. Historical and cultural environment. There are no known sites, structures, or objects of historical, architectural, or archeological significance in this project area which will be altered or destroyed by the proposed work.

PROJECT FORMULATION

53. Existing and prospective commerce. The existing channel of the Gulf Intracoastal Waterway between the Mississippi River-Gulf Outlet and the Michoud Canal has a controlling depth of about 12 feet over a bottom width of 150 feet. The Michoud Canal has a controlling depth of about 14 feet over a bottom width of 200 feet. These depths are sufficient for barge traffic, but are not adequate for the seagoing vessels necessary for the handling of import and export tonnage. Two existing firms on the Michoud Canal would derive immediate benefits from the proposed improvement. One of these industries is a firm importing foreign automobiles and the other is a manufacturer of fertilizers that exports to foreign ports. Other existing industries on the Michoud Canal are serviced by barge transportation which is adequate for their current needs and would not be immediately benefited by the proposed ship channel. Space is available for additional industrial development and local interests anticipate spending $5 million to develop public terminal facilities. This planned facility and the potential industrial development of the area will substantially enhance the long-term productivity in terms of industry, job opportunities, transportation, and other uses of land resources in the area.

a. Existing commerce. Existing commerce on the Gulf Intracoastal Waterway over the route of the proposed improvement is limited to shallow-draft commerce since the existing channels are insufficient to accommodate oceangoing vessels. The annual tonnage of existing traffic on the Gulf Intracoastal Waterway east of the Mississippi River-Gulf Outlet between 1959 and 1971 is shown below:

Year	Total tons
1959	6,934,560
1960	7,342,042
1961	7,555,653
1962	7,582,584
1963	8,154,078
1964	8,928,782
1965	9,713,604
1966	11,768,937
1967	13,484,456
1968	14,176,465
1969	13,712,394
1970	13,805,257
1971	16,390,218

The Michoud Canal contributed the following tonnages to the Gulf Intracoastal Waterway traffic between 1959 and 1971:

Year	Tons
1959	22,626
1960	14,040
1961	684
1962	12,531
1963	261,326
1964	571,511
1965	*
1966	811,994
1967	663,699
1968	754,262
1969	809,578
1970	877,782
1971	864,430

*Data not available.

Tonnages to and from Michoud Canal are included in the tonnage previously given for the Gulf Intracoastal Waterway.

b. Prospective commerce. Commerce handled on the Gulf Intracoastal Waterway and on the Michoud Canal has been transported in shallow-draft equipment. However, with improvement of the waterways to provide a 36- by 250-foot channel, import and export commerce which requires transportation in seagoing vessels will be handled. This commerce will consist of imported automobiles and exported fertilizers. For purpose of this analysis, the proposed channel enlargement to 36 by 250 feet is estimated to be in operation for 1975, and prospective commerce for that year as well as the years 2000 and 2025 are shown as follows:

Projected Commerce

Commodities	1975	2000[1]	2025[1]
Automobiles	41,200 units	73,000 units	73,000 units
Anhydrous ammonia	45,000 tons	145,000 tons	300,000 tons
Other fertilizer	96,400 tons	186,000 tons	323,600 tons

[1]Auto. units will remain constant after 1986, the year in which the capacity of the facility will be reached.

Large additional sites fronting the Michoud Canal are available for industrial development. Because of the close proximity to NASA and existing shallow- and deep-draft channels, further development is anticipated. The types of industry, whether to be serviced by shallow- or deep-draft vessels, have not been determined at this time and no tonnage has been estimated for future industrial developments.

54. Vessel traffic.

a. Present traffic. The trips and drafts of vessels using the Gulf Intracoastal Waterway over the route of the proposed improvement during 1971 are shown below:

Trips and Drafts of Vessels

Draft (feet)	Self-propelled vessels	Nonself-propelled vessels	Total
12	7	32	39
11	129	83	212
10	547	668	1,215
9	1,492	6,569	8,061
8	2,220	2,923	5,143
7	2,181	1,209	3,390
6 & less	1,521	9,779	11,300
Total	8,097	21,263	29,360

Data are not available as to trips and drafts of vessels now using Michoud Canal. However, these trips and drafts are included in the figures for the Gulf Intracoastal Waterway.

b. Future traffic. The seagoing vessels that will be required in the future to handle the prospective tonnage over the proposed improvement are shown below:

Future Vessel Requirements

Year	Draft (feet)	No. of trips
1975	27	15
	31	24
2000	27	34
	31	55
2025	27	62
	31	55

55. Difficulties attending navigation. The existing channel of the Gulf Intracoastal Waterway between the Mississippi River-Gulf Outlet and the Michoud Canal has a controlling depth of 12 feet over a bottom width of 150 feet. The Michoud Canal has a controlling depth of about 14 feet over a bottom width of 200 feet. These depths are not adequate for the seagoing vessels necessary for the handling of import and export tonnage. Oceangoing vessels needed for handling the cargo have loaded drafts ranging from 27 to 31 feet, beams of 64 to 70 feet, and lengths from 515 to 520 feet, thus requiring the 36- by 250-foot channel as proposed.

56. Plan of improvement. The most suitable plan of improvement for a ship channel to meet the needs of the study area and the desires of local interests is the construction of a 36- by 250-foot ship channel from the Mississippi River-Gulf Outlet along the present alinement of the Gulf Intracoastal Waterway and the Michoud Canal to and including a turning basin at the head of the Michoud Canal. The enlargement of the Gulf Intracoastal Waterway will be confined essentially within existing bank lines. The enlargement of the Michoud Canal will be generally centered in the existing channel thus leaving room on each side of the channel for construction of wharves and the tieing up and servicing of ships outside the project channel. No dredging will be accomplished within 100 feet of any pierhead, wharf, or other structure. A 2-foot overdepth for advanced maintenance and an additional allowance of 2 feet to cover the inaccuracies in dredging have been included in the cost estimate.

57. Access to port facility.

a. General. In order for the project to operate effectively as a deep-draft port facility, good roadway, railway, and barge access are necessary. In this respect, the Michoud Canal has excellent existing facilities to which additions can be readily made. The primary modes of access are described below.

b. Vehicular access. Immediate road access is available on the east side of the canal via Industrial Parkway and Intracoastal Drive, heavy duty two-lane roadways. Access to the northern end will be provided into the property development (public facilities) of the Board of Commissioners of the Port of New Orleans by connecting to Intracoastal Drive. Part of the west side of the Michoud Canal and the north side of the GIWW can be reached through Federal property operated by the National Aeronautics and Space Administration which, for security purposes, is closed to the general public. The northwestern part of the canal is adjacent to Old Gentilly Road, a four-lane highway. All of these immediate access roads connect to U. S. Highway 90, thence to Interstate Highway 10 via Louisiana Highway 47.

c. Rail access. The Louisville and Nashville Railroad main line passes within approximately 1,000 feet of the turning basin. Spur lines on both sides of the canal are presently in use and these are plans to extend a new spur into the future public facilities adjacent to the turning basin.

d. Marine access. The navigation area served by the project includes virtually all of the area served by the Port of New Orleans. The extensive network of inland waterways connected to the Mississippi River, the GIWW, the MR-GO, and many other public and private channels are all accessible by shallow-draft commerce to and from the project area. The proximity of Michoud Canal to the GIWW is one of the outstanding advantages of the project; i.e., excellent interconnection with inland barge traffic.

58. Required aids to navigation. The United States Coast Guard, Eighth Coast Guard District, has been consulted in regard to costs for aids to navigation for the plan of improvement. The estimated cost of installation of new aids is $9,000. The estimated annual maintenance cost is $1,500.

ECONOMIC ANALYSIS

59. Estimate of first cost.

a. General. Based on projected July 1973 price levels, the estimated first cost of construction of the Michoud Canal project is $4,739,000. This estimate consists of $1,035,000 for

lands and improvements, $25,000 for relocations, $3,222,000 for channels and canals, $203,000 for engineering and design, $245,000 for supervision and administration, and $9,000 for U. S. Coast Guard aids to navigation. A summary of first costs is presented below. A detailed estimate of first cost is presented in table 1.

Summary of Estimated First Costs
(Projected July 1973 price levels)

Cost acct. No.	Item	Federal $	Non-Federal $	Total $
09	Channels and canals	3,222,000	0	3,222,000
30	Engineering & design	203,000[1]	0	203,000[1]
31	Supervision & administration	245,000	0	245,000
01	Lands & improvements	0	1,035,000	1,035,000
02	Relocations	0	25,000	25,000
	Aids to navigation	9,000	0	9,000
	Total	3,679,000	1,060,000	4,739,000

[1]Includes $3,000 for hired labor real estate activities.

b. Comparison of estimates. Table 2 shows a comparison of the project document, PB-3, and general design memorandum estimates. Reasons for the differences between these estimates are cited below:

(1) GDM versus PB-3. The current estimate of $4,739,000 for the Michoud Canal project represents an increase of $2,556,000 when compared to the latest PB-3, effective 1 July 1972. The PB-3 estimate is based on the estimate contained in Senate Document No. 97, 90th Congress, 2d Session, and escalated to July 1972 price levels. Reasons for the difference between the GDM and PB-3 estimates follow:

(a) Channels and canals. The increase of $1,320,000 includes $196,000 for price level increase; $557,000 due to adopted spoil areas causing greater pumping distances ($675,000) offset by a reduction in the quantity of required channel excavation ($118,000); $285,000 due to an additional quantity of material required for dikes associated with the adopted spoil-disposal plan; $25,000 due to inclusion of environmental considerations during construction; and $257,000 due to an increase in contingency percentage from 15 to 25.

TABLE 1
MISSISSIPPI RIVER-GULF OUTLET
MICHOUD CANAL

ESTIMATE OF FIRST COST
(Projected July 1973 price levels)

Cost acct. No.	Item	Estimated quantity	Unit	Unit price $	Estimated amount $
	FEDERAL				
	CONSTRUCTION				
09	Channels and canals				
	Channels				
	Dredging (deposit area 1)	2,500,000	c.y.	0.30	750,000
	Dredging (deposit area 6)	1,000,000	c.y.	0.30	300,000
	Dredging (deposit area 7)	1,500,000	c.y.	0.81	1,215,000
	Spoil areas				
	Dike construction	285,000	c.y.	1.00	285,000
	Environmental protection	1	job	L.S.	25,000
	Subtotal				2,575,000
	Contingencies 25%±				647,000
	Subtotal channels and canals				3,222,000
30	Engineering & design 6.2%± (based on estimate of actual E&D required)				203,000[1]
31	Supervision & administration 7.6%± (based on estimate of actual S&A required)				245,000
	TOTAL FEDERAL CONSTRUCTION				3,670,000
	AIDS TO NAVIGATION				
	U. S. Coast Guard	1	job	L.S.	9,000
	TOTAL FEDERAL FIRST COST				3,679,000

[1]Includes $3,000 for hired labor real estate activities.

TABLE 1 (cont'd)

Cost acct. No.	Item	Estimated quantity	Unit	Unit price $	Estimated amount $
	NON-FEDERAL				
	LANDS AND IMPROVEMENTS				
01	Lands				
	Permanent R/W required				
	R/W for turning basin	6.8	acre	13,800	93,840
	R/W for channel	5.5	acre	550	3,025
	Maintenance spoil area	380	acre	550	209,000
	Dredge pipeline R/W	3.6	acre	550	1,980
	Construction easements				
	Spoil area 1	460	acre	414	190,440
	Spoil area 6	174	acre	1,518	264,132
	Spoil area 7	400	acre	220	88,000
	Dredge pipeline easement	2.0	acre	1,655	3,310
	Subtotal				853,727
	Contingencies 20%±				176,273
	Subtotal				1,030,000
	Acquisition costs by others (5 tracts)				5,000
	Resettlements (P.L. 91-646)				None
	TOTAL LANDS AND IMPROVEMENTS				1,035,000
	RELOCATIONS				
02	Relocations				
	Remove abandoned nitrogen pipeline cluster	1	job	L.S.	20,000
	Contingencies 25%±				5,000
	TOTAL RELOCATIONS				25,000
	TOTAL NON-FEDERAL FIRST COST				1,060,000
	TOTAL PROJECT COST				4,739,000

TABLE 2
COMPARISON OF ESTIMATES

Feature	Project Document (July 67 prices) $	PB-3 (effective July 72) $	GDM #1 (projected July 73 prices) $	Difference GDM #1 and PB-3 $	Difference GDM #1 and Proj. Doc. $
FEDERAL					
09 Channels and canals	1,171,000	1,902,000	3,222,000	+1,320,000	+2,051,000
30 Engineering and design	59,000	98,000	203,000[1]	+105,000	+144,000
31 Supervision and administration	70,000	100,000	245,000	+145,000	+175,000
Subtotal, Corps of Engineers	1,300,000	2,100,000	3,670,000	+1,570,000	+2,370,000
Aids to navigation(USCG)	20,000	9,000	9,000	0	-11,000
Subtotal, Federal	1,320,000	2,109,000	3,679,000	+1,570,000	+2,359,000
NON-FEDERAL					
01 Lands and improvements	43,000	74,000	1,035,000	+961,000	+992,000
02 Relocations	0	0	25,000	+25,000	+25,000
Subtotal, non-Federal	43,000	74,000	1,060,000	+986,000	+1,017,000
TOTAL PROJECT COST	1,363,000	2,183,000	4,739,000	+2,556,000	+3,376,000

[1] Includes $3,000 for hired labor real estate activities.

(b) Engineering and design. The net increase of $105,000 results from additional cost in design and coordination activities associated with selection of the finally recommended spoil-disposal plan.

(c) Supervision and administration. The increase of $145,000 resulted from recomputing the supervision and administration costs based on an analysis of actual work required.

(d) Aids to navigation (U.S. Coast Guard). There is no difference between the GDM and PB-3 estimates.

(e) Lands and improvements. The net increase of $961,000 is due to differences in the project document and GDM spoil-disposal plans. The GDM spoil-disposal plan varies considerably from the project document plan with respect to spoil-disposal area locations and sizes and thus precludes a direct comparison.

(f) Relocations. The net increase of $25,000 ($20,000 plus 25 percent contingency) results from inclusion of the pipeline cluster removal. Planning studies subsequent to preparation of the project document revealed the presence of the abandoned pipeline cluster.

(2) GDM versus project document. The estimated cost of $4,739,000 for the proposed Michoud Canal project represents a net increase of $3,376,000 over the project document estimate. Reasons for the difference between the design memorandum and project document estimates follow:

(a) Channels and canals. The net increase of $2,051,000 is due essentially to modification of the spoil-disposal plan presented in the project document. The project document contemplated using excavated materials for levee fill. Subsequent investigations revealed that the excavated materials were not suitable for levee fills and accordingly would have to be wasted. This required larger disposal areas and more diking which increased the cost. Additionally, the areas designated for disposal in the project document are no longer available for use due to industrialization of the area. This resulted in the designation of areas more distant than those originally intended for use thus increasing pumping costs. These reasons preclude a direct comparison of charges. Moreover, the contingency allowance was increased from 15 percent to 25 percent thus increasing costs ($257,000) as well as price level increases from July 1967 to July 1973.

(b) Engineering and design. The net increase of $144,000 results from analyzing the actual E&D costs associated with the recommended plan rather than by applying a fixed percentage

of construction cost of the project document plan. As described in subparagraph (a) above, the variation between the GDM and project document plans precludes more direct comparisons.

(c) Supervision and administration. The net increase of $175,000 results from analyzing the actual S&A costs associated with the GDM plan rather than by applying a fixed percentage of construction cost of the project document plan. As described above, the variation between the GDM and project document plan precludes more direct comparisons.

(d) Aids to navigation (U.S. Coast Guard). The net decrease of $11,000 is due to refinement of the estimate based on recent information furnished by the U. S. Coast Guard. The new estimate was based on actual needs for aids over the channel reach.

(e) Lands and damages. The net increase of $992,000 is due to differences in the project document and GDM spoil-disposal plans. As described above, the GDM spoil-disposal plan varies considerably from the project document plan with respect to spoil-disposal area locations and sizes and thus precludes a direct comparison.

(f) Relocations. Planning studies subsequent to preparation of the project document revealed the presence of the abandoned pipeline cluster. This relocation was not indicated or reported in the project document, hence the net increase of $25,000.

60. Estimate of annual charges. The estimated annual charges for the proposed 36- by 250-foot navigation channel and 36- by 800-by 800-foot turning basin, based on an interest rate of 3 1/4 percent, a 50-year project life, and projected July 1973 price levels are as follows:

Item	Estimate of Annual Charges		
	Federal	Non-Federal	
	$	$	
Total estimated first cost	3,679,000	1,060,000	
Interest at 3 1/4 percent	119,600	34,500	
Amortization 50 yrs. @ 3 1/4%	30,300	8,700	
Channel & turning basin maintenance	88,700	0	
Spoil dike maintenance	0	6,200	
Maintenance of navigational aids	1,500	0	
Subtotal	240,100	49,400	
Subtotal (Federal & non-Federal)		$289,500	
Aggregate annual loss in fish and wildlife resources		1,900 (rounded)	
TOTAL ANNUAL CHARGES		$291,400	

61. Estimate of benefits.

a. General. Two existing industries on Michoud Canal will derive immediate benefits from the project. One is an importer of foreign automobiles and the other is a manufacturer and exporter of fertilizer and industrial gases. Other industries on the canal are served adequately by shallow-draft equipment at present. However, several of these industries are considering possible deep-draft usage in the future. Undeveloped industrial sites exist along the canal and it is expected that deepwater access will attract other industrial users, however no benefits have been estimated for the prospective users. In addition to the above primary navigation benefits, economic development benefits which were not considered in the preauthorization analysis were found to be appropriate for inclusion at this time.

b. Automobile import.

(1) A study of the operations of the foreign car importer, International Auto Sales & Services, Inc., showed that during 1972 approximately 30,000 vehicles were imported through the Port of New Orleans. These vehicles are imported in shipload quantities and, due to the lack of adequate marshalling yards at existing wharves, additional handling and movement of the vehicles are necessary, adding considerable cost to the operations. It is estimated that this additional cost amounts to $4.62 per vehicle. The company owns 76 acres of land fronting Michoud Canal which it intends to use for unloading these automobiles if deepwater access is provided. This site now has buildings and other facilities which make it a suitable staging area. The only feature lacking is a wharf for mooring the ships and unloading the vehicles. The estimated annual cost for the required wharf facility is $48,200.

(2) The Michoud Canal site could handle a total of 6,000 vehicles at one time. At the present turnover period of 30 days (200 cars/day), maximum capacity of the facility is estimated at 73,000 vehicles annually. Projections indicate that this level of demand will be reached by 1988. This represents an annual equivalent figure of 63,800 vehicles. The facility will be fully utilized for the remainder of the project life.

(3) The average annual benefits from the importation of automobiles for the 50-year project life (1975-2025) are estimated at $246,600 ($294,800[2] gross benefits less $48,200 annual charges for the wharf).

[2] $4.62/car unit savings x 63,800 ann. eq. units = $294,800.

c. Fertilizer export.

(1) Air Products and Chemicals, Inc., owner of the fertilizer plant on the Michoud Canal, is currently exporting about 45,000 tons of anhydrous ammonia annually. Since ships cannot reach the plant, the New Orleans manufacturer has entered into a trade-off agreement under which a Texas City manufacturer located on a ship channel supplies the 45,000 tons of overseas shipments and the New Orleans producer furnishes a like amount to domestic customers of the Texas City firm at a discount of about $2.75/ton. However, it is estimated that the New Orleans firm could transfer the product from the facilities on Michoud Canal by barge to ships in the New Orleans harbor for about $2.14/ton. The product could be loaded on ships directly at the plant site at a cost of $0.48/ton, or at a saving of $1.66/ton. It is projected that annual exports of anhydrous ammonia by the firm will increase over the life of the project from the present 45,000 tons to 300,000 tons in year 2025, and would amount to an annual equivalent of 125,000 tons. The estimated average annual savings during the project life are $207,500.[3]

(2) With the project in place, the fertilizer producer contemplates the production of other chemical fertilizers such as phosphate, potash, and other nitrogen-based fertilizers in addition to the anhydrous ammonia. In estimating the quantities of additional fertilizers this plant would produce, it was assumed that production would begin in 1975, the same year in which the project will become active. It is estimated that in that year, an additional 96,400 tons of potash, phosphate, and other nitrogen fertilizers (excluding anhydrous ammonia) will be exported from the Michoud plant. By 2025, these exports will have increased to 323,600 tons. Annual equivalent tonnage amounts to 172,400 tons. Unit savings attributable to the project are estimated at $1.05/ton. The average annual benefits for these products are estimated at $181,000.[4]

d. Economic development benefits. The project is in Orleans Parish, within reasonable commuting distance to Jefferson, St. Bernard, and St. Tammany Parishes. These four parishes comprise the economic development area. They are qualified for financial assistance by the Economic Development Administration in compliance with the Public Works and Economic Development Act of 1965. A portion of the underemployed labor potential in the area can reasonably be expected to be employed on project construction. Labor

[3] $1.66/ton unit savings x 125,000 ann. eq. tons = $207,500
[4] $1.05/ton unit savings x 172,400 ann. eq. tons = $181,000

costs are projected to account for approximately 42 percent of construction expenditures. Approximately 82 percent of labor costs will represent payment to otherwise underemployed labor. When amortized for 50 years at an interest rate of 3.25 percent, the economic development benefit attributable to construction costs equals $45,200 ($3,222,000 x .42 x .82 x .04073). Benefits will accrue also from project operation and maintenance (O&M) expenditures. About 34.5 percent of all O&M charges will represent payment to labor resources which would be underemployed otherwise. These labor resources are anticipated to diminish on a straight-line basis to zero in 20 years. The figure was amortized over the 50-year project life at an interest rate of 3.25 percent ($94,900 x .34 ÷ 20 x 168.02012 x .04073) to derive an average annual benefit of $11,200. Total economic development benefits are $56,400.

e. Benefit summary. A summary of all benefits expected to accrue to the proposed enlargement is shown below:

Source of benefit	Amount
	$
Imported vehicles	246,600
Anhydrous ammonia	207,500
Other fertilizers	181,000
Economic development	56,400
Total average annual benefit	691,500

62. Maximization of benefits. The anticipated traffic (see paragraph 54) consists of 31-foot draft vessels for Volkswagens and 27-foot draft vessels for fertilizer. The proposed 36- by 250-foot channel is the minimum size channel that can safely accommodate the 31-foot draft vessels which will produce approximately 40 percent of the benefits. Larger channels would not produce any additional benefits since access is now limited by the 36-foot depth in the Mississippi River-Gulf Outlet. Therefore, the proposed 36- by 250-foot ship channel will produce the maximum excess of benefits over the annual costs.

63. Comparison of benefits and costs. The estimated average annual benefits from the proposed improvement are $691,500 and the estimated annual charges are $291,400. The resulting benefit-to-cost ratio is 2.38:1.

SCHEDULES FOR DESIGN AND CONSTRUCTION

64. Schedules for design and construction. The proposed channel enlargement will be accomplished under a single contract. The schedule for design and construction is tabulated below:

Contract	P&S Start	P&S Complete	Construction Advertise	Construction Award	Construction Complete	Estimated Construction Cost Including Contingencies
Enlargement of Michoud Canal and GIWW	1 May 73	15 Oct 73	1 Nov 73	20 Dec 73	Jan 75	$3,222,000

65. Funds required by fiscal year. To maintain the schedules for design and construction of the proposed Michoud Canal project, Federal funds will be required by fiscal year as follows:

Estimated cost through FY 73	$ 118,000
Funds required for FY 74	507,000
" " " FY 75	3,045,000
Total	$3,670,000

OPERATION AND MAINTENANCE

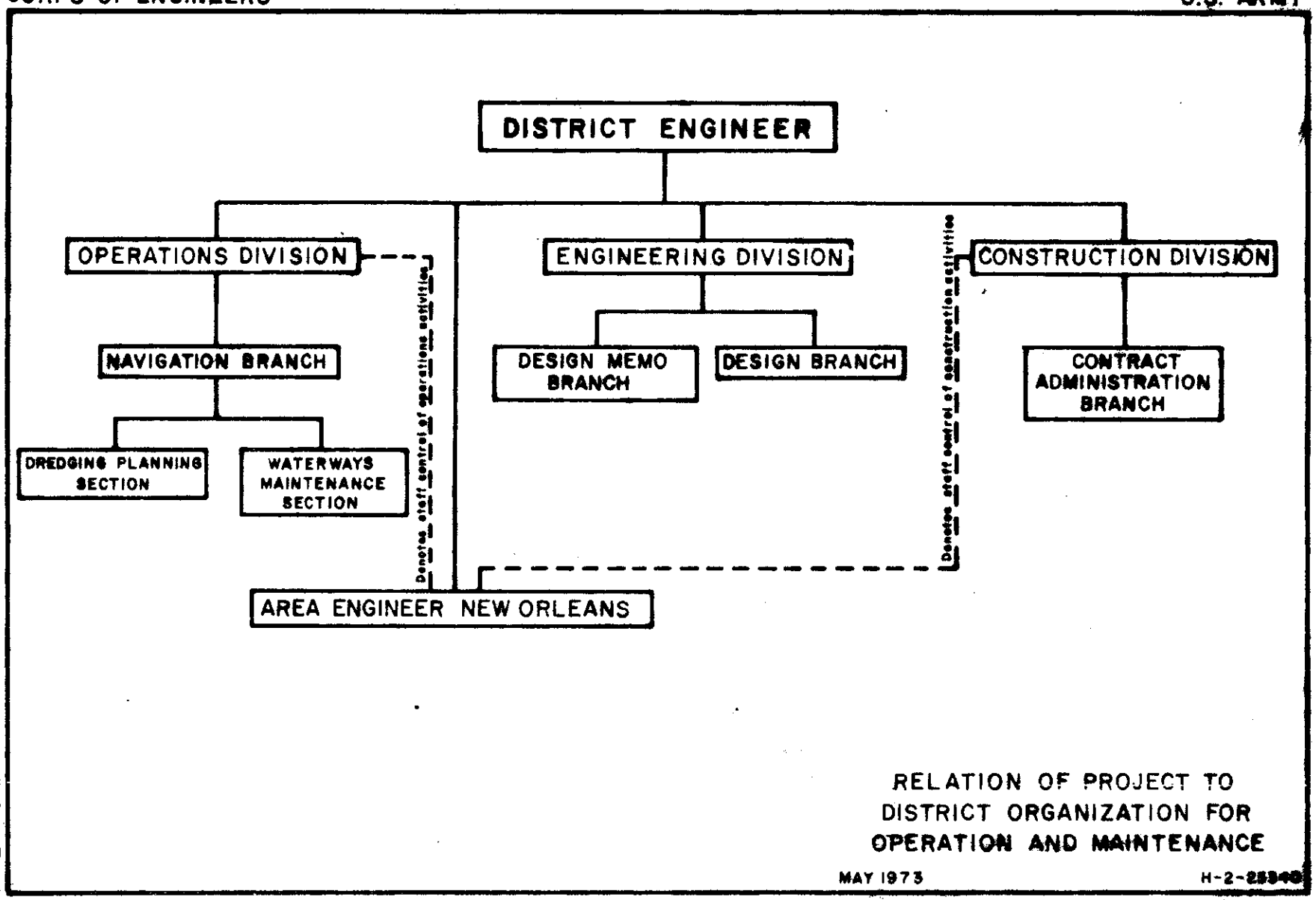
66. General. The Federal Government will be responsible for maintaining the channel and turning basin and aids to navigation over the 50-year project life. Local interests are responsible for maintaining the spoil retention dikes for the maintenance spoil-disposal area. The District organizational elements responsible for operating and maintaining the project are shown on figure 1.

a. Channel and turning basin maintenance. As discussed in paragraph 20 of this memorandum, it has been estimated that approximately 840,000 cubic yards of channel fill sediments will have to be removed at each maintenance operation, and that such maintenance will be required at 5, 10, 20, 30, and 40 years after initial construction. The annual charge for this maintenance is estimated to be $88,700.

b. Aids to navigation. The U. S. Coast Guard will be responsible for maintaining navigational aids related to this work. The annual cost for this maintenance is estimated to be $1,500.

c. Maintenance spoil area retention dikes. Local interests are required to provide and maintain the spoil dikes for the maintenance spoil-disposal area. The annual charge for this work is estimated to be $6,200. This cost is based on dike construction in year 5 estimated to cost $92,000 and a cost of $40,000 for rebuilding these dikes at each subsequent maintenance (years 10, 20, 30, and 40).

CORPS OF ENGINEERS U.S. ARMY



RELATION OF PROJECT TO
DISTRICT ORGANIZATION FOR
OPERATION AND MAINTENANCE

MAY 1973 H-2-25340

FIGURE 1

FIGURE 1

STATEMENT OF FINDINGS

67. Statement of findings.

a. The District Engineer, New Orleans District, has reviewed and evaluated, in light of the overall public interest, available data and information concerning the construction of a deepwater navigation channel by enlarging about 1 mile of the existing GIWW between the MR-GO and all of the existing Michoud Canal. He has considered the stated views of other agencies and the concerned public relative to the proposed action and practical alternatives. In addition to the no-action alternative, eight alternative plans for disposal of dredged material and an alternate channel alinement were considered.

b. The District Engineer analyzed the possible consequences of alternatives according to their environmental, social well-being, and economic effects, with respect to both regional and national development. He considers the proposed plan to be the most effective means of achieving the purposes of the authorized project--providing deepwater navigation access to existing and prospective industries along the Michoud Canal--with minimum adverse impact on the natural environment.

c. The following points were considered salient:

(1) The proposed action is consistent with existing plans for development of the Michoud Canal area, and will effectively meet the current and prospective needs for deep-draft access to such development.

(2) In the stated views of the Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, the most valuable marshlands in the area, in terms of overall estuarine productivity, are those which have not been previously modified by disposal of dredged material. The proposed action avoids any disposal of dredged material in such areas.

(3) The proposed action does involve disposal of dredged material on 380 acres of productive marsh which lie within the area protected by a federally authorized hurricane protection project now under construction. The adverse impacts associated therewith have been evaluated. They are reflected in the economic analyses made for the project and were explicitly considered in the planning process. There is no practicable means for avoiding or minimizing these impacts, and there is no practicable alternative plan for disposal of dredged material which would involve lesser total adverse impact.

(4) The no-action alternative would, in the District Engineer's judgment, impede the orderly development of the Michoud Canal area and impact unfavorably on the social well-being of the Metropolitan New Orleans area.

d. With respect to the proposed action, he finds as follows:

(1) It is based on a thorough analysis and evaluation of all considerations and known factors.

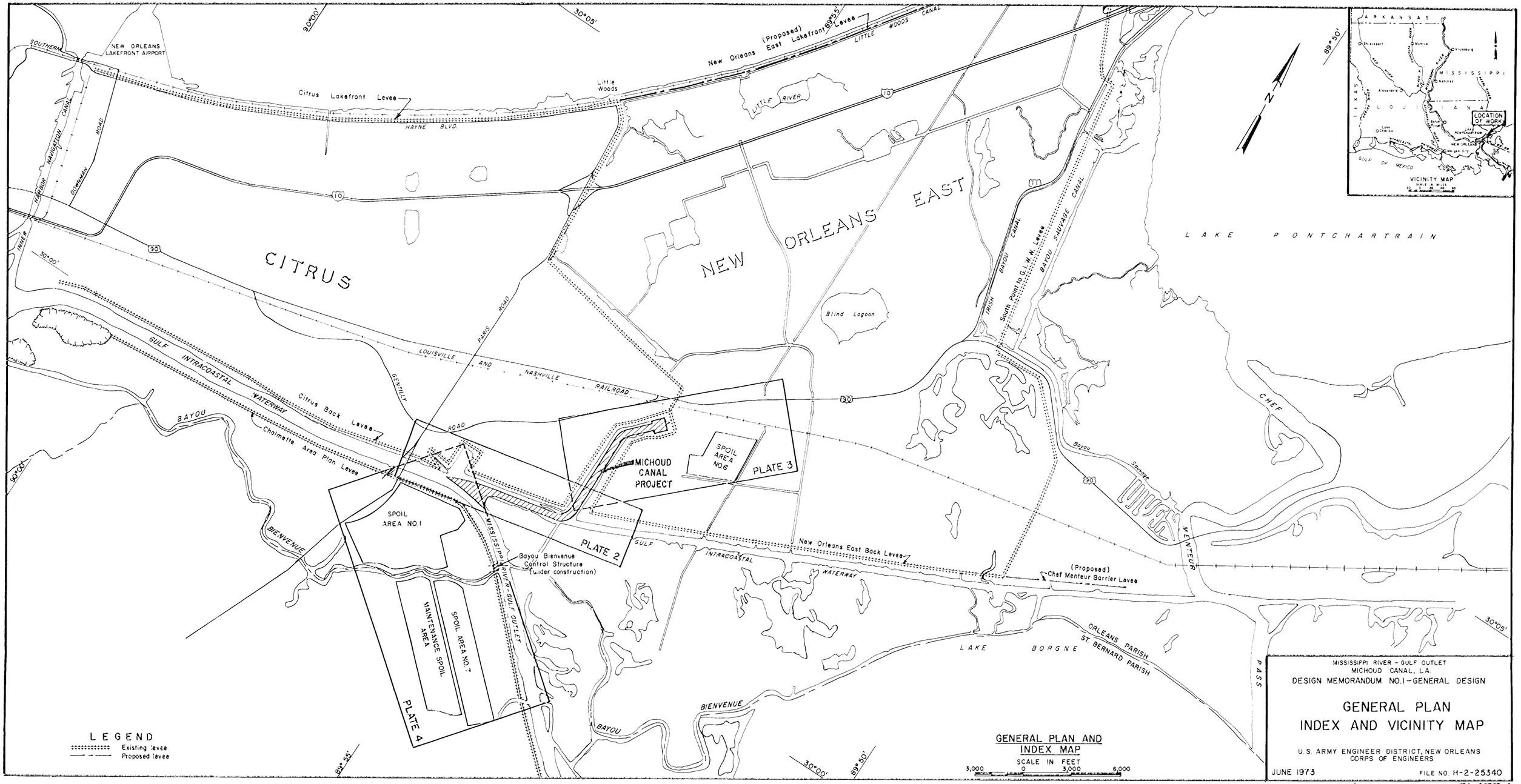
(2) It will effectively accomplish the purposes of the authorized project with minimum adverse impact on the natural environment.

(3) It is consonant with existing statutes and policy.

(4) The overall public interest will be best served by construction of the project.

RECOMMENDATIONS

68. Recommendations. Existing industries located on the Michoud Canal desire and need channels of adequate dimensions to permit oceangoing ships to reach their facilities. The MR-GO and IHNC currently provide adequate deep-draft access to the Mississippi River and the Gulf of Mexico. The proposed 36- by 250-foot channel construction will link Michoud Canal with these watercourses. The proposed construction should adequately serve the deep-draft needs of existing and prospective industries located along Michoud Canal. Immediate benefits will be derived by two existing industries located on the canal. Sites are available for additional industrial development which would derive benefits from the proposed construction and provide employment opportunities. Local interests anticipate developing public terminal facilities on the north end of the turning basin in conjunction with with their requirements of local cooperation. Evaluation of the environmental impact of the proposed action indicates that adverse effects will be minimal and temporary. Moreover, comprehensive analysis of the effects of the proposed construction indicates that the total benefits to be derived from such action far outweigh the associated adverse impacts. Study of all reasonable alternatives indicates that the plan presented herein is considered to be the best means of accomplishing project objectives and it is therefore recommended for approval.



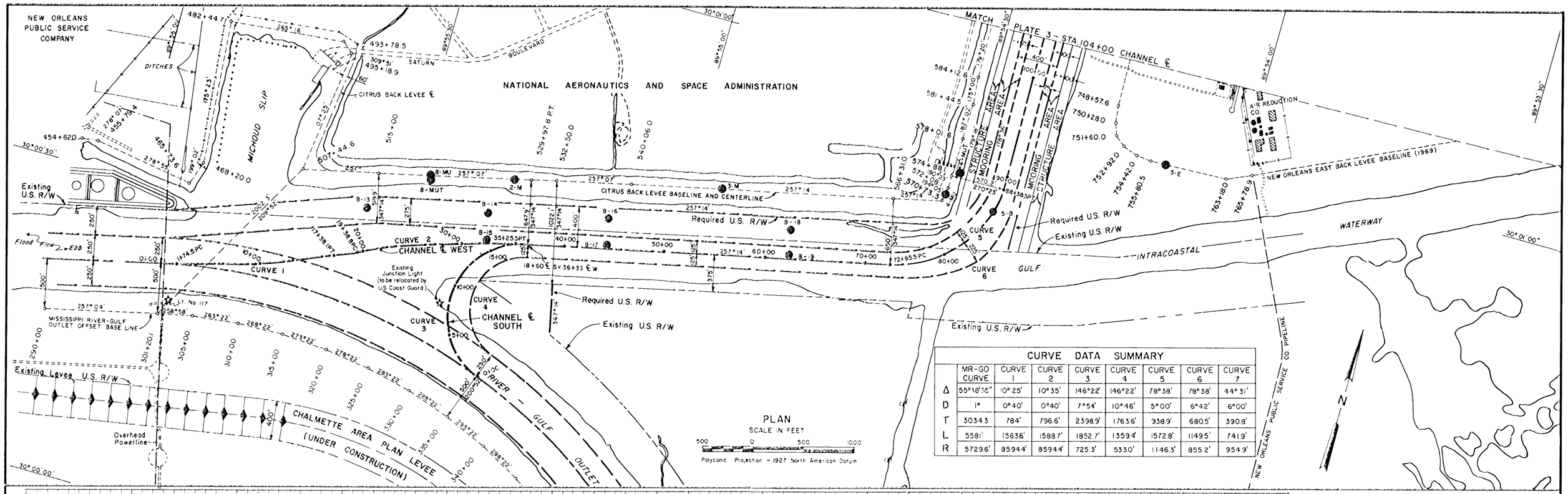
MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA.
DESIGN MEMORANDUM NO.1 - GENERAL DESIGN

GENERAL PLAN INDEX AND VICINITY MAP

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

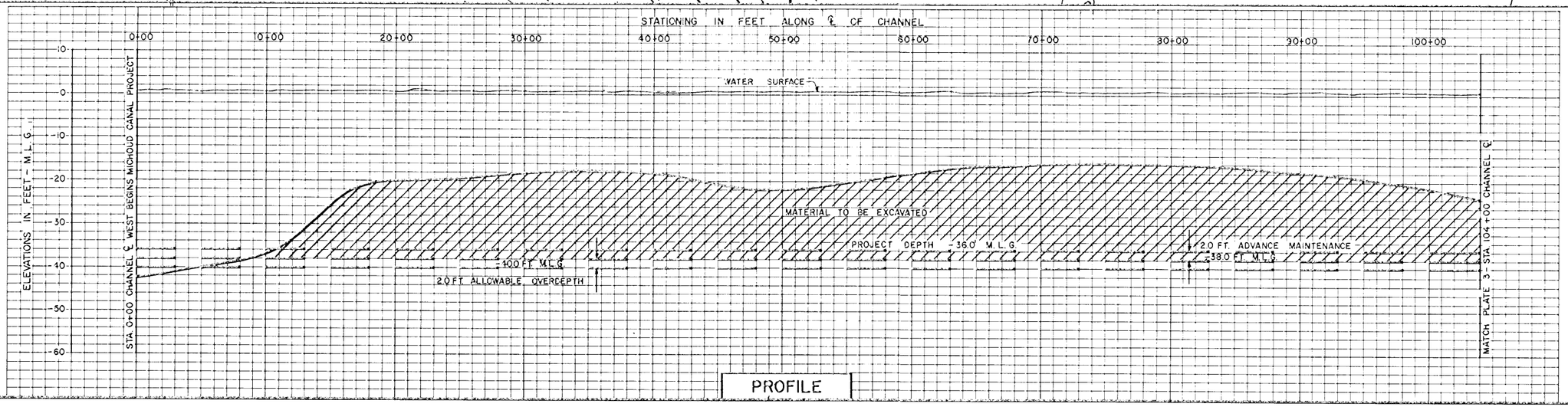
JUNE 1973 FILE NO. H-2-25340

PLATE 1



CURVE DATA SUMMARY

	MR-GO CURVE	CURVE 1	CURVE 2	CURVE 3	CURVE 4	CURVE 5	CURVE 6	CURVE 7
Δ	55°18'35"	10° 25'	10° 35'	146°22'	146°22'	78°38'	78°38'	44° 31'
D	1°	0°40'	0°40'	7°54'	10°46'	5°00'	6°42'	6°00'
T	3034.3	784'	796.6'	2398.9'	1763.6'	938.9'	680.5'	390.8'
L	5581'	1563.6'	1588.7'	1852.7'	1359.4'	1572.8'	1149.5'	741.9'
R	5729.6'	8594.4'	8594.4'	725.3'	533.0'	1146.3'	855.2'	954.9'



NOTES: Planimetry taken from October 1969 aerial photos.
Azimuths measured clockwise from south

LEGEND

I-B ● Soil boring location

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA.
DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

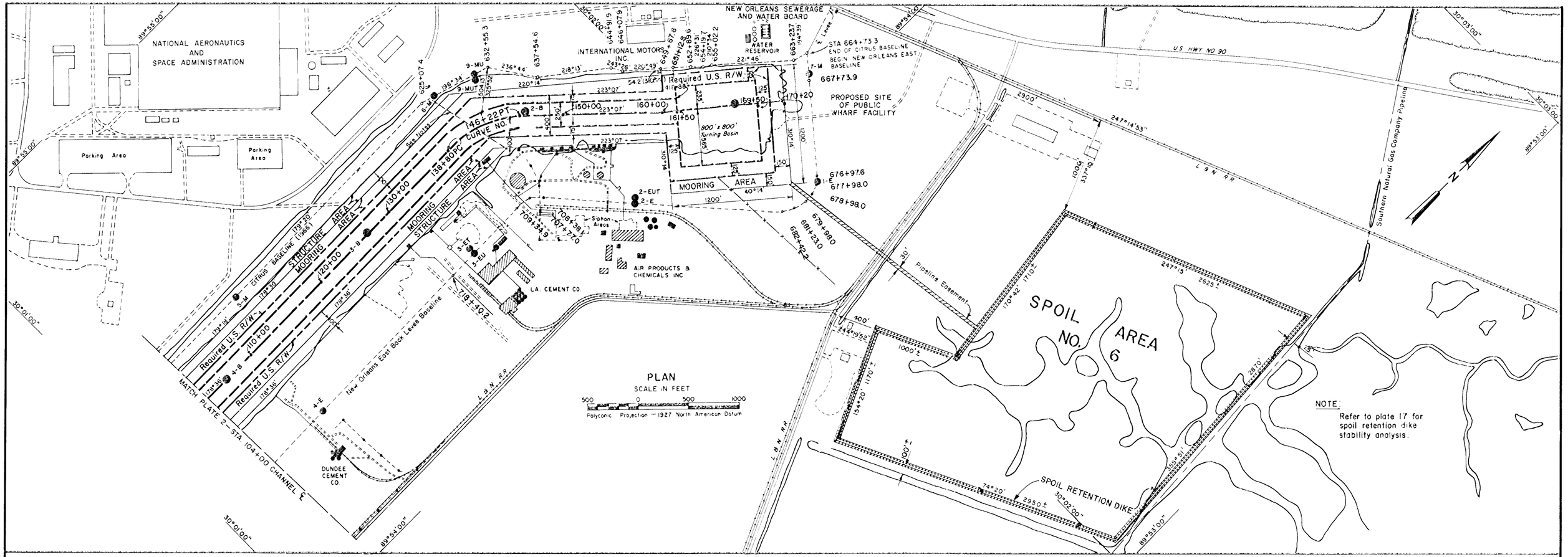
PLAN AND PROFILE STA. 0+00 TO STA. 104+00

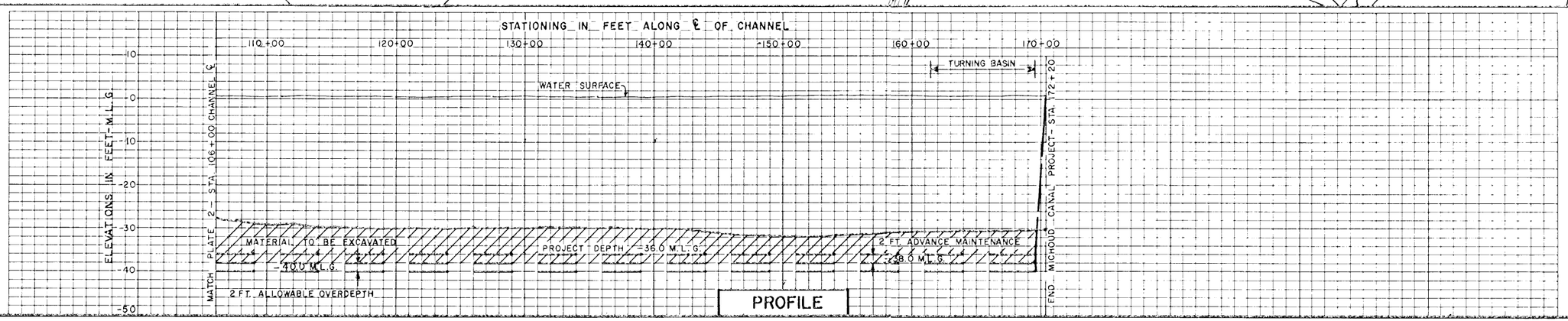
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO. H-2-25340

PLATE 2





NOTES:

A cluster of three high pressure nitrogen lines cross the canal from Citrus B/L Sta. 626+69. The sizes are 10", 2¾" and 1". As of July 1970 the lines are not in service and will be removed during construction.

Planimetry from October 1969 aerial photographs.

LEGEND

1-B ⊗ Soil boring location

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA.
DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

PLAN AND PROFILE STA. 104+00 TO STA. 172+00 SPOIL AREA NO. 6

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO. H-2-25340

PLATE 3

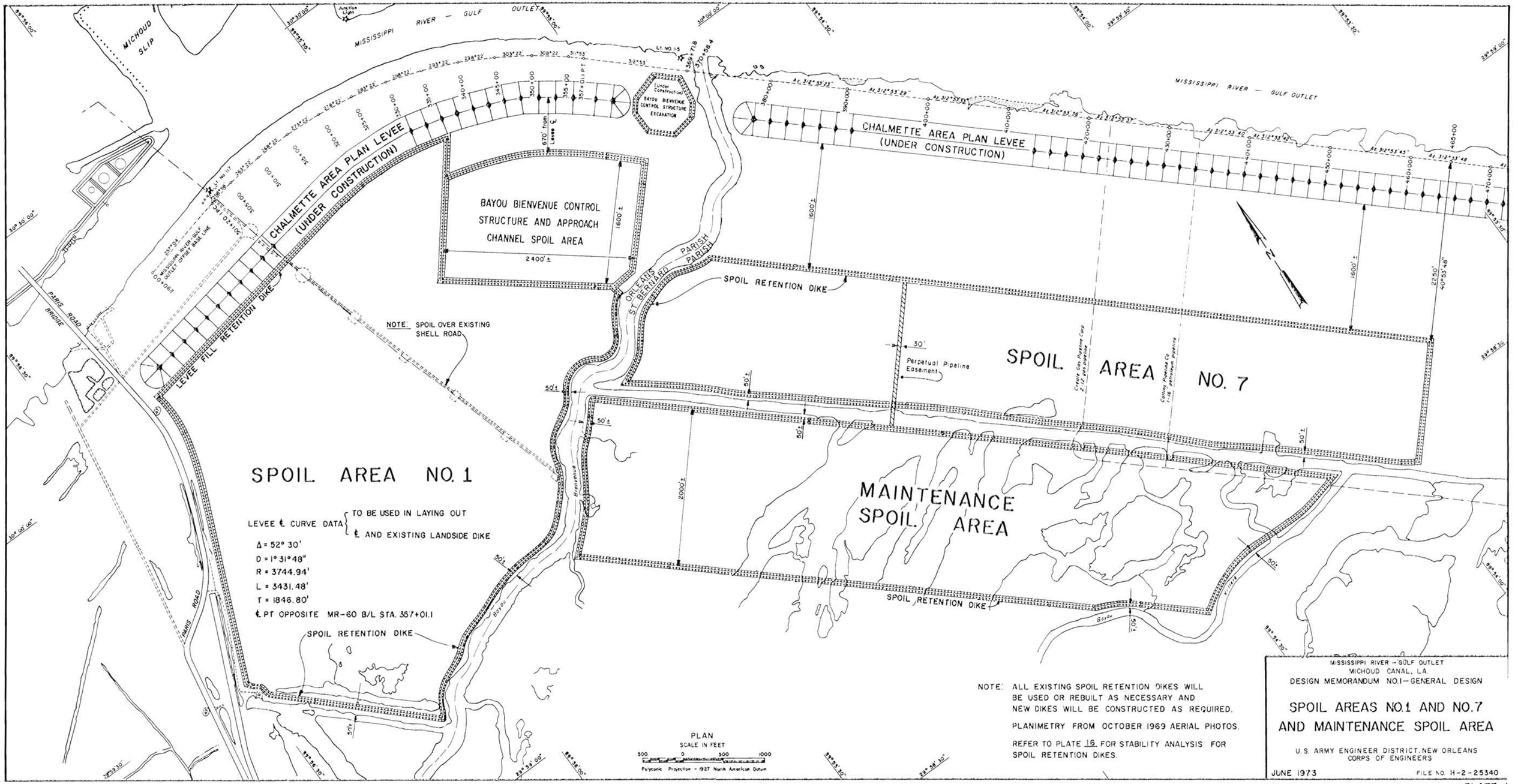
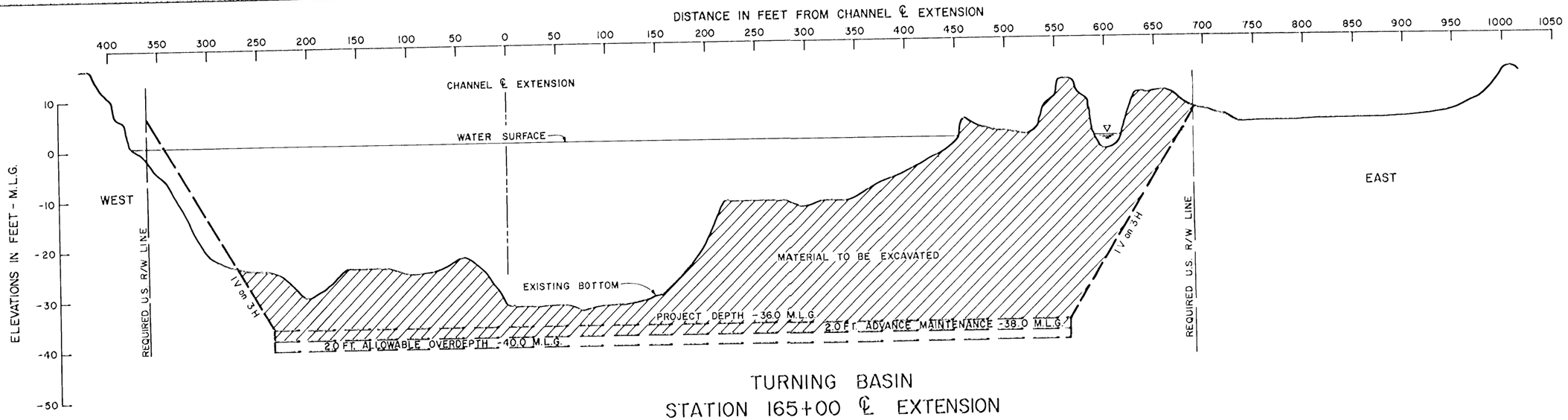
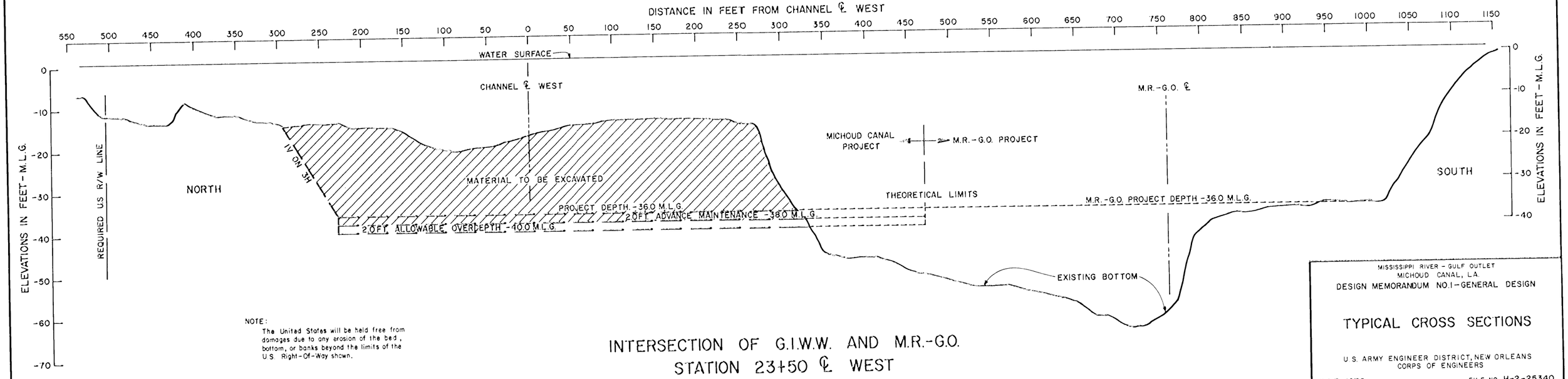

MICHOUD SLIP
MISSISSIPPI RIVER — GULF OUTLET
CHALMETTE AREA PLAN LEVEE (UNDER CONSTRUCTION)
BAYOU BIENVENUE CONTROL STRUCTURE AND APPROACH CHANNEL SPOIL AREA
2400'±
1600'±
BAYOU BIENVENUE CONTROL STRUCTURE EXCAVATION
LEVEE FILL RETENTION DIKE
PARIS ROAD BRIDGE
PARIS ROAD
NOTE: SPOIL OVER EXISTING SHELL ROAD
ORLEANS PARISH
ST. BERNARD PARISH
SPOIL RETENTION DIKE
30' Perpetual Pipeline Easement
Creole Gas Pipeline Corp 2-12" gas pipeline
Collins Pipeline Co 1-16 petroleum pipeline
SPOIL AREA NO. 1
SPOIL AREA NO. 7
MAINTENANCE SPOIL AREA
2000'±
Bayou Bienvenue
Bayou
LEVEE ℄ CURVE DATA { TO BE USED IN LAYING OUT ℄ AND EXISTING LANDSIDE DIKE
Δ = 52° 30'
D = 1° 31' 48"
R = 3744.94'
L = 3431.48'
T = 1846.80'
℄ PT OPPOSITE MR-60 B/L STA. 357+01.1
PLAN
SCALE IN FEET
500 0 500 1000
Polyconic Projection - 1927 North American Datum
NOTE: ALL EXISTING SPOIL RETENTION DIKES WILL BE USED OR REBUILT AS NECESSARY AND NEW DIKES WILL BE CONSTRUCTED AS REQUIRED.
PLANIMETRY FROM OCTOBER 1969 AERIAL PHOTOS.
REFER TO PLATE 16 FOR STABILITY ANALYSIS FOR SPOIL RETENTION DIKES.
MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA.
DESIGN MEMORANDUM NO.1 — GENERAL DESIGN
SPOIL AREAS NO.1 AND NO.7 AND MAINTENANCE SPOIL AREA
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS CORPS OF ENGINEERS
JUNE 1973
FILE NO. H-2-25340

PLATE 4



TURNING BASIN
STATION 165+00 ℄ EXTENSION



INTERSECTION OF G.I.W.W. AND M.R.-G.O.
STATION 23+50 ℄ WEST

NOTE:
The United States will be held free from damages due to any erosion of the bed, bottom, or banks beyond the limits of the U.S. Right-Of-Way shown.

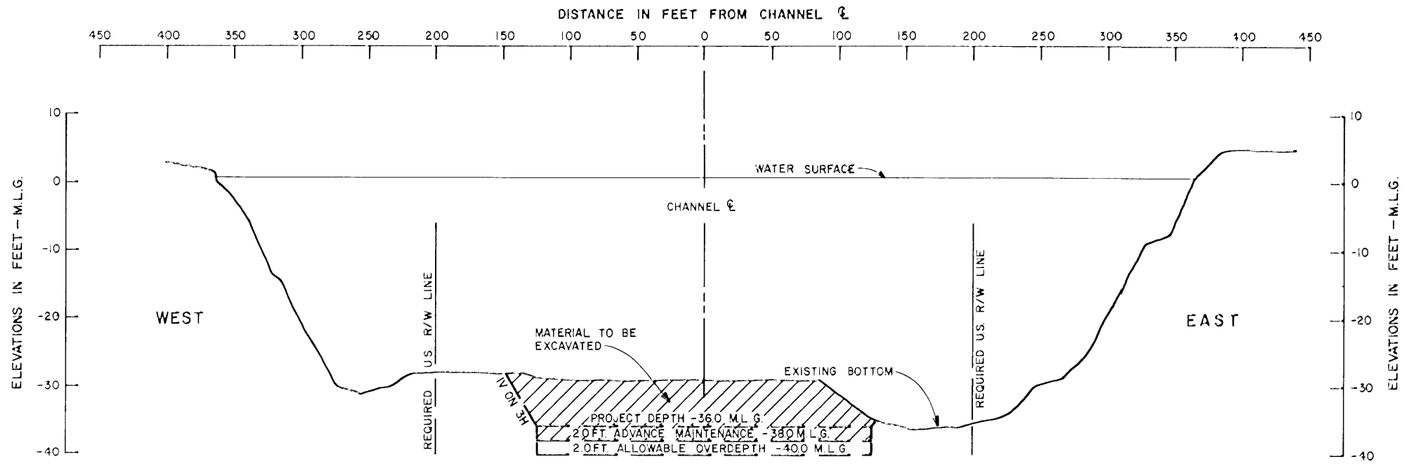
MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA.
DESIGN MEMORANDUM NO.1 - GENERAL DESIGN

TYPICAL CROSS SECTIONS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

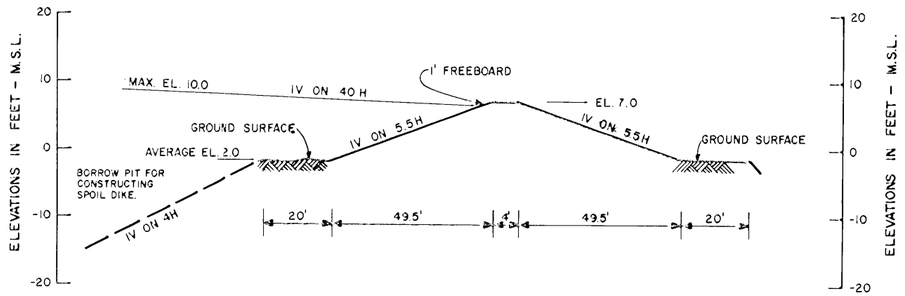
JUNE 1973 FILE NO. H-2-25340

PLATE 5

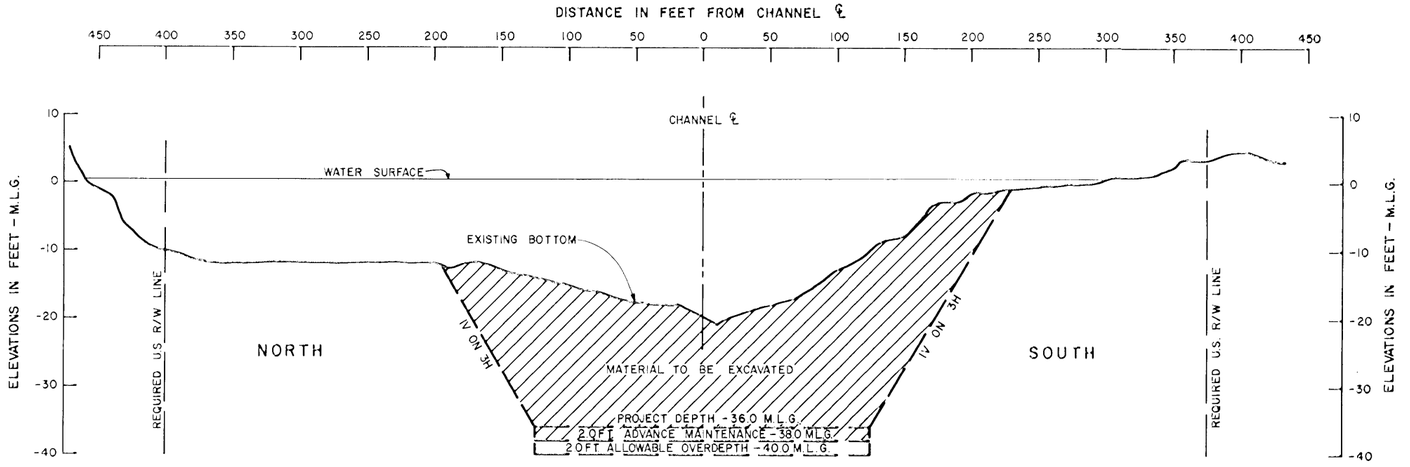


MICHOUD CANAL
STATION 125+00 CHANNEL ℄

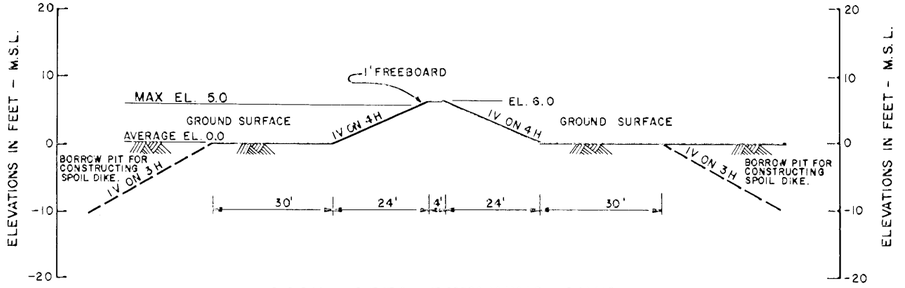
NOTE:
FOR DISPOSAL AREA No. 1 SLOPE
TO DRAW TOWARD BAYOU BIENVENUE.



TYPICAL SPOIL AREA RETAINING DIKE
SPOIL AREA NO. 1, NO. 7 AND MAINTENANCE AREA
NOT TO SCALE



G.I.W.W.
STATION 55+00 CHANNEL ℄



SPOIL AREA RETAINING DIKE
SPOIL AREA NO. 6
NOT TO SCALE

NOTE:
The United States will be held free from damages due to any erosion of the bed, bottom, or banks beyond the limits of the U.S. Right-Of-Way shown.

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA.
DESIGN MEMORANDUM NO.1-GENERAL DESIGN

TYPICAL CROSS SECTIONS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973 FILE NO. H-2-25340

PLATE 6

STATIONING ALONG ℄ CHANNEL WEST

10+00 20+00 30+00 40+00 50+00 60+00 70+00 80+00 90+00 100+00 102+00

B-13 B-15 B-17 B-19 5-B

WATER

RECENT

CHANNEL FILLING

INTRADELTA

NEARSHORE

PLEISTOCENE

ELEVATIONS IN FEET—M.L.G.

0 -10 -20 -30 -40 -50 -60 -70

STATIONING ALONG ℄ CHANNEL WEST

102+00 110+00 120+00 130+00 140+00 150+00 160+00 170+20

4-B 3-B 2-B 1-B

TURNING BASIN

WATER

RECENT

CHANNEL FILLING

INTRADELTA

NEARSHORE

PLEISTOCENE

ELEVATIONS IN FEET—M.L.G.

0 -10 -20 -30 -40 -50 -60 -70

LEGEND

- CH – fat clay
- CHO – clay w/org matter
- CL – lean clay
- SP – fine sand
- PT – peat
- ML – silt
- SM – silty sand

CHANNEL FILLING — vy soft clays w/org matter & peat

INTRADELTA — soft alternating clays & silt w/layers SM & SP

NEARSHORE — sands w/shell & shell fragments

PLEISTOCENE — stiff to vy stiff clays w/ SM & SP layers

1-B — Soil Boring Location

MISSISSIPPI RIVER – GULF OUTLET
MICHOUD CANAL, LA.

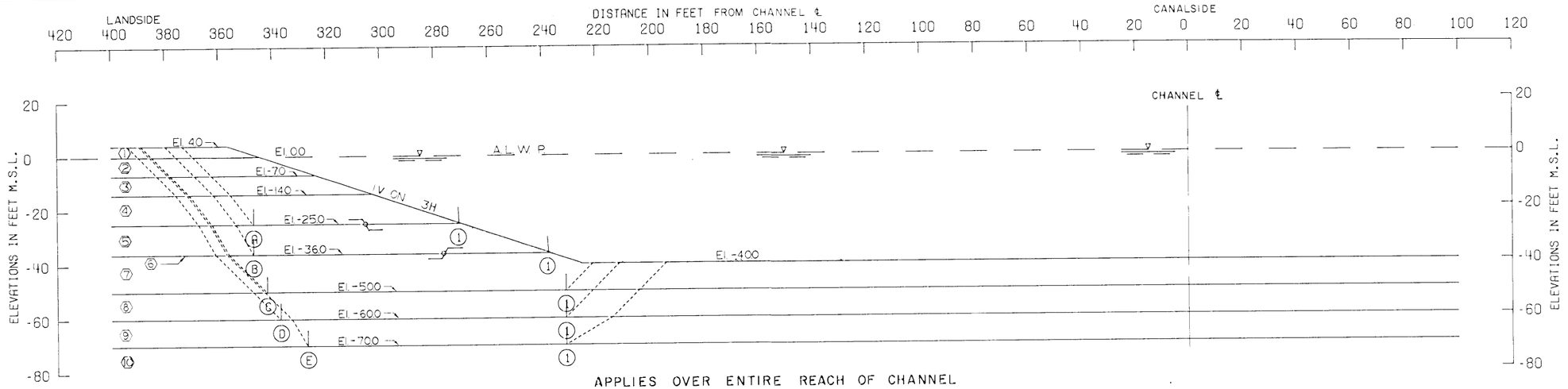
DESIGN MEMORANDUM NO. 1 – GENERAL DESIGN

SOIL AND GEOLOGIC PROFILE

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973 FILE NO. H-2-25340

PLATE 7



APPLIES OVER ENTIRE REACH OF CHANNEL

GENERAL NOTES

CLASSIFICATION, STRATIFICATION, SHEAR STRENGTHS, AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF THE UNDISTURBED BORINGS 2-EUT. SEE BORING DATA PLATE 21.

SHEAR STRENGTHS BETWEEN VERTICALS 1 AND 2 WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

STRATUM NO.	SOIL TYPE	EFFECTIVE UNIT WT. P.C.F.		C - UNIT COHESION - P.S.F.				FRICTION ANGLE
				CENTER OF STRATUM		BOTTOM OF STRATUM		
		VERT. 1	VERT. 2	VERT. 1	VERT. 2	VERT. 1	VERT. 2	DEGREES
⟨1⟩	CH	82.0	82.0	160.0	160.0	160.0	160.0	0.
⟨2⟩	CH	20.0	20.0	160.0	160.0	160.0	160.0	0.
⟨3⟩	CH	50.0	50.0	300.0	300.0	300.0	300.0	0.
⟨4⟩	ML	55.0	55.0	200.0	200.0	200.0	200.0	15.0
⟨5⟩	SP	60.0	60.0	0.	0.	0.	0.	30.0
⟨6⟩	CH	0.	0.	0.	0.	450.0	450.0	0.
⟨7⟩	CH	38.0	38.0	525.0	525.0	600.0	600.0	0.
⟨8⟩	CH	43.0	43.0	700.0	700.0	700.0	700.0	0.
⟨9⟩	SP	58.0	58.0	0.	0.	0.	0.	30.0
⟨10⟩	CH	43.0	43.0	1000.0	1000.0	1000.0	1000.0	0.

ASSUMED FAILURE SURFACE		RESISTING FORCES			DRIVING FORCES		SUMMATION OF FORCES		FACTOR OF SAFETY
NO.	ELEV.	R_A	R_B	R_P	D_A	$-D_P$	RESISTING	DRIVING	
Ⓐ ①	-25.00	15450	25300	122	18503	2	40873	18501	2.209
Ⓑ ①	-36.00	27558	40707	4	37273	2	68269	37271	1.832
Ⓒ ①	-50.00	43709	66600	10500	69458	2126	120809	67332	1.794
Ⓓ ①	-60.00	57725	72295	24500	95947	8074	154520	87873	1.758
Ⓔ ①	-70.00	77102	94688	46760	123342	18976	218551	104365	2.094

NOTES

Φ -- ANGLE OF INTERNAL FRICTION, DEGREES
C -- UNIT COHESION, P.S.F.
▽ -- STATIC WATER SURFACE
D -- HORIZONTAL DRIVING FORCE IN POUNDS
R -- HORIZONTAL RESISTING FORCE IN POUNDS
A -- AS A SUBSCRIPT, REFERS TO ACTIVE WEDGE
B -- AS A SUBSCRIPT, REFERS TO CENTRAL BLOCK
P -- AS A SUBSCRIPT, REFERS TO PASSIVE WEDGE

FACTOR OF SAFETY = $\frac{R_A + R_B + R_P}{D_A - D_P}$

⬡ STRATUM NUMBER
◯ WEDGE NUMBER

MISSISSIPPI RIVER – GULF OUTLET
MICHOUD CANAL, LA.

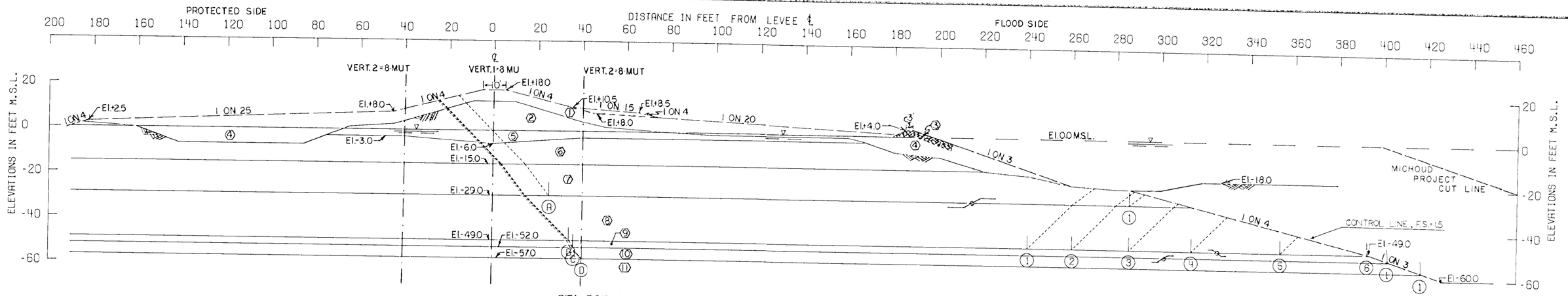
DESIGN MEMORANDUM NO. 1 – GENERAL DESIGN

(Q) CHANNEL STABILITY ANALYSIS FOR ENTIRE CHANNEL REACH

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973 FILE NO. H-2-25340

PLATE 8



STA. 507+44.6 TO STA. 540+00

GENERAL NOTES

CLASSIFICATION, STRATIFICATION, SHEAR STRENGTHS, AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF THE UNDISTURBED BORINGS 8-MU AND 8-MUT. SEE BORING DATA PLATES 25 & 26.

SHEAR STRENGTHS BETWEEN VERTICALS 1 AND 2 WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

STATIONING ALONG CITRUS BACK LEVEE.

STRATUM NO.	SOIL TYPE	EFFECTIVE UNIT WT. P.C.F.		C - UNIT COHESION - P.S.F. CENTER OF STRATUM		BOTTOM OF STRATUM		FRICTION ANGLE DEGREES
		VERT. 1	VERT. 2	VERT. 1	VERT. 2	VERT. 1	VERT. 2	
①	FILL	110.0	110.0	250.0	250.0	250.0	250.0	0.
②	CH	110.0	110.0	400.0	400.0	400.0	400.0	0.
③	RIPRAP	110.0	110.0	0.	0.	0.	0.	0.
④	FILL	40.0	40.0	200.0	200.0	200.0	200.0	0.
⑤	CH	40.0	40.0	300.0	200.0	300.0	200.0	0.
⑥	CH	40.0	40.0	400.0	200.0	400.0	200.0	0.
⑦	ML	55.0	55.0	200.0	200.0	200.0	200.0	15.0
⑧	CH	45.0	45.0	500.0	500.0	500.0	500.0	0.
⑨	SP	60.0	60.0	0.	0.	0.	0.	33.0
⑩	CH	60.0	60.0	800.0	800.0	800.0	800.0	0.
⑪	CH	60.0	60.0	800.0	800.0	800.0	800.0	0.

ASSUMED FAILURE SURFACE NO.		ELEV.	RESISTING FORCES R_A	R_B	R_P	DRIVING FORCES D_R	$-D_P$	SUMMATION OF FORCES RESISTING	DRIVING	FACTOR OF SAFETY
Ⓐ	①	-29.00	40171	121463	3461	84655	1015	165096	83640	1.974
Ⓑ	①	-49.00	60627	103000	25165	150911	22840	188793	128071	1.474
Ⓑ	②	-49.00	60627	113000	24256	150911	18680	197883	132231	1.496
Ⓑ	③	-49.00	60627	126000	20844	150911	14027	207471	136883	1.516
Ⓑ	④	-49.00	60627	140000	16000	150911	7196	216627	143715	1.507
Ⓑ	⑤	-49.00	60627	157045	8000	150911	1798	225673	149113	1.513
Ⓑ	⑥	-49.00	60627	162886	200	150911	1	223714	150910	1.482
Ⓒ	①	-52.00	68119	255104	4	161335	2	323229	161333	2.003
Ⓓ	①	-57.00	76018	301600	400	180404	2	378018	180401	2.095

NOTES

Φ -- ANGLE OF INTERNAL FRICTION, DEGREES
C -- UNIT COHESION, P.S.F.
▽ -- STATIC WATER SURFACE
D -- HORIZONTAL DRIVING FORCE IN POUNDS
R -- HORIZONTAL RESISTING FORCE IN POUNDS
A -- AS A SUBSCRIPT, REFERS TO ACTIVE WEDGE
B -- AS A SUBSCRIPT, REFERS TO CENTRAL BLOCK
P -- AS A SUBSCRIPT, REFERS TO PASSIVE WEDGE

FACTOR OF SAFETY = $\frac{R_A + R_B + R_P}{D_R - D_P}$

○ STRATUM NUMBER
○ WEDGE NUMBER

MISSISSIPPI RIVER – GULF OUTLET
MICHOUD CANAL, LA.

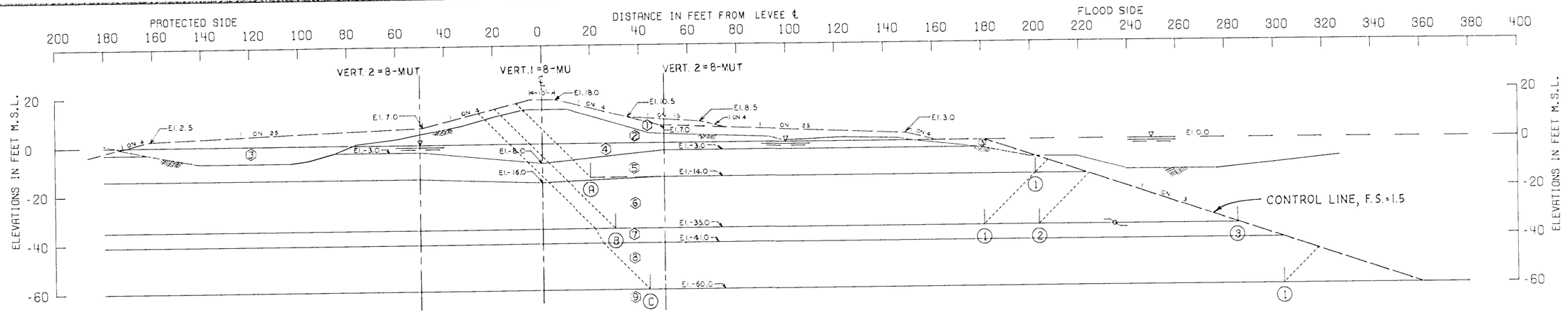
DESIGN MEMORANDUM NO. 1 – GENERAL DESIGN

(Q) LEVEE STABILITY ANALYSIS FLOODSIDE STA. 507+44.6 TO STA. 540+00

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO. H-2-25340



STA. 540+00 TO STA. 571+60

GENERAL NOTES

CLASSIFICATION, STRATIFICATION, SHEAR STRENGTHS, AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF THE UNDISTURBED BORINGS 8-MU AND 8-MUT SEE BORING DATA PLATES 25 & 26.

SHEAR STRENGTHS BETWEEN VERTICALS 1 AND 2 WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

STATIONING ALONG CITRUS BACK LEVEE.

STRATUM NO.	SOIL TYPE	EFFECTIVE UNIT WT. P.C.F.		C - UNIT COHESION - P.S.F. CENTER OF STRATUM		C - UNIT COHESION - P.S.F. BOTTOM OF STRATUM		FRICTION ANGLE DEGREES
		VERT. 1	VERT. 2	VERT. 1	VERT. 2	VERT. 1	VERT. 2	
①	FILL	110.0	110.0	250.0	250.0	250.0	250.0	0.
②	CH	110.0	110.0	400.0	400.0	400.0	400.0	0.
③	FILL	40.0	40.0	200.0	200.0	200.0	200.0	0.
④	CH	40.0	40.0	300.0	200.0	300.0	200.0	0.
⑤	CH	40.0	40.0	400.0	200.0	400.0	200.0	0.
⑥	CH	45.0	45.0	500.0	500.0	500.0	500.0	0.
⑦	SP	60.0	60.0	0.	0.	0.	0.	33.0
⑧	CH	45.0	45.0	800.0	800.0	800.0	800.0	0.
⑨	CH	45.0	45.0	800.0	800.0	800.0	800.0	0.

ASSUMED FAILURE SURFACE NO.		ASSUMED FAILURE SURFACE ELEV.	RESISTING FORCES R_A	R_B	R_P	DRIVING FORCES D_A	$-D_P$	SUMMATION OF FORCES RESISTING	DRIVING	FACTOR OF SAFETY
Ⓐ	①	-14.00	21094	38200	2100	45837	733	61394	45103	1.361
Ⓑ	①	-35.00	40611	75500	23100	100456	19471	139211	80985	1.719
Ⓑ	②	-35.00	40611	86750	20624	100456	12439	147986	88016	1.681
Ⓑ	③	-35.00	40611	115162	250	100456	1	156024	100454	1.553
Ⓒ	①	-60.00	83098	208000	22799	186598	6088	313898	180509	1.739

NOTES

Φ -- ANGLE OF INTERNAL FRICTION, DEGREES
C -- UNIT COHESION, P.S.F.
▽ -- STATIC WATER SURFACE
D -- HORIZONTAL DRIVING FORCE IN POUNDS
R -- HORIZONTAL RESISTING FORCE IN POUNDS
A -- AS A SUBSCRIPT, REFERS TO ACTIVE WEDGE
B -- AS A SUBSCRIPT, REFERS TO CENTRAL BLOCK
P -- AS A SUBSCRIPT, REFERS TO PASSIVE WEDGE

$$\text{FACTOR OF SAFETY} = \frac{R_A + R_B + R_P}{D_A - D_P}$$

○ STRATUM NUMBER
○ WEDGE NUMBER

MISSISSIPPI RIVER – GULF OUTLET
MICHOUD CANAL, LA.

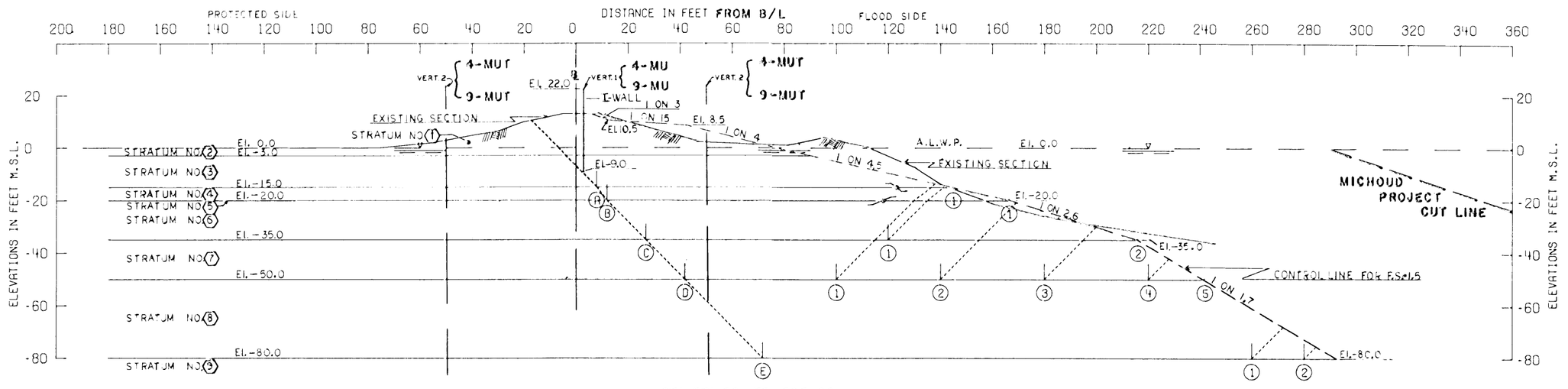
DESIGN MEMORANDUM NO. 1 – GENERAL DESIGN

(Q) LEVEE STABILITY ANALYSIS FLOODSIDE STA. 540+00 TO STA. 571+60

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973 FILE NO. H-2-25340

PLATE 10



STA. 571+60 TO 595+00

GENERAL NOTES

CLASSIFICATION, STRATIFICATION, SHEAR STRENGTHS, AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF THE UNDISTURBED BORINGS. **4-MU, 4-MUT, 9-MU, AND 9-MUT. SEE DATA PLATES 23, 24, 27 & 28, RESPECTIVELY.**

SHEAR STRENGTHS BETWEEN VERTICALS 1 AND 2 WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

STATIONING ALONG CITRUS BACK LEVEE.

STRATUM NO.	SOIL TYPE	EFFECTIVE UNIT WT. P.C.F.		C - UNIT COHESION - P.S.F.				FRICTION ANGLE
				CENTER OF STRATUM		BOTTOM OF STRATUM		
		VERT. 1	VERT. 2	VERT. 1	VERT. 2	VERT. 1	VERT. 2	DEGREES
(1)	CH	107.5	107.5	400.0	400.0	400.0	400.0	0.
(2)	CH	45.0	45.0	400.0	400.0	400.0	400.0	0.
(3)	CH	40.0	40.0	400.0	250.0	400.0	250.0	0.
(4)	ML	55.0	55.0	200.0	200.0	200.0	200.0	15.0
(5)	CH	0.	0.	0.	0.	467.0	335.0	0.
(6)	CH	40.0	40.0	567.0	401.0	667.0	467.0	0.
(7)	CH	40.0	40.0	767.0	534.0	867.0	600.0	0.
(8)	CH	60.0	60.0	1000.0	1000.0	1000.0	1000.0	0.
(9)	CH	60.0	60.0	1000.0	1000.0	1000.0	1000.0	0.

ASSUMED FAILURE NO.	ASSUMED SURFACE ELEV.	RESISTING FORCES R_A	R_B	R_P	DRIVING FORCES D_A	$-D_P$	SUMMATION OF FORCES RESISTING	DRIVING	FACTOR OF SAFETY
(A) (1)	-15.00	20328	36620	0	32580	0	56948	32580	1.748
(B) (1)	-20.00	25925	50928	0	42446	0	76853	42446	1.811
(C) (1)	-35.00	40992	44489	15587	76481	11768	101069	64712.	1.562
(C) (2)	-35.00	40992	89321	0	76481	0	130313	76481	1.704
(D) (1)	-50.00	59179	34970	32353	117899	35186	126504	82713	1.529
(D) (2)	-50.00	59179	58970	27397	117899	22201	145547	95698	1.521
(D) (3)	-50.00	59179	82970	19336	117899	10299	162087	107600	1.506
(D) (4)	-50.00	59179	106970	8504	117899	2012	174655	115887	1.507
(D) (5)	-50.00	59179	120170	0	117899	0	179349	117898	1.521
(E) (1)	-80.00	119179	188000	24074	223323	6898	331253	216424	1.531
(E) (2)	-80.00	119179	208000	9259	223323	1019	336439	222304	1.513

NOTES

Φ -- ANGLE OF INTERNAL FRICTION, DEGREES
C -- UNIT COHESION, P.S.F.
▽ -- STATIC WATER SURFACE
D -- HORIZONTAL DRIVING FORCE IN POUNDS
R -- HORIZONTAL RESISTING FORCE IN POUNDS
A -- AS A SUBSCRIPT, REFERS TO ACTIVE WEDGE
B -- AS A SUBSCRIPT, REFERS TO CENTRAL BLOCK
P -- AS A SUBSCRIPT, REFERS TO PASSIVE WEDGE

$$\text{FACTOR OF SAFETY} = \frac{R_A + R_B + R_P}{D_A - D_P}$$

⬡ STRATUM NUMBER
◯ WEDGE NUMBER

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA.

DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

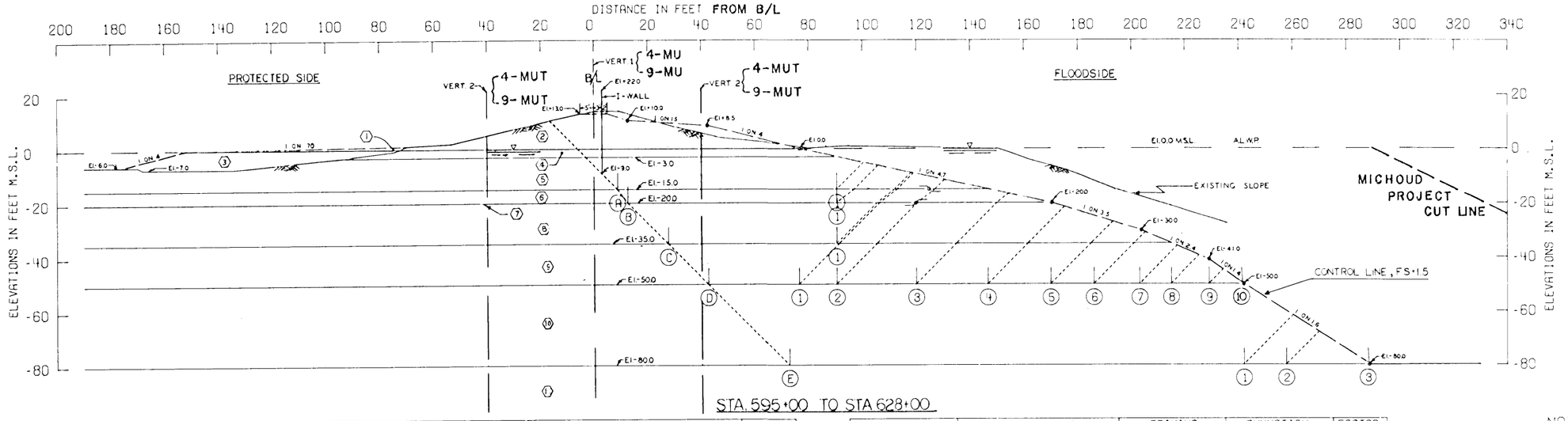
I-WALL LEVEE
(Q) STABILITY ANALYSIS
FLOOD SIDE STA. 571+60 TO STA. 595+00

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE 30-H-2-35340

PLATE 11



STA. 595+00 TO STA 628+00

GENERAL NOTES

CLASSIFICATION, STRATIFICATION, SHEAR STRENGTHS, AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF THE UNDISTURBED BORINGS. **4-MU, 4-MUT, 9-MU, AND 9-MUT.**
SEE DATA PLATES 23, 24, 27 & 28, RESPECTIVELY.

SHEAR STRENGTHS BETWEEN VERTICALS 1 AND 2 WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

STATIONING ALONG CITRUS BACK LEVEE.

STRATUM NO.	SOIL TYPE	EFFECTIVE UNIT WT. P.C.F.		C - UNIT COHESION - P.S.F. CENTER OF STRATUM		C - UNIT COHESION - P.S.F. BOTTOM OF STRATUM		FRICTION ANGLE
		VERT. 1	VERT. 2	VERT. 1	VERT. 2	VERT. 1	VERT. 2	DEGREES
⟨1⟩	FILL	102.5	102.5	200.0	200.0	200.0	200.0	0.
⟨2⟩	CH	107.5	107.5	400.0	400.0	400.0	400.0	0.
⟨3⟩	FILL	40.0	40.0	200.0	200.0	200.0	200.0	0.
⟨4⟩	CH	45.0	45.0	400.0	400.0	400.0	400.0	0.
⟨5⟩	CH	40.0	40.0	400.0	250.0	400.0	250.0	0.
⟨6⟩	ML	55.0	55.0	200.0	200.0	200.0	200.0	15.0
⟨7⟩	CH	0.	0.	0.	0.	467.0	335.0	0.
⟨8⟩	CH	40.0	40.0	567.0	401.0	667.0	467.0	0.
⟨9⟩	CH	40.0	40.0	767.0	534.0	867.0	600.0	0.
⟨10⟩	CH	60.0	60.0	1000.0	1000.0	1000.0	1000.0	0.
⟨11⟩	CH	60.0	60.0	1000.0	1000.0	1000.0	1000.0	0.

ASSUMED FAILURE SURFACE NO.		ELEV.	RESISTING FORCES R_A	R_B	R_P	DRIVING FORCES D_A	$-D_P$	SUMMATION OF FORCES RESISTING	DRIVING	FACTOR OF SAFETY
Ⓐ	①	-15.00	20041	22305	4944	32506	2372	47292	30134	1.569
Ⓑ	①	-20.00	25562	27346	9036	42199	4801	61945	37397	1.656
Ⓒ	①	-35.00	40039	29631	19296	76139	18070	88368	58069	1.532
Ⓓ	①	-50.00	56874	20196	35198	117467	43612	112268	73854	1.520
Ⓓ	②	-50.00	56874	28596	33546	117467	38754	119017	78713	1.512
Ⓓ	③	-50.00	56874	46296	30068	117467	29602	133238	87864	1.516
Ⓓ	④	-50.00	56874	62256	26819	117467	21012	145949	96454	1.513
Ⓓ	⑤	-50.00	56874	76296	22454	117467	13808	155624	103658	1.501
Ⓓ	⑥	-50.00	56874	85896	19314	117467	9693	162084	107773	1.504
Ⓓ	⑦	-50.00	56874	96096	15009	117467	5618	167979	111848	1.502
Ⓓ	⑧	-50.00	56874	103176	11263	117467	3162	171313	114304	1.499
Ⓓ	⑨	-50.00	56874	111696	5679	117467	955	174250	116511	1.496
Ⓓ	⑩	-50.00	56874	116896	0	117467	0	176207	117461	1.500
Ⓔ	①	-80.00	116874	169160	36623	222215	16473	322657	205742	1.568
Ⓔ	②	-80.00	116874	184860	24389	222215	7304	326123	214911	1.517
Ⓔ	③	-80.00	116874	215160	0	222215	0	332813	222208	1.498

NOTES

Φ -- ANGLE OF INTERNAL FRICTION, DEGREES
C -- UNIT COHESION, P.S.F.
▽ -- STATIC WATER SURFACE
D -- HORIZONTAL DRIVING FORCE IN POUNDS
R -- HORIZONTAL RESISTING FORCE IN POUNDS
A -- AS A SUBSCRIPT, REFERS TO ACTIVE WEDGE
B -- AS A SUBSCRIPT, REFERS TO CENTRAL BLOCK
P -- AS A SUBSCRIPT, REFERS TO PASSIVE WEDGE

$$\text{FACTOR OF SAFETY} = \frac{R_A + R_B + R_P}{D_A - D_P}$$

⟨⟩ STRATUM NUMBER
◯ WEDGE NUMBER

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA

DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

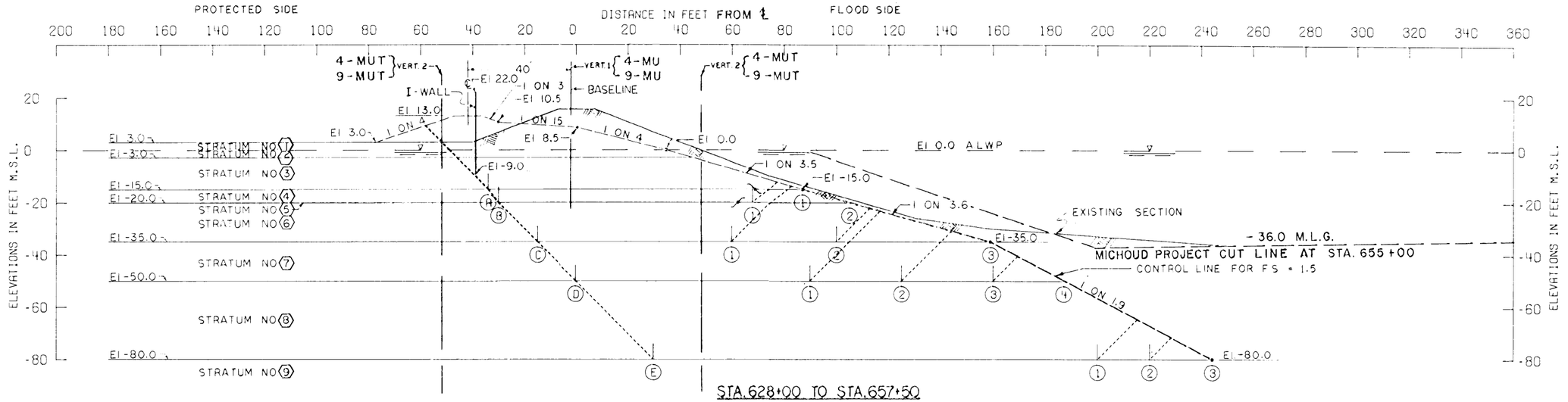
I-WALL LEVEE
(Q) STABILITY ANALYSIS
FLOOD SIDE STA. 595+00 TO STA. 628+00

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO. H-2-25340

PLATE 12



STA.628+00 TO STA.657+50

GENERAL NOTES

CLASSIFICATION, STRATIFICATION, SHEAR STRENGTHS, AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF THE UNDISTURBED BORINGS. 4-MU, 4-MUT, 9-MU, AND 9-MUT. SEE DATA PLATES 23, 24, 27 & 28, RESPECTIVELY.

SHEAR STRENGTHS BETWEEN VERTICALS 1 AND 2 WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

STATIONING ALONG CITRUS BACK LEVEE

STRATUM NO.	SOIL TYPE	EFFECTIVE UNIT WT. P.C.F.		C - UNIT COHESION - P.S.F.				FRICTION ANGLE
				CENTER OF STRATUM		BOTTOM OF STRATUM		
		VERT. 1	VERT. 2	VERT. 1	VERT. 2	VERT. 1	VERT. 2	DEGREES
①	CH	107.5	107.5	400.0	400.0	400.0	400.0	0.
②	CH	45.0	45.0	400.0	400.0	400.0	400.0	0.
③	CH	40.0	40.0	400.0	250.0	400.0	250.0	0.
④	ML	55.0	55.0	200.0	200.0	200.0	200.0	15.0
⑤	CH	0.	0.	0.	0.	467.0	335.0	0.
⑥	CH	40.0	40.0	567.0	401.0	667.0	467.0	0.
⑦	CH	40.0	40.0	767.0	534.0	867.0	600.0	0.
⑧	CH	60.0	60.0	1000.0	1000.0	1000.0	1000.0	0.
⑨	CH	60.0	60.0	1000.0	1000.0	1000.0	1000.0	0.

ASSUMED FAILURE SURFACE		RESISTING FORCES			DRIVING FORCES		SUMMATION OF FORCES		FACTOR OF SAFETY
NO.	ELEV.	R_A	R_B	R_P	D_A	$-D_P$	RESISTING	DRIVING	
Ⓐ ①	-15.00	16592	37137	0	31572	0	53729	31572	1.702
Ⓑ ①	-20.00	22212	39035	5099	41460	1783	66346	39677	1.672
Ⓑ ②	-20.00	22212	49051	0	41460	0	71263	41460	1.719
Ⓒ ①	-35.00	36981	42575	16075	75495	13188	95631	62306	1.535
Ⓒ ②	-35.00	36981	61255	10286	75495	4253	108522	71242	1.523
Ⓒ ③	-35.00	36981	88808	0	75495	0	125789	75495	1.666
Ⓓ ①	-50.00	58942	60675	25434	116913	18734	145051	98179	1.477
Ⓓ ②	-50.00	58942	81675	19332	116913	9348	159949	107565	1.487
Ⓓ ③	-50.00	58942	102675	10127	116913	2742	171744	114171	1.504
Ⓓ ④	-50.00	58942	118875	0	116913	0	177817	116913	1.521
Ⓔ ①	-80.00	118942	170000	30689	222337	10776	319631	211561	1.511
Ⓔ ②	-80.00	118942	190000	16896	222337	3265	325838	219072	1.487
Ⓔ ③	-80.00	118942	214400	0	222337	0	333342	222337	1.499

NOTES

Φ -- ANGLE OF INTERNAL FRICTION, DEGREES
C -- UNIT COHESION, P.S.F.
∇ -- STATIC WATER SURFACE
D -- HORIZONTAL DRIVING FORCE IN POUNDS
R -- HORIZONTAL RESISTING FORCE IN POUNDS
A -- AS A SUBSCRIPT, REFERS TO ACTIVE WEDGE
B -- AS A SUBSCRIPT, REFERS TO CENTRAL BLOCK
P -- AS A SUBSCRIPT, REFERS TO PASSIVE WEDGE

$$\text{FACTOR OF SAFETY} = \frac{R_A + R_B + R_P}{D_A - D_P}$$

⬡ STRATUM NUMBER
◯ WEDGE NUMBER

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA

DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

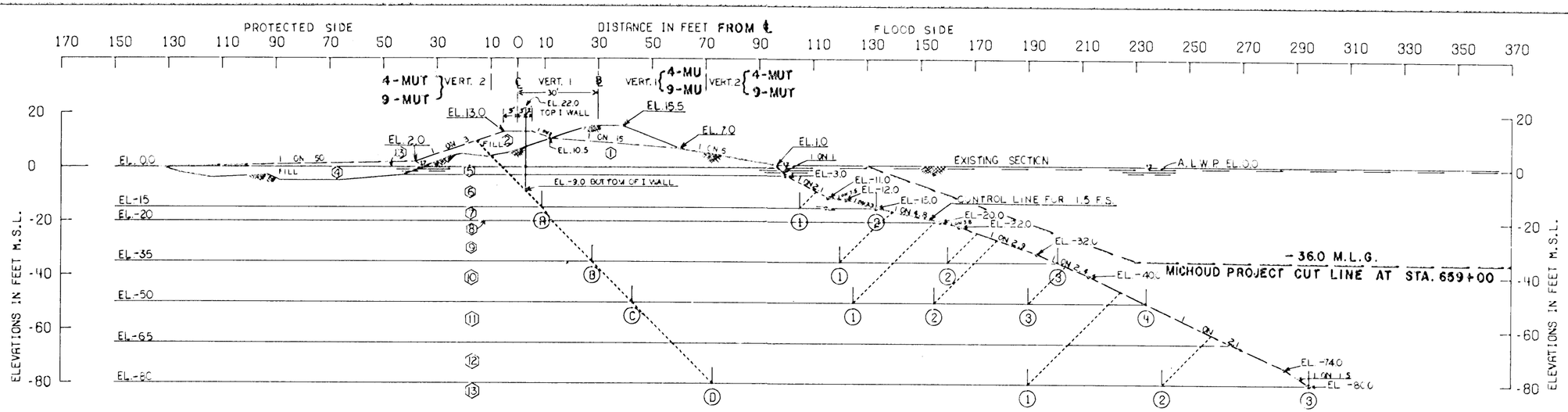
I-WALL LEVEE
(Q) STABILITY ANALYSIS
FLOOD SIDE STA.628+00 TO STA.657+50

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO. H-2-25340-

PLATE 13



STA. 657+50 TO STA. 664+73.3

GENERAL NOTES

CLASSIFICATION, STRATIFICATION, SHEAR STRENGTHS, AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF THE UNDISTURBED BORINGS, **4-MU, 4-MUT, 9-MU, AND 9-MUT.**
SEE DATA PLATES 23, 24, 27 & 28, RESPECTIVELY.

SHEAR STRENGTHS BETWEEN VERTICALS 1 AND 2 WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

STATIONING ALONG CITRUS BACK LEVEE

STRATUM NO.	SOIL TYPE	EFFECTIVE UNIT WT. P.C.F.		C - UNIT COHESION - P.S.F.				FRICTION ANGLE
				CENTER OF STRATUM		BOTTOM OF STRATUM		
		VERT. 1	VERT. 2	VERT. 1	VERT. 2	VERT. 1	VERT. 2	DEGREES
①	CH	107.5	107.5	400.0	400.0	400.0	400.0	0.
②	FILL	107.5	107.5	400.0	400.0	400.0	400.0	0.
③	FILL	102.5	102.5	200.0	200.0	200.0	200.0	0.
④	FILL	40.0	40.0	200.0	200.0	200.0	200.0	0.
⑤	CH	45.0	45.0	400.0	400.0	400.0	400.0	0.
⑥	CH	40.0	40.0	400.0	250.0	400.0	250.0	0.
⑦	ML	55.0	55.0	200.0	200.0	200.0	200.0	15.0
⑧	CH	0.	0.	0.	0.	467.0	335.0	0.
⑨	CH	40.0	40.0	567.0	401.0	667.0	467.0	0.
⑩	CH	40.0	40.0	767.0	534.0	867.0	600.0	0.
⑪	CH	60.0	60.0	1000.0	1000.0	1000.0	1000.0	0.
⑫	CH	60.0	60.0	1000.0	1000.0	1000.0	1000.0	0.
⑬	CH	60.0	60.0	1000.0	1000.0	1000.0	1000.0	0.

ASSUMED FAILURE SURFACE		RESISTING FORCES			DRIVING FORCES		SUMMATION OF FORCES		FACTOR OF SAFETY
NO.	ELEV.	R_A	R_B	R_P	D_A	$-D_P$	RESISTING	DRIVING	
Ⓐ ①	-15.00	17170	27841	3106	31837	1168	48118	30668	1.569
Ⓐ ②	-15.00	17170	34512	0	31837	0	51682	31836	1.623
Ⓑ ①	-35.00	38554	47354	14283	75373	10097	100191	65275	1.535
Ⓑ ②	-35.00	38554	66034	8780	75373	3182	113368	72190	1.570
Ⓑ ③	-35.00	38554	85181	0	75373	0	123735	75373	1.642
Ⓒ ①	-50.00	60602	51633	28267	116423	24013	140503	92409	1.520
Ⓒ ②	-50.00	60602	69633	22744	116423	14549	152980	101874	1.502
Ⓒ ③	-50.00	60602	90633	14763	116423	5412	165999	111010	1.495
Ⓒ ④	-50.00	60602	117033	0	116423	0	177636	116423	1.526
Ⓓ ①	-80.00	120603	117000	64823	228335	43535	302426	184800	1.637
Ⓓ ②	-80.00	120603	167000	37021	228335	15091	324624	213244	1.522
Ⓓ ③	-80.00	120603	221900	0	228335	0	342583	228335	1.500

NOTES

Φ -- ANGLE OF INTERNAL FRICTION, DEGREES
C -- UNIT COHESION, P.S.F.
▽ -- STATIC WATER SURFACE
D -- HORIZONTAL DRIVING FORCE IN POUNDS
R -- HORIZONTAL RESISTING FORCE IN POUNDS
A -- AS A SUBSCRIPT, REFERS TO ACTIVE WEDGE
B -- AS A SUBSCRIPT, REFERS TO CENTRAL BLOCK
P -- AS A SUBSCRIPT, REFERS TO PASSIVE WEDGE

$$\text{FACTOR OF SAFETY} = \frac{R_A + R_B + R_P}{D_A - D_P}$$

◯ STRATUM NUMBER
◯ WEDGE NUMBER

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA.

DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

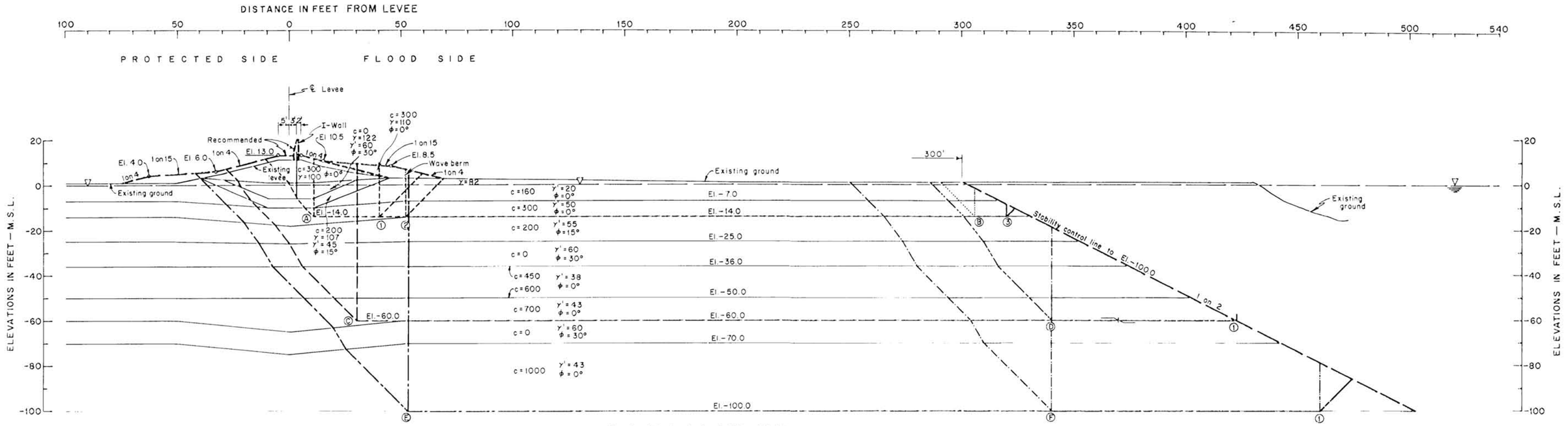
I-WALL LEVEE
(Q) STABILITY ANALYSIS
FLOOD SIDE STA. 657+50 TO STA. 664+73.3

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO. H-2-25340

PLATE 14



STA. 664+73.3 to STA. 751+50
STATIONING ALONG NEW ORLEANS EAST BACK LEVEE

Based on data from boring 2-EUT and 3-EU.
See plates 21 and 22 respectively.
For general notes see plate 11.

ASSUMED FAILURE SURFACE		RESISTING FORCES			DRIVING FORCES		SUMMATION OF FORCES		FACTOR OF SAFETY
NUMBER	ELEVATION	R_A	R_B	R_p	D_A	$-D_p$	ΣR	ΣD	
Ⓐ ①	-14.0	16,853	8,850	8,520	31,535	15,006	34,223	16,529	2.07*
Ⓐ ②	-14.0	16,853	12,450	7,400	31,535	10,375	36,703	21,160	1.73**
Ⓐ ③	-14.0	16,853	88,650	1,800	31,535	375	107,303	31,160	3.44
Ⓑ ③	-14.0	6,760	4,200	1,800	3,515	375	12,760	3,140	4.06
Ⓒ ①	-60.0	76,252	245,416	0	166,347	0	321,668	166,347	1.93
Ⓓ ①	-60.0	51,605	36,931	0	68,156	0	88,536	68,156	1.30
Ⓔ ①	-100.0	154,725	407,000	28,000	345,272	6,321	589,725	338,951	1.74
Ⓕ ①	-100.0	132,264	120,000	28,000	216,872	6,321	280,264	210,551	1.33

*F.S. without wave berm is 1.37.
**F.S. without wave berm is 1.47.

○ WEDGE NUMBER

MISSISSIPPI RIVER – GULF OUTLET
MICHOUD CANAL, LA.

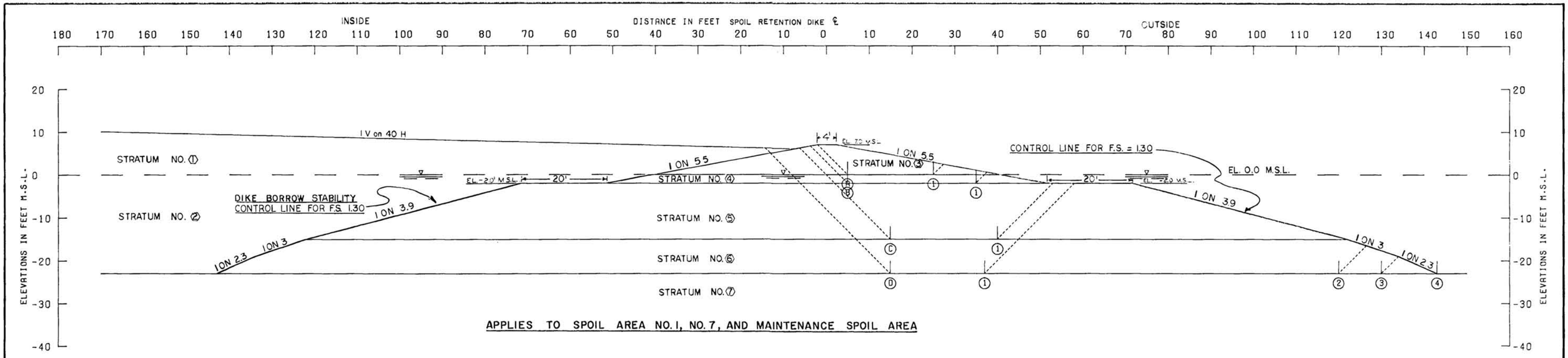
DESIGN MEMORANDUM NO. 1-GENERAL DESIGN

I-WALL LEVEE
(Q) STABILITY ANALYSIS
FLOOD SIDE STA. 664+73.3 TO STA. 751+27

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973 FILE NO. H-2-25340

PLATE 15



APPLIES TO SPOIL AREA NO. 1, NO. 7, AND MAINTENANCE SPOIL AREA

STRATUM NO.	SOIL TYPE	EFFECTIVE UNIT WT. P.C.F.		C - UNIT COHESION - P.S.F.				FRICTION ANGLE
				CENTER OF STRATUM		BOTTOM OF STRATUM		
		VERT. 1	VERT. 2	VERT. 1	VERT. 2	VERT. 1	VERT. 2	DEGREES
①	CH	92.5	92.5	20.0	20.0	20.0	20.0	0.0
②	CH	30.0	30.0	20.0	20.0	20.0	20.0	0.0
③	CH	100.0	100.0	125.0	125.0	125.0	125.0	0.0
④	CH	38.0	38.0	125.0	125.0	125.0	125.0	0.0
⑤	CH	42.0	42.0	200.0	200.0	200.0	200.0	0.0
⑥	CH	48.0	48.0	200.0	200.0	200.0	200.0	0.0
⑦	CH	42.0	42.0	400.0	400.0	600.0	600.0	0.0

ASSUMED FAILURE SURFACE			RESISTING FORCES			DRIVING FORCES		SUMMATION OF FORCES		FACTOR OF SAFETY
NO.		ELEV.	R_A	R_B	R_P	D_A	$-D_P$	RESISTING	DRIVING	
Ⓡ	①	0.00	1750	2500	596	2371	335	4846	2036	2.380
Ⓑ	①	-2.00	2173	3750	635	3817	256	6558	3561	1.842
Ⓒ	①	-15.00	7258	5000	5200	15839	4005	17458	11835	1.475
Ⓓ	①	-23.00	10197	4400	8400	27197	10244	22997	16953	1.357
Ⓓ	②	-23.00	10197	21000	2600	27197	1340	33797	25857	1.307
Ⓓ	③	-23.00	10197	23000	1600	27197	511	34797	26686	1.304
Ⓓ	④	-23.00	10197	25600	0	27197	0	35797	27197	1.316

NOTES

Φ -- ANGLE OF INTERNAL FRICTION, DEGREES
C -- UNIT COHESION, P.S.F.
▽ -- STATIC WATER SURFACE
D -- HORIZONTAL DRIVING FORCE IN POUNDS
R -- HORIZONTAL RESISTING FORCE IN POUNDS
A -- AS A SUBSCRIPT, REFERS TO ACTIVE WEDGE
B -- AS A SUBSCRIPT, REFERS TO CENTRAL BLOCK
P -- AS A SUBSCRIPT, REFERS TO PASSIVE WEDGE

FACTOR OF SAFETY = $\frac{R_A + R_B + R_P}{D_A - D_P}$

○ STRATUM NUMBER
○ WEDGE NUMBER

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA.

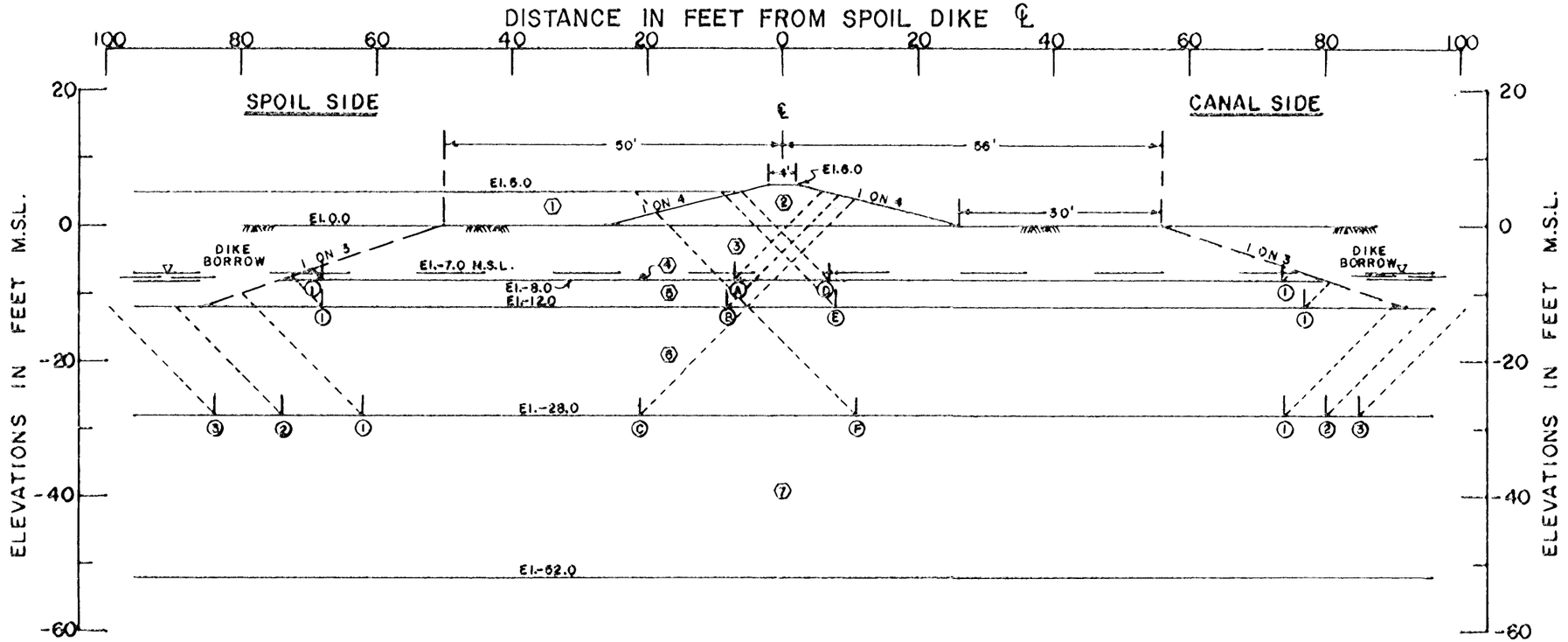
DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

(Q) SPOIL DIKE STABILITY ANALYSIS SPOIL AREA NO.1, NO. 7 AND MAINTENANCE SPOIL AREA

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973 FILE NO. H-2-25340

PLATE 16



APPLIES TO SPOIL AREA NO. 6

STRATUM NO.	SOIL TYPE	EFFECTIVE UNIT WT. P.C.F.		C – UNIT COHESION P.S.F.				FRICTION ANGLE DEGREES
				CENTER OF STRATUM		BOTTOM OF STRATUM		
		VERT. 1	VERT. 2	VERT. 1	VERT. 2	VERT. 1	VERT. 2	
①	FILL	90	90	140	140	140	140	0
②	CH	82	82	250	250	250	250	0
③	CH	20	20	250	250	250	250	0
④	CH	38	38	250	250	250	250	0
⑤	CH	38	38	250	250	250	250	0
⑥	CH	38	38	468	580	468	580	0
⑦	SP	60	60	0	0	0	0	30

ASSUMED FAILURE SURFACE		RESISTING FORCES			DRIVING FORCES		SUMMATION OF FORCES		FACTOR OF SAFETY
NO.	ELEV.	R_A	R_B	R_P	D_A	$-D_P$	RESISTING	DRIVING	
Ⓐ ①	El-8.0	6401	16250	749	3026	92	21400	7934	2.70
③ ①	El-12.0	7233	15000	2249	12391	507	24482	11884	2.06
Ⓒ ①	EL-28.0	16065	10250	9000	33661	8611	34315	25050	1.37
Ⓒ ②	EL-28.0	16065	13250	8000	33661	5775	36315	27886	1.30
Ⓒ ③	El-28.0	16065	16750	8000	33661	4889	38815	28772	1.35
Ⓓ ①	El-8.0	6401	16750	749	3026	92	22900	7934	2.89
Ⓔ ①	EL-12.0	7233	17250	1879	12477	329	26337	12148	2.17
Ⓕ ①	El-28.0	14505	15750	8250	38364	8881	38505	29483	1.31
Ⓕ ②	El-28.0	14505	17250	7968	38364	5802	39713	30562	1.30
Ⓕ ③	El-28.0	14505	18500	7905	38364	5511	40910	31053	1.32

NOTES

ø – ANGLE OF INTERNAL FRICTION, DEGREES.
C – UNIT COHESION, P.S.F.
℄ – STATIC WATER SURFACE.
D – HORIZONTAL DRIVING FORCE, IN POUNDS.
R – HORIZONTAL RESISTING FORCE, IN POUNDS.
A – AS A SUBSCRIPT, REFERS TO ACTIVE WEDGE.
B – AS A SUBSCRIPT, REFERS TO CENTRAL BLOCK.
P – AS A SUBSCRIPT, REFERS TO PASSIVE WEDGE

FACTOR OF SAFETY = $\frac{R_A + R_B + R_P}{D_A - D_P}$

⬡ STRATUM NUMBER
◯ WEDGE NUMBER

MISSISSIPPI RIVER – GULF OUTLET
MICHOUD CANAL, LA.

DESIGN MEMORANDUM NO. 1 – GENERAL DESIGN

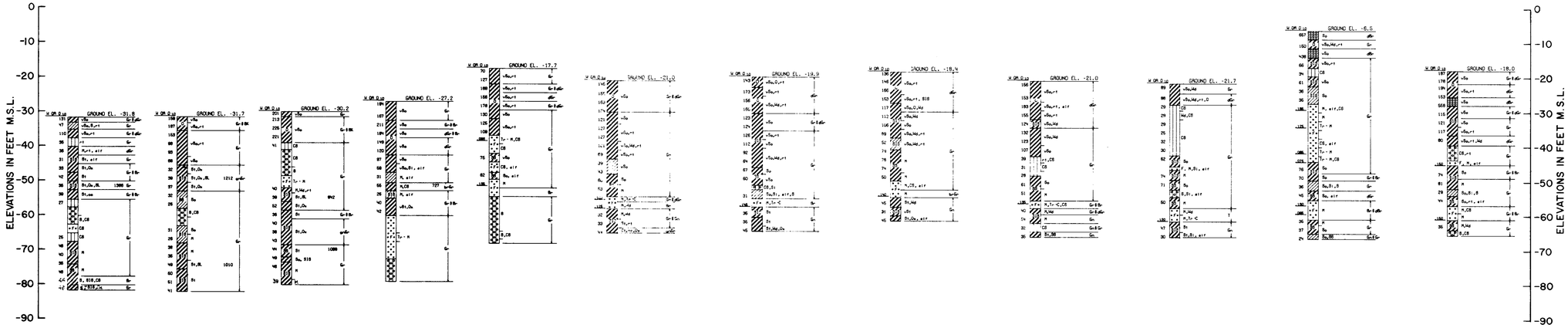
(Q) SPOIL DIKE STABILITY ANALYSIS SPOIL AREA NO. 6

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973 FILE NO. H-2-25340

PLATE 17

STATIONING ALONG CITRUS BACK LEVEE



NOTE:

B-13 thru B-19 made in conjunction w/ Citrus Back Levee Borrow Area.

1-B thru 5-B made in conjunction w/ N.O. East Back Levee Borrow Area.

Borings were made with a 1 7/8" I.D. core barrel sampler.

For location of borings see plates 2 and 3.

See plate A for boring legend.

MISSISSIPPI RIVER – GULF OUTLET
MICHOUD CANAL, LA.

DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

GENERAL TYPE SOIL BORINGS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

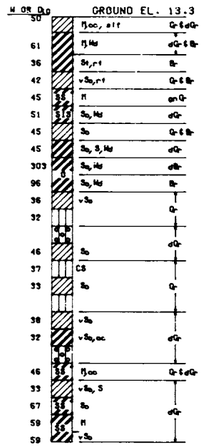
FILE NO. H-2-25340

PLATE 18

STATIONING ALONG CITRUS BACK LEVEE

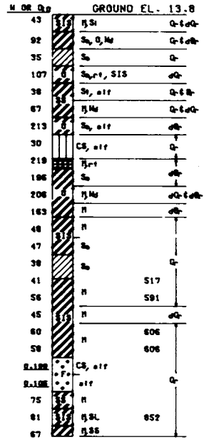
BOR. 2-M

STA. 528+34
6 FT. RT. OF B/L
30 DEC 65



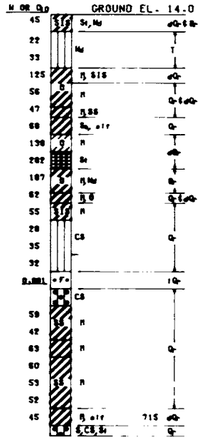
BOR. 3-M

STA. 548+95
5 FT. RT. OF B/L
7 JAN 66



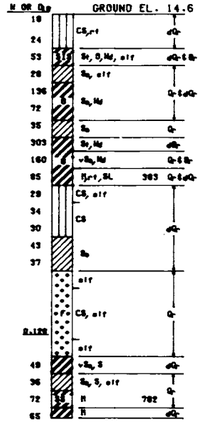
BOR. 5-M

STA. 598+45
5 FT. RT. OF B/L
7 JAN 66



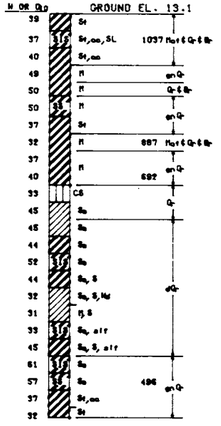
BOR. 6-M

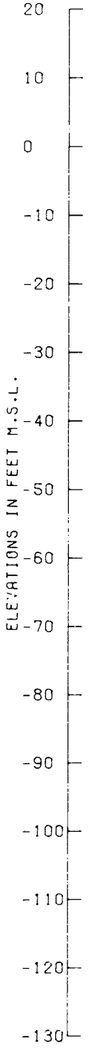
STA. 626+45
ON B/L
10 JAN 66

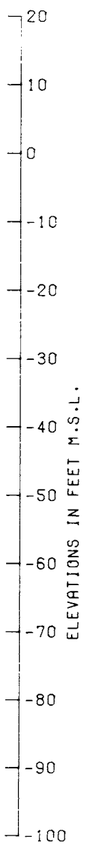


BOR. 7-M

STA. 666+79
ON B/L
10 JAN 66







NOTE:

Borings were made with a 1 7/8" I.D. core barrel sample.

For locations of borings see plates 2 & 3.

See plate A for boring legend.

MISSISSIPPI RIVER — GULF OUTLET
MICHOUD CANAL, LA.

DESIGN MEMORANDUM NO. 1 — GENERAL DESIGN

GENERAL TYPE SOIL BORINGS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

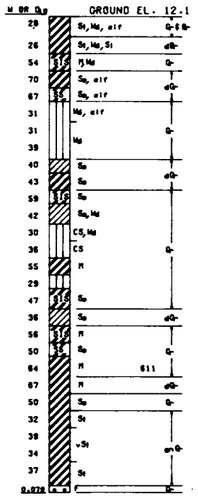
JUNE 1973 FILE NO. H-2-25340

PLATE 19

STATIONING ALONG NEW ORLEANS EAST BACK LEVEE

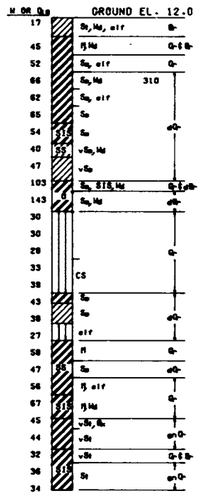
BORING NO. 1-E

STA. 677+21
ON C/L LEVEE
29 AUG. 66



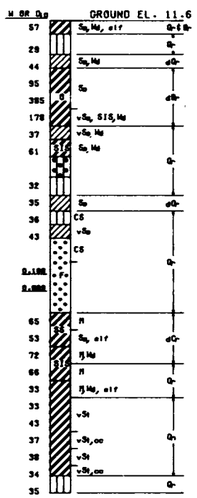
BORING NO. 2-E

STA. 697+20
ON C/L LEVEE
30-31 AUG. 66



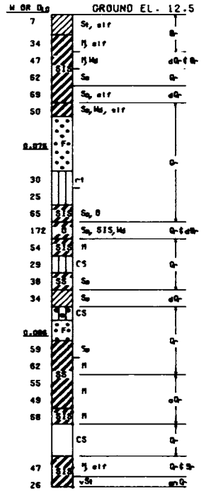
BORING NO. 3-ET

STA. 715+50
55 FT. CANAL SIDE
30-31 AUG. 66



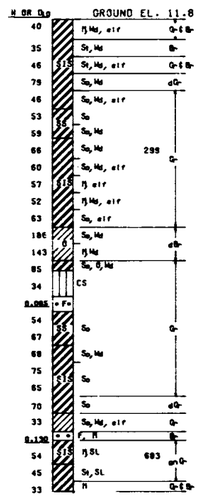
BORING NO. 4-E

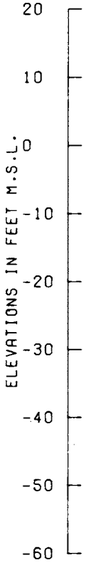
STA. 737+21
ON C/L LEVEE
31 AUG. 66

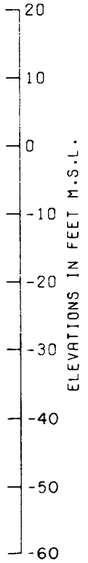


BORING NO. 5-E

STA. 757+20
ON C/L LEVEE
1 SEPT. 66







NOTE: Borings were made with a 1 7/8" I.D. core barrel sampler.
For locations of borings see plates 2 & 3.
See plate A for boring legend.

MISSISSIPPI RIVER – GULF OUTLET
MICHOUD CANAL, LA.

DESIGN MEMORANDUM NO. 1 – GENERAL DESIGN

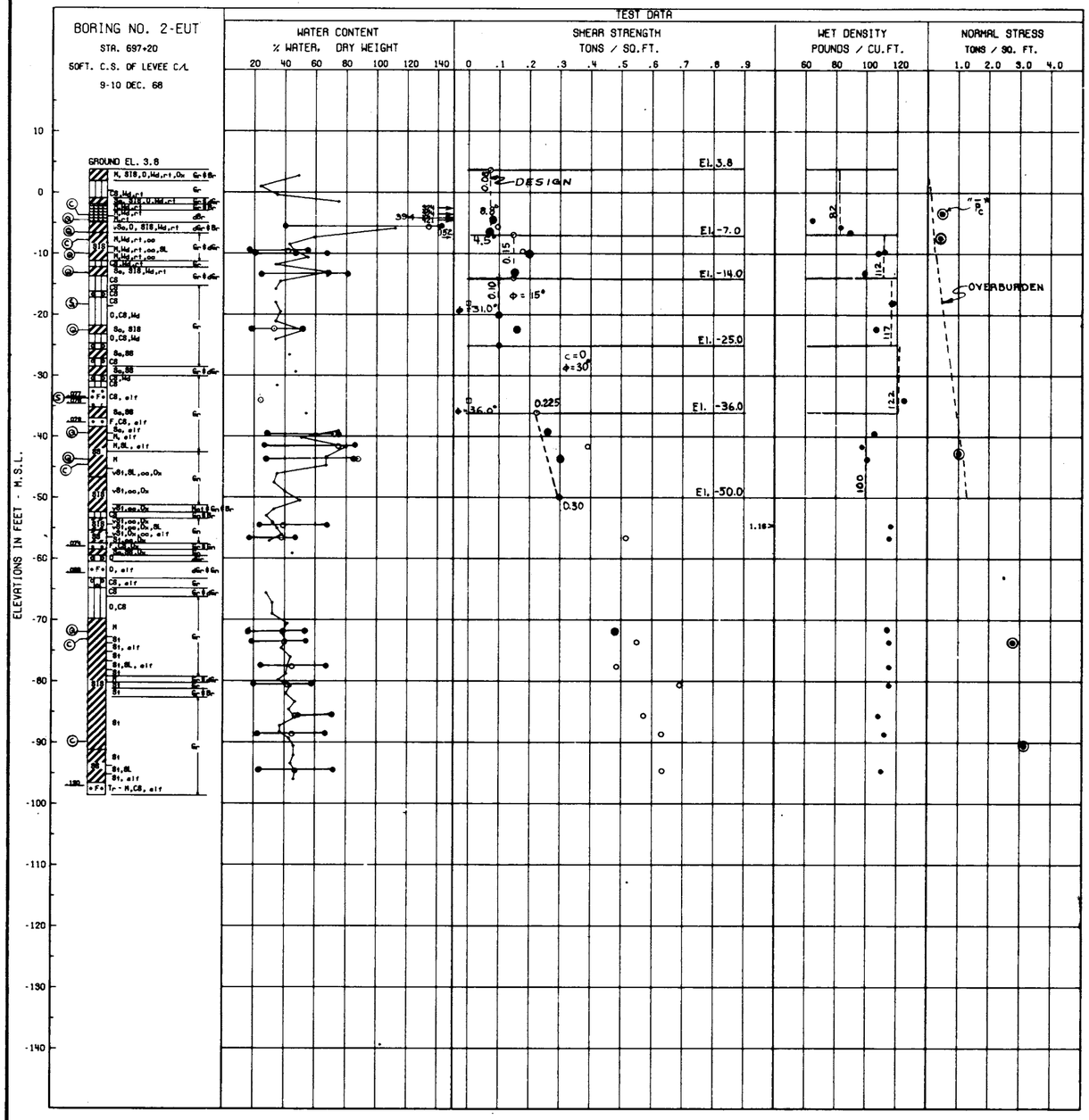
GENERAL TYPE SOIL BORINGS

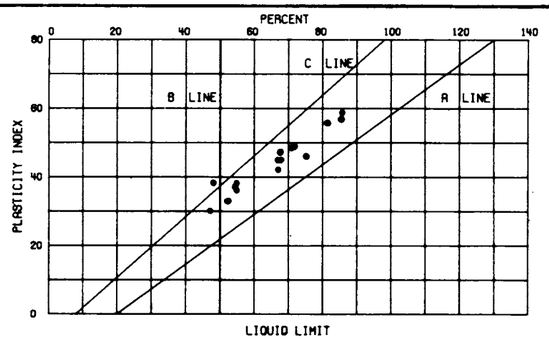
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

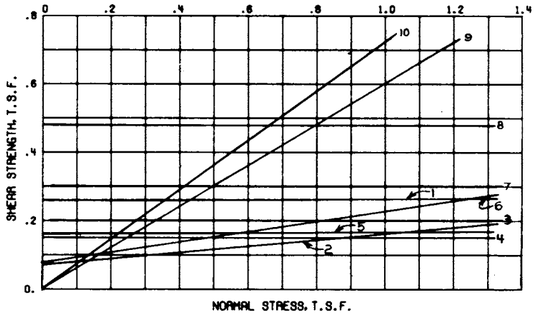
FILE NO. H-2-25340

PLATE 20



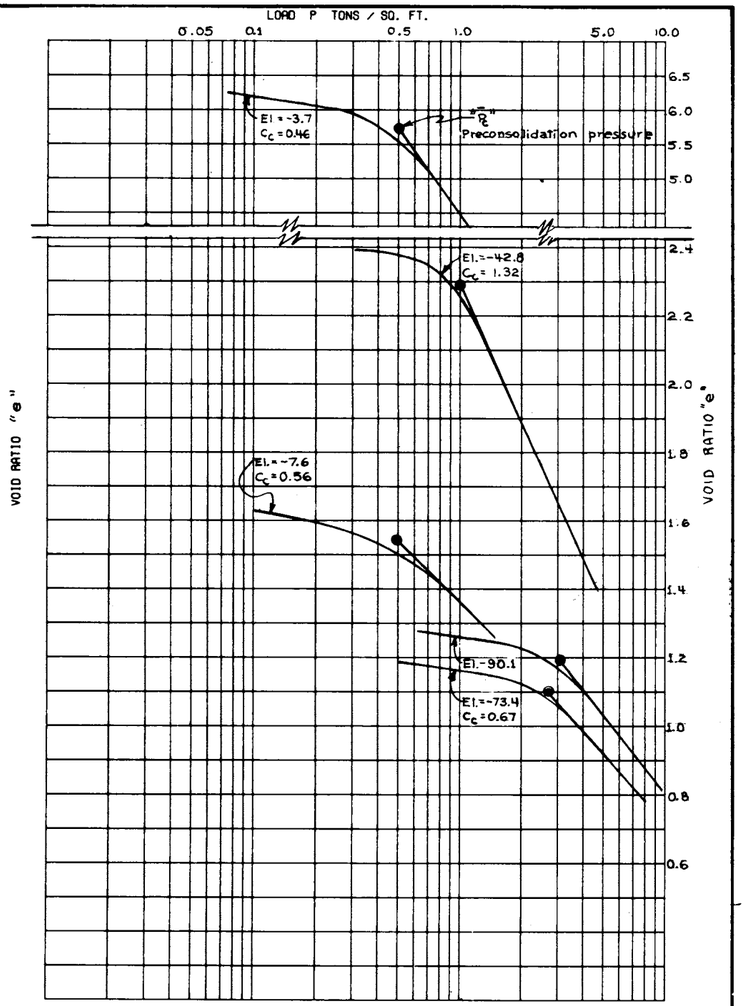


PLASTICITY CHART



SHEAR STRENGTH DATA

BORING NO.	ENVELOPE NO.	ENVELOPE EL.	TYPE	STRENGTH Φ	STRENGTH C - TSF	CLASS
2-EUT	1	- 4.6	Q	8.8°	0.08	CHO
	2	- 6.4		4.5°	0.07	CH
	3	- 10.0			0.20	CH
	4	- 13.1			0.15	CH
	5	-22.3		0	0.16	CH
	6	-39.3			0.26	CH
	7	-43.6			0.30	CH
	8	-71.8			0.48	CH
	9	-18.1	S	31.0°	0	ML
	10	-33.9		36.0°		SP



CONSOLIDATION DATA

⊕ - (UC) UNCONFINED COMPRESSION TEST
● - (Q) UNCONSOLIDATED - UNDRAINED SHEAR TEST
▲ - (R) CONSOLIDATED - UNDRAINED SHEAR TEST
⊡ - (S) CONSOLIDATED - DRAINED SHEAR TEST

BORINGS WERE TAKEN WITH A 5 INCH DIAMETER STEEL TUBE PISTON TYPE SAMPLER
FOR SOIL BORING LEGEND SEE PLATE A
FOR LOCATION OF BORINGS SEE PLATE 3
FOR GENERAL NOTES SEE PLATE 22

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA.
DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

UNDISTURBED BORING 2-EUT DATA

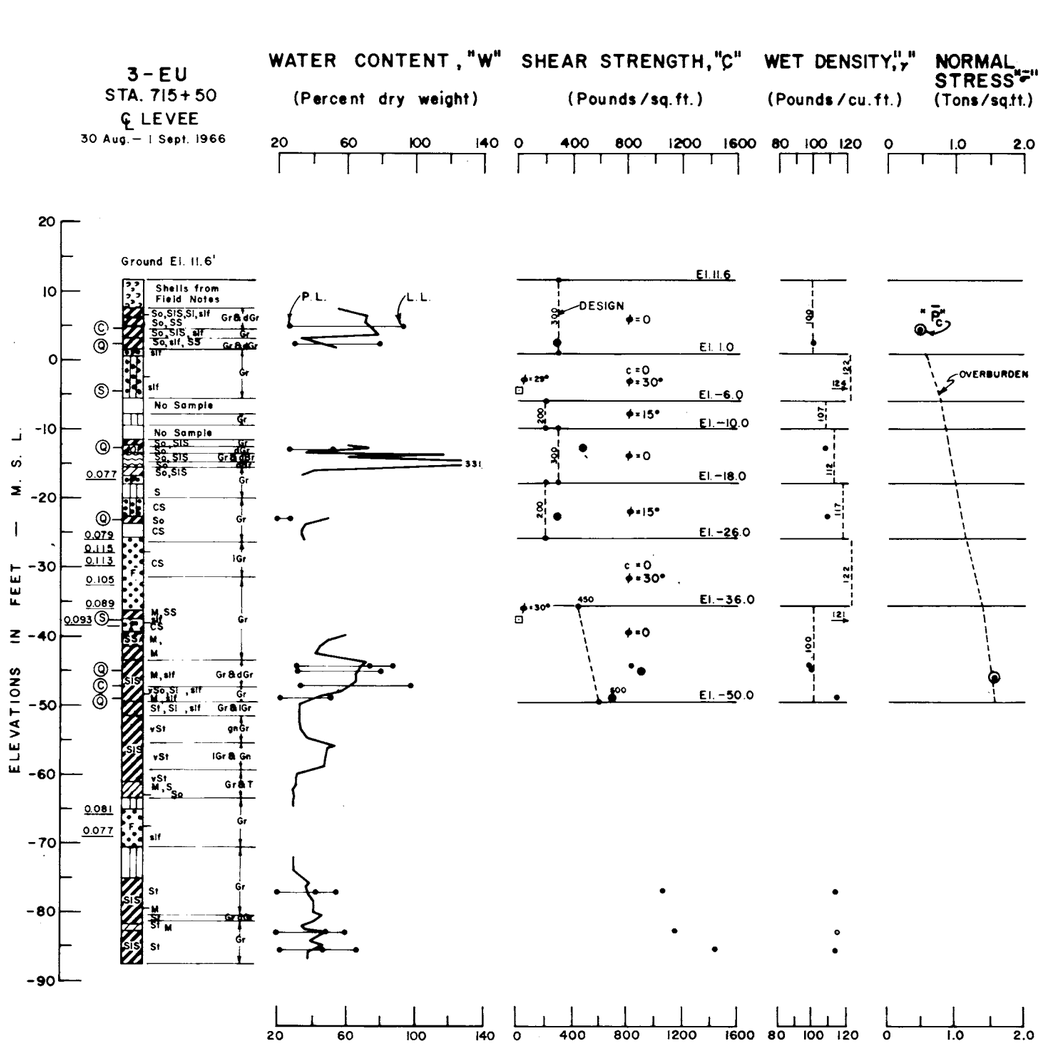
U.S. ARMY ENGINEER DISTRICT NEW ORLEANS
CORPS OF ENGINEERS

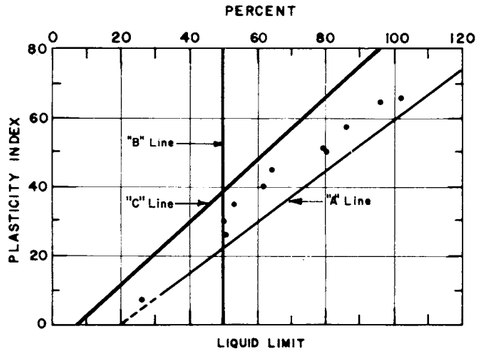
JUNE 1973

FILE NO. H-2-25340

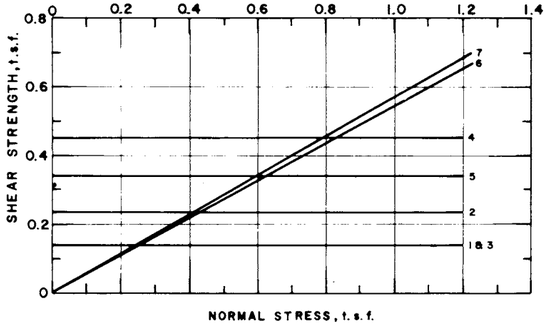
PLATE 21

3-EU
STA. 715+50
℄ LEVEE
30 Aug.– 1 Sept. 1966



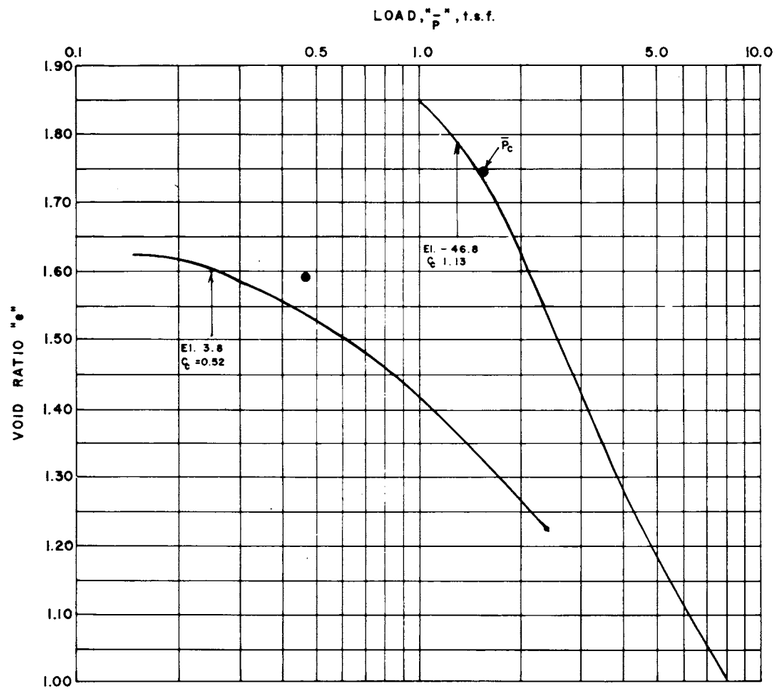


PLASTICITY CHART



ENVELOPE NO.	ENVELOPE EL.	TYPE	STRENGTH φ°	STRENGTH c (t.s.f.)	CLASS
1	2.1	Q	0	0.14	CH
2	-13.0	Q	0	0.23	CH
3	-23.0	Q	1	0.14	CL
4	-45.2	Q	1	0.45	CH
5	-49.2	Q	0	0.34	CH
6	-4.4	S	29	0.0	SM
7	-37.6	S	30	0.0	SP

SHEAR STRENGTH DATA



CONSOLIDATION DATA

GENERAL NOTES

- ° UC – Unconfined compression shear test
- ● Ⓠ – Unconsolidated undrained triaxial shear test
- ▲ Ⓡ – Consolidated undrained triaxial shear test
- ⊡ Ⓢ – Consolidated drained direct shear test
- Ⓒ – Consolidation test
- W – Natural water content
- L.L. – Liquid limit
- P.L. – Plastic limit
- c – Unit cohesion
- φ – Angle of friction
- γ – Unit weight of soil-water system
- σ̄ – Normal stress
- ◉ $\bar{p}_c$ – Preconsolidation pressure
- e – Void ratio
- C_c – Compression index
- O.B. – Overburden

For location of boring see plate 3

Borings were taken with a 5 inch diameter steel tube piston type sample.

See plate A for soil boring legend

MISSISSIPPI RIVER – GULF OUTLET
MICHOUD CANAL, LA.

DESIGN MEMORANDUM NO. 1 – GENERAL DESIGN

UNDISTURBED BORING 3-EU DATA

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

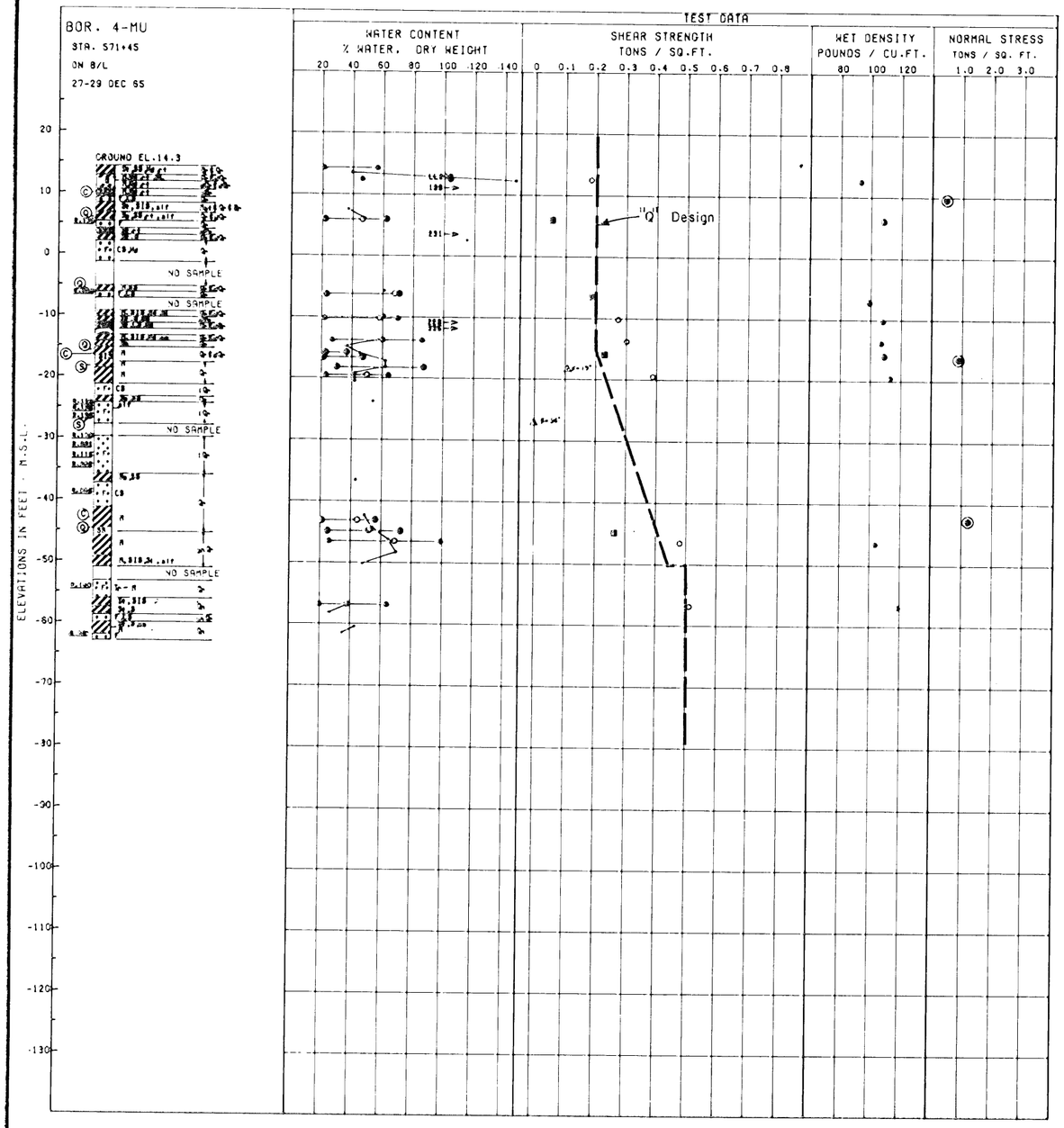
JUNE 1973

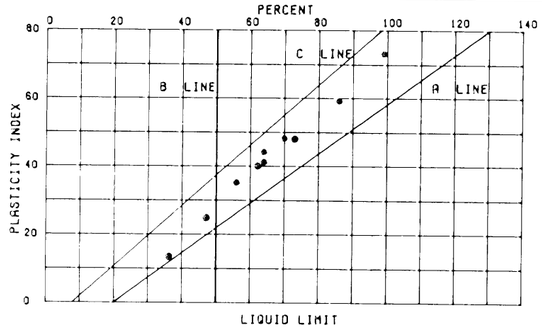
FILE NO. H-2-25340

PLATE 22

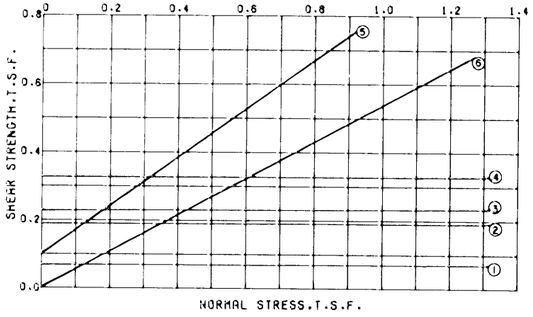
BOR. 4-MU
STA. 571+45
ON B/L
27-29 DEC 65

TEST DATA



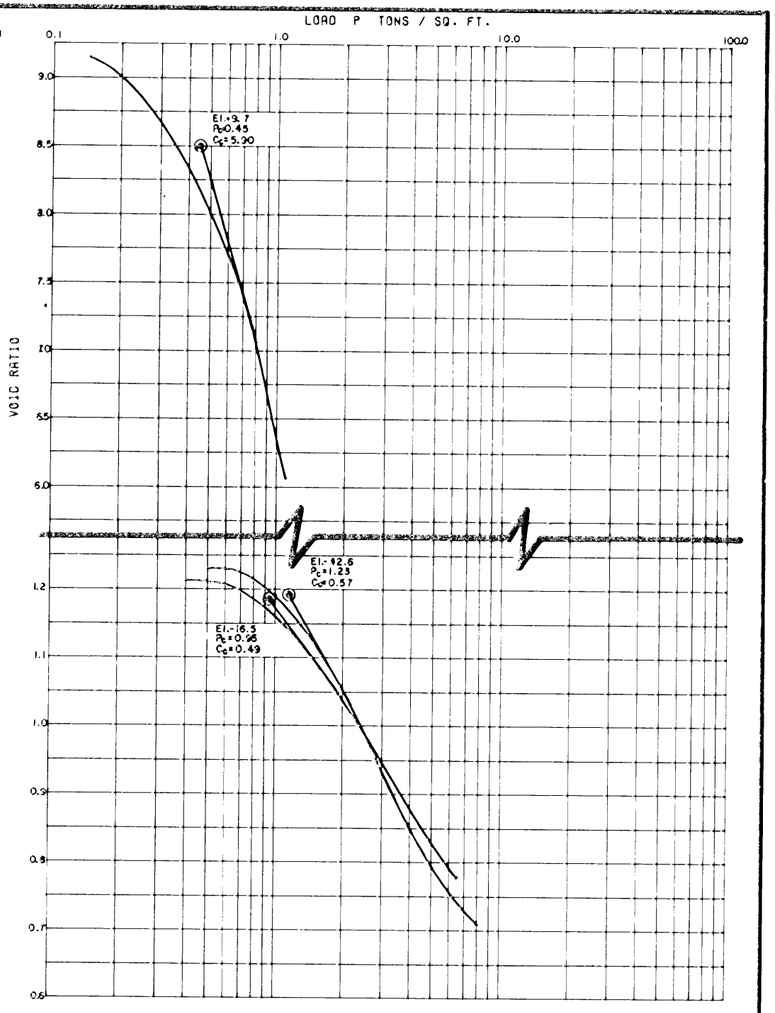


PLASTICITY CHART



SHEAR STRENGTH DATA

ENVELOPE NO.	ENVELOPE EL.	TYPE	STRENGTH Φ	STRENGTH C - TSF	CLASS
1	+5.0	Q	0	0.07	CH
2	-9.0	Q	0	0.19	CH
3	-15.8	Q	0	0.23	CL
4	-44.5	Q	0	0.33	CH
5	-18.1	S	13°	0.11	CH
6	-26.5	S	34°	0	SP



CONSOLIDATION DATA

○ - (UC) UNCONFINED COMPRESSION TEST
▨ - (Q) UNCONSOLIDATED - UNDRAINED SHEAR TEST
▲ - (R) CONSOLIDATED - UNDRAINED SHEAR TEST
△ - (S) CONSOLIDATED - DRAINED SHEAR TEST
BORINGS WERE TAKEN WITH A 3 INCH DIAMETER STEEL TUBE PISTON TYPE SAMPLER
FOR SOIL BORING LEGEND SEE PLATE A
FOR LOCATION OF BORINGS SEE PLATE 2

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA.
DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

UNDISTURBED BORING 4-MU DATA

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO. H-2-25340

PLATE 23

BOR. 4-MUT
STA. S75+15
60 FT. RT. B/L
6-9 MAY 56

GROUND EL. S.2

TEST DATA

WATER CONTENT
% WATER. DRY WEIGHT
20 40 60 80 100 120 140

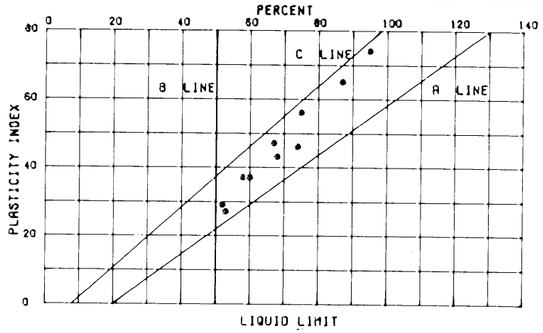
SHEAR STRENGTH
TONS / SQ.FT.
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8

WET DENSITY
POUNDS / CU.FT.
80 100 120

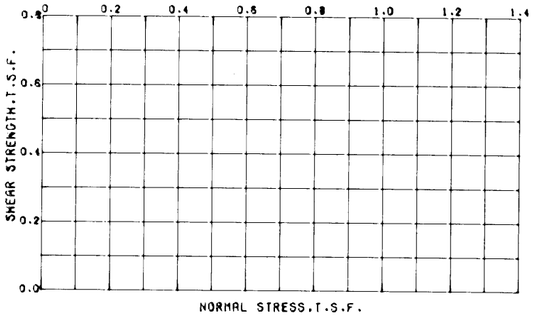
NORMAL STRESS
TONS / SQ. FT.
1.0 2.0 3.0

LL22
LL30
LL17
Q DESIGN

ELEVATIONS IN FEET - M.S.L.
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140

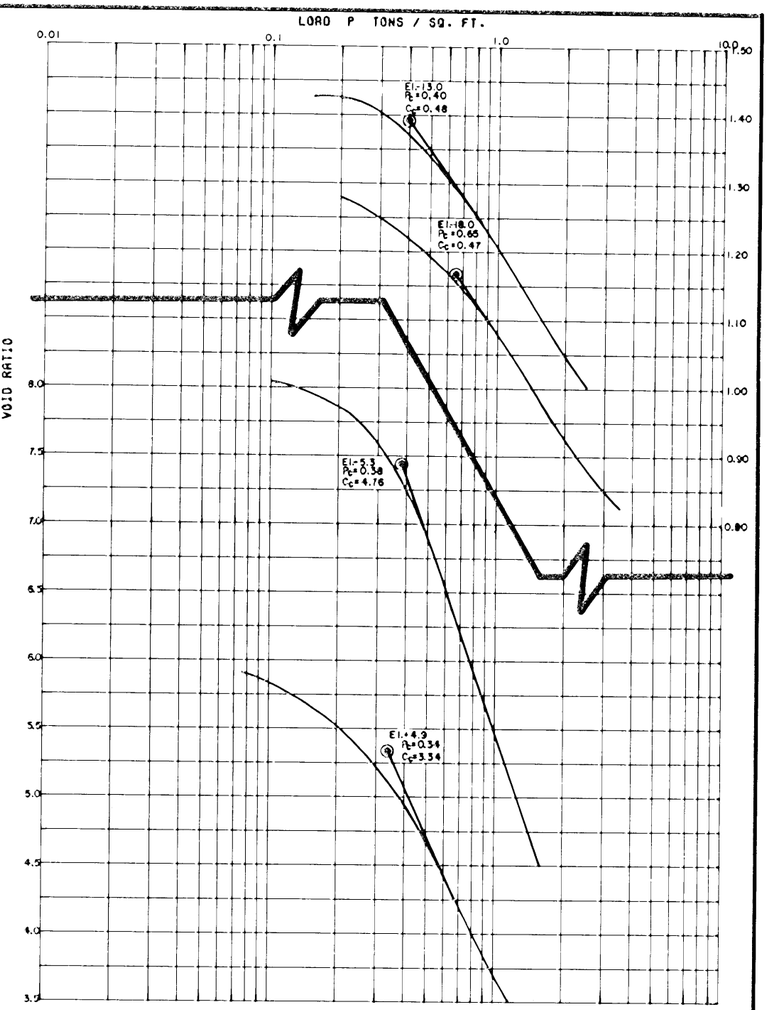


PLASTICITY CHART



SHEAR STRENGTH DATA

ENVELOPE NO.	ENVELOPE EL.	TYPE	STRENGTH Φ	STRENGTH C - TSF	CLASS



CONSOLIDATION DATA

○- (UC) UNCONFINED COMPRESSION TEST
⊞- (Q) UNCONSOLIDATED - UNDRAINED SHEAR TEST
⧋- (R) CONSOLIDATED - UNDRAINED SHEAR TEST
△- (S) CONSOLIDATED - DRAINED SHEAR TEST
BORINGS WERE TAKEN WITH A 5 INCH DIAMETER STEEL TUBE PISTON TYPE SAMPLER
FOR SOIL BORING LEGEND SEE PLATE A
FOR LOCATION OF BORINGS SEE PLATE 2

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA.

DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

UNDISTURBED BORING 4-MUT DATA

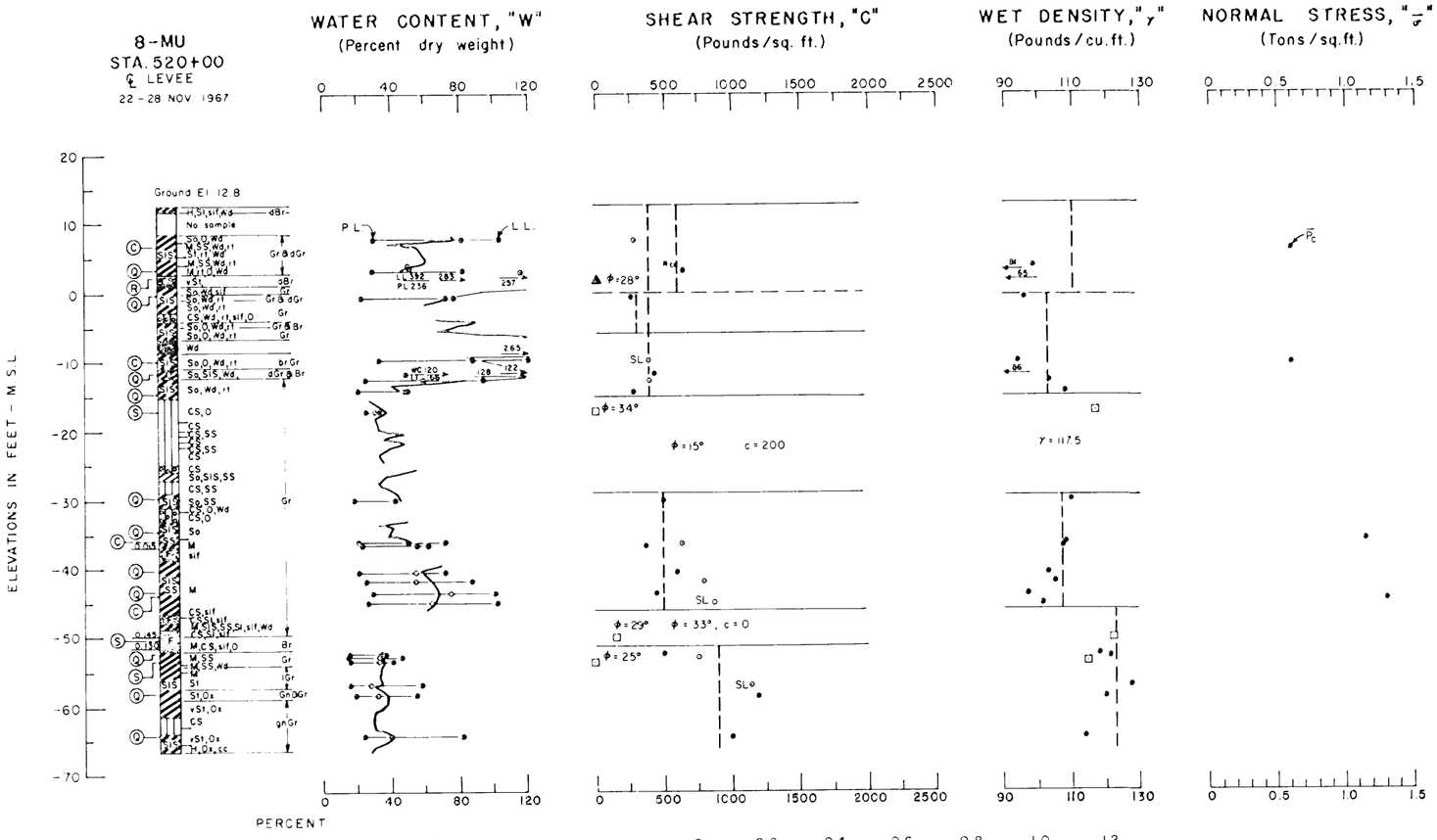
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

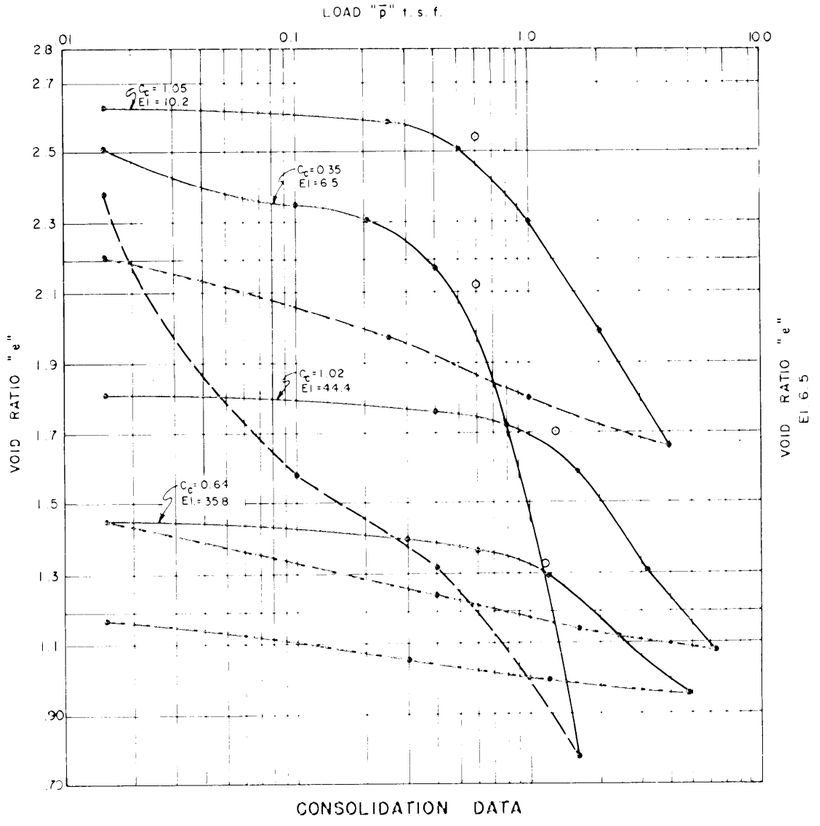
JUNE 1973

FILE NO. H-2-25340

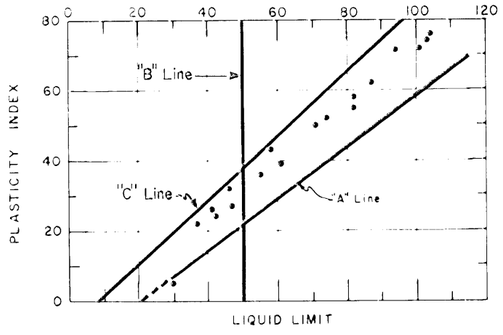
PLATE 24

8-MU
STA. 520+00
℄ LEVEE
22 - 28 NOV. 1967

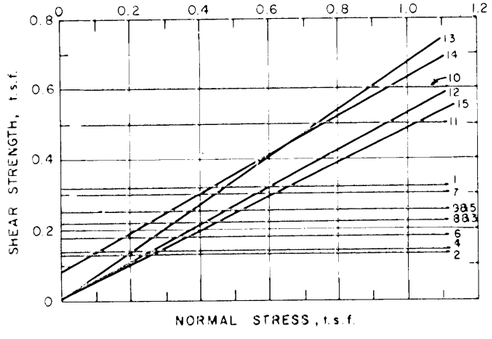




CONSOLIDATION DATA



PLASTICITY CHART



SHEAR STRENGTH DATA

ENVELOPE No.	El.	TYPE	STRENGTH φ°	STRENGTH (c, t.s.f.)	CLASS
1	+ 3.2		0	0.32	CH
2	- 0.5			0.13	CH
3	-11.5			0.22	CH
4	-14.2			0.14	CL
5	-23.9			0.25	CL
6	-36.4	Q		0.18	CL
7	-40.5			0.30	CH
8	-43.7			0.22	CH
9	-52.3			0.25	CL
10	-58.3			0.60	CH
11	-64.2		0	0.50	CH
12	+ 2.0	R	28	0.00	PI
13	-17.2		34	0.00	ML
14	-50.0	S	29	0.08	SM
15	-53.3		26	0.00	CL

GENERAL NOTES

- ○ UC - Uncontined compression shear test.
- ● Ⓠ - Unconsolidated undrained triaxial shear test.
- ▲ Ⓡ - Consolidated undrained triaxial shear test.
- □ Ⓢ - Consolidated drained direct shear test.
- Ⓒ - Consolidation test.
- w - Natural water content.
- L.L. - Liquid limit.
- P.L. - Plastic limit.
- c - Unit cohesion.
- φ - Angle of friction.
- γ - Unit weight of soil - water system.
- σ̄ - Normal stress.
- P̄c - Preconsolidation pressure.
- e - Void ratio.
- Cc - Compression index.
- O.B. Overburden.

NOTES: For soil boring legand see plate A
For location of boring see plate 2

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA.

DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

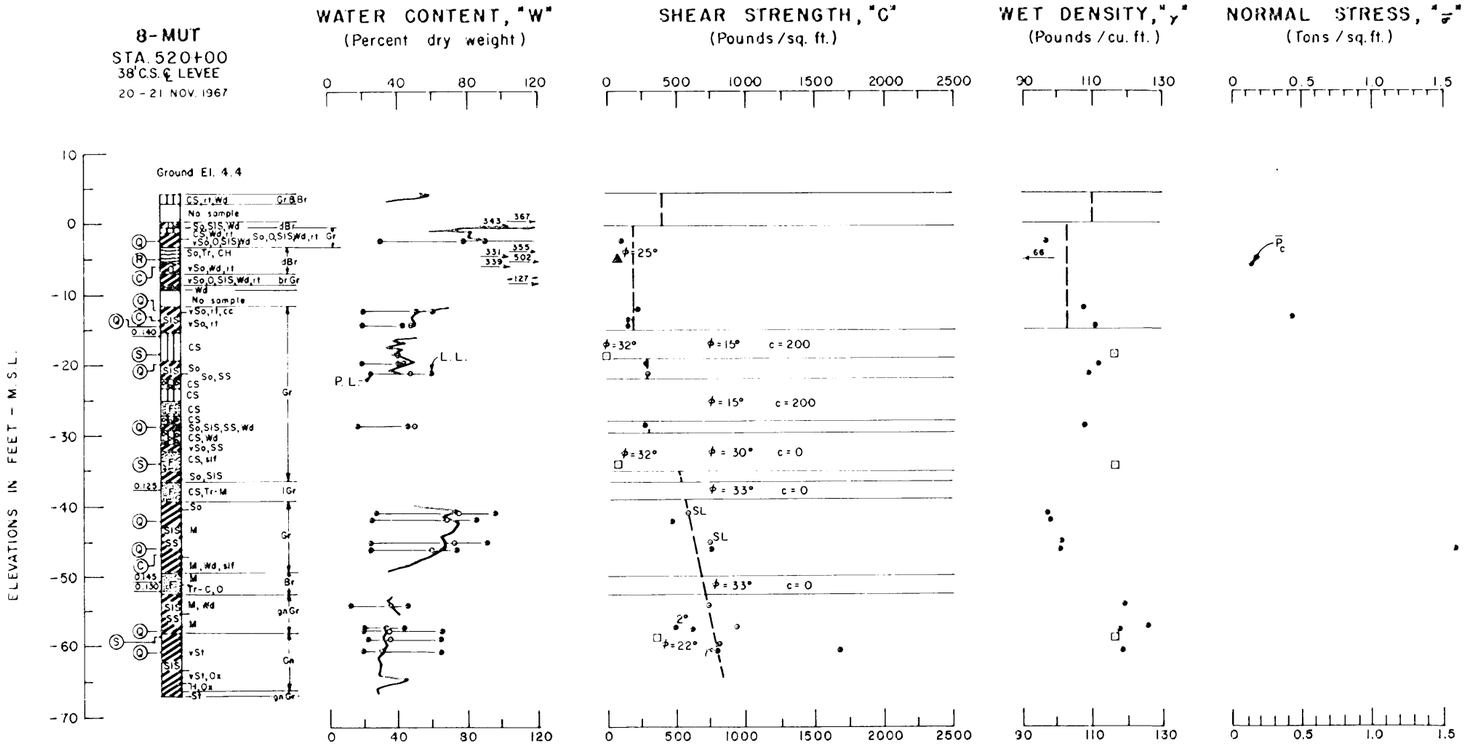
UNDISTURBED BORING 8-MU DATA

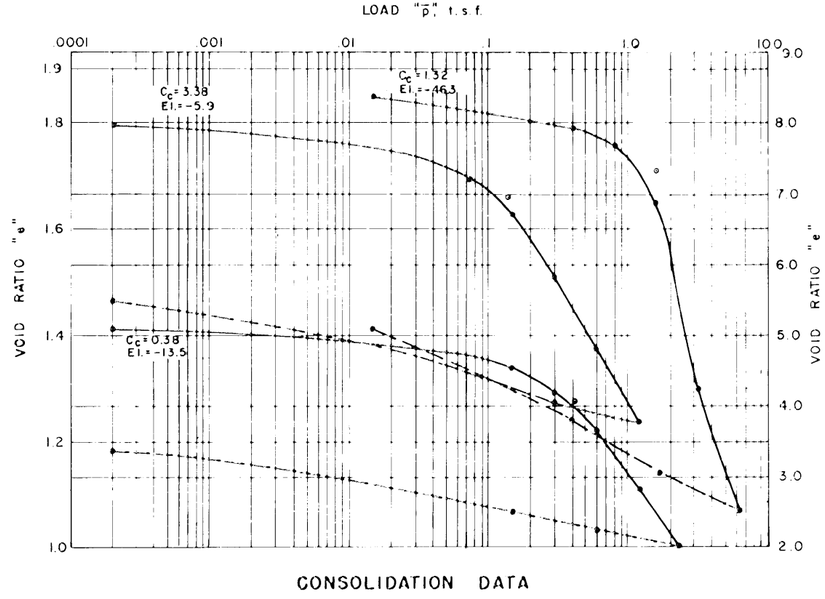
U.S. ARMY ENGINEER DISTRICT NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973 FILE NO. H-2-25340

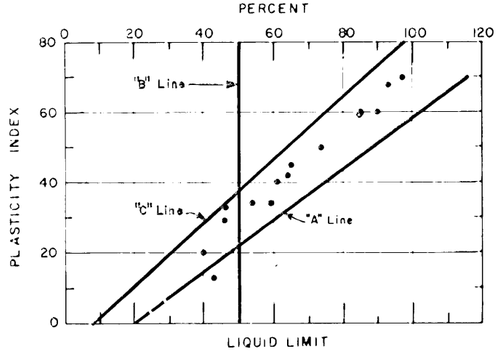
PLATE 25

8-MUT
STA. 520+00
38' C.S. ℄ LEVEE
20 - 21 NOV. 1967

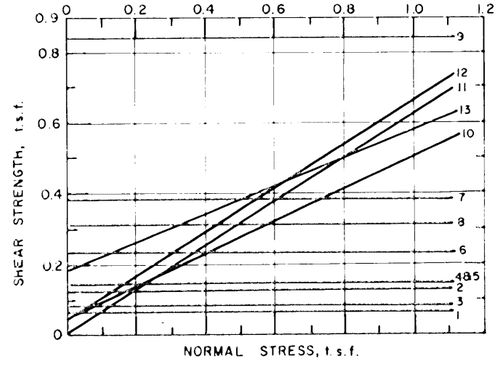




CONSOLIDATION DATA



PLASTICITY CHART



SHEAR STRENGTH DATA

ENVELOPE No.	El.	TYPE	STRENGTH φ°	STRENGTH c (t.s.f.)	CLASS
1	- 2.3		0	0.06	CH
2	-12.0			0.12	CH
3	-14.4			0.08	CH
4	-19.3			0.14	CH
5	-28.7	Q		0.14	CL
6	-42.4			0.23	CH
7	-46.3			0.38	CH
8	-57.7			0.31	CH
9	-60.8		0	0.84	CH
10	- 4.9	R	25	0.04	PT
11	-18.6		32	0.00	ML
12	-34.2	S	32	0.04	ML
13	-58.8		22	0.18	CH

NOTE:
For general notes see plate 25
For soil boring legend see plate A
For location of boring see plate 2

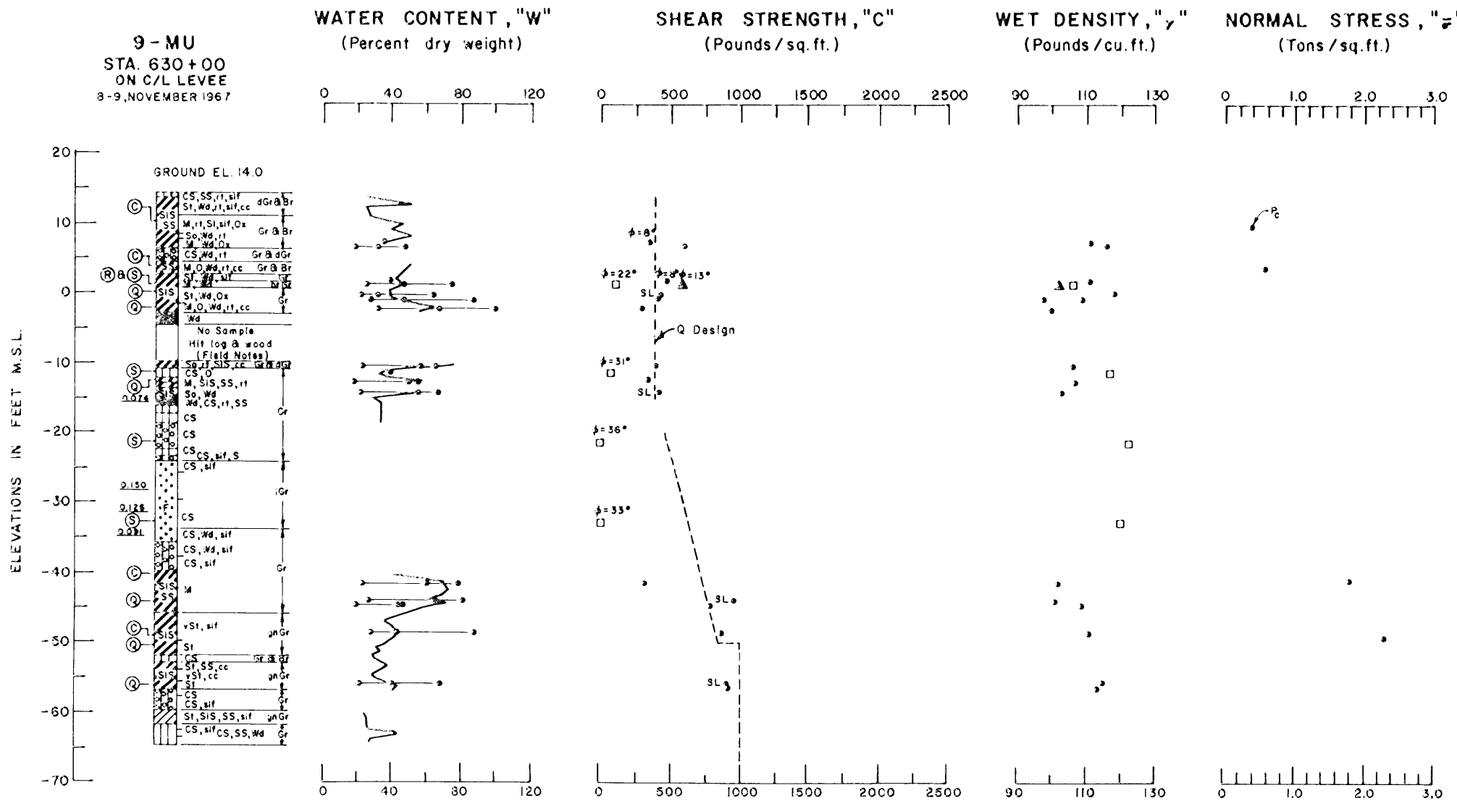
MISSISSIPPI RIVER-GULF OUTLET
MICHOUD CANAL, LA.
DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

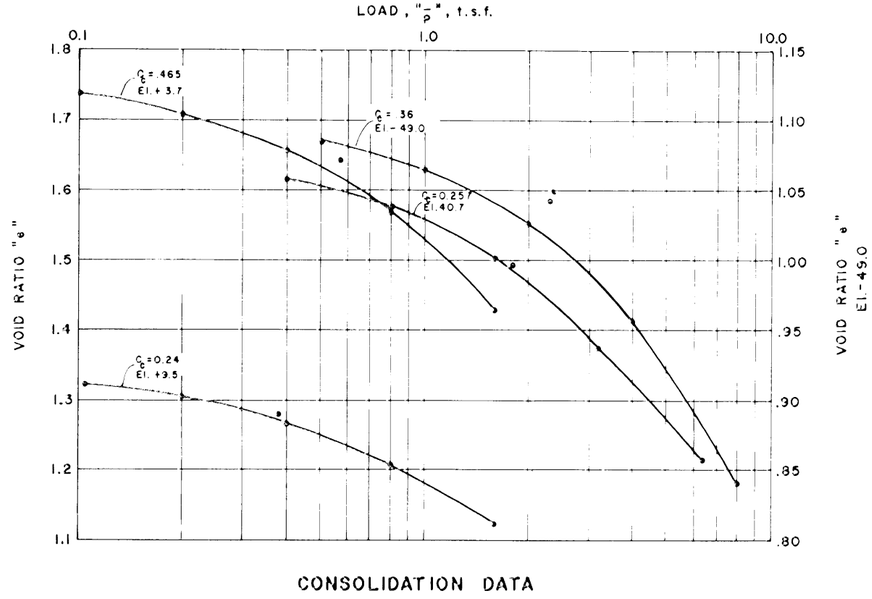
UNDISTURBED BORING 8-MUT DATA

U.S. ARMY ENGINEER DISTRICT NEW ORLEANS
CORPS OF ENGINEERS
JUNE 1973
FILE NO. 11-2-25340

PLATE 26

9-MU
STA. 630+00
ON C/L LEVEE
8-9, NOVEMBER 1967

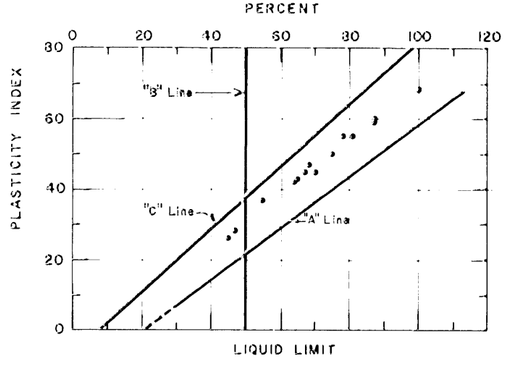




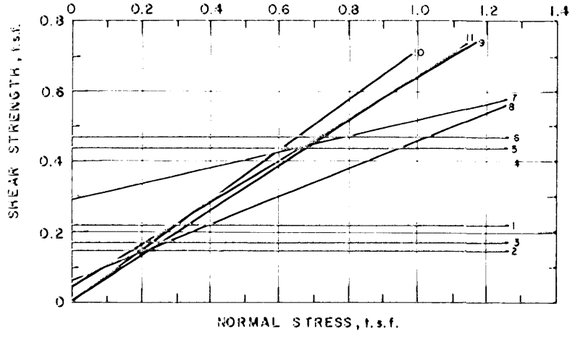
CONSOLIDATION DATA

- ⊘ - (UC) UNCONFINED COMPRESSION TEST
- ◑ - (Q) UNCONSOLIDATED-UNDRAINED SHEAR TEST
- ▲ - (R) CONSOLIDATED - UNDRAINED SHEAR TEST
- ⊡ - (S) CONSOLIDATED DRAINED SHEAR TEST

BORINGS WERE TAKEN WITH 5 INCH DIAMETER STEEL TUBE PISTON TYPE SAMPLER
FOR SOIL BORING LEGEND SEE PLATE A
FOR LOCATION OF BORINGS SEE PLATE 3
FOR GENERAL NOTES SEE PLATE 22



PLASTICITY CHART



SHEAR STRENGTH DATA

ENVELOPE NO.	EL.	TYPE	STRENGTH φ°	STRENGTH C (t.s.f.)	CLASS
1	- 0.9	Q	0.00	0.22	CH
2	- 2.3		0.00	0.15	CH
3	-12.6		0.00	0.17	CH
4	-44.3		0.00	0.40	CL
5	-48.2		0.00	0.44	CH
6	-56.1		0.00	0.47	CH
7	+ 1.1	R	13	0.29	CH
8	+ 1.1	S	22	0.06	CH
9	-11.2		31	0.04	CL
10	-21.2		36	0.00	SM
11	-32.7		33	0.00	SM

MISSISSIPPI RIVER-GULF OUTLET
MICHOUD CANAL, LA.

DESIGN MEMORANDUM NO. 1-GENERAL DESIGN

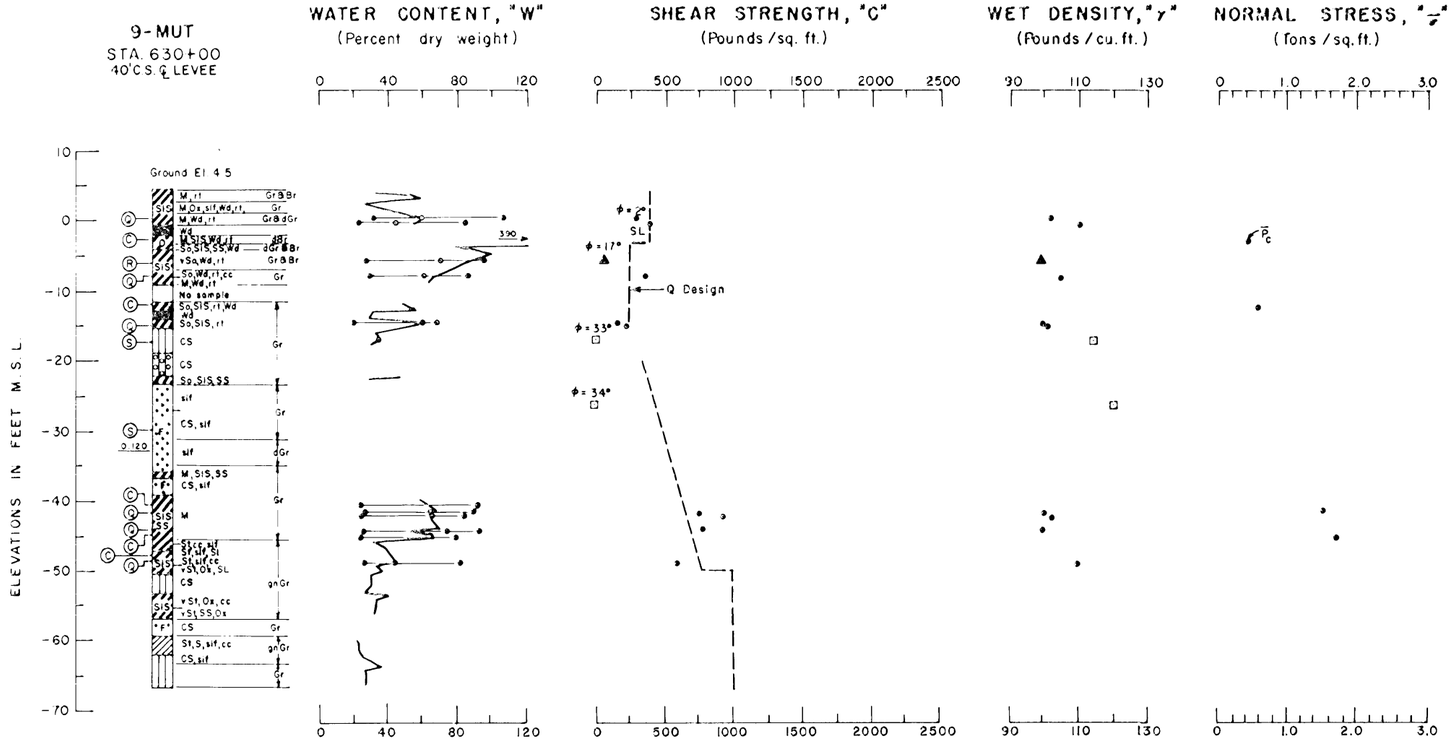
UNDISTURBED BORING 9-MU DATA

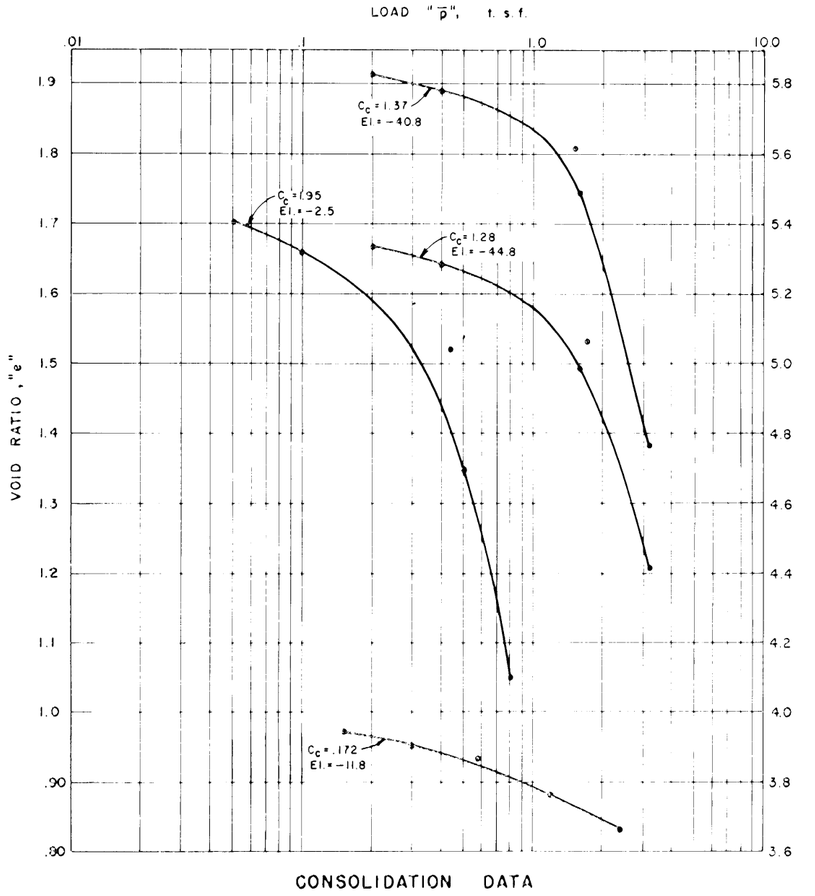
U.S. ARMY ENGINEER DISTRICT NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973 FILE NO. H-2-25340

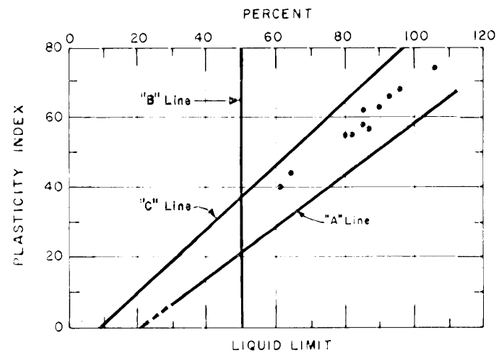
PLATE 27

9-MUT
STA. 630+00
40' C.S. ℄ LEVEE

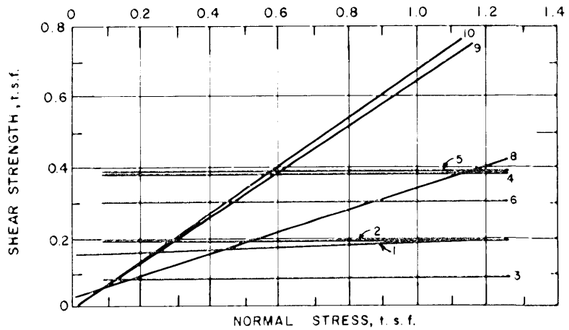




CONSOLIDATION DATA



PLASTICITY CHART



SHEAR STRENGTH DATA

ENVELOPE No.	ENVELOPE El.	TYPE	STRENGTH φ°	STRENGTH c (t.s.f.)	CLASS
1	0.2	Q	2.00	0.15	CH
2	- 7.9		0.00	0.19	CH
3	-14.2			0.08	CH
4	-41.5			0.38	CH
5	-43.8			0.39	CH
6	-48.7		0.00	0.30	CH
7	- 5.5	R	17	0.03	CH
8	-16.9	S	33	0.00	ML
9	-26.0		34	0.00	SM

○ - (UC) UNCONFINED COMPRESSION TEST
● - (Q) UNCONSOLIDATED-UNDRAINED SHEAR TEST
▲ - (R) CONSOLIDATED-UNDRAINED SHEAR TEST
⊡ - (S) CONSOLIDATED DRAINED SHEAR TEST

BORINGS WERE TAKEN WITH 5 INCH DIAMETER STEEL TUBE PISTON TYPE SAMPLER
FOR SOIL BORING LEGEND SEE PLATE A
FOR LOCATION OF BORINGS SEE PLATE 3
FOR GENERAL NOTES SEE PLATE 22

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA.
DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

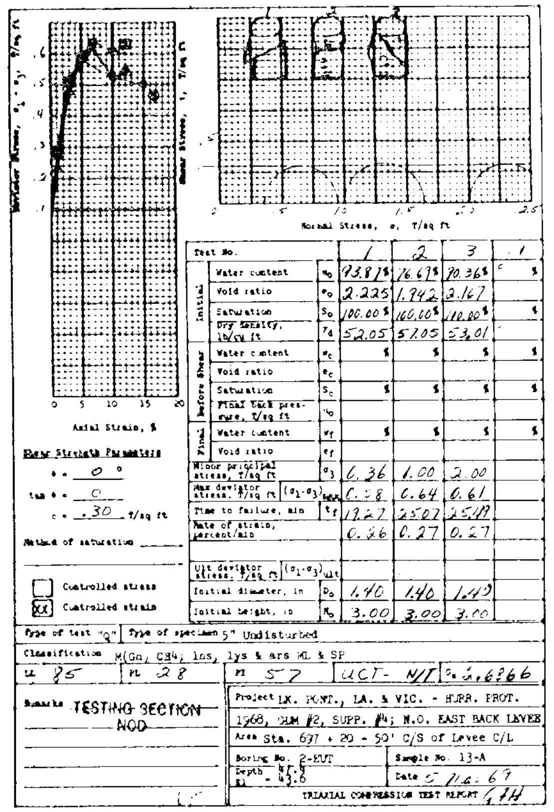
UNDISTURBED BORING 9-MUT DATA

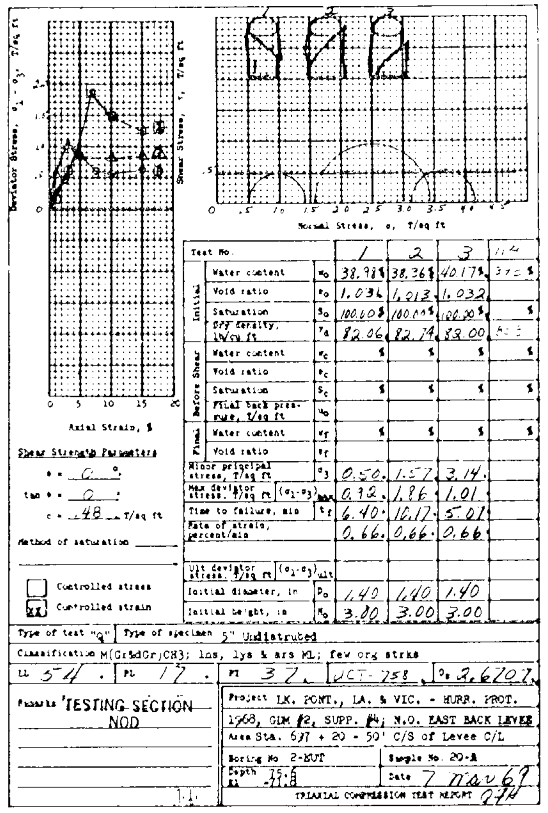
U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

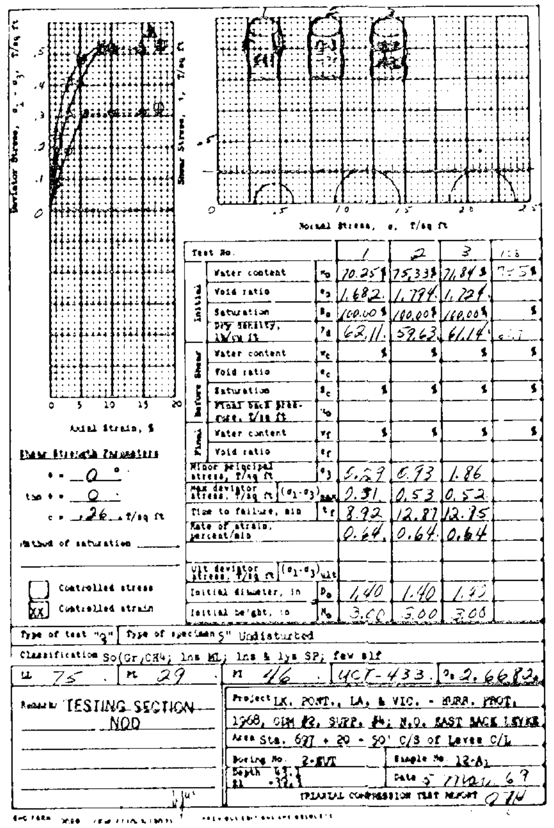
JUNE 1973

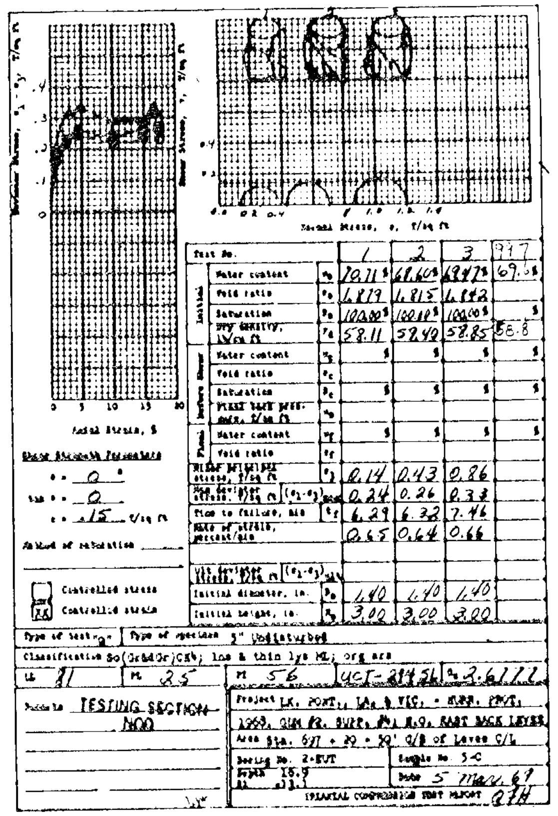
FILE NO. H-2-25340

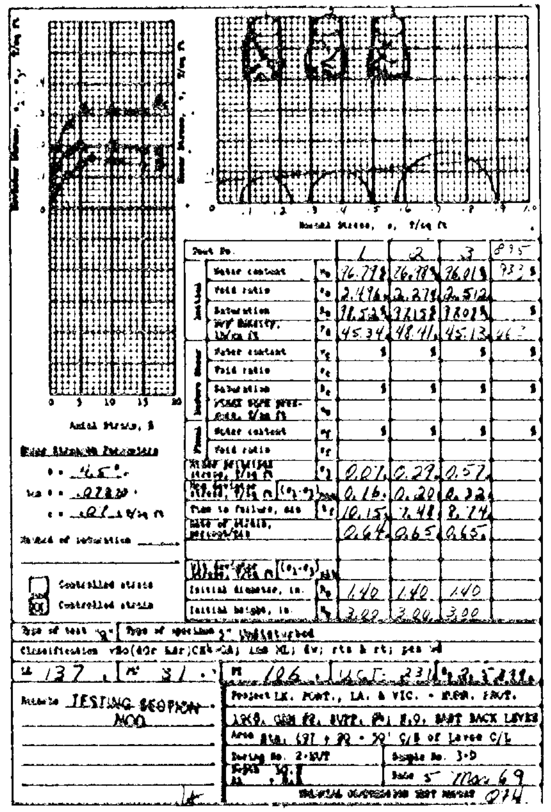
PLATE 28

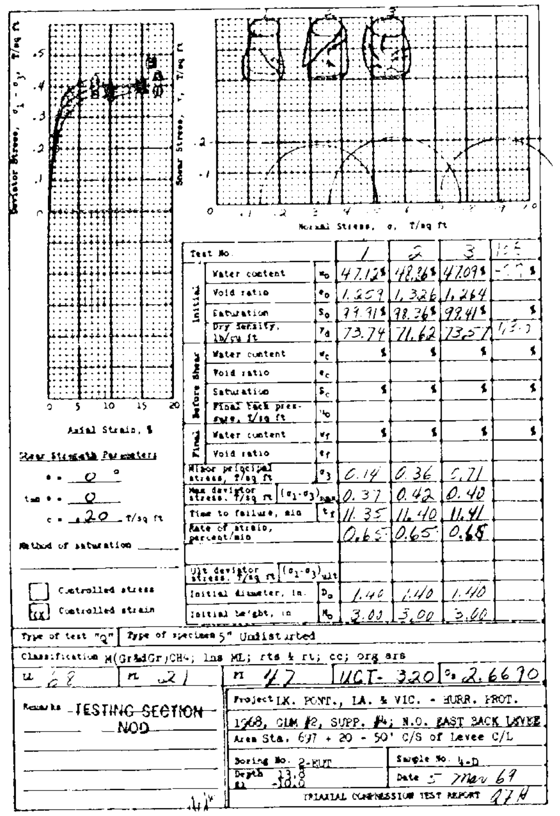


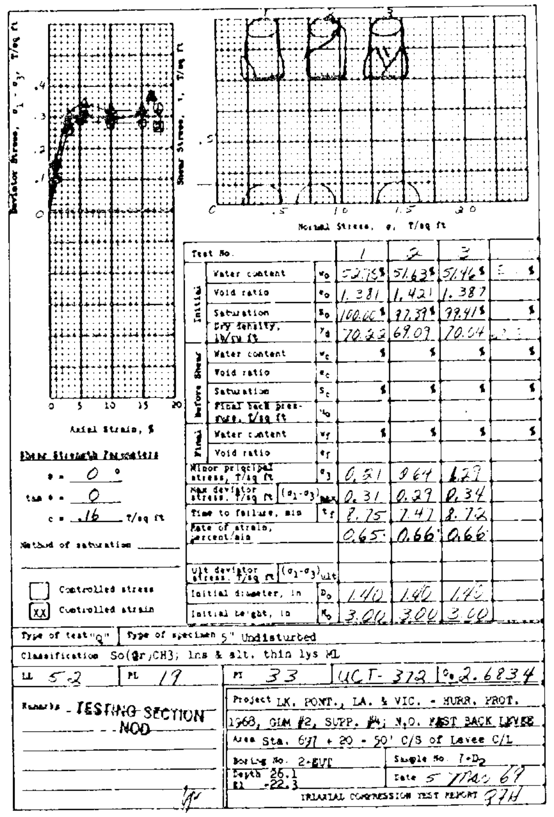


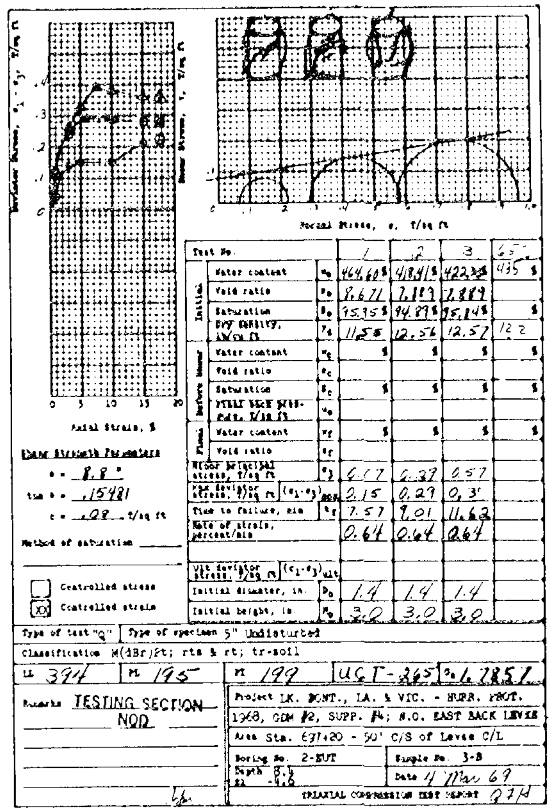


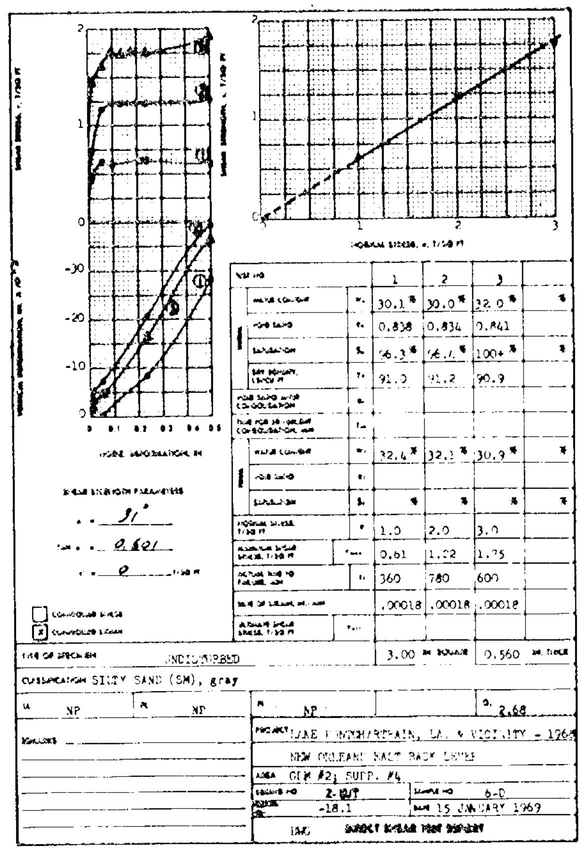


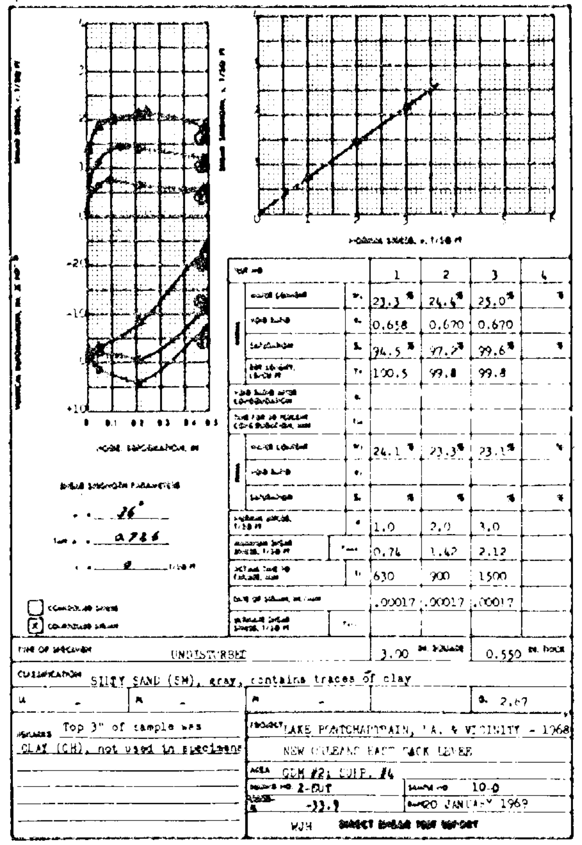












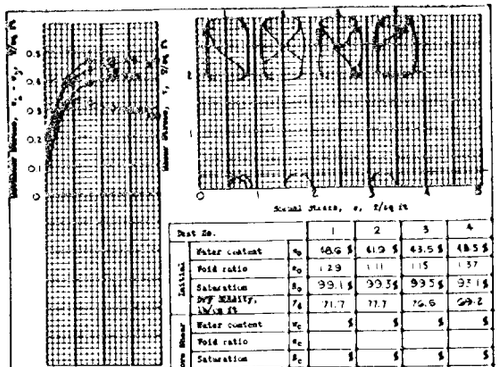
MISSISSIPPI RIVER – GULF OUTLET
MICHOUD CANAL, LA.

DESIGN MEMORANDUM NO. 1 – GENERAL DESIGN

DETAIL SHEAR STRENGTH DATA
BORING 2-EUT

U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973 FILE NO. H-2-25340



Test No.			1	2	3	4
Initial	Water content	w_o	58.6 %	61.9 %	63.5 %	68.5 %
	Void ratio	e_o	1.29	1.11	1.15	1.37
	Saturation	S_o	99.1 %	99.5 %	99.5 %	97.1 %
	Dry density, lb/cu ft	γ_d	71.7	77.7	76.6	69.2
Before Shear	Water content	w_c	%	%	%	%
	Void ratio	e_c				
	Saturation	S_c	%	%	%	%
	Final shear pressure, T/sq ft	σ_3				
Final	Water content	w_f	%	%	%	%
	Void ratio	e_f				
	Minor principal stress, T/sq ft	σ_3	0.50	1.50	3.00	0.50
	Max deviator stress, T/sq ft	$(\sigma_1-\sigma_3)_{max}$	0.33	0.47	0.47	0.41
	Time to failure, min	t_f	15	50	17	56
	Rate of strain, percent/min		0.40	0.30	0.47	0.40
	Ult deviator stress, T/sq ft	$(\sigma_1-\sigma_3)_{ult}$	0.28	0.47	0.47	0.41
	Initial diameter, in.	D_o	1.41	1.41	1.41	1.41
	Initial height, in	H_o	3.00	3.00	3.00	3.00

Shear Strength Parameters
ϕ = 0 °
tan ϕ = 0
c = 0.25 T/sq ft

Method of saturation ____

Controlled stress
Controlled strain

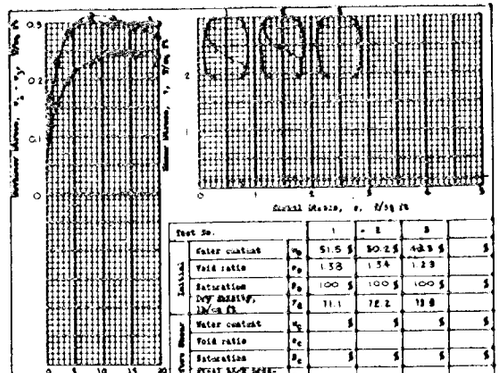
Type of test Q | Type of specimen UNDISTURBED

Classification GRAY YEL. SILTY CLAY (CH) , SLIGHTLY SANDY WITH SHELL FRAG. THAT

LL ? | PL 15 | PI 26 | D_s ?

Remarks

Project HURRICANE PROTECTION, N.O. & VIC.
Area
Boring No. 3-EU | Sample No. 2-D
Depth -18.0 | Date 12/2/66
TRIAXIAL COMPRESSION TEST REPORT



Test No.			1	2	3	
Initial	Water content	w_o	51.5 %	50.2 %	48.5 %	%
	Void ratio	e_o	1.38	1.34	1.29	
	Saturation	S_o	100 %	100 %	100 %	%
	Dry density, lb/cu ft	γ_d	71.1	72.2	73.8	
Before Shear	Water content	w_c	%	%	%	%
	Void ratio	e_c				
	Saturation	S_c	%	%	%	%
	Final shear pressure, T/sq ft	σ_3				
Final	Water content	w_f	%	%	%	%
	Void ratio	e_f				
	Minor principal stress, T/sq ft	σ_3	0.50	1.50	3.00	
	Max deviator stress, T/sq ft	$(\sigma_1-\sigma_3)_{max}$	0.24	0.50	0.32	
	Time to failure, min	t_f	24	18	20	
	Rate of strain, percent/min		0.50	0.67	0.60	
	Ult deviator stress, T/sq ft	$(\sigma_1-\sigma_3)_{ult}$	0.24	0.23	0.30	
	Initial diameter, in.	D_o	1.41	1.41	1.41	
	Initial height, in	H_o	3.00	3.00	3.00	

Shear Strength Parameters
ϕ = 0 °
tan ϕ = 0
c = 0.19 T/sq ft

Method of saturation ____

Controlled stress
Controlled strain

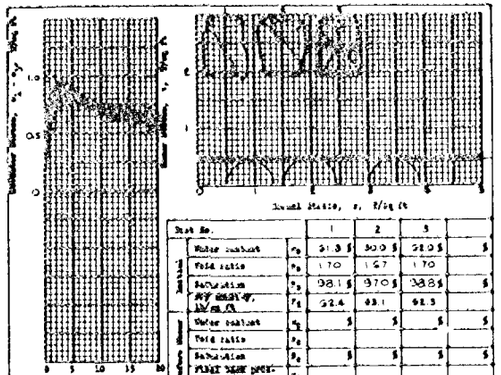
Type of test Q | Type of specimen UNDISTURBED

Classification GRAY CLAY (CL-ML) , WITH SILT LAMINATIONS

LL 26 | PL 19 | PI 7 | D_s 2.71

Remarks

Project HURRICANE PROTECTION, N.O. & VIC.
Area
Boring No. 3-UE | Sample No. 8-D1
Depth -23.0 | Date 12/2/66
TRIAXIAL COMPRESSION TEST REPORT



Test No.			1	2	3	
Initial	Water content	w_o	31.3 %	30.0 %	28.0 %	%
	Void ratio	e_o	1.70	1.67	1.70	
	Saturation	S_o	98.1 %	97.0 %	88.8 %	%
	Dry density, lb/cu ft	γ_d	92.4	93.1	92.3	
Before Shear	Water content	w_c	%	%	%	%
	Void ratio	e_c				
	Saturation	S_c	%	%	%	%
	Final shear pressure, T/sq ft	σ_3				
Final	Water content	w_f	%	%	%	%
	Void ratio	e_f				
	Minor principal stress, T/sq ft	σ_3	0.50	1.50	3.00	
	Max deviator stress, T/sq ft	$(\sigma_1-\sigma_3)_{max}$	0.33	0.28	0.00	
	Time to failure, min	t_f	15	15	3	
	Rate of strain, percent/min		0.47	0.15	0.17	
	Ult deviator stress, T/sq ft	$(\sigma_1-\sigma_3)_{ult}$	0.60	0.66	0.68	
	Initial diameter, in.	D_o	1.41	1.41	1.41	
	Initial height, in	H_o	3.00	3.00	3.00	

Shear Strength Parameters
ϕ = 0 °
tan ϕ = 0
c = 0.15 T/sq ft

Method of saturation ____

Controlled stress
Controlled strain

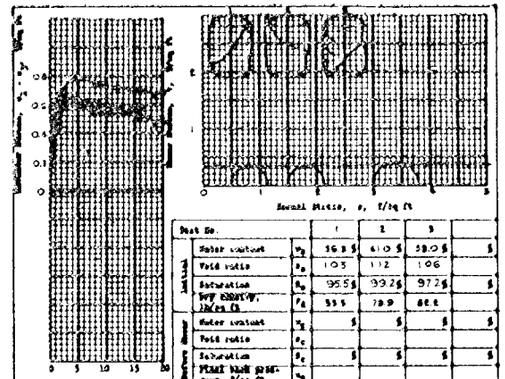
Type of test Q | Type of specimen UNDISTURBED

Classification GRAY CLAY (CH) , WITH SILT & VERY FINE SAND SEAMS

LL 80 | PL 50 | PI 30 | D_s 2.70

Remarks

Project HURRICANE PROTECTION, N.O. & VIC.
Area
Boring No. 3-EU | Sample No. 14-3
Depth -45.2 | Date 12/8/66
TRIAXIAL COMPRESSION TEST REPORT



Test No.			1	2	3	
Initial	Water content	w_o	36.3 %	41.0 %	38.0 %	%
	Void ratio	e_o	1.05	1.12	1.06	
	Saturation	S_o	95.5 %	99.2 %	97.2 %	%
	Dry density, lb/cu ft	γ_d	93.5	89.9	88.8	
Before Shear	Water content	w_c	%	%	%	%
	Void ratio	e_c				
	Saturation	S_c	%	%	%	%
	Final shear pressure, T/sq ft	σ_3				
Final	Water content	w_f	%	%	%	%
	Void ratio	e_f				
	Minor principal stress, T/sq ft	σ_3	0.50	1.50	3.00	
	Max deviator stress, T/sq ft	$(\sigma_1-\sigma_3)_{max}$	0.44	0.63	0.18	
	Time to failure, min	t_f	15	16	34	
	Rate of strain, percent/min		0.88	0.19	0.12	
	Ult deviator stress, T/sq ft	$(\sigma_1-\sigma_3)_{ult}$	0.52	0.56	0.70	
	Initial diameter, in.	D_o	1.41	1.41	1.41	
	Initial height, in	H_o	3.00	3.00	3.00	

Shear Strength Parameters
ϕ = 0 °
tan ϕ = 0
c = 0.28 T/sq ft

Method of saturation ____

Controlled stress
Controlled strain

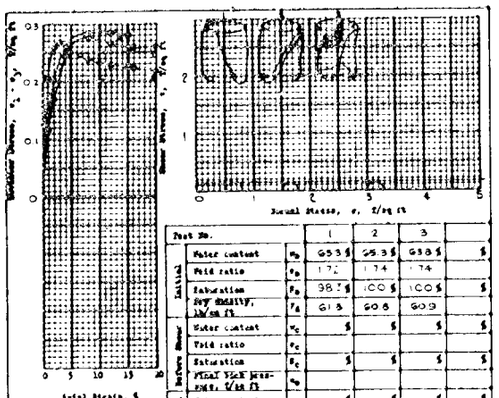
Type of test Q | Type of specimen UNDISTURBED

Classification GRAY CLAY (CH) WITH SAND POCKETS & SHELL FRAGMENTS

LL 50 | PL 22 | PI ?0 | D_s 2.71

Remarks

Project HURRICANE PROTECTION, N.O. & VIC.
Area
Boring No. 3-EU | Sample No. 15-B
Depth -49.2 | Date 12/5/66
TRIAXIAL COMPRESSION TEST REPORT



Test No.			1	2	3	
Initial	Water content	w_o	65.3 %	65.3 %	68.8 %	%
	Void ratio	e_o	1.72	1.74	1.74	
	Saturation	S_o	98.5 %	100 %	100 %	%
	Dry density, lb/cu ft	γ_d	67.5	67.8	66.9	
Before Shear	Water content	w_c	%	%	%	%
	Void ratio	e_c				
	Saturation	S_c	%	%	%	%
	Final shear pressure, T/sq ft	σ_3				
Final	Water content	w_f	%	%	%	%
	Void ratio	e_f				
	Minor principal stress, T/sq ft	σ_3	0.50	1.50	3.00	
	Max deviator stress, T/sq ft	$(\sigma_1-\sigma_3)_{max}$	0.28	0.27	0.29	
	Time to failure, min	t_f	18	7	61	
	Rate of strain, percent/min		0.40	0.38	1.31	
	Ult deviator stress, T/sq ft	$(\sigma_1-\sigma_3)_{ult}$	0.26	0.22	0.27	
	Initial diameter, in.	D_o	1.41	1.41	1.41	
	Initial height, in	H_o	3.00	3.00	3.00	

Shear Strength Parameters
ϕ = 0 °
tan ϕ = 0
c = 0.14 T/sq ft

Method of saturation ____

Controlled stress
Controlled strain

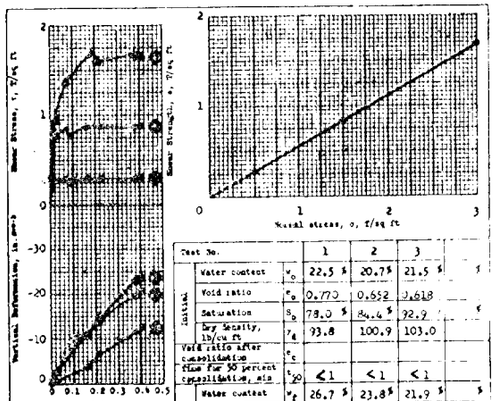
Type of test Q | Type of specimen UNDISTURBED

Classification GRAY CLAY(CH), w/ SAND POCKETS

LL ? | PL ? | PI ? | D_s 2.67

Remarks # ALL OF SAMPLE REQUIRED TO TEST 5 SPECIMENS SPECIFIED; NOT TESTED WITH LONG AXIS PERPENDICULAR TO VERTICAL AXIS OF SAMPLE. ALL 5 SPECIMENS REP. REPRESENTATIVE OF CLAY, NOT SAND

Project HURRICANE PROTECTION, N.O. & VIC.
Area
Boring No. 3-EU | Sample No. 2-C
Depth +2.1 | Date 12/1/66
TRIAXIAL COMPRESSION TEST REPORT



Test No.			1	2	3	
Initial	Water content	w_o	22.5 %	20.7 %	21.5 %	%
	Void ratio	e_o	0.770	0.652	0.618	
	Saturation	S_o	78.0 %	84.4 %	92.9	%
	Dry density, lb/cu ft	γ_d	93.8	100.9	103.0	
	Void ratio after consolidation	e_c				
	Time for 50 percent consolidation, min	t_{50}	≤ 1	≤ 1	≤ 1	
Final	Water content	w_f	26.7 %	23.8 %	21.9 %	%
	Void ratio	e_f				
	Saturation	S_f	%	%	%	%
	Axial stress, T/sq ft	σ	0.5	1.5	3.0	
	Maximum shear stress, T/sq ft	s_{max}	0.28	0.83	1.68	
	Actual time to failure, min	t_f	600	600	1440	
	Rate of strain, in./min		.00011	.00011	.00011	
	Ultimate shear strength, T/sq ft	s_{ult}	-	-	-	

Shear Strength Parameters
ϕ' = 49 °
tan ϕ' = 1.151
c' = 0 T/sq ft

Controlled stress
Controlled strain

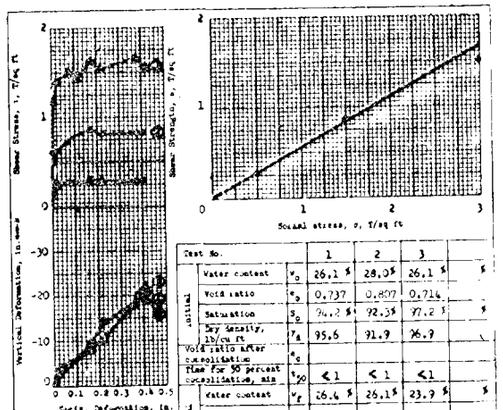
Type of specimen UNDISTURBED | 3.00 in. square | 0.471 in. thick

Classification SILTY SANDY CLAY, gray, with workpcs of clay and pockets less than ¼" thick

LL ——— | PL ——— | PI ——— | D_s 2.66

Remarks
Shear ¼" dia

Project HURRICANE PROTECTION
NEW ORLEANS & VICINITY BARRIER PLAN
Area NEW ORLEANS EAST BACK LEVEE
Boring No. 3-EU | Sample No. 4-A
Depth -4.4 | Date 30 November 1966
GDA DIRECT SHEAR TEST REPORT



Test No.			1	2	3	
Initial	Water content	w_o	26.1 %	28.0 %	26.1 %	%
	Void ratio	e_o	0.737	0.807	0.714	
	Saturation	S_o	94.2 %	92.5 %	97.2 %	%
	Dry density, lb/cu ft	γ_d	95.6	91.9	96.9	
	Void ratio after consolidation	e_c				
	Time for 50 percent consolidation, min	t_{50}	≤ 1	≤ 1	≤1	
Final	Water content	w_f	26.4 %	26.1 %	23.9 %	%
	Void ratio	e_f				
	Saturation	S_f	%	%	%	%
	Axial stress, T/sq ft	σ	0.5	1.5	3.0	
	Maximum shear stress, T/sq ft	s_{max}	0.28	0.86	1.50	
	Actual time to failure, min	t_f	600	1230	630	
	Rate of strain, in./min		.00012	.00013	.00012	
	Ultimate shear strength, T/sq ft	s_{ult}	0.28	0.82	-	

Shear Strength Parameters
ϕ' = 49 °
tan ϕ' = 1.151
c' = 0 T/sq ft

Controlled stress
Controlled strain

Type of specimen UNDISTURBED | 3.00 in. square | 0.471 in. thick

Classification SILTY CLAY, gray, with silty pockets of ¼" and 1".

LL ——— | PL ——— | PI ——— | D_s Calc

Remarks

Project HURRICANE PROTECTION
NEW ORLEANS & VICINITY BARRIER PLAN
Area NEW ORLEANS EAST BACK LEVEE
Boring No. 3-EU | Sample No. 12-C1
Depth -37.6 | Date 30 November 1966
GDA DIRECT SHEAR TEST REPORT

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LA.

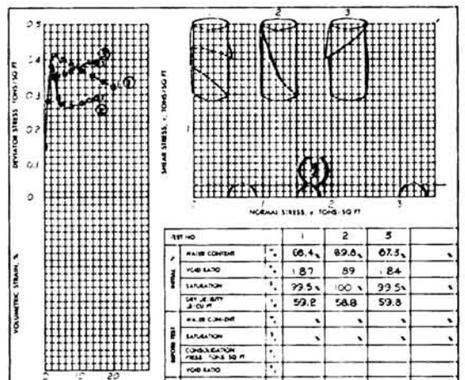
DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

DETAIL SHEAR STRENGTH DATA
BORING 3-EU

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973 | FILE NO. H-2-25340

PLATE 30



TEST NO			1	2	3	
INITIAL	WATER CONTENT	%	68.4	89.8	67.5	%
	VOID RATIO	%	1.87	.89	1.84	
	SATURATION	%	99.5	100 +	99.5	%
	DRY UNIT WT.	LB/CU FT	59.2	58.8	59.8	
BEFORE TEST	WATER CONTENT	%				%
	SATURATION	%				%
	CONSOLIDATION PRESS. TONS/SQ FT					
	VOID RATIO	%				
FINAL	WATER CONTENT	%				%
	VOID RATIO	%				
MAJOR PRINCIPAL STRESS, TONS/SQ FT		%	0.91	1.86	3.57	
MINOR PRINCIPAL STRESS, TONS/SQ FT		%	0.50	1.50	5.00	
TIME TO FAILURE, MIN			:8	:4	:9	
INITIAL DIAMETER, DO	IN.		1.41	1.41	1.41	
INITIAL HEIGHT, H_o, DO	IN.		5.00	5.00	5.00	

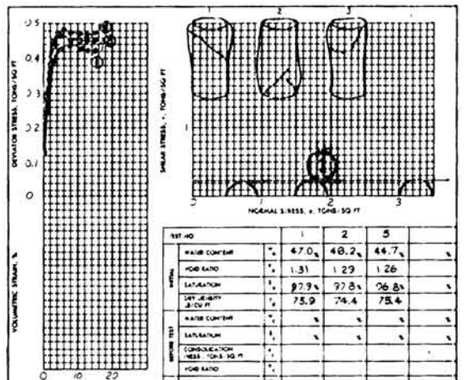
SHEAR VALUES
ϕ = 0 °
tan ϕ = 0
c = 0.19 TONS/SQ FT

TYPE TEST Q
METHOD OF SATURATION ____ ☐ CONSOLIDATED STRESS ☒ CONSOLIDATED STRAIN

TYPE OF SPECIMEN UNDISTURBED DATE OF SAMPLING # JOB NO.
CLASSIFICATION SOFT GRAY CLAY (CH) W/ FINE SAND SEAMS & FEW SHELLS
w 70 | n 23 | N 47 | $\gamma_s G_s$ = 2.72

REMARKS
0.2%/MIN. NO. 1 ₤2
0.135 " " " 5

PROJECT LAKE PONTCHARTRAIN HURRICANE PROTECTION, CITRUS BACK LEVEE
AREA
BORING NO 4-MU | SAMPLE NO 8-A
EL. -6.0 | DATE 5/8/66
TRIAXIAL COMPRESSION TEST REPORT



TEST NO			1	2	3	
INITIAL	WATER CONTENT	%	47.0	48.2	44.7	%
	VOID RATIO	%	1.31	1.29	1.26	
	SATURATION	%	97.9	97.8	96.8	%
	DRY UNIT WT.	LB/CU FT	75.9	74.4	75.4	
BEFORE TEST	WATER CONTENT	%				%
	SATURATION	%				%
	CONSOLIDATION PRESS. TONS/SQ FT					
	VOID RATIO	%				
FINAL	WATER CONTENT	%				%
	VOID RATIO	%				
MAJOR PRINCIPAL STRESS, TONS/SQ FT		%	0.94	1.97	3.48	
MINOR PRINCIPAL STRESS, TONS/SQ FT		%	0.50	1.50	5.00	
TIME TO FAILURE, MIN			:41	:11	:21	
INITIAL DIAMETER, DO	IN.		1.41	1.41	1.41	
INITIAL HEIGHT, H_o, DO	IN.		5.00	5.00	5.00	

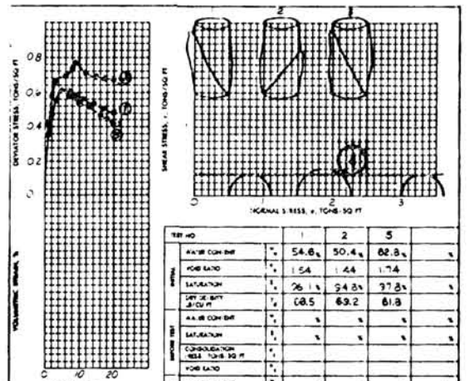
SHEAR VALUES
ϕ = 0 °
tan ϕ = 0
c = 0.231 TONS/SQ FT

TYPE TEST Q
METHOD OF SATURATION ____ ☐ CONSOLIDATED STRESS ☒ CONSOLIDATED STRAIN

TYPE OF SPECIMEN UNDISTURBED DATE OF SAMPLING # JOB NO.
CLASSIFICATION SOFT GRAY CLAY (CH) WITH SANDY SILT LAMINATIONS
w 36 | n 23 | N 13 | $\gamma_s G_s$ = 2.73

REMARKS
0.2%/MIN. NO. 1
0.5 " " " 2
0.9 " " " 5

PROJECT LAKE PONTCHARTRAIN HURRICANE PROTECTION, CITRUS BACK LEVEE
AREA
BORING NO 4-MU | SAMPLE NO 8-C
EL. -18.0 | DATE 5/19/66
TRIAXIAL COMPRESSION TEST REPORT



TEST NO			1	2	3	
INITIAL	WATER CONTENT	%	54.6	50.4	62.8	%
	VOID RATIO	%	1.54	1.44	1.74	
	SATURATION	%	96.1	94.8	97.8	%
	DRY UNIT WT.	LB/CU FT	68.5	69.2	61.8	
BEFORE TEST	WATER CONTENT	%				%
	SATURATION	%				%
	CONSOLIDATION PRESS. TONS/SQ FT					
	VOID RATIO	%				
FINAL	WATER CONTENT	%				%
	VOID RATIO	%				
MAJOR PRINCIPAL STRESS, TONS/SQ FT		%	1.11	2.27	5.60	
MINOR PRINCIPAL STRESS, TONS/SQ FT		%	0.50	1.50	5.00	
TIME TO FAILURE, MIN			:8	:52	:13	
INITIAL DIAMETER, DO	IN.		1.41	1.41	1.41	
INITIAL HEIGHT, H_o, DO	IN.		5.00	5.00	5.00	

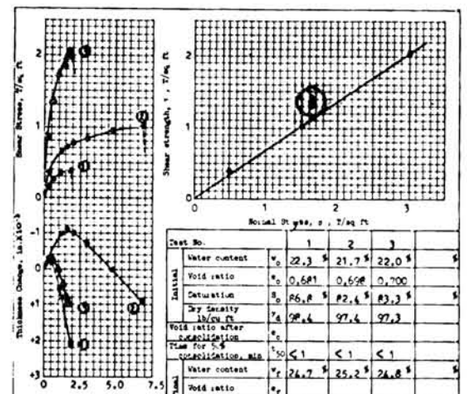
SHEAR VALUES
ϕ = 0 °
tan ϕ = 0
c = 0.33 TONS/SQ FT

TYPE TEST Q
METHOD OF SATURATION ____ ☐ CONSOLIDATED STRESS ☒ CONSOLIDATED STRAIN

TYPE OF SPECIMEN UNDISTURBED DATE OF SAMPLING # JOB NO.
CLASSIFICATION FIRM GRAY CLAY (CH) W/ FINE SAND LAMINATIONS
w 73 | n 25 | N 48 | $\gamma_s G_s$ = 2.71

REMARKS
0.3 %/MIN. NO. 1 ₤2
0.4 " " " 5

PROJECT LAKE PONTCHARTRAIN HURRICANE PROTECTION, CITRUS BACK LEVEE
AREA
BORING NO 4-MU | SAMPLE NO 15-D
EL. -44.5 | DATE 5/19/66
TRIAXIAL COMPRESSION TEST REPORT



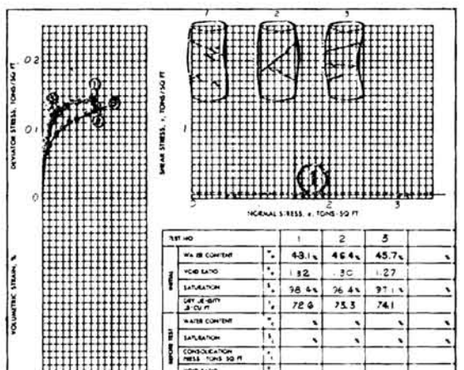
Test No.			1	2	3	
Initial	Water content	w_o	22.3 %	21.7 %	22.0 %	%
	Void ratio	e_o	0.681	0.658	0.700	
	Saturation	S_o	86.8 %	82.6 %	83.3 %	%
	Dry density, lb/cu ft	γ_d	98.6	97.6	97.3	
Void ratio after consolidation		e_c				
Time for 50% consolidation, min		t_{50}	< 1	< 1	< 1	
Final	Water content	w_f	24.7 %	25.2 %	24.8 %	%
	Void ratio	e_f				
	Saturation	S_f	%	%	%	%
Actual time to failure, min.		t_f	300	220	280	
Normal stress, T/sq ft		σ	0.50	1.50	3.00	
Maximum shear strength, T/sq ft		s	0.39	1.02	2.05	

Shear Values
ϕ' = 34°
tan ϕ' = 0.681
c' = 0

Test Type (Check One) S ☒ Controlled, stress ☐ Controlled, strain

Type of Specimen UNDISTURBED | 3.00 in. Square | 0.502 in. Thickness
Classification SAND (SP), gray
LL ____ PL ____ PI ____ G_s = 2.65
Remarks

Project LAKE PONTCHARTRAIN HURRICANE PROTECTION
CITRUS BACK LEVEE
Area
Boring No. 4-MU | Sample No. 11-B
Depth EL. -28.8 | Date 14 May 1966
JMS DIRECT SHEAR TEST REPORT



TEST NO			1	2	3	
INITIAL	WATER CONTENT	%	48.1	46.4	45.7	%
	VOID RATIO	%	1.82	1.30	1.27	
	SATURATION	%	98.4	96.4	97.1	%
	DRY UNIT WT.	LB/CU FT	72.6	73.3	74.1	
BEFORE TEST	WATER CONTENT	%				%
	SATURATION	%				%
	CONSOLIDATION PRESS. TONS/SQ FT					
	VOID RATIO	%				
FINAL	WATER CONTENT	%				%
	VOID RATIO	%				
MAJOR PRINCIPAL STRESS, TONS/SQ FT		%	0.65	1.83	5.15	
MINOR PRINCIPAL STRESS, TONS/SQ FT		%	0.50	1.50	5.00	
TIME TO FAILURE, MIN			30	:5	:5	
INITIAL DIAMETER, DO	IN.		1.41	1.41	1.41	
INITIAL HEIGHT, H_o, DO	IN.		5.00	5.00	5.00	

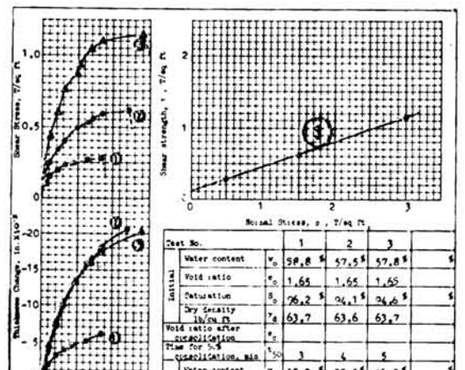
SHEAR VALUES
ϕ = 9 °
tan ϕ = 0
c = 0.07 TONS/SQ FT

TYPE TEST Q
METHOD OF SATURATION ____ ☐ CONSOLIDATED STRESS ☒ CONSOLIDATED STRAIN

TYPE OF SPECIMEN UNDISTURBED DATE OF SAMPLING # JOB NO.
CLASSIFICATION VERY SOFT GRAY CLAY (CH) W/ SHELLS, ORG. MATT, SAND POCKETS & SEAMS
w 62 | n 22 | N 40 | $\gamma_s G_s$ = 2.70

REMARKS
0.5%/MIN. NO. 1
1.0 " " " 2 & 5

PROJECT LAKE PONTCHARTRAIN HURRICANE PROTECTION, CITRUS BACK LEVEE
AREA
BORING NO 4-MU | SAMPLE NO 5-A
EL. +6.0 | DATE 5/18/66
TRIAXIAL COMPRESSION TEST REPORT



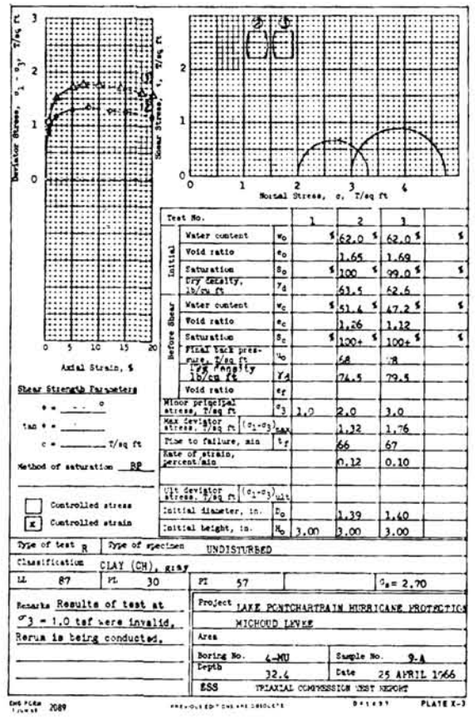
Test No.			1	2	3	
Initial	Water content	w_o	58.8 %	57.5 %	57.8 %	%
	Void ratio	e_o	1.65	1.65	1.65	
	Saturation	S_o	96.2 %	94.1 %	94.6 %	%
	Dry density, lb/cu ft	γ_d	63.7	63.6	63.7	
Void ratio after consolidation		e_c				
Time for 50% consolidation, min		t_{50}	3	4	5	
Final	Water content	w_f	58.9 %	60.5 %	61.5 %	%
	Void ratio	e_f				
	Saturation	S_f	%	%	%	%
Actual time to failure, min.		t_f	240	280	320	
Normal stress, T/sq ft		σ	0.50	1.50	3.00	
Maximum shear strength, T/sq ft		s	0.28	0.62	1.15	

Shear Values
ϕ' = 12°
tan ϕ' = 0.368
c' = 0.11

Test Type (Check One) S ☒ Controlled, stress ☐ Controlled, strain

Type of Specimen UNDISTURBED | 3.00 in. Square | 0.502 in. Thickness
Classification CLAY (CH), gray
LL 87 | PL 30 | PI 57 | G_s = 2.70 From R Test
Remarks

Project LAKE PONTCHARTRAIN HURRICANE PROTECTION
CITRUS BACK LEVEE
Area
Boring No. 4-MU | Sample No. 9-A
Depth 18.1 | Date 13 May 1966
JMS DIRECT SHEAR TEST REPORT



Test No.			1	2	3	
Initial	Water content	w_o	%	62.0 %	62.0 %	%
	Void ratio	e_o		1.65	1.69	
	Saturation	S_o	%	100 %	99.0 %	%
	Dry density, lb/cu ft	γ_d		61.5	62.6	
Before Shear	Water content	w_c	%	61.4 %	47.2 %	%
	Void ratio	e_c		1.26	1.12	
	Saturation	S_c	%	100+ %	100+ %	%
	Final back pressure, T/sq ft	u_b		68	68	
	Dry density lb/cu ft	γ_d		74.5	79.5	
	Void ratio	e_f				
Minor principal stress, T/sq ft		σ_3	1.0	2.0	3.0	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$		1.32	1.76	
Time to failure, min		t_f		66	67	
Rate of strain, percent/min				0.12	0.10	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$				
Initial diameter, in.		D_o		1.39	1.40	
Initial height, in.		H_o	3.00	3.00	3.00	

Axial Strain, %

Shear Strength Parameters
ϕ = — °
tan ϕ = —
c = — T/sq ft

Method of saturation BP

☐ Controlled stress
☒ Controlled strain

Type of test R | Type of specimen UNDISTURBED
Classification CLAY (CH), gray
LL 87 | PL 30 | PI 57 | G_s = 2.70

Remarks Results of test at σ_3 = 1.0 tsf were invalid. Rerun is being conducted.

Project LAKE PONTCHARTRAIN HURRICANE PROTECTION
MICHOUD LEVEE
Area
Boring No. 4-MU | Sample No. 9-A
Depth 32.6 | Date 25 APRIL 1966
ESS TRIAXIAL COMPRESSION TEST REPORT

DHS FORM 2089 PREVIOUS EDITIONS ARE OBSOLETE DATED 67 PLATE X-3

MISSISSIPPI RIVER—GULF OUTLET
MICHOUD CANAL, LA.

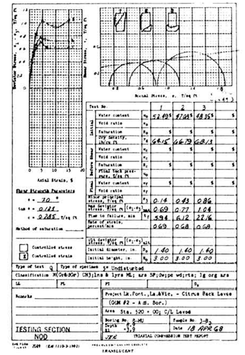
DESIGN MEMORANDUM NO. 1—GENERAL DESIGN

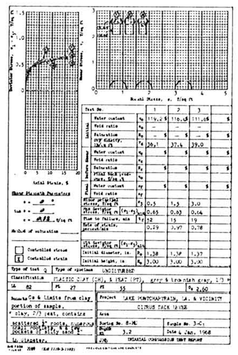
DETAIL SHEAR STRENGTH DATA
BORING 4-EUT

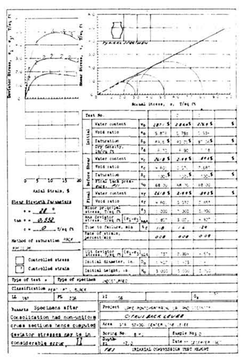
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

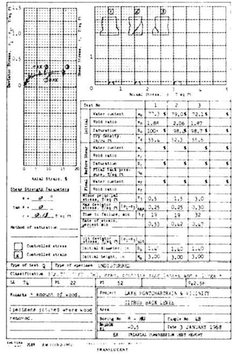
JUNE 1973 FILE NO. H-2-25340

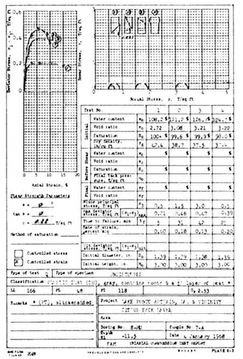
PLATE 31

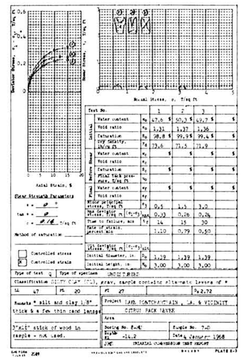


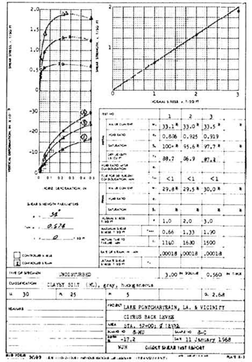


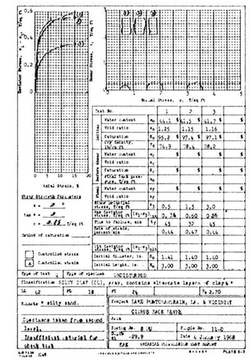


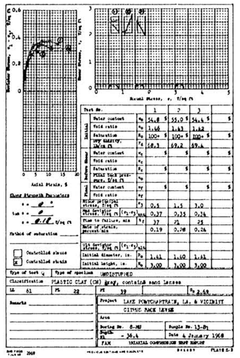


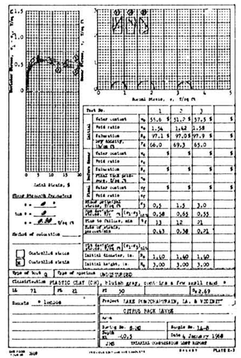


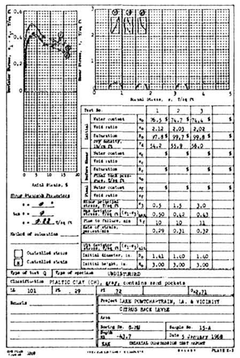


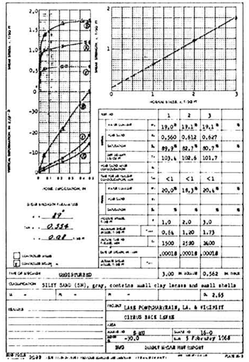


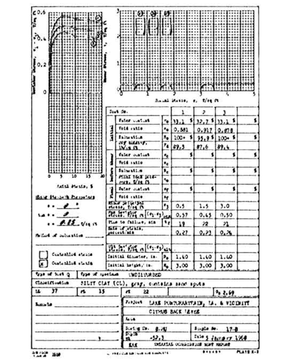


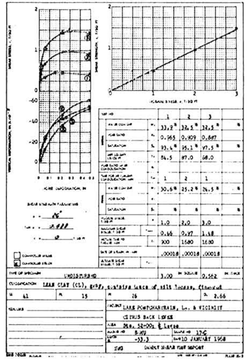


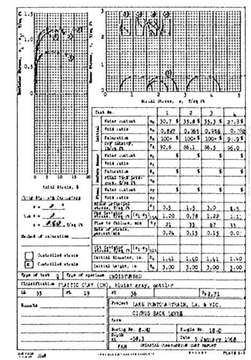


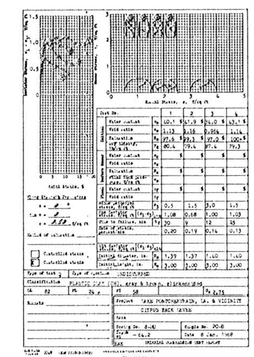












MISSISSIPPI RIVER--GULF OUTLET
MICHOUD CANAL, LA.

DESIGN MEMORANDUM NO. 1--GENERAL DESIGN

DETAIL SHEAR STRENGTH DATA

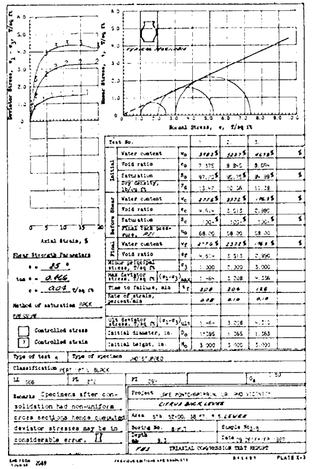
BORING 8--MU

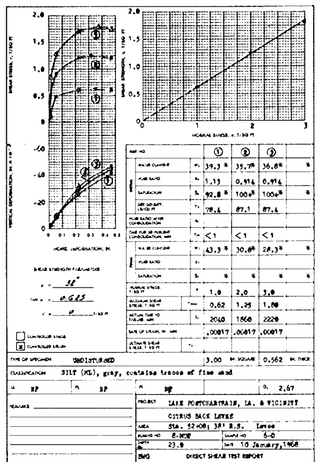
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

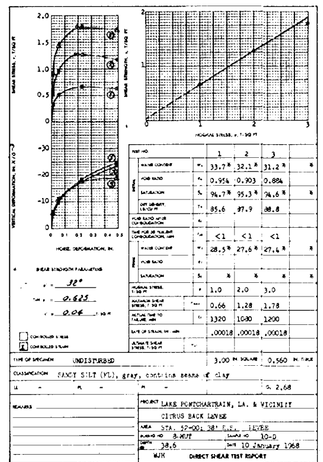
JUNE 1973

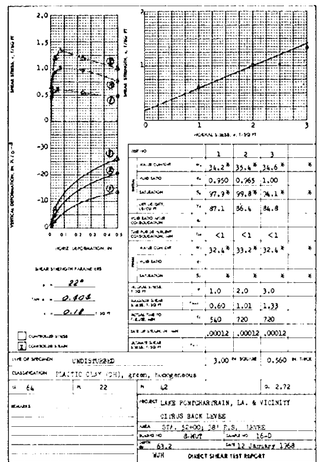
FILE NO. H-2-25340

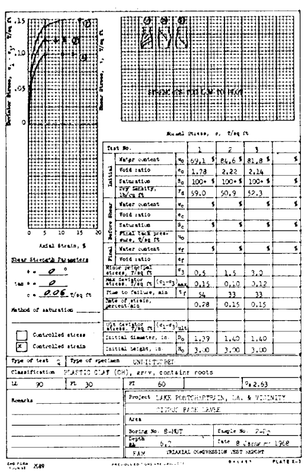
PLATE 32

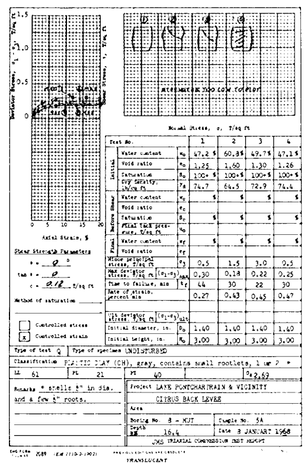


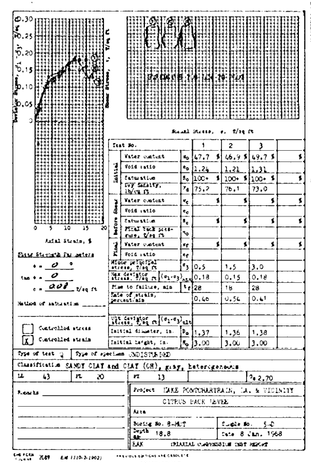


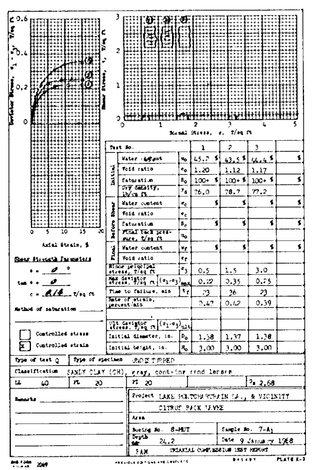


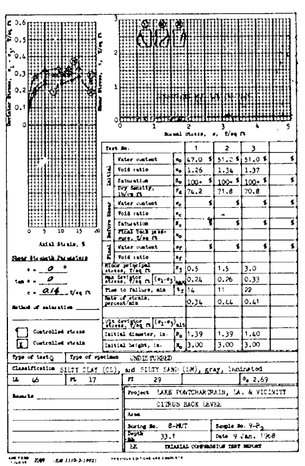


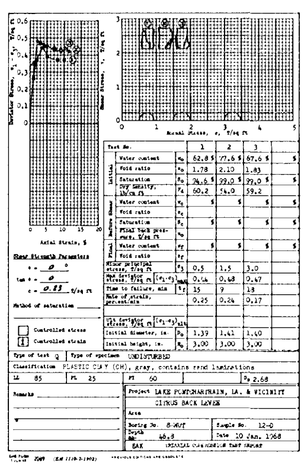


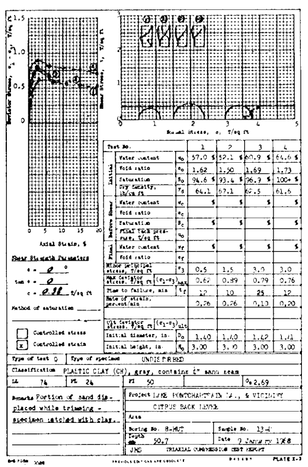


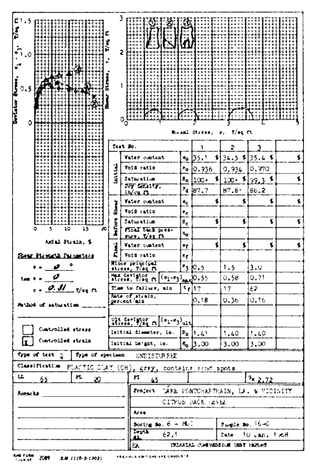


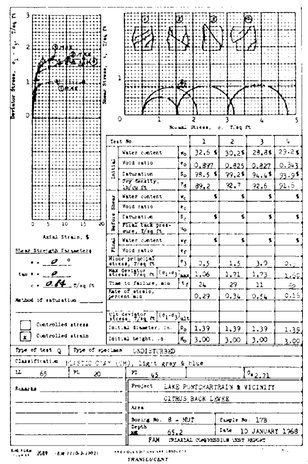












MISSISSIPPI RIVER – GULF OUTLET
MICHOUD CANAL, LA.

DESIGN MEMORANDUM NO. 1 – GENERAL DESIGN

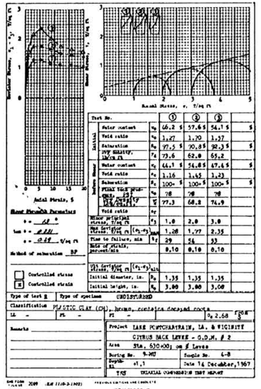
DETAIL SHEAR STRENGTH DATA
BORING 8-MUT

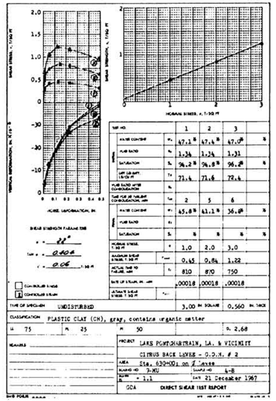
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

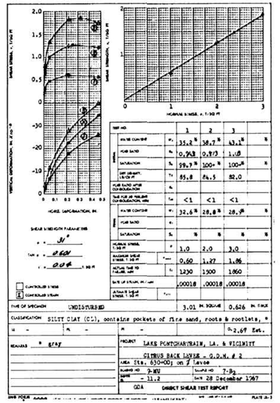
JUNE 1973

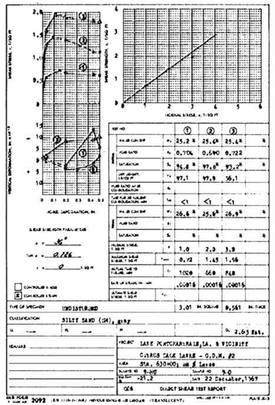
FILE NO. H-2-25340

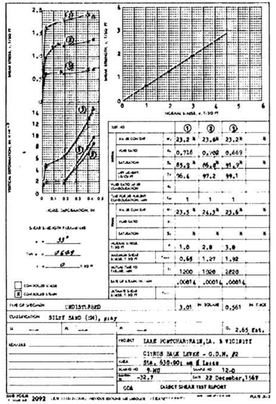
PLATE 33

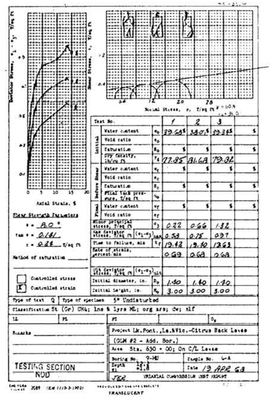


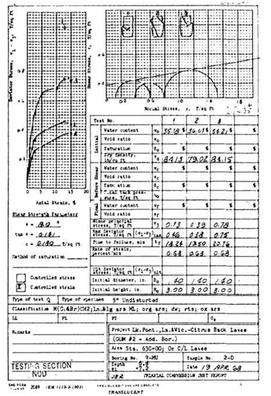


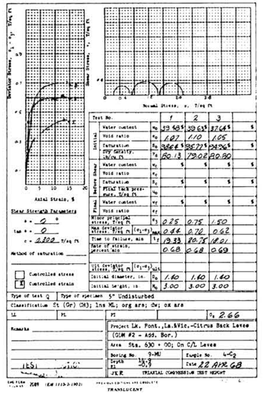


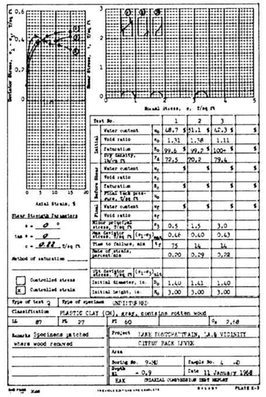


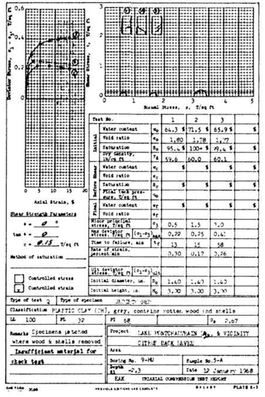


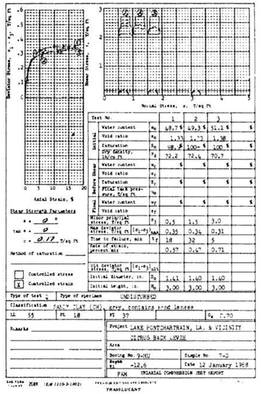


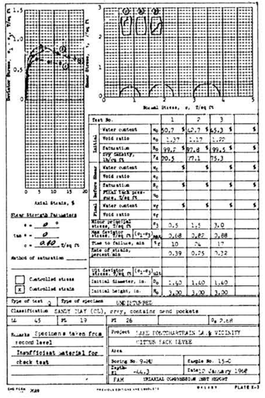


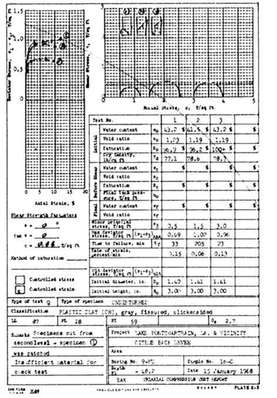


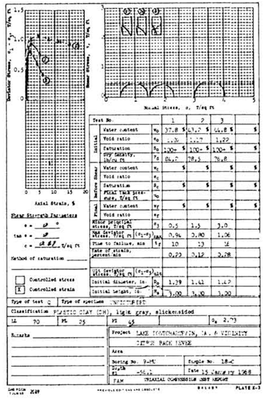












MISSISSIPPI RIVER—GULF OUTLET
MICHOUD CANAL, LA.

DESIGN MEMORANDUM NO. 1—GENERAL DESIGN

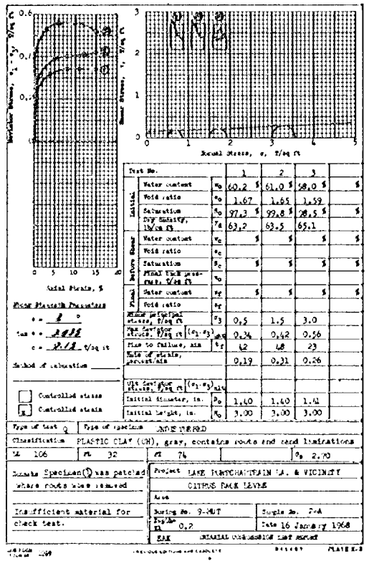
DETAIL SHEAR STRENGTH DATA
BORING 9-MU

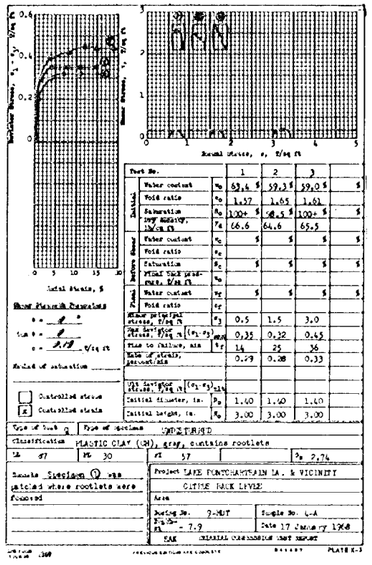
U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

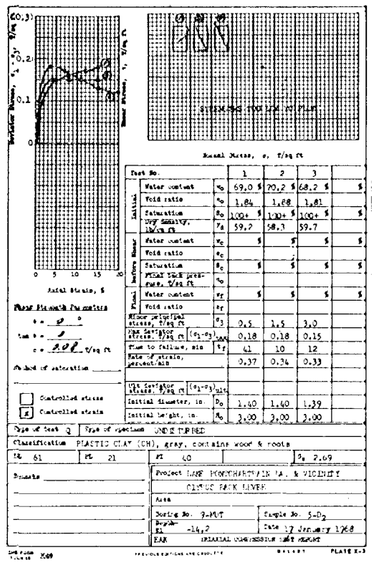
JUNE 1973

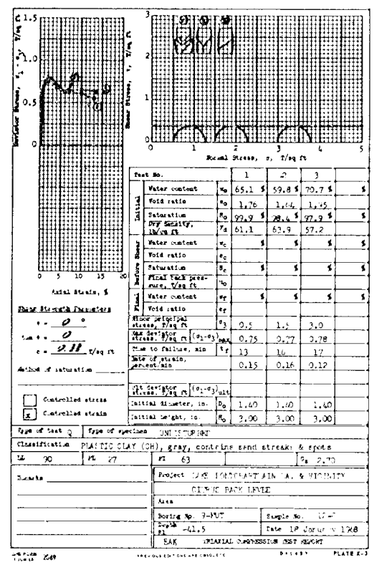
FILE No. H-2-25340

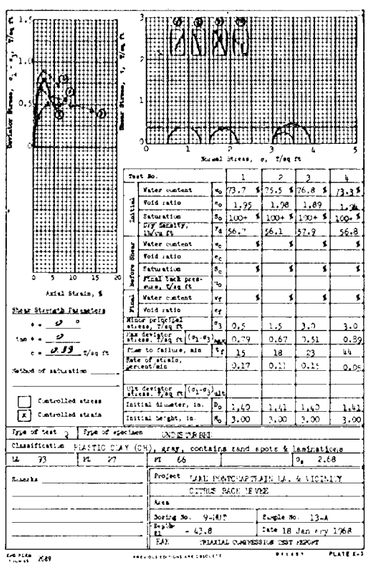
PLATE 34

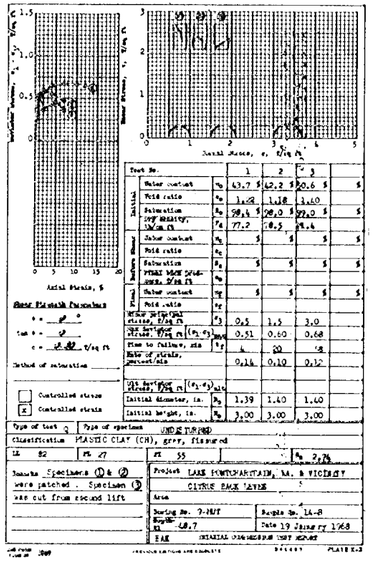


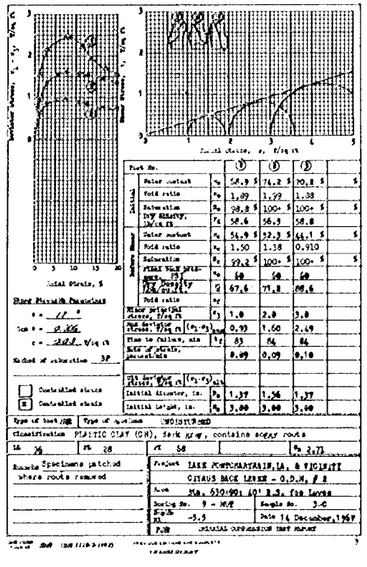


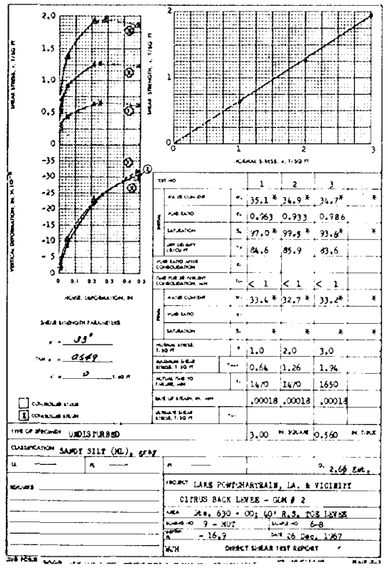


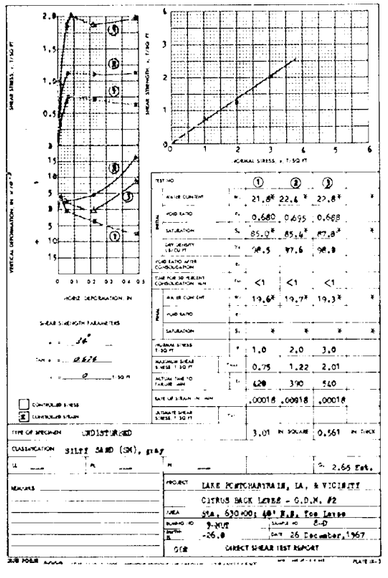












MISSISSIPPI RIVER—GULF OUTLET
MICHOUD CANAL, LA.

DESIGN MEMORANDUM NO. 1—GENERAL DESIGN

DETAIL SHEAR STRENGTH DATA
BORING 9-MUT

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO. H-2 25340

PLATE 35

UNIFIED SOIL CLASSIFICATION

MAJOR DIVISION		TYPE	LETTER SYMBOL	SYMBOL	TYPICAL NAMES
COARSE - GRAINED SOILS More than half of material is larger than No. 200 sieve size.	GRAVELS More than half of coarse fraction is larger than No. 4 sieve size.	CLEAN GRAVEL (Little or No Fines)	GW		GRAVEL, Well Graded, gravel - sand mixtures, little or no fines
			GP		GRAVEL, Poorly Graded, gravel-sand mixtures, little or no fines
		GRAVEL WITH FINES (Appreciable Amount of Fines)	GM		SILTY GRAVEL, gravel - sand - silt mixtures
			GC		CLAYEY GRAVEL, gravel - sand - clay mixtures
	SANDS More than half of coarse fraction is smaller than No. 4 sieve size.	CLEAN SAND (Little or No Fines)	SW		SAND, Well - Graded, gravelly sands
			SP		SAND, Poorly - Graded, gravelly sands
		SANDS WITH FINES (Appreciable Amount of Fines	SM		SILTY SAND, sand - silt mixtures
			SC		CLAYEY SAND, sand - clay mixtures
FINE - GRAINED SOILS More than half the material is smaller than No. 200 sieve size.		SILTS AND CLAYS (Liquid Limit <50)	ML		SILT & very fine sand, silty or clayey fine sand or clayey silt with slight plasticity
			CL		LEAN CLAY; Sandy Clay; Silty Clay; of low to medium plasticity
			OL		ORGANIC SILTS and organic silty clays of low plasticity
		SILTS AND CLAYS (Liquid Limit >50)	MH		SILT, fine sandy or silty soil with high plasticity
			CH		FAT CLAY, inorganic clay of high plasticity
			OH		ORGANIC CLAYS of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS			Pt		PEAT, and other highly organic soil
WOOD			Wd		WOOD
SHELLS			Sl		SHELLS
NO SAMPLE					

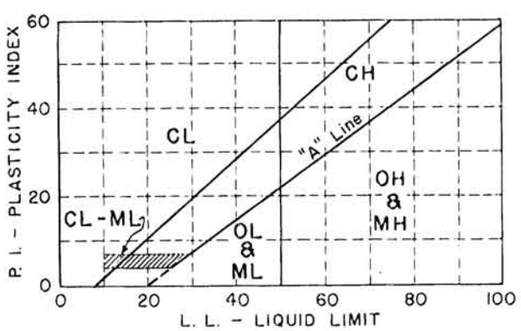
NOTE: Soils possessing characteristics of two groups are designated by combinations of group symbols

DESCRIPTIVE SYMBOLS

COLOR	
COLOR	SYMBOL
TAN	T
YELLOW	Y
RED	R
BLACK	BK
GRAY	Gr
LIGHT GRAY	lGr
DARK GRAY	dGr
BROWN	Br
LIGHT BROWN	lBr
DARK BROWN	dBr
BROWNISH-GRAY	br Gr
GRAYISH-BROWN	gy Br
GREENISH-GRAY	gn Gr
GRAYISH-GREEN	gy Gn
GREEN	Gn
BLUE	Bl
BLUE-GREEN	Bl Gn
WHITE	Wh
MOTTLED	Mot

CONSISTENCY FOR COHESIVE SOILS		
CONSISTENCY	COHESION IN LBS./SQ.FT. FROM UNCONFINED COMPRESSION TEST	SYMBOL
VERY SOFT	< 250	vSo
SOFT	250 - 500	So
MEDIUM	500 - 1000	M
STIFF	1000 - 2000	St
VERY STIFF	2000 - 4000	vSt
HARD	> 4000	H

MODIFICATIONS	
MODIFICATION	SYMBOL
Traces	Tr-
Fine	F
Medium	M
Coarse	C
Concretions	cc
Rootlets	rt
Lignite fragments	lg
Shale fragments	sh
Sandstone fragments	sds
Shell fragments	slf
Organic matter	O
Clay strata or lenses	CS
Silt strata or lenses	SIS
Sand strata or lenses	SS
Sandy	S
Gravelly	G
Boulders	B
Slickensides	SL
Wood	Wd
Oxidized	Ox



PLASTICITY CHART

For classification of fine - grained soils

NOTES:
FIGURES TO LEFT OF BORING UNDER COLUMN "W OR D_{10}"
Are natural water contents in percent dry weight
When underlined denotes D_{10} size in mm *
FIGURES TO LEFT OF BORING UNDER COLUMNS "LL" AND "PL"
Are liquid and plastic limits, respectively
SYMBOLS TO LEFT OF BORING
▽ Ground - water surface and date observed
(C) Denotes location of consolidation test **
(S) Denotes location of consolidated - drained direct shear test **
(R) Denotes location of consolidated - undrained triaxial compression test **
(Q) Denotes location of unconsolidated - undrained triaxial compression test **
(T) Denotes location of sample subjected to consolidation test and each of the above three types of shear tests **
FW Denotes free water encountered in boring or sample
FIGURES TO RIGHT OF BORING
Are values of cohesion in lbs./sq.ft. from unconfined compression tests
In parenthesis are driving resistances in blows per foot determined with a standard split spoon sampler ($1\frac{3}{8}$" I.D., 2" O.D.) and a 140 lb. driving hammer with a 30" drop
Where underlined with a solid line denotes laboratory permeability in centimeters per second of undisturbed sample
Where underlined with a dashed line denotes laboratory permeability in centimeters per second of sample remoulded to the estimated natural void ratio

* The D_{10} size of a soil is the grain diameter in millimeters of which 10% of the soil is finer, and 90% coarser than size D_{10}.

**Results of these tests are available for inspection in the U.S. Army Engineer District Office, if these symbols appear beside the boring logs on the drawings.

GENERAL NOTES:

While the borings are representative of subsurface conditions at their respective locations and for their respective vertical reaches, local variations characteristic of the subsurface materials of the region are anticipated and, if encountered, such variations will not be considered as differing materially within the purview of clause 4 of the contract.

Ground-water elevations shown on the boring logs represent ground-water surfaces encountered on the dates shown. Absence of water surface data on certain borings implies that no ground-water data is available, but does not necessarily mean that ground water will not be encountered at the locations or within the vertical reaches of these borings.

Consistency of cohesive soils shown on the boring logs is based on driller's log and visual examination and is approximate, except within those vertical reaches of the borings where shear strengths from unconfined compression tests are shown.

REVISION	DATE	DESCRIPTION	BY
3	5-3-71	ADDED UPPER LIMIT LINE (P.I.=0.9(LL-8)) ON PLASTICITY CHART	LMVED-G LETTER DT'D 23 APRIL 1971
2	6-8-64	SYMBOL FW, NOTE REVISED	ORAL FROM LMVGG 5 JUNE 1964
1	9-17-63	1ST PAR OF GENERAL NOTES REVISED	LMVD MULTIPLE LETTER, DATED 5 SEPT., 1963

SOIL BORING LEGEND

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
FILE NO. H-2-21800

PLATE A

MISSISSIPPI RIVER-GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

APPENDIX A
HYDROLOGY AND HYDRAULICS

MISSISSIPPI RIVER-GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

APPENDIX A
HYDROLOGY AND HYDRAULICS

1. Climatology.

a. Climate. The project is located in a subtropical latitude having mild winters and hot, humid summers. During the summer, prevailing southerly winds produce conditions favorable for convective thundershowers. In the colder seasons, the area experiences frontal passages which produce squalls and sudden temperature drops. Fogs are prevalent in the winter and spring when the water in the channels and bayous is somewhat colder than the surrounding air. Climatological data for the area are contained in monthly and annual publications of the National Weather Service titled "Climatological Data for Louisiana," and "Local Climatological Data, New Orleans, La."

b. Temperature. The first-order meteorological station in New Orleans has temperature records beginning in 1871. The normal temperature is about 70° F. and the recorded extremes are 7° and 102°. The normal temperatures in summer and winter are 83.1° and 57.1°, respectively. Summarized temperature records are shown in table A-1, duration of records are shown in table A-3, and station locations are shown on plate A-1.

c. Rainfall. Precipitation is generally heavy in two fairly definite rainy periods. Summer showers occur from about mid-June to mid-September, and heavy winter rains occur from mid-December to mid-March. Based on records of the station in New Orleans, the normal annual precipitation is 63 inches, with extremes of 85.7 inches in 1875 and 31.1 inches in 1899. Monthly rainfalls exceeding 12 inches are not uncommon, and as much as 25 inches has been recorded in a single month. The normal monthly rainfall ranges from 7.9 inches in July to 3.2 inches in October. Several stations have experienced calendar months in which no rainfall was recorded, the latest being October 1963. Snow occurs infrequently in the area. Summarized precipitation records are shown in table A-2, duration of records are shown in table A-3, and station locations are shown on plate A-1.

d. Wind. A recording anemometer was located near the project area at the GIWW and Paris Road bridge; however, during the passage of Hurricane Camille in August 1969 the instrument was destroyed and has not been restored to date. The National Weather Service anemometer at the New Orleans International Airport, installed in 1949, provides the longest record available in

TABLE A-1
Monthly Temperatures at New Orleans

Month	Degrees Fahrenheit Normal[1]	Maximum[2]	Minimum[2]	Month	Degrees Fahrenheit Normal[1]	Maximum[2]	Minimum[2]
Jan	56.0	67.2	41.2	Jul	83.4	91.7	71.5
Feb	58.2	67.2	38.6	Aug	83.5	89.9	70.3
Mar	62.8	75.3	48.1	Sep	80.2	86.2	65.0
Apr	69.7	83.0	60.4	Oct	72.6	80.0	52.6
May	76.8	85.5	63.8	Nov	62.0	76.7	48.1
Jun	82.3	91.1	69.2	Dec	57.1	66.6	46.4

Extreme minimum 7° F., 13 February 1899.
Extreme maximum 102° F., 30 June 1954 (also earlier dates)

[1]U. S. Weather Bureau Normals 1931-1960.
[2]Based on records from 1871 through 1969 (monthly average)

TABLE A-2
Monthly Rainfall at New Orleans

Month	Inches Normal[1]	Maximum[2]	Minimum[2]	Month	Inches Normal[1]	Maximum[2]	Minimum[2]
Jan	4.42	12.69	0.61	Jul	7.92	18.16	2.02
Feb	4.69	13.85	0.04	Aug	6.34	22.74	0.87
Mar	6.22	21.09	0.04	Sep	5.99	16.57	0.24
Apr	5.41	14.94	0.04	Oct	3.22	25.11	0.00
May	5.11	18.68	0.02	Nov	3.74	14.41	0.10
Jun	5.49	16.01	0.59	Dec	4.70	14.43	0.67

[1]U. S. Weather Bureau normals 1931-1960.
[2]Based on records from 1870 through 1969.

TABLE A-3
Meteorologic Stations

Identification no. on plate A-1	Station	Length of record in years (thru 1972)		Collecting agency
	Complete meteorological stations			
5	New Orleans	100		NWS[1]
6	New Orleans International Airport	25		NWS
	Recording rainfall stations			
7	New Orleans - Dublin Street	79		S&WB[2]
8	New Orleans - Jefferson Avenue	79		S&WB
9	New Orleans - Jourdan Avenue	39		S&WB
10	New Orleans - London Avenue	79		S&WB
	Non-recording rainfall stations			
11	Metairie	24		NWS
12	New Orleans - Citrus	18		NWS
13	Pearl River (disc. Jan 63)	56		NWS
14	Pearl River, Lock 1	24		NWS
15	Violet (disc. Jan 69)	13		NWS
	Rainfall (non-recording) and temperature stations	Rainfall	Temp.	
16	New Orleans Lakefront Airport (disc. Jul 54)	15	17	NWS
17	New Orleans - Audubon Park	82	82	NWS
18	Greater New Orleans (disc. Apr 66) Expressway Bridge	10	10	NWS
19	Slidell	16	16	NWS

[1]NWS - National Weather Service
[2]S&WB - Sewerage and Water Board of New Orleans

TABLE A-4
Wind Summaries, New Orleans International Airport
(1949-1964)

Wind direction (or velocity)	Percent of time												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
N	7.36	7.04	5.99	4.77	4.62	4.02	3.57	5.21	5.83	7.64	9.19	7.48	6.05
NNE	7.07	7.12	5.81	4.61	4.23	3.39	3.01	4.53	7.26	8.64	8.82	8.74	6.09
NE	8.13	8.93	7.78	5.33	5.52	5.00	4.90	7.07	13.30	12.39	9.94	10.11	8.19
ENE	8.30	7.64	7.15	5.64	5.04	5.14	4.47	6.49	15.95	12.53	10.12	9.48	8.16
E	5.67	6.11	5.03	4.70	4.61	4.40	4.60	5.66	8.30	7.61	6.12	7.03	5.82
ESE	3.55	3.72	4.66	5.13	4.84	3.72	3.07	3.07	4.18	4.50	3.75	4.24	4.04
SE	4.75	5.00	6.33	8.23	7.12	5.42	4.65	3.60	4.84	4.39	5.22	4.44	5.33
SSE	10.32	8.15	9.53	13.32	11.38	8.91	5.64	4.94	4.45	4.15	6.93	6.80	7.87
S	10.17	9.05	11.36	13.92	13.22	11.62	9.40	6.19	4.48	3.15	6.08	7.40	8.83
SSW	5.54	7.38	7.35	6.95	7.92	11.10	8.93	6.89	2.64	1.74	3.68	4.72	6.23
SW	2.81	5.07	4.14	4.51	6.19	7.22	8.59	7.18	2.02	1.44	1.93	2.43	4.46
WSW	2.09	2.74	2.66	2.48	3.13	4.17	5.71	4.70	1.44	1.38	1.54	1.71	2.82
W	2.58	3.11	2.60	2.41	3.13	3.98	6.01	5.48	1.86	2.00	2.70	2.58	3.21
WNW	3.06	3.36	3.25	3.04	2.21	3.12	4.93	3.91	1.88	2.52	3.12	2.87	3.11
NW	4.13	3.71	4.08	3.04	2.71	3.26	3.77	4.07	2.18	3.27	4.12	4.30	3.56
NNW	7.46	6.19	5.76	4.45	3.96	3.66	3.99	4.60	3.75	6.04	7.02	7.35	5.35
Calm	7.01	5.68	6.46	7.46	10.16	11.87	14.76	16.41	15.64	16.62	9.73	8.30	10.88
0-3 mi/h	12.33	10.14	10.95	12.38	16.00	19.58	23.53	25.82	22.73	23.54	15.89	14.31	17.32
4-7	24.67	23.29	21.19	23.49	29.63	36.42	39.54	38.03	29.16	27.60	26.55	24.86	28.74
8-12	33.41	32.83	32.55	33.64	34.27	32.86	28.71	28.11	29.25	28.76	30.20	32.93	31.45
13-18	22.29	25.85	27.09	24.77	17.32	10.39	7.45	7.38	15.78	16.12	20.54	21.83	18.01
19-24	6.01	6.74	6.69	4.60	2.42	0.63	0.64	0.56	2.51	3.34	5.39	5.02	3.69
25-31	1.16	1.12	1.40	1.04	0.33	0.10	0.09	0.09	0.39	0.58	1.33	0.99	0.72
32-38	0.11	0.03	0.13	0.06	0.02	0.02	0.02	0	0.11	0.06	0.10	0.05	0.06
39-46	0.03	0.02	0	0.02	0.01	0	0.02	0.01	0.05	0.01	0	0	0.01
47 and over	0	0	0	0	0	0	0	0	0.01	0	0	0	0

TABLE A-5
Hydrologic Stations

Identification number on plate A-1	Location	Type of water level gage	Records available
1	Gulf Intracoastal Waterway near Paris Road bridge	Recorder, June-Oct 44 Jun-Aug 45 Apr 48 to date Staff Apr 48-Feb 64	Stage Jun 44 to date (see dates under type of gage) Salinity 1948 to date
2	Lake Borgne at Chef Menteur Pass	Recorder	Stage Jul 57 to Oct 67
3	Chef Menteur Pass near Lake Borgne (U.S. Hwy. 90 bridge)	Recorder	Stage Oct 67 to date Salinity Mar 57 to date
4	Inner Harbor Navigation Canal near Seabrook bridge	Recorder	Stage Mar 65 Salinity 1957 1961-65 1967 to date

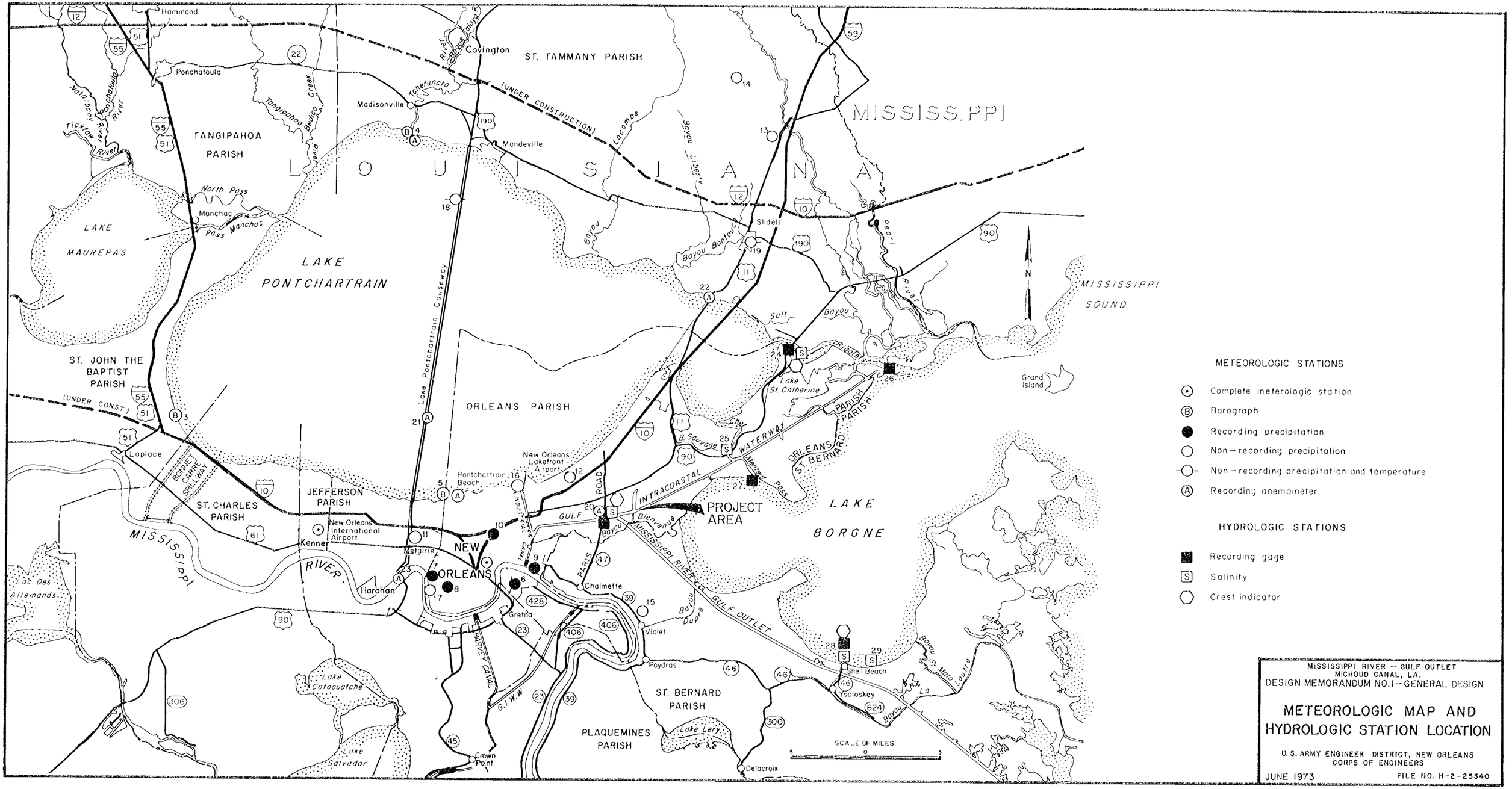
TABLE A-6
Average 8:00 a.m. Stage (in feet m.s.l.)
Gulf Intracoastal Waterway at Paris Road Bridge

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1963	0.92	0.38	0.75	0.71	0.59	0.79	0.86	0.90	2.08	1.60	1.45	0.77	0.98
1964	0.59	0.55	0.95	1.13	1.06	1.09	1.50	1.50	2.01	1.88	1.37	1.32	1.20
1965	0.91	1.08	0.43	0.70	1.02	1.38	1.07	1.64	2.97	2.01	1.87	1.40	1.37
1966	1.35	1.16	0.73	0.92	1.63	1.40	1.40	1.52	1.90	1.92	1.37	1.19	1.37
1967	0.92	0.86	0.77	1.12	1.04	1.56	-	-	-	-	1.71	1.58	-
1968	1.16	0.08	0.57	0.99	1.96	0.94	1.55	2.03	2.38	2.29	1.57	-	1.38
1969	-	1.44	1.24	1.47	1.68	1.60	1.52	2.44	2.50	3.08	1.71	1.28	1.81
Average	0.98	0.90	0.78	1.01	1.14	1.25	1.32	1.67	2.31	2.13	1.58	1.26	1.36

NOTE: High of Record 10.04 feet m.s.l. on 10 September 1965 (Hurricane Betsy)
Low of Record -2.19 feet m.s.l. on 5 March 1965

TABLE A-7
Average Annual High & Low Water Stages
Gulf Intracoastal Waterway at Paris Road Bridge

Year	Mean High Water (m.s.l.)	Mean Low Water (m.s.l.)
1959	Insufficient records	
1960	Insufficient records	
1961	2.58	1.66
1962	2.37	1.30
1963	2.27	1.27
1964	2.51	1.34
1965	2.77	1.37
1966	2.83	1.46
1967	Insufficient records	
1968	2.86	1.54
1969	3.30	1.87
1970	3.30	1.91



MISSISSIPPI RIVER – GULF OUTLET
MICHOUD CANAL, LA.
DESIGN MEMORANDUM NO. 1 – GENERAL DESIGN

METEOROLOGIC MAP AND HYDROLOGIC STATION LOCATION

U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973 FILE NO. H-2-25340

PLATE A-1

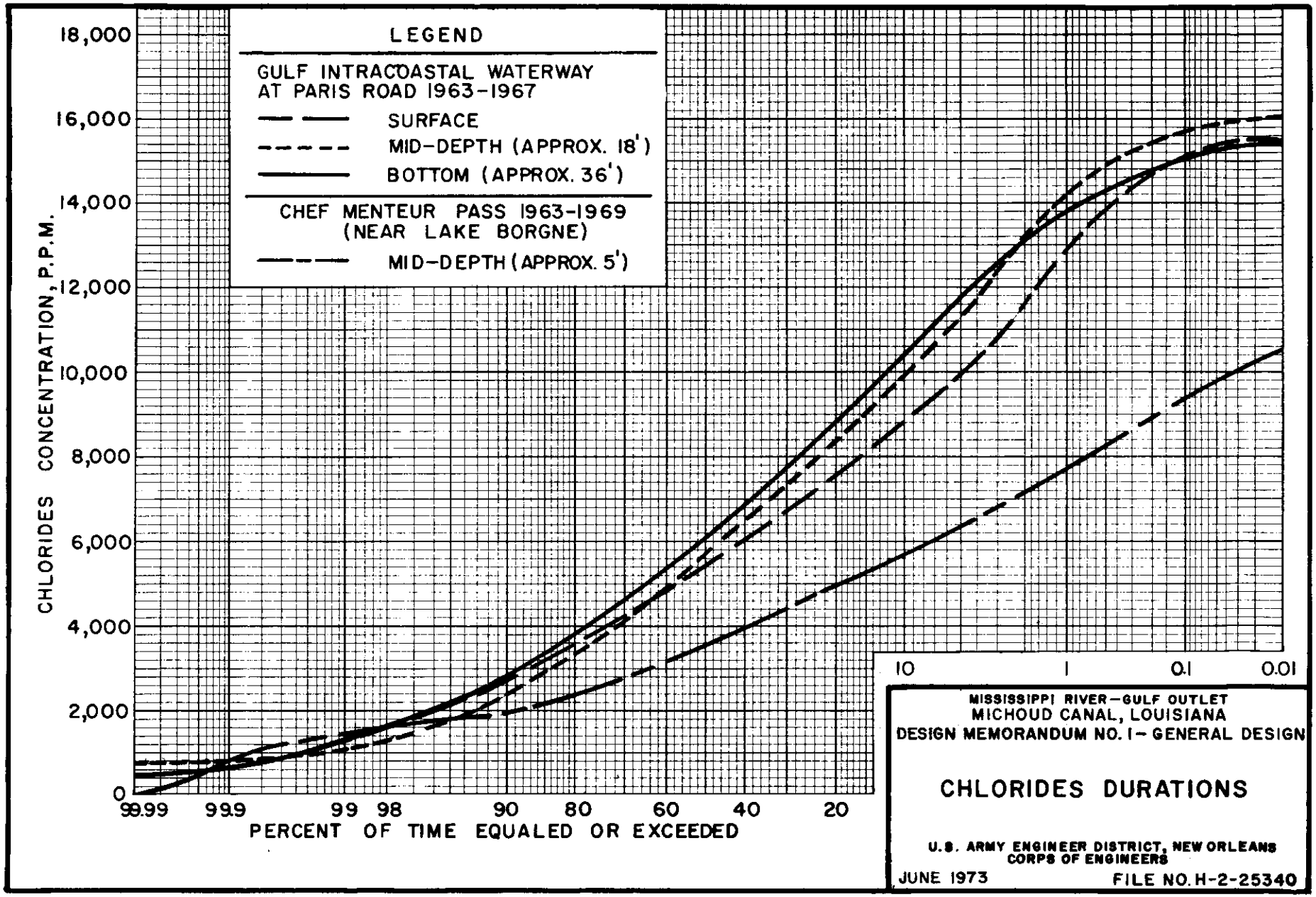

LEGEND
GULF INTRACOASTAL WATERWAY AT PARIS ROAD 1963-1967
SURFACE
MID-DEPTH (APPROX. 18')
BOTTOM (APPROX. 36')
CHEF MENTEUR PASS 1963-1969 (NEAR LAKE BORGNE)
MID-DEPTH (APPROX. 5')
CHLORIDES CONCENTRATION, P.P.M.
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
99.99
99.9
99
98
90
80
60
40
20
10
1
0.1
0.01
PERCENT OF TIME EQUALED OR EXCEEDED
MISSISSIPPI RIVER-GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO. 1- GENERAL DESIGN
CHLORIDES DURATIONS
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
JUNE 1973
FILE NO. H-2-25340

PLATE A-2

MISSISSIPPI RIVER-GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

APPENDIX B
COMPARISON OF ALTERNATE PLANS

MISSISSIPPI RIVER-GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

APPENDIX B
COMPARISON OF ALTERNATE PLANS

1. General. Ten different alternative plans were studied and thoroughly evaluated prior to the preparation of this design memorandum. Nine of these plans contemplated alternate spoil-disposal schemes and one plan considered an alternate channel alinement. Each alternate was evaluated with regard to economic feasibility and also with regard to environmental considerations. The alternative of "no-action" was also studied. Following is a brief description of each of the foregoing alternatives including "no-action." Table B-1 presented below shows comparative bases for each alternate plan and allows a rapid summary evaluation of the proposals.

2. Plan I. This plan, as shown on plate B-1, was formulated by the New Orleans District in the initial planning of the project subsequent to authorization. This plan closely approximates the project document plan. Interim construction spoil would be wasted north of the GIWW and immediately east of the Michoud Canal (area 3) and would commit about 690 acres of land. Another area (no. 1) consisting of 400 acres south of the MR-GO would be used for both construction and maintenance spoil. Area 2, consisting of 280 acres of natural marsh would be used for maintenance spoil only. This plan is estimated to cost $6,021,000 at current price levels. The plan is unacceptable from an environmental standpoint because of the total perpetual commitment of area no. 2 which is a highly productive natural marsh. Further, this plan was not acceptable economically, since much of area no. 3 has since been industrially developed and is no longer available for spoil-disposal usage. At the time this plan was studied, it was presented to local interests for review. The Dock Board indicated that the plan was not acceptable since the non-Federal costs were high when compared to other possible alternatives. Based on the aggregate per acre value of $6.85 (see paragraph 50c of this design memorandum), the 280 acres of natural marsh would sustain a loss of $1,918 per annum. Since this would be a permanent loss, the amortized value over a 50-year project life is $1,918 x 30.76923 x 0.04073 = $2,404.

3. Plan II. After the rejection of plan I for the reasons outlined above, plan II was formulated (see plate B-2). The primary difference between the two plans was that about 140 acres of industrial land nearest to the Michoud Canal and about 150 acres of other tracts were excluded. However, about 595 acres, somewhat more remote, were added. Spoil areas 1 and 2 did not change either

TABLE B-1
ALTERNATIVE PLANS
(Cost figures are derived from projected July 1973 price levels)

Plate Number	Rec. Plan VII B-8	Plan I B-1	Plan II B-2	Plan III B-3	Plan IV B-4	Plan V_A B-5	Plan V_B B-6	Plan VI B-7	Plan VIII B-9	Alternate Alinement B-10
First costs	$4,739,000	6,021,000	7,340,000	6,974,000	6,987,000	4,673,000	3,854,000	9,545,000	4,948,000	6,790,000
Annual costs	291,400	329,600	383,400	368,400	422,600	291,400	225,800	468,100	302,800	410,400
Annual economic benefits	691,500	691,500	691,500	691,500	691,500	691,500	691,500	691,500	691,500	691,500
B/C ratio	2.38:1	2.10:1	1.80:1	1.88:1	1.64:1	2.37:1	3.06:1	1.48:1	2.28:1	1.68:1
Environmental Considerations	acres	acres	acres	acres	acres	acres	acres	acres	acres	acres
Disposal areas for construction	(1,094)	(690)	(995)	(830)	(1,740)	(424)	(694)	(1,740)	(694)	(1,314)
Drained areas	174	690	995	830	0	174	174	0	174	174
Undrained leveed areas previously used for disposal	920	0	0	0	0	250	520	0	520	1,140
Undrained leveed areas not previously used for disposal	0	0	0	0	1,740	0	0	1,740	0	0
Disposal areas for maintenance	(380)	(280)	(280)	(280)	(1,580)	(0)	(0)	(520)	(0)	(570)
Undrained leveed areas previously used for disposal	0	0	0	0	0	0	0	520	0	0
Undrained leveed areas not previously used for disposal	380	0	0	0	0	0	0	0	0	0
Unleveed areas not previously used for disposal	0	280	280	280	1,580	0	0	0	0	570
Disposal areas for both maintenance and construction	(0)	(400)	(400)	(400)	(400)	(550)	(480)	(0)	(680)	(0)
Drained areas	0	0	0	0	0	0	0	0	0	0
Undrained leveed areas previously used for disposal	0	400	400	400	400	270	0	0	0	0
Unleveed areas not previously used for disposal	0	0	0	0	0	280	480	0	680	0
TOTAL ACREAGE	1,474	1,370	1,675	1,510	3,720	974	1,174	2,260	1,374	1,884

as to location or as to usage. This plan would require that spoil material be freely deposited over the Southern Natural Gas Company pipelines. The gas company objected to this. To satisfy the gas company, approximately 14,000 feet of additional control dikes with appurtenant control works would be required. Before this problem could be resolved, local interests withdrew about 180 additional acres from the plan. Plan II was no longer feasible for consideration because desirable tracts of land could not be committed by local interests. This spoil plan also included the use of spoil area 2, a natural marsh area, and was considered undesirable from an environmental standpoint. This plan is estimated to cost $7,340,000 at current price levels. Based on the aggregate per acre value of $6.85 (see paragraph 50c of this design memorandum), the 280 acres of natural marsh would sustain a loss of $1,918 per annum. Since this would be a permanent loss, the amortized value over a 50-year project life is $1,918 x 30.76923 x 0.04073 = $2,404.

4. Plan III. Plan III, shown on plate B-3, was essentially a variation of plans I and II. Throughout the formulation of plans I, II, and III, it was recognized that the U. S. Bureau of Sport Fisheries and Wildlife objected to what is shown on the plates as area 2. In letters dated 13 October 1965 and 17 November 1967, the Bureau stated its objections to spoiling on any marshland south of the GIWW because such spoiling would cause irreplaceable loss to the existing fish and wildlife resources in those marshes. But area 2 was desirable as a construction and future spoil area for the project because its proximity to the channel would result in minimum pumping costs. This plan basically contained the same shortcomings of the previous plans and was rejected for essentially the same reasons. This plan is estimated to cost about $6,974,000 at current price levels. As in the case of the previously discussed plans, the industrialization of the area east of Michoud Canal would preclude implementation of this proposal. Based on the aggregate per acre value of $6.85 (see paragraph 50c of this design memorandum), the 280 acres of natural marsh would sustain a loss of $1,918 per annum. Since this would be a permanent loss, the amortized value over a 50-year project life is $1,918 x 30.76923 x 0.04073 = $2,404.

5. Plan IV. Because of increasing land values of the industrial land near Michoud Canal, plan IV, as shown on plate B-4, was submitted by local interests. In this plan a large block of land south of the GIWW and labeled area C was substituted for area 2. An area of approximately 1,738 acres north of the GIWW and east of Maxent Lagoon was substituted for all the other construction spoil areas east of Michoud Canal previously considered by the other plans. Spoil area 1 would remain in plan IV. This plan was studied but was rejected by NOD because the additional pumping distances would make the Federal first costs unacceptably high. The use of spoil area C in place of area 2 did not overcome

the U. S. Bureau of Sport Fisheries and Wildlife objection to spoiling south of the GIWW. At current price levels this plan is estimated to cost $6,987,000. Based on the aggregate per acre value of $6.85, the 1,580 acres of natural marsh would sustain a loss of $10,823. Since this would be a permanent loss, the amortized value over a 50-year project life is $10,823 x 30.76923 x 0.04073 = $13,563.

6. Plan V_A. This plan is shown on plate B-5. Prior to the formulation of this plan it was apparent that the industrial lands east of the canal could not be extensively availed for spoil disposal. The only acreage in this area that was still acceptable is shown as area no. 6, plate B-5. It became necessary to reconsider the natural marsh area south of the GIWW (area 2) and to also consider larger disposal areas south of the MR-GO, shown as areas 1A, 1B, and 1C. Local interests objected to the use of any part of area 1 for perpetual maintenance spoil disposal because it would require long-term commitment of the real estate involved. There was no such objection for its use as a construction area because that would require a temporary commitment only. At current price levels, this plan is estimated to cost $4,673,000. Though this plan has economic merit, it still required the commitment of area 2 which was unacceptable environmentally. Based on the aggregate per acre value of $6.85 (see paragraph 50c of this design memorandum), the 280 acres of natural marsh would sustain a loss of $1,918 per annum. Since this would be a permanent loss, the amortized value over a 50-year project life is $1,918 x 30.76923 x 0.04073 = $2,404.

7. Plan V_B. This plan, as shown on plate B-6, is a modification of plan V_A. Plan V_B recommended using all of spoil area 2 (2A and 2B) for construction and maintenance spoil, and the total area 1 plus area 6 for construction spoil purposes. This plan was estimated to cost $3,854,000. Although this plan was the most economically justified plan of all plans considered, it also included spoil area 2 (as in plans I, II, and III) for which there were strong objections by the U. S. Bureau of Sport Fisheries and Wildlife. In light of the economic advantages available with this proposal, it was decided to again contact the Bureau for its comments. In a letter dated 31 May 1972, the Bureau again strongly objected to using area 2 for placement of dredged material. The following are quotations from that letter:

"Marshland habitat south of the GIWW is being rapidly destroyed as a result of navigational projects. Recently, approximately 1,800 acres of wetland habitat was destroyed in the vicinity of Chef Menteur Pass as a result of spoil disposal for relocation of the Gulf Intracoastal. We are extremely concerned by this continuous destruction of valuable marshland habitat south of

the Intracoastal Waterway. Preservation of these marshland areas is essentially to sustain the high level of biological productivity required to support the diversified fish and wildlife that presently inhabit these areas.

"An equally important function of these marsh areas is the production of organic matter which is directly related to the productivity of fishery resources in the adjacent waters. Synthesis of nutrients and the decomposition of organic matter within these wetlands form the basis of a rich and diverse food source for microscopic plant and animal plankton, which in turn provides the necessary food for successively higher organisms in the food chain. Dredging and filling of these areas will destroy this delicate balance between producer and consumer organisms. It is therefore essential that large sections of marshland areas south of the GIWW be preserved in their natural condition in order to insure the continued productivity of fish and wildlife resources."

The 480 acres of natural marsh would sustain a loss of $3,288 per annum. Since this would be a permanent loss, the amortized value over a 50-year project life is $3,288 x 30.76923 x 0.04073 = $4,121. This plan would require the use of an area of marsh which is cutoff from access by the various waterways and, accordingly, has the prospect of remaining in a natural condition for a very long time. Since there are several intangible factors in the known natural marsh productivity and value of natural marshes, it is extremely desirable to conserve such areas whenever reasonably possible. The area to be used by the proposed plan is near to highway access and is protected from hurricane tides. As such, it is subject to drainage and urban development in the near future. The U. S. Army Corps of Engineers concurs with the U. S. Bureau of Sport Fisheries and Wildlife in the objections to the use of spoil area 2. Accordingly, this area was rejected for environmental reasons despite the favorable economic considerations. This prompted the study of plans VI, VII, and VIII.

8. Plan VI. This plan is presented on plate B-7. Plan VI is very similar to plan IV in that it contemplated using the large area east of Maxent Lagoon and north of the GIWW for construction spoil. It also proposed using area 1 for construction and maintenance spoil. This plan was acceptable from an environmental standpoint. However, due to the remote location of the primary construction spoil-disposal area, costs for pumping were excessive resulting in an estimated first cost of $9,545,000. This scheme was accordingly rejected for economic reasons.

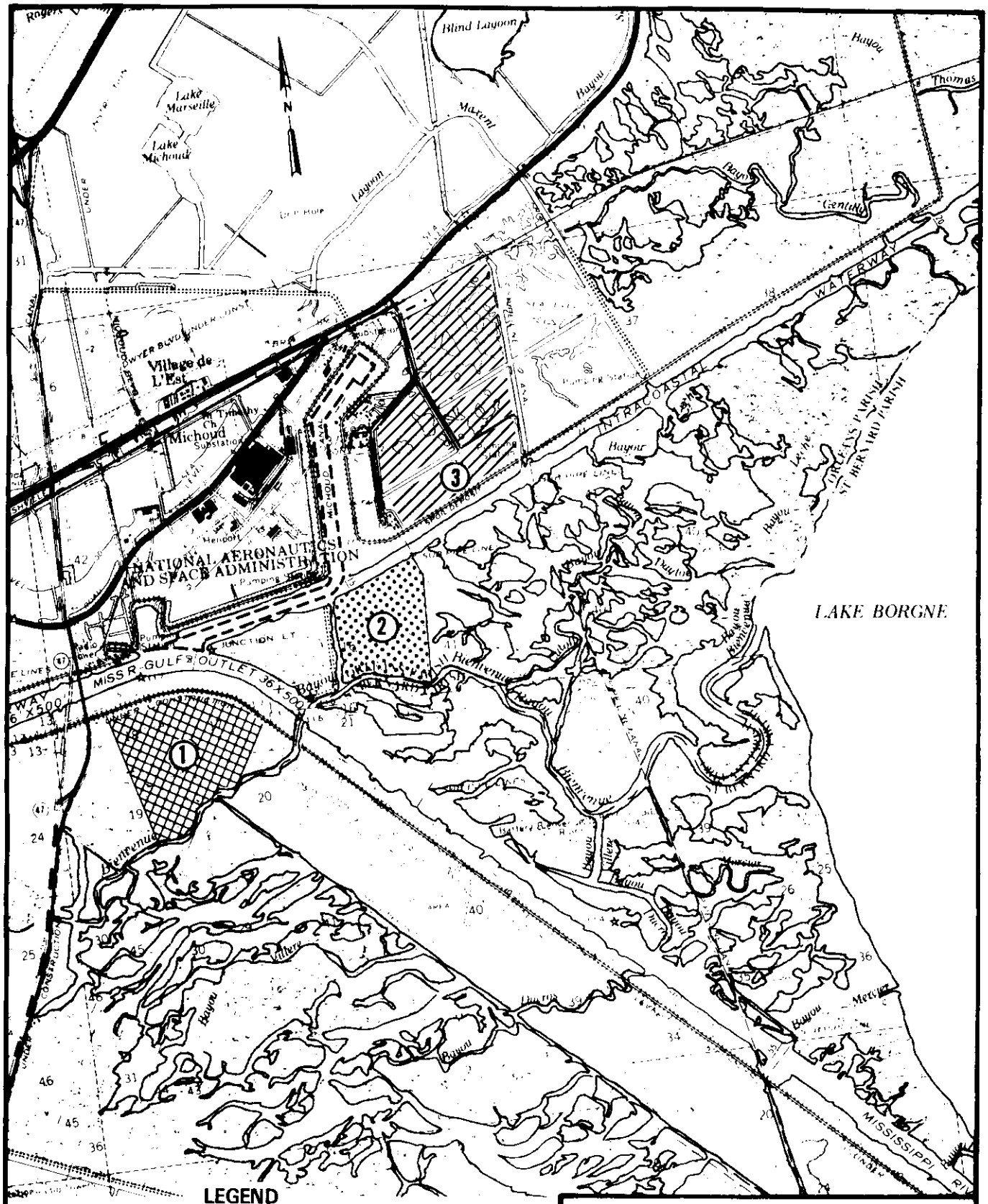
9. Plan VII (recommended plan). Plan VII, as shown on plate B-8, is the proposed plan and is the most feasible plan when all factors are considered. This plan is fully described in the main text of this design memorandum. The plan has been

fully coordinated with state and Federal fish and wildlife agencies and with local interests. It bears full approval of these agencies. This plan has a favorable benefit-to-cost ratio and is environmentally sound.

10. Plan VIII. This plan, as shown on plate B-9, was formulated at the same time as plan VII. Plan VIII differs from plan VII in that an area of marsh 4,000 feet wide south of Bayou Bienvenue was proposed for both construction and maintenance spoiling. This plan would approximately double the marsh acreage that would be destroyed when compared to plan VII, and thus, from an environmental standpoint, it is less desirable than plan VII. Economically, this plan which is estimated to cost $4,948,000 is slightly less favorable than the recommended plan. The 680 acres of undrained leveed marsh would sustain a loss of $4,658 per annum. Since this area is an undrained leveed area, it is estimated that this marsh would be lost to urban development in about 25 years. Accordingly, the amortized value over a 50-year project life is $4,658 x 16.93786 x 0.04073 = $3,213.

11. Alternate alinement plan. The alinement of the project channel is shown to be the same on plates B-1 through B-9. Only one alternative to this was considered, that being a channel to elevation -36 feet m.l.g. over a bottom width of 250 feet extending southward from the existing Michoud Canal, across Bayou Bienvenue, and into the MR-GO (see plate B-10). A small channel generally of this alinement now exists but would require considerable widening and deepening. The plan was rejected because it would have increased excavation quantities an additional 800,000 cubic yards. Increased spoil volume would require more marshland on which to spoil and would also be more costly. The estimated cost of this proposal is $6,790,000. No other feasible channel alinement was considered after authorization of the project. The 570 acres of natural marsh would sustain a loss of $3,905 per annum. Since this would be a permanent loss, the amortized value over a 50-year project life is $3,905 x 30.76923 x 0.04073 = $4,894.

12. "No-action" alternative. The authorized navigation improvement meets the present and foreseeable needs of navigation within the context of present national policies and includes features specifically formulated for the benefit of the environmental elements. The alternative of no action would have an adverse impact on the potential industrial development of the project area and would result in impeding progress in the needed development of the Port of New Orleans. No action would, however, result in delaying the economic development of the area, and would maintain longer the natural esthetics and production of the marsh area required for disposal of maintenance spoil.



LEGEND

- Project Channel
- Construction Spoil
- Maintenance Spoil
- Maintenance and Construction Spoil

SCALE 1:62,500

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO.1 — GENERAL DESIGN

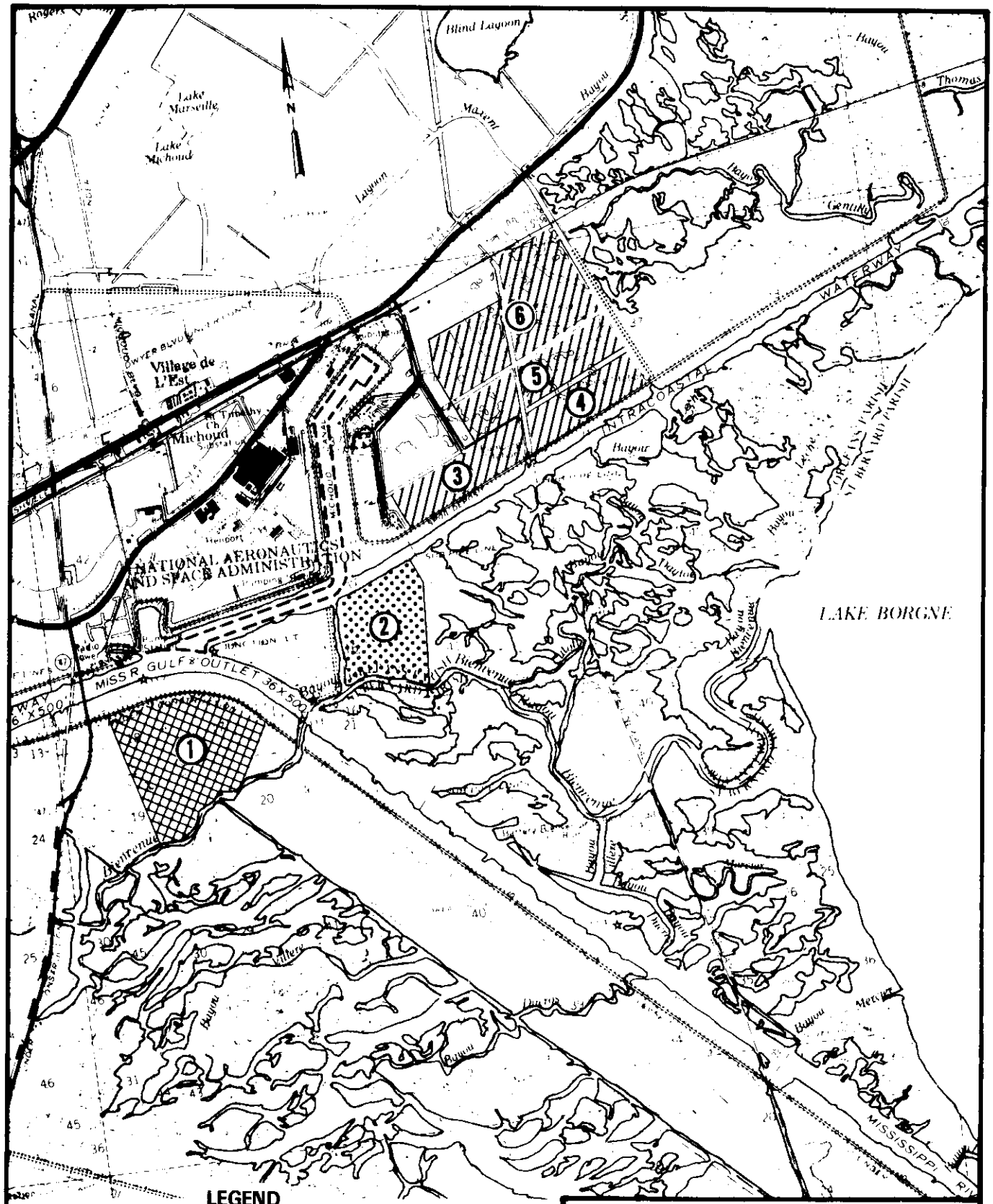
SPOIL PLAN I

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO. H-2-25340

PLATE B-1



LEGEND

- Project Channel
- Construction Spoil
- Maintenance Spoil
- Maintenance and Construction Spoil

SCALE 1: 62,500

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO.1 – GENERAL DESIGN

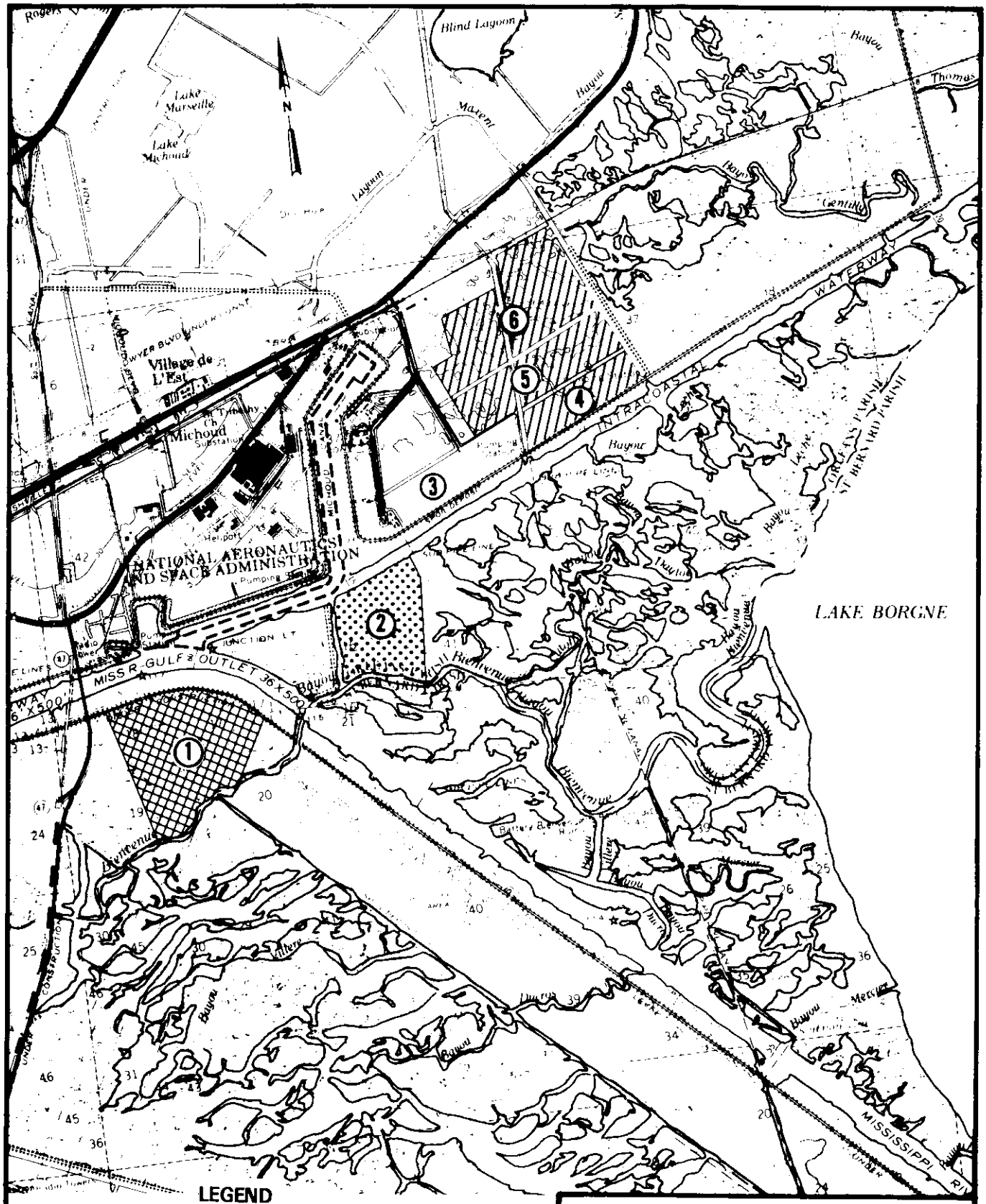
SPOIL PLAN II

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO H-2-25340

PLATE B-2



LEGEND

- **Project Channel**
- **Construction Spoil**
- **Maintenance Spoil**
- **Maintenance and Construction Spoil**

SCALE 1 : 62,500

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO.1 – GENERAL DESIGN

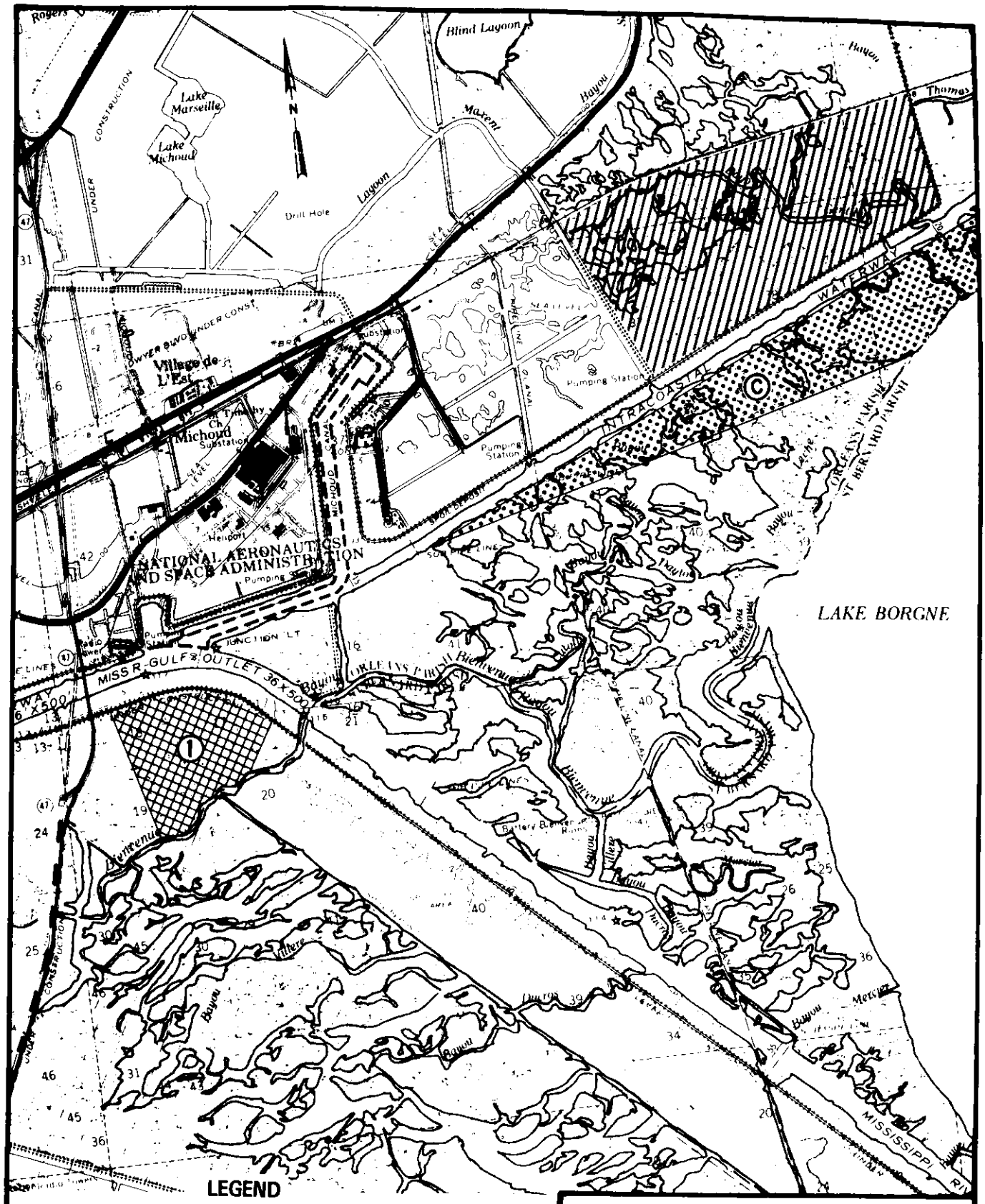
SPOIL PLAN III

U.S. ARMY ENGINEER DISTRICT NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO. H-2-25340

PLATE B-3



LEGEND

- Project Channel
- Construction Spoil
- Maintenance Spoil
- Maintenance and Construction Spoil

SCALE 1:62,500

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO.1 – GENERAL DESIGN

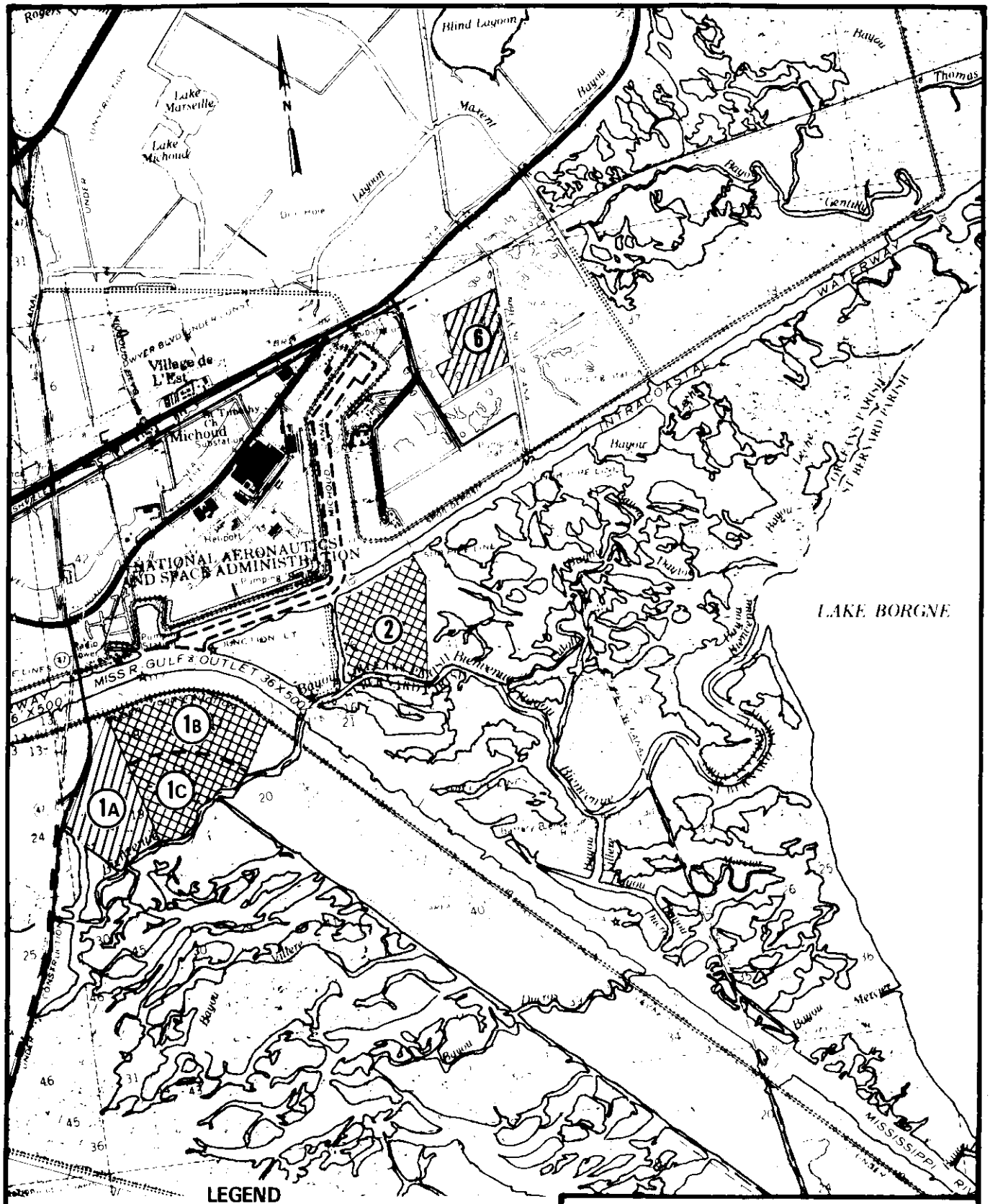
SPOIL PLAN IV

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO H-2-26340

PLATE B-4



MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO.1 — GENERAL DESIGN

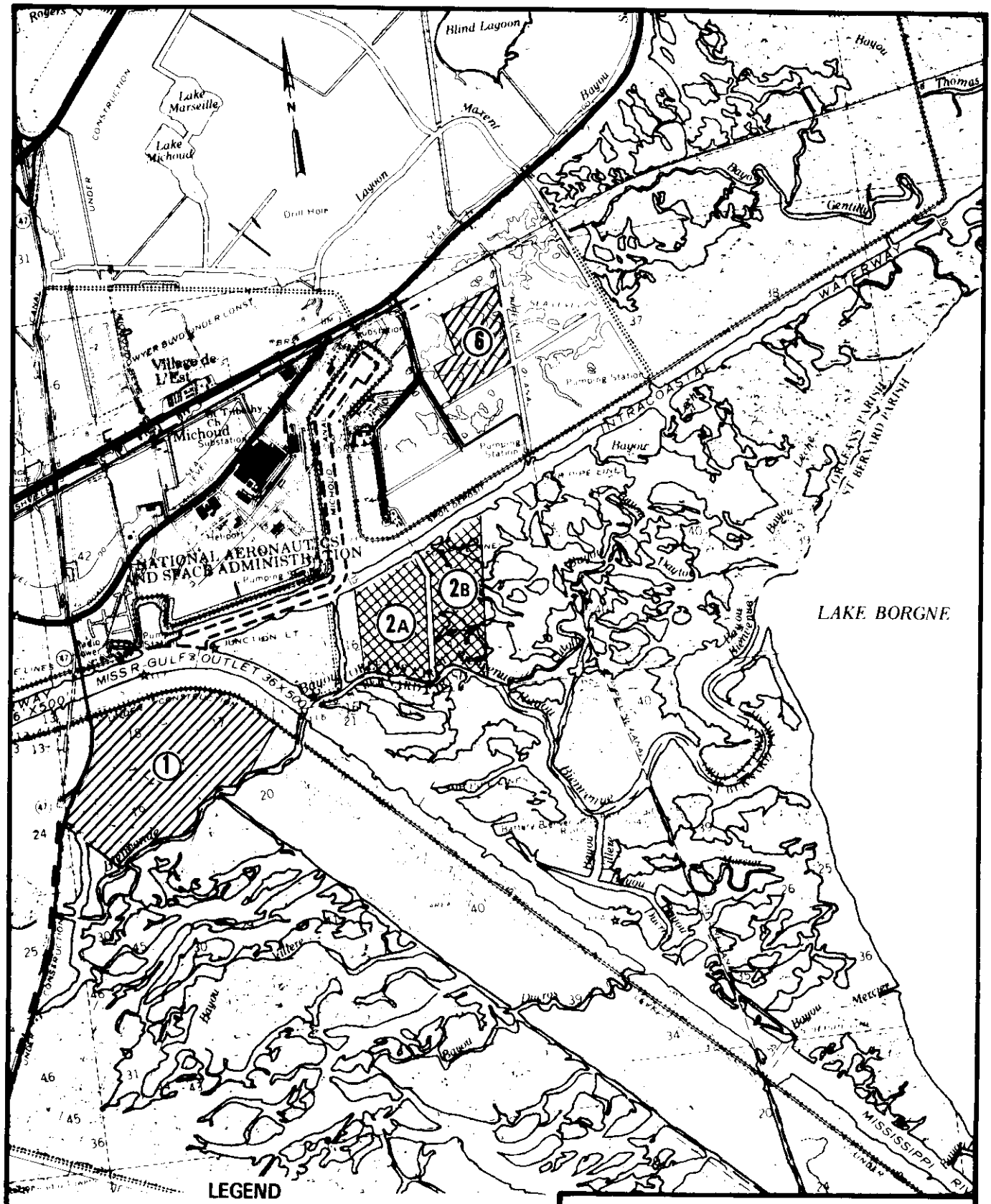
SPOIL PLAN V$_A$

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO H-2-25340

PLATE B-5



LEGEND

- Project Channel
- Construction Spoil
- Maintenance Spoil
- Maintenance and Construction Spoil

SCALE 1 : 62,500

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO.1 — GENERAL DESIGN

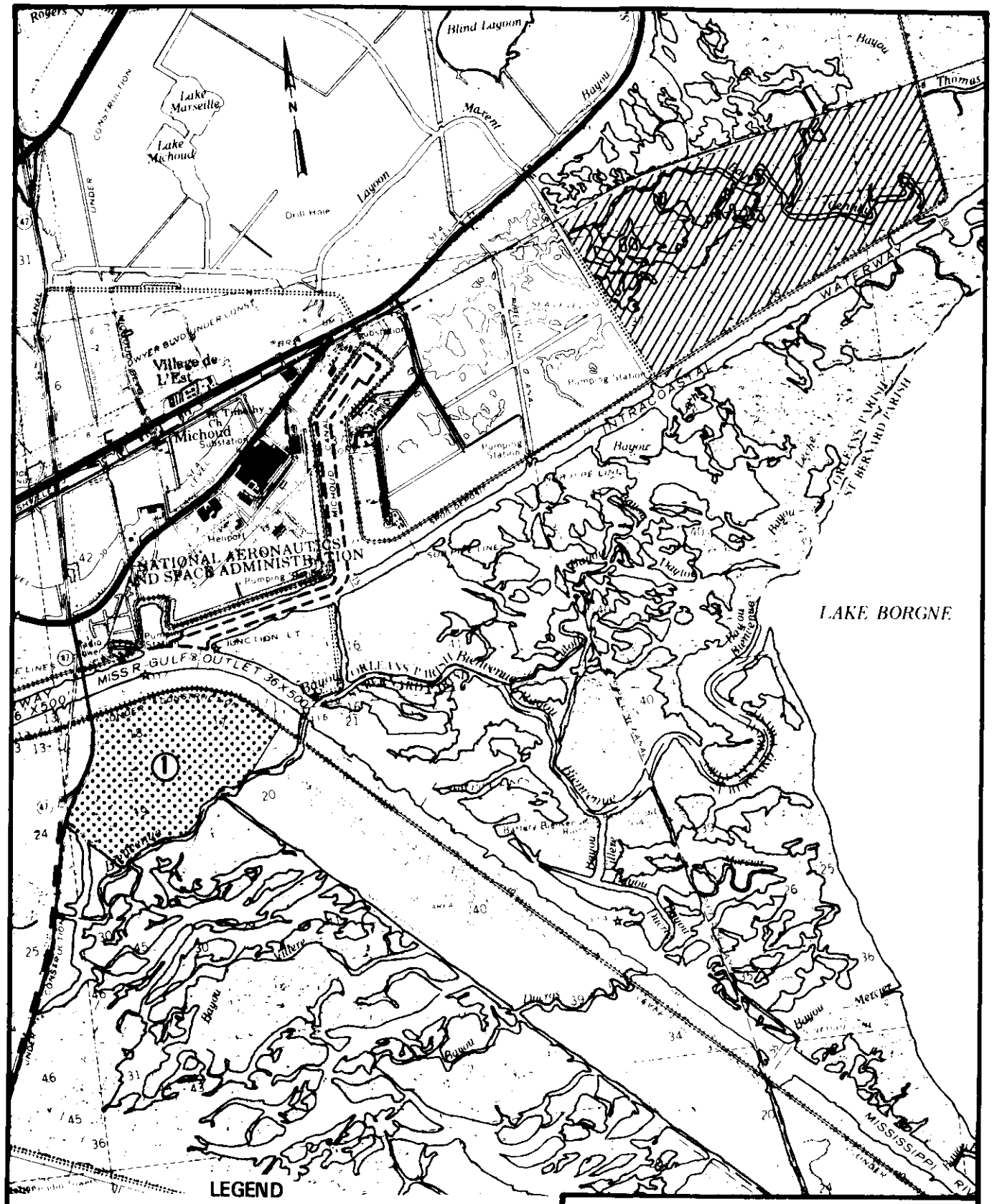
SPOIL PLAN V_B

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO H-2-25340

PLATE B-6



LEGEND

- Project Channel
- Construction Spoil
- Maintenance Spoil
- Maintenance and Construction Spoil

SCALE 1:62,500

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO.1 – GENERAL DESIGN

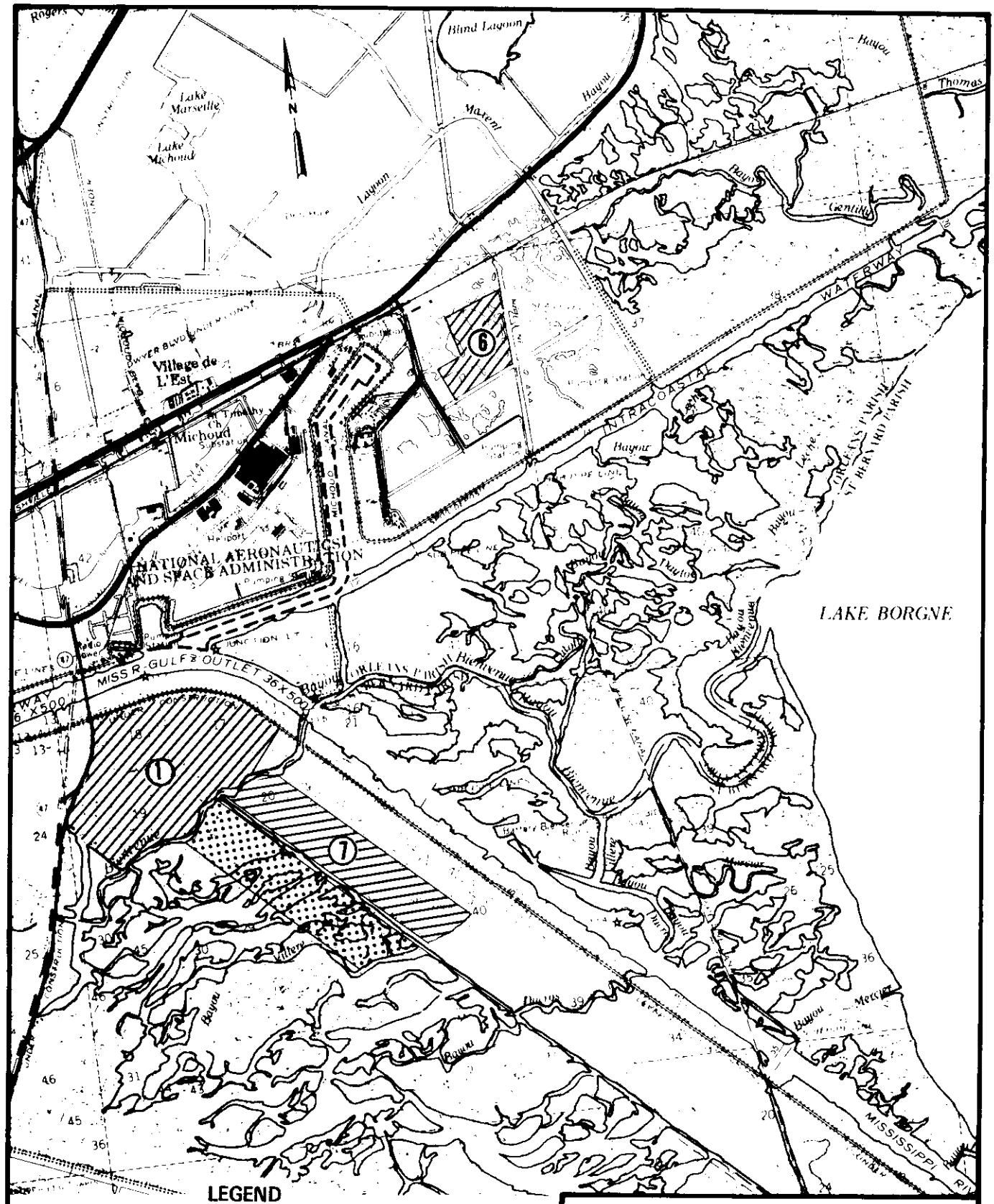
SPOIL PLAN VI

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO. H-2-25340

PLATE B-7



MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO.1 — GENERAL DESIGN

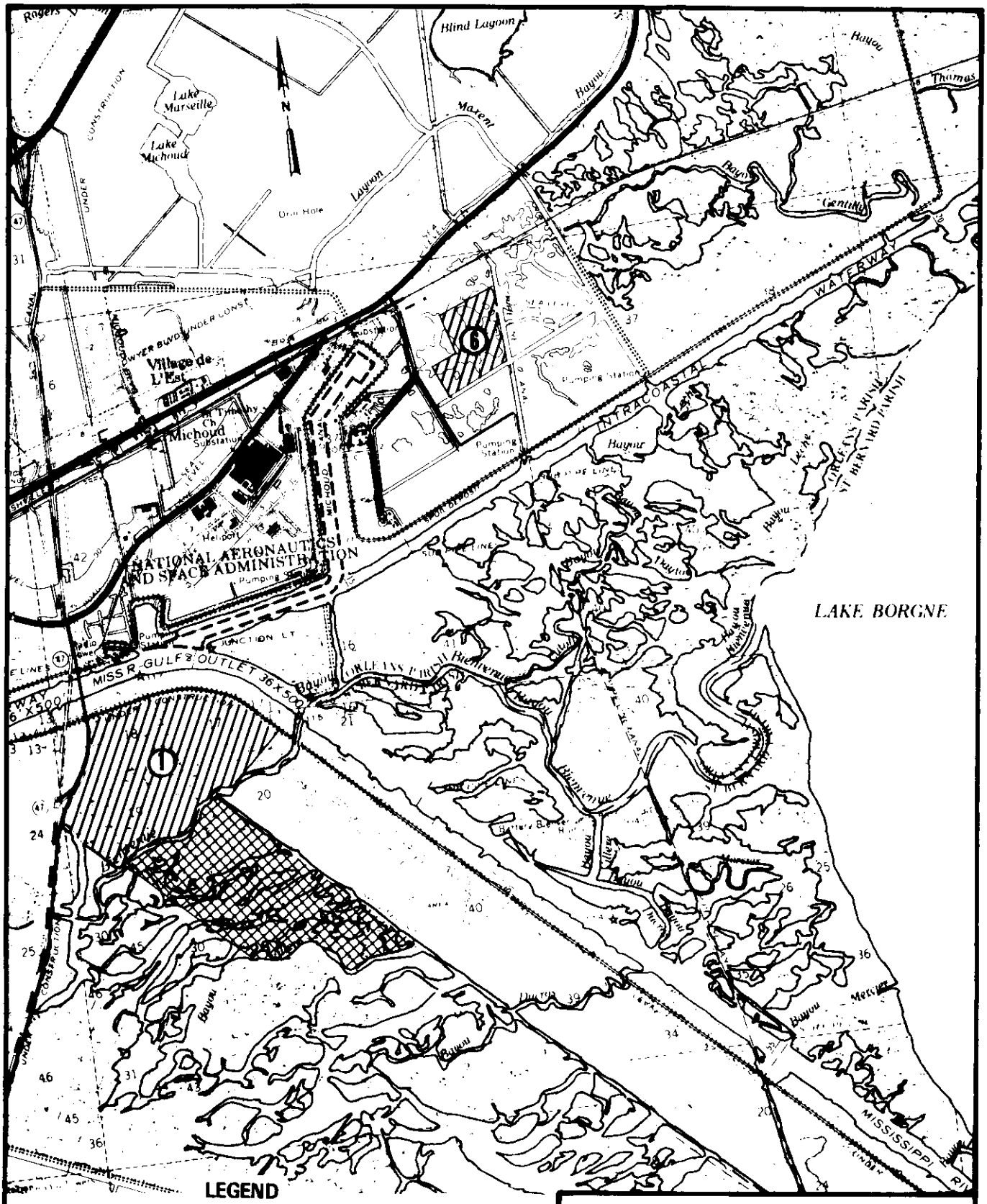
SPOIL PLAN VII

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO. H-2-25340

PLATE B-8



LEGEND

- Project Channel
- Construction Spoil
- Maintenance Spoil
- Maintenance and Construction Spoil

SCALE 1: 62,500

MISSISSIPPI RIVER GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO.1 – GENERAL DESIGN

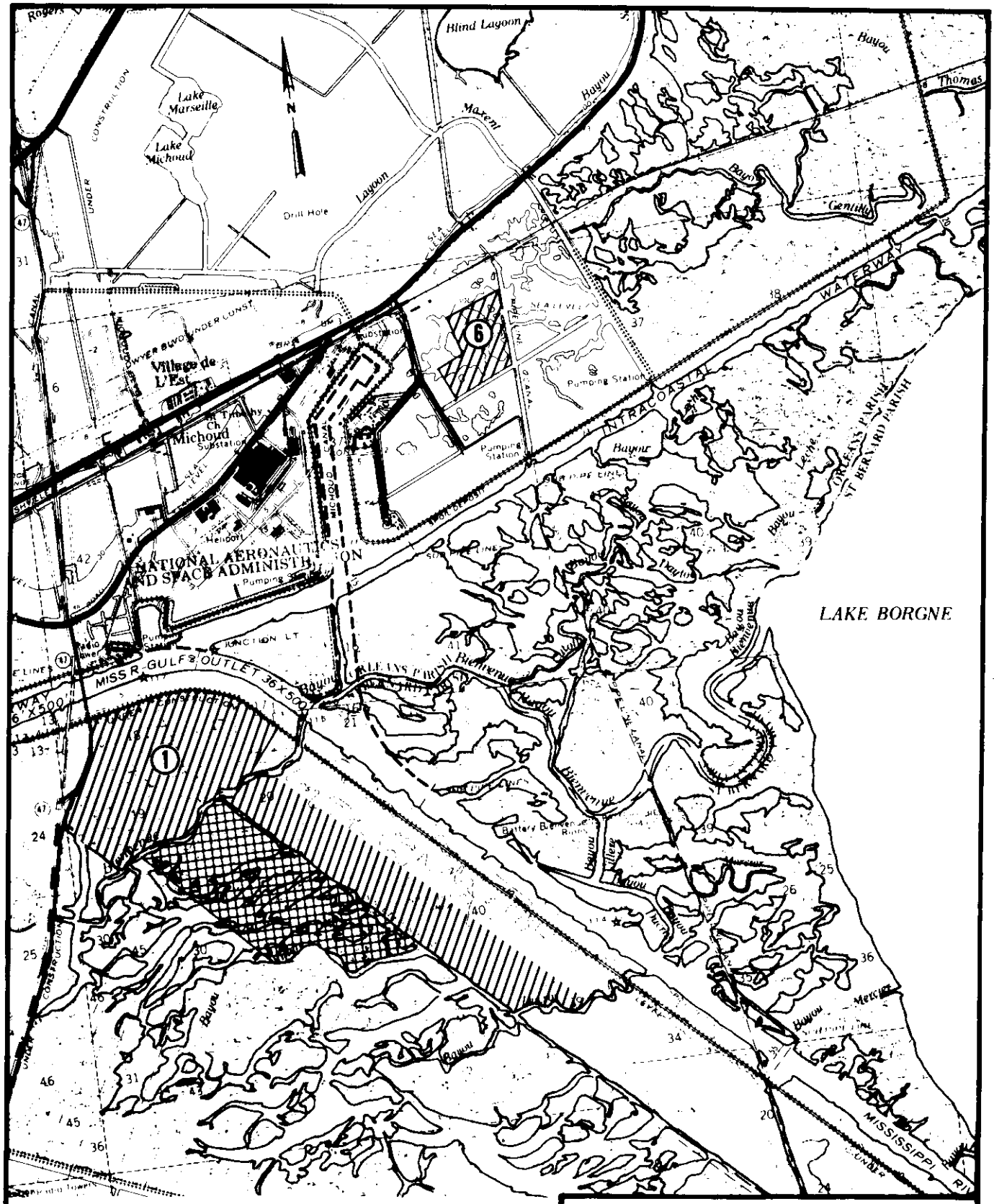
SPOIL PLAN VIII

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973

FILE NO. H-2-25340

PLATE B-9



LEGEND

- Construction Spoil
- Maintenance Spoil
- Maintenance and Construction Spoil

MISSISSIPPI RIVER - GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO.1 – GENERAL DESIGN

ALTERNATE ALINEMENT PLAN

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

JUNE 1973 FILE NO. H-2-25340

PLATE B-10

MISSISSIPPI RIVER-GULF OUTLET
MICHOUD CANAL, LOUISIANA
DESIGN MEMORANDUM NO. 1 - GENERAL DESIGN

APPENDIX C
CORRESPONDENCE RELATIVE TO COORDINATION WITH OTHER AGENCIES

IN REPLY REFER TO
LMNED-PP

18 August 1972

Mr. C. Edward Carlson, Regional Director
U. S. Department of the Interior
Fish and Wildlife Service
Bureau of Sport Fisheries and Wildlife
809 Peachtree-Seventh Building
Atlanta, Georgia 30323

Dear Mr. Carlson:

The meeting held in this office on 13 July 1972 concerning the project "Mississippi River-Gulf Outlet, Michoud Canal, Louisiana," resulted in our agreeing to furnish your staff cost estimates for three alternative spoil plans. Inclosure 1 is our memo to the files covering that meeting on which, near the end of the memo, the three alternatives are listed.

The inclosed drawings show each plan with corresponding costs thereon as follows:

a. Plan V_B (inclosure 2) is the current plan using spoil areas no. 1, 2, and 6.

b. Plan VI (inclosure 3) provides for using an area east of Maxent Lagoon and north of the GIWW (Intracoastal Waterway) for initial construction spoil. Spoil area no. 1 would be used for maintenance but would not be used for initial construction.

c. Plans VII (inclosure 4) and VIII (inclosure 5) are responsive to Mr. Welford's suggestion that we investigate a plan using spoil areas no. 1 and 6 for construction and a site south of Bayou Bienvenue for construction and maintenance.

Areas labeled on the drawings as "construction" would be acquired temporarily and areas labeled as either "construction and maintenance" or "maintenance" would be acquired permanently for use as spoil areas only.

Plan V_B is the least costly to both the Government and to local interests. Aside from economic considerations, there are other reasons why that plan appears preferable over the others.

Plan VI provides for permanent acquisition of spoil area no. 1. This would result in preventing development of lands protected from hurricane tides. Seventy percent of the money to provide that protection is Federal. Those same lands abut approximately 8,000 feet of deep-draft water frontage along the Mississippi River-Gulf Outlet (MR-GO). In addition, future plans of the Louisiana Department of Highways and the Federal Highway Administration provide for passing Interstate Route I-410 through the western edge of the area on an elevated roadway with an interchange to be at ground level. With such high quality highway access coupled with the equally high quality navigation access provided by the MR-GO and the GIWW, the area could undoubtedly become an important part of the Port of New Orleans. We feel that using the area on a "one-time" basis for initial construction spoil (as in plans V_B, VII, and VIII) will not interfere with the development of near-term port needs, but we feel that setting the area aside on a long-term basis (as in plan VI) would be incompatible with our other projects that are complete or nearing completion, and plans other governmental agencies propose for the future.

Plan VIII provides for a construction and maintenance area south of Bayou Bienvenue and west of the MR-GO. It also will have excellent highway access via the planned I-410. Shallow-draft navigation will be available through a floodgate structure currently under construction at the confluence of the bayou and the MR-GO. The area has good development possibilities; therefore, the assuring agency (Board of Commissioners of the Port of New Orleans) would prefer not to acquire it in perpetuity for spoil only.

Plan VII includes using the rear 2,000 feet of the spoil area now being used for maintenance of the MR-GO and about half the area discussed above. We have investigated this plan because it requires less diking in open marsh than Plan VIII which consequently reduces the cost. Otherwise, the observations made for plan VIII are also applicable for plan VII.

Please note that both plans VII and VIII include lands in St. Bernard Parish. It is improbable that the governing body of that parish would ever willingly agree to the use of land within its jurisdiction being used temporarily, much less permanently set aside, for projects outside the parish boundaries. If either plan were to be implemented, real estate acquisition would be complicated and time consuming, thus delaying the project several years. For these reasons we doubt the viability of plans VII and VIII.

LMNED-PP 18 August 1972
Mr. C. Edward Carlson

Plan V_B, as previously pointed out, is the least costly by approximately $1.2 million. It does not include any lands planned for port development to be set aside in perpetuity and it is feasible to the extent that local interests have agreed to support it by acquiring the necessary lands. It may be that permanently setting aside spoil area no. 2 could act as a barrier to future development of the triangular-shaped marsh area bounded by the GIWW, the MR-GO, and the west bank of Lake Borgne.

In addition to the above-listed economic and practical reasons for weighing one alternative against another, we also desire to minimize change to the environmental amenities of the project area. If we adopt a plan other than the most economical one, sufficient information must be included in our final report to support the additional cost. There are, of course, factors that cannot be expressed tangibly. To the extent that damages to fish and wildlife resources are subject to economic evaluation, these damages must be included in our justification.

Therefore, I request your comments on the plans covered by the inclosures with specific justification to support any plan you recommend that is more expensive than plan V_B. Please be as specific as possible in your analysis and express as many fish and wildlife costs as possible in monetary terms. We will then incorporate your data into the other parameters of the study to determine the most acceptable overall plan. Because the Bureau of Sport Fisheries and Wildlife is the agency most knowledgeable in evaluating fish and wildlife resources, we look forward to receiving your data and specific recommendations.

Our current schedule is based on our receiving your response by 29 September 1972. If that date cannot be met, please advise us. If you need further information, please let us know.

Sincerely yours,

5 Incl (dupe)
1. Memo to files
2. Dwg plan V_B, w/cost est
3. Dwg plan VI, w/cost est
4. Dwg plan VII, w/cost est
5. Dwg plan VIII, w/cost est

RICHARD L. HUNT
Colonel, CE
District Engineer

CF: wl cy incl
LMVEX, LMVED-TD

United States Department of the Interior
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
PEACHTREE-SEVENTH BUILDING
ATLANTA, GEORGIA 30323

AIRMAIL

October 24, 1972

District Engineer
U.S. Army Corps of Engineers
P.O. Box 60267
New Orleans, Louisiana 70160

Dear Sir:

Reference is made to your August 18, 1972, letter requesting our comments concerning alternative spoil plans for the Mississippi River-Gulf Outlet, Michoud Canal project, Louisiana.

As indicated in previous correspondence from this office and most recently in a September 15, 1972, meeting with representatives of your agency, we contended that the environmental loss from spoiling south of the Gulf Intracoastal Waterway (GIWW) was excessive and any plan which would sacrifice the integrity of this valuable marsh-land area would not be sanctioned by the Bureau.

In response to your request, we have reviewed the alternative spoil plans provided with your August 18 letter. Plan VII provides for using an existing spoil area, now being used for maintenance of the MR-GO, for placement of construction spoil from enlargement of the Michoud Canal. An additional 2,000 feet of marsh area lying between Bayous Bienvenue and Villere and adjacent to the MR-GO spoil area would be required for maintenance spoil. Therefore, we recommend the adoption of plan VII as being the most acceptable from a fish and wildlife standpoint.

We understand that the above information will allow you to finalize plans for the project. We will give further consideration to providing the additional information requested in your August 18 letter.

Sincerely yours,

Jack E. Hemphill

Acting Regional Director

LMNED-PP

31 September 1970

Mr. C. Edward Carlson, Regional Director
U. S. Department of the Interior
Fish and Wildlife Service
Bureau of Sport Fisheries and Wildlife
Peachtree-Seventh Building
Atlanta, Georgia 30323

Dear Mr. Carlson:

Reference is made to our letter of 23 March 1967 and to your reply dated 17 November 1967 relative to the proposed Mississippi River-Gulf Outlet, Michoud Canal, La., project.

The proposed plan of improvement is essentially the same as described in our referenced letter; however, we have located our proposed spoil disposal areas and would appreciate your views concerning location of the same. The general location of the channels, turning basin, and spoil disposal areas are shown on the inclosed two plates.

There are no environmental quality problems directly related with the enlargement of the existing channels, and proper steps will be taken to insure that the excavated material will be contained. The excavated spoil will be placed in two general areas, one north of the Gulf Intracoastal Waterway (GIWW) within an area scheduled for future industrial development by New Orleans East, Inc., and the other southwest of the Mississippi River-Gulf Outlet (MR-GO) in a spoil area permanently maintained for spoil disposal. You will note that no spoil will be placed in the marshes south of the GIWW, therefore, these marshes will not be affected by the project. Conservation measures will be taken to insure that suspended material will not be returned to the MR-GO/GIWW waterways. Effluent from the hydraulic dredging will be discharged inside spoil retention dikes which will encircle the individual spoil areas. Waste water from the spoil retention areas will be returned to the above mentioned waterways through control structures located as far as possible from the

LMNED-PP 3 September 1970
Mr. C. Edward Carlson

dredged inpnt material. This strict control will also prevent waste spoil material from entering the marshes and affecting fish and wildlife.

We would appreciate your comments concerning the project as would be applicable under the portion of Public Law 91-190 that is within the authority of the Fish and Wildlife Service by 21 September 1970 so they may be included in the general design memorandum for the project.

Sincerely yours,

2 Incl
Plates

HERBERT R. WEAR, JR.
Colonel, CE
District Engineer

Cy fur:
Mr. Richard Eichhorn, Field Supervisor
U. S. Fish and Wildlife Service
409 Merchants Bank Bldg.
Vicksburg, Mississippi 39180

UNITED STATES
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

SOUTH CENTRAL REGION
1402 ELM STREET, 3RD FLOOR
DALLAS, TEXAS 75202

Your Reference:
LMNED-PP
October 6, 1970

District Engineer
U.S. Army Engineer District, New Orleans
P. O. Box 60267
New Orleans, Louisiana 70160

Dear Sir:

Reference is made to your letter of September 3, 1970 concerning the proposed Mississippi River-Gulf Outlet, Michoud Canal, Louisiana project.

This office furnished you comments on the proposed channel enlargement by a letter of November 14, 1967 in which it was stated that care should be exercised in the disposal of spoil so that sediment would be held to a minimum. It is noted that in your latest studies you have determined the location of the spoil area and that these areas are to be encircled by retention dikes so that the suspended material will not be returned to the waterways. The waste water from the spoil areas is to be returned to the waterways through control structures which are to be located as far as possible from the dredged input material. This method of disposal and control of the spoil material would not have any adverse affect on water quality and should not effect the environment as it relates to water quality.

For compliance with Executive Order 11507 we recommend that construction specifications require contractors to:

a. Take precautions in the handling and storage of hazardous materials to prevent spillages that would result in degradation of the water quality.

b. Provide and operate sanitation facilities that will adequately treat domestic wastes to conform with Federal, state and local regulations.

Sincerely yours,

KENTON KIRKPATRICK
Director, Office of Planning

IN REPLY REFER TO
LMMED-PP

2 March 1972

Mr. Clark M. Hoffpauir, Director
Louisiana Wild Life and Fisheries Commission
400 Royal Street
New Orleans, Louisiana 70130

Dear Mr. Hoffpauir:

The general design memorandum for the project "Mississippi River-Gulf Outlet, Michoud Canal, Louisiana," is being prepared. During preauthorization stages your agency responded, by letter dated 20 September 1965, to our request for comments. The detailed channel design is essentially the same as was generally indicated to you previously. The project excludes enlargement of the Gulf Intracoastal Waterway (GIWW) east of Michoud Canal to Lake Borgne as suggested in your letter.

At the time of authorization, we had planned to deposit dredge spoil in two locations, i.e., generally that area shown on the attached drawings as spoil area no. 1 and another area east of the existing Michoud Canal and north of the GIWW of which area no. 6 is a part.

Subsequent to authorization, certain tracts within the area north of the GIWW adjacent to or near Michoud Canal have become unavailable for spoil deposition because of substantially increased land values. Some of those tracts have been sold to firms having no known interest in the project. Analyses of alternative sites nearer Chef Menteur Pass on the north side of the GIWW show those sites to be so remote that pumping costs of the dredged material are prohibitive. This District and local interests believe the combination shown on the inclosure to be the most economical of the feasible alternatives.

Spoil areas nos. 1 and 6 are generally those you have previously reviewed and do not constitute a significant change. Spoil area no. 2, however, is located within the marsh south of the GIWW, an area in which you believe the present water conditions should be maintained.

LMNED-PP 2 March 1972
Mr. Clark M. Hoffpauer

The plan provides for isolating the area from the surrounding marsh by raising existing high banks along Bayou Bienvenue and the GIWW, constructing new N-S connecting dikes between those channels, and installing waste water control structures at strategic points in the dike along the GIWW. Discharging excess water from spoil area no. 2 into the GIWW should minimize any resulting turbidity in Bayou Bienvenue. Input of dredged materials would be along the GIWW and control structures would be operated so as to optimize clarification of effluent. Upon completion of either construction or maintenance dredging operations, dikes across any natural channels would be reopened in order to restore natural drainage courses.

The present elevation of the marsh area is +0.5 foot mean sea level (m.s.l.). A zone 300 feet to 500 feet wide along the GIWW, slightly higher than the marsh, has firm footing. Along Bayou Bienvenue there is an existing natural ridge about 60 feet wide at elevation +1.0 to +1.5 m.s.l. We estimate the elevation of spoil area no. 2, 3 years after deposition, would be approximately +2.0 m.s.l. near the GIWW sloping to +1.0 m.s.l. near Bayou Bienvenue. Subsidence of the surface will proceed at a slow rate as the foundation materials continue to consolidate.

Based on experience in the GIWW, which has not required maintenance since its construction in 1942, we expect a similarly low level of maintenance to prevail for the Michoud Canal project. Consequently, after initial construction, spoil area no. 2 should revert to wildlife habitat, consisting of shrubs, woody plants, and weeds in two or three growing seasons. Whereas marshland species exist in the area at present, animals in the revised habitat will tend toward upland species, such as deer and rabbit.

I would appreciate your comments on the project, from a fish and wildlife standpoint, by 24 March 1972 for inclusion in the general design memorandum.

Sincerely yours,

1 Incl
Dwg file M-2-26021
(sheets 127, 128, & 137)

WILLIAM E. LEE, JR.
Lieutenant Colonel, CE
Acting District Engineer

CF: w/o incl
Ch, Design Br. WW Sec. , Engrg. Div.
Ch, Real Estate Div.

State of Louisiana

WILD LIFE AND FISHERIES COMMISSION
400 ROYAL STREET
NEW ORLEANS 70130

CLARK M. HOFFPAUER
DIRECTOR

April 20, 1972

Colonel Richard L. Hunt
District Engineer
U. S. Army
New Orleans District, Corps of Engineers
P. O. Box 60267
New Orleans, Louisiana 70160

Dear Colonel Hunt:

Reference is made to the March 8, 1972, general design memorandum for the project "Mississippi River-Gulf Outlet, Michoud Canal, Louisiana."

It was recommended in the September 20, 1965, correspondence to the District Engineer that spoil material dredged resulting from operation of the project "Mississippi River-Gulf Outlet, Michoud Canal, Louisiana" be placed on the north bank of the Intracoastal Waterway and be confined to land area. An alternate site, west of the Mississippi River Gulf Outlet in an area that has already been "spoiled" was also suggested.

Trawl samples in that immediate area have been collected since 1966, resulting in the capture of 42 species representing two phyla and 22 families of crustaceans and fishes. The small mesh size in the gear utilized only permitted capture of smaller specimens. other species of fishes and molluscs were not collected but are known to inhabit the area. All of the bayous, bays and lagoons south of Gulf Intracoastal Waterway and east of the Mississippi River-Gulf Outlet are utilized as nursery grounds by many species including important commercial species such as white shrimp, brown shrimp, blue crab,

menhaden, sand sea trout, spotted sea trout, Atlantic croaker, and other sciaenids. Maintenance of nursery areas in Louisiana's coastal zone is a primary concern since those areas are vitally important to our economy.

It is also reported (Sykes, 1963) that the Gulf States' estuaries produce 230 lbs. of marketable fish and shellfish/acre/year, discounting sportfish catches or forage species not utilized directly by the fisheries. Utilizing the 230 lbs/acre/year and 434 acres, an estimated loss of 99,820 lbs/year of fishery products results. This estimate is based on the premise that 434 acres of this estuarine area are totally usable for fish and shellfish productivity. In reality, approximately one-fifth of this area would be suitable for the productivity of shellfish and fish and this would total out to approximately twenty thousand pounds.

Historically, the marsh south of the Gulf Intracoastal Waterway and east of the Mississippi River-Gulf Outlet has been and remains an important waterfowl wintering area and furbearer habitat. Obviously, filling 434 acres with spoil and retaining by levees will render the area unsuitable for their habitation.

In our experience, dredging, construction of spoil retention levees, and associated operations is always accompanied by spoil seepage, surface runoff from precipitation, and tidal and wave action, thus increasing the amount of turbidity and particulate matter (composed of soil and vegetation) in the water column. These actions and reactions could cause damage to oyster leases in adjacent areas.

It was stated in the March 8, 1972, memorandum that the Corps and local interests believe that the most economical relocation of spoil is deposition at spoil area No. 2. We have suggested several other sites for spoil deposition and are vitally interested in maintaining the area north of Lake Borgne as a nursery area for

many species of fishes, shellfishes, crustaceans and a wintering area for ducks.

To reiterate, in our opinion, the site selected for spoil deposition (spoil area No. 2) would destroy an important nursery area for estuarine-dependent species and is not economically feasible in view of the facts recommended for spoil deposition be chosen or at least re-examined and evaluated. It is also suggested that spoil deposition in the section of marsh described above be postponed pending additional environmental impact studies since the other projects (Superport, Interharbor, Airport, navigational canals, widening and deepening the Mississippi River-Gulf Outlet) are in the planning stages.

All in all, there seems to be undue concern over the dumping of this spoil in the Michoud Ship Canal. It is hard to understand this concern over the Michoud area when we have had and are having millions of acres of estuarine marshlands influenced by the dredging of oilfield canals, pipeline canals, etc., which is still going on with very little control. If the 434 acres in question in the Michoud area are handled properly so as to allow no seepage or breaking of ring levees, I see no great damage to that area.

We appreciate the opportunity to review and offer comment on this project and request to be kept informed regarding its progress.

Sincerely yours,

Clark M. Hoffpauer
Director

CMH:js
cc: Bur. of Sport Fisheries & Wildlife, Atlanta, Ga.
Bur. of Sport Fisheries & Wildlife, Vicksburg, Miss.
Environmental Protection Agency
Oysters, Water Bottoms and Seafoods Division, LWLF

IN REPLY REFER TO
LMNED-MP

17 January 1973

Mr. Edward S. Reed
Executive Director & General Manager
Board of Commissioners of the
Port of New Orleans
P. O. Box 60046
New Orleans, Louisiana 70160

Dear Mr. Reed:

On 7 October 1972 we wrote you concerning the Mississippi River-Gulf Outlet, Michoud Canal project. Our letter generally sought your Board's concurrence with our plan VII. We consider this plan to be a viable plan of action and one which is acceptable to fish and wildlife interests.

We are currently attempting to finalize our environmental statement for the project as well as to complete the general design memorandum recommending a suitable plan of action. We have now reached an impasse in each of these reports, and additional work cannot commence without your concurrence in our recommendations. We therefore reiterate our request for your immediate approval.

It is additionally requested that your Board execute the assurance agreement submitted by our Real Estate Division by letter dated 22 June 1972. The agreement incorporates the requirements of the "Uniform Relocation Assistance and Real Property Acquisition Policy Act of 1970," Public Law 91-646, as well as the applicable sections of the "Flood Control Act of 1970," Public Law 91-611.

We would appreciate your response as soon as possible. Please let us know if you require any additional information.

Sincerely yours,

RICHARD L. HUNT
Colonel, CE
District Engineer

CF:
C/Real Estate Division

NEW ORLEANS CENTROPORT U.S.A.

January 24, 1973

Col. Richard L. Hunt
District Engineer
Department of the Army
New Orleans District, Corps of Engineers
P.O. Box 60267
New Orleans, La. 70160

Dear Colonel Hunt:

This is in response to your letter of January 17, 1973, your file LMNED-MP, concerning the Mississippi River-Gulf Outlet, Michoud Canal project.

Please be informed that this Board concurs with your recommendation of Plan VII as being a viable plan of action and one which is acceptable to fish and wildlife interests. We understand that with this concurrence you will be enabled to finalize your environmental statement for this project, as well as to complete the general design memorandum recommending a suitable plan of action.

This Board is presently working with other parties interested in the development of this project and is pleased to advise that negotiations are presently being conducted for the acquisition of the spoil areas involved. We are hopeful that execution of the assurance agreement may be forthcoming shortly.

Sincerely yours,

Edward S. Reed
Executive Port Director
and General Manager