PARTIAL DEFINITE PROJECT REPORT

CENTRAL AND SOUTHERN FLORIDA PROJECT

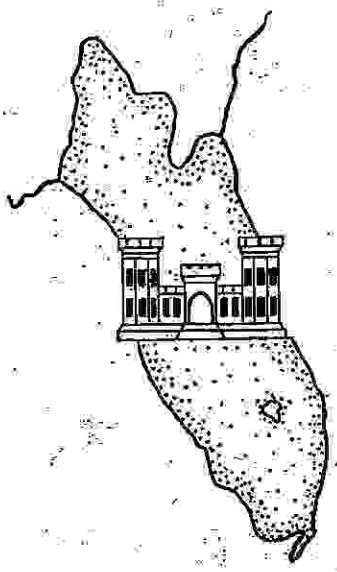
FOR FLOOD CONTROL AND OTHER PURPOSES

PART IV

LAKE OKEECHOBEE AND OUTLETS

SUPPLEMENT 2--HYDROLOGY AND HYDRAULIC DESIGN

-SECTION 5A--DESIGN MEMORANDUM
ADDITIONAL LAKE-REGULATING FACILITIES



CORPS OF ENGINEERS, U.S. ARMY
OFFICE OF THE DISTRICT ENGINEER
JACKSONVILLE, FLA.

MARCH 28, 1955

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PARTIAL DEFINITE PROJECT REPORT
CENTRAL AND SOUTHERN FLORIDA PROJECT

PART IV--SUPPLEMENT 2--SECTION 5A

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A. INTRODUCTION

1. Authorization.--a. Authorization 1948.--The existing project was partially authorized by the Flood Control Act approved June 30, 1948 (Public Law 858, 80th Cong., 2d sess.). Further authorization was contained in section 204 of the Flood Control Act approved May 17, 1950 (Public Law 516, 81st Cong., 2d sess.). These authorizations included most of the works necessary to afford flood protection to the rich agricultural development south of Lake Okeechobee and to the highly developed urban area along the lower east coast of the State.

b. Authorization 1954.--The remaining works of the Comprehensive Plan as presented in House Document No. 643, Eightieth Congress, second session (reference 4a), were authorized by the Flood Control Act approved September 3, 1954 (Public Law 780, 83d Cong., 2d sess.).

2. The overall problem.--Lake Okeechobee is the major water-storage and conservation reservoir for the Central and Southern Florida Project. Maximum use of Lake Okeechobee to serve the area depends on the provision of an adequate levee-protection system with sufficient outlet capacity to insure regulation of lake levels within safe limits. The hydrologic and hydraulic factors which are important in the design of the lake levees are as follows:

a. Storage level of Lake Okeechobee at the beginning of critical hurricanes.

b. Hurricane winds coincident with lake levels produced by severe floods.

c. Wind tides produced by hurricanes.

d. Wave action coincident with wind tides.

e. Lake-regulating facilities.

f. Resistance of levees to wave erosion.

g. Critical combination of hydrologic and hydraulic factors affecting height of Lake Okeechobee levees.

3. Scope and purpose of this section.--After the preparation of Part IV, Supplement 2, Section 5 (reference 4g), it became apparent that several alternative outlet channels and floodways should be considered in order to improve the security afforded by the overall system. This section contains the results of studies of possible alternative outlets. Enlargement and further improvement of existing outlets are considered, as is the provision of entirely new canals and floodways. In addition, this section contains a brief summary of pertinent data on the physical characteristics of lake-regulating facilities considered in previous studies. Hydraulic characteristics of major drainage facilities are presented in sufficient detail, with supplementary information, to permit an engineering review of hydraulic determinations. Assumptions regarding the general project plan, structural and mechanical design of facilities involved, and their economic justification are presented or will be presented in separate design memorandums or reports.

4. References.--Reference is made to the following:

a. The project document--Comprehensive Report on Central and Southern Florida for Flood Control and Other Purposes, dated December 19, 1947, printed as House Document No. 643, Eightieth Congress, second session.

b. Partial Definite Project Report, Part I (basic report)--Agricultural and conservation areas (with preliminary information on Lake Okeechobee and principal outlets), dated July 10, 1951.

c. Partial Definite Project Report, Part I, Supplement 8--Design memorandum, Development of plan of protection for agricultural area, dated February 6, 1953.

d. Partial Definite Project Report, Part IV, Supplement 1--Design memorandum, Effectiveness of Lake Okeechobee outlets, dated March 12, 1953.

e. Partial Definite Project Report, Part IV, Supplement 2, Section 1--Design memorandum, Storage level in Lake Okeechobee at beginning of critical hurricanes, dated October 13, 1953.

f. Partial Definite Project Report, Part I, Supplement 18--Design memorandum, Revision of hydrology and hydraulic design of West Palm Beach, Hillsboro, North New River, and Miami Canals, dated November 16, 1953.

g. Partial Definite Project Report, Part IV, Supplement 2, Section 5--Design memorandum, Lake-regulating facilities, dated January 12, 1954.

B. BASIC CONSIDERATIONS

5. General.--Facilities for discharge of water from Lake Okeechobee are required to serve three principal purposes, namely:

a. Release water as needed for agricultural purposes.

b. Make normal flood-control releases, at rates causing little if any damage along outflow channels, when the lake level exceeds the adopted maximum conservation pool elevation (16.4 ft.*) and is below the critical flood level.

c. Make emergency releases when extraordinary flood events result in such high lake levels as to seriously jeopardize the security of the Lake Okeechobee levees.

6. Storage in Lake Okeechobee.--The change in volume of storage in Lake Okeechobee is equal to inflow minus outflow. Inasmuch as the inflow is governed largely by natural runoff events and cannot be materially changed, it is necessary to either store runoff exceeding the capacity of the established conservation pool or release the inflow as fast as it enters the lake. To store such runoff would require raising the Lake Okeechobee levees, and to release the flow would require very large outflow channels and control structures. Either course of action involves high costs for construction items as well as certain other major problems. For example, if very high storage levels are permitted for prolonged periods during critical flood years, the hazards from possible levee failures are increased. On the other hand, if unusually high release rates are provided for, disproportionately high costs are involved and flood problems along outflow channels are aggravated. A careful analysis of feasible alternative combinations of storage and outflow facilities, with appropriate comparisons of costs and operational characteristics of plans, is necessary before the best combinations can be selected.

*All stages and elevations throughout this section refer to mean sea level datum.

7. Inflow to Lake Okeechobee.--The principal inflow to the lake after completion of the project will be from rainfall on the lake surface of about 730 square miles; discharge from agricultural area pump stations 2, 3, and 4; and runoff from the drainage area of 4,412 square miles. Major areas contributing to the inflow are Kissimmee River Basin, Fisheating Creek area, and the Indian Prairie and Harney Pond Canal areas. Drainage areas adjacent to Lake Okeechobee are shown on plate 1. The volume of runoff to the lake through pump stations would be relatively small and is not a major consideration. For consistency with studies in section 5 of this supplement (reference 4g), the standard project flood developed in Part I (basic report) (reference 4b), was used. Pertinent data are given in table 1.

TABLE 1

Standard project flood

Rainfall and discharge	Unit	Standard project flood
Annual rainfall, March-February	in.	84.1
Critical 5-month rainfall, June-October	in.	55.3
Peak 1-month rainfall	in.	23.8
Peak mean daily discharge to lake	acre-ft.	219,000
Critical 5-month discharge to lake	do.	6,150,000

8. Existing discharge facilities.--The effectiveness of lake outlets is discussed in detail in section 5 of this supplement (reference 4g). St. Lucie Canal and Caloosahatchee River are the main facilities for regulating outflow from Lake Okeechobee. St. Lucie Canal has the larger capacity and is more reliable for controlling lake stages. Discharge through Caloosahatchee River causes the lesser damage. However, during the flood season, Caloosahatchee River Valley is subject to flooding due to local rainfall which reduces the available capacity for control of Lake Okeechobee. During times when the additional regulatory capacity is needed and discharge from the Lake Okeechobee agricultural area is relatively small, the four major agricultural area canals (West Palm Beach, Hillsboro, North New River, and Miami) are of assistance in regulating lake stages. Capacities of the existing outlets are as follows:

Outlet	Existing capacity at lake stage 20.6 ft. (c.f.s.)
St. Lucie Canal	15,600
Caloosahatchee River	7,500
Agricultural area canals	Negligible
Total	23,100

9. Plans of protection considered.--a. Plans previously presented.--(1) Since development of the Comprehensive Plan for Central and Southern Florida, several plans for protection of the agricultural area have been considered. Plans 1 through 5 were discussed in detail in Part I, Supplement 8 (reference 4c). The most feasible of those plans were found to be plans 3 and 4, which are discussed further in Part I, Supplement 18 (reference 4f).

(2) Plan 3 envisions construction of all of the agricultural area canals and pump stations to the size and capacity required to provide the recommended flood protection (3/4-inch-a-day runoff removal) for existing and future developments within the area to be encircled by the authorized levees and to provide agricultural water for the area tributary to the four canals. St. Lucie Canal would be enlarged to 250-foot bottom width under plan 3.

(3) Plan 4 is identical with plan 3 construction for Miami and North New River Canals, but provides for further enlargement of West Palm Beach and Hillsboro Canals for lake-regulation capacity equal to the capacities of pump stations 5A and 6 respectively. St. Lucie Canal would be improved to 200-foot bottom width under plan 4. Alternative plan 4 presented herein (hereinafter referred to as plan 4A) is identical with plan 4 for the agricultural area canals but provides for no improvement of St. Lucie Canal.

b. The authorized project provides for improvement of St. Lucie Canal and the agricultural area canals and use of the existing capacity of Caloosahatchee River. Plan 4 would provide the following discharge capacities:

Outlet		Plan 4 capacity at lake stage 20.6 ft. (c.f.s.)
St. Lucie Canal		18,000
Caloosahatchee River (existing)		7,500
Agricultural area canals		
West Palm Beach	4,610	
Hillsboro	2,920	
North New River	1,250	
Miami	1,170	
		9,950
Total		35,450

Present construction on the agricultural area canals is based on the interim plan of protection--plan 3. That plan would provide the following regulation capacities:

Canal	Plan 3 capacity at lake stage 20.6 ft. (c.f.s.)
West Palm Beach	1,250
Hillsboro	800
North New River	1,250
Miami	1,170
Total	4,470

Plan 3 would meet all requirements for protection of the agricultural area. It would provide adequate water control and would remove excess rainfall, supply agricultural water, protect lands adjacent to the canal from overflow, and maintain optimum water levels insofar as possible. Total capacity of the agricultural area canals under the present plan of improvement (plan 3) would be 4,470 cubic feet a second with water surface at natural ground and 7,780 cubic feet a second with water surface at top of the canal levees. Plan 4 is now under consideration for ultimate development of the canals. Under that plan, the agricultural area canals would provide diversion capacities of 9,950 cubic feet a second with water surface at natural ground and 11,610 cubic

feet a second with water surface at top of the canal levees. Design criteria for plans 3 and 4 are presented in section 5 of this supplement (reference 4g).

10. Additional improvements considered.--Capacities of the outlets from Lake Okeechobee, enlarged as provided for under the existing authorization, would be very small compared with the inflow which could be expected under design conditions. In a general storm when the capacity of Caloosahatchee River and the agricultural area canals would be required to discharge excess water from their immediate drainage areas, the lake surface could be lowered a maximum of about 0.07 foot a day. During such periods when all outlets could be used, lowering of the lake surface could be increased to 0.12 foot a day. Thus the security of the entire system is dependent on the lake levees. In order to determine whether improvement of the security afforded by the authorized plan of improvement could be justified, the cost and feasibility of an additional outlet (or outlets) have been considered. Preferably, the outlet (or outlets) should be available to discharge water from Lake Okeechobee at all times. The feasibility of a canal to enter the Atlantic Ocean or Gulf of Mexico was considered. However, a preliminary examination of the average ground elevation and distance to be traversed indicated that costs of such a canal would be excessive. All additional diversion capacity that could be obtained by such means could be obtained more economically by additional enlargement of St. Lucie Canal, which offers the shortest distance to coastal waters. Additional canals were not considered to be economically practicable. It would also be possible to discharge water through the agricultural area to conservation area No. 3. North New River and Miami Canals could be enlarged to the capacities of the pump stations at the conservation area ends of those canals. An additional canal could be provided for regulation only. Consideration was given to an excavated canal and to a floodway. The floodway would hold excavation costs to a minimum but would increase the land required. Design features and costs of each of those possibilities have been determined and are presented in this section.

C. DESIGN CRITERIA

11. General.--Design for pump stations, canals, floodway, and flow through vegetated areas has been based on approved criteria for agricultural area canals.

12. Canal and floodway characteristics.--a. Side slopes were based on the most economical stable slopes for the type of materials found in the reach of canal under consideration. It was determined that the rock and marl material would stand on side slopes of 1 vertical on 1 horizontal, while sand and other unconsolidated materials would require side slopes of 1 vertical on 2 horizontal. Except for St. Lucie Canal and short reaches of West Palm Beach and Miami Canals where side slopes of 1 vertical on 2 horizontal were required, side slopes of 1 vertical on 1 horizontal were used throughout.

b. Cross sections were based on the most economical section with the specific side slopes that would carry the design discharge at the design water-surface elevation and slope. In order to obtain the most economical construction, a minimum bottom width of 20 feet was adopted. Floodway borrow canals are sized to meet levee requirements.

c. Transitions, 100 feet in length, are proposed wherever the cross-section dimensions of the canal are changed. In order that a transition in floodway width may cause minimum loss of head and turbulence, the floodway was widened 2 feet (1 foot on either side) in 2 feet.

d. Maximum permissible velocities.--Subsurface explorations along floodway canals show that channel-bank excavation materials consist of muck, marl, sand, and rock. Maximum permissible velocities have been determined as 2.5 feet a second in sand and other unconsolidated materials and 5 feet a second in areas of rock. During high lake stages, velocities in St. Lucie Canal exceed permissible design velocities for canals located in sand. Although those velocities require maintenance of St. Lucie River downstream, no serious erosion has occurred in the channel.

e. Roughness coefficients.--(1) Canals.--In accordance with directives from the Office, Chief of Engineers, a value of 0.030 for the coefficient of roughness "n" in Manning's formula was used for reaches where excavation would be in sand, and a value of 0.035 was used for reaches where excavation would be in rock. A value of 0.025 was used for St. Lucie Canal designs. That value was based on observations of the existing channel.

(2) Overland flow through nonmaintained vegetated areas.--Computation of flow through vegetated areas in the conservation area was based on a roughness coefficient of 1.3 for the lower 4-foot depth of flow and 0.01 for the area of flow above 4-foot depth, assuming that 60 percent of the area is effective. Those values are in accordance with criteria developed in Part I (basic report) (reference 4b). Incomplete studies indicated that Manning's "n" in vegetated areas would not be less than 0.350 nor more than 1.00, with an average value of about 0.700, depending on the density of vegetation. The values assumed in this report are therefore conservative.

(3) Maintained floodway.--Studies of floodways presentd in this report have been based on provision of a maintained strip. During periods when use of the floodway is expected, vegetation would be kept mowed or disked so that the average height would be no more than 2 feet. With continuous mowing, some of the vegetation would be newly cut and below average height and some of it above the average height. In accordance with Part CXIV, Chapter 9, of the Engineering Manual for Civil Works Construction, a value of 0.035 for Manning's "n" could be used for cleared but not continuously maintained floodways. However,

to take cognizance of the rapid growth of vegetation during the summer months, and the difficulties of maintaining such a large area, a value of 0.040 has been used for the coefficient of roughness "n" in Manning's formula. Consultation with the Soil and Water Conservation Branch, Research Service, United States Department of Agriculture, Fort Lauderdale, Fla., indicated that it is practicable to maintain such a floodway provided the land is properly prepared, drained, and sod established. That agency recommended that preparation of the area be much the same as for pasture, and that the area be well drained and seeded. If it is possible to cultivate the slow-growing grasses recommended by the Research Service, it is believed that the roughness coefficient of 0.040 used in this study would be conservative.

13. Design water-surface elevations.--a. Maximum design water-surface elevation for agricultural-drainage and lake-regulation canals has been considered as average ground elevation, in accordance with previously approved design criteria for agricultural area canals.

b. Design water-surface elevation in conservation area No. 3 was based on the water-surface elevation that would occur with design discharge. Stages were determined by backwater computations. The flow pattern used for discharge to conservation area No. 3 for floodway alinement A is shown on plate 2. A stage-discharge relation is also shown on that plate.

14. Ground subsidence.--Consideration of the subsidence of the peat and muck over the life of the project is an important factor affecting the capacity of overland flow in the floodway. The United States Department of Agriculture publication, "Subsidence of Peat Soils in the Everglades Region of Florida," dated August 1951, gives actual and predicted peat and muck soil depths for the period from 1912 to 2000 for the Lake Okeechobee agricultural area. For floodway designs, a ground subsidence of 2 feet during the life of the project was considered in reaches where the area had not been developed and little or no subsidence was considered in the northern reach where, because of agricultural activity, ground subsidence has already occurred at a high rate. Based on the referenced United States Department of Agriculture publication, that degree of subsidence can be expected to occur by about 1970. Drainage of the floodway area to provide maintenance would accelerate the rate of subsidence.

15. Levee grades.--Levees for canals and floodways would be 4 feet above the peak water-surface elevation that would occur during the standard project flood. Since gravity diversion canals and the floodway would be open to waves and wind tide in conservation area No. 3 the 2-mile reach north of the conservation area levee (L-5) was sloped upward to conform to the ultimate design grade of that conservation area levee.

16. Design computations for canals and floodway were made by application of Manning's formula in accordance with criteria and design assumptions in the above paragraphs and the provisions of Part CXIV, Chapter 9, of the Engineering Manual for Civil Works Construction. Only appreciable changes in velocity head were taken into account.

17. Bridge design and analysis.--The head loss through bridges that would be required over the floodway was determined by D'Aubuisson's formula, using values of "K" based on studies by D. L. Yarnell, as presented in United States Department of Agriculture Technical Bulletins 429 and 442. Bridges over the floodway were designed with sufficient openings on the overbank to permit adequate use of the overbank flow above and below the bridges.

18. Spillway design.--The net length of crest required for gravity spillways from the lake to the floodway and canals was determined by the weir formula, using values of "C" with reductions due to submergence based on recommendations presented in Part CXVI, Chapter 3, of the Engineering Manual for Civil Works Construction. Spillways were designed with sufficient openings to permit maximum use of the capacity of the floodway and gravity diversion canals for all operating stages.

D. PLANS OF IMPROVEMENT--ADDITIONAL FACILITIES

19. Plans of improvement.--Design features and costs were developed for three alternative plans which would increase the outlet capacity for regulation of Lake Okeechobee. These plans are:

a. Construction of a floodway from Lake Okeechobee to conservation area No. 3. The floodway would discharge by gravity, with a spillway structure at the lake end to regulate discharge.

b. Enlargement of North New River and Miami Canals to permit diversion from Lake Okeechobee up to the capacity of the pump stations at the conservation area ends of those canals.

c. Construction of an excavated canal from Lake Okeechobee to conservation area No. 3. That canal would also discharge by gravity. A spillway structure would be provided near the lake end to regulate discharge.

20. Floodway plan.--a. General.--It is possible to discharge water by gravity from Lake Okeechobee to conservation area No. 3. While the difference in water-surface elevations in Lake Okeechobee and conservation area No. 3 is practically zero for normal periods, as much as 5 feet difference would exist during the critical portion of the standard project flood. Because of the small fall available even during flood periods, velocities in the channels would be rather

low and the cross-section area required for significant capacity would be rather large. It is possible to provide the required cross-section area by excavation or by a wide floodway bounded by levees. The former would require a limited right-of-way, while the latter would reduce excavation costs but would require a wide right-of-way. Hydraulic-design and cost studies were made in order to develop the characteristics of the floodway.

b. Floodway alinement and design characteristics.--A number of alinements between Lake Okeechobee and conservation area No. 3 are considered possible, and three (A, B, and C) were studied for this report. Design for the shortest alinement (alinement A) is presented herein. Alternative alinements are shown on plate 3 and are described in the following subparagraphs.

(1) Alinement A, following the approximate drainage divide between North New River and Miami Canals, would have a length of 25.7 miles. Under existing conditions, the alinement (with the exception of the 5 miles immediately south of Lake Okeechobee) would pass through undeveloped lands. Ground elevations are favorable for floodway construction. The depth of organic material ranges between 3 and 7 feet; hence the lake-regulation capacity of the floodway would increase with expected subsidence. That alinement would reduce the Miami Canal drainage area by about 25 square miles, thereby reducing the design capacities of pump stations 3 and 8 to 2,380 and 3,860 feet a second respectively.

(2) Alinement B would be located adjacent to the existing Miami Canal except for the northerly 3 miles where, because of rights-of-way restrictions, it would be located west of Miami Canal. Ground elevations and depth of organic material are comparable to those for alinement A. A floodway along Miami Canal would necessitate elimination of pump stations 3 and 8 and would eliminate the need for the authorized improvement of Miami Canal (L-23, L-24, and L-25). Interior drainage of the adjacent agricultural area would be accomplished by six pump stations located along the floodway at intersections of the main east-west secondary drainage canals. Borrow canals for construction of the floodway levees would have sufficient capacity to meet water requirements of the adjacent agricultural lands. The length of alinement B would be 26.2 miles.

(3) Alinement C would extend southwesterly from the lake to the northeast corner of levee 1, thence southerly along the west side of levees 1, 2, and 3 (north), thence southeasterly along the west side of levee 3 (south) to conservation area No. 3, as shown on plate 3. The length of the floodway along that alinement would be 37.6 miles. Since ground elevations along levees 1, 2, and 3 (north) range between 16 and 18 feet, a floodway along that alinement would not provide sufficient capacity. For that reason, design for alinement C was predicated on a floodway in the northern and southern

reaches with transitions to a wide channel in the reach adjacent to levees 1, 2, and 3 (north). The advantage of a floodway along that alinement is that less rights-of-way would be required within the protected portion of the agricultural area than would be required for alinements A and B.

c. Proposed design.--(1) The floodway would be provided with levees along each side to protect the adjacent agricultural lands. Borrow canals for levees would be located inside the floodway. That location of borrow canals would provide additional capacity, serve for lake-regulation discharge, and provide for drainage of the floodway for maintenance. The floodway would be open at the south end, with a maintained area extending into conservation area No. 3, as shown on plate 3. Floodway designs for alinements A, B, and C are shown on plates 4, 5, and 6 respectively. Hydraulic-design data for alinement A are given in table 2.

TABLE 2

Floodway (alinement A)
Hydraulic-design data

Station	Location	Design water-surface elevation (ft.)	Approx. natural ground elevation (ft.)	Assumed subsided elevation (ft.)	Approx. width of floodway (1) (ft.)	Design levee grade (ft.)
0+00	Lake Okeechobee	20.6	-	-	500	24.6
1+00	End spillway	20.1	14.0	14.0	500	24.1
21+00		20.0	14.0	14.0	2,200	24.0
90+50		19.8	14.0	14.0	3,000	23.8
91+00	F.E.C. Ry.	-	-	-	-	-
91+50		19.7	14.0	14.0	3,000	23.7
126+50		19.6	14.0	14.0	5,000	23.6
305+50		19.3	14.0	13.9	5,000	23.3
306+00	A.C.L. RR.	-	-	-	-	-
306+50		19.2	14.0	13.9	5,000	23.2
1251+36		16.9	13.2	11.4	5,000	20.9
1356+46		16.8	13.0	11.0	5,000	26.4
1356+96	Service road	-	-	-	-	-
1357+46	Levee 5	16.7	13.0	11.0	5,000	26.4
1516+00		16.4	12.0	-	(2) 5,000	-

NOTES: (1) Including borrow canal.
(2) Maintained strip for 3 miles in conservation area No. 3 south of levee 5.

In development of the design, a channel section was considered through the extensively developed area south of Lake Okeechobee, since high rights-of-way costs and the cost of a long bridge for the Florida East Coast Railway crossing indicated that a large canal from the spillway structure to the railroad bridge and a smaller section for the railroad bridge might be more economical than a floodway section. However, later comparison indicated that excavation costs for the design with an enlarged canal section would exceed any probable savings in rights-of-way and bridge costs. Therefore, a floodway section was used for the reach near the lake. In both designs, United States Highway 27 would be relocated to cross the alinement over the stilling basin for the spillway. The alternative designs are shown on plate 7.

(2) Bridges.--Four bridges would be required across floodway alinement A. All except United States Highway 27 bridge would cross the wide floodway portion. Preliminary studies indicated that a design with bridges over the borrow canals and fill, with trestled openings over the floodway, would be most economical and would adequately serve the floodway. The Atlantic Coast Line Railroad bridge providing access to the Okeelanta sugar refinery would serve both rail and vehicular traffic to meet the needs of the sugar refinery. It has been assumed that a service bridge would be constructed at levee 5. Bridge locations are shown on plate 3.

(3) A spillway would be required at the centerline of the Lake Okeechobee levee to control discharge from the lake and, during hurricanes, to limit discharges through the floodway as required to prevent damages from wind tides and waves originating in conservation area No. 3. The spillway was sized to pass the design capacity of the floodway with maximum stage of 20.6 feet in Lake Okeechobee. Spillway locations for the three alternative alinements are shown on plate 3. A summary of the hydraulic-design data is given in table 3.

TABLE 3

Spillway at Lake Okeechobee
Hydraulic-design data

Item	Design
Discharge (c.f.s.)	16,800
Headwater elevation (ft.)	
Maximum (with gates opened)	20.6
Minimum (with gates opened)	16.4
Tailwater elevation (ft.)	
Maximum (with gates opened)	20.07
Minimum (with gates opened or closed)	13.0
Spillway crest	
Elevation (ft.)	8.0
Length (ft.)	260

d. Capacity.--The floodway would provide diversion capacity from the lake of 4,800 cubic feet a second at lake stage 17.4 feet and 16,800 cubic feet a second at lake stage 20.6 feet. Diversion capacities of all three considered alinements are the same at lake stage 20.6 but alinement C, because of the long canal section, would permit slightly greater discharge at lake stage 17.4 feet. In addition to diversion discharge from the lake, the floodway along Miami Canal (alinement B) would be required to carry runoff from the tributary area discharged by six local pump stations. It would be designed to carry 16,800 cubic feet a second at the lake and 23,040 cubic feet a second at conservation area No. 3.

e. Costs.--(1) Alternative alinements.--The most economical alinement for the floodway has been determined by an economic study based on the estimated annual costs for each alinement. The study indicates that the alinement along the drainage divide between Miami and North New River Canals (alinement A) is the most economical. Estimated annual costs for the three considered alinements are presented in table 4.

TABLE 4

Alternative floodway alinements
Estimates of annual costs

Item	Annual costs		
	Alinement		
	A	B	C
Floodway	$968,400	$1,130,300	$1,639,000
Spillway at lake	107,900	107,900	107,900
6 pump stations (Miami Canal)	-	364,000	-
Miami Canal	146,000	-	146,000
Pump station 3	115,000	-	124,300
Pump station 8	210,700	-	227,000
Total	1,548,000	1,602,200	2,244,200

(2) Floodway.--Estimated initial and annual costs of the floodway (alinement A) are given in table 5.

TABLE 5

Floodway (alinement A)
Estimates of initial and annual costs

Item	Costs
Initial:	
Floodway	$7,483,300
Spillway	2,778,000
Rights-of-way	1,007,900
Bridges	
U.S. Hwy. 27 (including relocation)	542,000
F.E.C. Ry.	1,447,000
A.C.L. RR. (combination RR. and hwy.)	1,719,000
Hwy. at levee 5	623,000
Total initial costs	15,600,200
Estimated annual costs	1,076,300

(3) Discussion.--Benefits from provision of the floodway would consist of reduction in maximum lake stages and hence reduction of the amount of water diverted through St. Lucie Canal, which would reduce damages along the lower St. Lucie River. The amount of benefits derived would be dependent on the plan of regulation and amount of diversion capacity provided by other facilities under consideration. The increased water supply to conservation area No. 3 would not be available during drought periods, and intangible benefits from the additional water supply have not been evaluated. However, discharge from the floodway would cause the water level in conservation area No. 3 to rise during flood periods, thereby necessitating increases in levee heights and additional water-control structures.

21. Enlargement of North New River and Miami Canals.--Under authorized plans of improvement, the design of North New River and Miami Canals is based on removal of excess runoff from the drainage areas and supplying agricultural water from Lake Okeechobee. The diversion capacity available for regulating lake stages would be that which could be discharged through the agricultural-drainage and water-supply facilities. A design has been prepared which provides for discharging water from Lake Okeechobee at the capacity of the pump station at the conservation area end of the canal. The designs were based on preliminary studies to determine the most economical profile and section. The designs for enlargement of North New River and Miami Canals are shown on plates 8 and 9 respectively. Hydraulic-design data and estimated costs for this plan are compared with those for the approved plan in tables 6 and 7 respectively.

TABLE 6

Enlargement of North New River and Miami Canals
Hydraulic-design data

Canal	Water-surface elevation (ft.)		Regulatory capacity (c.f.s.)	
	Lake Okeechobee	Pump station	Agricultural drainage (plan 3)	Lake regulation
North New River------	13.5	10.8	1,250	2,490
Miami----------	14.4	11.0	1,170	4,170
Total----------	-	-	2,420	6,660

TABLE 7

Enlargement of North New River and Miami Canals
Estimates of initial and annual costs

Canal	Initial costs			Annual costs*		
	Agricultural drainage (plan 3)	Lake regulation	Increase	Agricultural drainage (plan 3)	Lake regulation	Increase
North New River------	$2,875,900	$7,317,300	$4,441,400	$117,700	$302,800	$185,100
Miami--------	3,240,100	9,451,400	6,211,300	146,000	407,700	261,700
Total---	6,116,000	16,768,700	10,652,700	263,700	710,500	446,800

NOTE: *Includes estimated operation and maintenance costs.

Diversion discharge would not increase peak water stages in conservation area No. 3, since discharge to the conservation area would be limited to the capacity of pump stations which would be pumping agricultural drainage during the critical period. However, the water supply to conservation area No. 3 would be materially increased by regulatory lake discharges. Since available lake supply would be required for the agricultural area and conservation areas Nos. 1 and 2 during extended

droughts, the additional water supply to conservation area No. 3 would not be available during such periods. Benefits from additional water supply to conservation area No. 3 are intangible and have not been evaluated.

22. Gravity diversion canal.--a. General.--In order to develop the economics of an excavated gravity channel from Lake Okeechobee to conservation area No. 3, several canal capacities and alinements were investigated. As in the floodway plan, a spillway would be provided at the lake end of the canal and levees would be constructed on both sides of the canal for protection of the adjacent agricultural area. Bridges would be provided at all highway and railroad crossings.

b. Canal alinements.--Studies were based on a canal along alinements A and B proposed for the floodway (see paragraph 20 above). Alinement A would be along the drainage divide between North New River and Miami Canals (floodway alinement A). A canal on that alinement would be used solely for lake diversion, since it would be assumed that no local inflow would be discharged into it from adjacent lands. Alinement B would be along Miami Canal (L-23, L-24, and L-25). A canal on that alinement would eliminate the need for pump stations 3 and 8, but would be required to carry local interior drainage in addition to providing a firm regulatory capacity. As in the floodway plan, interior drainage of the adjacent agricultural area would be accomplished by six pump stations located along the canal at intersections of the main east-west secondary drainage canals. The canal section would be that required to supply the water requirements of the adjacent agricultural area.

c. Capacity.--Under plans 3 and 4 for development of the agricultural area canals, the discharge capacity of St. Lucie Canal would be increased by 6,200 and 2,400 cubic feet a second respectively. Gravity diversion canals through the agricultural area to provide equivalent diversion capacity were considered. Discharge capacities for plans studies are as follows:

Alinement	Gravity diversion canal capacity at lake stage 20.6 ft. (c.f.s.)	
	At Lake Okeechobee	At conservation area No. 3
A (along drainage divide)---	6,200	6,200
B (along Miami Canal)-------	2,400	9,150*
B (along Miami Canal)-------	6,200	12,950*

NOTE: *Discharge capacity of the canal along alinement B (Miami Canal) increased to provide for removal of agricultural drainage (6,750 c.f.s.) which would be discharged into the canal at a pump station located along the canal.

d. Proposed design.--Design for the gravity diversion canal along the drainage divide (alinement A) is shown on plate 10, and designs for enlargement of Miami Canal (alinement B) are shown on plate 11. Estimates of costs for alternative alinements A and B are given in table 8.

TABLE 8

Gravity diversion canal (alinements A and B)
Estimates of annual costs

Item	Annual costs		
	Alinement A	Alinement B (1)	
	6,200 c.f.s.	6,200 c.f.s.	2,400 c.f.s.
Miami Canal (L-23, L-24, and L-25)	$146,000	$815,600	$580,500
Diversion canal along drainage divide	568,100	-	-
Pump stations 3 and 8	357,100	-	-
Local pump station	-	394,000	394,000
Spillway	44,600	15,200	(2)
Bridges			
U.S.Hwy. 27	15,400	16,700	14,900
F.E.C. Ry.	22,500	22,500	21,500
A.C.L. RR.	24,000	24,000	22,200
Service (new)	6,900	9,200	8,100
Total annual costs	1,184,600	1,297,200	1,041,200
Agricultural area drainage facilities included or provided for above (3)	503,100	503,100	503,100
Cost for regulation capacity	681,500	794,100	538,100
Cost for each c.f.s. of capacity	110	128	224

NOTES: (1) Pump stations 3 and 8 would be replaced by six local pump stations.
(2) Existing hurricane gate (H.G.S. No. 3) would provide adequate spillway capacity for this design.
(3) Annual costs of approved facilities for agricultural area along Miami Canal, including $146,000 for L-23, L-24, and L-25, and $357,100 for pump stations 3 and 8.

e. Costs.--Estimated initial and annual costs of a diversion canal along alinement A are given in table 9.

TABLE 9

Gravity diversion canal (alinement A)
Estimates of initial and annual costs

Item	Cost
Initial	
Diversion canal	$12,822,700
Spillway	925,800
Rights-of-way	140,000
Bridges	
U.S. Hwy. 27	313,000
F.E.C. Ry.	431,000
A.C.L. RR.	458,000
Service (new)	139,000
Total initial costs	15,229,500
Estimated annual costs	681,500

f. Discussion.--Comparison of costs of the alternative alinements for a gravity diversion canal from Lake Okeechobee indicates that the alinement along the drainage divide between Miami and North New River Canals (alinement A) is the more economical. The cost of $110 for each cubic foot a second of diversion capacity along alinement A would be about constant for design diversion discharges above a capacity of 5,000 cubic feet a second, at which capacity the channel excavation would balance borrow material required for the levee embankment. As indicated in table 8, the cost for discharge through a gravity diversion canal along Miami Canal is $224 and $128 for each cubic foot a second for diversion discharges of 2,400 and 6,200 cubic feet a second respectively. The higher unit cost for the smaller diversion capacity is due to the increase in cost of handling of agricultural drainage required in order to provide coincidental gravity diversion from the lake. For gravity diversion along Miami Canal, the size of the canal required for local drainage is the principal factor affecting the cost of the canal. In view of the increased cost of local drainage and the higher cost for each cubic foot a second of diversion capacity from the lake, the location of a diversion canal along Miami Canal was not considered economically feasible. Benefits from construction of a gravity diversion canal would be similar to those provided by a floodway--that is, increase in the

security of the plan of improvement through reduction in maximum lake stages. The volume of water diverted through St. Lucie Canal would also be reduced. Water supply to conservation area No. 3 would not be appreciably increased during dry periods, and discharge during critical flood periods would cause a small increase in water levels in conservation area No. 3, which would require a small increase in levee heights and additional water-control structures.

E. PERFORMANCE OF ALTERNATIVE PLANS

23. Alternative plans considered for increasing the outlet capacity for regulation of Lake Okeechobee are summarized as follows:

a. Plan 3 envisions construction of all of the agricultural area canals (West Palm Beach, Hillsboro, North New River, and Miami) and pump stations on those canals to the size and capacity required to provide 3/4-inch-a-day runoff removal for existing and future developments within the area to be encircled by the authorized levees, and to provide agricultural water for the area tributary to the four canals. St. Lucie Canal would be enlarged to 250-foot bottom width. Plan 3 would increase the present total lake-regulation discharge capacity by about 10,700 cubic feet a second.

b. Plan 4 is identical with plan 3 for improvement of North New River and Miami Canals, but provides for further enlargement of West Palm Beach and Hillsboro Canals for lake-regulation capacity equal to the capacities of pump stations 5A and 6 respectively. The lake-regulation discharge capacities of West Palm Beach and Hillsboro Canals would be increased 3,360 and 2,120 cubic feet a second, respectively, over capacities provided by plan 3. St. Lucie Canal would be enlarged to 200-foot bottom width. Plan 4 would increase the present total lake-regulation discharge capacity by about 12,400 cubic feet a second.

c. Plan 4A is identical with plan 4 except that it provides for no enlargement of St. Lucie Canal. Plan 4A would increase the present total lake-regulation discharge capacity by about 10,000 cubic feet a second.

d. Plan 6 is identical with plan 3 for improvement of the agricultural area canals except for minor reductions in the capacities of pump stations 3 and 8. In addition it provides for construction of a floodway, via one of three alternative alinements, from Lake Okeechobee to conservation area No. 3. The floodway would discharge by gravity, with a spillway structure at the lake end to regulate discharge. Plan 6 provides for no improvement of St. Lucie Canal. That plan would increase the present total lake-regulation discharge capacity by about 21,300 cubic feet a second.

e. Plan 7 provides for enlargement of West Palm Beach, Hillsboro, North New River, and Miami Canals to the capacities of the pump

stations at the conservation area ends of those canals. No enlargement of St. Lucie Canal is included. Plan 7 would increase the present total lake-regulation discharge capacity by about 14,200 cubic feet a second.

f. Plan 8 is identical with plan 3 for improvement of the agricultural area canals. In addition, it provides for construction of a diversion canal from Lake Okeechobee to conservation area No. 3. That canal would discharge by gravity. A spillway would be provided near the lake end to regulate discharge. Plan 8 provides for no improvement of St. Lucie Canal. That plan would increase the present total lake-regulation discharge capacity by about 10,700 cubic feet a second.

24. Flood routings.--a. General.--Routings were made for the flood of record (1948), the standard project flood, and 150 and 200 percent of the standard project flood to determine the performance of several possible combinations of lake-regulating facilities under various flood conditions. Routings were performed using the procedure outlined as method A in Part IV, Supplement 2, Section 1 (reference 4e). Standard project flood routings were also made for conservation areas Nos. 2 and 3 to determine the effect of additional inflow on peak stages computed for those areas in Part I (basic report) (reference 4b).

b. Plan of regulation.--Lake Okeechobee would be regulated as follows:

(1) Lake stage below 16.4 feet.--When lake stages are below 16.4 feet discharge would be limited to that required for use in the agricultural area. In order to maintain the minimum depth required for navigation, discharge would not be permitted with a lake stage below 10.6 feet.

(2) Lake stage above 16.4 feet.--When lake stages exceed the maximum conservation pool elevation of 16.4 feet, lake-regulating facilities would be used to reduce damaging stages as much as possible with the available capacity. During periods of limited inflow, lake-regulating facilities would be used in the following order:

(a) Discharge would be made through the floodway or diversion canal and Caloosahatchee River up to their respective capacities.

(b) When additional regulation capacity is required, the agricultural area canals would be used provided their capacities were not required for local drainage.

(c) St. Lucie Canal would be used for lake regulation during all major floods when its capacity is required in addition to other outlets.

Lake regulation in the above order would reduce damages at Stuart to a minimum and, insofar as practicable, provide for gravity discharge of excessive floodwaters.

c. Results of routings.--Stage hydrographs for the flood of record (1948) routings are shown on plate 12. Comparison of the hydrographs for that flood shows very little difference in the performance of the various plans of improvement. Stage hydrographs for the standard project flood and for 150 and 200 percent of that flood are shown on plates 13 and 14 respectively. Results of the routings are summarized in tables 10 and 11.

d. Conservation areas.--Routings of the standard project flood over conservation areas Nos. 1, 2, and 3 indicated that the additional routed inflow to conservation area No. 3 would not affect the peak stages in conservation areas Nos. 1 or 2 determined in Part I (basic report) (reference 4b). In conservation area No. 3, the stages were slightly higher for plan 6 and plan 8 designs; table 12 gives the peak conservation area stage for the various lake-regulation plans.

TABLE 10

Lake Okeechobee

Results of routings

Maximum lake stages

Plan of improvement				Maximum lake stage (ft.)					
				Standard project flood		150 percent Standard project flood		200 percent Standard project flood	
Designation	Agricultural area canals plan(1)	St. Lucie Canal diversion capacity (c.f.s.) (2)	Total firm diversion capacity (c.f.s.)	Peak	Maximum 30-day	Peak	Maximum 30-day	Peak	Maximum 30-day
3	3	6,200	21,800	20.87	20.60	25.28	24.71	30.15	29.50
4	4	2,400	18,000	21.14	20.93	25.75	25.15	30.88	30.09
4A	4	0	15,600	21.54	21.17	26.57	26.11	31.53	30.88
6	3	0	32,400	20.57	19.92	22.99	22.35	25.38	24.25
7	7	0	15,600	21.28	20.95	26.28	25.73	31.30	30.51
8 (3)	3	0	21,800	20.94	20.70	25.27	24.81	29.95	29.29

NOTES: (1) Plan of development for agricultural area canals and pump stations.
(2) Enlargement over existing capacity.
(3) Diversion canal along North New River and Miami Canals drainage divide (regulatory capacity 6,200 c.f.s.).

TABLE 11

Lake Okeechobee

Results of routings

Stage-duration data

Plan of improvement				Flood duration (days)					
				Standard project flood		150 percent Standard project flood		200 percent Standard project flood	
Designation	Agricultural area canals plan (1)	St. Lucie Canal diversion capacity (c.f.s.) (2)	Total firm diversion capacity (c.f.s.)	Above lake stage 17.4 ft.	16.4 ft.	Above lake stage 17.4 ft.	16.4 ft.	Above lake stage 17.4 ft.	16.4 ft.
3	3	6,200	21,800	88	111	130	169	171	216
4	4	2,400	18,000	86	106	128	166	166	209
4A	4	0	15,600	94	116	146	174	184	221
6	3	0	32,400	75	96	101	147	133	180
7	7	0	15,600	84	101	127	165	170	188
8 (3)	3	0	21,800	87	109	128	167	167	211

NOTES: (1) Plan of development for agricultural area canals and pump stations.
(2) Enlargement over existing capacity.
(3) Diversion canal along North New River and Miami Canals drainage divide (regulatory capacity 6,200 c.f.s.).

TABLE 12

Conservation area No. 3
Peak stage of standard project flood

Plan of improvement	Peak stage (ft.)
Plans 3, 4, 4A, and 7----	10.5
Plan 6----------	11.2
Plan 8----------	10.8

25. Distribution of lake-regulation discharge was determined by routing the computed volumes of inflow to Lake Okeechobee for the period 1938 through 1953. These routings were made to determine the annual cost of pumping regulation flows and to estimate the annual damages to commercial and sport fishing near Stuart that would be caused by discharges from St. Lucie Canal. A summary of the distribution of lake-regulation discharge for the various plans is presented in table 13.

F. SUMMARY

26. Costs.--In order to show how the diversion canal and floodway under consideration would affect the costs of the overall plan, total initial, Feceral, and annual costs for the items affected are summarized in tables 14, 15, and 16 respectively. Plan 4 costs are those used for the latest approved estimate for the authorized project. The design lake-regulation capacities of all outlets (existing and considered) are summarized in table 14, with total initial costs of the plans. Economic comparison is presented in table 16, with the estimated annual costs and estimated damages caused by regulatory discharges through St. Lucie Canal. Those damages were estimated at $200,000 for every million acre-feet of discharge with an additional $100,000 for every month that it would be necessary to discharge during the tourist season (December through March). These damage values were based on economic data presented in Part I (basic report) (reference 4b) and studies of damages caused during recent floods.

27. Discussion.--Comparison of the relative costs and capacities of the additional outlets considered is presented in table 17. In order to evaluate the economic merit of those outlets in increasing the security of the overall plan of improvement, the comparison has been based on the additional discharge capacity available at a lake stage of 20.6 feet.

TABLE 13

Lake Okeechobee

Results of routings

Distribution of average annual lake-regulation discharge

Plan of improvement			Average annual lake-regulation discharge (1,000 acre-ft.) (3)							
			Agricultural area canals					Existing outlets		
Desig-nation	Agricul-tural area canals plan (1)	St. Lucie Canal diversion capacity (c.f.s.) (2)	West Palm Beach	Hillsboro	North New River	Miami	Total	Caloosa-hatchee River	St. Lucie Canal	Floodway or diversion canal
3	3	6,200	142	90	142	133	507	201	521	0
4	4	2,400	379	240	103	96	818	97	315	0
4A	4	0	381	244	104	97	826	115	289	0
6	3	0	74	46	74	69	263	121	277	569
7	7	0	306	194	164	276	940	62	228	0
8 (4)	3	0	94	59	93	88	334	156	335	405

NOTES: (1) Plan of development for agricultural area canals and pump stations.
(2) Enlargement over existing capacity.
(3) Total average annual diversion, 1,230,000 acre-feet.
(4) Diversion canal along North New River and Miami Canals drainage divide (regulatory capacity 6,200 c.f.s.).

TABLE 14

Comparison of lake-regulation capacities and total initial costs of plans considered
(Items affected by alternative plans)

Item	Plan 3 Agricultural drainage canals	Plan 4 Regulation on West Palm Beach and Hillsboro Canals	Plan 4A Regulation on West Palm Beach and Hillsboro Canals*	Plan 6 Floodway (alinement A)*	Plan 7 Regulation on all agricultural drainage canals	Plan 8 Diversion canal (alinement A)*
STRUCTURE CAPACITY (C.F.S.)						
S-2	3,600	3,600	3,600	3,600	3,600	3,600
S-3	2,580	2,580	2,580	2,580	2,580	2,580
S-5A	4,610	4,610	4,610	4,610	4,610	4,610
S-6	2,920	2,920	2,920	2,920	2,920	2,920
S-7	2,490	2,490	2,490	2,490	2,490	2,490
S-8	4,170	4,170	4,170	3,860	4,170	4,170
Spillway	-	-	-	16,800	-	6,200
Total capacity	20,370	20,370	20,370	36,960	20,370	27,570
CANAL AND FLOODWAY DIVERSION CAPACITY (C.F.S.)						
West Palm Beach Canal (L-10 and L-12)	1,250	4,610	4,610	1,250	4,610	1,250
Hillsboro Canal (L-14 and L-15)	800	2,920	2,920	800	2,920	800
North New River Canal (L-18, L-19, and L-20)	1,250	1,250	1,250	1,250	2,490	1,250
Miami Canal (L-23, L-24, and L-25)	1,170	1,170	1,170	1,170	4,170	1,170
Floodway-diversion canal	-	-	-	16,800	-	6,200
St. Lucie Canal	21,800	18,000	15,600	15,600	15,600	15,600
Caloosahatchee River	7,500	7,500	7,500	7,500	7,500	7,500
Total capacity						
Lake stage, 20.6 ft.	33,770	35,450	33,050	44,370	37,290	33,770
Lake stage, 17.4 ft.	26,270	26,400	26,200	25,970	30,890	24,470
Total firm capacity						
Lake stage, 20.6 ft.	21,800	18,000	15,600	32,400	15,600	21,800
Lake stage, 17.4 ft.	16,200	13,300	11,100	16,700	11,100	14,400
INITIAL STRUCTURE COSTS						
S-2	$2,456,800	$2,456,800	$2,456,800	$2,456,800	$2,456,800	$2,456,800
S-3	2,181,700	2,181,700	2,181,700	2,020,000	2,181,700	2,181,700
S-5A	3,353,500	3,353,500	3,353,500	3,353,500	3,353,500	3,353,500
S-6	1,801,100	1,801,100	1,801,100	1,801,100	1,801,100	1,801,100
S-7	1,871,600	1,871,600	1,871,600	1,871,600	1,871,600	1,871,600
S-8	3,026,700	3,026,700	3,026,700	2,801,700	3,026,700	3,026,700
Spillway	-	-	-	2,778,000	-	925,800
Total initial costs	14,691,400	14,691,400	14,691,400	17,082,700	14,691,400	15,617,200
INITIAL CANAL AND FLOODWAY DIVERSION COSTS						
West Palm Beach Canal (L-10 and L-12)	$2,743,600	$7,256,900	$7,256,900	$2,743,600	$7,256,900	$2,743,600
Hillsboro Canal (L-14 and L-15)	2,991,800	6,457,400	6,457,400	2,991,800	6,457,400	2,991,800
North New River Canal (L-18, L-19, and L-20)	2,875,900	2,875,900	2,875,900	2,875,900	7,317,300	2,875,900
Miami Canal (L-23, L-24, and L-25)	3,240,100	3,240,100	3,240,100	3,240,100	9,451,400	3,240,100
Floodway-diversion canal	-	-	-	12,822,200	-	14,303,700
St. Lucie Canal	14,174,100	6,195,200	-	-	-	-
Caloosahatchee River	-	-	-	-	-	-
Total initial costs	26,025,500	26,025,500	19,830,300	24,673,600	30,483,000	26,155,100
LAKE OKEECHOBEE LEVEES						
Maximum lake stage (ft.)	20.84	21.14	21.54	20.57	21.23	20.94
Initial costs	$25,900,000	$27,100,000	$28,400,000	$24,900,000	$27,650,000	$26,300,000
CONSERVATION AREA NO. 3 LEVEES						
Maximum stage (S.P.F.) (ft.)	10.5	10.5	10.5	11.2	10.5	10.8
Initial costs						
L-4	$938,300	$938,300	$938,300	$1,197,000	$938,300	$1,050,000
L-5	3,048,500	3,048,500	3,048,500	3,889,000	3,048,500	3,420,000
L-28	6,265,800	6,265,800	6,265,800	7,995,100	6,265,800	7,050,000
L-30	2,973,700	2,973,700	2,973,700	3,794,400	2,973,700	3,340,000
L-33 and L-37	2,918,900	2,918,900	2,918,900	3,724,500	2,918,900	3,240,000
Total initial costs	16,145,200	16,145,200	16,145,200	20,600,000	16,145,200	18,100,000
Grand total initial costs	82,762,100	83,962,100	79,066,900	87,256,300	88,969,600	86,172,300

NOTE: *Using existing St. Lucie Canal.

TABLE 15

Comparison of Federal costs of plans considered
(Items affected by alternative plans)

Item	Plan 3 Agricultural drainage canals	Plan 4 Regulation on West Palm Beach and Hillsboro Canals	Plan 4A Regulation on West Palm Beach and Hillsboro Canals*	Plan 6 Floodway (alinement A)*	Plan 7 Regulation on all agricultural drainage canals	Plan 8 Diversion canal (alinement A)*
INITIAL FEDERAL COSTS						
STRUCTURES						
S-2	$2,108,800	$2,108,800	$2,108,800	$2,108,800	$2,108,800	$2,108,800
S-3	1,878,100	1,878,100	1,878,100	1,731,500	1,878,100	1,878,100
S-5A	2,884,200	2,884,200	2,884,200	2,884,200	2,884,200	2,884,200
S-6	1,546,000	1,546,000	1,546,000	1,546,000	1,546,000	1,546,000
S-7	1,606,500	1,606,500	1,606,500	1,606,500	1,606,500	1,606,500
S-8	2,598,000	2,598,000	2,598,000	2,400,000	2,598,000	2,598,000
Spillway	-	-	-	2,380,000	-	1,952,000
Total initial Federal costs	12,621,600	12,621,600	12,621,600	14,657,100	12,621,600	13,416,600
CANALS AND FLOODWAY						
West Palm Beach Canal (L-10 and L-12)	1,694,400	5,558,600	5,558,600	1,694,400	5,558,600	1,694,400
Hillsboro Canal (L-14 and L-15)	1,737,100	4,704,300	4,704,300	1,737,100	4,704,300	1,737,100
North New River Canal (L-18, L-19, and L-20)	1,815,400	1,815,400	1,815,400	1,815,400	5,542,600	1,815,400
Miami Canal (L-23, L-24, and L-25)	2,690,400	2,690,400	2,690,400	2,690,400	7,943,000	2,690,400
Floodway-diversion canal	-	-	-	9,663,000	-	11,648,900
St. Lucie Canal	12,006,400	5,175,000	-	-	-	-
Caloosahatchee River	-	-	-	-	-	-
Total initial Federal costs	19,943,700	19,943,700	14,768,700	17,600,300	23,748,500	19,584,200
LAKE OKEECHOBEE LEVEES						
Maximum lake stage (ft.)	20.84	21.14	21.54	20.57	21.28	20.94
Initial Federal costs	$22,450,300	$23,450,300	$24,850,000	$21,600,300	$23,950,300	$22,800,000
CONSERVATION AREA NO. 3 LEVEES						
Maximum stage (S.P.F.) (ft.)	10.5	10.5	10.5	11.2	10.5	10.8
Initial Federal costs						
L-4	$805,400	$805,400	$805,400	$1,022,800	$805,400	$900,000
L-5	2,616,600	2,616,600	2,616,600	3,323,100	2,616,600	2,920,000
L-28	5,378,200	5,378,200	5,378,200	6,830,300	5,378,200	6,029,000
L-30	2,552,600	2,552,600	2,552,600	3,241,800	2,552,600	2,860,000
L-33 and L-37	2,505,500	2,505,500	2,505,500	3,182,000	2,505,500	2,800,000
Total initial Federal costs	13,858,300	13,858,300	13,858,300	17,600,000	13,858,300	15,500,000
Grand total initial Federal costs	69,873,900	69,873,900	66,098,600	71,457,700	74,178,700	71,300,800

NOTE: *Using existing St. Lucie Canal.

TABLE 16

Economic comparison of plans considered

Item	Plan 3 Agricultural drainage canals	Plan 4 Regulation on West Palm Beach and Hillsboro Canals	Plan 4A Regulation on West Palm Beach and Hillsboro Canals*	Plan 6 Floodway (alinement A)*	Plan 7 Regulation on all agricultural drainage canals	Plan 8 Diversion canal (alinement A)*
ANNUAL COSTS						
STRUCTURES						
S-2	$154,200	$154,200	$154,200	$154,200	$154,200	$154,200
S-3	124,300	124,300	124,300	115,000	124,300	124,300
S-5A	321,400	399,000	401,000	298,800	376,000	305,000
S-6	190,300	227,700	228,700	179,400	216,200	182,700
S-7	174,800	161,900	162,200	152,300	166,000	158,600
S-8	232,800	229,700	230,800	210,700	263,700	232,800
Spillway	-	-	-	107,500	-	44,600
Total annual costs	1,197,800	1,296,800	1,301,200	1,218,300	1,300,400	1,202,200
CANALS AND FLOODWAY						
West Palm Beach Canal (L-10 and L-12)	122,400	310,400	310,400	122,400	310,400	122,400
Hillsboro Canal (L-14 and L-15)	132,100	278,000	278,000	132,100	278,000	132,100
North New River Canal (L-18, L-19, and L-20)	117,700	117,700	117,700	117,700	302,800	117,700
Miami Canal (L-23, L-24, and L-25)	146,000	146,000	146,000	146,000	407,700	146,000
St. Lucie Canal	550,300	299,500	-	-	-	-
Caloosahatchee River	-	-	-	-	-	-
Floodway-diversion canal	-	-	-	968,400	-	636,900
Total annual costs	1,068,500	1,151,600	852,100	1,486,600	1,298,900	1,155,100
LAKE OKEECHOBEE LEVEES						
Maximum lake stage (ft.)	20.84	21.14	21.54	20.57	21.28	20.94
Annual costs	$1,133,200	$1,175,500	$1,230,000	$1,097,900	$1,194,900	$1,160,000
CONSERVATION AREA NO. 3 LEVEES						
Maximum stage (S.P.F.) (ft.)	10.5	10.5	10.5	11.2	10.5	10.8
Annual costs						
L-4	$35,200	$35,200	$35,200	$49,000	$35,200	$42,000
L-5	112,000	112,000	112,000	155,000	112,000	136,000
L-28	237,700	237,700	237,700	328,000	237,700	280,000
L-30	112,500	112,500	112,500	156,000	112,500	133,000
L-33 and L-37	110,200	110,200	110,200	152,000	110,200	129,000
Total annual costs	607,600	607,600	607,600	840,000	607,600	720,000
ANNUAL DAMAGES						
ROUTED DAMAGES						
St. Lucie Canal						
Average annual discharge (Acre-ft.)	521,000	315,000	289,000	277,000	228,000	335,000
Average annual damages	$116,500	$63,000	$58,000	$55,000	$46,000	$67,000
ANNUAL COSTS AND DAMAGES						
Total annual costs of items affected	4,007,100	4,231,500	3,990,900	4,642,800	4,401,800	4,237,300
Total estimated annual damages	116,500	63,000	58,000	55,000	46,000	67,000
Grand total annual costs and damages	4,123,600	4,294,500	4,048,900	4,697,800	4,447,800	4,304,300

NOTE: *Using existing St. Lucie Canal.

TABLE 17

Comparison of lake-regulating facilities on a cost versus capacity basis

Plan of improvement	Regulating outlet	Total costs		Capacity at lake stage 20.6 ft. (c.f.s.)			Total costs per c.f.s.	
		Initial	Annual	Improved	Existing or plan 3	Additional	Initial	Annual
3	St. Lucie Canal--------	$14,174,100	$550,300	21,800	15,600	6,200	$2,300	$90
4	West Palm Beach Canal and pump station 5A*---	4,513,300	242,600	4,610	1,250	3,360	1,350	72
4	Hillsboro Canal and pump station 6*--------	3,465,600	171,800	2,920	800	2,120	1,650	81
6	Floodway----------	15,600,200	1,076,300	16,800	0	16,800	930	64
7	North New River Canal and pump station 7*----	4,441,400	176,300	2,490	1,250	1,240	3,580	142
7	Miami Canal and pump station 8*----------	6,211,300	292,600	4,170	1,170	3,000	2,070	98
8	Diversion canal--------	15,229,500	681,500	6,200	0	6,200	2,450	110

NOTE: *Additional costs and capacities of agricultural area canals based on plan 7 costs and capacity minus plan 3 costs and capacity.

A floodway 1 mile wide would be the most economical outlet in terms of cost for each cubic foot a second of regulating capacity at a lake stage of 20.6 feet. It would also increase in effectiveness with higher lake stages and thus offer maximum security to the Lake Okeechobee levee system, at the least cost. However, the floodway would require 16,115 acres of rights-of-way, thus reducing the potential production of the Lake Okeechobee agricultural area by about 2 percent. The cost of enlarging West Palm Beach and Hillsboro Canals up to the capacities of pump stations 5A and 6, respectively, and pumping the regulatory discharge from the lake is the next most economical. This would be materially lower in cost than providing the same gravity capacity in either St. Lucie Canal or the most favorable diversion canal from Lake Okeechobee to conservation area No. 3. The capacity available at this cost is the maximum possible without increasing pump station capacities. Studies also indicate that costs of enlarging St. Lucie Canal would be less than providing a gravity canal from Lake Okeechobee to conservation area No. 3.

CORPS OF ENGINEERS U.S. ARMY

AREA

I Lake Okeechobee and tributary areas

II Tributary to Caloosahatchee River

III Agricultural areas

CENTRAL AND SOUTHERN FLORIDA
DRAINAGE AREAS

SCALE IN MILES
20 0 20 40

JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY PARTIAL DRR PART II, SUPP 2, SEC 5A
DATED MARCH 28, 1955
FILE NO. 400-23.085

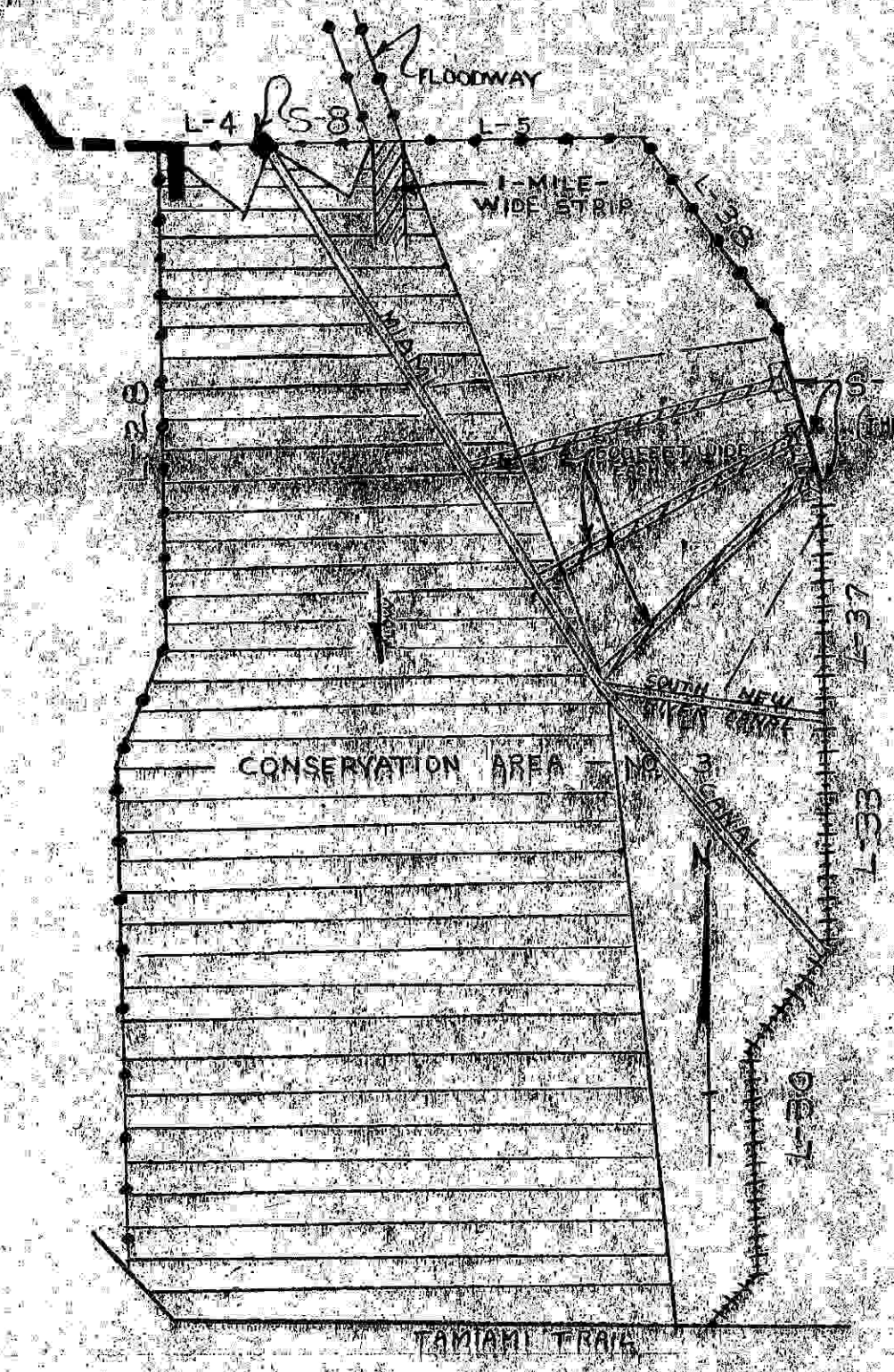


FIG. 1 FLOW PATTERN FOR FLOODWAY AND S-8 IN CONSERVATION AREA NO. 3

SCALE IN MILES

0 1 2 3 4 5 6 7 8 9 10 15

U.S. ARMY

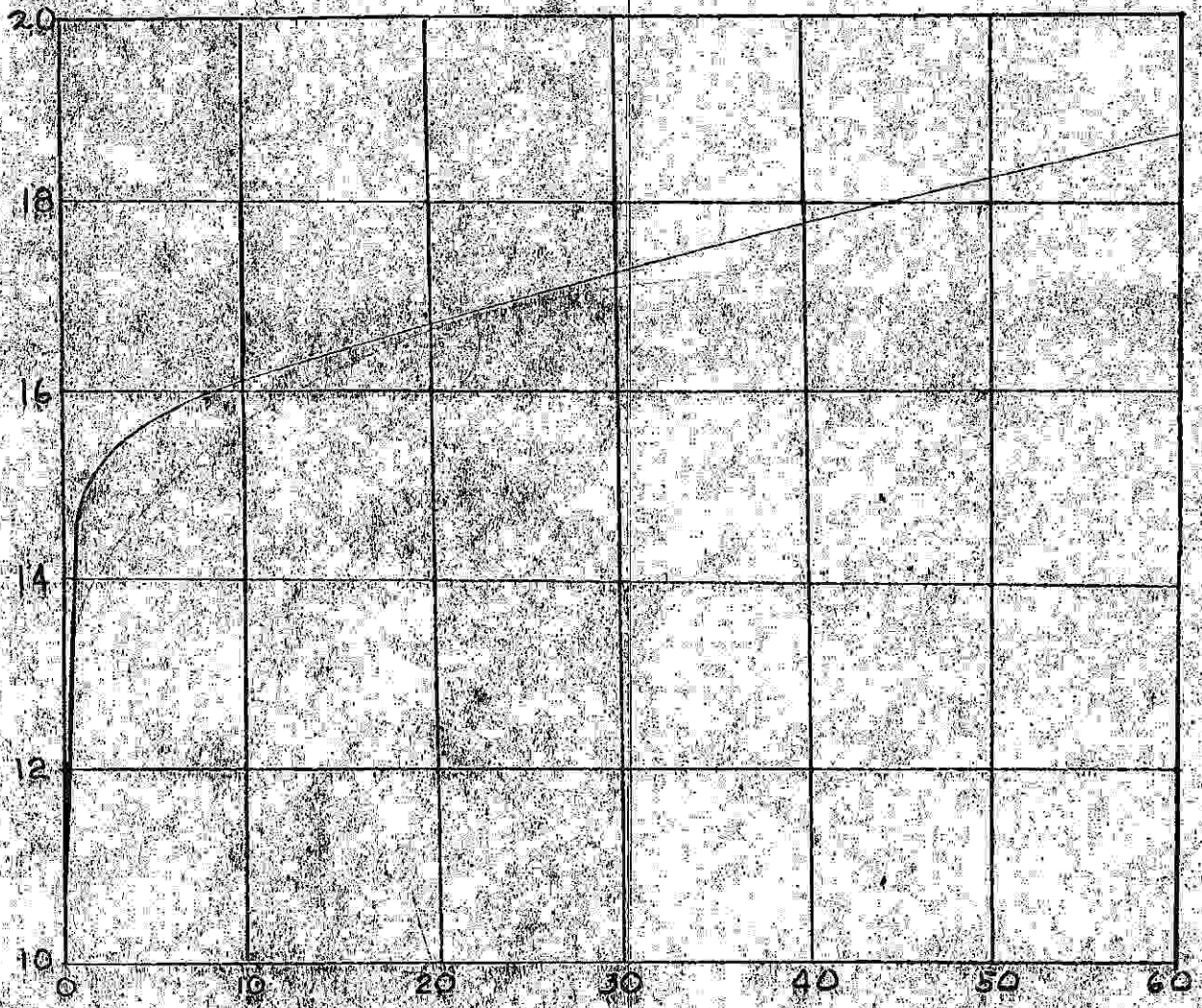


FIG. 2 DISCHARGE - 1,000 C.F.S.
FLOODWAY RATING CURVE AT
LEVEE 5

LEGEND

- EXISTING SPILLWAY
- AUTHORIZED LEVEE
- EXISTING LEVEE
- AUTHORIZED PUMP STATION
- AUTHORIZED CANAL
- EXISTING CANAL
- MOWED STRIP

CENTRAL AND SOUTHERN FLORIDA

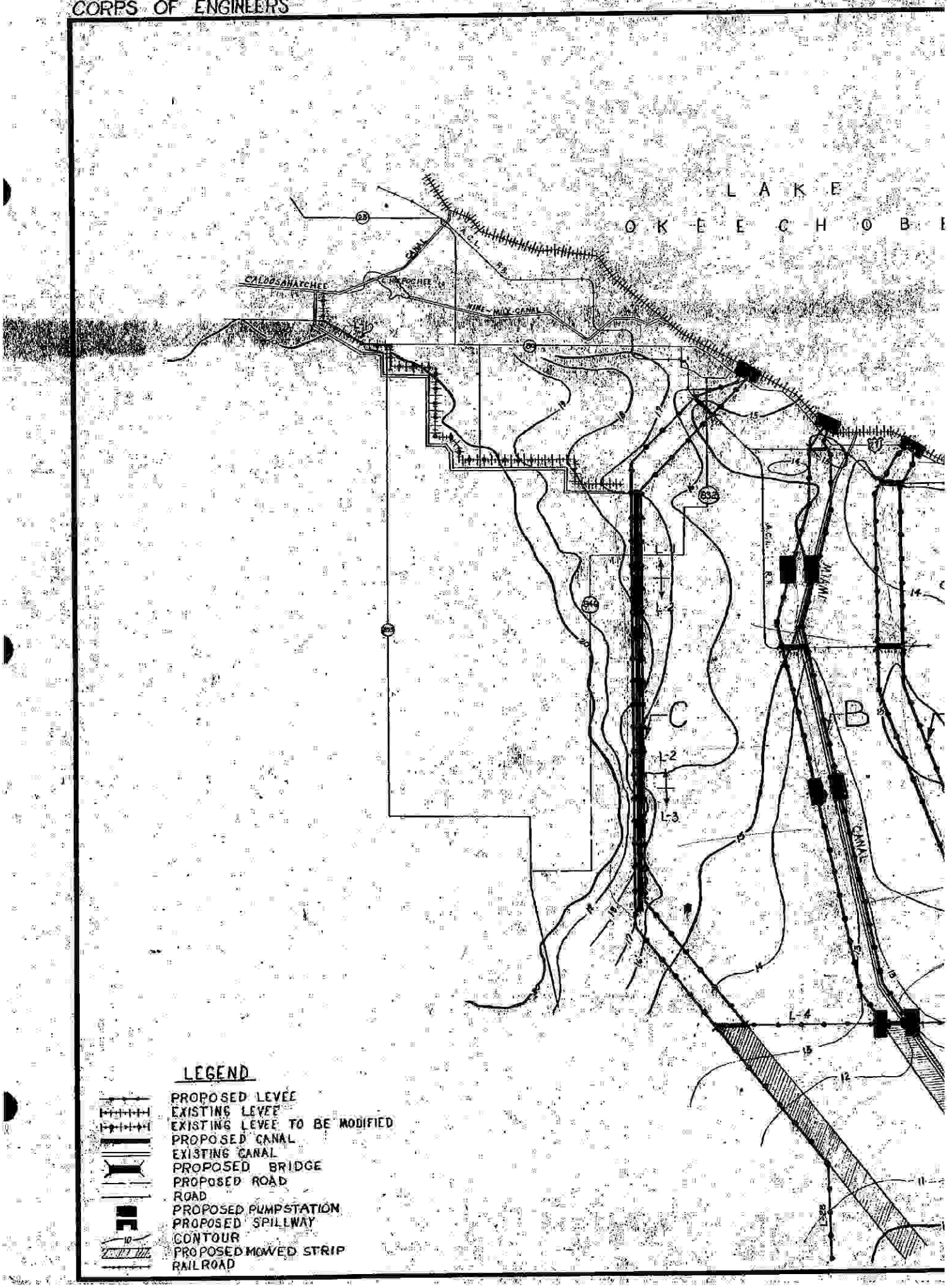
PLAN 6
FLOODWAY ALINEMENT A
TAILWATER DATA

SCALE AS SHOWN

JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY PARTIAL DPR, PART IV,
SUPP 2, SEC. 5A

DATED MARCH 28, 1955 FILE NO 4.00-23,085

CORPS OF ENGINEERS



U.S. ARMY

CENTRAL AND SOUTHERN FLORIDA

PLAN 6

FLOODWAY ALINEMENTS A, B, AND C

SCALE IN MILES

0 1 2 3 4 5

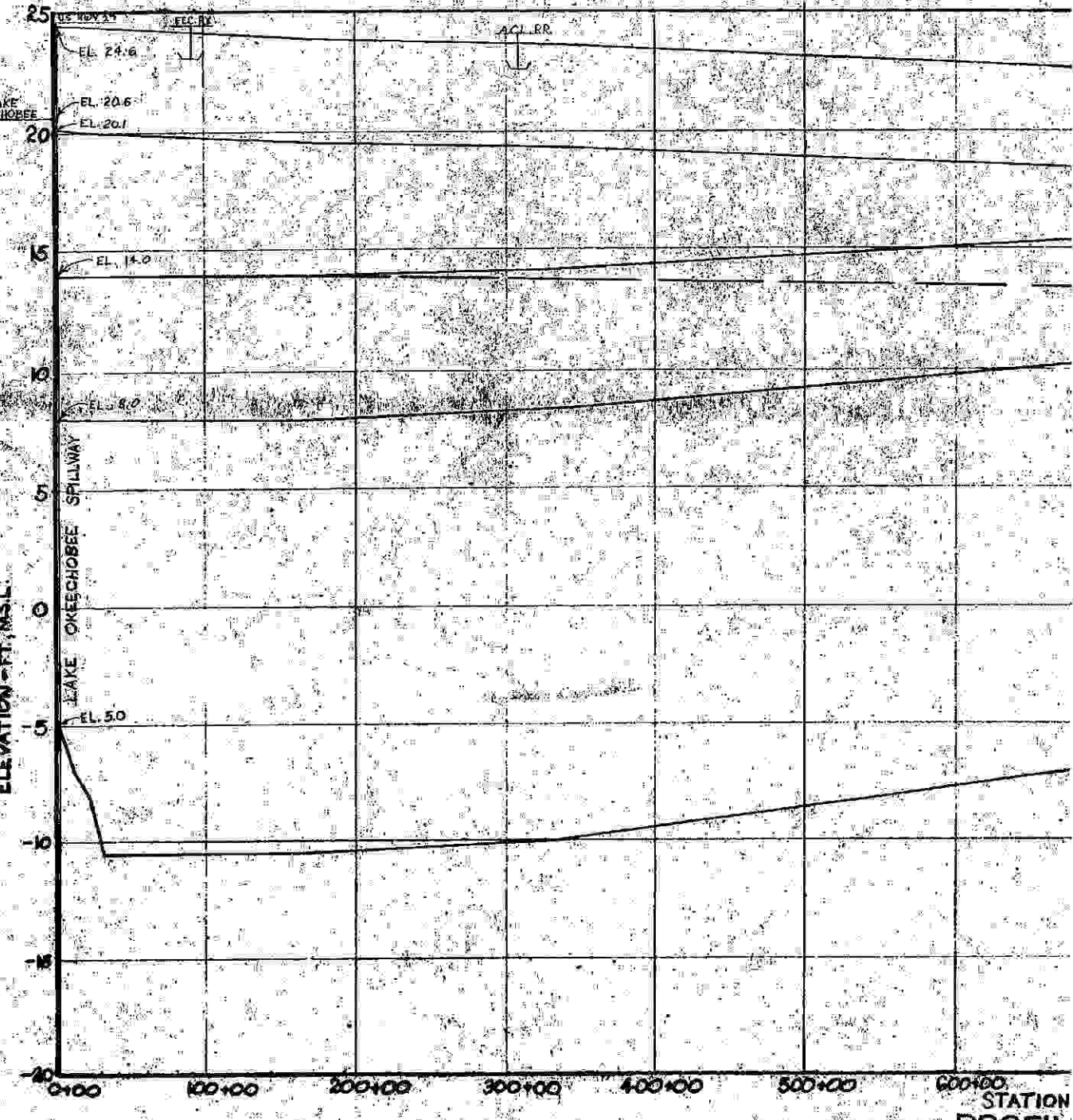
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS

TO ACCOMPANY PARTIAL DPR, PART IV, SUPP 2, SEC 5A

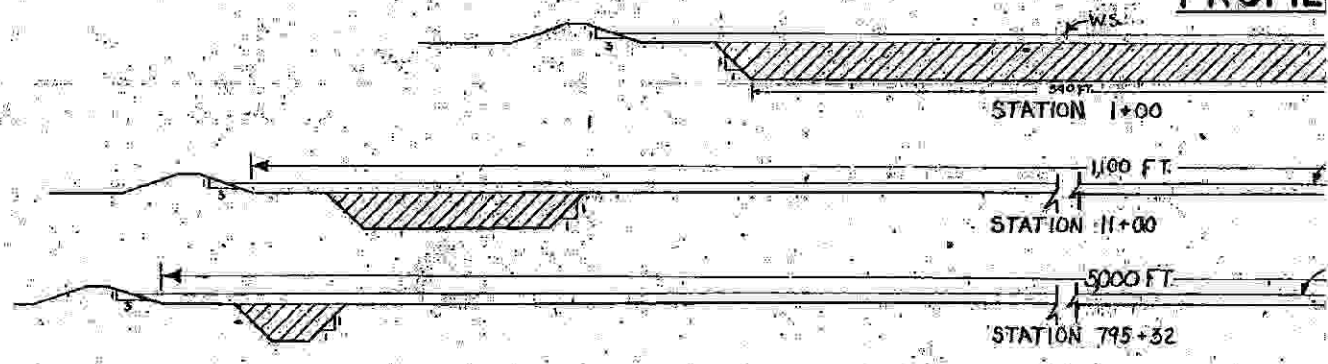
DATED MARCH 28, 1955 FILE NO. 400-23,066

PLATE 2

CORPS OF ENGINEERS



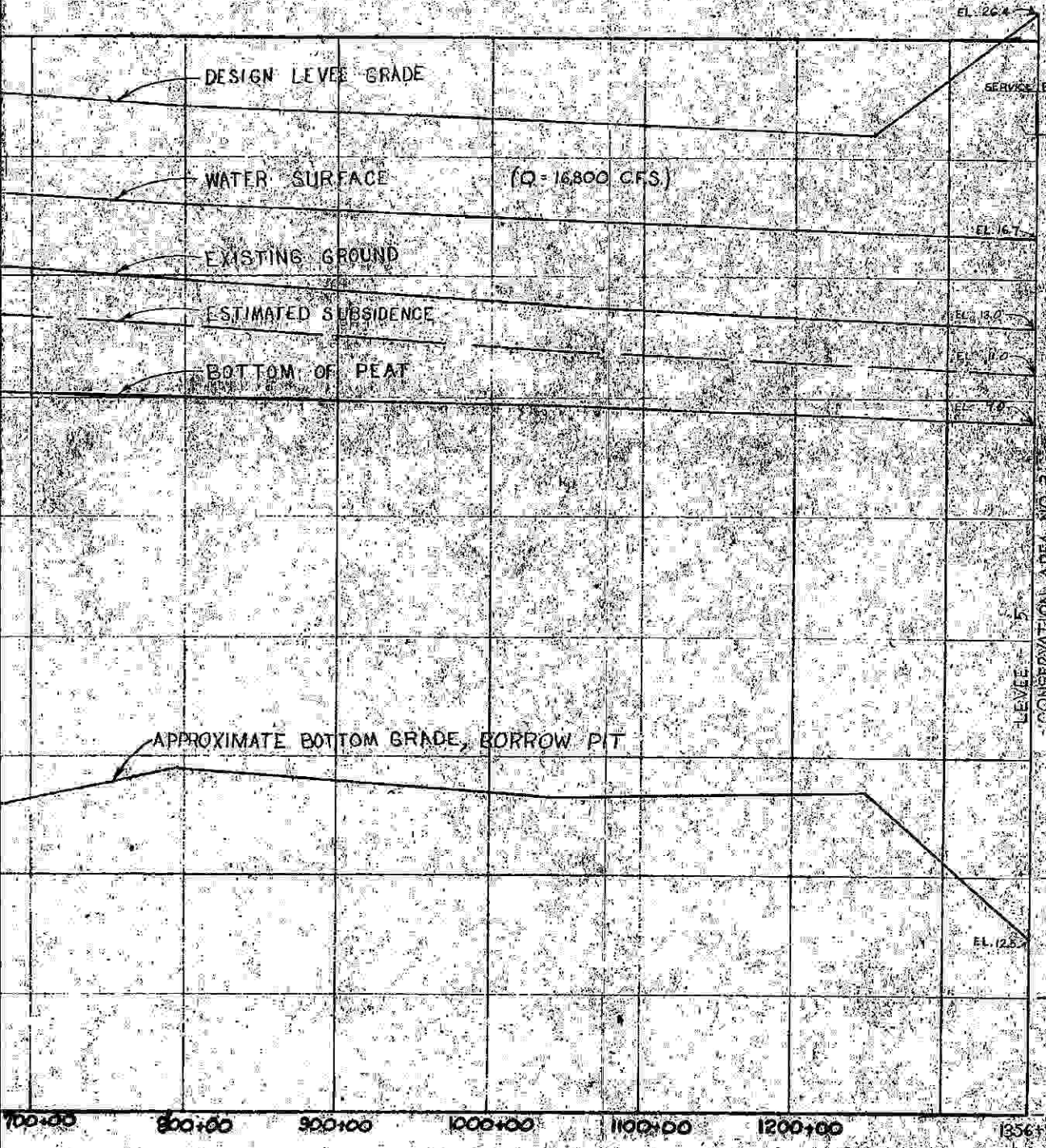
PROFIL



TYPICAL SECTIONS

SCALE IN FEET
0 40 80

U.S. ARMY



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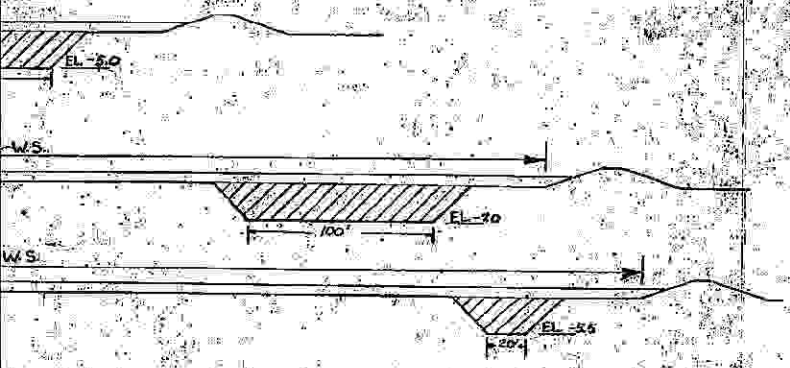


CENTRAL AND SOUTHERN FLORIDA

PLAN 6

FLOODWAY DESIGN ALINEMENT A

JACKSONVILLE DISTRICT, CORPS OF ENGINEERS

TO ACCOMPANY PARTIAL D.P.R.

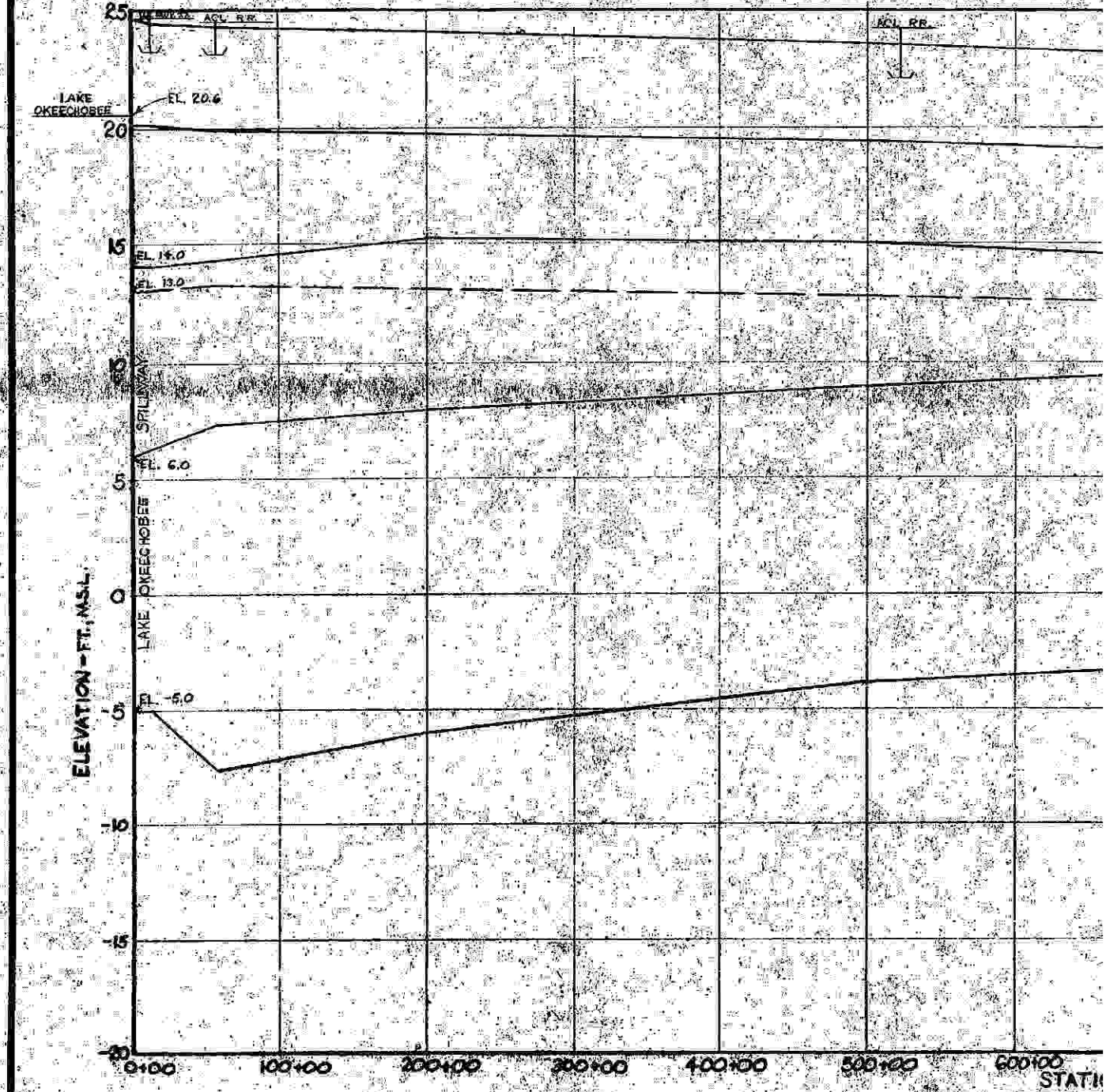
PART IV, SUPP. 2, SEC. 5A

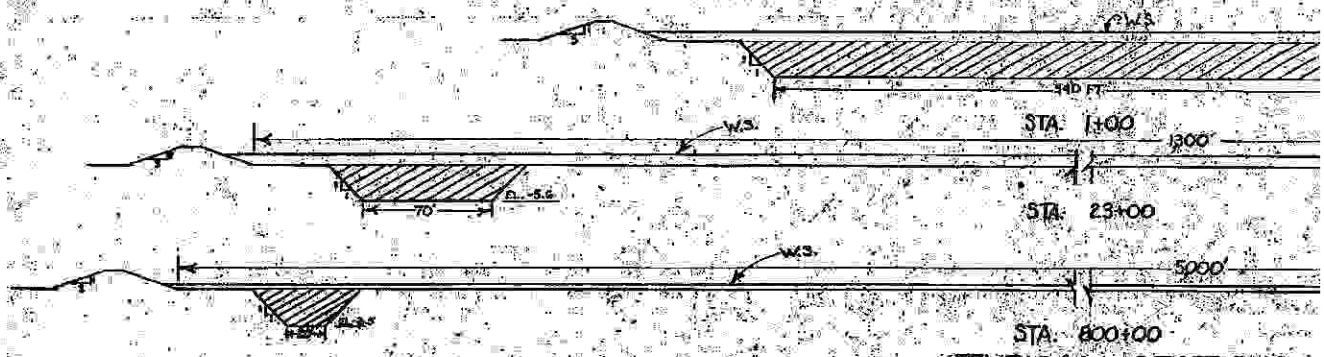
FILE NO. 400-23,085 DATED MARCH 28 1955

SCALE AS SHOWN

PLATE

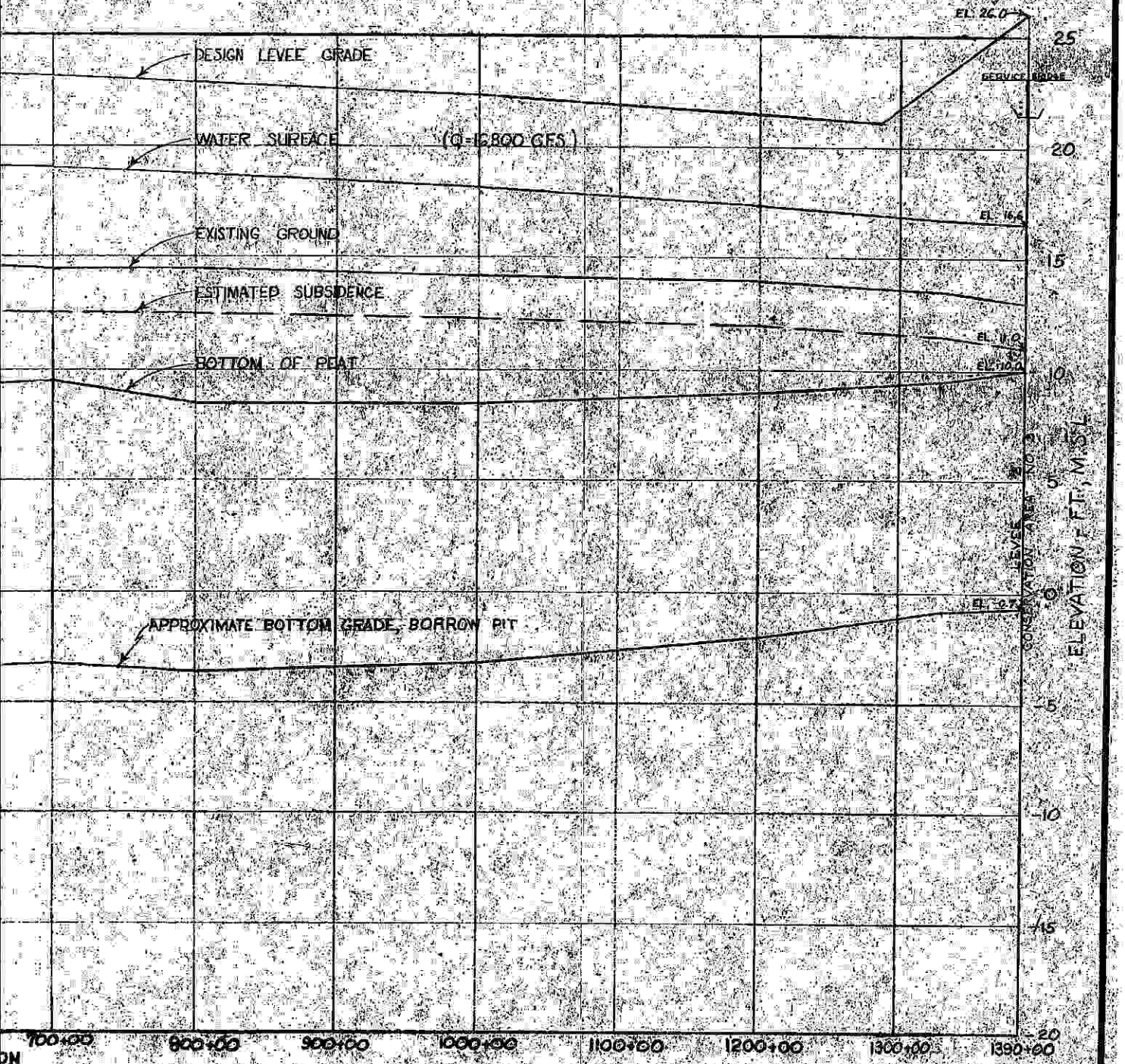
CORPS OF ENGINEERS

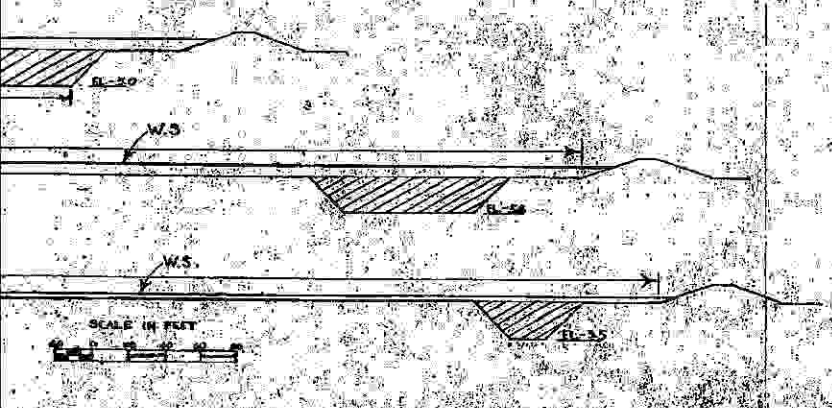




TYPICAL SECTIONS

U.S. ARMY

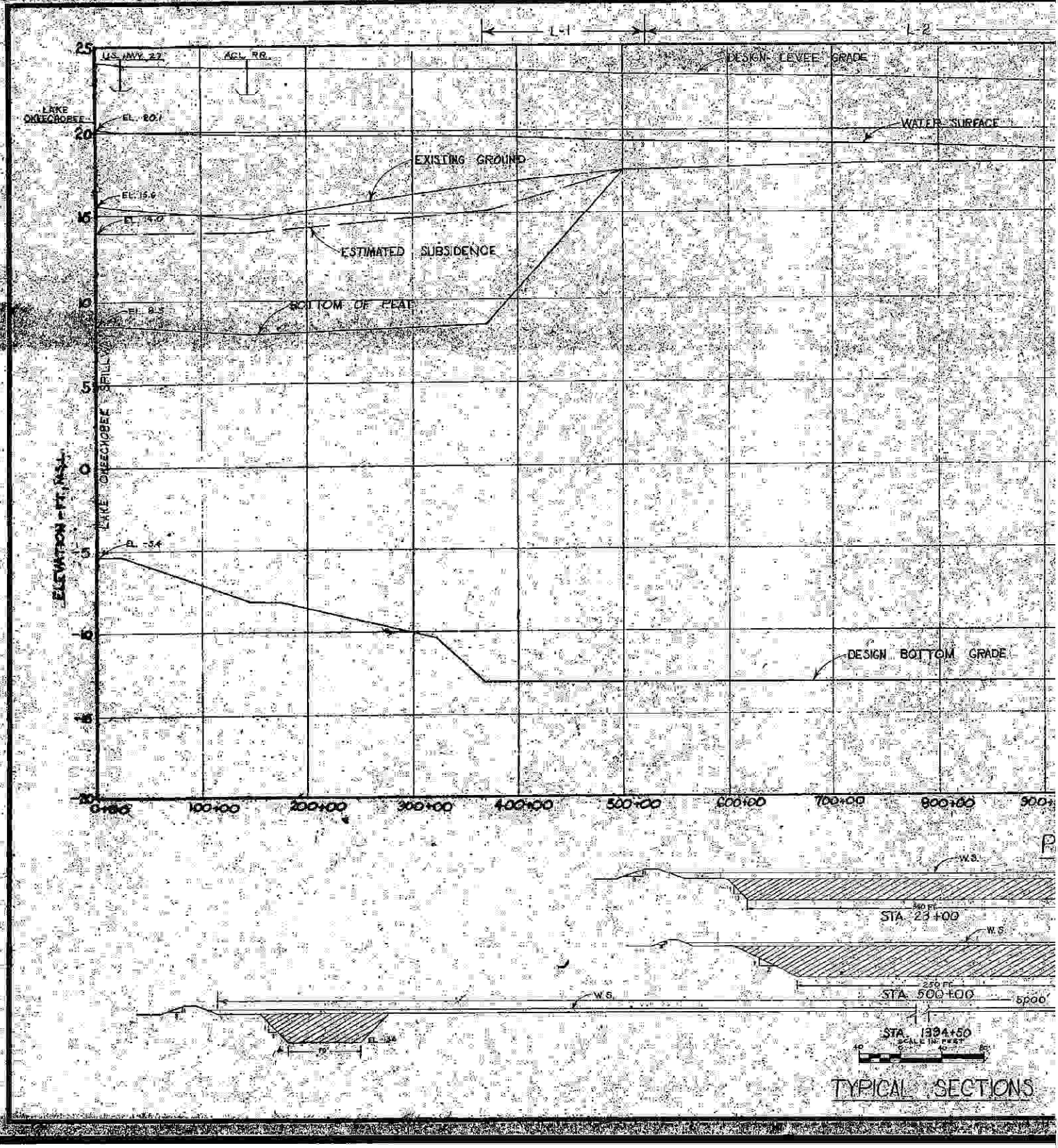




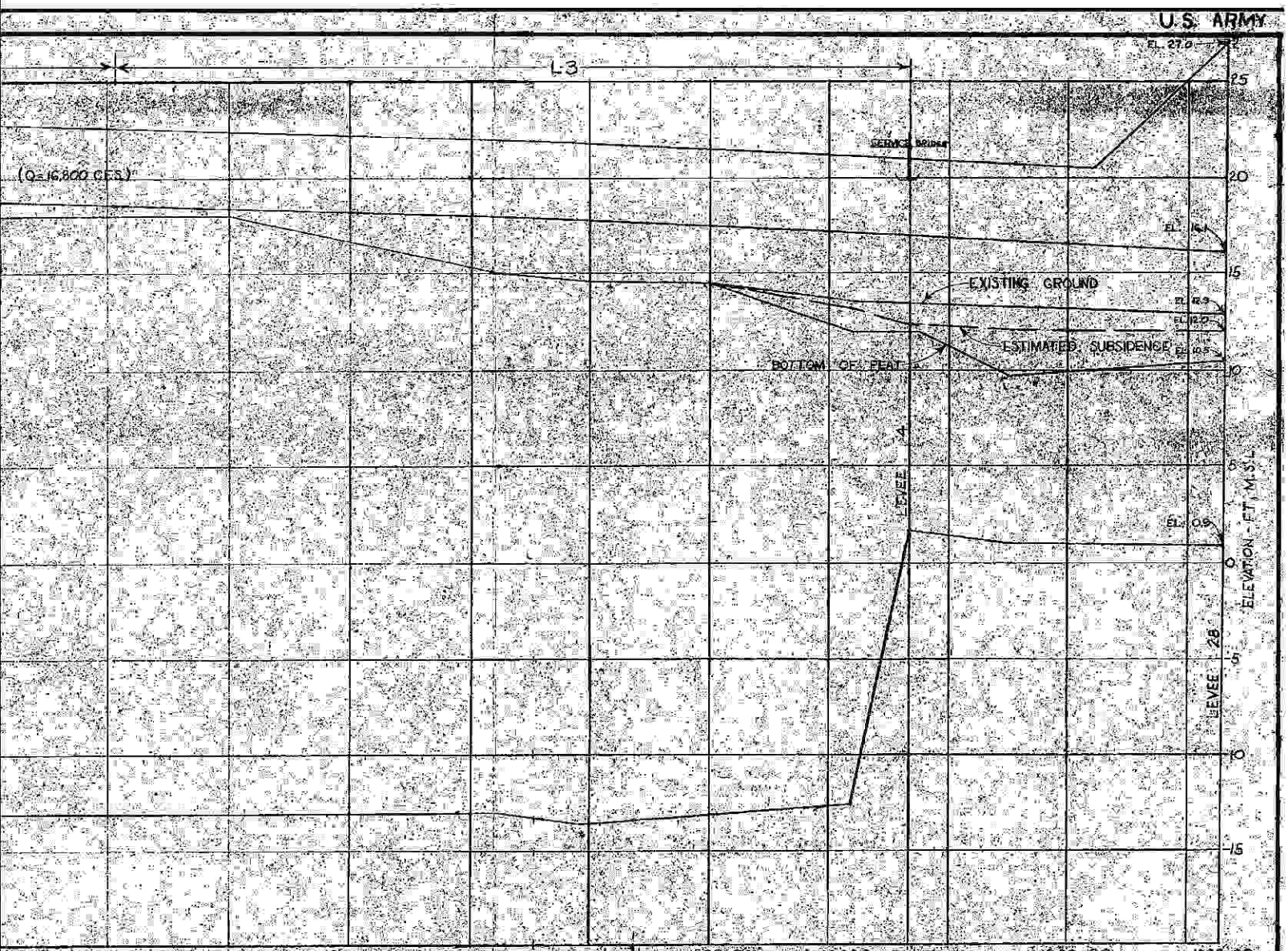
NOTE:
ALL CANAL SIDE SLOPES 1 VERTICAL ON 1 HORIZONTAL.

CENTRAL AND SOUTHERN FLORIDA
PLAN 6
FLOODWAY DESIGN ALINEMENT B
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY PARTIAL D.P.R.
PART IV, SUPP 2, SEC. 5A
FILE NO. 400-23085 DATED MARCH 28, 1955
SCALES AS SHOWN

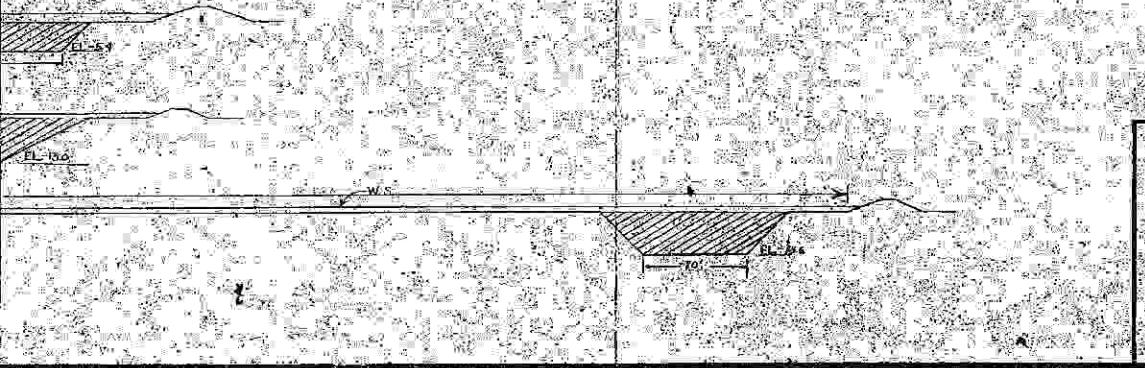
CORPS OF ENGINEERS



U.S. ARMY

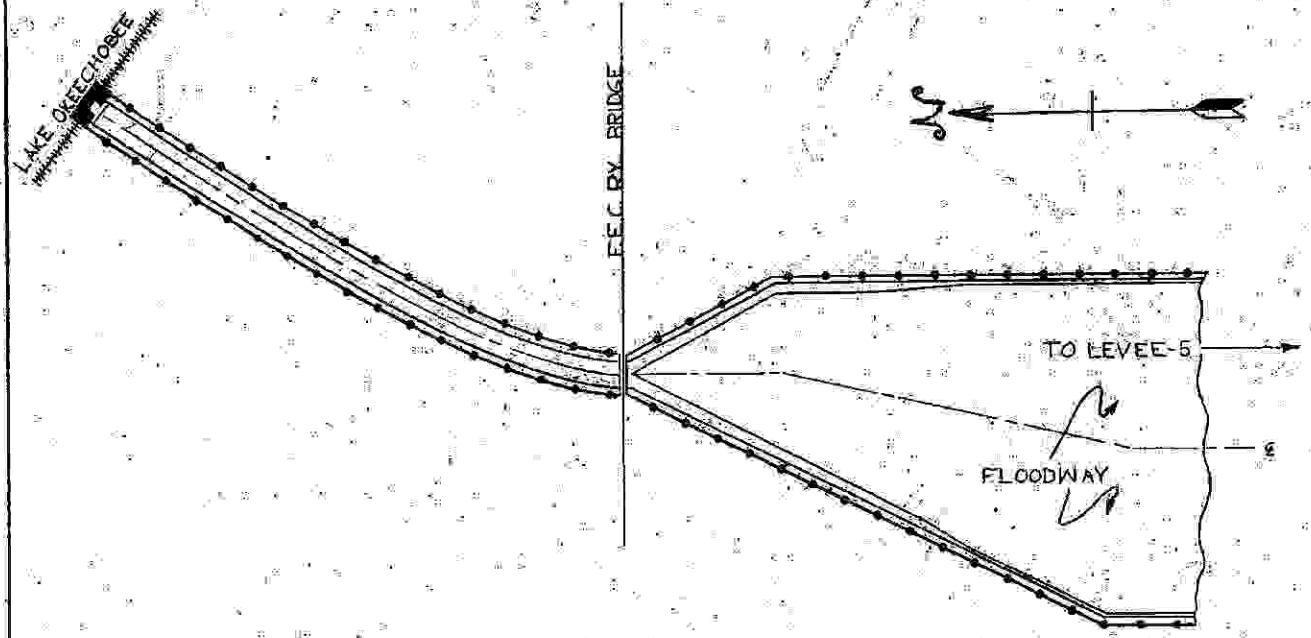


STATION
ROFILES

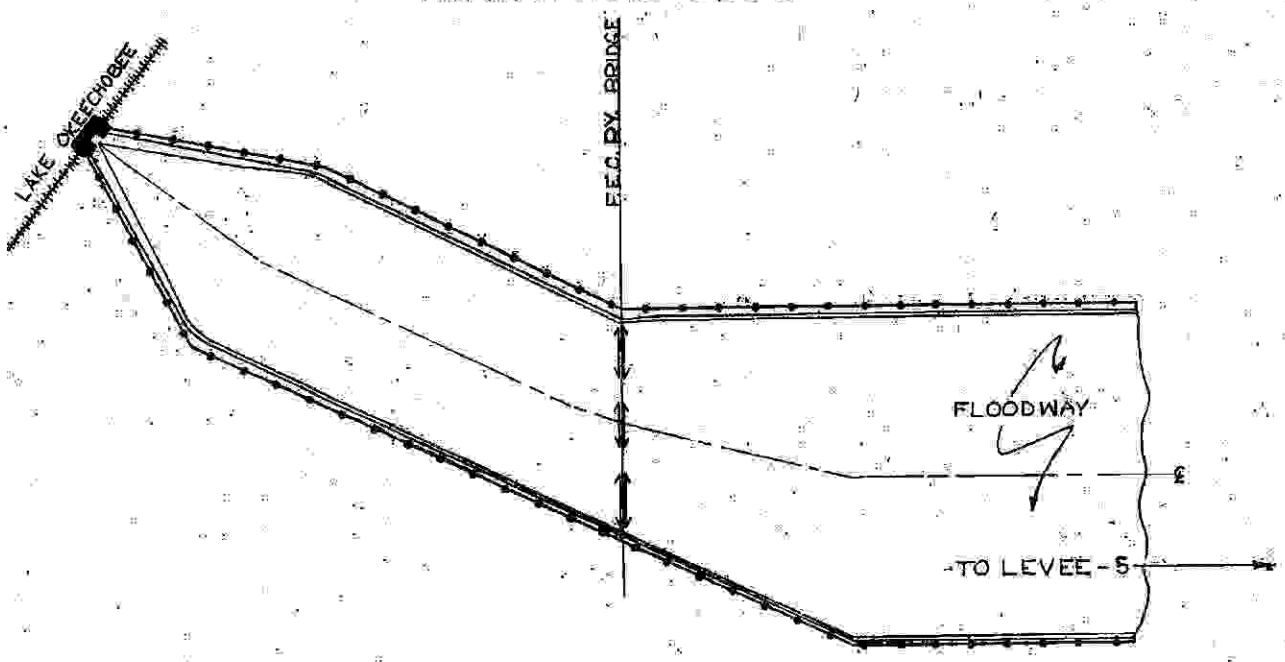


CENTRAL AND SOUTHERN FLORIDA
PLAN 6
FLOODWAY DESIGN
ALINEMENT C
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY PARTIAL D.P.R.
PART IX (SUPP 2) SEC 5A DATED MARCH 26, 1955
SCALES AS SHOWN FILE NO. 789-23.085

PLATE 6



PLAN
TRANSITION DESIGN-1



PLAN
TRANSITION DESIGN-2
(RECOMMENDED)

LEGEND
- PROPOSED LEVEE
- EXISTING LEVEE
- PROPOSED SPILLWAY
- PROPOSED CANAL
- PROPOSED RAILROAD BRIDGE

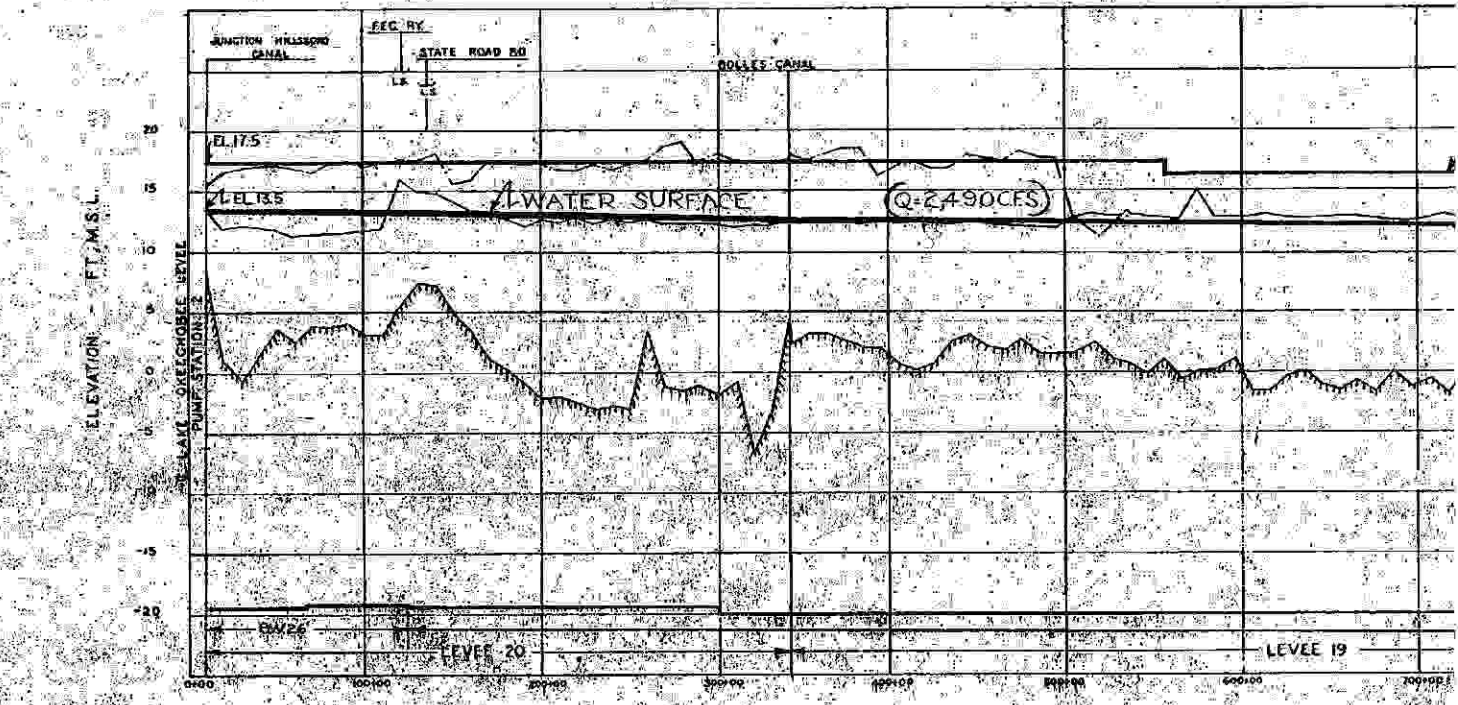
CENTRAL AND SOUTHERN FLORIDA
PLAN 6
FLOODWAY TRANSITIONS ALTERNATIVE DESIGNS

SCALE IN FEET
1000 0 1000 2000 3000 4000 5000 6000

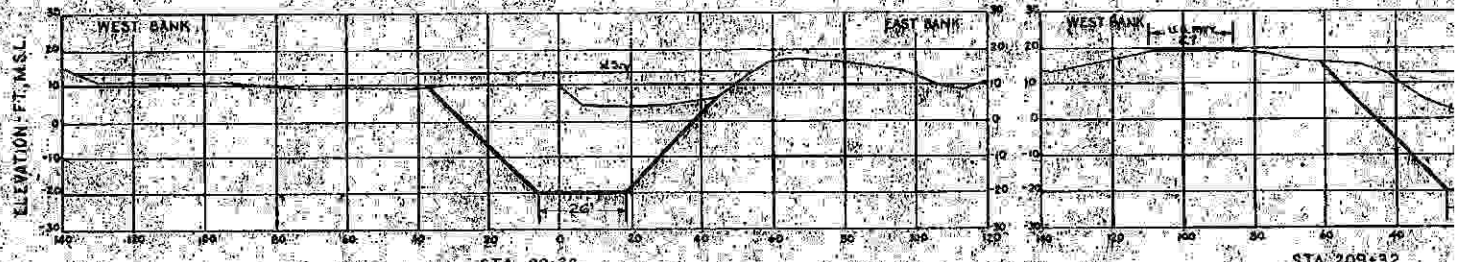
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY PARTIAL D.P.R., PART II, SUPP 2, SEC 5A
DATED MARCH 28, 1955 FILE No. 400-23,085

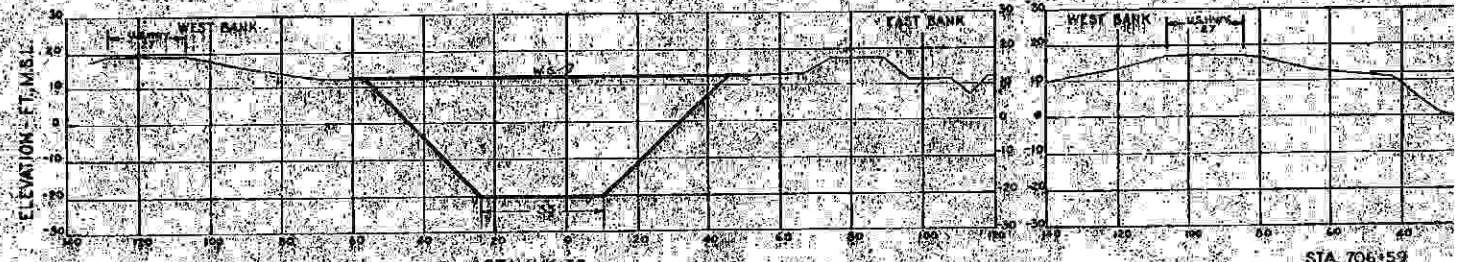
PLATE 7

CORPS OF ENGINEERS



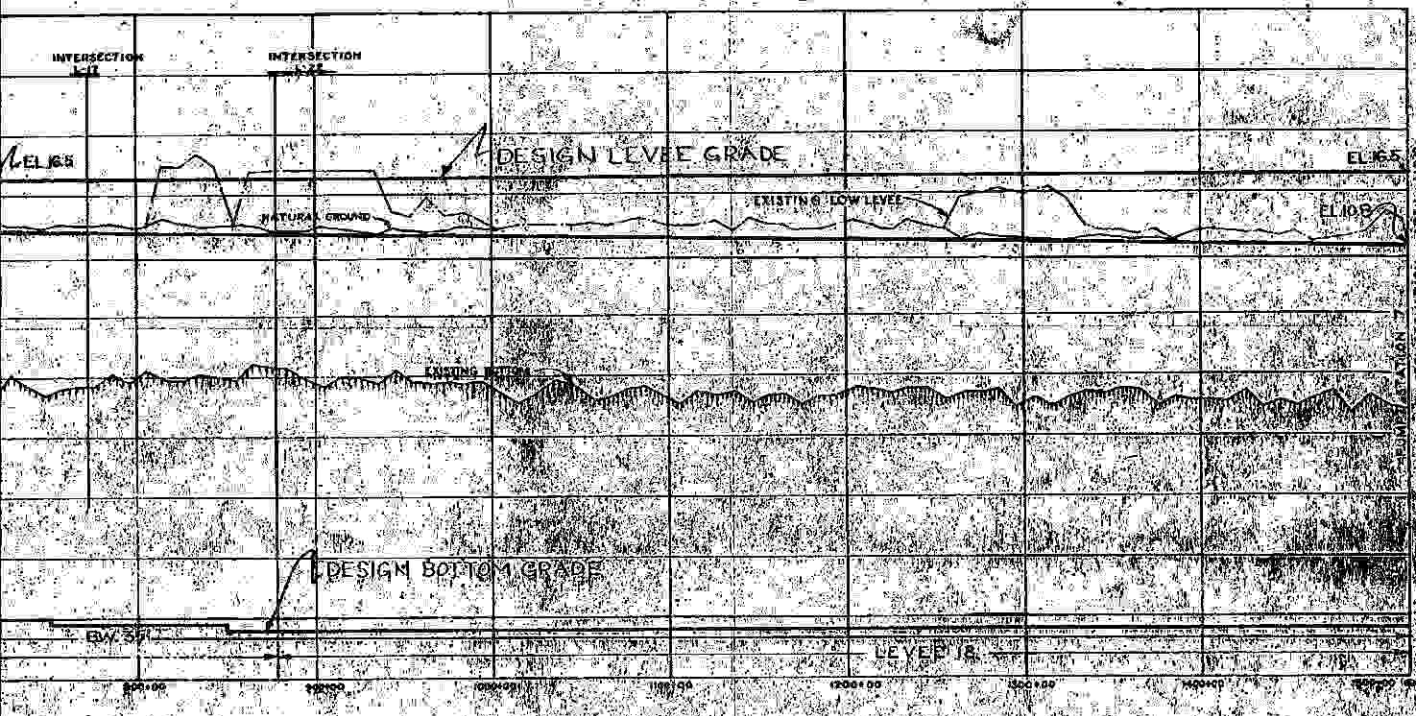
ST
PR



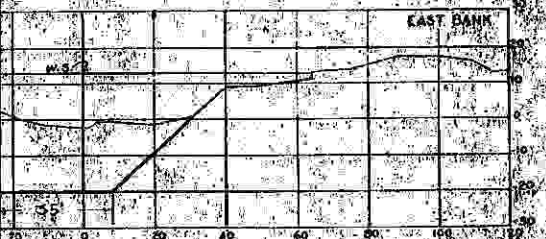


TYPICAL SECTION

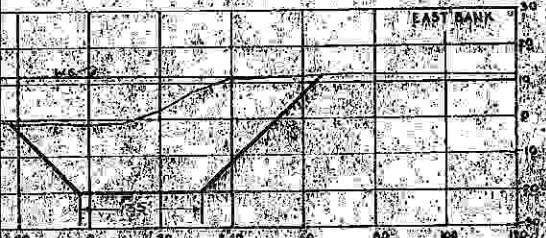
U.S. ARMY

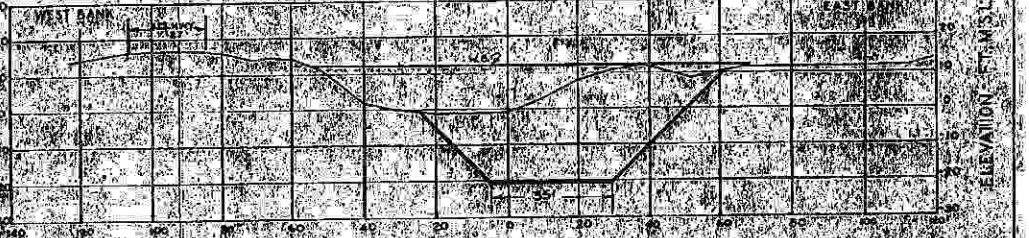


ATION
OFILES

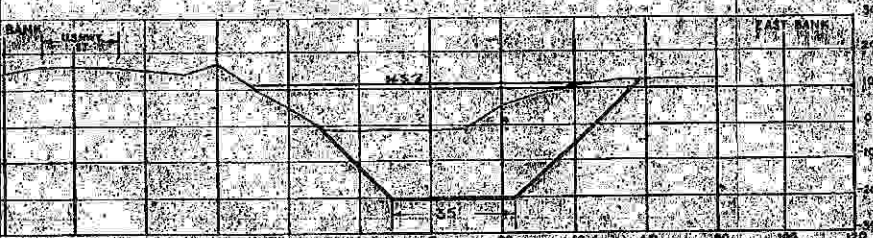


STA. 287+32





STA. 935+59



STA. 1216+59

NOTE -
ALL SIDE SLOPES 1 VERTICAL ON 1 HORIZONTAL

CENTRAL AND SOUTHERN FLORIDA

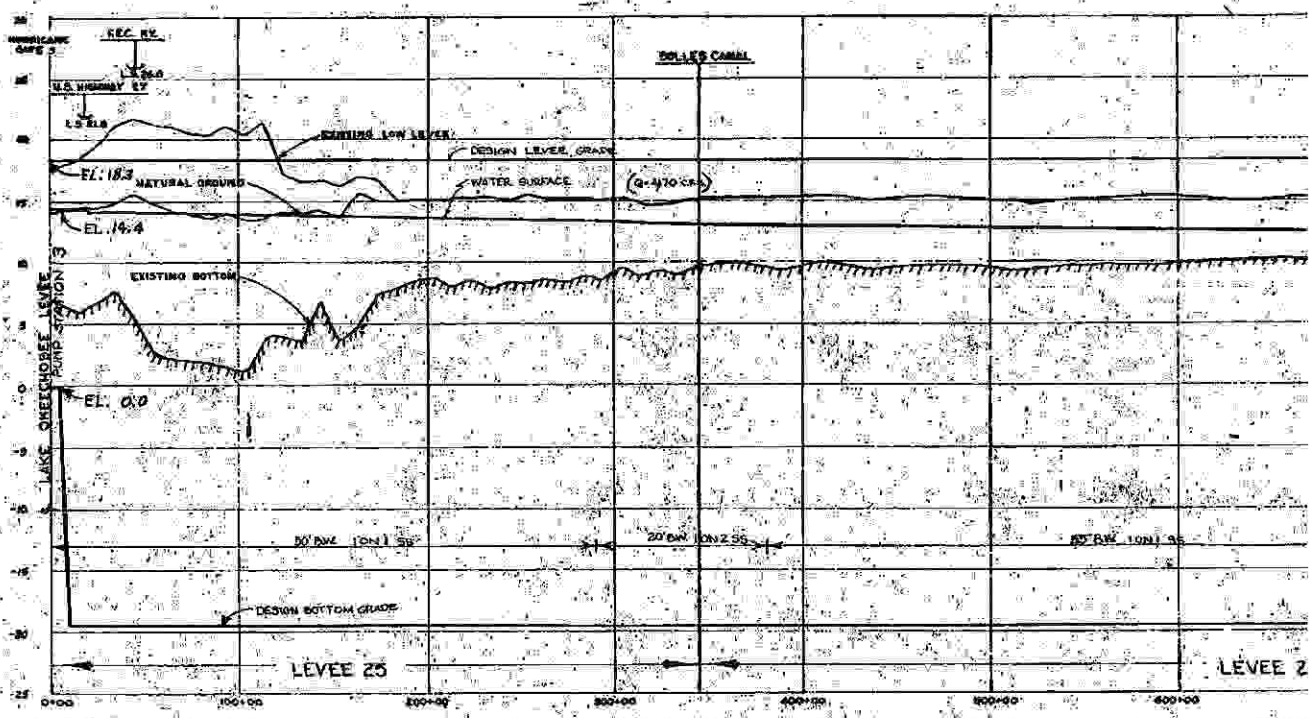
PLAN 7

NORTH NEW RIVER CANAL (LEVEES 18 & 20)

JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY PARTIAL D.E.R., PART IV, SUPPLE. SEC. 5A, DATED MARCH 25, 1955
FILE NO. AGO-23.088

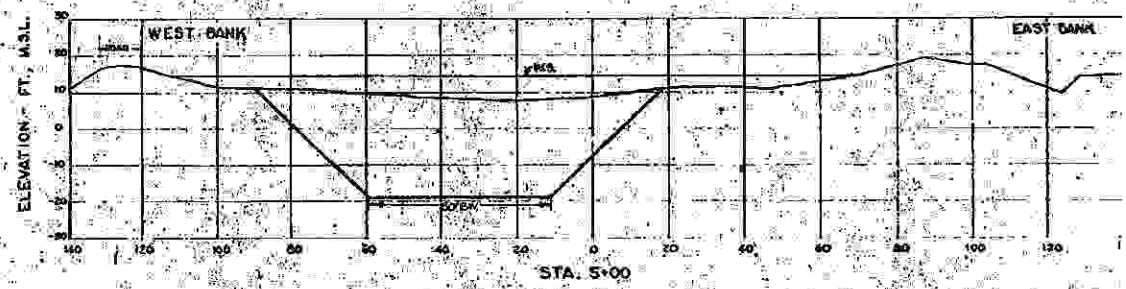
PLATE 8

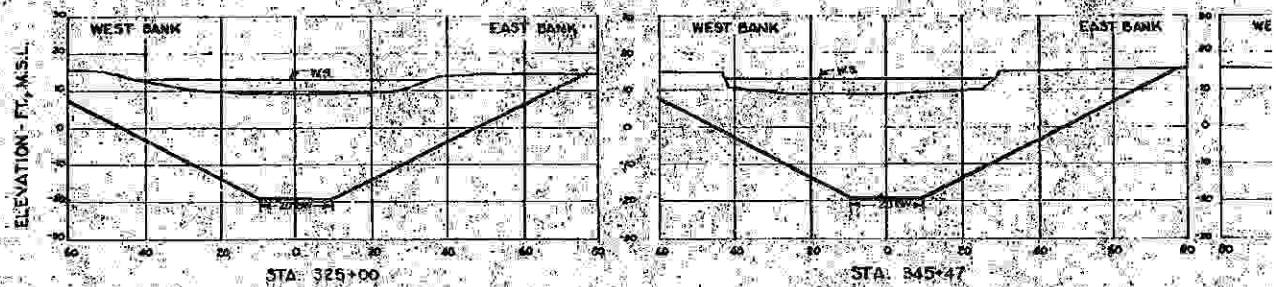
CORPS OF ENGINEERS

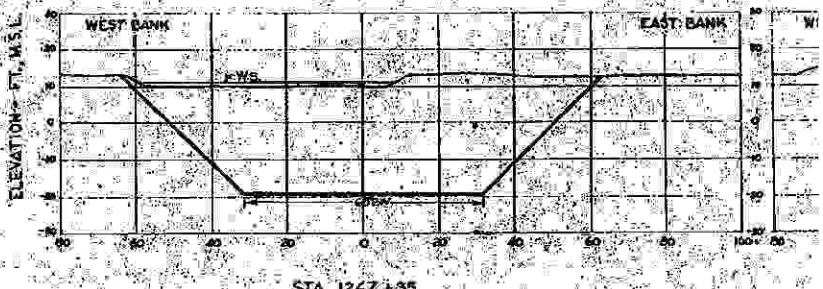


STA

PRO

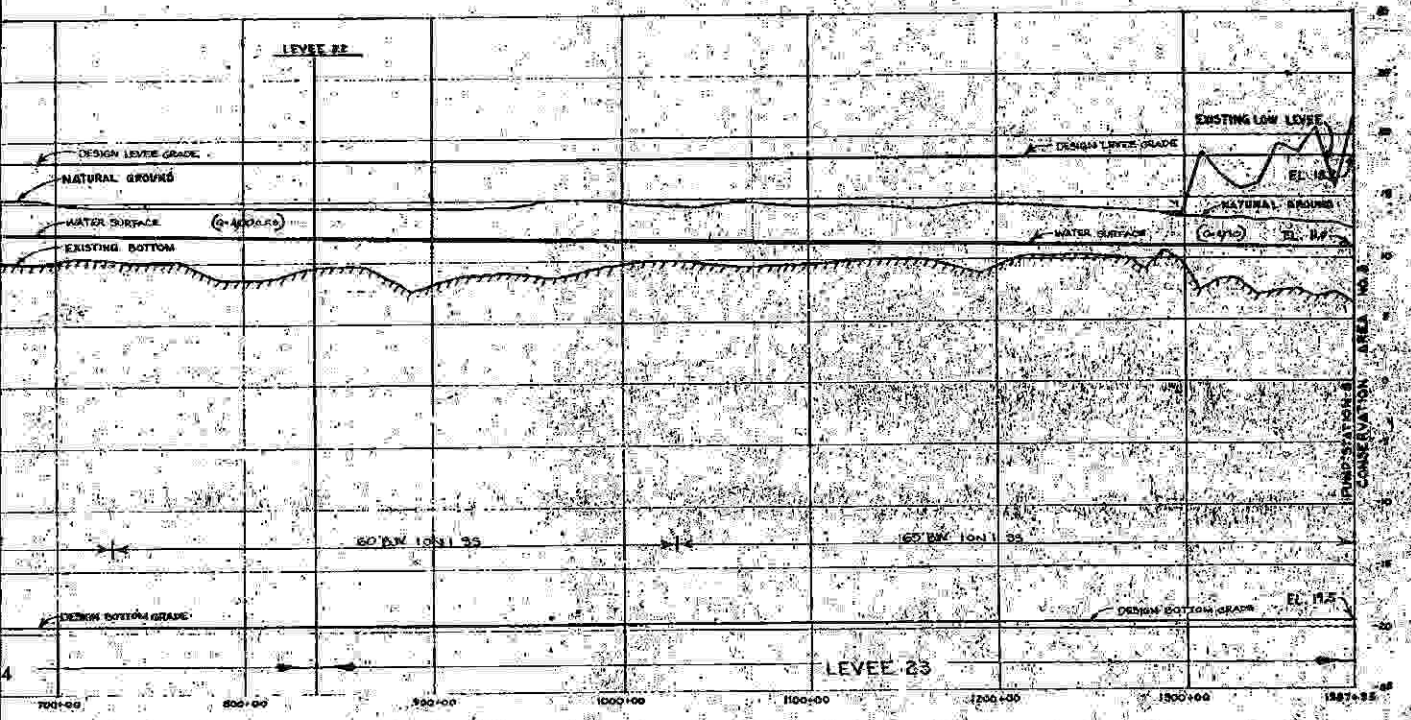






TYPICAL

U.S. ARMY



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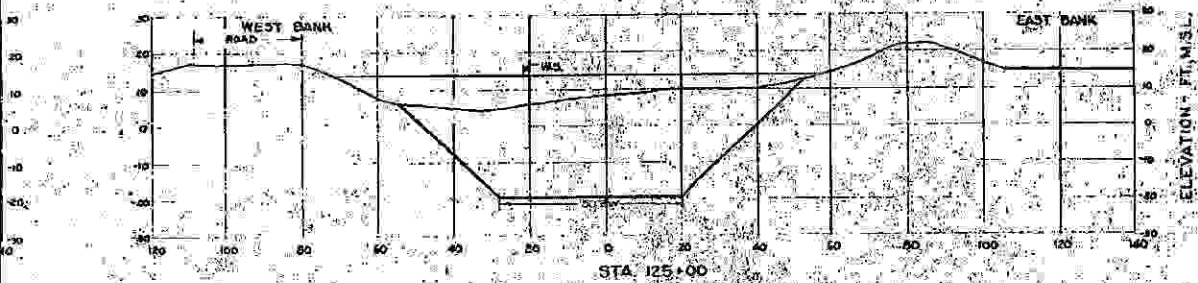
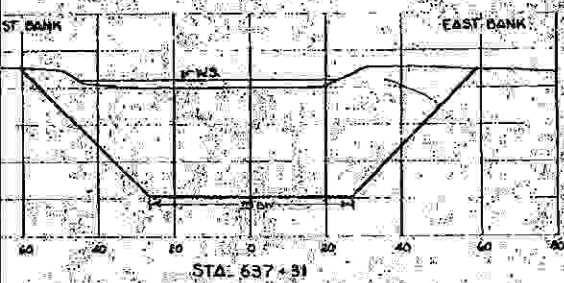
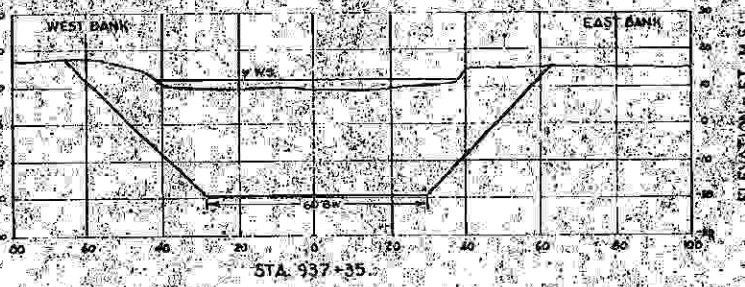
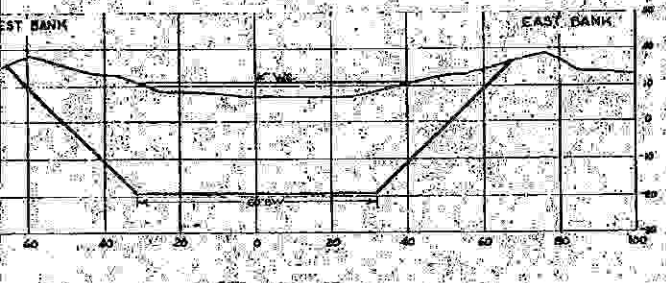
FILES









SECTIONS

NOTE:
FROM STATION 293+00 TO STATION 383+00 THE SIDE SLOPES ARE 1 VERTICAL ON 2 HORIZONTAL. SIDE SLOPES FOR ALL OTHER REACHES ARE 1 VERTICAL ON 1 HORIZONTAL.

CENTRAL AND SOUTHERN FLORIDA

PLAN 7

MIAMI CANAL

(LEVEES 23, 24, 125)

SCALE: AS SHOWN

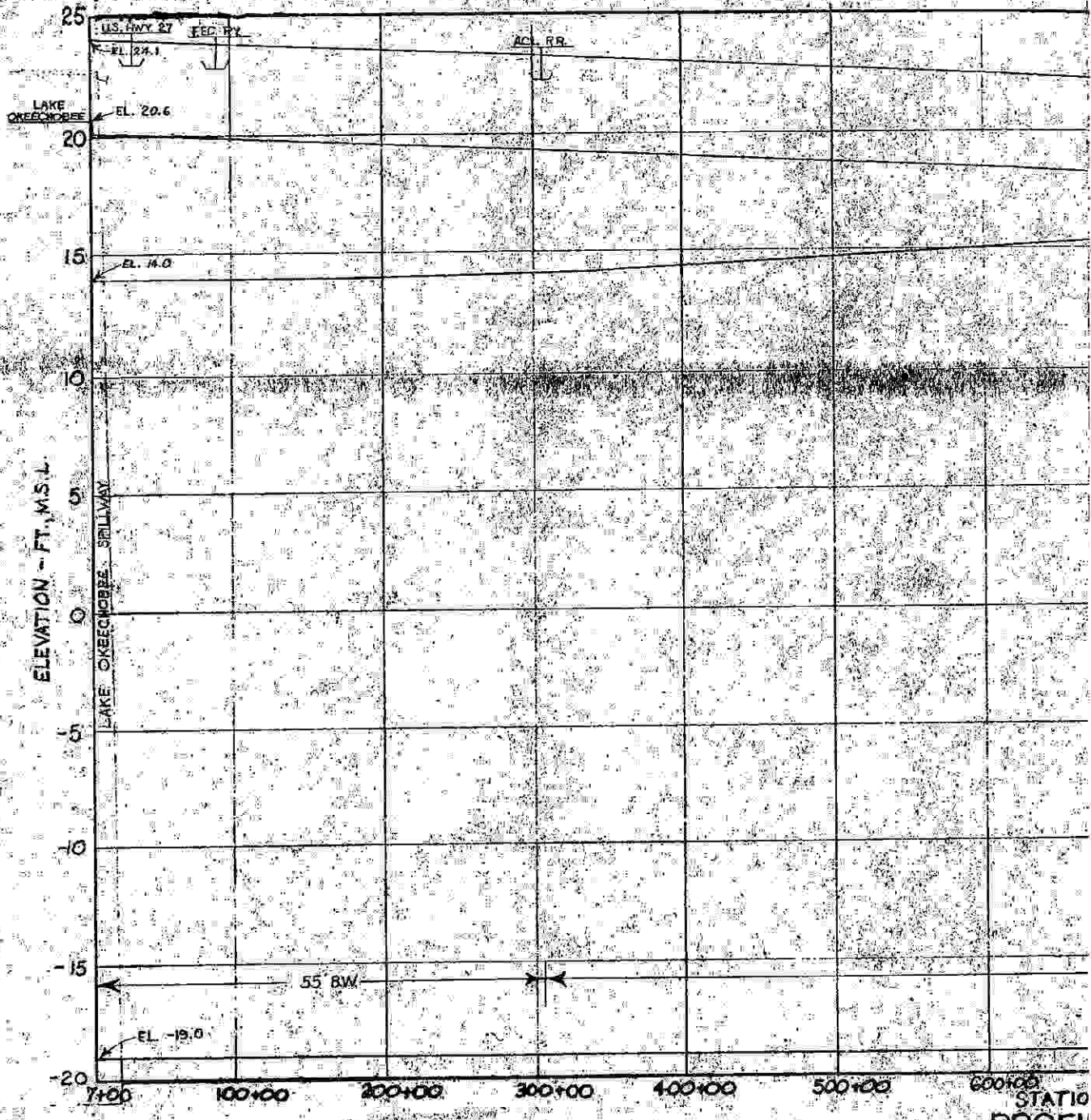
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS

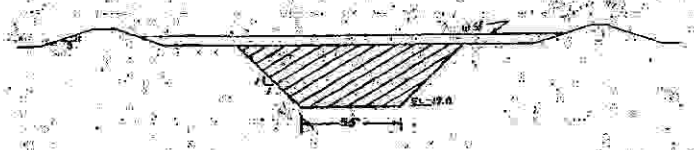
TO ACCOMPANY PARTIAL D.R.R.

PART IV, SUPP 2, SEC. 5A DATED MARCH 28, 1955

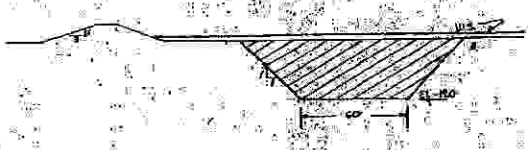
FILE NO. 4-00-23.065

CORPS OF ENGINEERS





STA. 8+00



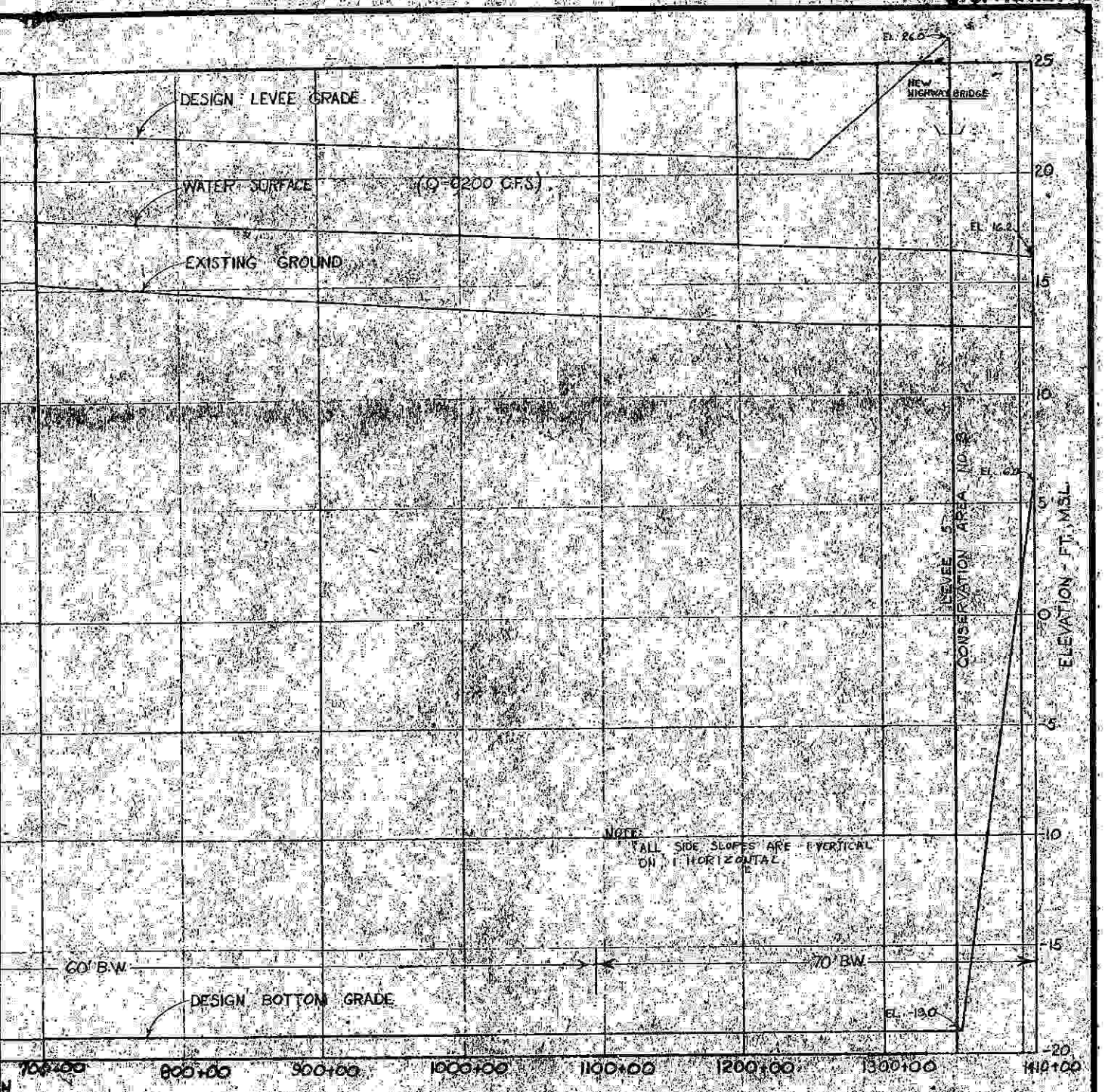
STA. 1093+00

SCALE IN FEET

40 0 40 80

TYPICAL SECTIONS

U.S. ARMY



STA. 1357+00

CENTRAL AND SOUTHERN FLORIDA

PLAN 8

GRAVITY CANAL DESIGNS

ALINEMENT A

JACKSONVILLE DISTRICT, CORPS OF ENGINEERS

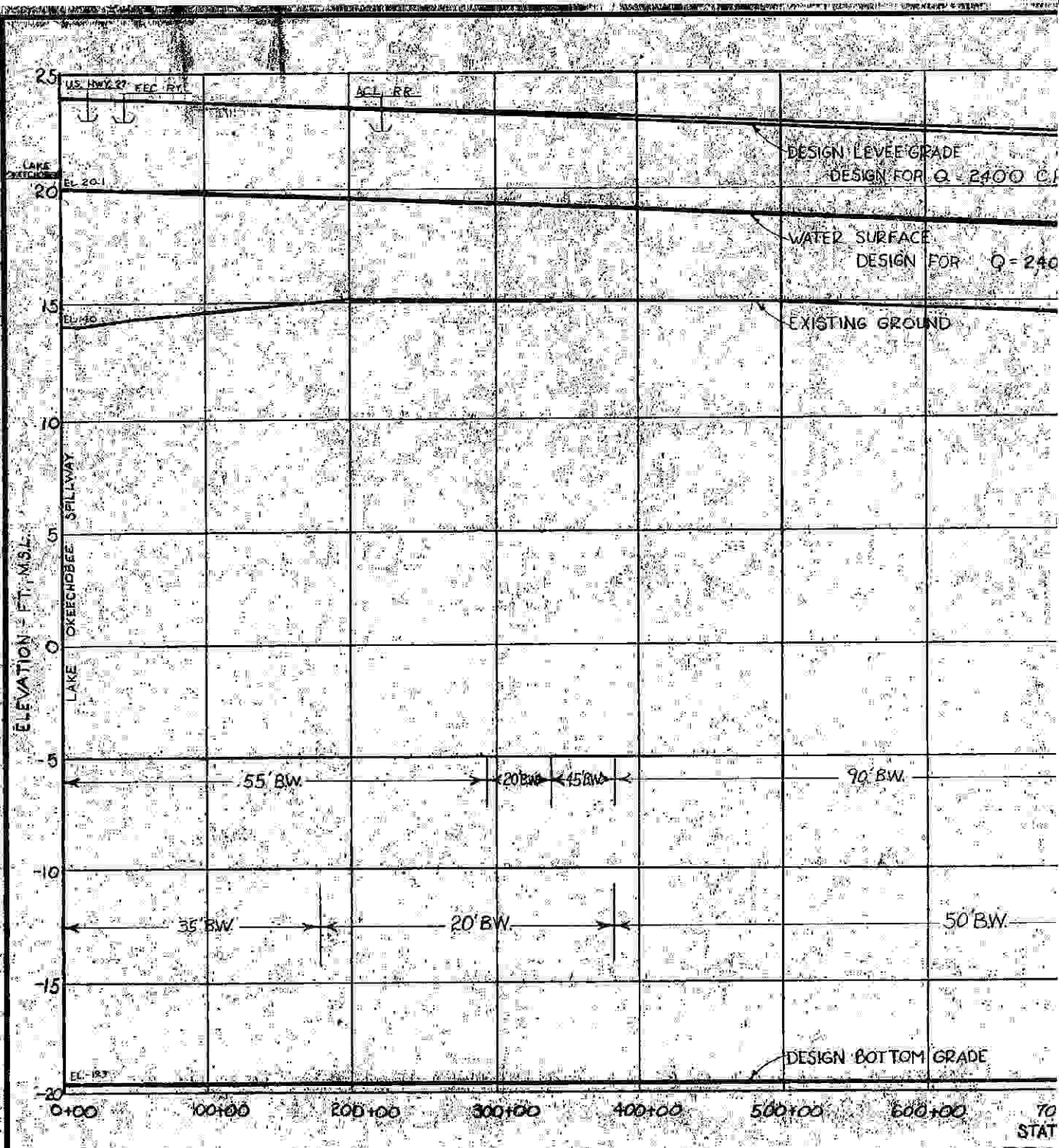
TO ACCOMPANY PARTIAL DPR,

PART IV, SUPP 2, SEC 5A

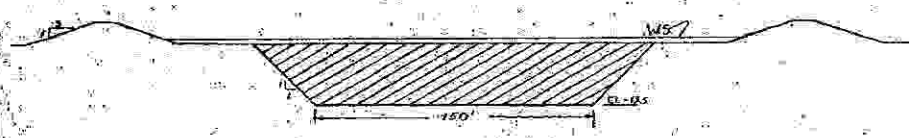
FILE NO. 400-23.085, DATED MARCH 28, 1955

SCALE AS SHOWN

PLATE 10



STA. 338+00



STA. 1387+35

SCALE IN FEET

40 0 40 80

TYPICAL SECTIONS

DESIGN B-2

EL. 26.0

NEW HIGHWAY BRIDGE

DESIGN LEVEE GRADE
DESIGN FOR Q = 6,200 C.F.S.

WATER SURFACE
DESIGN FOR Q = 6,200 C.F.S.

0 C.F.S.

EL. 5.0

LEVEE NO. 3

CONSERVATION AREA

DESIGN FOR Q - 6,200 C.F.S.

100 B.W.

150' B.W.

TRANSITION 100' B.W. TO 150' B.W.

DESIGN FOR Q - 2,400 C.F.S.

100' B.W.

85' B.W.

TRANSITION 100' B.W. TO 85' B.W.

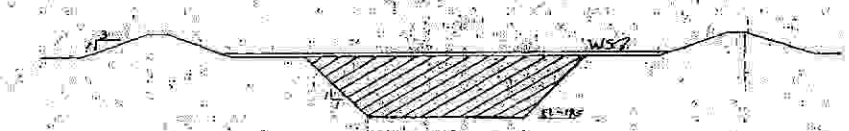
EL. 8.5

800+00 900+00 1000+00 1100+00 1200+00 1300+00 1353+00

ION

FILES

STA. 338+00



STA. 1387+35

DESIGN B-3

NOTE

FROM STATION 293+00 TO STATION 383+00 THE SIDE SLOPES ARE 1 VERTICAL ON 2 HORIZONTAL. SIDE SLOPES FOR ALL OTHER REACHES ARE 1 VERTICAL ON 1 HORIZONTAL.

CENTRAL AND SOUTHERN FLORIDA

PLAN 8

GRAVITY CANAL DESIGNS

ALINEMENT B

JACKSONVILLE DISTRICT, CORPS OF ENGINEERS

TO ACCOMPANY PARTIAL D P R.

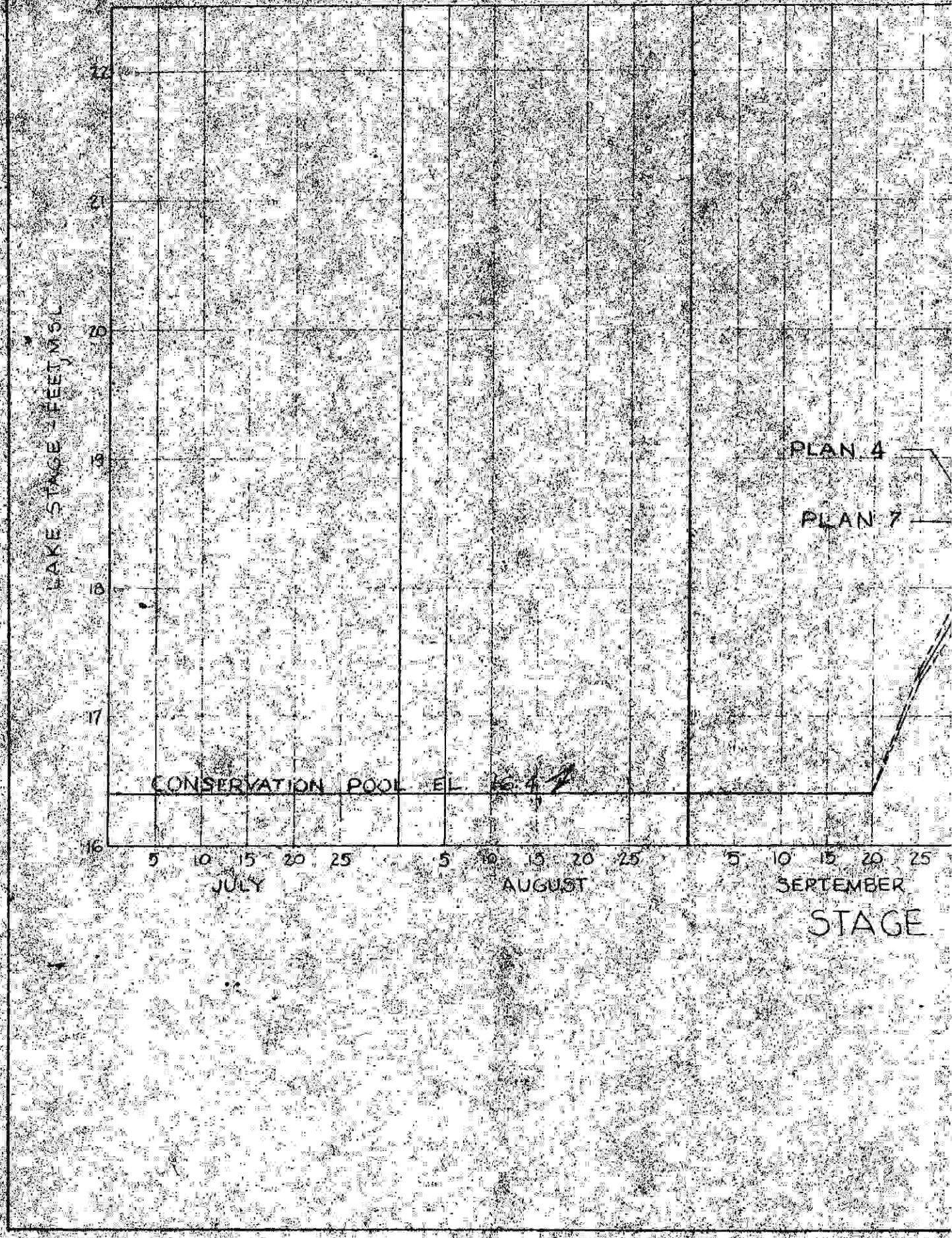
PART IV, SUPP 2, SEC. 5A

FILE NO. 400-23085 DATED MARCH 28, 1955

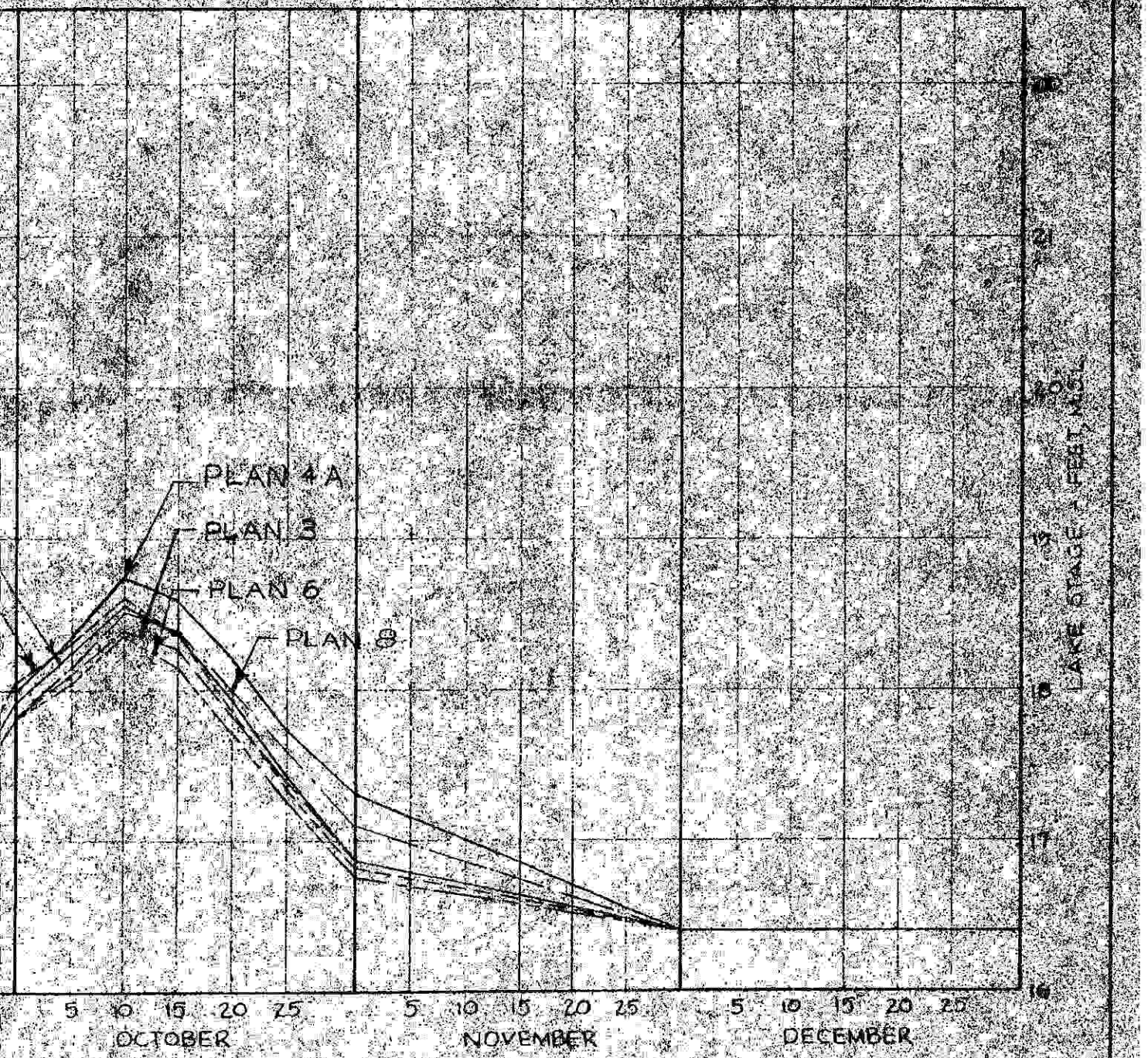
SCALE AS SHOWN

PLATE 11

CORPS OF ENGINEERS



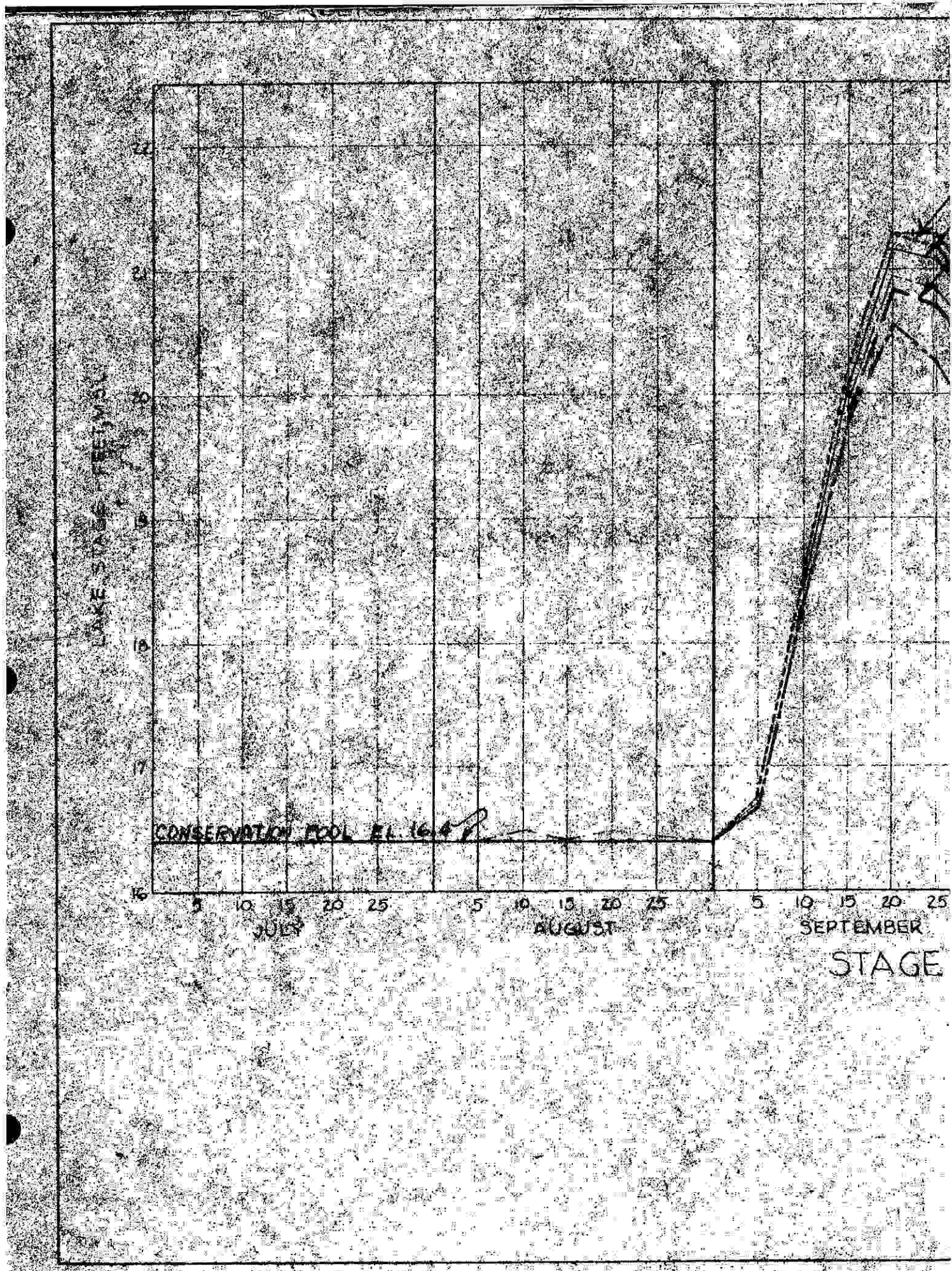
U.S. ARMY

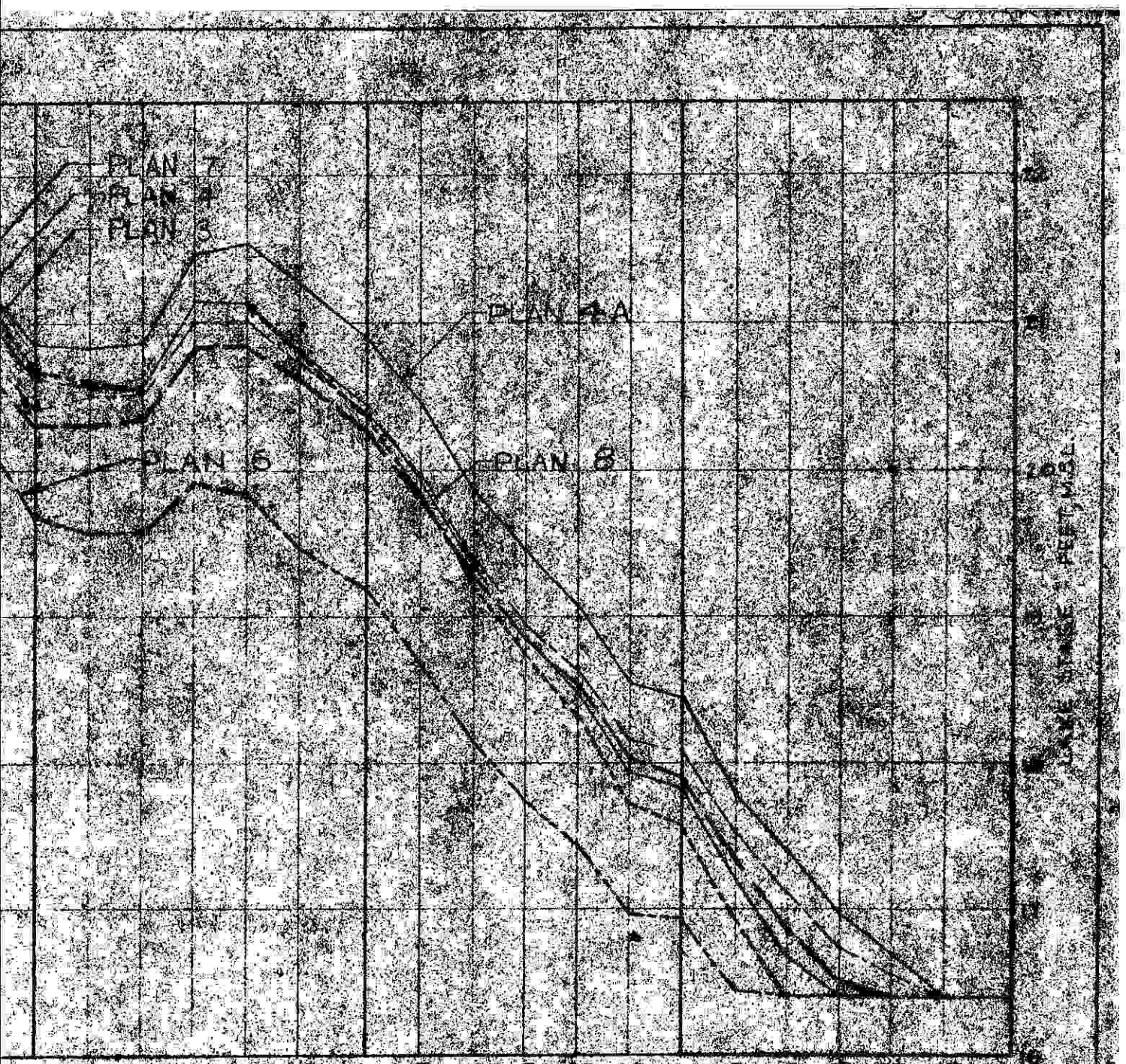


HYDROGRAPHS

CENTRAL AND SOUTHERN FLORIDA
LAKE OKEECHOBEE
STAGE HYROGRAPHS
1948 FLOOD
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY PARTIAL D.P.R.
PART IV, SUPP 2, SEC 5A
DATED MARCH 28, 1955 FILE NO. 400-2[illegible]

PLATE 12


22
21
20
19
18
17
16
CONSERVATION POOL EL. 16.4
5 10 15 20 25 5 10 15 20 25 5 10 15 20 25
JULY
AUGUST
SEPTEMBER
STAGE



HYDROGRAPHS

CENTRAL AND SOUTHERN FLORIDA

LAKE OKEECHOBEE

STAGE HYROGRAPHS STANDARD PROJECT FLOOD

JACKSONVILLE DISTRICT, CORPS OF ENGINEERS

TO ACCOMPANY PARTIAL D.P.R., PART II, SUPP 2, SEC. 5A

DATED MARCH 28, 1955 FILE NO. 930-22.085

PLATE 13

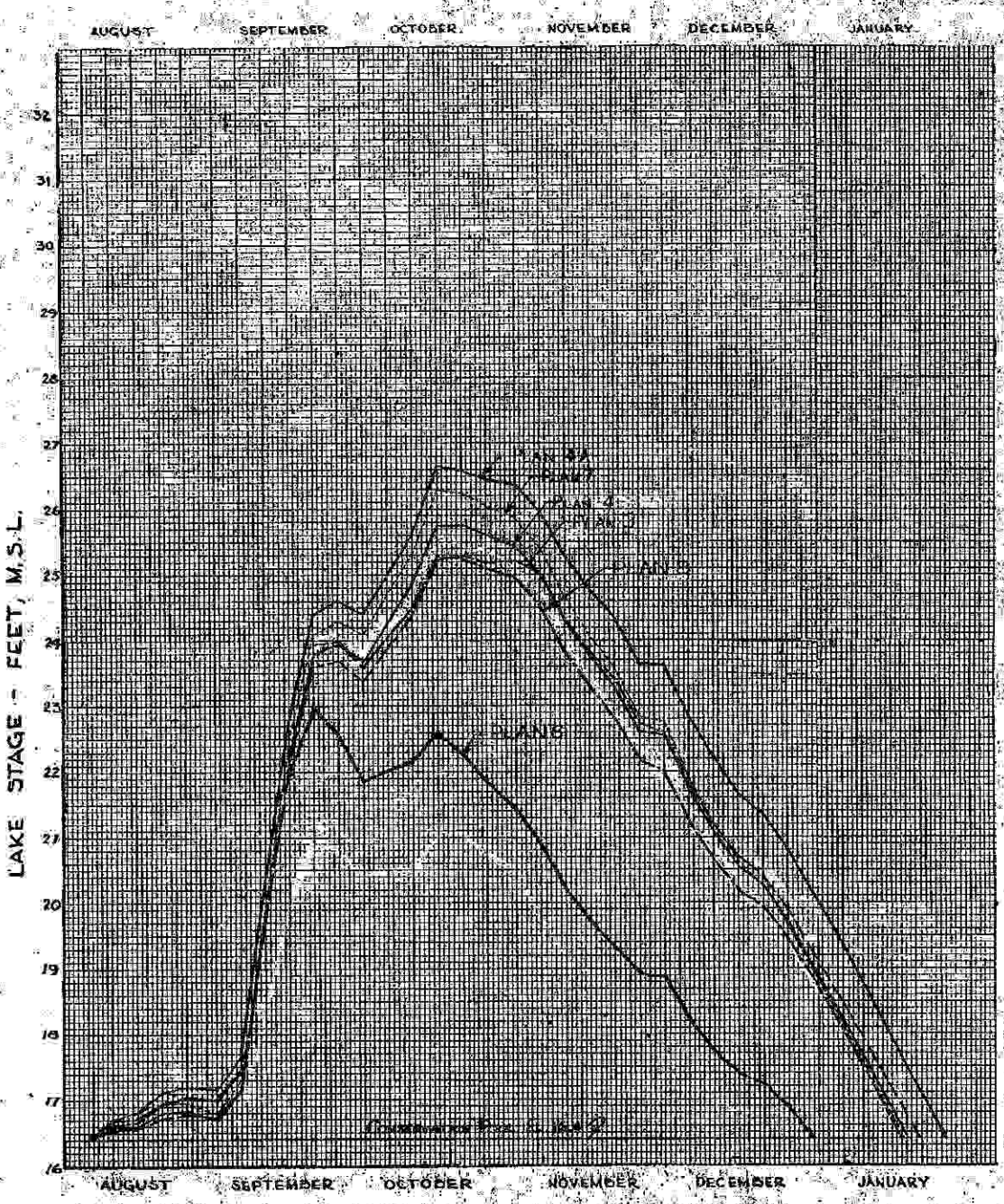


FIGURE 1 - STAGE HYDROGRAPH FOR 150 PERCENT OF STANDARD PROJECT FLOO

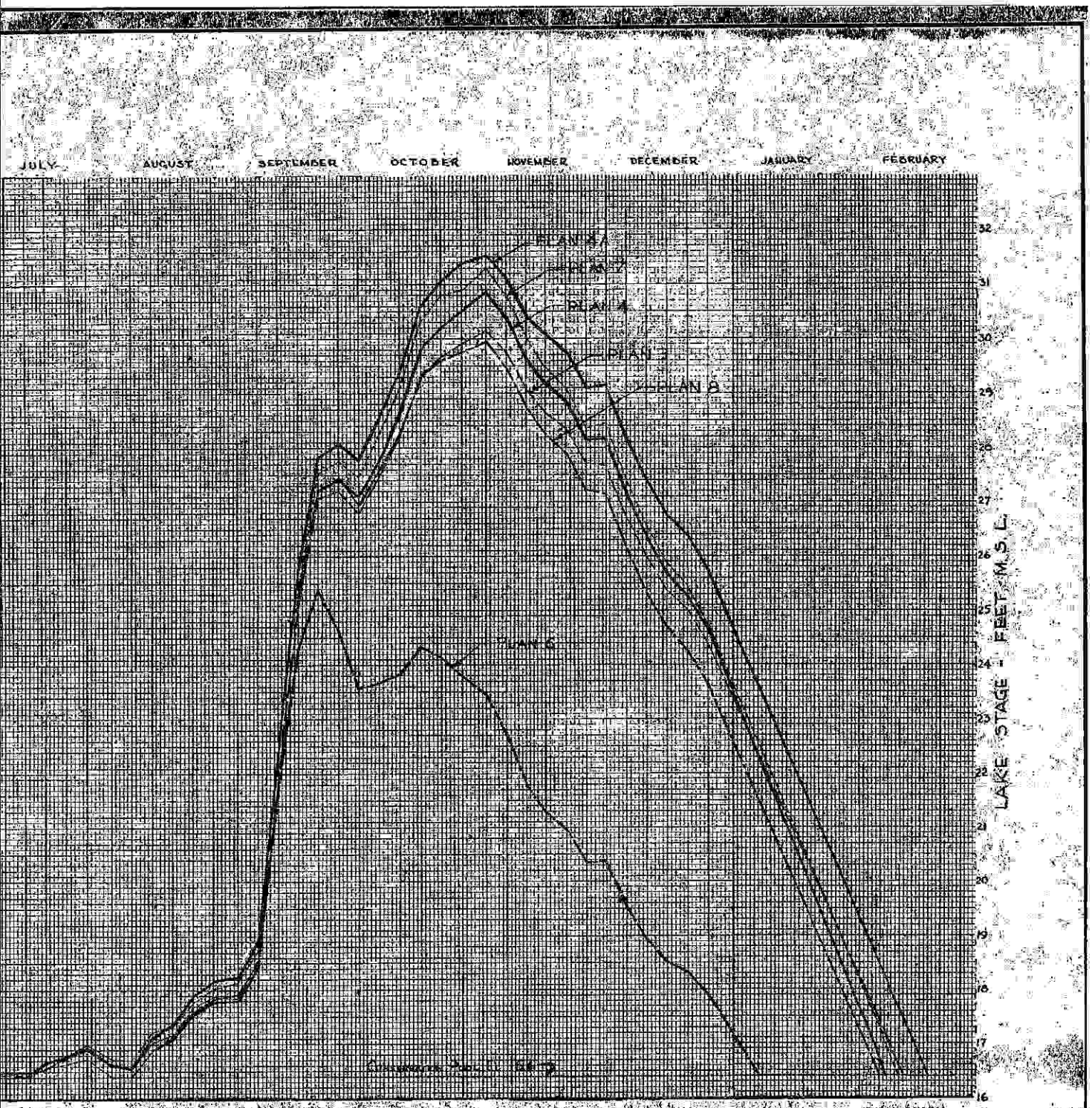


FIGURE 2 - STAGE HYDROGRAPH FOR 200 PERCENT OF STANDARD PROJECT FLOOD

NOTES:
1. ROUTING BASED ON CONTINUING ALL STORAGE TO LIMITS OF LAKE
2. ROUTING RESULTS ESTIMATED AFTER DECEMBER 31

CENTRAL AND SOUTHERN FLORIDA
LAKE OKEECHOBEE
STAGE HYDROGRAPHS
FLOODS LARGER THAN
STANDARD PROJECT FLOOD
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY PARTIAL D.P.R.,
PART IV, SUPP. 2, SEC. 5A
DATED MARCH 28, 1955 FILE NO. 400-23085

PLATE 14