

CALOOSAHATCHEE RIVER AND LAKE OKEECHOBEE DRAINAGE AREAS, FLA.

LETTER

FROM THE

CHIEF OF ENGINEERS UNITED STATES ARMY

TO THE

CHAIRMAN OF THE COMMITTEE ON COMMERCE

UNITED STATES SENATE

SUBMITTING

A REVIEW OF THE REPORTS ON CALOOSAHATCHEE RIVER AND LAKE
OKEECHOBEE DRAINAGE AREAS, FLA., SUBMITTED IN HOUSE
DOCUMENT NO. 215, SEVENTIETH CONGRESS, AND IN SENATE
DOCUMENT NO. 213, SEVENTIETH CONGRESS



PRESENTED BY MR. FLETCHER

JANUARY 6 (calendar day, MARCH 18), 1930.—Referred to the Committee on
Commerce and ordered to be printed with an illustration

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CALOOSAHATCHEE RIVER AND LAKE OKEECHOBEE DRAINAGE AREAS, FLORIDA

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, March 15, 1930.

HON. HIRAM W. JOHNSON,
*Chairman Committee on Commerce,
United States Senate, Washington, D. C.*

MY DEAR SENATOR: 1. Referring to letter of the chairman of the Committee on Commerce, United States Senate, dated December 9, 1929, inclosing a copy of a resolution of your committee requesting the Board of Engineers for Rivers and Harbors to review the reports on Caloosahatchee River and Lake Okeechobee drainage areas, Florida, submitted in House Document No. 215, Seventieth Congress, first session, and in Senate Document No. 213, Seventieth Congress, second session, with a view to determining whether the plans therein set forth can now be so modified as to provide a reasonable and necessary measure of safety within a practicable limit of expenditure, and with a view also to arriving at an equitable and feasible apportionment of costs as between the United States and the State of Florida, and/or other local interests, I inclose herewith the report of the board in response thereto.

2. In House Document No. 215, Seventieth Congress, first session, the first of the reports under review, a channel 6 feet deep and 80 feet wide was recommended to be provided in the Caloosahatchee River between the western boundary of the Everglades drainage district and Fort Myers, at an estimated cost of \$620,000, with \$15,000 annually for maintenance, subject to certain conditions of local cooperation, which would result, among other things, in providing a navigable waterway across the State.

3. Subsequent to the submission of this report great hurricanes occurred in August and September, 1928, which caused much damage and extensive loss of life, and indicated that plans for flood control previously made by local interests were probably insufficient. At about the same time the Everglades drainage district found that it would be impossible to sell the bonds by which it proposed to finance these flood control projects and the local cooperation previously referred to in connection with the navigation project. For this reason reconsideration of the earlier recommendations was necessary, and the former report was reviewed in response to a resolution of the Committee on Commerce of the Senate. The report in review, printed as Senate Document No. 213, Seventieth Congress, second session, constitutes the second document, the further review of which is now requested. In this document it was recommended that a project for the combined purposes of navigation and flood control be undertaken, consisting of a channel 6 feet deep and at least 80 feet wide from deep water in Lake Okeechobee to Fort Myers, the improvement of Taylors Creek to provide a channel 6 feet deep and 60 feet

wide to Okeechobee City, rock levees following the south shore of the lake and similar levees on the north shore, at an estimated cost of \$10,740,000. It was recommended that the United States contribute \$4,000,000 toward the cost of this project and that the State of Florida or other local interests contribute not more than \$6,740,000, agree to maintain the work within the limits of the Everglades drainage district, and comply with certain minor conditions of local cooperation.

4. It was estimated that the cost of those portions of this project which were directly valuable in providing suitable facilities for navigation would be \$2,000,000, and it was found that local interests had expended in the past approximately \$2,000,000 additional for work which would form a useful part of the proposed navigation system. Although it appeared that the benefits to navigation which would result from the proposed project would justify only a comparatively limited expenditure by the Federal Government, it was considered that \$4,000,000, the sum of the foregoing items, might be taken as the amount which the Federal Government would be justified in contributing to the cost of the project.

5. Local interests have since made extensive engineering investigations and now present a new design for the levees along Lake Okeechobee, the proposed levee section consisting of a core of muck and earth, provided with a toe of riprap extending down to bedrock on the lake side, and a pavement of rock covering the entire surface of the levee, with thicknesses of 3½ feet on the lake face, 3 feet on the crest, and 2 feet on the rear face. The proposed grade line of this levee is at elevation 31, which is the same as previously recommended for the rock levee. Local interests have also presented evidence to show that the expenditures which they have made for work which would form a useful part of the proposed navigation project amount to much more than \$2,000,000.

6. The district engineer is of the opinion that the new levee section recommended by local interests is sufficiently strong and should be substituted for the one previously recommended, because of the very considerable saving in the cost of the project which would result, estimated at \$1,887,580. The amount of material required to construct the new levee section is so great that its excavation will be sufficient to form a navigable channel around the south shore of the lake, thus making unnecessary the channel from Moore Haven to deep water in the lake, which was previously recommended.

7. The district engineer, therefore, sets up a new project for navigation and flood control, which differs from the old one by providing the larger but cheaper levee section and a navigation channel around the south shore of Lake Okeechobee instead of directly across from Moore Haven to the head of St. Lucie River. He estimates the total cost of the project to be \$9,027,000, and the cost of providing equivalent navigation facilities without any flood-control features to be \$2,410,200.

8. He analyzes the figures presented by local interests purporting to show the amount of their past expenditure which can properly be considered as being of service to the present or reasonably prospective commerce of Lake Okeechobee and the Everglades region. He points out that they have included large expenditures for the development of harbors and port facilities on the Atlantic coast, which appear to have no bearing on the project under discussion. After eliminating

such items, he determines that the total sum which should be considered in this connection is \$4,402,291. He therefore finds that a division of the costs of the new project between the United States and local interests on the same basis as that previously recommended would be as follows:

Cost of providing equivalent navigation facilities.....	\$2, 410, 000
Cost of improvements useful for navigation constructed by local interests.....	4, 402, 000
Total to be paid by the United States.....	6, 812, 000
To be paid by local interests.....	2, 215, 000
Total cost, exclusive of right of way.....	9, 027, 000

9. The district engineer has also studied the control of the floods of the lower Everglades district which do considerable damage to villages and improved land in the vicinity of Miami. Local interests have planned and partially constructed a levee to protect this area, but this improvement will be ineffective unless the outlets draining this portion of the Everglades are very materially enlarged. Local interests desire the United States to undertake the work of enlarging the Snake Creek Canal, the Miami Canal and River, and the Snapper Creek Canal, at a total estimated cost of \$4,950,750. If a lesser amount of work is undertaken, they desire a more limited enlargement of the Miami River and Canal only, at an estimated cost of \$1,595,500, and state that this will give the amount of relief most urgently needed. The district engineer concludes that while flood control is needed in this locality, it appears to be entirely a local problem not affecting any important Federal interests nor depending to any considerable extent on the control of Lake Okeechobee. The proposed excavation in the Miami River is far in excess of anything that could be justified as an aid to navigation. He has no information about the project except the rather incomplete plans and estimates furnished by local interests, and he suggests that a preliminary examination and survey should be authorized by Congress if the preparation of plans and estimates for this local project is desired.

10. The board has given careful consideration to the new levee section proposed by local interests, and is of the opinion that the new section will be as good as and in some respects superior to the all rock section previously recommended provided that it is never overtopped by the flood waters of the lake. If overtopping should occur, it believes that the new section would then be found inferior to the previous one and might possibly be destroyed. The estimate of the maximum height to which floods caused by hurricanes may rise in Lake Okeechobee is based on very limited information. The construction of the proposed project would probably lead to a large increase in the population of the adjacent district and a future failure of this levee might cause a catastrophe much worse than that which occurred in 1928. The board therefore believes that it would not be safe to trust the protection of this area to a levee of the proposed type with its crest at elevation 31. However, if the crest is raised to elevation 34, the margin of safety against overtopping will be very substantially increased and, although the levee will be more expensive than the one proposed by local interests, the estimated cost is \$1,223,000 less than that of the levee previously recommended.

11. In studying the report of the district engineer on the expenditures made by local interests for work which would be of service to navigation, the board finds that certain items have been included which, in their opinion, would not contribute anything essential to a suitable navigation project. After eliminating these items the board finds that the sum of \$3,150,000 may fairly be accredited as local cooperation for the benefit of general navigation and commerce. In estimating the cost of providing independently navigation facilities equivalent to those provided by the proposed plan combining navigation and flood control, it believes that such an estimate should be based on a channel directly across Lake Okeechobee and not, as in the district engineer's estimate, on a longer and more expensive channel around the south side of the lake. On this basis the cost of equivalent navigation facilities is estimated as follows:

Channel in the Caloosahatchee River and Canal.....	\$1, 085, 000
Channel in Taylors Creek.....	58, 000
Channel in St. Lucie River.....	25, 000
Channel from Moore Haven into Lake Okeechobee.....	348, 000
Total.....	1, 516, 000

12. The board is of the opinion that the expenditure by the United States of any considerable amount on this project in the interests of navigation is not justified by the present or prospective commerce. However, should Congress see fit to provide for Federal participation in the project, the board reports that the sum of \$4,666,000 may be taken as the measure of Federal interest therein. This sum is made up of \$1,516,000, the estimated cost of providing equivalent navigation facilities without providing for flood control, and \$3,150,000, accredited above for work already done by local interests. The board therefore recommends that if Congress desires to contribute to a combined project for navigation and flood control in this locality, the project adopted should be substantially as set forth in the report of the district engineer, except that the elevation of the crest of the levees on Lake Okeechobee should be 34 feet above sea level, and that it should be provided that the channels forming the proposed cross-State waterway shall be navigable waters of the United States and subject to the Federal laws for the protection of such waterways, and that the State of Florida or other local interests shall contribute \$3,812,000 toward the cost of the improvements; furnish evidence satisfactory to the Secretary of War that they will construct the north-shore levee to a design to be approved by the Chief of Engineers, estimated to cost \$1,214,000; provide all lands needed for levees, channels, and the disposal of spoil; agree to maintain all works and channels within the limits of the Everglades drainage district and to charge no tolls on any of these navigable waterways, and agree that whenever authorized by Congress the United States shall have the right to modify or improve any of these waterways and their appurtenant structures.

13. As regards flood control in the lower Everglades in the vicinity of Miami, the board concurs with the district engineer that this is entirely a local problem and that any recommendations made on such a project should be based on an independent survey specifically authorized by Congress. No such authorization exists at the present time.

14. After consideration of the above-mentioned reports, I concur in general in the opinion of the Board of Engineers for Rivers and Harbors. About 2,000 lives were lost in the 1928 hurricane. No one can foretell when a similar hurricane may occur in the future. Protection must be designed for the extraordinary and unexpected. The safety of the lives of the inhabitants, the protection of their property and the future development of the Everglades depend upon the levees being made high enough and strong enough to be safe against any contingency which can be reasonably anticipated. A levee as proposed by the local engineers can be depended upon to hold the lake waters unless it should be overtopped during a storm of the most severe character. Its construction would probably produce the confidence necessary to bring about the reclamation and settlement of lands not yet fully reclaimed, and as the area becomes more thickly settled greater loss of life and larger property damage might result from its failure. I am of the opinion, therefore, that the United States should not participate in the construction of any levee of lesser grade or section than that proposed by the Board of Engineers for Rivers and Harbors. While the proposed project will provide many miles of shallow navigable waterways, including a connection between the Atlantic Ocean and the Gulf of Mexico, only a very limited Federal contribution can be justified by the benefits which may be expected to result from the construction of such a waterway. However, in view of the great disasters which have occurred in this locality in the past, and of the valuable land which will be reclaimed by this project, Congress may desire to make a substantial Federal contribution thereto. If this should be the case, I recommend that a project be adopted for navigation and flood control in the Caloosahatchee-Lake Okeechobee areas, as follows:

(a) For improving the Caloosahatchee River and Canal from Lake Okeechobee to the Gulf of Mexico by straightening and by dredging a channel which will provide a discharge outlet capacity of 2,500 cubic feet per second from Lake Okeechobee, and a navigation channel at least 6 feet deep and 80 feet wide, including the necessary control works.....	\$1, 557, 000
(b) For improving Taylors Creek by providing a channel 6 feet deep and 60 feet wide from Okeechobee City into Lake Okeechobee.....	58, 000
(c) For a levee and a navigation channel 6 feet deep and 80 feet wide following in general the south shore of the lake.....	6, 663, 000
(d) For a levee on the north shore of the lake.....	1, 214, 000
(e) For improving the St. Lucie River to provide a channel 6 feet deep and 80 feet wide.....	25, 000
(f) For protection works in St. Lucie Canal.....	175, 000
Total estimated cost.....	9, 692, 000

Provided that all levees shall be subject to modification of location and design at the discretion of the Chief of Engineers; that the State of Florida or other local interests shall contribute \$3,812,000 toward the cost of the above improvements, furnish evidence satisfactory to the Secretary of War that they will construct the north shore levee to a design to be approved by the Chief of Engineers, estimated to cost \$1,214,000; provide all lands needed for levees, channels, and the disposal of spoil; agree to maintain all works and channels within the limits of the Everglades drainage district and to charge no tolls on any of these navigable waterways; and agree

that whenever authorized by Congress the United States shall have the right to modify or improve any of these waterways and their appurtenant structures; and that the St. Lucie Canal, the Caloosahatchee Canal, and other channels forming the proposed cross-State waterway shall be navigable waters of the United States and subject to the Federal laws for the protection of such waterways.

Very truly yours,

LYTLE BROWN,
Major General, Chief of Engineers.

REPORT OF THE BOARD OF ENGINEERS FOR RIVERS AND
HARBORS

WAR DEPARTMENT,
BOARD OF ENGINEERS FOR RIVERS AND HARBORS,
Washington, D. C., March 12, 1930.

Subject: Caloosahatchee River and Lake Okeechobee drainage areas,
Florida.

To: The Chief of Engineers, United States Army.

1. This report is submitted in response to the following resolution, adopted December 9, 1929:

Be it resolved by the Committee on Commerce, United States Senate, That the Board of Engineers for Rivers and Harbors created under section 3 of the river and harbor act, approved June 13, 1902, be, and it is hereby, requested to review the reports on Caloosahatchee River and Lake Okeechobee drainage areas, Florida, submitted in House Document No. 215, Seventieth Congress, first session, and in Senate Document No. 213, Seventieth Congress, second session, with a view to determining whether the plans therein set forth can now be so modified as to provide a reasonable and necessary measure of safety within a practicable limit of expenditure and with a view also to arriving at an equitable and feasible apportionment of costs as between the United States and the State of Florida and/or other local interests.

In the furtherance of the aforementioned objectives the board is requested—

First. To give due consideration to plans for levees and other protective works prepared by the State of Florida and/or its subordinate agencies concerned in the control of floods in and the drainage of the Caloosahatchee River and Lake Okeechobee drainage areas.

Second. To determine what improvements may be necessary or advisable in the interests of navigation and flood control to facilitate the commercial use of the several drainage canals which now connect Lake Okeechobee with the sea.

Third. To determine the advisability of constructing in connection with a protective levee around the lake or any portion thereof, a belt-line canal to connect with the canals hereinbefore mentioned.

Fourth. To determine the amount heretofore expended by the State of Florida, by subordinate municipalities, and/or by special taxing districts in the creation of canals, channels, jetties, harbors, and port facilities which may be of service to the present or reasonably prospective commerce of the Lake Okeechobee and Everglades regions of Florida and the extent to which the expenditures so made may fairly be accredited as local cooperation for the benefit of general navigation and commerce.

2. In House Document No. 215, Seventieth Congress, first session, it was reported—

That modification of the existing project for Caloosahatchee River, Fla., is deemed advisable, so as to provide for a channel 6 feet deep and 80 feet wide, extending from the western boundary of the Everglades drainage district to Fort Myers, at an estimated cost of \$620,000 and \$15,000 annually for maintenance, subject to the provision that local interests shall construct and maintain, coincidentally with the said improvement by the United States, a channel at

least 80 feet wide and 6 feet deep, at a lake stage of 15 feet at mean low water at Punta Rasa, together with the necessary locks and dams in the Caloosahatchee River, from the western boundary of the Everglades drainage district to and through Lake Okeechobee and in the St. Lucie Canal and River to the eastern boundary of the Everglades drainage district, and subject to the further provisions that no tolls shall be charged on any of the above waterways and that local interests shall furnish, free of cost to the United States, the necessary rights of way and land for the proposed improvement of the Caloosahatchee River.

3. At the time this recommendation was made it was expected that the Everglades drainage district would proceed with its plans for constructing a levee around the south shore of Lake Okeechobee from a point 3 miles north of Moore Haven to Bacom Point and, in connection therewith, a channel on the lakeward side of the levee 80 feet wide and 6 feet deep, and would make certain enlargements of the Caloosahatchee Canal. This work, in connection with the recommended Federal project, would solve the flood problems on the south and west sides of the lake and provide 6-foot navigation from the Atlantic coast to the Gulf of Mexico.

4. In 1928, subsequent to the submission of the foregoing report, the region in question was visited by a destructive hurricane, which caused great flood damage and loss of life. Resolutions were passed by the Committee on Commerce of the Senate and the Committee on Rivers and Harbors of the House of Representatives, requesting that the report be reviewed with a view to modification based on experience in that hurricane. When the review was made it was found that the plans of the Everglades drainage district for issuing bonds for the construction of the levee and channel on the south side of the lake had failed and that construction of those works in the manner previously contemplated was improbable. After considering the great height and violence of the storm flood caused by the 1928 hurricane, it was decided that the levees should be larger and longer and should contain a much greater proportion of rock than was originally planned. Since rock lies largely at a greater depth than 6 feet below the lake surface, the excavation of the levee material would be deeper and narrower than was originally planned and would not provide a waterway of adequate width. While such width could be provided by additional excavation, it was found more desirable to secure the desired navigation channel across the lake by the dredging of a cut 6 feet deep and 80 feet wide from the head of the Caloosahatchee River to deep water in Lake Okeechobee. It was also found that similar levees were needed on the north side of the lake.

5. In view of these facts, the Board of Engineers for Rivers and Harbors in its report contained in Senate Document No. 213, Seventieth Congress, second session, set up a plan for navigation and flood control which contained the following items:

Improvement of Caloosahatchee River and Canal.....	\$1, 557, 000
Rights of way for Caloosahatchee improvement.....	325, 000
Dredging in St. Lucie River.....	25, 000
	<hr/>
	1, 907, 000
Dredging Taylors Creek.....	58, 000
Levee along south shore.....	7, 500, 000
Levee along north shore.....	1, 600, 000
	<hr/>
	11, 065, 000

It was stated that the cost of the features considered as in the interest of navigation was \$4,000,000, including \$2,000,000 for work already done by local interests and \$2,000,000 for new work. The board considered that present and prospective benefits to navigation would not justify the expenditure of the \$2,000,000 required to complete the navigation project but expressed the opinion that, should Congress see fit to provide for Federal participation in the project, the sum of \$4,000,000 might be taken as a measure of the Federal interest. The total estimated cost for all work, exclusive of rights of way, was \$10,740,000. The board accordingly recommended that, should Congress desire to provide Federal participation on the basis described above, the project outlined in the report submitted in House Document No. 215, Seventieth Congress, first session, be modified so as to provide for a comprehensive project for navigation and flood control, at an estimated cost of \$10,740,000 (exclusive of lands), provided that local interests be required to contribute to the project to the extent of furnishing \$6,740,000; to provide the necessary rights of way and land for all works and improvements; and to maintain such of those works and improvements as lie within the Everglades drainage district; and provided that they charge no tolls on any of the navigable waterways provided for.

REPORT OF THE DISTRICT ENGINEER

6. The district engineer has reported upon the four points, the consideration of which was requested in the resolution quoted in paragraph 1 above. The first of these refers to the plans of local interests. In this connection he received a report made by a firm of consulting engineers for the board of commissioners of Okeechobee flood-control district. This report recommended a navigation and flood-control plan similar in its major features to that presented in Senate Document No. 213, Seventieth Congress, second session. It recommended a levee section with a core of earth or muck, toes of rock up to elevation 14, and a surface paved with selected rock riprap 3½ feet thick on the front face, 3 feet thick on the crown, and 2 feet thick on the rear. The crown is 10 feet wide, the side slopes 1 on 2½ and the slope of the toes 1 on 1½, and the crest is at elevation 31. In connection with the excavation of the material required to furnish the earth and muck for this section a navigable channel at least 6 feet deep and 80 feet wide would be produced. This section is 3 feet higher than that originally proposed as part of the plan of the commissioners of the Everglades drainage district. It has the same grade line as that of the levee, "largely of rock," recommended in Senate Document No. 213, Seventieth Congress, second session, but differs in having a rock toe extending down to bed rock and in having a greater proportion of soft material in the core. The consulting engineers suggested an alternative location of the levee at the southeast corner of the lake as shown at "A" on the attached map. They also suggested that it might be well to provide a depth of 8 feet in the navigable channels to conform to that of the intracoastal waterway with which they will be connected but did not estimate the increased cost which this would involve.

7. The district engineer concludes that the design proposed by the consulting engineers is adequate and can not be materially altered

with safety for the purpose of reducing cost. He states that the proposed new location of the levee in the southeast corner of the lake would result in a small saving of construction cost and an increase in maintenance costs. It would protect two islands otherwise unprotected. He concludes that its adoption is not warranted without further study but that the project should be so worded as to permit its adoption later if found desirable.

8. The total estimated cost of the north and south levees with the new section recommended by the district engineer is \$7,212,420, as compared with \$9,100,000 with the section previously recommended, a reduction of \$1,887,580. In addition the adoption of the new plan would eliminate the necessity for a dredged channel from Moore Haven out to deep water, thus effecting a further saving of \$348,000.

9. The second point under review requires the consideration of improvements in connection with further utilization of the various drainage canals connecting Lake Okeechobee with the sea. The report of the consulting engineers states that these canals can be improved to provide navigable channel 6 feet deep and 80 feet wide at a cost of \$15,775,648, and that such improvement is entitled to serious consideration. These canals are all navigable at present under more or less adverse conditions. In 1928, 132,000 tons of rock and sand was moved on the Miami Canal, 1,100 tons of unclassified freight on the West Palm Beach Canal, and 2,927 tons on the Hillsboro Canal. No movement of freight was reported on the other canals. The district engineer points out that the recommended improvement of the St. Lucie Canal and St. Lucie River will, in conjunction with the Intracoastal Waterway connect Lake Okeechobee with Fort Pierce, at which point satisfactory rail and water connections with the north are found. The improvement of the other canals would not offer better facilities since their Atlantic terminals are farther from the northern commercial centers than is Fort Pierce, and are also more distant from Lake Okeechobee, except the port of West Palm Beach, which is 14½ miles nearer the lake but 53 miles farther from northern points.

10. The third point under consideration is the advisability of a belt-line canal on the south shore of Lake Okeechobee to connect with the various drainage canals. Since the district engineer has concluded that further expenditures for the improvement of these drainage canals is not advisable, it is to be assumed that he would not recommend a belt-line canal solely for this purpose. However, the project which he favors for furnishing flood control on the south of the lake and navigation from the Atlantic to the Gulf coast includes such a canal provided by the excavation necessary in the construction of the south levee. It is to be noted that if a belt-line canal is not provided these canals can be connected with deep water in the lake by dredged cuts at an estimated cost of less than \$470,000 if such connections should later be deemed advisable.

11. The last item under review relates to the past expenditures by local interests and the extent to which they may be accredited as local cooperation in the project. Local interests state that the amount actually spent for work of value to navigation is \$9,617,417. The district engineer points out that this includes \$3,817,947 for the improvements of various sea ports. He holds that this money was spent for the benefit of these ports and not for navigation on the

Okeechobee system, and that these improvements will be of little or no value to the Okeechobee project. He also shows that \$1,584,596 of the money spent on the construction of the St. Lucie Canal was for excavation in excess of that which would be required to produce a satisfactory navigable channel. He allows credit for \$423,400 for borrow-pit excavation in connection with the existing south-shore levee because that excavation would be of value in constructing a purely navigation canal along the south shore. He concurs with them in allowing \$753,926 for the West Palm Beach, Hillsboro, North New River, and Miami Canals, this amount being 70 per cent of the cost of locks and spillways on these canals. His total estimate of the cost of navigation works already provided by local interests is \$4,402,291.

12. The estimated cost of constructing the combined project for navigation and flood control which is recommended by the district engineer is \$9,027,000. The estimated cost of providing an equivalent navigation project with no flood-control features is \$2,410,200, exclusive of the cost of right of way. The district engineer considers that the United States should properly pay an amount equal to the cost of providing equivalent navigation facilities plus the amount already paid by local interests for works of value to navigation, and that local interests should be required to meet the remaining costs of the combined project. This leads to the following division of costs:

Cost of providing equivalent navigation facilities.....	\$2, 410, 000
Cost of improvements useful for navigation constructed by local interests.....	4, 402, 000
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Total to be paid by United States.....	6, 812, 000
To be paid by local interests.....	2, 215, 000
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Total cost, exclusive of right of way.....	9, 027, 000

He considers that local interests should be required to furnish the necessary rights of way. These rights of way have already been acquired by the organizations engaged in drainage work, chiefly the board of commissioners of the Everglades drainage district, except the rights of way on the Caloosahatchee River, the estimated cost of which is \$325,000. As regards the proposed local participation, to the extent of \$2,215,000, he recommends that \$1,175,000 be made in cash and that local interests undertake to construct the north side levees at an estimated cost of \$1,040,000.

13. The consulting engineers estimated the annual savings in transportation costs that would be effected by the proposed project at \$6,261,765 if based on water haul to and from Baltimore. By using Savannah as the base port for sugar and miscellaneous freights and Baltimore for other commodities, the annual savings were estimated at \$2,879,265. The district engineer points out that these figures are based on an estimate of traffic which would become available on completion of the plans of the Everglades drainage district for a \$20,000,000 project for the drainage and reclamation of the Everglades. The plan of the district commissioners for financing this project has collapsed and the improvement has been postponed to an indefinite future date. Various Florida interests are seriously opposed to this reclamation project. Plans previously adopted by northern interests for the development of 70,000 acres

of Everglades land have been suspended because of the postponement of the reclamation project. The district engineer also points out that these estimates of savings should be based on movements only to the nearest suitable port which would cause a substantial reduction. He states that credit is taken for savings of \$165,000 of gasoline and oil which is due to the improvement of the harbor at Fort Pierce and has nothing to do with the Lake Okeechobee project. Further, more than \$500,000 is credited to the movement of fruit and vegetables by water. The developed sections of the Everglades are well served by good roads and experience has shown that these commodities will not move by water in large quantities. The district engineer concludes that the savings from the construction of the navigation improvement will be very much less than is estimated by the consulting engineers. However, he believes that there are possibilities of great savings and ample justification for the improvement, which he recommends.

14. The district engineer made a special study of the problem of controlling floods in the lower Everglades adjacent to Miami. He finds that the works recommended on Lake Okeechobee will prevent the waters of the lake from entering this area. However, the rainfall on the lower Everglades in itself produces serious floods. These have been aggravated by the construction of Federal Highway No. 94, the Tamiami Trail, across this area along an east and west line south of Miami, which is so constructed as to hinder the natural run-off to the south. Plans have been made by local interests for controlling these floods by the construction of a levee 38 miles long protecting the cities of the Atlantic coast, and the developed lands adjacent to them, and the provision of greater run-off capacity by the enlargement of Snake Creek Canal, Miami Canal and River, and Snapper Creek Canal to give each a capacity of 4,000 cubic feet per second. The estimated cost of these channel enlargements is \$4,950,750. It is considered that the most urgent needs of the locality can be met by the enlargement of a part of the Miami Canal and River, at an estimated cost of \$1,595,500. The area protected includes 300 square miles of valuable land and a population exceeding 50,000. Local interests have spent more than \$2,850,000 in reclaiming this land and state that they plan the further expenditure of \$3,000,000 following the execution of the plan outlined above. It is understood that they desire the United States to undertake or aid in the major flood control project.

15. The district engineer states that this appears to be entirely a local problem not affecting any important Federal interests nor depending to any considerable extent on the control of Lake Okeechobee. The proposed excavation in the Miami River is far in excess of anything that could be justified as an aid to navigation. No information is at hand other than that furnished by local interests, and he suggests that a preliminary examination and survey might be authorized by Congress to permit of the preparation of plans and estimates to take care of this local problem.

16. The district engineer recommends that the United States improve the Caloosahatchee River and Canal from Lake Okeechobee to the Gulf of Mexico by straightening and by dredging a channel which will provide a discharge outlet capacity of 2,500 cubic feet per second from Lake Okeechobee and a navigation channel at least

6 feet deep and 80 feet wide, including the necessary control works, at an estimated cost of \$1,557,000; improve Taylors Creek by providing a channel 6 feet deep and 60 feet wide from Okeechobee City into Lake Okeechobee at an estimated cost of \$58,000; provide a levee and a navigation channel 6 feet deep and 80 feet wide following in general the south shore of the lake at an estimated cost of \$6,172,000; improve the St. Lucie River to provide a channel 6 feet deep and 80 feet wide at an estimated cost of \$25,000; provide for the protection of the St. Lucie Canal from erosion and silting at an estimated cost of \$175,000; the levees to be subject to modifications of location and design at the discretion of the Chief of Engineers; provided that the State of Florida, or other local interests contribute \$1,175,000 towards the cost of the above improvements, furnish evidence satisfactory to the Secretary of War that they will construct the north shore levee to a design to be approved by the Chief of Engineers, estimated to cost \$1,040,000, provide all lands needed for levees, channels and the disposal of spoil, agree to maintain all work and channels within the limits of the Everglades drainage district and to charge no tolls on any of these navigable waterways and agree that whenever authorized by Congress the United States shall have the right to modify or improve any of these waterways and their appurtenant structures. He further recommends that in adopting the project Congress expressly provide that the St. Lucie Canal, the Caloosahatchee Canal and the other channels forming the proposed cross-State waterway, shall be navigable waters of the United States and subject to the Federal laws for the protection of such waterways. The division engineer concurs.

DISCUSSION BY THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

17. Referring to the committee resolution requesting this review, the first matter for consideration is:

To give due consideration to plans for levees and other protective works prepared by the State of Florida and/or its subordinate agencies concerned in the control of floods in and the drainage of the Caloosahatchee River and Lake Okeechobee drainage areas.

The discussion of this question follows:

18. The protective works proposed by the consulting engineers of the Okeechobee flood-control district comprise levees for protection of the south and north shores of the lake of the same length and height as those recommended by the Chief of Engineers in the report under review, but of a different type of construction. The levee design proposed by local engineers has a top width of 10 feet, side slopes of 1 on 2½, and a crest elevation of 31 feet. The center of the levee is composed of earth and muck. The lake face is covered with 3½ feet and top covered with 3 feet of riprap, the outer half of which would be handlaid; the landward slope is protected with a 2-foot layer of riprap. The riprap on the lake face is carried down to about 2 feet below ground level where it rests on a rock toe 10 feet and more in thickness, which is carried down to bedrock. On the land side this rock toe is proposed where required by foundation conditions. Material for the earth and muck core and for the riprap armor would be excavated from the lake immediately in front of the levee; this excavation would provide a channel not less than 6 feet

deep and from 40 to 80 feet wide. Some additional muck excavation, which is included in the cost of the levees, will provide a navigable channel of 80 feet width throughout. As much as practicable of the existing muck levee would be incorporated in the new levee. The estimated cost of levees of this design is \$6,172,000 for the south shore and \$1,040,000 for the north shore levee. The district engineer recommends adoption of this type of levee as proposed by the consulting engineers of the Okeechobee flood-control district.

19. The muck and earth core will be more impervious than a rock-fill levee; the heavy covering of riprap will afford adequate protection against wave action, which experience shows is not excessive, and the rock toes, carried to bedrock will give better protection against undermining and settlement than the rock-fill type, unless the latter should be carried down to bedrock. The cost of rock levees founded on bedrock would be about \$13,000,000. It is believed that such a costly type of construction is not necessary.

20. The muck-core type of levee, even if heavily riprapped, would be more liable to damage or failure if overtopped, than a rock levee. With the lake regulated below 17 feet, as is proposed, a top elevation of 31 gives a freeboard of 14 feet. This freeboard would give protection against occurrence of conditions similar to those of the 1928 hurricane. That hurricane was the most severe that has ever visited this area since records have been kept, and sustained wind velocities were probably as great as any of record anywhere in the United States. While worse conditions are not probable, it can not be said that they may not occur nor can it be stated exactly to what height a greater storm than that of 1928 might cause the lake to rise. It is known that an appreciable quantity of water escaped from the lake, over and through the low-muck levees during the 1928 storm. It is impossible to determine with certainty to what height this water would have risen had it all been confined by levees of sufficient height. In view of the increased liability to damage of the muck-core type in case of overtopping, the board believes that there should be an additional height of 3 feet above the 31 feet elevation considered sufficient for the rock-levee type.

21. The board, after careful study of the muck-core type of levee, and comparison with the all-rock type previously recommended, is of the opinion that with a 3-foot increase in height the muck type will afford reasonable protection against the hurricane tides of the lake. The levees should be built to an elevation of 34 feet, at an estimated cost of \$6,663,000 for the south-shore levee, and \$1,214,000 for the north-shore levee. The total estimated cost of the two levees is \$7,877,000, which is \$1,223,000 less than the estimated cost of the levees recommended in Senate Document No. 213, Seventieth Congress, second session.

22. The second matter for consideration is:

To determine what improvements may be necessary or advisable in the interests of navigation and flood control to facilitate commercial use of the several drainage canals which now connect Lake Okeechobee with the sea.

The board has considered the advisability of improvements designed to facilitate the commercial use of the several drainage canals which now connect Lake Okeechobee with the sea. The project already recommended includes the provision of a suitable navigable channel

through the St. Lucie Canal. This will furnish a more valuable waterway than could be obtained by the improvement of any of the other canals. It is also the best of the canals for use in regulating the level of Lake Okeechobee. The other canals are in fact navigable on a limited scale at the present time but there is no actual movement of freight on some of them and the use of the others is small. The complete improvement of any one of these on the scale recommended for the St. Lucie Canal would require large expenditures and would result simply in a duplication of the facilities provided by the latter canal, with no public benefit at all commensurate with the cost. The board therefore agrees with the district engineer that no Federal expenditures for the improvement of these canals for navigation is justified at the present time other than the work previously recommended on the St. Lucie Canal.

23. The third question to be reported upon is:

To determine the advisability of constructing, in connection with the protective levee around the lake or any portion thereof, a belt-line canal to connect with the canals hereinbefore mentioned.

The board has considered the advisability of constructing, in connection with the south-side levee, a belt-line canal to connect with these drainage canals. A waterway across Lake Okeechobee, connected with the Atlantic Ocean by way of the St. Lucie River and with the Gulf of Mexico by way of the Caloosahatchee River would be of considerable value for navigation and is desirable if it can be secured at a reasonable cost. Such a waterway could be constructed along the south side of the lake by taking advantage of the excavation necessary for constructing the south-side levee. It could also be obtained by excavating a cut from Moore Haven to deep water in Lake Okeechobee. The relative cost and desirability of these alternate methods depend upon the section adopted for the levee and the size of the borrow pit, which will be required to furnish material for levee construction. With the use of the levee section previously recommended by the board, the most advisable way to get a navigable channel across Lake Okeechobee is by means of a cut from Moore Haven to deep water. Such a waterway would not have navigable connections with the various drainage canals but, as stated above, the value of these canals for navigation is considered to be very small. The construction of a levee of the type and cross section now proposed will provide a belt-line canal having connections to the drainage canals, and will render unnecessary a direct connection from Moore Haven to deep water in Lake Okeechobee. As an independent improvement, however, it is not considered to have any material value from the standpoint of navigation, and if navigation alone were considered a route directly across the lake with no connections to the drainage canals would be preferable because of its lower cost.

24. The board was also requested—

To determine the amount heretofore expended by the State of Florida, by subordinate municipalities, and/or by special taxing districts in the creation of canals, channels, jetties, harbors, and port facilities which may be of service to the present or reasonably prospective commerce of the Lake Okeechobee and Everglades regions of Florida and the extent to which the expenditures so made may fairly be accredited as local cooperation for the benefit of general navigation and commerce.

The estimates submitted by local interests of amounts heretofore expended in the creation of canals, channels, jetties, harbors, and port facilities which may be of service to the present or reasonably prospective commerce of the Lake Okeechobee navigation system, have been considered. These estimates amount to \$9,617,417 and include large expenditures for facilities at the Atlantic ports which appear to have no bearing on the project under discussion. The district engineer eliminates certain items, and submits the following, which in his opinion should be allowed:

1. Drainage canals (1.1 per cent of excavation).....	\$74,000
2. Locks and spillways, drainage canals (70 per cent of cost).....	753,926
3. Caloosahatchee Canal, excavation.....	303,007
4. Caloosahatchee Canal, locks.....	331,956
5. Excavation St. Lucie Canal.....	2,486,000
6. Borrow pit, channel south shore.....	423,400
7. Taylors Creek.....	14,843
8. New River Channel.....	3,514
9. Aids to navigation.....	11,645
Total.....	4,402,291

For reasons previously stated in paragraph 22, the board considers that items 1 and 2 of the foregoing table, pertaining to the drainage canals, should be eliminated. Further, item 6, \$423,400 allowed for borrow pits already constructed in connection with the small existing south-side levees, should be eliminated, since it does not appear that this excavation will serve to reduce the cost of the project, as the excavation necessary to construct the levee to elevation 34 is sufficient to provide a suitable navigable channel. Further, if navigation alone is considered the route across the lake would be used and these borrow pits are not on that route. The sum of these items is \$1,251,326, which the board believes should be deducted from the total recommended by the district engineer, reducing the latter to approximately \$3,150,000, which may be considered as expenditures which may fairly be accredited as local cooperation for the benefit of general navigation and commerce.

25. The cost of providing independently navigation facilities equivalent to those provided by the proposed plan combining navigation and flood control has been estimated as follows:

Channel 80 feet wide and 6 feet deep in Caloosahatchee River and Canal.....	\$1,085,000
Similar channel in Taylors Creek.....	58,000
Similar channel in St. Lucie River.....	25,000
Channel from Moore Haven into Lake Okeechobee.....	348,000
Total.....	1,516,000

This estimate is lower than that made by the district engineer, since he used the longer route along the south shore of the lake instead of the cheaper and better one directly across from Moore Haven to the head of the St. Lucie River.

CONCLUSIONS AND RECOMMENDATIONS OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

26. In response to that portion of the committee resolution which requires the board to determine whether the plan heretofore set forth can now be modified so as to provide a reasonable and necessary

measure of safety within a practicable limit of expenditure, the board reports the following modified plan for navigation and flood control in the Caloosahatchee-Lake Okeechobee areas seems adequate and feasible:

(a) For improving the Caloosahatchee River and Canal from Lake Okeechobee to the Gulf of Mexico by straightening and by dredging a channel which will provide a discharge outlet capacity of 2,500 cubic feet per second from Lake Okeechobee, and a navigation channel at least 6 feet deep and 80 feet wide, including the necessary control works.....	\$1, 557, 000
(b) For improving Taylors Creek by providing a channel 6 feet deep and 60 feet wide from Okeechobee City into Lake Okeechobee.....	58, 000
(c) For a levee and a navigation channel 6 feet deep and 80 feet wide following in general the south shore of the lake.....	6, 663, 000
(d) For a levee on the north shore of the lake.....	1, 214, 000
(e) For improving the St. Lucie River to provide a channel 6 feet deep and 80 feet wide.....	25, 000
(f) For protection works in St. Lucie Canal.....	175, 000
Total estimated cost.....	9, 692, 000

All levees to be subject to modification of location and design at the discretion of the Chief of Engineers.

27. In response to that portion of the committee resolution which calls for a plan for an equitable and feasible apportionment of costs as between the United States and the State of Florida and/or other local interests, the board reports that in its opinion the expenditures by the United States of any considerable amount on this project in the interests of navigation is not justified by the present or prospective commerce. Should Congress, however, see fit to provide for Federal participation in the project, the sum of \$4,666,000 may be taken as the measure of Federal interest therein. This sum is made up of \$1,516,000, the estimated cost of providing equivalent navigation facilities without providing for flood control, and \$3,150,000, the estimated cost of work already done by local interests. Under this scheme of apportionment the cost to be met by local interests would be \$5,026,000, which could be contributed in cash, or if the north levee be actually constructed by local interests, the amount to be contributed would be \$3,812,000.

28. If a project of this character be adopted by Congress, it should contain provisos that the State of Florida, or other local interests, contribute \$3,812,000 toward the cost of the above improvements, furnish evidence satisfactory to the Secretary of War that they will construct the north shore levee to a design to be approved by the Chief of Engineers, estimated to cost \$1,214,000, provide all lands needed for levees, channels and the disposal of spoil, agree to maintain all works and channels within the limits of the everglades drainage district and to charge no tolls on any of these navigable waterways and agree that whenever authorized by Congress the United States shall have the right to modify or improve any of these waterways and their appurtenant structures. Congress should also expressly provide that the St. Lucie Canal, the Caloosahatchee Canal and the other channels forming the proposed cross-State waterway, shall be navigable waters of the United States and subject to the Federal laws for the protection of such waterways.

29. As regards flood control in the lower Everglades in the vicinity of Miami, the board concurs with the district engineer that this is

entirely a local problem of drainage, flood control and reclamation; that it is not dependent to any considerable extent on the control of Lake Okeechobee, and affects no important Federal interest. It appears that recommendations on such a project should be based upon complete information developed by an independent survey specifically authorized by Congress. No such authorization exists at the present time.

For the board:

HERBERT DEAKYNE,
Brigadier General, Assistant Chief of Engineers,
Senior Member.

REEXAMINATION OF CALOOSAHATCHEE RIVER AND LAKE OKEECHOBEE DRAINAGE AREAS, FLA.

SYLLABUS

The district engineer submits a modified levee design which he believes is adequate for the purpose and which he believes can not be materially altered to reduce cost. He believes that improvements by the United States in the drainage canals connecting Lake Okeechobee with the sea in the interest of navigation and flood control are not warranted at this time except measures for the protection of the St. Lucie Canal. He believes that the construction of a belt line canal around the south shore of the lake in connection with a protection levee is desirable and has included such a canal in his estimates. He finds that local interests have expended \$4,402,000, which might fairly be accredited as local cooperation for the benefit of navigation and commerce and has taken such expenditures into consideration in his recommendation as to participation in the project by the United States. He believes that flood control for protection of the Miami area is largely a local problem and that navigation benefits to be derived in connection therewith are not commensurate with the cost.

He recommends: That the United States improve the Caloosahatchee River and Canal from Lake Okeechobee to the Gulf of Mexico by straightening and by dredging a channel which will provide a discharge outlet capacity of 2,500 cubic feet per second from Lake Okeechobee and a navigation channel at least 6 feet deep and 80 feet wide, including the necessary control works, at an estimated cost of \$1,557,000; improve Taylors Creek by providing a channel 6 feet deep and 60 feet wide from Okeechobee City into Lake Okeechobee at an estimated cost of \$58,000; provide a levee and a navigation channel 6 feet deep and 80 feet wide following in general the south shore of the lake at an estimated cost of \$6,172,000; improve the St. Lucie River to provide a channel 6 feet deep and 80 feet wide at an estimated cost of \$25,000; provide for the protection of the St. Lucie Canal from erosion and silting at an estimated cost of \$175,000; the levees to be subject to modifications of location and design at the discretion of the Chief of Engineers; provided that the State of Florida, or other local interests, contribute \$1,175,000 toward the cost of the above improvements, furnish evidence satisfactory to the Secretary of War that they will construct the north shore levee to a design to be approved by the Chief of Engineers, estimated to cost \$1,040,000, provide all lands needed for levees, channels and the disposal of spoil, agree to maintain all work and channels within the limits of the Everglades drainage district and to charge no tolls on any of these navigable waterways and agree that whenever authorized by Congress the United States shall have the right to modify or improve any of these waterways and their appurtenant structures. It is further recommended that in adopting the project Congress expressly provide that the St. Lucie Canal, the Caloosahatchee Canal and the other channels forming the proposed cross-State waterway, shall be navigable waters of the United States and subject to the Federal laws for the protection of such waterways. The total estimated cost of the above project to the United States will be \$6,812,000 for new work, with \$15,000 annually for maintenance in the Caloosahatchee River west of the western limit of the Everglades drainage district, and in the St. Lucie River east of the eastern limit of the Everglades drainage district.

WAR DEPARTMENT,
UNITED STATES ENGINEER OFFICE,
Jacksonville, Fla., February 20, 1930.

Subject: Review of reports on the Caloosahatchee River and Lake Okeechobee drainage areas, Florida.

To: The Chief of Engineers, United States Army (through the division engineer).

1. This report is submitted in compliance with a resolution of the Committee on Commerce, United States Senate, adopted December 9, 1929, which reads as follows:

Be it resolved by the Committee on Commerce, United States Senate, That the Board of Engineers for Rivers and Harbors created under section 3 of the river and harbor act, approved June 13, 1902, be, and it is hereby, requested to review the reports on Caloosahatchee River and Lake Okeechobee drainage areas, Florida, submitted in House Document No. 215, Seventieth Congress, first session, and in Senate Document No. 213, Seventieth Congress, second session, with a view to determining whether the plans therein set forth can now be so modified as to provide a reasonable and necessary measure of safety within a practicable limit of expenditure and with a view also to arriving at an equitable and feasible apportionment of costs as between the United States and the State of Florida and/or other local interests.

In the furtherance of the aforementioned objectives the board is requested—

First, to give due consideration to plans for levees and other protective works prepared by the State of Florida and/or its subordinate agencies concerned in the control of floods in and the drainage of the Caloosahatchee River and Lake Okeechobee drainage areas;

Second, to determine what improvements may be necessary or advisable in the interests of navigation and flood control to facilitate the commercial use of the several drainage canals which now connect Lake Okeechobee with the sea;

Third, to determine the advisability of constructing, in connection with a protective levee around the lake or any portion thereof, a belt-line canal to connect with the canals hereinbefore mentioned; and

Fourth, to determine the amount heretofore expended by the State of Florida, by subordinate municipalities, and/or by special taxing districts in the creation of canals, channels, jetties, harbors, and port facilities which may be of service to the present or reasonably prospective commerce of the Lake Okeechobee and Everglades regions of Florida and the extent to which the expenditures so made may fairly be accredited as local cooperation for the benefit of general navigation and commerce.

The duty of making this review and preparing this report was assigned to the district engineer. Further instructions were received in a telegram from the Chief of Engineers through the division engineer, dated January 21, 1930, "that the protection of Miami, Fla., must be fully covered in the report."

2. The board of commissioners of Okeechobee flood-control district was interested in submitting data on this subject and desired that these data should be accumulated and submitted, if possible, in time for this project to be considered by the present session of Congress. They authorized and directed the firm of Hills, Youngberg & Luce, general and consulting engineers, Jacksonville, Fla., to secure the desired information and present it in the form of a report to the district engineer. That report was received on February 12, 1930, and is submitted herewith. A map of the locality, showing the location and cross section of the levees and channels recommended for the Caloosahatchee River and Lake Okeechobee drainage areas and the flood control plans proposed by local interests for the protection of the Miami area, is submitted herewith.

3. The report submitted by local interests is very comprehensive, covering the subject in great detail, and consisting of 174 typewritten

pages. For these reasons it is difficult to include in this report a fair and comprehensive summary of the report of local interests. Various phases of that report will be reproduced and discussed hereafter. A digest of the conclusions of local interests is given in the letter transmitting their report and is quoted as follows:

(a) The general tenor of our conclusions may be stated as follows:

With particular reference to the lower Everglades.—(1) It is our conclusion that solution of the problem of water control in the lower Everglades or "Miami area" in the interest of flood control and navigation will require (in addition to those improvements already provided or to be provided by and at the expense of local interests) the improvement of—

- (a) Miami River and Canal,
- (b) Snapper Creek Canal,
- (c) Snake Creek Canal,

at a total estimated cost of \$4,950,750. A maximum of immediate relief will be afforded by that portion of such works involved in improvement of Miami River and Canal from the mouth of the river to the Florida East Coast Railway Bridge at Hialeah, at an estimated cost of \$1,595,500.

Within the area local interests have already expended, in provision of works for flood control and navigation, the sum of \$2,850,000 and are prepared to expend not less than \$3,000,000 additional after provision of the river and canal improvements above set out.

(b) *With particular reference to the Caloosahatchee-Lake Okeechobee area.*—

(1) It is our conclusion that a full control of the waters of the lake is necessary for the existing and future development of the region and for the certain protection of human lives.

Very large amounts of both public and private capital have heretofore been invested in the Lake Okeechobee-Everglades region. Complete statistics are not available, but the investments of all kinds which have been made in the past and which are projected for the early future will aggregate not less than one-quarter billion dollars. The present population of the Everglades numbers 48,000 persons. When development projects now under way are completed within the next 6 to 10 years the population will be not less than 150,000 and more probably 200,000 persons.

(2) It is our conclusion that an orderly control of the waters of the Caloosahatchee and Lake Okeechobee drainage areas, in the interests of flood control and navigation, can be accomplished by the improvement of

- (a) Caloosahatchee River.
- (b) Taylors Creek.
- (c) St. Lucie Canal and River, and by the construction of
- (d) Levees along the north shore and
- (e) along the south shore of the lake.

If the said levees be built to a certain levee design A, hereinafter described in detail, we estimate that the total cost of all of the above works will be \$9,027,420.

We submit for consideration an alternative "cut-off location" for the south shore levee, which location, if adopted, will (in lieu of the above-named total cost) result in a total cost of \$8,585,568.

(3) It is our conclusion that the needs of existing and immediately potential commerce in the region are very large; that they justify such an improvement of existing canals and waterways as will secure channels leading from the lake to both sides of the peninsula not less than 6 feet deep and 80 feet wide at bottom. However, in consideration of the fact that the intracoastal waterways on both sides of Florida are projected to an 8-foot depth, we suggest that it would be the part of wisdom to provide a cross-State channel of that standard depth. The costs of the lesser channel are embraced within the total estimated costs set forth in the preceding subparagraph.

(4) It is our conclusion, after a careful examination of all factors involved, that the annual benefits or "savings in freight costs" to be derived from such an improvement of existing waterways as will afford efficient barge line connection between the lake region and the several ports on either side of the peninsula, may, with an entirely reasonable degree of conservatism, and basing on Baltimore as a representative mid-distance port, be estimated at \$6,261,765.

Or, otherwise, with a more extreme degree of conservatism and basing on Savannah as a close-in port having a sugar refinery and other facilities, the annual benefits may be estimated at not less than \$2,879,265.

(5) It is our conclusion that, in addition to the Caloosahatchee and St. Lucie cross-State canal systems, the other principal canals, viz, West Palm Beach,

Hillsboro, North New River, and Miami, will, if further improved, more efficiently serve requirements in respect of flood control and navigation, and that such improvement in the interests of present and reasonably prospective needs is entitled to serious consideration at this time. We find that these waterways can be improved to secure channels 6 feet deep and 80 feet wide at estimated costs ranging from \$2,257,150 for the West Palm Beach Canal to \$5,305,300 for the Miami Canal, or an aggregate cost for the four waterways of \$15,775,648.

(6) It is our conclusion, after detailed examination of all capital investments made by the several special port districts, by municipalities and by the Everglades drainage district, after deducting as "deferred credits" 60 per cent of the large expenditures actually made by the public for port facilities (on the ground that these deductions represent expenditures made in advance of existing requirements and hence are not economically warranted at this time) and after making full allowance for all sums heretofore expended by the United States for new work and for maintenance, that, in full justice to all interests concerned, there "may fairly be accredited as local cooperation for the benefit of general navigation and commerce" the sum of \$9,617,417 and for flood control the sum of \$2,860,627, making a total justifiable credit of \$12,487,044.

4. Since the reports under review were submitted, and since the report of the Everglades Engineering Board of Review was written, further studies have been made in this office, resulting in a new levee design, location, and estimate of cost which affect to some extent the plans for the location and extent of navigation channels in Lake Okeechobee. The design, location, and estimate of cost of the levees were worked out in conference with the consulting engineers for local interests and are identical with the levee plans, location, and estimate of cost submitted in their report. The levee plans and location are shown on the accompanying map and more fully described and discussed hereafter.

NAVIGATION CANALS

5. No survey of the canals in the Everglades drainage district, other than the St. Lucie Canal has been made by this office. The report of local interests, however, contains estimates for the cost of improving four of these canals so as to secure a navigable channel 6 feet deep and 80 feet wide, prepared by Mr. F. C. Elliot, chief drainage engineer of the Everglades drainage district. These estimates are reproduced as follows:

	Excavation	Cost	Total cost
West Palm Beach Canal:	<i>Cubic yards</i>		
Earth.....	5,001,000	\$750,150	
Rock.....	1,670,000	1,002,000	
New Lock No. 1.....		180,000	
New Lock No. 2.....		325,000	
			\$2,257,150
Hillsboro Canal:			
Earth.....	6,285,000	942,750	
Rock.....	3,993,000	2,593,800	
New Lock No. 1.....		180,000	
New Lock No. 2.....		325,000	
			4,041,550
North New River Canal:			
Earth.....	4,378,560	656,784	
Rock.....	4,791,440	2,874,864	
New Lock No. 1.....		180,000	
New Lock No. 2.....		200,000	
New Lock No. 3.....		260,000	
			4,171,648
Miami Canal:			
Earth.....	4,702,000	705,300	
Rock.....	6,600,000	3,960,000	
New Lock No. 1.....		180,000	
New Lock No. 2.....		200,000	
New Lock No. 3.....		260,000	
			5,305,300
Grand total.....			15,775,648

6. These canals are now capable of being navigated to some extent. The report of local interests gives the following information in regard to their present navigability:

All canals are equipped with two locks, but the Caloosahatchee Canal has three. For each canal that lock nearest Lake Okeechobee is designated No. 1. In this statement of depths of the various canals the water levels will govern as indicated, to wit: At Lake Okeechobee Locks: Mean level, upper pool, 16 feet; lower pool, 14 feet.

i. St. Lucie Canal:

Mean depth in canal, 10 feet.

Mean depth—

Lock No. 1. Over upper sill, 8.6 feet; over lower sill, 8.1 feet.

Lock No. 2. Over upper sill, 8.5 feet; over lower sill, 9 feet.

Lock No. 1. Width, 30 feet; length, 150 feet.

Lock No. 2. Width, 30 feet; length, 150 feet.

ii. West Palm Beach Canal:

Mean depth in canal—

Station 450 to Lake Okeechobee (station 2070), 6 feet.

Lake Clarke to station 450, 4 feet.

West end Lake Clarke to Lake Worth, 6 feet.

Mean depth—

Lock No. 1. Over upper sill, 7 feet; over lower sill, 6.8 feet.

Lock No. 2. Over upper sill, 6 feet; over lower sill, 5 feet.

Lock No. 1, 25 feet wide, 130 feet long.

Lock No. 2, 25 feet wide, 135 feet long.

iii. Hillsboro Canal:

Mean depth in canal—

From Lake Okeechobee (station 0+00) to station 684, 6 feet.

From station 684 to station 1650, 4 feet.

From station 1650 to Hillsborough River, 5 feet.

Mean depth—

Lock No. 1. Over upper sill, 4.5 feet; over lower sill, 3.5 feet.

Lock No. 2. Over upper sill, 5 feet; over lower sill, 5.5 feet.

All Hillsboro Canal locks 25 feet wide and 130 feet long.

iv. North New River Canal:

Mean depth in canal—

Lake Okeechobee from station 0+00 to station 1200, 5 feet.

Note.—Shoal at station 1200 (approximate). 3.5 feet.

Station 1200 to station 1854+70, 5 feet.

Station 1854+70 to New River, 9 feet.

Mean depth—

Lock No. 1. Over upper sill, 5.5 feet; over lower sill, 3.8 feet.

Lock No. 2. Over upper sill, 6 feet; over lower sill, 4 feet.

Lock No. 1. 25 feet wide, 130 feet long.

Lock No. 2. 22 feet wide, 110 feet long.

This canal has been completed under Everglades drainage district specifications from station 1854-70 to New River station 3046.60, a distance of 22.5 miles.

v. Miami Canal:

Mean depth in canal—

From Lake Okeechobee (station 4107) to station 3600, 5 feet.

From station 3600 to station 1545, 2 to 3 feet.

From station 1545 to Miami River (station 0+00), 8 feet.

Mean depth—

Lock No. 1. Over upper sill, 7 feet; over lower sill, 6 feet.

Lock No. 2. Over upper sill, 4 feet; over lower sill, 4 feet.

Lock No. 1, 25 feet wide, 130 feet long.

Lock No. 2, 22 feet wide, 90 feet long.

The Miami Canal has been excavated to Everglades drainage district specifications from Miami River (station 0+00) to the junction of the Miami and South New River Canals (station 1545), distance 29.1 miles.

vi. Caloosahatchee Canal:

Approach channel in Lake Okeechobee; mean depth, 6 feet.

Mean depth—

Canal, 7 feet.

Lock No. 1. Over upper sill, 6.75 feet; over lower sill, 6.4 feet.

Lock No. 2. Over upper sill, 7 feet; over lower sill, 7 feet.

Lock No. 3. Over upper sill, 8 feet; over lower sill, 6 feet.

All Caloosahatchee locks 30 feet wide by 150 feet long.

7. The following table, giving the tonnage of water-borne commerce in each of these canals for the calendar year 1928, is derived from information contained in the report of the Chief of Engineers for the fiscal year 1929:

Table showing the commerce of Everglades canals in tons of 2,000 pounds for the calendar year 1928

	Tons
Miami Canal (all rock and sand)	131, 959
West Palm Beach Canal	1, 129
Hillsboro Canal	2, 927
Total	136, 015

8. With the expenditure of about \$25,000 in the St. Lucie River as recommended in this report, a channel at least 6 feet deep and 80 feet wide would be available connecting Lake Okeechobee with the intracoastal waterway at St. Lucie Inlet. With the completion of the portion of the intracoastal waterway from St. Lucie Inlet to Fort Pierce, funds for which have been allotted, a channel in this portion at least 8 feet deep and 75 feet wide will be available. Fort Pierce now has a harbor and entrance channel at least 22 feet deep and it also has terminal facilities and railway connections. The distance from Clewiston to Fort Pierce via the St. Lucie Canal and River and the intracoastal waterway, is 80.5 miles. The distance from Clewiston to Miami via the Miami Canal is 100 miles, to Port Everglades (Hollywood Harbor) via the North New River Canal is 86½ miles, and to the port of West Palm Beach via the West Palm Beach Canal is 66 miles. Cargo loaded on vessels at Miami, Port Everglades, and the port of West Palm Beach will be 124, 98, and 53 statute miles, respectively, farther from north Atlantic ports than cargo loaded at Fort Pierce. These ports at Miami, Port Everglades, and West Palm Beach have depths of 25, 35, and 16 feet, respectively. The Hillsboro Canal does not lead directly to any east coast port but is connected with such ports by the intracoastal waterway. Hillsboro Canal intersects the intracoastal waterway 17 miles north of Port Everglades. As indicated in paragraph 28, page 29 of the report, contained in Senate Document No. 213, Seventieth Congress, second session, the provision of an outlet flood-control channel for Lake Okeechobee in the North New River Canal would be several times as expensive as a similar outlet in the Caloosahatchee River. The condition with reference to the other canals is similar. In view of the above, it would appear that expenditures by the United States for the improvement of these drainage canals in the interests of navigation and flood control are not warranted at this time.

BELT-LINE CANAL

9. As described hereafter, the excavation for the levees as now designed can be done so as to provide a navigation canal at least 6 feet deep and 80 feet wide following the south shore levee and connecting the Caloosahatchee and St. Lucie navigation canals.

EXPENDITURES BY LOCAL INTERESTS FOR NAVIGATION FACILITIES

10. The report of local interests gives the following information in regard to the funds which have been expended on coastal ports which may be of service to commerce to and from the Everglades:

Expenditures by private interests:

Fort Pierce Harbor	\$2, 000, 000
St. Lucie Inlet Harbor	1, 250, 000
Lake Worth Inlet Harbor (port of Palm Beach)	4, 281, 000
Hollywood Harbor (Port Everglades)	4, 000, 000
Miami Harbor	4, 523, 000
Total	16, 054, 000

Expenditures by the United States:

St. Lucie Inlet Harbor	23, 729
Miami Harbor (new work and maintenance)	4, 149, 026
Caloosahatchee River (new work and maintenance)	379, 942
Total	4, 552, 697

Grand total

20, 606, 697

11. In view of the assertion said to have been made that ample accommodations could be provided through the development of not more than two ports on the lower east coast, instead of five, the report of local interests has taken 40 per cent of the total figure given in the preceding paragraph and deducted the amount expended by the United States, resulting in a total of \$3,817,947 as the amount claimed as a credit to navigation in the Everglades on account of port improvements.

12. Within the last few years preliminary examination reports have been submitted by the district engineer recommending against any Federal participation in the improvement of Fort Pierce Inlet Harbor, St. Lucie Inlet Harbor, Lake Worth Inlet Harbor, and Hollywood Harbor, thus indicating that the district engineer believed that the money expended by private interests on these projects was not a sufficient credit to justify the United States in spending any further money toward their improvement. In the case of Miami Harbor, which is a Federal project, the funds contributed by local interests are considered to be the local cooperation justifying the participation in the development of that harbor by the United States. These funds therefore are not regarded by the district engineer as a credit to navigation or flood control improvements in the Everglades. The report of local interests claims as credit for navigation all the funds which have been expended by the Everglades drainage district on the Caloosahatchee Canal, Moore Haven to Fort Thompson. The amount expended is given as \$634,963. That report also furnishes an estimate of the cost of providing a navigable channel 6 feet deep and 80 feet wide from Lake Okeechobee to the Atlantic Ocean as a separate and distinct proposition from the St. Lucie Canal. That

estimate amounts to \$4,070,596 and is claimed to be the proportion of the cost of the St. Lucie Canal which should be credited to navigation.

13. Summarizing the amounts claimed to be accredited as local cooperation in the interests of navigation and flood control, the report of local interests presents the following table:

Project	Navigation	Flood control	Drainage
(a) Port facilities.....	\$3,817,947	-----	-----
(b) Cross-state waterways:			
St. Lucie Canal.....	4,070,596	\$2,277,984	-----
Caloosahatchee Canal.....	634,963	-----	-----
(c) Four other principal canals.....	1,093,911	582,643	\$6,913,727
(d) Other drainage works.....	-----	-----	2,443,509
Total.....	9,617,417	2,860,627	9,357,236

Total to be accredited as local cooperation in the interests of navigation and flood control, \$12,478,044.

14. Estimates of the amount which should be accredited to navigation in the Everglades, in the opinion of the district engineer, and a discussion of these estimates are given hereafter.

FLOOD CONTROL IN THE MIAMI AREA

15. The following subparagraphs are extracts from the report of local interests describing the problem, the proposed remedy, and the cost of flood control or drainage in the lower Everglades in the vicinity of the cities of Miami, Hialeah, Country Club Estates, and Opa-Locka:

(a) *Effect of lake control.*—The control of Lake Okeechobee as discussed in the preceding section of this report will relieve the Everglades lands from subjugation to the lake waters, and the problem of reclamation of those lands will be reduced to that of providing orderly control of the waters originating as rainfall upon the lands themselves.

(b) *Problem of the "lower glades."*—That problem, however, is one of magnitude and importance. The Everglades comprise an area of 4,000,000 acres, or 6,250 square miles—over two and one-half times the area of the State of Delaware, and greater than the combined areas of the States of Connecticut and Rhode Island. A concentration of the storm run-off from the entire area would not infrequently produce a discharge as great as 70,000 second-feet—sufficient to cover an area of 200 square miles a foot deep in slightly less than 24 hours.

(c) Plans for the control of the storm waters of the Everglades have been prepared and adopted by Everglades drainage district. They will involve the future construction of some 16 main canals, at an estimated cost (in addition to moneys heretofore expended) of more than \$22,700,000. (See Report of Everglades Engineering Board of Review: May, 1927.) Their construction within any reasonable future period of time can not now be anticipated.

(d) In the meanwhile the great volume of water originating upon the Everglades is unchecked in its southward movement into the

"lower glades" area lying generally west of Miami. Federal Highway No. 94, locally known as Tamiami Trail, has been built across the "lower glades," in an east and west direction along a line lying somewhat south of Miami. It serves to check, to a substantial degree, the further southward movement of those waters to their ultimate outlet at the southern end of the State.

(e) Aggravated by the effect of Federal Highway No. 94, the area in question has become, in practical effect, the catch basin for the waters of the Everglades. Excessive rain in the Everglades creates disastrous floods in the area in question at times when Lake Okeechobee does not overtax the existing facilities for its control. While at times such floods may and do develop independently of the lake, their height and duration are increased by delayed delivery of lake waters whenever that body passes out of control.

(f) *Plans for control of floods.*—The officials of the various communities involved and various private interests have given extensive consideration to the development of a solution of the condition. Inquiries which we have made of the parties concerned disclose an apparently well developed consensus of opinion as to the steps to be taken. These steps may be described as follows:

First. It is proposed to protect the area in question from the Everglades waters by the construction of a levee, to begin on high land at approximately the northwest corner of section 10, township 51 south, range 41 east, about 8 miles west of Hollywood; extending west for 13 miles to the northwest corner of section 9, township 51 south, range 39 east; thence south approximately 23 miles to the southwest corner of section 33, township 54 south, range 39 east; and thence southeasterly for a distance of approximately 2 miles to high land at the approximate center of section 10, township 55 south, range 39 east. The crossing of the Miami canal by the levee will ultimately be provided by control works which can be opened to permit downstream passage of outside waters after the excessive waters originating within the area have been removed. At present the crossing is provided by a rock dam. The existing dam acts as a barrier preventing any upstream passage of vessels. Facilities permitting navigation upstream would require provision of locks at the point of crossing.

(g) Such a levee, constructed of local materials to a top elevation of 10 feet and to a total length of approximately 38 miles, in the location indicated on the accompanying map, will inclose an area of approximately 300 square miles, or 192,000 acres, which will include the municipalities and developed agricultural lands described above. It will include substantial portions of southern drainage district, Dade drainage district, and Hollywood reclamation district, all of which are subdistricts of Everglades drainage district. The levee described has already been constructed in principal portion; such work having been done by and at the expense of local interests.

(h) *Estimates of costs of flood control.*—The second step proposed for the protection of the area will involve provision of outlet capacity adequate to control and discharge the waters originating within it. Local interests consider a run-off capacity of 1½ inches in 24 hours (equivalent to 12,000 cubic feet per second from the entire area) as necessary thereto. Such capacities would be provided by improvement of Snake Creek Canal, Miami Canal and River, and Snapper

Creek Canal, each to capacities of 4,000 second-feet within the limits of the area. Such capacities would involve channel dimensions, grades, quantities of excavation, and estimated costs as follows (quantities of excavation and estimated costs furnished by local interests):

(1) *Snake Creek Canal*—

Location: From mouth to west line of sec. 31, T. 51 S., R. 41 E., as indicated on accompanying print.

Bottom width: 100 feet.

Side slopes: Vertical.

Hydraulic depth: 15 feet.

Grade at upper end: -10.5.

Grade at lower end: -15.0.

Discharge capacity: 4,000 cubic feet per second.

Excavation: 3,500,000 cubic yards, at \$0.25, \$875,000.

(2) *Miami River and Canal*—

Location: From mouth to proposed west boundary levee, as indicated on accompanying print.

Grade at upper end: -10.5.

Grade at lower end: -15.0.

Hydraulic depth: 15 feet.

Side slopes: Vertical.

Bottom width from mouth to point 3,400 feet below mouth of Miami Canal: 150 feet.

Bottom width from point 3,400 feet below mouth of Miami Canal to mouth of Miami Canal: 120 feet.

Bottom width from mouth of Miami Canal to Florida East Coast Railway bridge at Hialeah: 125 feet.

Bottom width from Florida East Coast Railway bridge to upper end at proposed west line levee: 100 feet.

Discharge capacity of lower sections, 4,000 cubic feet per second.

Excavation:

From mouth of Miami River to mouth of Miami Canal, 1,120,000 cubic yards, at \$0.90.....	\$998,000
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From mouth of Miami Canal to Florida East Coast Railway bridge at Hialeah, 1,195,000 cubic yards, at \$0.50.....	597,500
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From Florida East Coast Railway bridge at Hialeah to proposed west line levee, 3,000,000 cubic yards, at \$0.50.....	1,500,000
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Total for Miami Canal, 5,315,000 cubic yards.....	3,095,000
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(3) *Snapper Creek Canal*:

Location: From mouth to northwest corner of sec. 7, T. 54 S., R. 40 E., as indicated on accompanying print.

Bottom width: 100 feet.

Side slopes: Vertical.

Hydraulic depth: 15 feet.

Grade at upper end: -10.5.

Grade at lower end: -15.0.

Discharge capacity: 4,000 cubic feet per second.

Excavation: 3,921,000 cubic yards, at \$0.25, \$980,250.

(i) The work described above, which is in addition to the substantial construction already performed by local interests in the provision of part capacities in the outlets in question, will involve a total estimated cost of \$4,950,750.

(j) Local interests advise that, while the development of each of the three outlets to capacities described is essential to flood control within the area, a maximum of immediate relief will be afforded by provision of the proposed improvements in that portion of Miami River and Canal extending from the mouth of the river to the Florida East Coast Railway bridge at Hialeah, at an estimated cost, as above, of \$1,595,500.

(k) *Summary*.—Summarizing all of the above, the area in question includes over 300 square miles of valuable lands. It includes a population in excess of 50,000 people, and great investments in roads, schools, highways, homes, and industrial developments, all of which are subjected to the dangers and damage of uncontrolled floods. Local interests have already expended in excess of \$2,850,000, and are prepared to expend in excess of \$3,000,000 additional in provision of reclamation and flood-control facilities following the provision of major outlets estimated to cost a total of \$4,950,750. Substantial relief will be afforded by the provision of that part of such outlets involved in the improvement of the Miami River and Canal from the river mouth up to the Florida East Coast Railway bridge, at an estimated cost of \$1,595,500, which will also afford substantial benefits to the interests of navigation.

16. While the need for flood protection or drainage in this area is evidently urgent, it appears to be more or less a problem of local drainage, involving a considerable expenditure of money, to correct a condition which is neither entirely new nor dependent to any considerable extent on the flood control of Lake Okeechobee. The expenditure apparently necessary in the Miami River for drainage purposes is evidently far in excess of any expenditure which could be justified solely for navigation purposes. Instructions to include flood control for the Miami area in this review report were received from the Chief of Engineers on January 22, 1930. No consideration has been given to this project in reports previously submitted. No preliminary examination and survey has been made by the department for this project and the time available for the preparation of this report has not been sufficient to make the detailed surveys and studies that are regarded as advisable. The district engineer is therefore entirely dependent upon local interests for the data necessary to the solution of the problem and an estimate of its cost. Under these circumstances he hesitates to submit a favorable recommendation involving such a large expenditure of funds and suggests that if Congress is interested in expending Federal funds on such a local drainage problem, a preliminary examination and survey be authorized to determine plans and cost for providing flood control, drainage, and navigation in the lower Everglades.

ECONOMICS

17. The report of local interests contains a very comprehensive discussion of the economic situation and estimates the savings which might accrue from the provision of suitable navigation facilities in the Everglades, and summarizes this estimate of savings as follows:

ESTIMATE I

For commodities (a) to (f) Baltimore or more northern ports are used as basing points:

(a) Lumber: Unit differential in favor of water, \$1.25 per ton; total output available for shipment, 285,000 tons; output estimated to benefit, 50 per cent; savings, 142,500 tons, at \$1.25.....	\$178,125
(b) Gasoline and fuel oils: Unit differential in favor of water, 1 cent per gallon; total volume available for shipment, 54,327,860 gallons; volume estimated to benefit, 30 per cent; savings, 16,500,000 gallons, at 1 cent.....	165,000

(c) Fruits and vegetables: Unit differential in favor of water, \$150 per carload; total volume available for shipment, 13,386 carloads; volume estimated to benefit, 25 per cent; savings, 3,347 cars, at \$150-----	\$501, 975
(d) Peanut-oil products: Unit differential in favor of water, \$10 per ton; total volume available for shipment, 22,750 tons; volume estimated to benefit, 100 per cent; savings, 22,750 tons at \$10-----	227, 500
(e) Fiber board and allied products: Unit differential in favor of water, \$1.25 per ton; total volume available for shipment, 500,000 tons; volume estimated to benefit, 50 per cent; savings, 250,000 tons, at \$1.25-----	312, 500
(f) Caloosahatchee Valley tonnage: Total volume available for shipment, 839,500 tons; volume estimated to benefit, 25 per cent after elimination of duplications; net saving-----	366, 665
Subtotal-----	1, 751, 765
For the next succeeding commodities Baltimore is used as basing point:	
(g) Sugar and sugar products: Unit differential in favor of water, \$8.20 per ton; total volume available for shipment, 500,000 tons; volume estimated to benefit, 60 per cent; savings, 300,000 tons, at \$8.20-----	2, 460, 000
(h) Miscellaneous freights: Unit differential in favor of water, \$8.20 per ton; total volume available for shipment, 1,000,000 tons; volume estimated to benefit, 25 per cent; savings, 250,000 tons, at \$8.20-----	2, 050, 000
Subtotal-----	4, 510, 000
Subtotal, items (a), (b), (c), (d), (e), and (f)-----	1, 751, 765
Grand total of all savings, Estimate I-----	6, 261, 765

ESTIMATE II

Commodities (a), (b), (c), (d), (e), and (f), as in Estimate I: Total savings-----	\$1, 751, 765
For the following commodities Savannah is used as a basing point:	
(g) Sugar and sugar products: Unit differential in favor of water, \$2.05 per ton; total volume available for shipment, 500,000 tons; volume estimated to benefit, 60 per cent; savings, 300,000 tons at \$2.05-----	615, 000
(h) Miscellaneous freights: Unit differential in favor of water, \$2.05 per ton; total volume available for shipment, 1,000,000 tons; volume estimated to benefit, 25 per cent; savings, 250,000 tons at \$2.05-----	512, 500
Subtotal-----	1, 127, 500
Subtotal, items (a), (b), (c), (d), (e), and (f)-----	1, 751, 765
Grand total of all savings, Estimate II-----	2, 879, 265

18. The estimate of savings submitted in paragraphs 91 to 100 of the report printed in House Document No. 215, Seventieth Congress, first session, as well as the estimate of savings given in the next preceding paragraph (17), are based on the future development of the Everglades, dependent not only on flood control and navigation but also on the construction of the proposed drainage canals and subdrainage developments by individuals. The financing plans of the Everglades drainage district, which were progressing favorably when the reports printed in House Document No. 215, Seventieth Congress, first session, were written, involving the issuance of \$20,000,000 of bonds, have failed and the Everglades drainage district is not now in a position financially to carry out its plans for reclamation. As stated in the report of local interests, The Brown Co. has suspended its operations until the Everglades drainage district

completes its drainage plans to such an extent as to protect the Brown Co.'s holdings.

19. Time is not available for a detailed analysis or discussion of the economic data and estimate of savings submitted by local interests. The following comments, however, may be pertinent:

(a) In the estimate of savings submitted by the district engineer in House Document No. 215, Seventieth Congress, first session, as well as in the estimate of savings submitted by local interests, the saving in a number of instances is based on the difference between the cost of all-water shipments by barge between the Everglades and the nearest port and between that port and Savannah, Baltimore, and New York, as compared with the cost of all-rail shipments between the Everglades and Savannah, Baltimore, and New York. It is probable that these estimates of savings should be based only on the difference in cost between all water and other means of shipment between the Everglades and the nearest ports, which would reduce these estimates very materially. For example, comparing estimate No. 1 with estimate No. 2, paragraph 17, the estimate of savings is reduced from \$6,261,765 to \$2,879,265 by using Savannah instead of Baltimore as a basic point. These estimates would be correspondingly reduced by using Miami or Jacksonville as basic points rather than Savannah and Baltimore.

(b) The estimate of saving on gasoline, of the report of local interests, is based on a saving of 1 cent per gallon on gasoline delivered at Fort Pierce due to the improvements made by local interests to that harbor. This appears to have nothing to do with any savings which might accrue from development of navigation in the Everglades.

(c) This office is convinced that, theoretically, great savings could be effected by the shipment of fruit and vegetables by water out of the State of Florida, but for some reason the shippers do not take advantage of this cheap method of shipment, to any great extent. There are now good roads leading from the developed section of the Everglades to the harbors at Miami, Hollywood, Lake Worth, and Fort Pierce on the east coast and the diagonal drainage canals are capable of being navigated to some extent, but no extensive effort is made to ship fruits and vegetables from these ports. Arrangements are now being made to provide 8-foot depth navigation in the Indian River from St. Lucie Inlet to Fort Pierce and beyond, and 5-foot depth navigation in the east coast canal from St. Lucie Inlet to Miami Harbor. Regardless of the extensive facilities for cold storage installed by the Clyde Line at their docks at Miami and New York and on their fast passenger steamers plying between these points, and contrary to expectations, fruits and vegetables are not extensively shipped by this method. According to statistics published in the annual reports of the Chief of Engineers, there were 6,490 tons of fruits and vegetables shipped out of Miami in 1927 and only 6,174 tons shipped out in 1928.

(d) In the case of the estimate of savings on lumber submitted by local interests, there is apparently no charge made to water transportation for the transportation of the lumber from the mill to barge lines and for the transfer at such points.

20. Generally, however, the estimate of savings of House Document No. 215, and that submitted by local interests, disclose great possibilities in the way of savings which may be effected by improve-

ments for navigation, flood control, and drainage, in the Everglades, and it is believed that there is ample justification for the expenditures by the United States recommended in this report.

ESTIMATES

21. *Levees.*—Estimates of quantities for Lake Okeechobee levees are based upon a detail survey, on the south shore of the lake from Bacom Point to 5 miles north of Moore Haven, about 63 miles, of the alignment of the existing levee, elevations of land surface and depth to rock. Land surface and rock elevations are not only furnished along a center line profile but extend 500 feet on either side of the existing levee center line. North of Bacom Point, on the east and north side of the lake, the land elevations have been taken from general topographic surveys and the elevations of rock surface from rock strata in excavations for canals, borrow pits for roads, and other excavations. The information is considered sufficient for a fair degree of accuracy. Unit cost prices are based upon current prices paid for excavation in the locality over a long period of time. The unit prices assumed are, for all excavation of materials not classified as rock, 15 cents per cubic yard, and for rock, 70 cents per cubic yard. An unclassified price of 90 cents per cubic yard for the south shore levee and 84 cents per cubic yard for the north shore levee has been assumed to provide for the selection of larger rock and the barging to the site of suitable rock where the same is not immediately available for the lake side riprapping. These prices have been fixed by computation upon a percentage basis.

(a) The levee recommended as designed has a top elevation of 31 feet and a rock fill toe from bedrock to elevation 14 feet on the lake side and where required on the land side. The rock fill toe has a 10-foot crown width at elevation 14 feet, a 1 on 1½ slope on the outside and a vertical back. The levee above elevation 14 feet has slopes 1 on 2½, a 10-foot crown width, a 3½-foot rock cover on the lake side slope, the top 18 inches consisting of selected larger rock from elevation 18 feet to the top; a 3-foot cover of rock on the crown and a 2-foot cover of rock on the land side slope, extending down to the natural land surface. The rock footing at the base of the land side slope has a width of from 6 to 7 feet and extends from 3 to 6 feet below the land surface. The central core of the levee is composed of sections of the old levee, muck, and other material. In designing the levee consideration was given to a levee built of heterogeneous materials as dredged allowing it to take its natural slopes. Such a design was found to be impracticable and under some conditions impossible for the following reasons:

(1) A top covering, preferably of rock, is necessary to prevent the muck from oxidizing, drying up, blowing away, and catching fire, also to resist wave action and erosion particularly in case the levee should be overtopped.

(2) With a levee so constructed sections of it would be pure muck and other sections would contain large percentages of rock. The natural muck foundation would not sustain this load and settlement would take place for a long period of time, requiring years of heavy delayed construction work before a state of equilibrium would be reached, before the top covering could be economically placed, and before the levee would be safe for flood control.

(3) It is desirable to utilize the existing levee. In constructing that levee and for drainage purposes, large ditches have been excavated on both sides of it. Unless controlled the new levee would flow into these ditches, causing wasteful construction work until they were filled up.

The rock toes on the front and back of the levee as designed are for the purposes of confining the core of the levee whatever its composition (old levee, old levee foundation, and new fill of muck or rock) and of furnishing the necessary resistance against sloughing or sliding. On the lake side the thickness of the rock covering has been made 3½ feet with the top 18 inches of selected rock for resistance to wave action. Experience in the 1928 storm indicates that waves are generally not over 3 feet high and that no serious damage was attributable to wave action alone. The excavation to construct the levee will be executed so as to provide a navigation channel 6 feet deep and 80 feet wide with 1 foot overdepth along the south shore.

(b) *South shore levee.*—The estimated cost of the south shore levee is as follows:

10,413,000 cubic yards earth excavation, at 15 cents per cubic yard	\$1,561,950
4,882,500 cubic yards rock excavation, at 90 cents per cubic yard	4,394,250
6 floodgates, at \$36,000 each	216,000

Total, south shore levee..... 6,172,200

(c) *North shore levee.*—The estimated cost of the north shore levee is as follows:

2,410,000 cubic yards earth excavation, at 15 cents per cubic yard	\$361,500
808,000 cubic yards rock excavation, at 84 cents per cubic yard	678,720

Total, north shore levee..... 1,040,220

(d) The total estimated cost of the north and south shore levees is \$7,212,420.

(e) The costs of levees designed as described in paragraph (a), but having rock toes built to elevation 22 feet, corresponding closely to the levee recommended by the Chief of Engineers in Senate Document No. 213, Seventieth Congress, second session, are as follows:

South shore levee:

11,857,300 cubic yards earth excavation, at 15 cents per cubic yard	\$1,778,595
8,252,800 cubic yards rock excavation, at 70 cents per cubic yard	5,776,960
637,000 cubic yards selected riprap, at 70 cents per cubic yard	445,900
6 flood gates, at \$36,000 each	216,000

Total..... 8,217,455

North shore levee:

2,747,400 cubic yards earth excavation, at 15 cents per cubic yard	412,110
1,373,600 cubic yards rock excavation, at 70 cents per cubic yard	961,520
98,900 cubic yards rock selected riprap, at 70 cents per cubic yard	69,230

Total..... 1,442,860

Total north and south levees..... 9,670,215

(f) The estimated cost of an all-rock levee 10 feet wide on top, with slopes of 1 on 1½, is as follows:

South shore levee:	
17,401,000 cubic yards earth excavation, waste uncovering rock, at 12 cents per cubic yard.....	\$2, 088, 000
383,000 cubic yards earth excavation, south side Fisheating Creek, at 15 cents per cubic yard.....	57, 450
11,790,000 cubic yards rock excavation, main levee, at 70 cents per cubic yard.....	8, 253, 000
63,300 cubic yards riprap, south side Fisheating Creek, at 70 cents per cubic yard.....	44, 310
430,000 cubic yards selected riprap, at 70 cents per cubic yard.....	301, 000
6 floodgates, at \$36,000 each.....	216, 000
Total.....	<u>10, 959, 760</u>

North shore levee:	
4,487,000 cubic yards earth excavation waste uncovering rock, at 12 cents per cubic yard.....	538, 440
2,510,000 cubic yards rock excavation, at 70 cents per cubic yard.....	1, 757, 000
449,000 cubic yards earth excavation connecting levees to high land, at 15 cents per cubic yard.....	67, 350
84,000 cubic yards riprap on connecting levees to high ground, at 70 cents per cubic yard.....	58, 800
68,900 cubic yards selected riprap, at 70 cents per cubic yard.....	48, 230
Total.....	<u>2, 469, 820</u>
Total, north and south shore levees.....	<u>13, 429, 580</u>

(g) The cost of a navigation channel 6 feet deep and 80 feet wide, with 1 foot overdepth, from Miami Canal Lock No. 1 to deep water in Lake Okeechobee, at lake stage 14 feet, is as follows:

161,000 cubic yards earth excavation, at 15 cents per cubic yard....	\$24, 150
142,000 cubic yards rock excavation, at 70 cents per cubic yard....	99, 400
Total.....	<u>123, 550</u>

(h) The cost of a navigation channel 6 feet deep and 80 feet wide, with 1 foot overdepth, from the Hillsboro and North New River Canal Locks Nos. 1 to deep water in Lake Okeechobee, at lake stage 14 feet, is as follows:

367,080 cubic yards earth excavation, at 15 cents per cubic yard....	\$55, 062
244,140 cubic yards rock excavation, at 70 cents per cubic yard....	170, 898
Total.....	<u>225, 960</u>

(i) The total cost of navigation channels which should be provided in case the cut-off levee from Bacom Point to Ritta (subparagraph j) were constructed, is the sum of the estimates in (g) and (h), \$349,510.

(j) The estimated cost of a cut-off levee from Bacom Point to Ritta, via Kreamer and Ritta Islands, having a crown width of 26 feet, slopes 1 on 2, a 20-foot horizontal thickness of rock on slopes from bedrock to top elevation 31 feet and a 10-foot vertical thickness of rock on the crown with 18 inches of selected hand placed riprap on the top and on both slopes from elevation 18 feet to the top, and a central core of rock and muck, 590 stations, is as follows:

2,724,000 cubic yards unclassified rock and muck excavation, at 60 cents per cubic yard.....	\$1, 634, 400
125,700 cubic yards hand-laid riprap, at \$1.80 per cubic yard.....	226, 260
2 floodgates, at \$36,000 each.....	72, 000

Total.....	1, 932, 660
Navigation channels estimate, paragraph (i).....	349, 510

Total cut-off levee and navigation channels.....	2, 282, 170
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(k) The estimated cost of a shore levee with design as described in paragraph (a), from Bacom Point to Ritta, for comparison with cut-off levee, paragraph (j), is as follows:

3,925,480 cubic yards earth excavation, at 15 cents per cubic yard....	\$588, 822
1,864,100 cubic yards rock excavation, at 90 cents per cubic yard....	1, 677, 690
3 floodgates, at \$36,000 each.....	108, 000

Total.....	2, 374, 512
Saving by adopting cut-off.....	92, 342

(l) The estimated cost of levee, described in paragraph (a), with cut-off levee, paragraph (j), substituted for a portion of it, is as follows:

South shore levee:	
Estimate, paragraph (b).....	\$6, 172, 200
Less estimate, par. (k), 1,273 stations, levee on south shore, Bacom Point to Ritta.....	2, 374, 512

Net cost, exclusive 1,273 stations on shore line, Bacom Point to Ritta.....	3, 797, 688
Plus estimate, par. (j), cut-off levee, Bacom Point to Ritta.....	1, 932, 660
Navigation channels Hillsboro, North New River and Miami Canals to deep water in Lake Okeechobee.....	349, 510

Total south shore levee on cut-off route, Bacom Point to Ritta.....	6, 079, 858
North shore levee estimate, par. (c).....	1, 040, 220

Total north and south shore levee.....	7, 120, 078
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(m) The estimated cost of a navigation channel 6 feet deep and 80 feet wide with 1 foot overdepth which might have been built in place of the St. Lucie Canal, based upon a minimum upper pool level of 14 feet, with only one lock at the eastern end, is as follows:

8,390,000 cubic yards earth excavation, at 15 cents per cubic yard..	\$1, 258, 500
161,700 cubic yards rock excavation, at 70 cents per cubic yard....	113, 190
1 lock at present site No. 2 Lock.....	725, 000

Total.....	2, 096, 690
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(n) The estimated cost of a navigation channel in the St. Lucie Canal the same as (m), but with locks and pool elevations as now constructed, is as follows:

10,262,000 cubic yards earth excavation, at 15 cents per cubic yard..	\$1, 539, 300
575,900 cubic yards rock excavation, at 70 cents per cubic yard....	403, 130
Lock No. 1, actual cost.....	125, 677
Lock No. 2, actual cost.....	417, 689

Total.....	2, 485, 796
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(o) The estimated cost of a navigation channel 6 feet deep and 80 feet wide, with 1 foot overdepth, along the south shore of Lake

Okeechobee from Bacom Point to Moore Haven, independent of levee excavation, at lake stage 14 feet, is as follows:

4,282,000 cubic yards earth excavation, at 15 cents per cubic yard.....	\$642, 300
857,000 cubic yards rock excavation, at 70 cents per cubic yard.....	599, 900
Total.....	1, 242, 200

(p) The estimated cost of a navigation channel same as (o) but built in conjunction with levee construction, on that basis that canal is charged with all earth and rock excavation in excess of one-half of that required for levee, is as follows:

2,973,000 cubic yards earth excavation, at 15 cents per cubic yard.....	\$445, 950
482,000 cubic yards rock excavation, at 70 cents per cubic yard.....	337, 400
Total.....	783, 350

(q) The estimated cost of a channel 6 feet deep and 80 feet wide, with 1 foot overdepth, within the Everglades drainage district, from Moore Haven to Fort Thompson, independent of the flood-control channel, is as follows:

2,925,000 cubic yards earth excavation, at 15 cents per cubic yard.....	\$438, 750
Improvement to locks and spillways.....	26, 250
Total.....	465, 000

(r) The estimated cost of the Caloosahatchee Canal to provide a flood-control channel having a discharge of 2,500 cubic feet per second, within the Everglades drainage district, from Moore Haven to Fort Thompson, is as follows:

3,356,000 cubic yards earth and rock excavation, unclassified, at 26 cents per cubic yard.....	\$872, 560
Improvements to locks and spillways.....	64, 440
Total.....	937, 000

(s) The estimated cost of the enlargement of the Caloosahatchee Canal and River to provide a flood-control discharge capacity of 2,500 cubic feet per second and a navigation channel at least 6 feet deep and 80 feet wide, with 1 foot overdepth, from Lake Okeechobee to the Gulf of Mexico, is as follows:

Estimate, par. (r), inside Everglades drainage district.....	\$937, 000
Outside of Everglades drainage district, estimate in pars. 55, (a) and (b), House Document 215, Seventieth Congress, first session, as used by the Chief of Engineers in par. 2 of Senate Document No. 213, Seventieth Congress, second session.....	620, 000
Total.....	1, 557, 000

DISCUSSION

22. In conformity with one of the requirements of the Committee on Commerce resolution (par. 1), the reports mentioned in that resolution have been reviewed to determine whether the plans therein set forth can now be so modified as to provide a reasonable and necessary measure of safety within a practical limit of expenditure. The review has resulted in a new levee design and a revision of the plans for navigation channels in Lake Okeechobee. The design of the new levee is described in paragraph 21 (a) and the cost estimated in paragraphs 21 (b), (c), and (d). The estimate of cost of the south

shore levee, paragraph 21 (b), includes the cost of a belt-line canal at least 6 feet deep and 80 feet wide with 1 foot overdepth on the lake side of the south shore levee and connecting the Caloosahatchee and St. Lucie Canals. Otherwise, the improvements, and the estimated costs thereof, now proposed are the same as those proposed in the documents under review. On this basis, an estimate of the cost of the improvements now proposed to provide levees for flood control, safe and sufficient outlet capacities for the control of Lake Okeechobee, a navigation channel at least 6 feet deep and 80 feet wide, with 1 foot overdepth from the Gulf of Mexico to the Atlantic Ocean, and a channel 6 feet deep and 60 feet wide with 1 foot overdepth in Taylors Creek, is as follows:

Protection against shoaling in St. Lucie Canal caused by side drainage during storms.....	\$175, 000
Improvement to the St. Lucie River.....	25, 000
South shore levee, Lake Okeechobee.....	6, 172, 200
North shore levee, Lake Okeechobee.....	1, 040, 220
Navigation channel 6 feet deep, 60 feet wide, 1 foot overdepth, in Taylors Creek.....	58, 000
Enlargement of Caloosahatchee Canal and River.....	1, 557, 000
Total.....	9, 027, 420
Acquisition of right of way for levee.....	20, 000
Right of way for channel in the Caloosahatchee River.....	325, 000

Total, including right of way..... 9, 372, 420

23. In connection with the levee design consideration has been given to the economic effect of lowering the standard for minimum low water in Lake Okeechobee from elevation 14 to 12 feet, and correspondingly lowering the height of the levees, and deepening the navigation channels. The saving in lowering the levee 2 feet would be about \$775,000. The cost of deepening the channel following the south shore levee by 2 feet would be about \$707,000. The saving would not be sufficient to offset the disadvantage from an agricultural standpoint of lowering the water table of the lands surrounding and naturally draining into Lake Okeechobee. Moreover, it is believed that hurricane winds occurring between limits of lake elevation from 12 to 18 feet will produce wind tides of about the same height. Also, it is believed that the lake would reach approximately the same maximum elevation starting from either elevation of 12 or 14 feet. Technical studies which have been made in connection with this review also lead to the conclusion that a standard minimum low water regulation of Lake Okeechobee to elevation 14 feet is the most suitable for all conditions.

24. A further economy was considered in the so-called cut-off levee described in paragraph 21 (j). The estimated saving to be effected by the construction of such a levee, including the cost of navigation channels in the lake necessary with this construction, as shown in paragraph 21 (k), is \$92,342. It is believed that this saving would not be sufficient to cover the cost of the necessary maintenance of the existing levee from Bacom Point to Ritta. Furthermore, the cut-off levee could not be readily seen by people living along the south and southeast shore of the lake and they would not feel as safe or secure or as well satisfied with this levee as one along the shore. However, further studies, investigations, and surveys, should the project be

authorized, might indicate that the construction or the cut-off levee would be desirable.

25. As required by the Committee on Commerce resolution (see par. 1), a study has been made to determine an equitable and feasible apportionment of costs as between the United States and the State of Florida and/or other local interests. In order to show the result of this study, the following set up is submitted:

(a) The estimated cost of navigation without flood control is as follows:	
Improvement of Caloosahatchee Canal within the Everglades drainage district from Moore Haven to Fort Thompson, see par. 21(g).....	\$465, 000
Improvement of Caloosahatchee River outside of Everglades drainage district, Fort Thompson to Gulf, Senate Document No. 213.....	620, 000
Navigation channel along the south shore of Lake Okeechobee, par. 21(o).....	1, 242, 200
Navigation channel 6 feet deep, 60 feet wide, 1 foot overdepth, Taylors Creek, Senate Document No. 213.....	58, 000
Navigation channel 6 feet deep, 80 feet wide, 1 foot overdepth, in St. Lucie River, Senate Document No. 213.....	25, 000
Total.....	2, 410, 200
Right of way, Caloosahatchee River.....	325, 000
Total, including right-of-way.....	2, 735, 200

(b) The estimated cost of navigation heretofore provided by local interests, such as locks, spillways, and navigation channels, which might be credited as local cooperation, is indicated in the following table:

Excavation, Hillsboro, North New River, and Miami Canals.....	\$74, 000
Locks and spillways, West Palm Beach, Hillsboro, North New River, and Miami Canals, 70 per cent of the cost.....	753, 926
Taylor Creek Channel.....	14, 843
New River Channel.....	3, 514
Aids to navigation.....	11, 645
Caloosahatchee Canal:	
Excavation.....	\$303, 007
Locks Nos. 1, 2, and 3.....	331, 956
	634, 963
Navigation channel 6 feet deep, 80 feet wide, with 1 foot overdepth in St. Lucie Canal.....	2, 486, 000
Navigation channel along south shore of Lake Okeechobee provided as an incident to levee construction.....	423, 400
Total cost of navigation provided by local interests.....	4, 402, 291

The amounts credited to local interests in the above table for navigation differ from those set up in the report of local interests on pages 172 and 174, in the following respects: No credit has been allowed for construction of port facilities to the amount of \$3,817,947 for reasons stated in paragraph 12 above; the credit allowed for construction of the St. Lucie Canal is \$2,486,000 instead of \$4,070,596, the former figure being the cost of a channel 6 feet deep, 80 feet wide, with 1 foot overdepth, as estimated by the district engineer; credit has been allowed for the actual excavation in the borrow pit along the south shore which would be useful as a navigation channel, amounting to \$423,400, while local interests allowed \$225,983 as a share in the cost of levee construction.

(c) The proportion of the project which may be regarded as fairly chargeable to the United States on the basis of the above figures is as follows:

Cost to complete navigation project (sub par. (a) above).....	\$2, 410, 000
Credit for past work by local interests useful to navigation (sub-par. (b) above).....	4, 402, 291
Total cost chargeable to navigation.....	6, 812, 291
Taken as.....	6, 812, 000

An additional amount of \$2,215,000 from local interests would be required to complete the entire project of \$9,027,000. Such interests might be required to build the north shore levee within a reasonable period at an estimated cost of \$1,040,000 and to contribute in addition the sum of \$1,175,000.

(d) In paragraph (b) credit has been given to navigation expenditures for the entire cost of navigation channels in the St. Lucie and Caloosahatchee Canals and for the excavation along the south shore useful to navigation. This is a liberal basis and there might be some grounds for crediting to flood control one-half of the excavation in these items, amounting to \$971,317, \$151,503, and \$211,700, respectively, making a total reduction of \$1,334,520 in the credit allowed local interests for past navigation expenditures and reducing the total of subparagraph (b) above from \$4,402,291 to \$3,067,771.

26. The United States Government would not be justified in the proposed expenditure upon the present showing of tonnages. The provision of navigation facilities coincident with the provision of levee protection is necessary in order to make possible a permanent and progressive development of agriculture and other industries. The provision of levee protection carries with it additional collateral and indirect benefits that can not be measured by tonnage alone. These additional benefits are difficult to evaluate but are nevertheless real and substantial. The increased productivity of the lands made possible by protection and the corresponding increase of land values is probably the outstanding measure of benefits. The land directly affected by levee protection is estimated at 195,000 acres. An increase of productivity of \$3 per acre is sufficient to pay interest and provide a sinking fund to retire the cost of the entire project in 20 years, interest at 4 per cent, not taking into consideration the increase in value of these lands. The prospect of a great development of the sugar industry alone justifies the expectation of land productiveness far in excess of \$3 per acre. The prospect of the development of a sugar industry within the boundaries of the United States, able to compete in quantity and cost of production with the best foreign industries, is not only a local benefit but a nation-wide benefit. It is only upon such prospective collateral and indirect benefits that this expenditure at this time can be justified. It is believed that these prospective benefits justify the participation of the United States Government in this project to the extent proposed.

SUMMARY OF CONCLUSIONS

27. The following is a summary of conclusions:

(a) That the levee design recommended in this report, which is in accord with the views of the consulting engineers for local interests,

is adequate and can not be materially altered with safety for the purpose of reducing cost: That a saving could be made in the south shore levee by adopting the cut-off levee described in paragraph 21 (j), but that its adoption is not warranted without further study, and the project should be made sufficiently elastic to permit its later adoption in the discretion of the Chief of Engineers.

(b) That improvements by the United States in the drainage canals now connecting Lake Okeechobee with the sea in the interests of navigation and flood control and to facilitate their commercial use are not warranted at this time except as to measures recommended for the protection of the St. Lucie Canal from the effects of erosion.

(c) That the construction of a belt-line canal around the south shore of the lake in connection with a protective levee is advisable as it not only would serve to connect the heads of the drainage canals but would be a link in the cross-State waterway.

(d) That expenditures by local interests which might fairly be accredited as local cooperation for the benefit of navigation and commerce have been made to the extent of \$4,402,291, and that an equitable subdivision of costs under the project proposed would be, United States \$6,812,000, local interests \$2,215,000, local interests also to furnish rights of way.

(e) That flood control for the protection of the Miami area is largely a local problem which should be provided for by local interests, and that the navigation benefits would practically be confined to the Miami River, the required expenditure for which is believed to be much greater than the navigation benefits would warrant.

RECOMMENDATION

28. It is recommended: That the United States improve the Caloosahatchee River and Canal from Lake Okeechobee to the Gulf of Mexico by straightening and by dredging a channel which will provide a discharge outlet capacity of 2,500 cubic feet per second from Lake Okeechobee and a navigation channel at least 6 feet deep and 80 feet wide, including the necessary control works, at an estimated cost of \$1,557,000; improve Taylor's Creek by providing a channel 6 feet deep and 60 feet wide from Okeechobee City into Lake Okeechobee at an estimated cost of \$58,000; provide a levee and a navigation channel 6 feet deep and 80 feet wide following in general the south shore of the lake at an estimated cost of \$6,172,000; improve the St. Lucie River to provide a channel 6 feet deep and 80 feet wide at an estimated cost of \$25,000; provide for the protection of the St. Lucie Canal from erosion and silting at an estimated cost of \$175,000; the levees to be subject to modifications of location and design at the discretion of the Chief of Engineers; provided that the State of Florida, or other local interests contribute \$1,175,000 toward the cost of the above improvements, furnish evidence satisfactory to the Secretary of War that they will construct the north shore levee to a design to be approved by the Chief of Engineers, estimated to cost \$1,040,000, provide all lands needed for levees, channels, and the disposal of spoil, agree to maintain all work and channels within the limits of the Everglades drainage district and to charge no tolls on any of these navigable waterways and agree that whenever authorized by Congress the United States shall have the right to modify or

improve any of these waterways and their appurtenant structures. It is further recommended that in adopting the project Congress expressly provide that the St. Lucie Canal, the Caloosahatchee Canal, and the other channels forming the proposed cross-State waterway, shall be navigable waters of the United States and subject to the Federal laws for the protection of such waterways. The total estimated cost of the above project to the United States will be \$6,812,000 for new work, with \$15,000 annually for maintenance in the Caloosahatchee River west of the western limit of the Everglades drainage district, and in the St. Lucie River east of the eastern limit of the Everglades drainage district.

L. V. FRAZIER,
Lieutenant Colonel, Corps of Engineers,
District Engineer.

[First Indorsement]

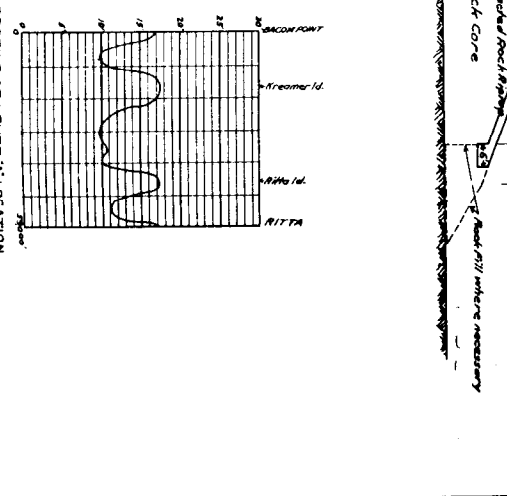
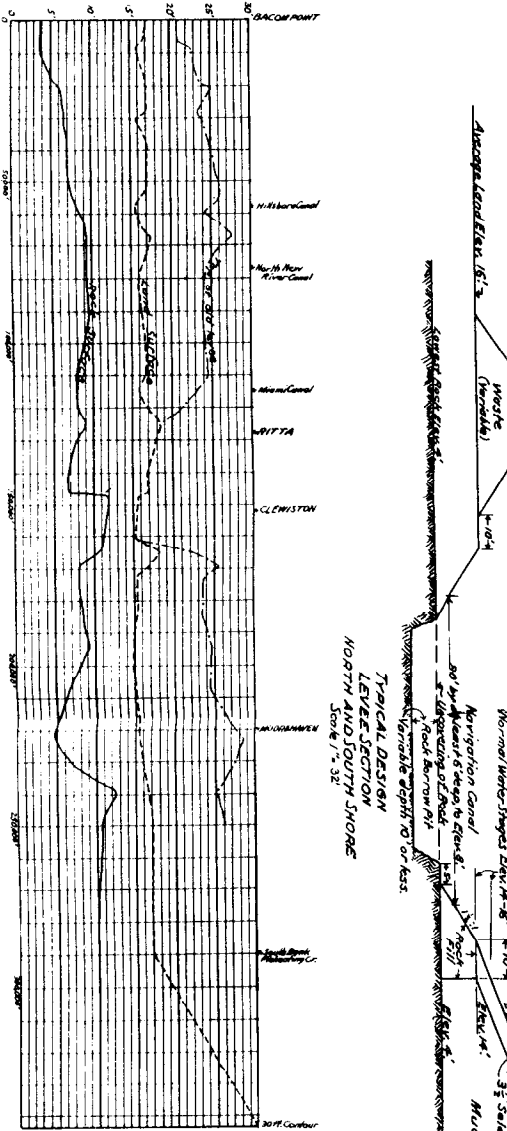
OFFICE DIVISION ENGINEER, GULF OF MEXICO DIVISION,
New Orleans, La., February 20, 1930.

To the CHIEF OF ENGINEERS, UNITED STATES ARMY,
Washington, D. C.

Concurring in the views and recommendations of the district engineer.

MARK BROOKE,
Lieutenant Colonel, Corps of Engineers,
Division Engineer.

U.S. GOVERNMENT PRINTING OFFICE
 Drawn by C.P.P. File No. 3-12-8719
 To accompany report dated February 20, 1930
 Associate Engineer
 Submitted: *[Signature]*
 U.S. ENGINEER OFFICE, JACKSONVILLE, FLORIDA
 Approved: *[Signature]*
 Lt. Col. Corps of Engineers
 SCALE 1:48,000
 ONE SHEET
 MADE WITH A VIEW TO FLOOD CONTROL AND NAVIGATION
 FEBRUARY, 1930
 SURVEY OF CALOOSAHATCHEE RIVER AND
 LAKE OKEECHOBEE DRAINAGE AREAS
 REVIEW OF REPORT ON
 BACOM POINT TO RITTA



POSITIONS OF LEVELS IN LOCATION

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