COMPREHENSIVE REPORT ON CENTRAL AND SOUTHERN FLORIDA FOR FLOOD CONTROL AND OTHER PURPOSES

LETTER

FROM

THE SECRETARY OF THE ARMY

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, UNITED STATES ARMY, DATED FEBRUARY 19, 1948, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS, ON A PRELIMINARY EXAMINATION AND SURVEY OF, AND A REVIEW OF REPORTS ON, RIVERS, LAKES, AND CANALS OF CENTRAL AND SOUTHERN FLORIDA FOR FLOOD CONTROL AND OTHER PURPOSES, MADE PURSUANT TO CONGRESSIONAL AUTHORIZATIONS

May 6, 1948.—Referred to the Committee on Public Works and ordered to be printed, with five illustrations

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LETTER OF TRANSMITTAL

DEPARTMENT OF THE ARMY,
Washington, D. C., April 26, 1948.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

DEAR MR. SPEAKER: I am transmitting herewith a report dated February 19, 1948, from the Chief of Engineers, United States Army, together with accompanying papers and illustrations, on a preliminary examination and survey of rivers, lakes, and canals of central and southern Florida for flood control and other purposes. This comprehensive investigation has been made in response to a number of congressional authorizations which are listed in the report.

In accordance with section 1 of Public Law 534, Seventy-eighth Congress, the proposed report of the Chief of Engineers was furnished to the Governor of Florida for his review. Comments and recommendations of the Governor regarding the proposed plan of improvement are set forth in copy of his letter of February 17 herewith.

A copy of the report was also referred to the Secretary of the Interior. The comments of the Department of the Interior are contained in the enclosed communication dated April 13, 1948.

The Bureau of the Budget advises that there is no objection to the submission of the report to Congress.

Sincerely yours,

KENNETH C. ROYALL,
Secretary of the Army.

COMMENTS OF THE STATE OF FLORIDA

STATE OF FLORIDA,
EXECUTIVE DEPARTMENT,
Tallahassee, February 17, 1948.

Maj. Gen. R. C. CRAWFORD,
Acting Chief of Engineers,
War Department,
Washington 25, D. C.

DEAR GENERAL CRAWFORD: Receipt is acknowledged of your letter of February 13, 1948, which transmitted the proposed report of the Chief of Engineers on the comprehensive plan for improvement of flood control in central and southern Florida. This plan has my approval as Governor of the State.

As pointed out in the report, further refinement of the plan is to be contemplated in order that it may be made to conform as nearly as possible to the desires of local interests. The questions relating to the

allocation of costs within the State and the creation of a single State agency with authority to administer the program will, of course, have to be determined by the Florida State Legislature.

The proposed program appears to be feasible and designed to solve a grave need. I want to express the gratitude of the State for your recognition of the problem as one which touches a national asset which should be protected and assured an orderly development for the use of present and future generations.

Sincerely,

MILLARD F. CALDWELL,
Governor.

COMMENTS OF THE DEPARTMENT OF THE INTERIOR

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington 25, D. C., April 13, 1948.

Lt. Gen. R. A. WHEELER,
Chief of Engineers,
Department of the Army.

MY DEAR GENERAL WHEELER: By letter dated February 13, 1948 (file ENGWF), General Crawford transmitted for the information and comments of the Department of the Interior your proposed report on flood control and other purposes in central and southern Florida, together with reports of the Board of Engineers for Rivers and Harbors and of the district and division engineers. I am also advised that in view of the urgent need for the flood protection and water control contemplated in the report that it has been submitted to the Bureau of the Budget, and, in view thereof, a copy of this letter is being sent to the Director of that Bureau.

Opportunity to review your report under the provisions of Public Law 732, Seventy-ninth Congress, and in accordance with established procedures regarding coordination between Federal agencies, is greatly appreciated, since the proposed report affects the interests of the Bureau of Indian Affairs, the National Park Service, and the Geological Survey, as well as the Fish and Wildlife Service. In this connection, it is noted that in the preparation of the district engineer's report a high degree of cooperation has been received from agencies of the Department at field level which has been of material assistance to the Corps of Engineers in the preparation of the plan of improvement. Benefit of close cooperation at regional level has also accrued to agencies of the Department and as outlined hereafter it seems evident that as plans for development are perfected, the closest cooperation should be maintained at regional level in order that certain of the proposals for development as they may affect the interests and obligations of interested agencies of this Department may be mutually agreed upon. To that end the views and recommendations of the various agencies are set forth rather specifically herein.

The National Park Service concurs in the general program outlined in your report and its objectives. Insofar as the Everglades National Park is concerned, the main points for consideration are the maintenance of an adequate level of fresh ground water to prevent salt-water

encroachment which would change the environment for wildlife, as well as the vegetation; and the critical need for maintaining a reasonably large supply of fresh water so that disastrous fires may be prevented, especially during the hazardous season between October and May when rainfall is low. Periodical flooding has always been a natural occurrence in the region of the park; it is essentially a water park. Basically, therefore, as concerns the National Park Service, the question is not one of too much water, but a guaranty that there shall not be too little.

The Everglades National Park has been established so recently that the National Park Service has had neither time nor resources to make studies as to the actual effect of the project on the park or as to the best means whereby the project may be made to contribute to the preservation of the park in its natural state, in accordance with the expressed will of the Congress.

Your report proposes that in dry periods water would be released from proposed conservation areas into the Everglades National Park which would assist in reducing fires and other damages which accompany periods of drought. It also provides for spillways along the Tamiami Canal. As stated, the floodwaters would not ordinarily do as much damage to the park as reduction in dry season flows. However, it is essential that the release of floodwaters be adequately distributed to the natural drainage of the park so that no artificial drainage facilities will become necessary, and so that no more of the natural habitat for the wildlife be flooded than in the past.

The National Park Service concurs in this objective of the plan but advises that insufficient data are available at this time to enable the Service to determine what water-control structures would be necessary to facilitate the release of stored water into the park during dry periods and the distribution over the park of the water released or spilled. Your report does not state what definite regulations would be promulgated to insure the release of such waters.

Specifically, the Everglades National Park is a unique park area set aside by the Congress to be preserved in its natural state. If the flood-control project is to contribute to this end, or at least not adversely affect it, it seems imperative that the details of the plan as it may affect the park be jointly worked out by the Corps of Engineers and the National Park Service.

The point of view of the Bureau of Indian Affairs is somewhat different than that of the National Park Service in that it favors proposals or programs whereby flooding may be reduced on reservation lands or lands specifically set aside for the beneficial use of the Seminole Indians.

The Bureau approves the construction of a levee approximately parallel to the shores of Lake Okeechobee extending from Kissimmee River to Fisheating Creek with extensions along either bank of the Indian Prairie and Harney Pond Canals with adequate outlets for local drainage and control works for dry periods. The Bureau believes that this protective work and canal improvements for water control will greatly benefit the 35,800 acres of grazing and agricultural lands on the Seminole Indian Reservation in Glades County where the Bureau of Indian Affairs is endeavoring to rehabilitate the Florida Seminole Indians.

On the other hand, the Bureau of Indian Affairs protests the proposed plan of developing a water conservation area in Broward County which would take in all of the State Seminole Indian Reservation consisting of 104,800 acres. It is pointed out that these lands were specifically set aside for the beneficial use of the Seminole Indians by the State of Florida, and that if the proposed plan is carried through it will deprive the Seminoles of a valuable grazing and hunting area.

During dry periods, from about December through May, the Bureau of Indian Affairs has secured benefits from these lands in Broward County by grazing several hundred of the Seminole cattle, a part of the herd being developed on the Hendry County Reservation. It appears that if this area is turned into a water conservation area, the Seminoles would lose grazing benefits and all big game would be driven from the area.

Recommendations have been made heretofore at regional level by the superintendent of the Indian Agency at Fort Myers through advisement of the district engineer at Jacksonville, Fla., of the plans regarding the development and protection of the Big Cypress Reservation and the State Indian reservation from floodwaters; also long-range plans for developing a livestock program for the Seminole Indians of Florida. He recommended that a canal and dike be constructed running north and south along the Collier-Broward County line which would help to protect the lower sections of the Federal reservation in Hendry County from floodwaters.

It is further recommended that a plan be devised to protect the State Indian reservation from flooding by either locating the proposed north-south canal 6 miles farther east or by some other means so that the Seminoles would not lose the use of these lands which are badly needed for their livestock operations. If the canal is constructed as proposed along the Collier-Broward County line, it will be necessary to provide a stock driveway over the canal so that the Indians can reach the State Indian reservation lands during the winter grazing season.

The Fish and Wildlife Service has heretofore furnished two reports to the district engineer. The first, submitted on October 31, 1947, was a preliminary evaluation report on the Everglades drainage and flood-control project, and the second, submitted December 18, 1947, was a preliminary evaluation report on the central Florida drainage and flood-control project. The Fish and Wildlife Service advises that these two reports were both of a preliminary nature and both prepared in the relatively short time between October 9, 1947, and December 18, 1947.

The Fish and Wildlife Service finds that on review of the comprehensive report three points are not clear and require amendment as follows:

1. In paragraph 70, item (*b*), it should be made clear that the estimates of annual benefits of $291,000 are preliminary estimates which may be revised following more complete studies.

2. Paragraph 39, item (*d*), should be amended by the addition of the following:

This Service leases and manages the Istokpoga Refuge in the vicinity of Lake Istokpoga, and plans are being made for the eventual establishment of a refuge in the Loxahatchee area.

3. Paragraph 48, should state that—

> The extensive changes wrought in the Everglades areas will result in the loss of certain unique wildlife habitats. The Fish and Wildlife Service decries this loss even though it may be overshadowed by benefit to the fishery.

Aside from the points mentioned above, the Fish and Wildlife Service advises that the report considers fish and wildlife as adequately as it can in light of the preliminary nature of the Service's findings. It is requested, however, at such time as the definite project reports may be prepared, that the Fish and Wildlife Service be given an opportunity to recommend measures to insure minimum damage to, and maximum benefits for, wildlife resources.

In addition to specific recommendations outlined heretofore, your report brings up certain questions relating to the water investigational program of the Geological Survey, particularly in the Everglades and the lower east coast of Florida. The investigations in these areas, being cooperative in nature, are supported in part by funds from several State agencies and municipalities and are for the purpose of providing water data for a substantial number of activities of local, as well as Federal interests. It is considered highly important that such investigations be assured not only continuity but proper expansion leading up to a well coordinated network of water measurements, ground-water observation, and chemical sampling stations, which are adequate for all future needs. Such a well-balanced program is also of value to the regional activities of the National Park Service, the Fish and Wildlife Service, the Bureau of Indian Affairs, as well as for your program.

It is apparent that the characteristics of the waters with respect to their occurrence, movement, and quality, will be appreciably changed by the proposed flood control and other works in southern Florida. The definition of these characteristics is being accomplished by the Geological Survey largely in cooperation with a considerable number of State and municipal agencies and in some part through the transfer of funds to the Geological Survey by the Corps of Engineers. This joint and well-coordinated undertaking has developed basic water data of value, not only to your agency in its proposed plan but to the bureaus of the Department heretofore enumerated and to bureaus of other Federal agencies. The data are also vital to the non-Federal development in the area fields, such as irrigation, municipal, and industrial water supply, and highway drainage and design.

The assurance of continuity in the Geological Survey's program of basic water investigations is made the more important by the proposed flood-control program. The past records of stream and canal flow, water-table elevations and variations in chemical quality would, in many areas, remain of value only as records of the antecedent conditions. The new characteristics produced by the proposed physical works would necessarily be redefined in order to determine the availability of water under all conditions of flood and drought for the many interested parties and the numerous activities referred to above.

I have no reason to believe but that the Corps of Engineers will recognize the responsibilities of the Geological Survey to the large number of Federal, State, and municipal agencies in the continued

study of the waters of southern Florida and in the correlation and release of the water data in such a form that it can be readily used for the operations and developments within the scope of the many local activities.

The Department concurs in the comprehensive plan of improvement proposed in the report designed to remove excess water from urban, pasture, and farm lands, to conserve water for control of ground-water levels during dry periods, and to prevent overflow of the coastal area by water from the Everglades. However, as concerns programs which may affect the Everglades National Park, it is felt imperative that plans of operation should be the subject of negotiated agreements between the Corps of Engineers and the National Park Service prior to construction and so recognized in authorizing legislation for the project. As to the recommendations and views of the Bureau of Indian Affairs, the Fish and Wildlife Service, and the Geological Survey, as outlined herein, I trust that they will be given earnest consideration during the formulation of the definite plans and in the carrying out of project operations.

Sincerely yours,

WILLIAM G. WARNE,
Assistant Secretary of the Interior.

COMPREHENSIVE REPORT ON CENTRAL AND SOUTHERN FLORIDA FOR FLOOD CONTROL AND OTHER PURPOSES

REPORT OF THE CHIEF OF ENGINEERS, UNITED STATES ARMY

DEPARTMENT OF THE ARMY,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, February 19, 1948.

Subject: Report on central and southern Florida for flood control and other purposes.

To: The Secretary of the Army.

1. I submit for transmission to the Congress my report on the rivers, lakes, and canals of central and southern Florida for flood control, and other purposes. This is a report of great significance to the Nation, as it concerns a large and potentially rich and productive section of the State of Florida. The development of this region, however, has been retarded by destructive floods aggravated by winds of hurricane force, as well as by recurring periods of drought.

2. This report has been made in response to authorizations in various flood-control and river and harbor acts of Congress, and in response to resolutions of appropriate congressional committees, which provide for preliminary examinations and surveys of rivers, lakes, and canals in the upper St. Johns, Kissimmee, Lake Okeechobee-Caloosahatchee, and Everglades drainage areas. The problems of flood protection, drainage, and water control in these areas are physically interrelated, and the areas form a single economic unit. Accordingly, a single comprehensive survey has been made in response to the congressional authorizations, and the resulting unified plan of improvement is presented in this report.

3. The area under consideration embraces some 15,570 square miles in central and southern Florida. Development and settlement of this area has progressed in spite of the difficulties inherent in a land where there is either too much or too little water, according to variations of the seasons and changes from year to year. Hurricane-driven floods of 1926 and 1928 resulted in the loss of some 2,500 lives in the area around Lake Okeechobee, producing one of the greatest disasters in the history of this Nation. The existing Federal project for flood control and navigation on Lake Okeechobee and its outlets has afforded a high degree of protection against a repetition of such a disaster. In addition, numerous drainage and flood-control works constructed by local interests have been instrumental in bringing the area to its present degree of development. However, the problem of "too much water" has not yet been solved, as the recent flood of 1947 caused damages estimated at $59,000,000, during the summer

and fall of that year, even though direct overflow from Lake Okeechobee was prevented by Federal protective works. Recession of floodwaters has been so slow that gravity drainage from some agricultural areas is not yet possible as of the date of this report. Floods of similar magnitude occur with relative frequency, and minor flooding occurs almost every year. On the other hand, during the dry years from 1943 through 1946, cattle died in the pastures of the Kissimmee Valley for lack of water; smoke from burning muck lands of the Everglades darkened the coastal cities; and salt water moved inland along drainage canals and through the underlying rock as the supply of fresh water diminished.

4. The district engineer has prepared a comprehensive plan of improvement for flood protection, water control, and allied purposes. It provides the protection and control works urgently needed to prevent a repetition of recent destructive flooding, as well as the related major drainage outlets, control structures, and water-conservation facilities which are needed to stabilize the present agricultural economy of the region and are essential to ultimate development. The details of this plan of improvement are set forth in the report of the district engineer included herewith. The first cost of the plan of improvement is estimated at $208,135,000. The cost of its maintenance and operation is estimated at $3,703,000 annually.

5. Development of the comprehensive plan of improvement would afford a high degree of flood protection throughout this area; it would provide for removal of excess waters in wet seasons, and for their control, storage, and use in maintaining water levels during dry periods. Adequate control of water levels is essential for agricultural use of lands in this area and for maintenance of municipal water supplies. The comprehensive plan would benefit in varying degrees over 2,300,000 acres of land, as well as numerous cities and towns. In addition to these primary purposes, the improvements would reduce the dry season intrusion of salt water into lands and water supplies of coastal areas. Its features would produce substantial benefits from the preservation of fish and wildlife resources. Although the navigation benefits are relatively small and incidental when compared with the primary features of flood protection and water control, the proposed channels and control works would afford the basic framework for a system of interlocking navigable waterways throughout central and southern Florida, which would connect at several points with the Intracoastal Waterway. Investigation of the feasibility of correlating additional navigation improvements with the works proposed under this plan is already provided for in reports requested by Congress under other authorizations.

6. This comprehensive plan of improvement is a modification and extension of the existing Federal project for the Caloosahatchee and Lake Okeechobee drainage areas, Florida, which was authorized by the River and Harbor Acts of July 3, 1930, and modified in subsequent acts of Congress. As indicated above, the comprehensive plan of improvement will serve the purposes of flood protection, drainage, and water control to a far greater degree than navigation. Consequently, it is believed that this project should be considered henceforth as one for flood control and other purposes, and that its further consideration should be under the provisions of flood-control law.

7. The plan as a whole and each of its major features are multiple-purpose in concept and design. Accordingly, each feature of the plan contributes to the realization of the primary benefits through flood protection, drainage, and control of water. Analysis of the benefits and costs of the plan of improvement shows clearly that it is justified economically by a wide margin.

8. The studies of the reporting officers show that benefits will accrue in large measure to the Nation as a whole, as well as to the State and local interests concerned. In recognition of the scope and type of benefits of this project, the district engineer has made a division of cost between the Federal Government and local interests which I believe is a sound and fair method for taking into account the relative national and local interest involved. He finds that large local benefits in the form of increased land use warrant a contribution by local interests of $29,152,000 toward construction of the project, in addition to the minimum requirements of local cooperation prescribed by flood-control law. The Board of Engineers for Rivers and Harbors has reviewed this aspect of the problem and believes that this contribution should be met by local interests as the work progresses by payments of 15 percent of the construction cost of each feature of the work, as it reaches the construction stage. This procedure would afford a practical means of payment by local interests over the period in which the project is developed. It should be noted, however, that application of 15 percent to the construction cost of each feature, to determine the local participation in that feature, does not necessarily imply that this charge should be borne only by local interests in the immediate locality of the feature to be constructed. In most cases project features are closely interrelated from an engineering standpoint and produce benefits extending beyond immediate locations of the works. The apportioning of local costs among various areas and interests, and the securing of funds by taxation or other methods to meet local charges, is properly a function of the State or other responsible local agency which may be established to administer the requirements of local cooperation. In this connection, I concur with the district engineer in his suggestion that there should be established, preferably by the State of Florida, a single local agency with which the Federal Government can deal on all matters of local cooperation on this project.

9. The comprehensive plan of improvement presented in this report is a long-range plan for development by progressive stages over a period of time, but its benefits will accrue proportionately as successive features of the plan are completed. The Board of Engineers for Rivers and Harbors finds that the first phase of the project should be construction of the principal structures required for protection of the east coast area and the principal works necessary to control lake levels and reduce flood damage in the improved area south of Lake Okeechobee. The estimated cost of this first phase is $70,000,000. Local interests have stressed their need for immediate protection against repetition of a flood such as that of 1947. Initiation of the first phase will begin to provide that immediate relief and completion of this phase will afford a substantial part of the necessary flood protection for present developed areas.

10. The Board of Engineers for Rivers and Harbors has given careful consideration to the procedure for maintenance and operation of this

project. I am in full agreement with the view of the Board that maintenance and operation should be by local interests at local cost, except for maintenance and operation of specified major protection and control works which should remain a Federal responsibility.

11. I note that the Board of Engineers concurs with the district engineer's finding that certain island lands in Lake Okeechobee cannot be protected adequately at reasonable cost; but, unlike the district engineer, considers that local interests should be permitted to make such use of these islands as they may desire at their own risk. I concur with the findings of the Board on this matter.

12. There has been constant coordination with local interests throughout the preparation of this plan and report. The State of Florida and local organizations have expressed themselves as favoring, generally, the comprehensive plan of improvement. Differences of opinion exist only on minor details of the plan and on the location and size of certain features. As indicated by the Board of Engineers for Rivers and Harbors, further refinement of the plan, to make it conform as nearly as possible to the desires of local interests, will be undertaken in cooperation with a responsible State or local agency prior to construction, in accordance with the usual procedure on projects of this kind.

13. The district engineer's plan and report have also been coordinated with other Federal agencies which have an interest in this area. The framework of the plan itself has been established in conformity with the investigations and soil surveys made by the Soil Conservation Service of the Department of Agriculture in cooperation with the United States Geological Survey and State of Florida. The regional office of the Fish and Wildlife Service of the Department of the Interior has assisted the district engineer with suggestions which have been incorporated into the plan of improvement, and has furnished estimates of benefits that will accrue from preservation of fish and wildlife resources. The office of indian affairs for the State of Florida has endorsed the proposed plan of improvement and recognized its beneficial effects upon Seminole Indian Reservation lands. The superintendent of the Seminole Indian Agency has also pointed out that certain other lands, held in trust by the State of Florida for the Indians, have been included within the limits of conservation areas, and has requested revisions with respect to these lands. In this connection, it is my understanding that adjustment for use of these lands is properly a matter between the State of Florida and the Indians. Consequently, the State should give proper consideration to such lands in its action in providing lands for the project. The plan of improvement has also been developed in full recognition of the importance of the Everglades National Park which has been established recently at the southwestern tip of the Florida peninsula. Release of water from conservation storage will assist in restoring and maintaining natural conditions within the national park area, by reducing damage from drought and fire which have threatened the preservation of lands, vegetation, and wildlife.

14. In summary, I conclude that the comprehensive plan of improvement presented by the reporting officers, and recommended by

the Board of Engineers for Rivers and Harbors, provides the basic framework for a practical and permanent solution of the problems of flood protection and water control in central and southern Florida. The mild climate and inherent fertility of this area make inevitable its continued development. Under the disruptive influences of flood and drought, this development will go forward in a haphazard manner, with eventual loss of irreplaceable resources of water and soil. The existence and functioning of the proposed plan of improvement will remove these hazards and provide the pattern for progressive protection and development. Since the area is unique in its combination of a semitropical climate with fertile soil and abundant water, it represents a national asset which should be protected and assured an orderly development for the use of present and future generations. In addition, flood protection and major drainage improvements are urgently needed as an emergency measure.

15. The comprehensive plan of improvement as a whole should be adopted by the Congress, as such approval will permit planning of individual features to proceed in a logical manner and will enable the Corps of Engineers to work out remaining details in coordination with the State or local agency concerned. The first phase of the improvement with an estimated cost of $70,000,000 should be undertaken at the earliest possible date as a matter of great urgency.

16. I have given careful consideration to the plan presented by the reporting officers and to the views of the Board of Engineers for Rivers and Harbors. I concur with the Board of Engineers for Rivers and Harbors in recommending modification of the existing Federal project for the Caloosahatchee and Lake Okeechobee drainage areas to provide for further improvement in the interests of flood control, drainage, and related purposes, generally in accordance with the district engineer's comprehensive plan for flood control and other purposes in central and southern Florida, with such modifications thereof as in the discretion of the Secretary of the Army and Chief of Engineers may be advisable, at an estimated cost to the United States of $171,041,000 for construction and $749,000 annually for maintenance and operation, subject to the conditions that local interests shall provide all lands, easements and rights-of-way; make a cash contribution of 15 percent of the estimated construction cost for each part of the work prior to its initiation, except that the total cash contribution for the comprehensive project shall not exceed $29,152,000; and furnish assurances satisfactory to the Secretary of the Army that they will hold and save the United States free from damages due to the construction and operation of the works and that they will maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army, except the levees, channels, locks, and control works of the St. Lucie Canal, Lake Okeechobee, and Caloosahatchee River and the main spillways of the conservation areas.

R. A. Wheeler,
Lieutenant General, Chief of Engineers.

REPORT OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBOR

DEPARTMENT OF THE ARMY,
THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS,
Washington, February 9, 1948.

Subject: Central and southern Florida.
To: The Chief of Engineers, United States Army.

1. This report is in response to the following resolutions adopted May 29, 1940, October 23, 1945, October 24, 1945, May 28, 1946, June 19, 1946, and July 5, 1946:

Resolved by the Committee on Rivers and Harbors of the House of Representatives, United States, 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 is hereby, requested to review the reports on Caloosahatchee River and Lake Okeechobee drainage areas, Florida, submitted in Senate Document Numbered 213, Seventieth Congress, second session, and subsequent reports, with a view to determining whether the existing project should be modified in any way at the present time to provide protection for Kreamer, Ritta, and Torry Islands in the southern portion of Lake Okeechobee.

Resolved by the Committee on Flood Control, House of Representatives, 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 is hereby requested to review the report on the Caloosahatchee River and Lake Okeechobee drainage area, Florida, published as House Document Numbered 215, Seventieth Congress, first session, and subsequent reports, with a view to determining the advisability of modifying the existing project in the interest of drainage and flood control along the West Palm Beach Canal and the Hillsboro Canal.

Resolved by the Committee on Commerce of the 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 is hereby, requested to review the report on the Caloosahatchee River and Lake Okeechobee drainage area, Florida, published as House Document Numbered 215, Seventieth Congress, first session, and subsequent reports, with a view to determining the advisability of modifying the existing project in the interest of drainage and flood control along the West Palm Beach Canal and the Hillsboro Canal.

Resolved by the Committee on Flood Control, House of Representatives, 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 is hereby requested to review the report on the Caloosahatchee River and Lake Okeechobee drainage area, Florida, published as House Document Numbered 215, Seventieth Congress, first session, and subsequent reports, with a view to determining the advisability of drainage improvement and flood control along North New River Canal in Broward County, Florida.

Resolved by the Committee on Commerce of the 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 is hereby, requested to review the report on Caloosahatchee River and Lake Okeechobee drainage areas, Florida, submitted in Senate Document Numbered 115, Seventy-first Congress, second session, and previous reports, with a view to determining the advisability of providing additional control works in the Caloosahatchee River, Florida, for controlling floods and improving ground water conditions adjacent to the river.

Resolved by the Committee on Flood Control, House of Representatives, 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 is hereby requested to review the report on the Caloosahatchee River and Lake Okeechobee drainage areas, Florida, published as House Document Numbered 215, Seventieth Congress, first session, and other reports covering the St. Lucie River, with a view to determining the advisability of undertaking improvements in the interest of flood control and for other purposes along the north fork of the St. Lucie River and its tributaries, Florida.

It is also in review of the reports on preliminary examination and survey of Kissimmee River Valley and its tributaries, Florida, author-

ized by the Flood Control Act approved August 28, 1937; Kissimmee River, Fla., including regulation and stabilization of water levels, authorized by the Flood Control Act approved August 11, 1939; Indian River, upper St. Johns River and Marsh, and North Fork, St. Lucie River, and their tributaries, the Kissimmee River and its tributaries, Florida, authorized by the Flood Control Act approved August 18, 1941; Fisheating Creek, Fla., authorized by the River and Harbor Act approved March 2, 1945; West Palm Beach Canal, Hillsboro Canal, New River Canal, and Miami Canal, for the purpose of raising the water table in the area of Lake Okeechobee, Fla., authorized by the River and Harbor Act approved July 24, 1946; and Caloosahatchie River and Lake Okeechobee drainage area, Florida, for drainage improvement and flood control along North New River Canal in Broward County, Fla., authorized by the Flood Control Act approved July 24, 1946.

2. The streams covered in these authorizations drain a relatively flat area of 15,570 square miles in central and southern Florida and have interrelated problems of flood control and drainage. The St. Johns headwaters area consists of lakes, marshes, and prairie lands at elevations from 22 to 24 feet above sea level, parts of which, with varying degrees of saturation and winds, drain either westward toward the Kissimmee River, southward toward the St. Lucie River, or northward through the St. Johns River. The Kissimmee River Basin comprising an area of 4,375 square miles, is generally flat with a gentle slope southward toward Lake Okeechobee, and is dotted with shallow lakes and interconnecting sloughs and channels. The river has its source in several small streams near the city of Orlando at elevation 60 and flows southward through Lake Kissimmee at elevation 52 and through the flat prairie lands south of the lake to empty into Lake Okeechobee, a nearly circular body of fresh water, 730 square miles in area. Lake Okeechobee originally had a surface elevation ranging from about 12 to 19 feet above mean sea level. It had no well-defined outlet. At the higher levels water from the lake would spread over the vast Everglades area to the south or spill slowly into the flat areas to the west of the lake to reach the Caloosahatchee River, or escape through seepage and overland flow to various sloughs to the east. Control of the lake has been obtained by the construction of levees along the south and east shores, and by outlet canals connecting the St. Lucie River and several other small streams on the Atlantic coast and the Caloosahatchee River on the Gulf coast. Lake level is maintained insofar as possible between 12.56 and 15.56 feet above mean sea level. The Everglades, a grassy marsh roughly 40 miles wide and 100 miles long, extends from the lake southward to the sea at the southern end of Florida. Water from the lake originally entered the area by seepage and overflow, and together with the rain water that fell over the area, flowed slowly through the grass and other vegetation to escape eastward and southward to the sea through small streams along the coast. The strip of sandy land, 5 to 10 miles in width, containing the highly developed recreational and agricultural areas along the Atlantic coast, forms the eastern border of the Everglades.

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3. Much of the land in the area under consideration was transferred by the United States under the Swamp and Overflowed Land Grant Act of September 28, 1850, to the State of Florida and is still owned by the State. The Everglades embracing 2,800,000 acres was the largest single unit transferred. Construction of six major canals for the drainage of these fertile muck lands; the Caloosahatchee, Miami, North New River, Hillsboro, West Palm Beach, and St. Lucie Canals, was accomplished by the Everglades Drainage District, a State agency, between 1906 and 1928. Expenditures totaled $18,000,000 and although the work performed was of limited character it was largely responsible for an important agricultural development comprising about 130,000 acres south of Lake Okeechobee. Subdrainage districts have bee ı formed in this area which together witn individual landowners and corporations have constructed ditches, dikes, and pumping plants valued at approximately $5,000,000. In addition, similar subdrainage districts have been formed along the eastern border of the Everglades between West Palm Beach and Miami, in the upper St. Johns River Basin, in the North Fork of St. Lucie River area, and in parts of the Kissimmee Basin where truck farming is in progress. Expenditures for water control in these latter areas approximate $6,000,000. Federal projects for improvement provide for a navigable depth of 8 feet from the Intracoastal Waterway at St. Lucie Inlet on the Atlantic coast across the State by way of St. Lucie Canal, Lake Okeechobee, and the Caloosahatchee River to the Gulf of Mexico at Punta Rasa, with a number of connecting channels. The total length of this waterway is 155 miles. The improvement includes control works in the St. Lucie Canal and Caloosahatchee River for regulating the level of Lake Okeechobee, and levees around the southern and northern shores of the lake having a total length of 68 miles. Present operating procedures for control of lake level contemplate a range of stage of from 12.56 to 15.56 feet above mean sea level. The project is completed except for deepening the authorized channels from 6 feet to 8 feet, and making certain modifications of the control structures.

4. The population of the 18 counties in or tributary to the area under consideration is 727,000, a large part of which is concentrated along the east-coast ridge, around Lake Okeechobee, and on the borders of the Kissimmee River Basin. Wide interior areas are in undeveloped marshlands and pasture, and remain sparsely settled. Production of vegetables, sugarcane, ramie, and citrus fruits, and cattle raising are the predominant agricultural activities of the area. Truck farming is carried on immediately south of Lake Okeechobee, in smaller areas in the Kissimmee River Basin, and along the eastern border of the Everglades. Citrus fruits are produced in the area from the western and northern limits of the Kissimmee Basin to the Davie area in the Everglades southwest of Fort Lauderdale. About 268,000 acres are in citrus groves. Farming in the flat muck lands of the Everglades requires diking to prevent overflow by high water on the surrounding lands, and pumping plants to remove water during wet periods and to supply water in dry periods. Cattle raising is the chief industry of the Kissimmee and St. Johns areas and in recent years has spread into parts of the Everglades. About 120,000 head of cattle are marketed from the area each year.

5. Flood conditions occur frequently in the area and are caused by water from continued heavy rainfall which saturates the soil, fills the

lakes, streams and canals, and spreads in thin sheets over vast areas of the flatlands to move slowly as overland flow in the direction of the prevailing slope. The inundation, which lasts for weeks at a time, destroys crops and pasture and requires evacuation of inhabitants and livestock. Major floods, which occur about once in every 6 years in the St. Johns area affect 1,050,000 acres. In the Kissimmee and adjacent Fisheating Creek areas the occurrence is of similar frequency and 598,000 acres are affected. The farm lands of the Everglades and all the towns lying generally south of the lake are still subject to destructive flooding by continued heavy rainfall, which existing artificial canals and pumping plants cannot remove, and also to overland flow from adjacent undeveloped areas. The urban east-coast area from West Palm Beach to Miami is subject to flooding by local rainfall and by overflow from the Everglades. The major flood of 1947 inundated outlying surburban areas of West Palm Beach; 30 percent of the city of Fort Lauderdale including the business district, railroads, industrial and residential sections; large areas in the western part of Miami and the outlying communities of Miami Springs and Hialeah; and damaged roads, utilities, railroads, and airports in the coastal area. Total damages for this area alone are estimated at $41,900,000. The average annual flood damage for the St. Johns area is estimated as $2,077,000; for Kissimmee and related areas $1,500,000; for the Lake Okeechobee and Everglades areas $4,130,000; and for the coastal region $3,857,000; a total of $11,564,000 for the comprehensive area.

6. Local interests desire a comprehensive plan of improvement for flood protection and water control for the area as a whole. They feel that the scope and complexity of such a plan places it beyond the capabilities of the State or local agencies.

7. The district engineer is of the opinion that a comprehensive plan of improvement designed to remove excess water from urban, pasture, and farm lands, to conserve water for control of ground-water levels during dry periods, and to prevent overflow of the coastal area by water from the Everglades, is urgently needed for protection of property and farming, and to assure further development of the region in an orderly manner. He proposes a plan providing for levees, channel work, and control structures at lake outlets in the St. Johns and Kissimmee areas; for increased levee protection around Lake Okeechobee and enlargement of its outlets, the Caloosahatchee and St. Lucie waterways; for enlargement of existing drainage canals, and the construction of new canals and levees, and pumping plants, for control of water in the Everglades area; and levees and channel work in the coastal area. He states that the cost of adequately protecting Kreamer, Ritta, and Torry Islands in Lake Okeechobee would be excessive in comparison with their value and is of the opinion that they should be abandoned for agricultural purposes.

8. The proposed improvements in the Kissimmee, St. Johns, and related areas north and east of Lake Okeechobee will result in quicker run-off of floodwaters and better drainage of large areas of pasture and cultivated lands. Enlargement of the Lake Okeechobee outlets and increased levee work around the lake will give more adequate control of the lake levels, will permit conservation of additional water for use during dry periods, and provide full protection during severe hurricanes. The works proposed for the Everglades will give flood protection, better drainage, and a water supply during dry periods, to

657,000 acres of developed and potentially productive agricultural land south of the lake. The plan contemplates formation of a conservation area, comprising approximately 1,500 square miles generally south and east of the agricultural area, by the construction of impounding levees. The levee on the east side would prevent overflow from the Everglades into the coastal area. Maintenance of water in the conservation area would provide a supply for use in the east-coast agricultural lands when needed, raise the ground-water table, improve water supply and ameliorate salt-water intrusion in the east-coast water supply well fields and streams, and benefit fish and wildlife in the Everglades. Improvements in the coastal area would result in flood protection and better drainage for communities and agricultural lands.

9. The cost of the comprehensive plan is estimated as $208,135,000 of which $200,193,000 is for construction and $7,942,000 for lands and rights-of-way. Annual maintenance and operation is estimated as $3,703,000. Annual charges are estimated to total $11,943,000 and annual benefits $24,573,000. The ratio of benefits to cost is 2.05. The district engineer is of the opinion that the plan proposed provides for the most feasible and economical solution of the flood control and related water problems in central and southern Florida and that it should be adopted to provide the flood protection urgently needed, and as a long-range plan for control and use of the water resources of the area. In view of the large benefits from land improvement, estimated as $15,855,000 per year, he believes that local interests should be required to make a cash contribution of $29,152,000 toward the initial cost of the project and in addition provide without cost to the United States, all lands, easements, and rights-of-way necessary for the construction and operation of the project and bear the cost of maintenance and operation of all features except that the cost of maintenance and operation of the control works, levees, channels, and navigation locks of the St. Lucie Canal, Lake Okeechobee, and Caloosahatchee River should continue to be borne by the Federal Government. As coordinated operation of certain major features of the plan would be essential, he believes that the Federal Government should maintain and operate, at local cost, levees, canals, pumping stations, and control works, not essentially of a local character, in cooperation with appropriate State and local agencies.

10. He accordingly recommends modification of the existing Federal project for Caloosahatchee and Lake Okeechobee drainage areas to provide for the comprehensive plan for flood control and other purposes in central and southern Florida as proposed in his report at an estimated Federal cost of $171,041,000 for construction and $669,000 annually for maintenance and operation, *Provided:* That the Federal Government operate and maintain certain works subject to the condition that local interests pay the cost; that local interests furnish assurances that they will provide all lands, easements and rights-of-way and will pay such cash contributions as may be required; and hold and save the United States free from damages due to the construction works. The division engineer concurs in the recommendation of the district engineer.

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

11. Local interests were informed of the views and recommendations of the reporting officers and, at their request, were given an opportunity to express their views relative to the proposed comprehensive plan at a public hearing held locally by the Board. Both United States Senators and the Governor of Florida attended the hearing and, together with a large majority, indicated their general approval of the plan. Certain interests who endorsed the plan as a whole requested its approval by the Board with provision for making minor modifications they considered desirable. Extension of the project works to include protection for several small islands in Lake Okeechobee, for lands south of Tamiami Trail and along Indian River was requested. Maintenance and operation of the project works by local interests were considered desirable by some witnesses. Subsequent to the hearing the Board made an inspection tour through the east-coast, Everglades, and Lake Okeechobee areas. The Board was impressed by the fertility of the agricultural lands now in use, by the great potential productivity of lands yet undeveloped, and by the unusual vulnerability to floods and drought of the area in general.

12. The comprehensive plan of improvement proposed by the reporting officers provides flood protection for agricultural and grazing lands and for the important east-coast urban areas of Florida. In addition it provides for drainage and water control of vast areas of developed and potential agricultural lands. The need for flood control is clearly indicated by the extensive damage from the flood in 1947 alone, which amounted to $59,000,000. Farming of the fertile lands of the Everglades has been attempted on a relatively small scale and has proved highly successful in those portions where water-control facilities have been installed. The extension of this agricultural development to additional suitable areas will benefit both local interests and the Nation as a whole. Its accomplishment requires a carefully planned system of major drainage, and water and flood-control improvements.

13. Evidence presented at the hearing by individuals and organized groups shows that much concern has developed relative to the exact location and effect of the improvements on their respective lands and holdings and to the time that will elapse before the various works are completed. In considering these matters, the Board notes that the report clearly sets forth the principal objectives which have been taken into account in the preparation of the plan. It feels that such further refinement of the plan as will be required prior to construction should be undertaken in cooperation with a responsible local or State agency and that modifications necessary to conform to the desires of local interests should be made insofar as they are justified and do not adversely effect the principal objectives of the plan. As to the order of execution of the works, the Board believes that the first phase of the project should consist of the principal structures required for protection of the east-coast area and the principal works necessary to control lake levels and reduce flood damage in the improved area south of Lake Okeechobee. Detailed planning for project features in the

upper St. Johns and Kissimmee areas should also be included in this phase.

14. The lands on Kreamer, Ritta, and Torry Islands in Lake Okeechobee are subject to inundation and excessive seepage at times of high lake levels, but they cannot be protected adequately at reasonable cost. The Board recognizes, however, that these islands while small in area are rich and productive for agricultural use, and believes that they can continue to be farmed profitably at the risk of local operators. Consequently, the Board recommends that no provision be made for the protection or abandonment of the islands in Lake Okeechobee and that local interests be permitted to make such use of these islands as they may desire at their own risk.

15. The plan proposed by the district engineer will cost $208,135,000 for construction and $3,703,000 annually for maintenance and operation. Benefits from prevention of flood damages are estimated at $8,251,000 per year, from improvement of property at $15,855,000, from navigation at $176,000, and from preservation of fish and wildlife at $291,000, a total of $24,573,000 annually. The Board concurs with the district engineer that, in view of the large local benefits, local interests should be required to participate in the construction to the extent of furnishing all lands and rights-of-way and making a cash contributon of $29,152,000. As the construction work will extend over a long period of years the lands and rights-of-way should be furnished as and when needed. Contributions likewise should be required from time to time as the work progresses. It is felt that the additional investigations and the preparation of detailed plans for construction work should be undertaken by the Federal Government without local interests being required to contribute toward the cost, but for any part of the work carried to the construction stage a contribution should be required, prior to construction, in the amount of 15 percent of the construction cost, which is the approximate relation to the total contribution noted above to the total construction cost less the amount required for advance planning, lands, and rights-of-way.

16. The Board is of the opinion that the principal control and protection works of the plan should be maintained and operated by the Federal Government at Federal cost. These include the levees, channels, locks, and control works of the St. Lucie Canal, Lake Okeechobee, and Caloosahatchee River, and the main spillways designed for control of water levels in the conservation area. The average annual cost of maintenance and operation of these improvements is estimated as $749,000, which includes $326,800 for maintenance and operation of the existing Federal works. The remainder of the improvements should be maintained and operated by local interests at local cost.

17. The Board recommends modification of the existing Federal project for the Caloosahatchee and Lake Okeechobee drainage areas to provide for further improvement in the interests of flood control, drainage, and related purposes, generally in accordance with the district engineer's comprehensive plan for flood control and other purposes in central and southern Florida, with such modifications thereof as in the discretion of the Secretary of the Army and the Chief of Engineers may be advisable, at an estimated cost to the United States of $171,041,000 for construction and $749,000 annually for main-

tenance and operation, subject to the conditions that local interests shall provide all lands, easements and rights-of-way; make a cash contribution of 15 percent of the estimated construction cost for each part of the work prior to its initiation, except that the total cash contribution for the comprehensive project shall not exceed $29,152,000; and furnish assurances satisfactory to the Secretary of the Army that they will hold and save the United States free from damages due to the construction and operation of the works and that they will maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army, except the levees, channels, locks and control works of the St. Lucie Canal, Lake Okeechobee, and Caloosahatchee River and the main spillways of the conservation areas.

For the Board:

R. C. CRAWFORD,
Major General,
Senior Member.

REPORT OF THE DISTRICT ENGINEER

SYLLABUS

The river basins in central and southern Florida which are affected by this report cover 15,570 square miles, including the drainage areas of upper St. Johns River, North Fork of St. Lucie River, Kissimmee River, and other tributaries to Lake Okeechobee, Caloosahatchee River, St. Lucie Canal, the Everglades, and numerous coastal drainage areas from Brevard County southward to lower Dade County. Local interests have requested that the United States provide water control works throughout the area to collectively provide an interrelated and comprehensive system of water control sufficient to prevent recurrence of disastrous flooding such as occurred in 1947.

The district engineer finds that tremendous benefits are attributable to such a plan in prevention of flood damages and in enabling higher and more extensive use of areas now subject to flooding. He finds that all principal area divisions of the proposed improvement show economic justification. He finds considerable benefits attributable to collateral uses such as navigation; conservation of wildlife, water, and soil resources; amelioration of salt-water intrusion in coastal areas; and improvement of ground-water levels for agriculture.

The district engineer recommends that the existing Federal project for the Caloosahatchee River and Lake Okeechobee drainage area, be modified and extended to provide the comprehensive plan for flood control and other purposes in central and southern Florida, as proposed in this report, subject to the stated provisions of local cooperation.

DEPARTMENT OF THE ARMY,
UNITED STATES ENGINEER OFFICE,
Jacksonville, Fla., December 19, 1947.

Subject: Comprehensive report for flood control and other purposes in central and southern Florida.

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

I. INTRODUCTION

1. *Authority.*—This report is submitted in compliance with certain provisions of Flood Control and River and Harbor Acts which authorize preliminary examinations and surveys for flood control and related purposes of rivers, lakes, and canals in central and southern Florida,

and with several resolutions of appropriate congressional committees, and which request reviews of previous reports on the Caloosahatchee River and Lake Okeechobee drainage areas with a view to determining whether the existing Federal project should be modified. These specific congressional authorizations are listed in appendix A.[1] Since the several authorizations cover the entire area of central and southern Florida which has interrelated flood problems, the district engineer has been authorized to cover these authorizations in a single comprehensive survey report.

2. *Scope.*—(*a*) The flood problems of central and southern Florida are closely interrelated with the development of water and land resources of the entire area; this report therefore considers all related problems of water control and use. Such a comprehensive approach was authorized by the Chief of Engineers as a result of numerous conferences held in 1946 and 1947 and was confirmed by letter of November 14, 1947.

(*b*) This authority permitted the district engineer to cover in his surveys the geographical area necessary to insure a coordinated study of the problems as a whole from an engineering and economic standpoint, within the limits of congressional authorizations for examinations and surveys. As a result, the survey and report in its geographical scope covers that part of central and southern Florida lying generally south of the latitude of Cape Canaveral and east of the divide which separates drainage into the Atlantic from that flowing to the Gulf of Mexico.

(*c*) In its scope the comprehensive plan presented in this report is modification and extension of the existing Federal project for improvement of the Caloosahatchee River and Lake Okeechobee drainage area, originally authorized by the River and Harbor Act of July 3, 1930.

(*d*) Prosecution of the survey and preparation of this report has been based upon voluminous records of previous surveys and studies made by the Corps of Engineers, supplemented by additional field surveys and investigations, hydrographic studies, aerial mapping, and flood-damage surveys to bring the basic physical and economic information up to date. Full use was made of the studies and reports of other Federal agencies, such as the Soil Conservation Service of the Department of Agriculture, the United States Geological Survey of the Department of the Interior, and the Florida Geological Survey. In addition, a great mass of basic information was available from the reports and records of the Everglades drainage district of the State of Florida, and from counties, subdrainage districts, and other local agencies.

3. *Prior reports.*—(*a*) Early reports: The rivers, lakes, and marshlands of central and southern Florida, and particularly the region known as the Everglades, have been the subject of a large number of studies, surveys, and reports by Federal and local agencies for 100 years. This interest in the problems of control of the waters and use of the lands of the area began in 1847–48 with the preparation of the first report on the entire Everglades area by Mr. Buckingham Smith, an agent appointed by the Secretary of the Treasury to procure "authentic information in relation to what are generally called the 'Ever Glades' on the peninsula of Florida." More than half a century

[1] Not printed.

later, certain studies and reports, authorized by the State of Florida, furnished information under which drainage and flood control improvements were initiated by the State and local agencies. As the extent of Federal interest in this area became apparent, generally from the standpoint of improvement of navigable waterways, numerous surveys and reports were made by the War Department covering Lake Okeechobee, the St. Johns, Kissimmee, and Caloosahatchee Rivers, and adjacent areas.

(*b*) Current reports: When the seriousness and scope of the flood control and major drainage problems in this area were emphasized by the disastrous hurricanes and floods of 1926 and 1928, additional surveys by the Corps of Engineers of the War Department resulted in the report of March 15, 1930, on the Caloosahatchee River and Lake Okeechobee drainage areas, published as Senate Document No. 115, Seventy-first Congress, second session, on which congressional authorization of the existing project for flood control and navigation was based. More recent studies and reports of the Corps of Engineers have resulted in certain modifications of the project, and in the procurement of a large amount of engineering and economic information of basic value in the solution of the problems of the area.

(*c*) The prior reports and studies, both published and unpublished, which have been utilized in preparing this report, are listed in appendix A.[1]

II. DESCRIPTION

4. *General area.*—The area considered in this report lies entirely in the State of Florida and covers the central and southern part of the State south of the latitude of Cape Canaveral and the city of Orlando, and generally east of the ridge which divides the waters which flow into the Atlantic from those which reach the Gulf of Mexico. The individual drainage basins included in this area constitute, for all practical purposes, a single watershed as in most cases their waters intermingle during periods of heavy rainfall and their problems of water control and use, as well as their economic problems, are closely interrelated. This area includes some 15,570 square miles. The area has been divided into subdivisions from north to south to facilitate the report.

5. *The upper St. Johns River and related areas.*—The headwaters of the St. Johns River form in a flat area of lakes, marshes, and prairies, mostly in Indian River County; the area is separated from the saline Indian River by a low coastal ridge 3 to 10 miles wide and ranging up to elevation 30. Astride this ridge and extending westerly into the St. Johns marshes are numerous drainage district levees which cut off natural drainage to Indian River during flood periods. This flat area varies from 22 to 24 feet above sea level, although some elevations up to 80 feet are found along the western dividing ridge. Direction of drainage is largely indeterminate and differences in rainfall over parts of the area, as well as the direction of winds, divert flows either westward toward the Kissimmee, southward toward the St. Lucie River, or to north and east where waters collect to form the St. Johns. Open water and the beginnings of the channel of the St. Johns River appear first in the latitude of Melbourne; thence northward the river follows

[1] Not printed.

a tortuous channel interrupted by a number of lakes until a more definite channel develops below Lake Harney. The part of the St. Johns River considered in this report is that lying south of Lake Harney. The southern part of this flat area merges imperceptibly with the drainage influence of the North Fork of St. Lucie River, the channel of which is not well defined until near its tidal outlet. At the extreme southern end of the area and across the course of the present St. Lucie Canal lie the Allapattah Flats, a slough which originally connected with the waters of Lake Okeechobee by seepage or overland flow.

6. The uniformly flat lands of this entire area are without predominant slope. They are generally grassy prairies through which streams and sloughs meander. The northern or upper St. Johns River section is practically treeless except on the sides of the basin, and growths of pine, other timber, and densely wooded marshy areas are to be found in the southern part toward Allapattah Flats and the St. Lucie River. The soil of the area is generally sand and clay with some extensive muck lands, all of which is underlain by sedimentary deposits of various limestones.

7. *The Kissimmee River Basin and related areas.*—This part of the area under consideration embraces the Kissimmee River Basin, and its headwater lakes, including those on the low- indeterminate divide between the St. Johns and Kissimmee Rivers. The drainage area of Lake Istokpoga, the section known as the Indian Prairie, and the basin of Fisheating Creek, as well as certain minor streams such as Taylor Creek, are also physically and economically a part of the Kissimmee Basin. This entire area of about 4,375 square miles drains into Lake Okeechobee from the north and northwest.

8. The original source of the Kissimmee River was in Lake Kissimmee, but channel and drainage work between headwater lakes in the upper basin and on the divide between it and the St. Johns now place the source of the Kissimmee in several small streams which rise southerly of the city of Orlando. The air line length of the basin from its headwaters to its outlet in Lake Okeechobee is about 106 miles, but the river's course through lakes and winding channels traverses about twice that distance. The basin is bounded on the west by a fairly high, sandy ridge, where elevations reach from 150 to 300 feet above sea level. This ridge separates the Kissimmee Basin from the basin of the Peace River which drains to the Gulf of Mexico. On the east a low, poorly defined ridge about 1 to 4 miles wide separates the Kissimmee Basin from the headwater areas of the St. Johns and St. Lucie Rivers.

9. The entire Kissimmee Basin, and related areas between the limits described above, is generally flat with a gentle slope southerly toward Lake Okeechobee, and is dotted with shallow lakes and interconnecting sloughs and channels. Elevations of as much as 100 feet above sea level are reached in the gently rolling headwater areas north of Lake Kissimmee, where extensive areas of swampy timberland are interspersed with flat pinewood lands, pastures, and cultivated areas. Lake Kissimmee lies at an elevation of about 52 feet above sea level from which the river flows to Lake Okeechobee with a minimum elevation of about 12.5 feet above sea level. Southward of Lake Kissimmee the basin land is usually characterized as prairie, and is generally quite flat. Soils of the entire Kissimmee Basin are largely sand and sandy loam, with some muck areas on top of clay and marl formations.

Extensive cultivated areas lie along the western border of the basin and in the Lake Istokpoga section. However, aside from scattered areas and hammocks of pine, oak, cypress, and cabbage palms, the level expanse south of Lake Kissimmee consists of prairie grasslands, with some areas of sawgrass and palmetto.

10. *Lake Okeechobee and its outlets.*—Lake Okeechobee which receives most of the waters which accumulate in the Kissimmee Basin and connected areas, lies about 30 miles from the Atlantic coast and 60 miles from the Gulf of Mexico. It is a large, roughly circular fresh-water lake about 730 square miles in area. Much of it is very shallow, and the deepest parts extend only to about sea level. The average elevation of Lake Okeechobee is about 13 feet mean sea level.

11. In its former natural state Lake Okeechobee had no well-defined outlet; its rising waters would spread over the vast Everglades area to the south, or spill slowly into the flat areas west of the lake and find their way to the Caloosahatchee River, or escape by seepage and some overland flow to the Allapattah, Hungryland, and Loxahatchee Sloughs to the east.

12. Under present conditions Lake Okeechobee has been impounded by levees which block escape of its waters into the Everglades; its present outlets are the the St. Lucie Canal and the Caloosahatchee River which have been constructed and improved to afford a continuous navigable channel across the State and to provide a measure of control of lake levels.

In previous reports and other documents on Lake Okeechobee and its environs, elevations of the lake and its project works were referred to a so-called Lake Okeechobee datum, the zero of which was established as 1.44 feet below mean sea level. In order to bring all elevations in the area into conformity, beginning on July 1, 1947, all elevations in this and future reports of this office (unless otherwise specified) are referred to standard mean sea level as used by all other interests in the area. When desired, mean-sea-level elevations can be approximately converted to Lake Okeechobee datum by adding 1.5 feet, and vice versa.

13. *The Everglades.*—In its original state the region now known as the Everglades was a vast solitude of sawgrass and water and was aptly termed by its Indian inhabitants the "Pa-hay-okee" or "grassy water." Under natural conditions the waters of Lake Okeechobee would rise over the southern rim of the lake, push through the dense growth of custard-apple and other growth which formed that rim, and move slowly southward through the dense sawgrass marsh. These waters would mingle with the tremendous amount of rain water standing over the flat expanse of the Everglades and flow slowly through the grass and other vegetation to escape eastward through a few small rivers which flowed through the east-coast barrier ridge, or to pass eventually to the sea through the marshes and tangled mangrove thickets which mark the southern tip of the Florida Peninsula.

14. This grassy marsh is some 40 miles wide on the average and extends about 100 miles from Lake Okeechobee to the sea at the southern end of Florida; arms of the Everglades also extend partly around the eastern and western shores of Lake Okeechobee. It lies in a trough of sedimentary limerock and is bordered on the east by a narrow coastal ridge which attains elevations up to 13 feet above sea level. On the west the Everglades are bounded by sandy ground

which rises to an elevation of about 25 feet above sea level and embraces the areas known as the Devil's Garden and Big Cypress Swamp.

15. The continuous growth and decay of the sawgrass and other vegetation over long periods of geologic time has resulted in the deposit of peaty muck which now composes the soil of the Everglades. Present general elevation of these mucklands at Lake Okeechobee averages about 17 feet above mean sea level, while at the latitude of Miami the ground surface of the Everglades is only from 6 to 7 feet above sea level. From that point it slopes imperceptibly to the mangrove and salt marshes at the end of the peninsula. The depth of the muck over the rock decreases generally from about 8 to 14 feet at Lake Okeechobee to about 1 foot in the latitude of Miami. The soil and geology of the Everglades have been described and investigated in detail by the Soil Conservation Service of the Department of Agriculture in its report of 1947.

16. The original condition of the Everglades has been greatly altered by the development of drainage and flood-control works, first by State and local interests and later by the Federal Government. At present that portion of its mucklands, which has been afforded a degree of drainage and protection, constitutes one of the richest agricultural areas in the world. The problems of water control over this unique area, however, have not yet been solved and are considered in detail in this report.

17. *The coastal areas.*—In West Palm Beach, Broward, and Dade Counties the coastal ridge which forms the eastern border of the Everglades is a strip of sandy land varying from 5 to 10 miles in width. It is in general a highly developed urban and agricultural area. South of Miami in Dade County this coastal area widens as the Everglades bend to the west to include a newly developed, rich agricultural area that extends almost to the southern coast. Streams and artificial drainage channels in this area are short and flow directly into the coastal lagoons which follow this entire coastline from Lake Worth to Biscayne Bay. The generally low elevation and flat topography of most of the coastal area results in slow run-off of excess water and in generally poor natural drainage. Heavy and prolonged rainfall accumulates and stands for long periods on much of the land unless removed by drainage works; this frequent flooding has been and is one of the greatest handicaps to full development of the potentialities of the area. During the summer and fall of 1947 most of the land in the area was submerged by the worst such flood in many years. This condition will be discussed in more detail later in this report.

III. ECONOMIC DEVELOPMENT

18. *General.*—The area under consideration in this report has developed in the past 50 years from an almost unknown wilderness. It contains some of the richest and most productive agricultural areas in the United States. In spite of this advance in economic status and its great future potentialities, large parts of this area remain thinly populated and undeveloped. Details regarding the economic development of this area are set forth in appendix B [1] and are summarized in the following paragraphs.

[1] Not printed.

19. *Population.*—The resident population of the 18 counties included in or tributary to this area has increased from 367,219 in 1930 to 727,097 in 1945 (appendix B).[1] These figures do not include winter residents and tourists who double the population of east coast centers during the winter season, or migratory workers who greatly increase the population of the Lake Okeechobee area during the period of heaviest crop production, which is also in the winter. As a general rule, the bulk of the permanent population is concentrated along the east-coast ridge and the eastern margin of the Everglades, and around Lake Okeechobee and on the borders of the Kissimmee River Basin. Wide interior areas are devoted largely to pasture lands and remain sparsely settled. The population in the Okeechobee-Everglades area (Palm Beach, Broward, and Dade Counties) has grown as follows:

1910	17,510	1940	378,522
1920	66,542	1945	477,891
1930	214,830		

20. *Agriculture.*—Details regarding land use and potentialities are shown in appendix B [1] and are based on data developed by the United States Department of Agriculture, the Florida State Department of Agriculture, and investigations throughout the area. These data show that production of vegetables, sugarcane, ramie, and citrus fruit, and cattle raising are the predominant agricultural activities of the area. Farming in the fertile but flat muck soils of the Everglades can only be successfully carried on if the fields are surrounded by dikes to prevent overflow by high water in the canals or on the surrounding lands and if reversible pumps are provided to pump water from the fields into the canals in wet periods and water from the canals onto the fields in dry periods, so as to maintain a favorable ground-water elevation in the soil during the growing season. This method is universally used throughout the developed Everglades area.

(*a*) Cattle raising is the predominant activity throughout the greater part of the Kissimmee Basin and on the pasture lands provided by the prairies and marshes of the upper St. Johns and North Fork of St. Lucie River. In recent years, extensive cattle-raising activity has spread into parts of the Everglades west and south of Lake Okeechobee and along the eastern and western margins of the Everglades in Palm Beach, Broward, Dade, Collier, and Hendry Counties. Growth of the cattle industry has been augmented by the introduction of grasses which have proved suited to the climate and more nutritious than native prairie grass. Importation and development of higher quality stock has also greatly improved the industry. Further improvement along these lines appears likely. About 50 percent of the land in the area under consideration is devoted to cattle raising, or will probably eventually be used for that purpose. The cattle industry in the area has grown from a total of about 95,000 head in 1930 to about 410,000 head in 1947. Following the flood of 1934 several years were required to return the industry to a normal rate of growth. A decline of about 25,000 head is indicated as a direct result of the 1947 flood; however, this number does not reflect the loss of next spring's anticipated calf crop. About 120,000 head of cattle are marketed from this area each year for a gross value of over $6,000,000.

[1] Not printed.

Thousands of acres of flat woodland are held in reserve to provide for emergency pasture when the more valuable lowlands are flooded. With the provision of flood control and adequate water control, this reserve pasture would be no longer required and could be placed into more useful production. The cattle industry, however, has developed in spite of serious set-backs such as the conditions for example during 1947, when flooded pasture lands caused the loss of many cattle and the sale and evacuation of entire herds. In addition, water standing on the pasture lands has made the grass unfit for consumption by cattle and has killed thousands of acres of planted grass. Representatives of cattle interests have also stated that the best strains of cattle will not thrive in permanently wet pastures. Consequently the future of the cattle industry in central and southern Florida is closely related to the control of water over this area.

(*b*) Truck farming: Production of vegetables accounts for use of about 160,000 acres (about 1.3 percent) of the area under consideration. However, the high value of these crops, due to the fact that in favorable years two or three successive crops can be produced during the winter, when fresh vegetables from other areas are very scarce, makes it one of the most important economic factors, and its related packing and processing activities afford a livelihood for a large part of the population. The muck lands immediately south of Lake Okeechobee provide the largest truck-farming area, although smaller productive areas are operated along the western border of the Kissimmee Basin, south of Lake Istokpoga, in scattered areas along the eastern border of the Everglades, and south of Miami in the vicinity of Homestead. High-value truck crops include beans, tomatoes, eggplant, cabbage, potatoes, celery, and many others. The total acreage of vegetable production has increased from 59,000 acres in the 1930–31 season to 160,000 acres during the 1945–46 season. A substantial portion of the increase in vegetable production has resulted from development of the fertile lands in the Lake Okeechobee area. The total value of truck produce from 160,000 acres in the area for the 1945–46 season was $67,000,000. Continuance and expansion of truck farming in this area is almost entirely dependent on prevention of overflows such as that of 1947, which caused widespread destruction of crops; on the proper regulation of ground-water levels; and, from a long-term standpoint, on correct land-use practices, as has been pointed out by the Department of Agriculture.

(*c*) Sugarcane and other products: The United States Sugar Corp. is the largest producer of agricultural products in the area. The corporation controls about 128,000 acres around the south and east shores of Lake Okeechobee, of which about 32,000 acres are under water control and producing sugarcane. A number of small producers grow cane which is harvested by the sugar corporation. Sugar mills of the corporation at Clewiston and Canal Point have daily capacities of 4,000 and 1,500 tons of cane, respectively. The Canal Point mill has not been in operation for several years and is now largely obsolete, the cane being shipped to Clewiston. Corporation officials state that a larger mill would be constructed near the eastern lake shore if definite assurances were given that prewar Federal sugar quota restrictions would be modified for postwar operations, and that a more profitable relationship between fixed prices of sugar and minimum labor wage scales would be permitted. The Okeelanta Growers

and Processors Cooperative are constructing a sugar mill south of Bolles Canal near South Bay. It is about 80 percent completed and the cooperative expects to begin grinding cane during the 1948 season. Members have about 5,000 acres of cane planted, which an official stated would be about the season capacity of the mill. In Indian River County at Fellsmere another sugar mill and refinery has been in operation for several years. They have about 10,000 acres planted to sugarcane. Negotiations for a fourth mill to be located at Moore Haven are reported to have been completed and a mill site purchased. Actual construction on the mill will begin in the near future. The total value of sugarcane grown in the area in 1945–46 is estimated at $11,764,000 from 40,000 acres.

(*d*) Ramie: A new crop of the area having considerable promise is ramie, an Oriental plant having a fibrous stalk which is processed into a high-grade textile fiber of unusually high tensile strength. To date most of the fiber has been used in bearing packings due to its resistance to wear. The leaves and nonfibrous stem components yield a protein-rich alfalfa substitute for stock and poultry feed. The proteins are also extracted commercially for use in foodstuffs and other purposes. The crop is particularly attractive to farmers in that it is a perennial and, like sugarcane, makes profitable use of the land the year round. Six to ten crops each year are harvested as the growth is very rapid. It is no more tolerant of excess water than are tender truck crops, however, and the loss due to flooding at any time is serious, since replanting is then required at considerable expense, whereas with no flooding one planting will produce for many succeeding years. Two ramie decorticating plants have been constructed in the area and considerable other capital has been invested in this enterprise. Those most familiar with the area and with ramie believe that the crop will be successfully produced in the area if water control is provided. There is a large demand for the fiber and the net return per acre will be second to that from sugarcane (which is about $120 per acre annually). About 3,000 acres have been planted for experimental purposes, with an additional 50,000 acres available for planting in the near future.

(*e*) Citrus fruits: Citrus fruits are produced in the area from the western and northern limits of the Kissimmee Basin to the Davie area southwest of Fort Lauderdale in the Everglades from existing groves of about 268,540 acres. In addition, the climate of the Homestead and Redlands areas south of Miami permits production of tropical fruits, such as avocados, which will grow in very few places in the temperate zone. Although citrus plantings in the low-lying lands in the area inundated by the 1947 flood are a small percentage of the total acreage in the State, they produce about 3,000,000 boxes annually for a net yield to growers of about $4,000,000 (based on average net returns for the past 5 years from the annual report of the Florida State Marketing Bureau). Early reports from county agricultural agents indicate a loss of about 53 percent of the trees inundated during the 1947 flood.

(*f*) Other agricultural activities include poultry raising, dairying, and the production of noncommercial crops.

21. *Forest products.*—Practically all the forest in this area is cut-over land, but stands of timber suitable for commercial use remain on the western borders of the Everglades, in the Kissimmee Basin, and in

Palm Beach and Martin Counties. An adequate program of reforestation is needed to restore to productive use large acreages of cut-over lands in this area which are now covered with scrub palmetto and brush.

22. *Industrial development.*—Principal industries are those devoted to the processing of agricultural products of the area such as the mills of the United States Sugar Corp. at Clewiston and the vegetable-packing houses at Belle Glade. Other industries are ice plants, sawmills, and other plants and commercial establishments which service the local population. Commercial fishing and processing of fish and other sea food is of substantial importance.

23. *Mining and petroleum products.*—There is no mining activity in this area except the operation of quarries for sand and limestone. Drilling for oil has been undertaken at various times and places throughout the area, generally without success on a commercial scale. It is understood, however, that a well in the Sunniland district in Big Cypress Swamp on the western border of the Everglades is now producing oil in commercial quantities, and drilling in other parts of the area is actively in progress.

24. *Recreational boating and sport fishing* are important commercial activities along the east coast and to a lesser extent in Lake Okeechobee. Over 200,000 passengers were carried in such activities during the prewar year of 1941.

25. *Urban development.*—The east coast section included in this area contains the cities of West Palm Beach, Fort Lauderdale, and Miami, as well as many smaller cities and towns. Along certain reaches of the east coast ridge, urban development is almost continuous. Several thriving towns, including Canal Point, Pahokee, Belle Glade, Clewiston, and Moore Haven, have sprung up around the southern rim of Lake Okeechobee, but there is little urban development in other parts of the area except on the high ridge along the western and northern borders of the Kissimmee Basin.

26. *Utilities.*—The entire area is adequately served by telephone lines. Waterworks and sewage-disposal plants, electricity, and manufactured gas are available in urban areas. Electric power is generally developed at central or Diesel electric plants and distributed by transmission lines.

27. *Transportation.*—The area is adequately served by the Seaboard Air Line, the Atlantic Coast Line, and the Florida East Coast Railways. Improved State highways connect all important towns and farming areas and many miles of farm-to-market roads extend into less-developed sections. Inland water transportation is available via the cross-State waterway provided by the St. Lucie-Lake Okeechobee-Caloosahatchee River system, and connection with ocean-going shipping can be made at several lower east coast ports. Commercial or municipal airfields are located at the principal cities and towns. Regular commercial air-line service is available at Miami and West Palm Beach.

IV. HYDROLOGY

28. The hydrology of central and southern Florida is set forth in detail in appendix C [1] and summarized in the following paragraphs.

29. *Climate.*—In central and southern Florida, and particularly south of Lake Okeechobee, the four normal seasons of the temperate

[1] Not printed.

zone are replaced by the two seasons, wet and dry, characteristic of the Tropics. Mean annual temperatures vary from 75° Fahrenheit at Miami to 72° at Kissimmee, and average about 73° for the entire area. The water areas provided by the lakes, marshes, and channels, and the proximity of the Atlantic Ocean and the Gulf of Mexico, temper the climate, and extreme temperature ranges are not great. Highest summer temperatures seldom exceed 100° and nights, particularly in the Everglades area, are very cool. Temperatures as low as 20° have been experienced, however, in the Lake Okeechobee area. Relative humidity is generally very high throughout the area. Normal winds are generally from the southeast.

30. *Rainfall.*—About 70 percent of the rainfall occurs from May through October, which is the wet season. In the spring and early summer, thunderstorms of local high intensity and short duration sweep over the area, followed quickly by hot sunshine. Showers occur almost daily, or perhaps several times a day, during July and August. Heavier and more prolonged rainfalls occur generally from August through October and are often intensified by tropical storms which occasionally reach hurricane proportions. Mean annual rainfall varies from about 58 inches at Miami to 51 inches at Kissimmee. Precipitation for the first 10 months of 1947 at Dania totaled 102.43 inches, and that at Fort Lauderdale 96.11 inches. Other stations in the area recorded similarly excessive precipitation. At the other extreme, the precipitation for 1945 at Miami totaled only 31.96 inches, and that at Fort Lauderdale even less. Such wide differences in annual and seasonal rainfall on the area indicate the difficulties involved in planning effective works for both drainage and water conservation. Rainfall during the six dry months averages about 2 to 3 inches per month; that during the wet season, about 7 inches per month. The most intense rainfall ever recorded in the area was 21.9 inches in 24 hours at Canal Point on Lake Okeechobee.

31. *Hurricanes.*—Central and southern Florida are in the path of tropical hurricanes which originate in the equatorial doldrums and move in from the Caribbean and Atlantic on curving paths at speeds of 10 to 40 miles an hour. The destructive forces of these storms are the winds whirling counter-clockwise about the storm centers at velocities reaching over 100 miles an hour. They are usually accompanied by intense rainfall. The majority of these storms strike the State in a westerly or northwesterly direction, although hurricanes of lesser intensity approach through the Yucatan Channel and cross the Gulf of Mexico to strike Florida from the southwest or west. The most dangerous hurricane season includes August, September, and October, although they have been experienced as late as November. The hurricane which struck Miami and the Lake Okeechobee area in 1926 caused severe property damage and large loss of life at Moore Haven, when waters of Lake Okeechobee were driven over that town. In 1928, a similar but more destructive storm struck from Palm Beach to the Lake Okeechobee area, where wind-driven lake waters overflowed the northern and southern lake shores and drowned about 2,300 people, producing one of the greatest disasters in the history of the country. In 1935, another high velocity hurricane caused loss of life and great property damage in the area of the Florida Keys. The

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two recent hurricanes of 1947, which struck the Everglades and Lake Okeechobee area after a long period of heavy rainfall, caused large property damage due to winds and heavy rainfall. The September 17 to 18 storm was accompanied by winds with sustained velocities of 65 miles an hour and gusts reaching 99 miles an hour at hurricane gate No. 2 at Clewiston. Sustained velocities over 100 miles an hour were reported nearer the center. That storm caused a small amount of erosion at the base of the levees constructed about Lake Okeechobee by the Corps of Engineers in 1934–36. The levees held firmly against the wind tide which reached a maximum elevation of 21.90 mean sea level (6.17 feet above the lake level) and wave heights estimated at 6 to 8 feet, trough to crest, thereby preventing any loss of life or property damage from lake waters. A number of lesser hurricanes have passed through the area without causing much damage.

32. *Evaporation.*—Evaporation and transpiration losses are very high throughout this area and particularly in the Okeechobee-Everglades area where large water surfaces are exposed. Estimates indicate an excess of average annual rainfall over evaporation of only 8.8 inches around Lake Okeechobee and about 12.3 inches in the Everglades. This balance varies considerably, however, from year to year and water losses due to evaporation and transpiration are less during the season of heavy rainfall. The effect of evaporation and transpiration is therefore an essential factor in the flood-control and water-conservation problem.

33. *Dry periods.*—During the winter and spring, periods of drought lasting from 2 to 3 months are common. At Belle Glade on the southern shore of Lake Okeechobee, only 1 inch of rainfall was recorded in a 4-month period (December 1938 to March 1939). In addition, it appears that there are alternating periods of years when precipitation is below normal, when the pasture lands and Everglades become quite dry; and periods of years of abundant rainfall when the entire area is saturated. The occurrence of cycles of this kind is not well defined by the relatively brief records available.

34. *Run-off and stream flow.*—(*a*) The generally flat topography of the area, its vegetation, and the absorptive nature of its soils combine to produce very low run-off characteristics. Long continued rains gradually saturate the soils and fill the natural lakes and sloughs. Natural stream channels, such as the Kissimmee River, are inadequate to carry off the water accumulated over large level areas. The water therefore spreads over the lower lands in a thin sheet and moves slowly as overland flow in the direction of the prevailing slope. In the areas where the slope is indeterminate the direction of winds and differences in rainfall distribution will change the direction of drainage. Artificial drainage outlets, pumping, and dikes are means used to accelerate this run-off.

(*b*) Much of the northern part of the area under consideration drains into Lake Okeechobee resulting in annual fluctuations in lake level which occasionally cannot be controlled within the prescribed limits of 12.56 and 15.56 mean sea level (14 and 17 lake datum) because of the limited capacity of the St. Lucie Canal and Caloosahatchee River. In addition, due to subsidence of muck lands in the Everglades, a considerable part of the area immediately south of Lake Okeechobee now drains back into it in wet periods. In the coastal and southern

areas, waters collecting over the Everglades spread eastward as well as southward, to inundate low urban areas in and adjacent to West Palm Beach, Fort Lauderdale, and Miami.

35. *Floods of record.*—Numerous floods have occurred throughout the area with increasing damages as development progressed. The most severe recorded in recent years occurred in 1924, 1926, 1930, 1934, 1941, and 1947. Detail stage and discharge data on these floods and others are presented in appendix C.[1]

36. *Extent and character of flooded area.*—The character of flooding is generally the same throughout this entire area. Flooding to some degree begins shortly after the first of June and often continues until November, and even later in certain localities. This flooding results from continuous rainfall over the flat area and is often aggravated by tropical disturbances and by inability of natural stream channels with little fall to remove the water. The areas subject to this overflow and the damages caused thereby vary considerably according to location.

(*a*) Upper St. Johns River and related areas: Characteristics of floods and flooded areas in the upper St. Johns Basin above Lake Harney and related areas to the north are generally the same as those of the Kissimmee Basin described below. Major floods which occur about once in every 6 years generally cover about 1,050,000 acres. Minor floods occur more frequently, covering about 100,000 acres. There is no urban development in this flood area except Sanford further downstream, but agricultural losses and damages to highways, farm property, and other miscellaneous damages average $2,077,000 annually, and the 1947 flood damages were $5,000,000.

(*b*) Kissimmee River Basin and related areas: The situation in the Kissimmee Basin and in related areas on Lake Istokpoga and Fisheating Creek is typical of the flood characteristics described above. Water accumulates on the flat lands, and the outlets of lakes such as Kissimmee and Istokpoga are entirely inadequate to permit even the slow run-off from tributary areas during major storms. Similarly, the winding shallow channel of the Kissimmee River cannot handle the run-off from the entire valley without the flooding of large areas.

(*c*) The area in this basin actually inundated by major floods such as that of 1947 is estimated at 598,000 acres. Included are parts of the towns of Kissimmee (population 4,010 in 1945), and St. Cloud (population 1,202 in 1945), and several small settlements. Most of the area is pasture land devoted to cattle raising, but rich truck-farming areas around Lake Istokpoga and at other points are also included. Such major floods have occurred at a frequency of about one in 6 years. Minor floods occur with greater frequency and overflow as much as 150,000 acres. Water remains on the land from 1 to 6 months.

(*d*) Urban losses in the Kissimmee-Fisheating Creek area are quite small but agricultural losses, particularly those to the cattle-raising industry, are substantial. In 1947 these amounted to about $4,000,000, and the smaller flood of 1934 caused damages estimated at about $2,000,000 based on current values. Average annual damages, including those of more frequent minor floods, have been estimated at $1,500,000.

[1] Not printed.

(*e*) Lake Okeechobee and the upper Everglades: The flood characteristics of the Lake Okeechobee-upper Everglades area differ from those of the area to the north and are unique. In its natural state all of the area around the rim of Lake Okeechobee, except the sandy ridge above the northeastern shore, was subject to overflow from the normal raising of the lake levels due to local rainfall and inflow from the north. Levees and outlet canals constructed by the Federal Government now protect the eastern, southern, and western shores from direct overflow from the lake. Prior to construction of these works, hurricane-driven tides of Lake Okeechobee were a serious hazard to life and property in this area. The storms of 1926 and 1928 caused heavy loss of life and severe property damages.

(*f*) The level lands of the Everglades and all of the towns lying generally south of the lake perimeter are still subject to destructive flooding by continued heavy rains over the area, which existing artificial channels and pumping plants cannot remove. The area is also subject to flooding by overland flow of waters accumulating on wild lands lying east of the lake and south of the St. Lucie Canal, and by overland flow from areas to the west. These waters fill up the canals so that pumping of excess water from diked farms is impossible, and pile up against local farm and subdrainage-district dikes, cause them to fail, and inundate thousands of acres of truck-farming and sugarcane lands.

(*g*) Damages from overflows in the upper Everglades around Lake Okeechobee have been very large and constitute a serious obstacle to continued development. In 1947, flood damages in this area aggregated $8,000,000 and smaller flood damages occur every year. Average annual flood damages in the Okeechobee-Everglades area are estimated at $4,130,000.

(*h*) The coastal area: Most urban east-coast areas from West Palm Beach to Miami are subject to flooding by local rainfall and by overflows from the Everglades. At West Palm Beach (population 40,599 in 1945), flooding during 1947 was confined largely to outlying suburban areas. At Fort Lauderdale (population 26,185 in 1945) over 30 percent of the city was inundated and the flooded area included the main business district, railroads, industrial sections, and residential sections. Large areas in the western part of the city of Miami (population 192,122 in 1945) and the outlying communities of Miami Springs and Hialeah were flooded. Damages were incurred to roads, utilities, railroads, and airports.

Prompt and continued relief activity by the Red Cross was necessary in these areas to care for many people driven from their homes. While the total overflow area along the coast is not great in comparison with that in the inland agricultural sections, the concentration of population and property in those areas produce large damages when floods occur. Part of the damage in those areas may be attributed to the ineffectiveness of local canals and protective works which had not been properly maintained by local interests or protected from encroachments. Damages of the 1947 floods to the east-coast areas of Dade and Broward Counties are estimated at $41,895,000 and, as these areas will inevitably grow and expand even without adequate flood protection, larger damages may be expected unless preventive measures are taken. Average annual flood damages in the east-coast and lower Everglades area are estimated at $3,857,000.

(*i*) An unusual flood situation exists south of Miami in the area south of Perrine, which includes Homestead and other towns and some 44,000 acres of cultivated lands. About 6,000 acres of that area are subject to flooding, both by waters of the Everglades which spread into it from the west and by storm-driven tides from the Atlantic which spread salt water over the lands and cause heavy damages to croplands and groves.

37. *Standard project flood.*—The October 1941 storm which centered in north-central Florida was selected for the project storm from which rainfall area-depth curves were used to determine the design rainfall. It was found uneconomical to design for the total rainfall of the project storm; therefore 30 and 50 percent were used for design purposes in the Kissimmee Basin and St. Johns Basin, respectively. The resulting run-off was found to equal about the maximum flood of record in each instance. In the Everglades and coastal areas the design was predicated upon various rates of run-off removal as determined by the land use (appendix C).[1]

V. EXISTING PROJECTS

38. *Projects of the Corps of Engineers.*—Existing projects in the areas which are under the jurisdiction of the Secretary of the Army and supervision of the Chief of Engineers are summarized below:

(*a*) Upper St. Johns River: There are no existing Federal improvements in the upper St. Johns River area above Lake Harney.

(*b*) Kissimmee River: The existing Federal navigation project on the Kissimmee River provides for a channel 30 feet wide and 3 feet deep at ordinary low stages, extending from the town of Kissimmee to Fort Bassenger about 37 miles above the mouth of the Kissimmee River. An extension of this channel up Istokpoga Creek is also a part of the project. The total length of the channels is about 109 miles. This project is inadequate for any navigation except skiffs and shallow-draft motorboats, and no funds have been spent on the project since 1928. Past expenditures by the United States on this minor project have been $23,500 for new work and $25,000 for maintenance.

(*c*) Caloosahatchee River and Lake Okeechobee drainage areas: The existing Federal project for the Caloosahatchee River and Lake Okeechobee drainage areas was authorized and modified by a number of river and harbor acts of the Congress from the act of June 25, 1910, to that of March 2, 1945. The bulk of the work, however, which included the present navigable channel across the State and works for control of Lake Okeechobee was authorized by the River and Harbor Act of July 3, 1930. The comprehensive plan of improvement set forth in this report is a necessary modification and extension of the present authorized project. Since this project, as modified and extended in scope, will serve the purposes of flood control and water conservation to a greater degree than its original purpose of navigation, it is treated as a flood-control project and is set up to conform to the laws and procedure of flood-control work, except that the further maintenance and improvement of the navigable waterways will be treated as river and harbor work.

(*d*) The existing project for the Caloosahatchee River and Lake Okeechobee drainage areas provides for a navigable waterway with a

[1] Not printed.

depth of 8 feet from the Intracoastal Waterway at St. Lucie Inlet on the Atlantic coast across the State by way of St. Lucie Canal, Lake Okeechobee, and the Caloosahatchee River to the Gulf of Mexico at Punta Rasa, with a number of connecting channels. The total length of this cross-State waterway is almost 155 miles. In addition to its navigation feature, this project includes control works in the St. Lucie Canal and Caloosahatchee River for regulating levels of Lake Okeechobee, and levees around the southern and northern shores of Lake Okeechobee having a total length of about 68 miles. Hurricane gates are provided in the levees at five points where local drainage canals leave the lake and where Taylor Creek enters it on its northern shore. Present operating procedures for control of Lake Okeechobee contemplate a range of lake stages of from 12.56 to 15.56 feet above mean sea level (14 to 17 feet former Okeechobee datum). The existing project is essentially complete, except for deepening the authorized channels from the existing depth of 6 feet to 8 feet and completing certain modifications of control structures.

(*e*) Harbor improvements: Authorized harbor and channel improvements in this area are at Canaveral Harbor, Fort Pierce Harbor, St. Lucie Inlet, Lake Worth Inlet and port of Palm Beach, Hollywood Harbor (Port Everglades), Miami Harbor, all on the east coast. At Fort Myers, on the west coast, there is an authorized Federal project for a turning basin and a channel to the municipal yacht basin to serve shallow-draft navigation, consisting principally of pleasure craft, but construction has not been started. Since these harbor projects are only indirectly affected as a general rule by the plan of improvement considered in this report, further details of their character and cost are not given.

(*f*) New River: The River and Harbor Act of 1945 authorized minor improvement of the New River and its south fork in Broward County at an estimated cost of $69,000. No work has been done on the project to date.

(*g*) Removal of water hyacinths and such other vegetation from navigable fresh-water streams, canals, and lakes in this area is authorized by Congress. This work is a continuous program. The total cost to June 30, 1947, for the entire Jacksonville district has been about $913,000 and the latest approved annual expenditure for this work is $75,000. While the greater portion of the funds are expended on the northern half of St. Johns River, the latest annual working estimate for the area covered by this report is $8,400.

(*h*) Snagging and clearing and emergency flood protection: Under its authority for improvement of navigable streams for snagging and clearing and for emergency flood fighting and protection, the Corps of Engineers expended over $422,000 in this area for emergency work during the floods of 1947 up to December 15. This emergency work was performed by cooperative action on the part of the Federal Government and local interests and resulted in a substantial degree of flood relief. Some of the emergency work performed will be useful as a part of improvements for flood control proposed in this report.

39. *Projects of other Federal agencies.*—(*a*) The Soil Conservation Service of the Department of Agriculture has cooperated with the agricultural experiment station, University of Florida, in preparing an exhaustive study of soils and water control in the Everglades region. The report on this study was completed in 1947.

(*b*) The United States Geological Survey of the Department of the Interior worked in cooperation with the Soil Conservation Service in developing the geology of the Everglades region, for incorporation in the study referred to above.

(*c*) The National Park Service of the Department of the Interior administers the Everglades National Park, which embraces some 454,000 acres of wild land in Dade, Monroe, and Collier Counties at the extreme southern tip of the peninsula. Funds for acquisition of lands for this national park were furnished by the State of Florida, and it was formally opened on December 6, 1947.

(*d*) The Fish and Wildlife Service of the Department of the Interior supervises the game-refuge features of the Everglades National Park and is interested in the preservation of fish and wildlife throughout this area.

(*e*) The Office of Indian Affairs of the Department of the Interior supervises generally the Indian population living in and on the margins of the Everglades. One reservation area, located in Glades County, would receive water-control benefits by the plan of improvement described in this report which includes improvement of both Indian Prairie and Harney Pond Canals which pass through the reservation. Another reservation area in southeastern Hendry County has begun a promising program of cattle raising. The area is adjacent to a recommended canal which would flow southward to Tamiami canal. Amelioration of pasture flooding and better water-table control would be provided by the canal and its several control structures.

40. *Projects of local interests.*—(*a*) State of Florida: Much of the land of the area covered by this survey and report was transferred by the United States to the State of Florida by reason of the Swamp and Overflowed Land Grant Act of September 28, 1850. By this act the Federal Government turned over to the several States, including Florida, certain public lands designated as swamp and overflowed lands. Under this grant Florida received over 20,000,000 acres. The Everglades, embracing some 2,800,000 acres, was the largest single unit of this land.

(*b*) A condition of the grant by the Federal Government was that the proceeds from sales of the lands would be applied exclusively, so far as necessary, to reclaiming them by means of levees and drains. In order to carry out its part of this bargain, the State organized by legislative act in 1855 an "internal improvement fund of the State of Florida," and appointed State officials as trustees to supervise the administration of the swamp and overflowed lands and the funds received from their disposal. Subsequent acts of the State legislature in 1905, 1907, and 1913 created an agency known as the Everglades drainage district, with power to tax and issue bonds and to use funds accruing from sale of land to carry on drainage work within its specified limits. This district has carried on drainage operations in the Everglades up to the present time. In 1929 the Florida State Legislature created the Okeechobee flood-control district to furnish the local cooperation required by the Federal Government for the authorized Caloosahatchee River and Lake Okeechobee project. This agency did not actually build any projects but has completed its assigned mission, insofar as the existing Federal project is concerned. It is still in existence. Thus, while legally the State itself has not been

engaged in flood control and drainage in this area, it has established agencies which have carried on this work in the Everglades. Furthermore, the Everglades drainage district, the trustees of the internal improvement fund, and the State department of education own vast acreages in the area covered by this present study.

(*c*) Everglades drainage district: Premature efforts at controlling floods and improving drainage in central and southern Florida began in about 1881 under an agreement between the State and Hamilton Disston and his associates. Some dredging was done in the Kissimmee Basin and between the headwaters of the Caloosahatchee River and Lake Okeechobee, but no effective work was accomplished and operation ceased in 1889. Actual drainage and flood-control operations in the Everglades began in 1906 when the Everglades drainage district started dredging canals. The district has since constructed six major drainage canals: The Caloosahatchee, Miami, North New River, Hillsboro, West Palm Beach, and St. Lucie, and a number of minor canals and laterals, with an aggregate length of over 400 miles. It also provided spillway structures with navigation locks in its major canals and a low levee around the southern shore of Lake Okeechobee. Practically all this work was completed prior to 1928; since then operations of the district have been largely on an administrative basis. Expenditures by the Everglades drainage district have totaled over $18,000,000. The work performed by the Everglades drainage district prior to 1928 was largely responsible for a considerable development in the Everglades, concentrated largely in the area around Lake Okeechobee. Population increased from practically zero in the "Glades" in 1910 to about 48,000 in 1928; and acreage under cultivation increased from zero to 96,000 acres. In the same period the length of improved roads in the Everglades increased from 42 to almost 600 miles.

(*d*) Local drainage projects: Following the start of flood control and drainage by the Everglades drainage district, subdrainage districts were organized by counties, local groups, and corporations under the laws of the State of Florida. There are now 12 active subdrainage districts around the southern perimeter of Lake Okeechobee and extending into the Everglades south and east of the lake. These districts have constructed drainage ditches, dikes, and pumping plants which afford varying degrees of protection and water control over about 100,000 acres. Individual landowners and corporations outside the organized subdrainage districts have provided water-control facilities on some 30,000 acres. At present prices, the value of water-control works in the area is about $5,000,000. In addition, similar subdrainage districts have been developed along the entire eastern border of the Everglades from West Palm Beach to south of Miami, in the upper St. Johns and North Fork of St. Lucie River areas, and in the parts of the Kissimmee Basin where truck farming is in progress. Expenditures for water control in these latter areas are difficult to obtain and evaluate but would probably approach $6,000,000. In many cases the benefit of these districts has been dissipated by ineffective maintenance and the works constructed have not functioned properly because of lack of effective major drainage outlets and overall water control structures.

(*e*) When the peaty muck soil of the Everglades becomes dry, it burns freely, and many thousand acres have been destroyed by such

fires. The Everglades fire-control district was created by the State legislature in 1935 to combat muck and vegetation fires in the Everglades. This agency is now active and maintains a system of look-out towers, fire-fighting equipment, and reconnaissance aircraft for fighting fires. It also conducts an educational program to aid in fire prevention.

VI. IMPROVEMENTS DESIRED

41. *Public hearings.*—In order to obtain the views and suggestions of local interests, public hearings have been held throughout the entire area under consideration in this report at the following localities:

Belle Glade	Aug. 13, 1941, Apr. 30, 1946, June 18 and Aug. 4, 1947.
Leesburg	Apr. 16, 1946.
Sebring	Apr. 17, 1946.
Fort Pierce	Apr. 24, 1946, and June 19, 1947.
Titusville	Apr. 25, 1946.
Kissimmee	May 9, 1946.

In addition, conferences with local interests for discussion of the problems and plans have been held at West Palm Beach, Miami, and at numerous other localities. A digest of the proceedings of these hearings, together with copies of resolutions and pertinent correspondence, is being furnished with this report as a separate exhibit.[1]

42. *Desires of local interests.*—(*a*) The desires of local interests with respect to flood control, drainage, and water conservation were developed in detail in the hearings referred to above. In addition, consultation with county engineers and officials of the various counties have developed the views of those agencies. Similar action has been taken with officials of the Everglades drainage district and many of the local subdrainage districts. The desires of local interests are also reflected in numerous resolutions adopted by local organizations of all kinds throughout this area and the State of Florida. Copies of these resolutions [1] are being furnished to higher authority for review during consideration of this report.

(*b*) In the Kissimmee Valley and upper St. Johns and related areas there is strong local interest in measures which will relieve the flood situation over wide areas of pasture land. The Florida Cattlemen's Association has indicated great interest and urged immediate action on such measures. In addition, agricultural interests, subdrainage districts, and county officials in these sections have proposed measures for prevention of overflow of farm lands south of Lake Istokpoga and pasture lands in the Fisheating Creek section. Water conservation to augment dry season supplies is also desired in these areas. Citrus growers along the western divide of the Kissimmee Basin and on the ridge between the St. Johns Basin and Indian River are particularly interested in water control for water supply and frost protection.

(*c*) Interests in the Lake Okeechobee and upper Everglades area desire measures for relief of local flooding of the flat lands lying around the lake. They are also interested in additional outlet capacity for Lake Okeechobee, with a view to maintaining lower lake levels to reduce pumping costs where drainage from farm lands is pumped into the lake. Other interests in the lake area and in the Everglades more distant from Lake Okeechobee desire additional

[1] Not printed.

storage in the lake for water supply and improvement of ground-water levels during dry periods, and for frost protection.

(*d*) Along the east coast, urban interests desire protection from flood waters of the Everglades and improvement of local protection works and drainage outlets to the sea. Agricultural interests and the communities in this area are much concerned with the progressive salt-water intrusion which has occurred during dry periods, and desire that measures to relieve this situation be included in any plan of improvement. In addition, the east-coast cities and towns are looking toward Lake Okeechobee and the Everglades as a source of future water supply, in expectation of large population increases. In the east-coast area south of Miami, agricultural interests desire protection from overflow by wind-driven tides of the Atlantic which inundate and damage a large area. Cattle interests along the eastern borders of the Everglades desire removal of flood waters from pasture lands.

(*e*) In the Caloosahatchee Valley local interests have expressed the desire for improved water control on rich agricultural and citrus lands bordering that river and for control of salt-water intrusion on its lower reaches.

(*f*) Local interests also desire further inland navigation improvements in this area. However, they have withdrawn the request in conjunction with the comprehensive plan of development, and request that navigation be considered later in a separate report.

(*g*) In summary, local interests are discouraged by the futility of repairing or restoring local levees and canals which are inadequate in the face of major floods. They find themselves unable to cope with the problem of adequate water conservation for use in dry periods. They now ask for a comprehensive plan of flood protection and water control and are convinced that the solution of the problem lies in a coordinated plan of improvement for the area as a whole. They feel that the scope and complexity of such a plan places it beyond the capabilities of State or local agencies. In certain instances, the desires of local interests are in conflict to such an extent that in all probability nothing can be accomplished by local agencies. Under a coordinated plan of improvement, however, most of these conflicts would be eliminated and works best meeting the needs of the area as a whole would be obtained.

VII. PROBLEMS AND SOLUTIONS CONSIDERED

43. *Basic problem.*—(*a*) In its natural state the part of central and southern Florida considered in this report was a vast wilderness of water, forest, prairie, and marshland. The forces of nature had combined to establish a fine balance which supported the vegetable, animal, and human life that prevailed and resulted in building up the land to the condition in which white men first found it. A large part of this land, the Everglades, was still in a formative stage when its development began. The inherent fertility of the area and its resources made its development and use inevitable. This development, however, resulted in physical changes which altered the natural balance between water and soil, and much of the development was undertaken without any real knowledge of the area or of the hazards involved. The parched prairies and burning mucklands of the Everglades in 1945, the flooding of thousands of acres of farms and

communities in 1947, and the intrusion of salt water into lands and water supplies of the east coast are basically the results of altering the balance of natural forces. The basic problem of this area is, therefore, to restore the natural balance between soil and water in this area insofar as possible by establishing protective works, controls, and procedures for conservation and use of water and land.

44. *Flood control.*—The provision of adequate flood control is essential to continued occupation and use of large areas in this section; without it further development would be hazardous. It is an essential of any comprehensive plan for the area. Due to its basic nature, the flood problems and solutions considered are described briefly for each part of this area:

(*a*) Upper St. Johns and related areas: The upper St. Johns area is peculiar in that its flood waters may move either west to the Kissimmee, east and north to the St. Johns, or southward toward the North Fork of St. Lucie River. Flood control and major drainage improvements in this general area from Brevard and Osceola Counties southward to Martin County must therefore be planned jointly and in coordination with plans for the Kissimmee. For example, an attempt to remove flood waters from this area only by way of the St. Johns would result in over-design of structures in an attempt to handle waters which at times would move naturally to the south or west. In addition, the river distance from Lake Poinsett to the ocean is 235 miles by way of the St. Johns River with a total drop of only about 12 feet.

(*b*) Kissimmee Basin and related areas: The flood characteristics of this area are described in preceding paragraphs. Flood damages accrue largely to agricultural lands. The uniformly level topography of the basin precludes establishment of large storage reservoirs. The problem is, therefore, one of removing excess waters from pasture and farm lands as rapidly as possible to reduce damage to crops, cattle interests, and small communities, without resulting overdrainage in dry seasons. Increasing the capacities of natural channels to permit escape of flood waters, and provision of control works in channels and lake outlets for retention of waters in natural reservoirs for use during dry periods, appears to offer a feasible solution of the problem. The nature of this area is such that it is not practicable or economical to afford complete flood protection, but the improvements outlined above will afford relief up to the maximum flood of record.

(*c*) Lake Okeechobee-Everglades area: In the Lake Okeechobee area, floods from the lake presented a serious hazard to human life and to development of the area prior to construction of the present levee system by the Federal Government. Continued vigilance regarding this aspect of the flood problem in this area is still necessary because the flood danger results from the largely unpredictable nature and magnitude of hurricanes. Review of measures for control of Lake Okeechobee and protection from its waters is an important part of the plan presented in this report. The character and extent of the additional flood problem in this area has been described in preceding paragraphs. The flood condition results from local rainfall on the flat lands around the lake and from overland flow of waters from adjacent wild lands, and not from overflow from Lake Okeechobee. Accordingly, measures have been considered for more rapid removal of local run-off by means of canals and pumping stations, for inter-

ception of overland flow by means of levees, and for its diversion and disposal into storage areas. Any final solution of the flood problem in the area adjacent to Lake Okeechobee must be closely correlated with maintenance of ground-water levels for agriculture.

(*d*) East-coast areas: The flood problem of the east coast generally from north of West Palm Beach to Miami is largely one of preventing overflow of low outlying urban areas and farm lands by waters from the Everglades. Flooding in this section is not particularly hazardous to human life, but it does cause large recurring property damage and presents a definite threat to public health. The solution in this case appears to be construction of levees to prevent such overflow, and improvement or provision of canals and structures to remove and control local run-off from local coastal areas. In the agricultural area south of Miami the flood problem is one of protecting productive farm lands from overflow by storm-driven tides of the Atlantic, as well as from inflow from the lower Everglades. Suitable levees would protect this area.

45. *Water control.*—(*a*) Water control and flood control are so closely interrelated in central and southern Florida that it is usually impracticable to state that a problem is one of water control or flood control. Furthermore, engineering structures in many cases must serve both purposes to be effective. Water control coordinates the control of ground-water levels and conservation of water for use in dry periods. Because of this interrelation, both problems are involved in practically all the solutions discussed briefly in the foregoing paragraph.

(*b*) In approaching the water-control problem, as related to other problems of water use, it has been recognized that under existing flood-control law, Federal participation is properly limited to major drainage improvements. For the purposes of this study, such improvements are interpreted to be improvement of natural waterways or existing artificial waterways and their tributaries which will provide an outlet for drainage from an organized drainage district, or group of drainage districts, or an outlet for the drainage from a local governmental unit such as a county or town. It was considered, however, that new artificial drainage channels could be constructed by the Federal Government whenever that procedure would be more economical than improvement of natural or existing drainage courses. Collection of drainage water within local drainage districts, such as those around Lake Okeechobee and in other parts of the area, or within local governmental units and private holdings, and its discharge into major drainage outlets, should remain a local responsibility. Likewise, the diking of local drainage districts and farms to protect them from the run-off from adjacent areas and property should remain a local responsibility.

(*c*) The drainage problem has also been approached with knowledge that it will probably never be possible to completely drain all of the lands in this area. In fact, it would be most unwise to attempt to do so. Overdrainage of certain lands is now a serious problem which must be rectified. Consequently, solution of the drainage problem contemplates only drainage of lands, such as the Everglades area of 1,000 square miles south of Lake Okeechobee, which appear suited to long-term agricultural use. Lands of this kind occur elsewhere throughout the area, but in quantities too small for large-scale develop-

ment or protection. Major drainage outlets with control works for maintaining water levels during dry periods have been planned for protection and improvement where sufficient benefits exist. Other lands of poor quality which are now generally in a wild, undrainable condition should remain undrained and be protected and maintained in their natural condition.

46. *Water conservation.*—Under the general heading of water conservation consideration has been given to storing excess flood waters for beneficial use, to the control and use of stored waters, and the maintenance of ground-water levels for agriculture and other purposes. Water conservation is needed throughout the entire area.

(*a*) In the Kissimmee and upper St. Johns Basins and related areas the need exists to retain excess flood waters in the fall for release into natural and artificial channels, so that adequate ground-water tables can be maintained under pasture lands and to provide for stock watering during the dry season. The only practicable method of meeting this need appears to be the retention of storage in natural lakes and sloughs, and control of outlet channels needed for flood control and drainage. Such works are provided for in the plan presented in this report.

(*b*) In the Everglades south of Lake Okeechobee, extremely dry years like 1945 and others have evidenced clearly the need for retention of water and its proper distribution during dry periods. Even in their natural state the Everglades were apparently dry at times, as it is understood that evidences of muck fires have been found deep in layers of Everglades soil, which must have occurred centuries ago. Even normal years have their dry winter seasons when rainfall is light, and there is need for pumping water back into canals to hold ground-water levels high enough for agricultural needs. In addition, because of oxidation and decomposition when dry, the deep muck and peat soils of the Everglades have subsided from 3 feet to 6 feet since over-drainage has changed their natural wet state and restoration of optimum ground-water levels is necessary to reduce further subsidence. Consequently, it has been necessary to design all canal systems with control structures in their lower ends and to provide for pumping plants to discharge water into conservation areas to meet dry-season needs. Modifications of the regulation of Lake Okeechobee have also been provided to increase the water supply of these areas.

(*c*) Along the east coast the primary reason for conserving water is the increasing demand for municipal water supply. Demand of the cities of West Palm Beach, Fort Lauderdale, and Miami has practically doubled in the past few years. Anticipated population increases indicate that increased supplies will be necessary. Following recent dry years of 1938, 1943, and 1945, when the Everglades were relatively dry, water levels in wells of the coastal areas progressively decreased to where many wells went dry. In some cases there was salt-water intrusion into the wells, resulting in decreased pumping or abandonment. A practical rectification of this problem, which fits in with measures for flood protection, is the establishment of conservation areas on wild lands in the Everglades, which are unsuitable for agriculture. Maintenance of these large areas in a wet condition would contribute largely to recharge of fresh ground-water tables along the east coast.

(*d*) Cities along the east coast have also considered future water-

supply needs and look to the interior fresh-water lakes, including Lake Okeechobee, as a possible future source of supply. The comprehensive plan set forth in this report will lend itself to future modifications to meet such longer-range requirements as they arise.

47. *Salt-water intrusion.*—Along all of the coastal areas, salt-water intrusion has become a serious problem during dry years. Between 1910 and 1942, the rate of salt-water encroachment in the aquifer was 235 feet a year in the Miami area. In the dry period of 1942, salt water intruded into the underlying rock at rates of from 200 to 800 feet a year. This rate of intrusion has been more rapid in dry years like that of 1945 when the Everglades were dry and flow of fresh water in canals leading across the east coast to the sea was negligible. At such times salt water moves up the various canals for distances up to 5 miles. The destructive effects of the salt-water intrusion have become evident on groves, farm lands, and in municipal water supplies. The various counties and municipalities along the coast have been forced to move well fields further inland and to acquire areas for water impoundment purposes to bolster ground-water levels. The reduction of this hazard is also tied in with control of water levels in the Everglades and on other interior lands. Storage of water in conservation areas in the Everglades will aid in recharging with fresh water the underground storage for the east coast and maintaining the head of fresh ground water necessary to prevent salt-water intrusion. Control structures should be provided to release water from such conservation areas to maintain flow in east-coast canals during dry periods, and structures at seaward canal outlets should be provided to prevent inflow of salt water. Problems of salt-water intrusion, similar to those of the east coast, exist in the lower reaches of the Caloosahatchee River Valley, and possible methods of abatement are much the same as those described above.

48. *Preservation of fish and wildlife.*—Southern and central Florida were originally one of the greatest natural habitats for fish, birds, and game on the North American Continent. The shores of Lake Okeechobee and the Everglades once afforded a refuge for thousands of water fowl and other birds which are now virtually extinct. The Fish and Wildlife Service of the Department of the Interior has investigated the possibilities of preserving the fish and game resources of this area and has presented plans for accomplishing this purpose. The plan of improvement presented in this report has been developed with full consideration given to this important feature. In brief, it appears that large parts of the Everglades should be held and protected as conservation areas which would be ideal for preservation of wildlife. Certain other natural marshes in the St. Johns River Basin and elsewhere should likewise remain in their natural state for preservation of fish and wildlife and their drainage is not proposed under this plan.

49. *Navigation.*—Numerous navigation improvements desired by local interests have been studied in preparing this report. Investigation of some of these navigational improvements has previously been authorized by Congress while some are entirely new projects proposed by local interests during discussions of the problems of this area.

(*a*) Cross-State waterway: Deepening of the cross-State waterway (St. Lucie-Okeechobee-Caloosahatchee route) to a depth of 8 feet was authorized by Congress in the River and Harbor Act of March 2, 1945. The present approved estimated cost is $275,000. It has

been found that improvement of the St. Lucie Canal and Caloosahatchee River to provide increased control of Lake Okeechobee would result in navigable depths of more than 8 feet and would provide, incidentally, the greater part of this authorized project.

(*b*) Interlocking waterways in central Florida: Included in authorizations for this survey and report are authorized investigations of interlocking waterways in central Florida leading from the St. Johns to the Kissimmee River and thence to Lake Okeechobee. In accordance with agreements with local interests, navigation will be considered in a later report.

(*c*) Navigation locks: Local interests have requested that small locks for passage of recreational craft be built as part of outlet control structures on the Coral Gables, Little River, and Biscayne Canals in the Miami area. The possibility of providing such locks has been considered, but it has been found that the cost of such structures would far outweigh any benefits which might accrue at this time from use by pleasure craft or occasional commercial boats. In view of their lack of economic justification at this time, such locks have not been included as a part of the plan. However, in design of control structures for the canals, provision will be made for possible future lock installations if future studies should show justification therefor, or if local interests should desire to build such locks.

(*d*) Incidental navigation: Many of the canals proposed in this report for water control will provide useful waterways for small craft for access and for recreational boating and proper consideration has been given to such uses.

50. *Power development.*—There is no present possibility of economical development of hydroelectric power for commercial uses in connection with plans for flood control and other purposes in this area. A small generator is installed at both the St. Lucie and Ortona locks to provide power for operation. However, during droughts numerous complaints have been received relative to their use of water.

51. *Watershed treatment.*—Due to the flat topography as well as the soil characteristics of this area, it appears that measures for prevention of soil erosion and retardation of run-off will not be necessary. Conservation of soils of this area, particularly in the Everglades region, is of basic importance. The Soil Conservation Service of the Department of Agriculture is working cooperatively with agricultural agencies of the State of Florida to promote the use of soil-management practices which will prevent wastage of soil by oxidation, burning, and improper use.

52. *Recreational uses.*—As indicated previously, recreational boating is now an important factor in the economic picture of this area. Extension of this activity may be anticipated as the plan proposed in this report is developed. The conservation areas proposed as a part of this plan should afford opportunities for sport fishing, hunting, and other recreational pursuits. Recreational facilities as such are not proposed at this stage of planning, but will be given full consideration in planning for the construction of specific features.

53. *Mosquito and malaria control.*—(*a*) The Everglades and other marsh areas are comparatively prolific breeders of mosquitoes. While any plan of improvement would undoubtedly affect their breeding habits somewhat, it is doubtful if the over-all situation would be greatly changed. The chief southern malaria vector, *Anopheles*

quadrimaculatus, is present in this area but does not breed well, probably because it prefers neutral or slightly alkaline waters, whereas these waters are strongly acid. The flight range of that mosquito is normally less than 2 miles and, since all heavily populated areas are farther from proposed conservation areas, they would not be exposed to infestation.

(*b*) The salt-marsh mosquitoes which are the most numerous pests for several miles inland, due to their great flight range, would not be affected by the improvement. There are several species of fresh-water pest mosquitoes which could breed freely in the conservation areas, but the general effect of a water-control plan should be beneficial because their flight range is short and the land near dwellings would have improved drainage due to improved drainage-canal facilities. The improvement of the canals and flooding of the marshy areas would encourage growth of small fish which are natural mosquito enemies and would also tend to reduce the shore line to a shorter length. The growth of marginal vegetation which is the favorite place of concealment for mosquito larvae would be restricted.

54. *Pollution abatement and public health.*—Many of the towns along the coast discharge sewage effluent and polluting wastes into the local drainage canals. Also most all of the suburban areas are served by septic tanks and ground toilets. During the 1947 flood these facilities were flooded, presenting a serious health hazard and resulting in hundreds of suburban families moving out of the flooded area. The comprehensive plan would give relief from such dangerous conditions.

VIII. COMPREHENSIVE PLAN

55. *General.*—The comprehensive plan of improvement which has been developed during the progress of the survey is set forth in the following paragraphs of this section and shown on drawing, sheets 1 to 3. The physical and engineering details are given in appendix D.[1] Certain features which were considered but not included in the proposed plan are also described. In general, the proposed plan of improvement provides those features for flood control and other purposes which are feasible from an engineering standpoint and have economic justification. These works would generally provide full protection from a storm similar to that of 1947. These features, as well as certain items which have been rejected, are described in a general order from north to south by physical subdivisions of the area.

56. *Upper St. Johns and related areas.*—(*a*) Upper St. Johns: The plan for this area contemplates improvements of Lakes Poinsett, Washington, and Wilmington. Levees and control works would be provided downstream from Lakes Poinsett and Washington, and outlet channels with control works would be provided from each of the three lakes to Indian River, capable of discharging floods up to the maximum of record. The costs of the improvements are estimated at $10,084,000 for construction and $517,000 for lands and relocations, making a total first cost of $10,601,000. The annual cost of maintenance and operation is estimated at $28,000.

(*b*) North Fork St. Lucie River: In the upper prairies, North Fork of St. Lucie, and Allapattah Flats area, improvement and control structures would be provided in the existing Belcher Canal and diversion canal; a new canal with a control structure would be provided on

[1] Not printed.

the St. Lucie-Martin county line. The costs of the improvements are estimated at $10,238,000 for construction and $186,000 for lands and relocations, making a total first cost of $10,424,000. The annual cost of maintenance and operation is estimated at $47,000.

57. *Kissimmee River Basin and related areas.*—(*a*) Kissimmee Basin: (1) The plan for the Kissimmee River Basin contemplates improvements of Lakes Mary Jane, Preston, Alligator, Gentry, East Tohopekaliga, Tohopekaliga, Hatchineha, and Kissimmee, and of the Kissimmee River. These lakes would be used as storage basins for flood control to reduce the rate of run-off to the Kissimmee River during excessive rainfall, as conservation reservoirs to supply water when needed, and to maintain a favorable ground-water table during periods of deficient rainfall. The improvements to provide these facilities would consist of levees and control structures at the outlets of the lakes, an improved channel downstream from each structure, and enlarged channel and control structures in the river. The improvements would be capable of controlling floods up to the maximum of record.

(2) The costs of the improvements in the Kissimmee River Basin are estimated at $23,179,000 for construction, and $537,000 for lands and relocations, making a total first cost of $23,716,000. The annual cost of maintenance and operation is estimated at $200,000.

(*b*) Istokpoga area: (1) The plan for the Istokpoga area provides for control of Lake Istokpoga for flood storage, for conservation of water for use during droughts, and for reducing run-off to the Kissimmee River. The Lake Istokpoga improvements would control floods up to the maximum of record. Flood flows would be passed through the controlled spillway and the Harney Pond Canal, improved and extended, to Lake Okeechobee. Flood protection for the agricultural lands would be provided by levees along the eastern and southern shores of the lake. Water control for the cultivated lands would be provided by control structures and improvements of the existing Indian Prairie, Harney Pond, State Road 70, and Slough ditch canals.

(2) The costs of the improvements in the Istokpoga area are estimated at $9,507,000 for construction and $572,000 for lands and relocations, making a total first cost of $10,079,000. The annual cost of maintenance and operation is estimated at $75,000.

(*c*) Fisheating Creek area: (1) The plan for the Fisheating Creek area would provide for flood control for the greater part of the area. A chute spillway in the bank of Fisheating Creek where it enters the flood plain about 8 miles from its mouth would divert part of the flood flow from the lower water course, and pass it through a flood discharge canal to Lake Okeechobee. This canal would be formed by connecting up the existing borrow pits along the north side of the existing Lake Okeechobee levee and by extending that channel to the spillway.

(2) The costs of the improvements in the Fisheasting Creek area are estimated at $750,000 for construction, and $5,000 for lands, making a total first cost of $755,000. The annual cost of maintenance and operation is estimated at $14,000.

(*d*) Moore Haven and Newhall drainage district: (1) The plan would provide for flood protection for the town of Moore Haven and for the adjoining Newhall drainage district by extending the western end of the existing Lake Okeechobee levee southwestward to cut off floodwaters from Fisheating Creek; by extending the flood emergency project levee along State Road 78 southward to join the old Ever-

glades drainage district dike, thereby cutting off floodwaters from Nicodemus Slough; and by draining some floodwaters from that slough southward to Lake Hicpochee through controls and the improved and extended ditch along the west side of the Newhall drainage district.

(2) The costs of the improvements for Moore Haven and Newhall drainage district are estimated at $314,000 for construction, and $2,000 for lands, making a total first cost of $316,000. The annual cost of maintenance and operation is estimated at $6,000.

58. *Lake Okeechobee-Everglades area.*—(*a*) Lake Okeechobee: (1) In its present status and as considered under the comprehensive plan of improvement, Lake Okeechobee is a multiple-use reservoir with flood control, navigation, and water-conservation functions. Its waters are impounded by the present levee system and a measure of control is provided by the existing St. Lucie Canal and improved Caloosahatchee River. The existing levees around the rim of Lake Okeechobee protect seven towns and over 130,000 acres of developed rich agricultural land from direct overflow from the lake. The outlet canals and the lake provide a navigable waterway across Florida. Between elevations of 12.56 and 15.56 feet above mean sea level (the present prescribed limits of regulations) the lake provides storage of 1,320,000 acre-feet of water. This great reservoir and its controls are the heart of any plan for flood control and water conservation in south Florida.

(2) Lake control: Due to the importance of control of Lake Okeechobee, this matter has been given careful study in this and prior reports. Features of the comprehensive plan proposed for the Kissimmee Basin would accelerate discharge into the lake during flood periods and would assist in maintaining its levels during dry seasons. In addition, the present and prospective dry-season water needs of the Everglades area south of Lake Okeechobee indicate that some increases in lake storage may be required to more fully meet this increasing demand. Consideration of these factors has led to inclusion in the plan, of provisions for modification of laké control. Since all indications are that this could be obtained most economically by enlargement of the St. Lucie Canal and Caloosahatchee River, estimates have been based on such provisions. Provision of an additional outlet canal is a possibility which will be given further consideration as detailed plans are prepared prior to construction. The exact extent to which discharge may need to be increased will depend on further studies of the effects of projects planned in the watershed to the north and on detailed studies of water supply requirements, determination of optimum levels of lake regulation, and consideration of necessary levee heights.

(3) Levees: The existing levees around the perimeter of Lake Okeechobee were designed to withstand a hurricane attack even more severe than that of 1928. They served their intended purpose in 1945 and 1947 by withstanding hurricane-driven tides and waves with relatively minor damage and with no danger of overtopping or breaching. Experience gained as a result of the floods and winds of 1947 indicates, however, that a low levee should be extended around the lake shore from the St. Lucie Canal northward to tie in with the present north shore levee, to protect the development which has taken place in that area since the existing levee project was built. Also, a

low levee should be provided along the northwestern shore of the lake from the Kissimmee River to Fisheating Creek to protect pasture lands of the Indian Prairie section from overflow by normal rises and wind tides on the lake. This limited protection along the northwestern shore is adequate for present protection of this area, which is pasture land without urban development. In addition to these extensions, some modification of existing levees may be found desirable in the light of experience gained during the 1947 storm.

(4) Completion of navigation improvement: Enlargement of the St. Lucie Canal and Caloosahatchee River, and modifications of the levee systems for Lake Okeechobee, would result in deepening existing channels for lake-control purposes. This would incidentally provide depths of 8 feet or more in the waterway across Florida and would substantially complete that authorized project. Deepening of the channel in the Caloosahatchee River without control works at its seaward end would aggravate salt-water intrusion and over-drainage during droughts, which are already serious problems in that area. Consequently, the plan provides for construction of a new lock and spillway on the Caloosahatchee River above Fort Myers.

(5) Lands and relocations: Lands and rights-of-way required for improvements proposed for Lake Okeechobee and its outlets would be those necessary for the levee extensions on the northwestern and northeastern shores of Lake Okeechobee, for widening of outlet canals and for location of control structures. These rights-of-way in the aggregate would be comparatively small.

(6) Islands in Lake Okeechobee: (*a*) Kreamer, Ritta, and Torry Islands, in the southern part of Lake Okeechobee, were completely submerged during the flood of 1947 and all drainage-control works, such as dikes and pumping stations, were severely damaged, Lake Okeechobee reaching a maximum stage of 18.74 feet mean sea level on October 3. The total area of these three islands varies from 440 acres above elevation 16 feet mean sea level to 4,150 acres at elevation 12 feet mean sea level. Only about 30 persons live on the islands, as most operators of island farm lands and their employees live on the mainland. Although local interests on the islands have provided farm dikes, about 40 percent of the total area would be flooded by lake stages of 17 feet mean sea level and the entire acreage now in use is flooded at stages of 18.5 feet mean sea level. It would be possible to protect these islands, except against hurricanes, by higher ring levees and pumping plants, under lake conditions that would prevail upon completion of the comprehensive plan and to maintain them in agricultural use, but the large cost of such work would be excessive in comparison with their value.

(*b*) During drought periods there is inadequate water supply for the developed area immediately south of Lake Okeechobee due to the lake being at low stages. The development of the comprehensive plan will bring into production about 527,000 acres of rich muck land south of the area now in cultivation which must be supplied with water during droughts. Consequently, local interests are expected to increase their demand for generally higher lake levels to furnish the required water for ground-water control during such periods. Higher lake levels would demand higher ring levees about the islands and result in ever-increasing pumping and levee maintenance costs. It is foreseeable that activities on the islands could be carried on only by almost year-

round pumping. These increased costs, plus the first construction cost, would soon exceed the benefits to local interests, resulting in the island project becoming economically unsound. The activity on the islands has been the source of continual demands and agitation for lower lake stages as the elevation of the islands decreased from subsidence. Consequently, the agitation of island owners will continue to increase as more lake storage is required and subsidence takes its toll of the muck soil. Since any levees that could be economically built and maintained would not offer protection against hurricanes, they would be a hazard to human life in that they would give a false sense of security. Therefore, the comprehensive plan contemplates the abandonment of the islands for agricultural purposes because their continued use would be economically unsound and would maintain a controversial problem which could not be justly ignored.

(7) The first cost of additional improvements of Lake Okeechobee and its outlets, as a part of the comprehensive plan, is estimated at $57,463,000 for construction and $1,621,000 for lands and relocations, making a total first cost of $59,084,000. The annual cost of maintenance and operation of Lake Okeechobee and its outlets, including existing Federal improvements, is estimated at $669,000.

(*b*) Everglades area: (1) The plan would provide flood protection and water control for 1,027 square miles of developed and potentially productive agricultural land adjoining the southern shore of Lake Okeechobee. Flood protection would be provided by constructing levees around the area and by joining them to the existing Lake Okeechobee levee. Water control would be accomplished by the construction of a canal network connected to eight pumping stations on the perimeter of the system. The network would be formed by improving existing canals within the area and by constructing interconnecting and rim canals. The pumps would dispose of excess run-off within the area by pumping from the canal network into the lake and/or into the conservation area to the south; and would also pump water into the area from Lake Okeechobee when needed during dry seasons. The system would also permit a flood discharge of 7,000 cubic feet per second from Lake Okeechobee to the conservation area for aiding the control of Lake Okeechobee. Conservation would be provided by pumping excess run-off from the area into the conservation area.

(2) The costs of the improvements in the Everglades agricultural area are estimated as $36,077,000 for construction, and $520,000 for lands and relocations, making a total first cost of $36,597,000. The annual cost of maintenance and operation is estimated at $1,948,000.

59. *East-coast area.*—This area consists of the coastal-ridge section and the eastern portions of the Everglades extending from the north Palm Beach County line to the southern tip of Florida.

(*a*) Everglades conservation area: (1) The plan would create three interconnected reservoir areas totaling about 1,500 square miles which would occupy portions of Dade, Broward, and Palm Beach Counties. These reservoirs would store the maximum-record rainfall on the conservation area plus the run-offs from the area north of West Palm Beach Canal, the Everglades agricultural area, and some flood discharge from Lake Okeechobee. Impoundment of these waters would prevent their flowing eastward and flooding the developed areas along the coastal ridge. Maintenance of water in the

conservation area would provide water for use on the east-coast agricultural lands when needed, raise the ground-water table and improve water supply for the east-coast communities, ameliorate salt-water intrusion in the east-coast water supply well fields and streams, and benefit fish and wildlife in the Everglades. The reservoirs would be created by constructing a system of levees from the West Palm Beach Canal southward between the main body of the Everglades and the west edge of the coastal ridge to the Tamiami Trail, westward on that trail to the Collier County line, then northward to tie into the west rim levee of the Everglades agricultural area. Levees along the Hillsboro and North New River Canals would divide the conservation reservoir into three parts, interconnected by spillways through the levees. Gated spillways in the Tamiami Trail levee would permit discharge of excess water from the conservation area onto the low-lying areas to the south, and thence to the lower end of the peninsula. The part of the east coast protection levee which forms the eastern boundary of the conservation area is the major feature for protection of the east coast.

(2) The cost of the improvements in the Everglades conservation area is estimated as $31,114,000 for construction, and $2,110,000 for lands, making a total first cost of $33,224,000. The annual cost of maintenance and operation is estimated at $277,000.

(*b*) Palm Beach County: (1) The planned improvements in Palm Beach County serve various purposes. Flood relief and water control for the Hungryland and Loxahatchee sloughs would be provided by constructing a canal to the coast with a control structure near its outlet. Flood discharge from Lake Mangonia would be diverted by a canal to Lake Worth. Water control for the Lake Osborne area would be provided by a control at the outlet of the channel at the West Palm Beach Canal, and by a short canal from Lake Osborne to Lake Worth with a control structure at its outlet to prevent salt-water intrusion. Lake Ida would be benefited similarly by a short canal and control structure. Construction of spillways in the conservation levees at the West Palm Beach and Hillsboro Canals would provide water to the entire area when needed during drought periods.

(2) The cost of the improvements in Palm Beach County is estimated as $2,668,000 for construction, and $380,000 for lands and relocations, making a total first cost of $3,048,000. The annual cost of maintenance and operation is estimated at $38,000.

(*c*) Broward County: (1) The plan for improvements in Broward County provides for flood relief, water control, and alleviation of salt-water intrusion. These would be secured by improving and extending the existing Cypress Creek, Middle River, Plantation Road, and Hollywood Canals, and by placing control structures in those canals. Culverts and spillways in the levees to the west would bring water from the conservation reservoirs to this area by way of Cypress Creek, Middle River, Plantation Road, North New River, and Dania Cut-off Canals for use during dry seasons and for preventing salt-water intrusion.

(2) The cost of the improvements in Broward County is estimated as $948,000 for construction, and $174,000 for lands and relocations, making a total first cost of $1,122,000. The annual cost of maintenance and operation is estimated at $33,000.

(*d*) Davie agricultural area: (1) The plan would provide for flood

protection and water control for an area of approximately 105 square miles of developed and potentially productive agricultural land west of Dania along the South New River Canal. Flood protection would be provided by constructing and improving levees around the area; these would be connected to the Broward County conservation area levee on the west. Water control would be provided by improving the South New River Canal and constructing a pumping station at the conservation area levee. The pump would discharge excess water into the conservation area or draw therefrom for use during dry periods. A culvert in the canal at State Road No. 7 would permit flow for water supply and salt-water control in the Dania Cut-off Canal and along the coast.

(2) The cost of the improvements in the Davie agricultural area is estimated as $3,694,000 for construction and $20,000 for lands, making a total first cost of $3,714,000. The annual cost of maintenance and operation is estimated at $267,000.

(*e*) Dade County: (1) The plan of improvements for Dade County would provide for flood control and protection, water control, and alleviation of salt-water encroachment. These benefits would be secured by improving the channels, and constructing control structures at the outlets of the following existing canals:

Miami (in part)	Snake Creek	Coral Gables
Comfort	Biscayne	Snapper Creek
Tamiami	Little River	Black Creek

Culverts at the head of Snake Creek, Miami, and Tamiami Canasl would provide for the flow of water from the Everglades conservation reservoirs into the area for use during dry seasons. The levee (some 74 miles long) surrounding the agricultural lands of the Perrine-Homestead area would protect against flood waters from the Everglades and against ocean tides driven by hurricanes from the south and east. Salt barrier-type spillways and culverts, 13 in all, in the east and south walls of this levee would control the discharge from the canals and prevent salt-water intrusion.

(2) The cost of the improvements in Dade County is estimated as $13,987,000 for construction, and $1,298,000 for lands and relocations, making a total first cost of $15,285,000. The annual cost of maintenance and operation is estimated at $101,000.

60. *Meteorological and hydrological control system.*—For the proper operation of an integrated system for water control, it is necessary to cover the entire area under consideration with an adequate interrelated net of meteorologic and hydrologic stations. The net should be adequate to properly indicate conditions of rainfall, lake and river stages and flow, temperature, evaporation, relative humidity, barometric pressure, and wind velocity and direction. Automatic radio transmission of stages from key stations on the principal streams is also considered to be essential. The data would form the basis for a system of flood forecasting on the major streams and for other studies enabling progressive improvements in operating procedures for the entire water-control system. The total cost of meteorological and hydrological instruments and construction is estimated at $170,000.

61. *Summary of cost.*—The total cost of the comprehensive plan described in the preceding paragraphs is:

	First cost			Annual maintenance and operation
	Construction	Lands and relocations	Total	
Upper St. Johns and related areas	$20,322,000	$703,000	$21,025,000	$75,000
Kissimmee River and related areas	33,750,000	1,116,000	34,866,000	295,000
Lake Okeechobee-Everglades	93,540,000	2,141,000	95,681,000	2,617,000
East coast	52,411,000	3,982,000	56,393,000	716,000
Meteorological and hydrological	170,000		170,000	
Total	200,193,000	7,942,000	208,135,000	3,703,000

62. *Construction program.*—The comprehensive plan is a long-range plan for the control and use of the water resources of most of central and southern Florida. It should be initiated at the earliest possible date, as the need for flood protection, water control, and conservation of water is urgent. If and when the plan is authorized by the Congress, future progress in its accomplishment will depend equally on congressional appropriations for planning and construction and on prompt action by local interests in providing the cooperation required of them.

63. Assuming, however, that adequate appropriations were made by Congress and that requirements of local cooperation were met, the entire comprehensive development could be completed under an orderly and efficient construction program in 10 years. It is considered, however, that completion of certain parts of the plan should be deferred beyond this period, as the need for such features will depend on progressive development of the areas.

64. All features set up as parts of the comprehensive plan are considered necessary and economically justified. It is impracticable to establish definite priorities at this time for construction of individual items. Some parts of the plan, however, such as those required for protection of human life and of existing highly-developed urban and agricultural areas, are obviously more urgently needed than the longer-range features of the plan. In addition, engineering considerations will require an order of development which would produce, step-by-step, construction of the works which can be operated from the beginning with the greatest efficiency, and which would obtain progressively, from the beginning, the benefits which the plan is designed to produce. With such practical considerations in mind, it appears that logical construction stages would be as follows:

Stage A.—Construct the main levee between the Everglades and the east coast area, modify control facilities and levees of Lake Okeechobee, and initiate control works in headwaters of the Kissimmee and St. Johns Rivers.

Stage B.—Initiate levees to inclose the agricultural area south of Lake Okeechobee, and the pumping plants; provide local protection works in West Palm Beach, Broward and Dade Counties, and improve the Kissimmee River channel.

Stage C.—Complete levees inclosing the Everglades conservation areas on the south and west; complete levees inclosing the Everglades agricultural area;

complete connecting channels and control works in the Kissimmee, upper St. Johns, and North Fork of St. Lucie River areas.

Stage D.—Complete levees, pumping plants, and outlet canals of the Everglades agricultural area, and complete control works for the conservation areas.

65. Any such general program must be sufficiently flexible to permit such changes as would become desirable in the prosecution of a project of the magnitude of the comprehensive development. For example, if lands and rights-of-way and other necessary assurances of local cooperation are made available by local interests for any feature of the plan, and that feature can be constructed and operated in accordance with the over-all purposes of the plan, it should not be delayed pending initiation of other features. The general program set forth above would, however, afford an orderly step-by-step development which would obtain progressively the full benefit of the comprehensive development.

IX. ECONOMIC ANALYSES

66. *Estimated benefits.*—The flood protection and water control that would be afforded by the proposed improvements would result in large benefits from the prevention of flood damages and from increased or higher use of land throughout the area. In addition the project would produce other substantial benefits from navigation, preservation of fish and wildlife, improved water supply, reduction of salt-water intrusion in coastal areas, and from improvement of sanitary conditions. All of these benefits that could be evaluated in monetary terms without making approximations have been estimated in detail in appendix B.[1] In considering benefits by the related areas which comprise the comprehensive plan, it should be recognized that it is not possible to make a complete division of benefits among areas. Similarly the division of costs between areas cannot be accepted as exact because of the interrelation of the various components of the plan. The division of both benefits and costs between areas as used in this report has been made as accurately as possible to permit analysis of the economic justification of the improvements proposed for each area. The benefits estimated in appendix B [1] are summarized in the following paragraphs.

67. *Prevention of flood damages.*—(*a*) General: Estimates of flood damages which would be prevented by the proposed improvements have been based on all records of floods and flood losses for the various areas under consideration. In spite of the scarcity of flood damage records, due to the relatively recent development, sufficient records are available to indicate with reasonable accuracy the frequency of flooding and the damages which may be anticipated. Consequently it has been possible to prepare flood frequency-damage relationships for each of the component areas of the comprehensive development. In each case considerable weight has been given to damages incurred during the flood of 1947 since it has been possible to complete a general flood damage survey since that flood. Some departure from usual procedures in analysis of flood damages and benefits of flood protection has been necessary because of the peculiar flood characteristics of central and southern Florida. The uniformly flat topography and the fact that floods are due to the accumulation of waters from long wet periods, which produce large overland flows, preclude the

[1] Not printed.

possibility of developing stage or discharge-damage relationships. It is believed, however, that estimates of damages are sufficiently accurate to show the magnitude of the flood problem and the economic merit of the proposed improvements.

(*b*) Flood damages in 1947: Damages as a result of the flood of 1947 were heavy and widespread. This flood caused a loss of over $10,900,000 to citrus growers in Broward and Dade Counties where 8,400 acres of groves were destroyed in addition to loss of fruit crops. The loss to sugarcane planters around Lake Okeechobee was estimated at $1,450,000; and cattle raisers throughout the area suffered damages of over $3,400,000. In addition many miles of highways were submerged, with resulting dislocation of transportation facilities and large costs for rebuilding and resurfacing. Urban damages were heaviest in Broward and Dade Counties, where flooded areas included the center of Fort Lauderdale, and the Miami Springs and Hialeah sections of Miami. The complete flood damage survey made by the Corps of Engineers resulted in an estimated total loss of $59,000,000, as a result of the flood of 1947, including both direct and indirect losses.

(*c*) Average annual flood damages: The flood of 1947 was estimated to be one of about 25-year frequency on the lower east coast and of from 6- to 10-year frequency in other parts of the area. Minor floods occur from the upper St. Johns to the lower Everglades as often as every other year but damages from such overflows are relatively light. Floods greater than that of 1947 have occurred in all parts of central and southern Florida, according to past records, and their recurrence at this time would result in much greater losses than those experienced in 1947. All of these factors were taken into consideration in preparing flood frequency-damage curves and in computing the average annual flood damages to be anticipated in this area under present conditions if flood protection is not provided, as follows:

Upper St. Johns and related areas	$2, 077, 000
Kissimmee River Valley and related areas	1, 500, 000
Lake Okeechobee-Everglades area	4, 130, 000
East coast-Everglades area	3, 857, 000
Total average annual flood damage	11, 564, 000

(*d*) Flood damages prevented: In determining the flood damages that would be prevented by the proposed improvements the following factors were taken into consideration:

(1) There will be some normal development of the area without adequate flood protection. Consequently estimates of average annual flood damages were increased by conservative percentages to reflect the increased losses that would result over the life of the project due to this normal development. Such increases to account for normal development varied from 7 percent in the upper St. Johns area to 20 percent in the east cost-Everglades area.

(2) The proposed flood protection works would not eliminate all flood damages, as it was not economically feasible to provide complete flood protection for all areas and against all major overflow of very infrequent occurrence. Accordingly the flood damage anticipated even with the proposed works in operation was estimated on the flood frequency-damage curves for each related area; and was deducted from the total average annual flood damage to give the following estimate of flood damages that would be prevented by the proposed improvements.

Upper St. Johns area	$957, 000
Kissimmee area	990, 000
Lake Okeechobee-Everglades	3, 746, 000
East coast-Everglades	2, 558, 000
Total average annual flood damage prevented	8, 251, 000

(3) The benefit from prevention of these average annual flood damages would be obtained progressively as the various features of the comprehensive plan are completed and would continue during the 50-year economic life of the project features.

68. *Land-use benefits.*—In addition to preventing flood losses, the improvements proposed would result in large benefits due to increased land use. In computing the part of such benefits that could be credited to the project, care was exercised to avoid any duplication with flood prevention benefits. The increased land-use benefits were obtained as follows:

(*a*) Agricultural: The proposed improvements would provide the basic flood protection and water control which is essential to the development and use of over 725,000 acres of rich agricultural land which is now practically unused. They would also contribute largely to more intensive and profitable use of existing pasture and farm land; as shown in the following table:

Area	Existing pasture and farm lands and pasture benefited	Potential new farm lands and pasture benefited	Total
	Acres	*Acres*	*Acres*
Upper St. Johns	452,000	67,000	519,000
Kissimmee	555,000	0	555,000
Okeechobee-Everglades	341,000	531,000	872,000
East coast-Everglades	227,000	128,000	355,000
Total	1,575,000	726,000	2,301,000

(*b*) The benefits which would result from increased or higher use of these lands were estimated as the difference between their net productive or earning power under present conditions and that which would prevail if adequate flood protection and water control was provided. In all instances the crop or land use providing the lower benefit was used, when several uses were possible, to be on the conservative side. Factual data to serve as a basis for computing returns for various land uses, and under conditions with and without water control, were obtained from marketing agencies, producers' associations, individual farm and ranch operators, and from county agents. In computing net returns all local costs of production, including local drainage district costs and farm measures for farm water control, as well as losses due to flood and drought, have been deducted or properly accounted for. These net increases in production, which will result in large measure from adequate flood protection and water control, range from about $1 per acre annually due to more intensive use of existing pasture lands in the Lake Okeechobee-Everglades area to an increase of $200 per acre annually for new citrus land in the Davie area in Broward County. Computations of increases are based on 1945–46 price levels and are considered a reasonable average for this area.

(*c*) The full net increase in return which would result from flood protection and water control was not claimed as creditable to the proposed improvements. Benefits credited to the project were modified to take the following factors into consideration:

(1) Since increased productiveness of lands would vary from the maximum on those given complete flood protection and full water control to zero benefit for

unprotected areas, the full net increase possible was reduced by an appropriate amount, which varied according to the area under consideration.

(2) Since some degree of normal development would take place without adequate flood protection and water control, and local interests would through their own efforts and expenditures proceed with a certain degree of development in the future, the increased land-use benefit credited to the proposed improvements was further reduced by a variable percentage for each area to reflect normal local development.

(3) In some area, such as the Lake Okeechobee-Everglades area, where the increased land-use benefit depends upon the development and use of large acreages of new land, a development period of 20 years was used for realization of the benefits; and average annual benefits over the life of the project were reduced to conform to this condition.

(*d*) The average annual benefits due to increased land use, which are considered creditable to the proposed improvements, have been estimated on the basis of the foregoing principles in appendix B [1] and may be summarized as follows:

Upper St. Johns area	$860,000
Kissimmee area	853,000
Lake Okeechobee-Everglades area	9,919,000
East coast-Everglades area	3,686,000
Total	15,318,000

(*e*) Urban benefits: Provision of adequate flood protection would also result in some increase in use of land for urban development and in higher type of development in existing urban areas now subject to flooding. The part of this increase in use of land for urban purposes which has been credited to the project has been estimated conservatively, as it is believed that a substantial part of such development would take place even without adequate flood protection. The present expansion of east-coast urban areas into the borders of the Everglades is an example of this anticipated urban expansion. Such development without flood protection would of course increase the flood hazard in these areas and result in larger damages in future floods, and consideration has been given to this factor in computing future flood damages. The increased use of property for urban purposes, which is creditable to the proposed improvements, has been estimated as follows on an average annual basis:

Upper St. Johns area	
Kissimmee area	$2,000
Lake Okeechobee-Everglades area	81,000
East coast area	454,000
Total	537,000

69. *Additional benefits.*—(*a*) Navigation benefits: The comprehensive plan contemplates enlargement of the St. Lucie Canal and Caloosahatchee River and navigable channels around Lake Okeechobee, which would incidentally provide the 8-foot waterway authorized by the River and Harbor Act of March 2, 1945. Since the cost of the comprehensive plan includes the 8-foot waterway the annual navigation benefits of this work, amounting to $176,000, are credited to the improvement. The proposed improvements would also result in some expansion of recreational boating throughout this area, and in considerable local use of the improved canals for access and for movement of supplies and equipment. Such incidental navigation uses are believed to be substantial but have not been evaluated.

(*b*) Preservation of fish and wildlife: Estimates of the Fish and

[1] Not printed.

Wildlife Service of the Department of the Interior attribute average annual benefits of $291,000 to features of the comprehensive plan which would aid in the preservation of fish and wildlife throughout the area. These estimates have been reviewed and are considered to give a reasonable indication of the value of the plan for this important purpose and are credited to it.

(*c*) Drainage: Benefits due to improvement of major drainage outlets, conservation of water, and control of water level for agricultural use are reflected by and included in the benefits attributed to increased or higher use of farm and urban lands summarized above.

(*d*) Salinity control: It is recognized that control of salinity is one of the urgent problems to be met by the comprehensive plan of improvement. No attempt has been made to evaluate the extensive benefits claimed by local interests by virtue of excluding salt water from existing canals and by maintaining higher ground-water tables, thereby restricting salt-water intrusion. These benefits are real and extensive as indicated by the proposed construction of a lock and dam for salinity control in Miami River by local interests at an estimated cost of $700,000; the continued drilling of Miami water-supply wells further inland from the east coast resulting in long expensive pipe lines; and the creation of water-conservation areas by Dade, Broward, and Palm Beach Counties. Benefits due to prevention of damages due to salt-water inundation in the Homestead-Perrine area are included under flood-control benefits.

(*e*) Water supply: Establishment and operation of conservation areas in the Everglades would aid materially in recharging underground fresh-water reservoirs of the east-coast area, thereby maintaining and improving present water supplies of cities and towns of that area. While this is a real benefit anticipated from the development, it has not yet been evaluated in monetary terms because of the extended and costly surveys which would be necessary to establish the full extent of this beneficial effect. In addition, the more complete control of Lake Okeechobee contemplated under the comprehensive plan makes it adaptable to future development as a water supply for east-coast cities in the event of large population increases.

(*f*) Recreational: Substantial recreational benefits would result from the comprehensive plan. While real and important, they have not been evaluated in monetary terms in this report.

(*g*) Other benefits of the plan which are largely intangible include a general stabilization of the security and economy of this entire area, prevention of suffering occasioned by floods, and the improvement of health and welfare conditions of the population.

70. *Summary of benefits.*—The average annual benefits of the proposed improvements which have been evaluated in monetary terms and described in the foregoing paragraphs may be summarized as follows:

(*a*) Prevention of flood damages	$8, 251, 000
(*b*) Increased use of land attributable to project	15, 855, 000
(*c*) Navigation	176, 000
(*d*) Preservation of fish and wildlife	291, 000
Total average annual benefits	24, 573, 000

71. *Comparison of benefits and costs.*—Comparison of the estimated average annual benefits of the proposed development as a whole with

its total annual charges indicates that it has a benefit-cost ratio of 2.05. It is therefore apparent that the plan as a whole is economically justified by a wide margin. Due to the interrelation of the features of the comprehensive development and the necessity for their coordinated construction and operation, it is impossible to divide benefits among the individual canals, levees, and control works, and to compute their economics separately. The economics of the various parts of the plan which can be set up in separate groupings have been investigated and are as follows:

Grouping	Total annual benefits	Total annual charges	Benefit-cost ratio
Upper St. Johns and related areas	$1,848,000	$920,000	1.98
Kissimmee River and related areas	1,915,000	1,693,000	1.13
Lake Okeechobee-Everglades area	13,922,000	6,370,000	2.18
East coast-Everglades area	6,888,000	2,960,000	2.32
Total	24,573,000	11,943,000	2.05

The foregoing shows that, while certain parts of the plan show a higher economic value than others, all parts of the plan are economically justified.

X. LOCAL COOPERATION

72. The comprehensive development set forth in this report would result in large benefits which would accrue partly to the Nation as a whole and partly to local interests. Consequently, a proper division of the cost of the project between the Federal Government and local interests is of the greatest importance. Conclusions regarding the extent of local cooperation to be required and the division of cost are set forth below.

73. *Lands, easements, and rights-of-way.*—In the accomplishment of flood-control projects such as the levees, control works, diversion channels, flood-channel improvements, and major drainage canals, such as are proposed in the comprehensive plan, it has been found that local interests are best qualified to furnish necessary lands, easements, and rights-of-way. Moreover, present flood-control law requires that local interests furnish such lands, easements, and rights-of-way for local flood-protection projects. Establishment and operation of the conservation areas planned for the Everglades would require flowage easements over lands of these areas and the imposition of suitable restrictions on use of these lands. The State or other responsible local interests should be required to acquire title to or flowage easements over these lands; to impose and enforce restrictions as to use which are considered satisfactory to the Secretary of the Army; and to furnish, without cost to the United States, the necessary flowage easements over lands of the conservation areas. This requirement should be considered applicable to any other lands which future development of the comprehensive plan may indicate to be required for conservation areas. The total cost of lands, easements, and rights-of-way, including provision of the conservation areas, to be borne by local interests is estimated at $3,898,000.

74. *Relocations and alterations.*—Local interests should be required to bear the cost of all relocations and alterations of highways and public utilities which may be required for the construction of the

project, including alterations and relocations of highway bridges, and to bear the cost of lands required for such relocations and changes. However, enlargement of the Tamiami Trail embankment, and provision of control structures therein, to form the southern levee of the Everglades conservation area is an integral construction feature of the comprehensive development. Similarly, the portions of State Roads 84 and 25 adjacent to the conservation area would be enlarged to form portions of the conservation-area retention levees proposed in the comprehensive plan. This work is not required for highway purposes and effects no essential improvement in the existing highway. The cost of the embankment and highway thereon should, therefore, be borne entirely by the United States. The total cost of relocations and alterations to be borne by local interests, as described above, is estimated as $4,044,000. The cost of relocations and alterations of railroad bridges would be borne by the Federal Government.

75. *Maintenance and operation.*—(*a*) Cost: The cost of maintaining and operating all facilities of the comprehensive development after completion, in accordance with regulations prescribed by the Secretary of the Army, should be borne by local interests, except that the cost of maintenance and operation of the control works, levees, channels, and navigation locks of the St. Lucie Canal, Lake Okeechobee, and Caloosahatchee River should continue to be borne by the Federal Government. The average annual cost of maintenance and operation to be borne by local interests when the project is complete is estimated at $3,034,000. This charge would be zero at the beginning of the construction period, gradually increased to the full amount as features of the project are completed, and continue thereafter for the life of the project.

(*b*) Operating agency: Coordinated operation of the major features of the comprehensive development would be essential if the estimated benefits are to be obtained. This operation would affect 18 Florida counties, the agricultural communities of organized subdrainage districts, as well as urban areas along the east coast. It would also involve a great variety of engineering works and require continuous study and improvement of operative procedures. In view of these considerations, it is believed that as a general rule the Federal Government should maintain and operate all features of the project including levees, canals, pumping stations, and control works, in cooperation with the appropriate State and local agencies; and local interests should pay the cost. There are, however, certain features which are essentially local in their effect, and could be operated as individual units by local interests without interference with functioning of the over-all plan, although their operation and maintenance must be coordinated with the over-all plan by regulations prescribed by the Secretary of the Army. Essentially local project features include the canals, levees, and control works in Palm Beach, Broward, and Dade Counties, east of the main protection levee as well as certain improvements in the North Fork of St. Lucie River area. For such essentially local works, operation and maintenance should be by local interests whenever suitable local agencies, such as counties, are available to carry on this work and whenever, in the discretion of the Secretary of the Army, the purposes of the comprehensive plan could best be served by turning over such works to local interests for operation and maintenance.

76. *Lake Okeechobee levees and outlets.*—Lake Okeechobee together with its outlets is, in effect, a multiple-use reservoir with flood-control, navigation, and water-supply functions. Its improvement and operation for these purposes is the heart of the comprehensive plan. It appears essential that maintenance and operation of the control works, channels, navigation locks, and levees involved in this feature be by the Federal Government. The modifications of levees and lake control now proposed in the comprehensive plan would result in large benefits by providing deeper navigation channels and providing a higher degree of flood protection to the thickly populated area around Lake Okeechobee. These modifications would also provide improved control and conservation of water which would be of substantial benefit to the agricultural area south and east of Lake Okeechobee. The fact that modification of lake control and the levees about Lake Okeechobee produces large increased land-use benefits, as well as benefits from flood control and navigation, has been recognized by the following division of cost for the entire project which results in dividing the cost of proposed modifications about 61 percent to the Federal Government and 39 percent to local interests.

77. *Highways.*—Except for previously discussed alterations of Tamiami Trail and State Roads 84 and 25, the provision of roads included as a Federal part of the comprehensive development would be limited to those minimum roads and trails required for access to the project features for construction, maintenance, and operation. If the State or counties desire construction of improved highways on levees or along canals, the cost of such highway work, over and above that required for the Federal access roads, should be borne by local interests.

78. *Division of cost.*—The total cost of the proposed comprehensive improvement has been divided between the Federal Government and local interests according to the following principles:

(*a*) The project as a whole produces benefits from flood control, navigation, and preservation of fish and wildlife, and benefits from increased use of land. The cost of the project has, therefore, been divided between these two groups of uses according to the proportion their benefits bear to the total benefit, as follows:

	Percent
(1) Part chargeable to flood control, navigation, preservation of fish and wildlife	35.4
(2) Part chargeable to increased use of land	64.6

(*b*) The cost of the part of the project which is for flood control, navigation, and fish and wildlife preservation (35.4 percent) has been considered as a Federal responsibility.

(*c*) The cost of the part of the project which is for increased land use (64.6 percent) should be divided between the Federal Government and local interests, because both the Nation as a whole and the local people share in benefits due to increased use of land.

(*d*) Division of the part of the cost chargeable to increased land use has been made by recognizing the established Federal practice with irrigation projects which results in dividing the first cost equally between the Federal Government and local interests; and in charging local interests with costs of maintenance and operation. This has the effect, on the average over a number of projects, of dividing the total cost (first cost plus maintenance and operation) approximately

60 percent to local interests and 40 percent to the Federal Government. Accordingly, these proportions have been used in dividing the part of the cost of this project chargeable to increased use of land.

(*e*) The total cost to be divided between the Federal Government and local interests is as follows:

Construction of all project features	$200, 193, 000
Lands and relocations	7, 942, 000
Total first cost	208, 135, 000
Present worth of annual maintenance at 3½ percent for 50 years, $3,034,000×23.45562	71, 162, 000
Total economic cost	279, 297, 000

(*f*) Application of the principles described in subparagraphs (*a*) to (*d*) above results in the following division of the total economic cost of this project:

	Federal share	Local share	Total
(1) The part of the cost chargeable to flood control, navigation, and preservation of fish and wildlife (35.4 percent) is chargeable to the Federal Government:			
35.4 percent of first cost ($208,135,000)	$73, 680, 000		$73, 680, 000
35.4 percent of present worth of maintenance and operation ($71,162,000)	25, 191, 000		25, 191, 000
Total	98, 871, 000		98, 871, 000
(2) The part of the cost chargeable to increased use of land is:			
64.6 percent of first cost ($208,135,000)	(40 percent) 53, 782, 000	(60 percent) $80, 673, 000	134, 455, 000
64.6 percent of present worth of maintenance and operation ($71, 162, 000)	18, 388, 000	27, 583, 000	45, 971, 000
Total	72, 170, 000	108, 256, 000	180, 646, 000
(3) Division of total economic cost	171, 041, 000 (61 percent)	108, 256, 000 (39 percent)	279, 297, 000 (100 percent)

79. *Summary of local requirements.*—(*a*) The flood-protection, drainage, and water-control features of the comprehensive development would operate jointly to produce large benefits attributable to increased or higher use of both agricultural and urban property. The preponderance of such benefits over benefits from other sources indicates that substantial local cooperation is warranted. Consequently, it is believed that local interests should be required to make a contribution to the cost of the project over and above the minimum requirements of flood-control law. The appropriate contribution, over and above other requirements of local contribution, required to meet the proposed division of the total cost of the project is as follows:

Total local share of economic cost		$108, 256, 000
Deduct the following local costs:		
Lands, rights-of-way, and easements	$3, 898, 000	
Relocations	4, 044, 000	
Maintenance and operation (present worth)	71, 162, 000	
		79, 104, 000
Local contribution to be required		29, 152, 000

(*b*) The local share of the cost of the comprehensive plan has been set forth above as a single sum merely to show the ultimate division of the cost of the project when it is complete. It should be clearly understood that this local cooperation may be extended over the period

of years in which the project is developed and operated, and need not be forthcoming as a whole before the project is started. Construction of urgently needed features of the plan should be started as soon as assurances of local cooperation, satisfactory to the Secretary of the Army, are provided.

80. (*a*) *Division of first cost and maintenance cost.*—First cost: On the foregoing basis of local contribution, the first cost would be divided as follows:

(1) Federal investment (82 percent): Federal share of construction cost		$171,041,000
(2) Non-Federal investment (18 percent):		
Lands and relocations	$7,942,000	
Contribution to construction cost	29,152,000	
		37,094,000
(3) Total first cost		208,135,000

(*b*) Annual maintenance cost:

(1) Federal annual maintenance cost: Maintenance and operation of Lake Okeechobee levees and outlets	$669,000
(2) Non-Federal annual maintenance cost: Maintenance and operation of all items other than Lake Okeechobee levees and outlets	3,034,000
Total annual maintenance cost	3,703,000

81. *Assurances of local cooperation.*—(*a*) Due to the urgency of the flood- and water-control problem in central and southern Florida, it has been necessary to complete this report for the comprehensive plan as expeditiously as possible. Consequently, it has been impracticable, in the short time available, for the State or other local agencies to develop an organization with the authority necessary to furnish firm assurances of cooperation for inclusion in this report. Existing agencies of the State, such as the Everglades Drainage District and Okeechobee Flood Control District, appear to lack authority to underwrite a program of the scope proposed under this comprehensive plan of improvement. This situation can be rectified by action of the State legislature, or by cooperative action of groups of local interests, prior to the time when construction may be started.

(*b*) The comprehensive plan set forth in this report has been discussed in detail with representatives of the State of Florida and with officials of counties, cities, and subdrainage districts and other local organizations. Many such officials and organizations have indicated their concurrence in and desire to support the plan of improvement. The wide local interest in this plan and the attitude of local interests toward participation in its cost are evidenced by the resolutions and communications furnished with this report as an exhibit.[1] It is felt, therefore, that action leading to adequate assurances of local cooperation may be anticipated.

(*c*) The procedure to be followed by local interests in providing the required local cooperation may be developed in detail by future negotiations. This might take the form of action by the State to form a new agency, or extend the present scope of the Everglades Drainage District or the Okeechobee Flood Control District, to obtain by taxation the necessary funds to pay for relocations and for acquisition of lands, easements, and rights-of-way, and to provide annually the sums required as contribution to first cost and for maintenance and operation. In any event it is considered that there should be

[1] Not printed.

established, preferably by the State of Florida, a single local agency with which the Federal Government can deal on all matters of local cooperation for this subject.

82. *Local provisions for securing certain portions of the conservation area.*—During the past few months Palm Beach, Broward, and Dade Counties have held elections and have passed acts enabling them to designate areas within the counties for conservation purposes. The acts were approved by the voters by overwhelming majorities. The acts further enable the counties to cooperate with other organized bodies in securing the dedication of such lands for conservation uses. Lands so dedicated can be exempted from taxation. Since the entire Everglades conservation area is in those three counties, it is evident that public opinion supports the conservation plan in general; this has cleared the way for future efforts toward securing the necessary lands. A large portion of the conservation area in Palm Beach County has already been secured, largely through the efforts of the Everglades Drainage District. Negotiations are under way to dedicate this area to public use under the direction of the United States Fish and Wildlife Service, since it is topographically suited to fish and wildlife purposes without other modifications. The secured area involves over 100,000 acres of lake and marshland. Of this, various subdivisions of the State dedicated about 70,000 acres. The remainder was secured by trading for lands outside the area or by dedication by private owners. This represents a sizable accomplishment and is indicative of the desire of local interests to secure a practical over-all water-control plan.

XI. COORDINATION WITH OTHER AGENCIES

83. *Federal agencies.*—The interests of other agencies of the Federal Government in the area under consideration are summarized briefly in previous paragraphs. The comprehensive plan has been developed with full consideration of the functions of those agencies and with their plans for this area as indicated in the following subparagraphs.

(*a*) Department of Agriculture: The Soil Conservation Service of the Department of Agriculture, in cooperation with the State of Florida and the United States Geological Survey, has completed an exhaustive study of Soil and Water Control in the Everglades Region. The report on this study was completed in 1947. In addition to providing valuable basic data on soils, geology, climate, and water requirements that report presented plans and recommendations for water control for the Everglades region. The comprehensive plan presented in this report includes all the important particulars of the plan of improvement considered necessary by the Soil Conservation Service. Copies of correspondence indicating the interchange of views and information between the Corps of Engineers and the Soil Conservation Service regarding this project are being furnished with this report as an exhibit.[1]

(*b*) Fish and Wildlife Service: It is believed that the development of the plan proposed in this report affords an excellent example of the coordination of improvements for flood control, water control, and related purposes with requirements for preservation of fish and wildlife. This Fish and Wildlife Service of the Department of the Interior has been consulted fully during the preparation of the comprehensive

[1] Not printed.

plan proposed in this report. The benefits to preservation of fish and wildlife included in this report were furnished by that Service, and its reports setting forth needs and recommendations are being furnished with this report as appendix F.[1] Comparison of the recommendations of the Fish and Wildlife Service with the comprehensive plan shows that the expressed desires of the Fish and Wildlife Service have been met on all essential points.

(*c*) National Park Service: The comprehensive plan proposed in this report has been prepared in full recognition of the Everglades National Park which has been established at the extreme southwestern tip of the peninsula. Since the park was opened formally on December 6, 1947 only a few days before completion of this report it has not yet been possible to examine all aspects of the relationship of the national park area to the plan proposed in this report. The proposed plan of improvement, however, would not damage or interfere with this great national park as the purposes of the comprehensive plan are aimed at restoring and preserving natural conditions over areas which appear unsuited to agriculture. During large floods, such as that of 1947, substantial releases of water through the controlled Tamiami Trail embankment would result in flows into the national park area which would be similar to those which prevailed when the natural flood waters of the Everglades passed to the sea through that region. In dry periods it would be possible, because of the proposed conservation areas, to release water into the park area which would assist in reducing fires and other damages which accompany periods of drought. In brief, it is believed that this comprehensive water-control plan and the national park plan are complementary features of Federal activity necessary to restore and preserve the unique Everglades region.

(*d*) Bureau of Indian Affairs: Since the Everglades and adjacent areas to the west are now the natural homes of the Seminole Indians, the effect of the improvement upon Indian reservations and activities has been investigated. The western levee of the Everglades conservation area which would separate the Everglades from the Devil's Garden and Big Cypress Swamp country to the west, has been established tentatively along the line between ranges 34 and 35 east. This is also the line between Broward and Dade Counties on the east and Collier County on the west. This location was adopted partly because it is now understood that all Indian lands lie west of that line and it was desired to exclude them from the conservation area subject to flooding. In addition, the drainage canal planned to follow the western side of this levee would afford a controlled drainage outlet for the area to the west where the Indian reservation is located in the vicinity of old Fort Shackleford. This would afford a major outlet for flood control and drainage of over 42,000 acres of Indian lands, as well as of the other lands in this largely undeveloped western area. Included with exhibits accompanying this report is a letter of October 29, 1947 from the superintendent of the Seminole Indian agency, office of indian affairs for the State of Florida, indicating his concurrence with the proposed plan.

84. *Local agencies.*—There has been full coordination and consultation with agencies of the State of Florida, such as the Fish and Game Commission and the Everglades Drainage District, as well as with

[1] Not printed.

affected counties and other interested local agencies. Resolutions and statements from many of these agencies are also being furnished as exhibits with this report.

XII. CONCLUSIONS AND RECOMMENDATIONS

85. *Discussion.*—The problems of flood control, drainage, and water use in central and southern Florida are complex. They range from protection of life and property from hurricane-driven tides at Lake Okeechobee to maintenance of water levels to combat the burning and destruction of muck lands of the Everglades. The plan presented in this report has been prepared after full consideration of these varied problems. Its preparation has been greatly facilitated by information and requirements furnished by other Federal agencies and by the full cooperation of local agencies and individuals. The comprehensive plan is not a panacea for all the difficulties inherent in the development of this region. No feasible plan of improvement within the realm of economic justification could completely banish flooding of this area, or insure that all needed water supplies will be available during the driest periods. However, when completed the development would provide a high degree of flood protection and conservation of the water resources of the region. A long-range plan of this kind for flood protection and water control is urgently needed now, so that development of the region can proceed in an orderly manner which will preserve its resources of water and land for future generations. Analysis of economics shows that the project as a whole is justified by a wide margin. Construction and subsequent operation of the comprehensive development to insure that its purposes are obtained would require the best efforts and continued cooperation of Federal, State, and local agencies, but the interest shown in this plan by the State of Florida and local interests indicates that this can be accomplished.

86. *Conclusions.*—It is concluded that the comprehensive plan proposed in this report provides for the most feasible and economical solution of flood control and related water problems in central and southern Florida, and that it should be adopted to provide the flood protection now urgently needed, and as a long-range plan for the control and use of the water resources of the area. Its cost will necessarily be large, but its benefits will be larger, and its ultimate development appears essential to further growth of this area and stabilization of its economy. The large Federal interest in this project is reflected by the benefits from flood control and navigation which it would produce, and its local benefits would warrant the substantial participation by local interests proposed in this report.

87. *Recommendations.*—It is therefore recommended:

(*a*) That the existing Federal project for the Caloosahatchee River and Lake Okeechobee drainage areas be modified and extended to provide for the comprehensive plan for flood control and other purposes in central and southern Florida, as proposed in this report at an estimated Federal first cost of $171,041,000, and $669,000 for annual maintenance and operation, and at an estimated non-Federal first cost of $37,094,000 and $3,034,000 for annual maintenance and operation, and as so modified and extended, be approved for prosecution by the Federal Government under the direction of the Secretary

of the Army and the supervision of the Chief of Engineers, with such modifications thereof and changes therein as may be found desirable by the Secretary of the Army upon recommendation of the Corps of Engineers.

(*b*) That the works for flood control and other purposes described in this report be maintained and operated by the Federal Government subject to the requirement that the State of Florida or other responsible local interests pay the annual cost of such maintenance and operation after completion of the works; except that the Secretary of the Army may turn over certain essentially local features to responsible local interests for operation in accordance with regulations prescribed by the Secretary of the Army upon the recommendation of the Chief of Engineers; and except that the cost of maintenance and operation of control works, navigation channels and locks, and levees of Lake Okeechobee and its outlets be borne by the Federal Government.

(*c*) That no money appropriated for the prosecution of features of this plan be expended on construction until the State or other responsible local interests shall have furnished assurances satisfactory to the Secretary of the Army that they will provide, without cost to the United States, all lands, easements, and rights-of-way necessary for construction and operation of such features, and that they will pay such cash contributions, and pay for relocations as may be required for these purposes, and hold and save the United States free from damages due to the construction works.

(*d*) That this project as modified and extended be considered as one for flood control and related purposes, and that its further consideration be under the provisions of flood control laws.

(*e*) That, in addition to previous authorizations for the Caloosahatchee River and Lake Okeechobee drainage areas in Florida, there be authorized to be appropriated by the Congress annual sums adequate for initiation and prosecution of the comprehensive plan in a logical step-by-step manner as described in this report.

WILLIS E. TEALE,
Colonel, Corps of Engineers,
District Engineer, Jacksonville, Fla.

RECOMENDATIONS OF THE DIVISION ENGINEER

[First endorsement]

OFFICE, DIVISION ENGINEER,
SOUTH ATLANTIC DIVISION,
Atlanta, Ga., December 31, 1947.

To the CHIEF OF ENGINEERS, UNITED STATES ARMY.

1. There are ample grounds, both economic and social, for the approval of a comprehensive project for water control in south Florida as outlined in the report of the district engineer. Any authorization should, however, provide latitude for changes, even major ones, should the advisability of such changes develop in the final planning stages. Since construction of the comprehensive project will take place over an extended period, many features of the plan will require further detailed study prior to the initiation of construction. Features which are not intimately tied to other portions of the comprehensive project should, at the time of constuction,

be justified individually by a current economic study and from the standpoints of safety and health hazards.

2. The district engineer has not sufficiently emphasized the importance of water conservation in the Lake Okeechobee-Everglades and lower-east-coast areas, nor has he claimed full credit for the benefits to be derived therefrom. If the coastal and Everglades sections of south Florida are to continue to prosper and develop, conservation of their water resources is as important and urgent as is provision of additional drainage and elimination of flood damage. Lack of water in the area during dry seasons has repeatedly done damage to crops, cattle, and the muck soil, perhaps as great in the long run as that caused by the less frequent but more spectacular major floods. Water supplies of the coastal cities have been affected or threatened by salt-water intrusion as rates of pumping from the natural subsurface supplies increased. Failure to conserve water either to recharge subsurface supplies or to provide satisfactory direct sources of fresh water to urban areas has caused and will cause further costly modifications of water-supply systems. The need for water will increase greatly with the expected continued development of the entire area. Therefore, both in the planning and operation of the works, provision for the storage of water should be made to the maximum practicable limit or to the extent that will meet all foreseeable demands. Until the need for fresh water has been satisfied, only the irreducible minimum that cannot be conserved should be discharged to coastal waters to be lost to the area for useful purposes.

3. The division engineer concurs in the recommendation of the district engineer.

MASON J. YOUNG,
Colonel, Corps of Engineers,
Division Engineer.

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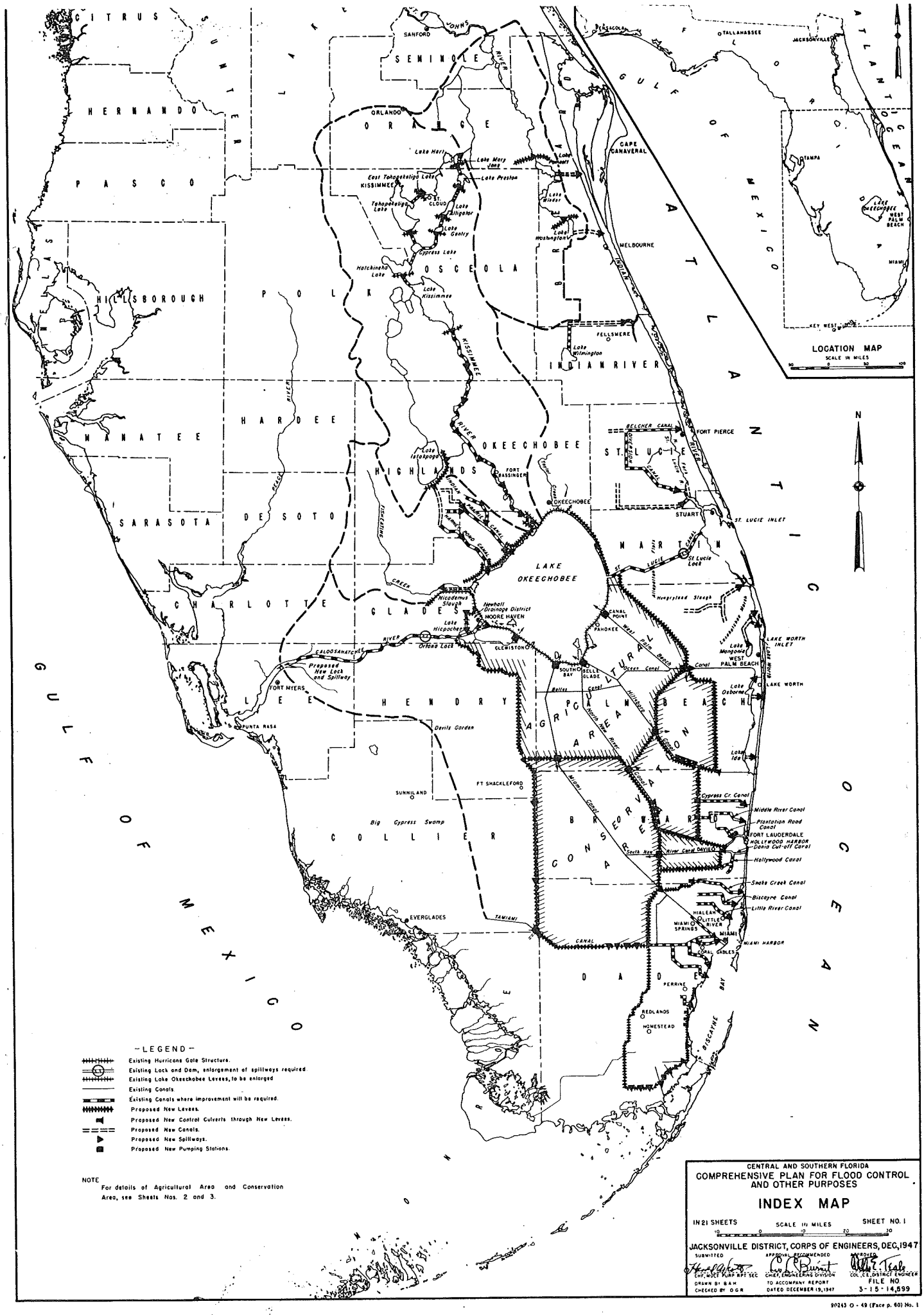

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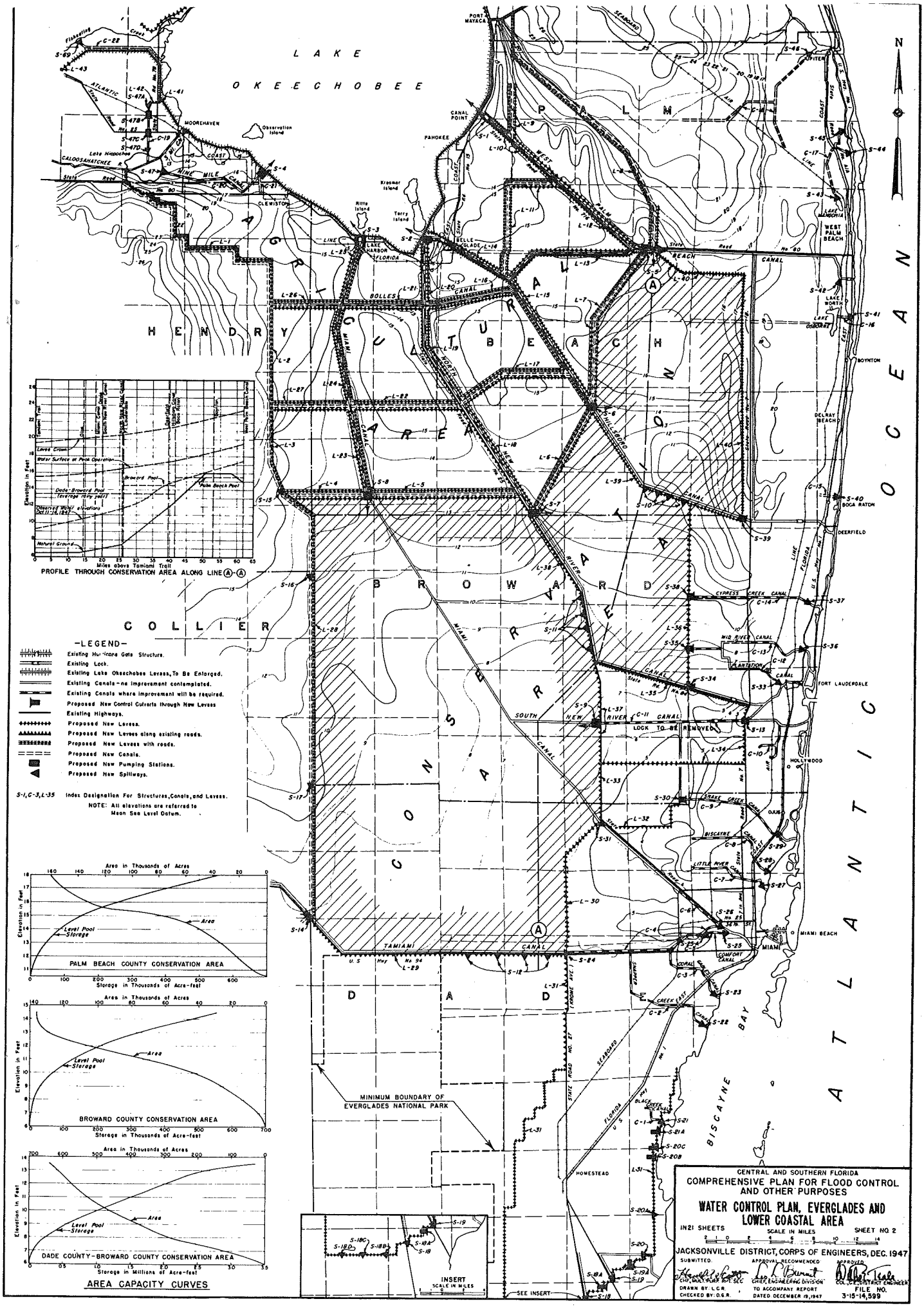
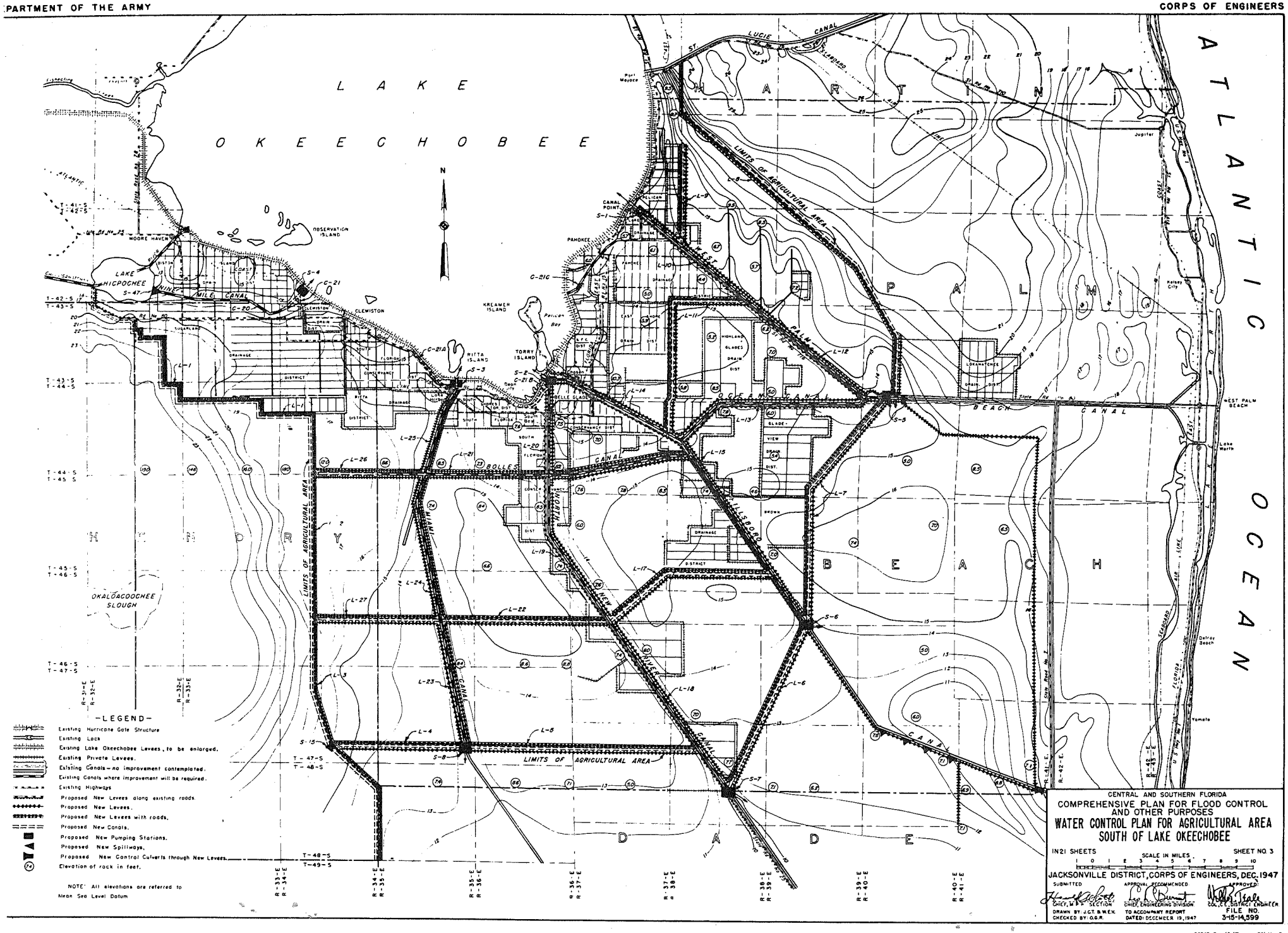
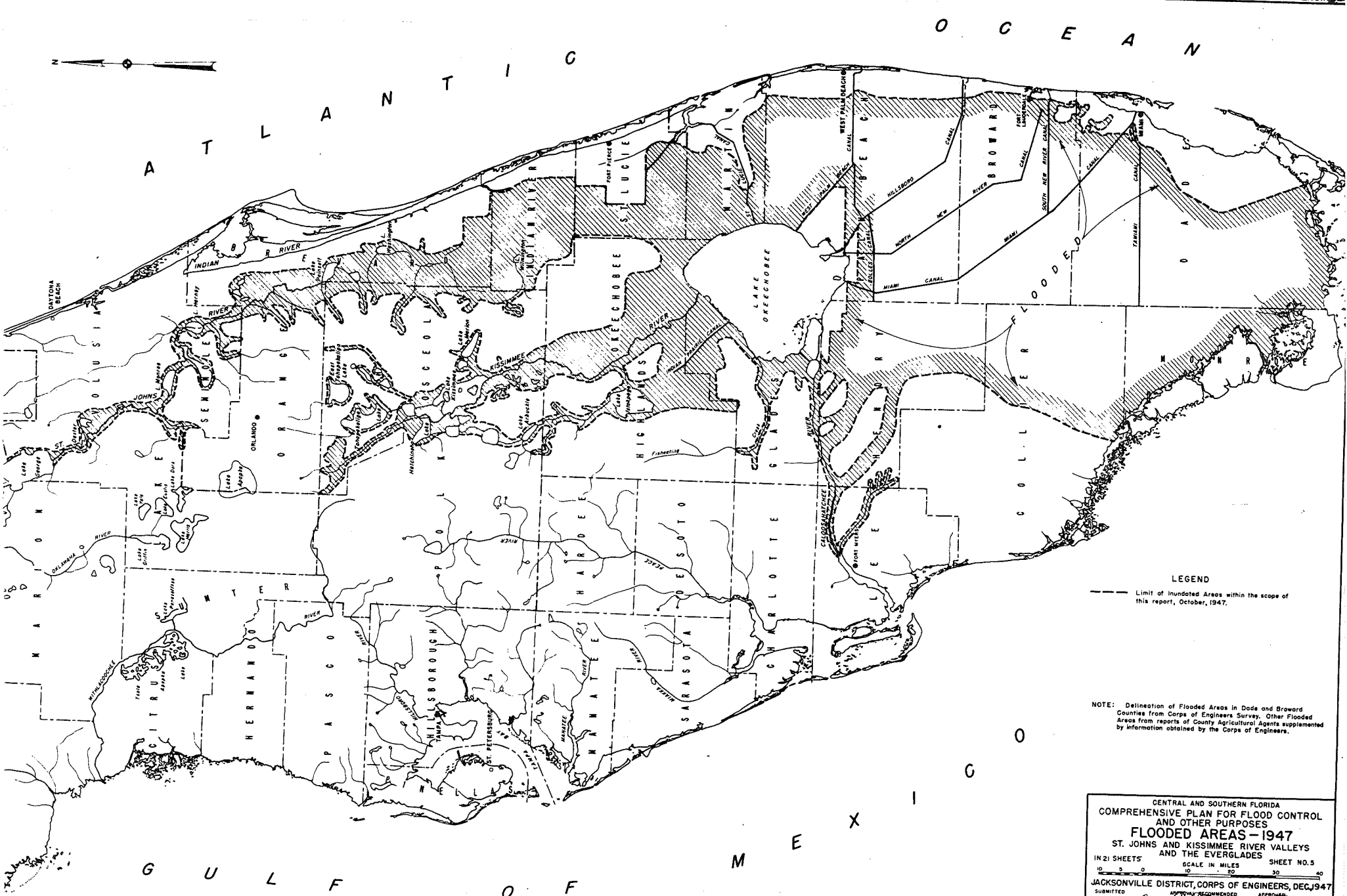
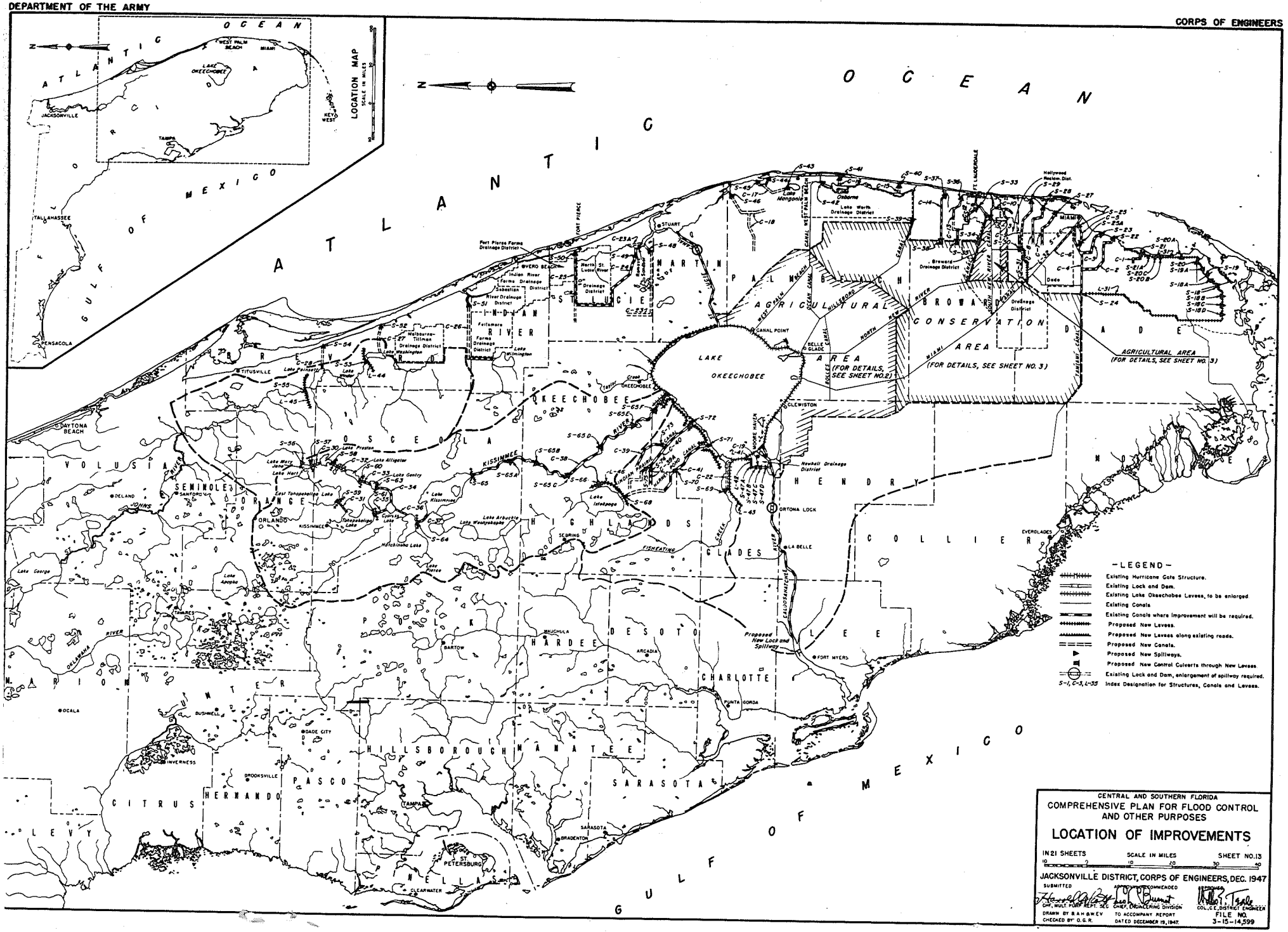

LAKE OKEECHOBEE
HENDRY
GLADES
PALM BEACH
COLLIER
BROWARD
DADE
ATLANTIC OCEAN
BISCAYNE BAY
MOOREHAVEN
CLEWISTON
BELLE GLADE
PAHOKEE
CANAL POINT
PORT MAYACA
JUPITER
WEST PALM BEACH
BOYNTON
DELRAY BEACH
BOCA RATON
DEERFIELD
FORT LAUDERDALE
HOLLYWOOD
MIAMI
MIAMI BEACH
HOMESTEAD
TAMIAMI CANAL
MINIMUM BOUNDARY OF EVERGLADES NATIONAL PARK
SEE INSERT
INSERT
SCALE IN MILES
PROFILE THROUGH CONSERVATION AREA ALONG LINE (A)-(A)
Miles above Tamiami Trail
Elevation in Feet
Levee Crown
Water Surface at Peak Operation
Dade-Broward Pool (Average rainy years)
Broward Pool
Palm Beach Pool
Observed Water elevations Oct 11-16, 1947
Natural Ground
-LEGEND-
Existing Hurricane Gate Structure.
Existing Lock.
Existing Lake Okeechobee Levees, To Be Enlarged.
Existing Canals-no improvement contemplated.
Existing Canals where improvement will be required.
Proposed New Control Culverts through New Levees
Existing Highways.
Proposed New Levees.
Proposed New Levees along existing roads.
Proposed New Levees with roads.
Proposed New Canals.
Proposed New Pumping Stations.
Proposed New Spillways.
S-1, C-3, L-35 Index Designation For Structures, Canals, and Levees.
NOTE: All elevations are referred to Mean Sea Level Datum.
Area in Thousands of Acres
Elevation in Feet
Level Pool Storage
Area
PALM BEACH COUNTY CONSERVATION AREA
Storage in Thousands of Acre-feet
BROWARD COUNTY CONSERVATION AREA
Storage in Thousands of Acre-feet
DADE COUNTY-BROWARD COUNTY CONSERVATION AREA
Storage in Millions of Acre-feet
AREA CAPACITY CURVES
CENTRAL AND SOUTHERN FLORIDA
COMPREHENSIVE PLAN FOR FLOOD CONTROL AND OTHER PURPOSES
WATER CONTROL PLAN, EVERGLADES AND LOWER COASTAL AREA
IN 21 SHEETS
SCALE IN MILES
SHEET NO. 2
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS, DEC. 1947
SUBMITTED:
APPROVAL RECOMMENDED:
APPROVED:
CHIEF, ENGINEERING DIVISION
COL., C.E. DISTRICT ENGINEER
DRAWN BY: I.C.R.
CHECKED BY: O.G.R.
TO ACCOMPANY REPORT DATED DECEMBER 19, 1947
FILE NO. 3-15-14,599


LAKE OKEECHOBEE
ATLANTIC OCEAN
MARTIN
PALM BEACH
HENDRY
DADE
N
LAKE HICPOCHEE
MOORE HAVEN
OBSERVATION ISLAND
CLEWISTON
KREAMER ISLAND
RITTA ISLAND
TORRY ISLAND
CANAL POINT
PAHOKEE
BELLE GLADE
OKALOACOOCHEE SLOUGH
LIMITS OF AGRICULTURAL AREA
WEST PALM BEACH CANAL
HILLSBORO CANAL
NORTH NEW RIVER CANAL
ST. LUCIE CANAL
WEST PALM BEACH
Jupiter
Lake Worth
Delray Beach
Yamato
Port Mayaca
Pelican Bay
Kelsey City
T-41-S
T-42-S
T-43-S
T-44-S
T-45-S
T-46-S
T-47-S
T-48-S
T-49-S
R-31-E
R-32-E
R-33-E
R-34-E
R-35-E
R-36-E
R-37-E
R-38-E
R-39-E
R-40-E
R-41-E
R-42-E
-LEGEND-
Existing Hurricane Gate Structure
Existing Lock
Existing Lake Okeechobee Levees, to be enlarged.
Existing Private Levees.
Existing Canals—no improvement contemplated.
Existing Canals where improvement will be required.
Existing Highways
Proposed New Levees along existing roads.
Proposed New Levees.
Proposed New Levees with roads.
Proposed New Canals.
Proposed New Pumping Stations.
Proposed New Spillways.
Proposed New Control Culverts through New Levees.
Elevation of rock in feet.
NOTE: All elevations are referred to Mean Sea Level Datum
CENTRAL AND SOUTHERN FLORIDA
COMPREHENSIVE PLAN FOR FLOOD CONTROL AND OTHER PURPOSES
WATER CONTROL PLAN FOR AGRICULTURAL AREA SOUTH OF LAKE OKEECHOBEE
IN 21 SHEETS
SHEET NO. 3
SCALE IN MILES
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS, DEC. 1947
SUBMITTED
APPROVAL RECOMMENDED
APPROVED:
CHIEF, W.P. SECTION
CHIEF, ENGINEERING DIVISION
COL. C.E. DISTRICT ENGINEER
DRAWN BY: J.C.T. & W.E.V.
CHECKED BY: O.G.R.
TO ACCOMPANY REPORT
DATED: DECEMBER 19, 1947
FILE NO. 3-15-14,599


ATLANTIC OCEAN
GULF OF MEXICO
N
DAYTONA BEACH
INDIAN RIVER
ST. JOHNS RIVER
ORLANDO
KISSIMMEE RIVER
OKEECHOBEE RIVER
LAKE OKEECHOBEE
HILLSBORO CANAL
NORTH NEW RIVER CANAL
MIAMI CANAL
SOUTH NEW RIVER CANAL
TAMIAMI CANAL
WEST PALM BEACH
FORT PIERCE
FORT LAUDERDALE
MIAMI
FORT MYERS
TAMPA
ST. PETERSBURG
TAMPA BAY
ST. LUCIE
MARTIN
PALM BEACH
BROWARD
DADE
MONROE
COLLIER
HENDRY
GLADES
HIGHLANDS
OKEECHOBEE
OSCEOLA
ORANGE
SEMINOLE
VOLUSIA
LAKE
MARION
SUMTER
CITRUS
HERNANDO
PASCO
HILLSBORO
POLK
HARDEE
DESOTO
MANATEE
SARASOTA
CHARLOTTE
LEE
FLOODED
LEGEND
Limit of Inundated Areas within the scope of this report, October, 1947.
NOTE: Delineation of Flooded Areas in Dade and Broward Counties from Corps of Engineers Survey. Other Flooded Areas from reports of County Agricultural Agents supplemented by information obtained by the Corps of Engineers.
CENTRAL AND SOUTHERN FLORIDA
COMPREHENSIVE PLAN FOR FLOOD CONTROL AND OTHER PURPOSES
FLOODED AREAS—1947
ST. JOHNS AND KISSIMMEE RIVER VALLEYS AND THE EVERGLADES
IN 21 SHEETS
SCALE IN MILES
SHEET NO. 5
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS, DEC. 1947
SUBMITTED
APPROVAL RECOMMENDED
APPROVED
CHIEF, ENGINEERING DIVISION
TO ACCOMPANY REPORT
DATED DECEMBER 19, 1947.
COL., C.E., DISTRICT ENGINEER
DRAWN BY L.C.R.
CHECKED BY C.M.P.
FILE NO. 3-15-14,599

DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS



CENTRAL AND SOUTHERN FLORIDA
COMPREHENSIVE PLAN FOR FLOOD CONTROL
AND OTHER PURPOSES

LOCATION OF IMPROVEMENTS

IN 21 SHEETS
SCALE IN MILES
SHEET NO.13

JACKSONVILLE DISTRICT, CORPS OF ENGINEERS, DEC. 1947

SUBMITTED
CHF., MULT. PURP. REPT. SEC.

APPROVAL RECOMMENDED
CHIEF, ENGINEERING DIVISION

APPROVED
COL., C.E., DISTRICT ENGINEER

DRAWN BY B.A.H. & W.E.V.
CHECKED BY O.G.R.

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