

STATE OF FLORIDA—EVERGLADES DRAINAGE  
DISTRICT REPORT OF  
EVERGLADES ENGINEERING BOARD OF REVIEW.  
MAY, 1927

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PART 1.

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RECOMMENDATIONS, FINDINGS AND  
CONCLUSIONS.

A. RECOMMENDATIONS.

The 5th, 7th and 9th paragraphs of the letter of instructions, dated March 22nd, 1927, from the Board of Commissioners, Everglades Drainage District, to the Everglades Engineering Board of Review, read as follows:

“The Board further requests that you make such recommendations for the future drainage of the Glades as you deem proper, as engineers, for this or any other board to follow in order that the work may be completed.”

“The Board would like a report as to whether it will be possible to drain the entire Everglades in one plan or whether it would be better to drain the Everglades by unit plan.”

“Further, gentlemen, the Board desires you to give us any and all information that you think would be needful and helpful, proper and wise, for this or any other board to follow in the final drainage and reclamation of the Everglades.”

The recommendations called for in the above instructions are presented herewith, in Sections 1 to 20, inclusive, below, as follows:

1. *1927 Revised Plan for Everglades Drainage.*

The Engineering Board of Review recommends that the Board of Commissioners, Everglades Drainage District, now adopt, for general guidance in future work, a "1927 Revised Plan for Everglades Drainage," substantially as outlined in these recommendations, comprising three essential general features, as follows:

- (a) A 1927 Revised Plan for the Control of Lake Okeechobee.
- (b) A 1927 Revised Plan for a system of Everglades Main Drainage Canals.
- (c) A 1927 Plan for Progressive Everglades Drainage of successive unit areas of lands, with corresponding progressive construction of successive sections of the Everglades Main Drainage Canals.

2. *Basis of 1927 Revised Plan for Everglades Drainage.*

The recommended 1927 Revised Plan for Everglades Drainage is based on a thorough study by the Everglades Engineering Board of Review of the whole Everglades drainage problem.

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1927 REVISED PLAN FOR THE CONTROL OF LAKE OKEECHOBEE.

The recommended 1927 Revised Plan for the control of Lake Okeechobee is presented in paragraphs 3 to 11, inclusive, below:

3. *1927 Revised Lake Okeechobee Control Canal Plans.*

The Everglades Engineering Board of Review recommends that the plans for construction of Lake Okeechobee control canals be revised to conform to the following procedure:

- (a) Proceed immediately to complete the St. Lucie control canal to its full capacity under the present plans, and to construct reliable adequate protection against partial stoppage by eroded materials washed in by storms and drainage channels.

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Estimated cost of completing St. Lucie Canal to present plans, January 1, 1927 \$723,880  
 Estimated cost of protection against stoppage .....\$175,000

Total .....\$898,880

Safe estimated capacity at stage 17.0 of St. Lucie Canal completed to present plans 5000 c.f.s.

(b) Proceeds to provide, promptly, an added control canals capacity of 2500 c.f.s. at Lake stage 17.0 (with proportional capacities at other lake stages).

(1) By enlarging the Caloosahatchee Canal to 2500 c.f.s. capacity at Lake stage 17.0, with suitable provision for discharge of this volume safely down the Caloosahatchee River.  
 Estimated cost .....\$872,560

or, (2) By deepening the St. Lucie Canal 5 feet.  
 Estimated cost .....\$1,224,000  
 Safe estimate of total Lake Okeechobee control canals capacity at stage 17.0, when (b) is completed ..... 7500 c.f.s.

(c) Ultimate provision for both the Caloosahatchee Canal improvement and the deepening of St. Lucie Canal 5 feet, as outlined in (b) above, or the extension and enlargement of Canal B, may prove advisable.

Safe estimate of total Lake Okeechobee control canals capacity at stage 17.0 when (c) is completed ..... 10,000 c.f.s.

4. Recommended Maximum and Minimum Control Levels for Lake Okeechobee.

The Everglades Engineering Board of Review recommends that the official limits set for the control of Lake Okeechobee maximum and minimum levels shall be 17.0 and 14.0 feet, respectively, above mean low water, Gulf of Mexico, Punta Rosa datum.

With the control work recommended herein available, the

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lake should never be permitted to rise materially above 17.0 feet, because of the danger to human life when disastrous storms coincide with high levels.

It is probable that during years of low rainfall it may prove impracticable to prevent occasional recession of the lake to levels below elevation 14.0.

5. *Main Drainage Canals Not Available for Use as Control Canals During Critical Storm Periods.*

The Main Drainage Canals should be reserved during critical storm periods for drainage purposes exclusively, and should not be considered as available for Lake Okeechobee control purposes at such times.

6. *Regulations for Managing Lake Okeechobee Control Canals.*

Regulations for the management of the use of Lake Okeechobee control canals should be considered as subject to modification from year to year, in the light of experience with their effects on lake levels, and in the light of further experience with the needs of Everglades cultivated lands, as to drainage.

The Everglades Engineering Board of Review recommends as follows:

Control canals opened whenever lake reaches stage 14.5 on a pronounced rise during the rainy season. Control canals kept open whenever the lake is above stage 15.0 and closed when it falls below stage 15.0.

7. *Revised Plan for Lake Okeechobee Levee.*

The Everglades Engineering Board of Review recommends the immediate construction of a greatly enlarged and highly safeguarded levee around the southwestern, southern, and southeastern shores of Lake Okeechobee, from a point about 3 miles northwest of Moore Haven to Bacom Point, about 2½ miles southwest of Pahokee, as indicated on the map accompanying this report (See Figure 2), and conforming to the following specifications:

(a) The levee shall be built to elevation 27.0 (or 10 feet above the maximum control level of Lake Okeechobee).

(b) Storm tide gates of suitable design, must be provided for the Caloosahatchee, Miami, North New River and Hillsboro Canals, capable of standing safely to hold back the lake waters to elevation 27.0.

(c) The entire lake side slope of the levee from low water to crest, and its crest for a width of 7 feet at elevation 27.0 shall be riprapped with rock for a thickness of 3 feet.

(d) The cross section of the levee shall be in accordance with one of the two alternative designs shown in Figure 3, and Figure 4, herewith.

Figure 3, shows the minimum Lake Okeechobee Levee section recommended by the Engineering Board of Review.

Estimated cost of Lake Okeechobee Levee, Figure 3, \$805,000.

Figure 4, shows the Lake Okeechobee sections recommended by the Chief Drainage Engineer in his biennial report, dated January 1, 1927, revised to bring the crest to elevation 27.0, and with an increased amount of stone riprap.

Estimated cost of Lake Okeechobee Levee, Fig-	
ure 4 Design, Total .....	\$1,680,000
Value of 1,165 salable residence lots at \$500....	582,000
	<hr/>
Properly chargeable to Everglades Drainage...	\$1,098,000
	<hr/>

The Everglades Engineering Board of Review believes the Figure 3 design to be safe, but grants that the Figure 4 design would provide flatter slopes to safeguard against possible erosion on the land side during hurricane storms, besides affording location for a highway well above possible highest water, and a large number of desirable residence lots.

The Everglades Engineering Board of Review recommends that thorough investigation be made by the Chief

Drainage Engineer to determine whether or not it may be necessary to extend the Lake Okeechobee Levee from Bacom Point northward, and if so, how far.

8. *Regular Patrol and Reliable Maintenance of Lake Okeechobee Levee Necessary.*

Attention is called to the absolute necessity for regular patrol and reliable maintenance of Lake Okeechobee Levee at all times.

The lands outside this levee have already subsided as much as 3 feet over considerable areas and in some cases over 4 feet, and will undoubtedly subside in time to materially lower levels. Eventually they will be below the proposed high level control of Lake Okeechobee.

It is essential that the levee be watched and be constantly kept intact, well up to elevation 27.0, adding rock to the top of the levee to restore its height whenever lowered by any cause. If the Figure 3 design is adopted for the levee, the land slopes must be completely sodded with Bermuda grass.

9. *Lake Okeechobee Navigation Requirements at Low Level Stages.*

With the recommended control of Lake Okeechobee it is expected that during dry years the water in the lake will fall below elevation 14.0 and that the maintenance of navigation will require the provision of channels of proper depth within the lake to meet the needs of navigation. The Everglades Engineering Board of Review believes that the protection of life and the prevention of overflow from the lake justify the temporary inconvenience to navigation caused by low stages in the lake during dry years. It is not believed that it is a proper function of Everglades Drainage District to construct necessary navigation channels within the lake and no provision has been made for their construction by the district.

10. *Control of Lake Okeechobee Levels by a Floodway to the South Rejected as Impracticable.*

The Everglades Engineering Board of Review has investigated the possibility of controlling the levels of Lake Okeechobee by a floodway to the south, and finds the project impracticable, because of its great cost, the great distance to the sea, the extremely slight fall per mile available, the consequent extremely low velocities attainable, and the maintenance difficulties.

11. *Control of Lake Okeechobee Levels by Diverting the Flood Flow of the Kissimmee River Directly to the Sea Rejected as Impracticable.*

The Everglades Engineering Board of Review has investigated the possibility of controlling the levels of Lake Okeechobee by diverting the flood flow of the Kissimmee River directly to the sea before it reaches Lake Okeechobee, and finds the project impracticable as:

(a) The flood flow of the Kissimmee River is many times the capacity needed for Lake Okeechobee control canals, and its diversion would require a channel of much larger capacity than the outlet canal. This is because of the immense storage provided in Lake Okeechobee by a small rise.

(b) The ground surface levels between the Kissimmee River and the ocean or gulf are so high as to make the cost of a channel of sufficiently low level prohibitive even for the same size channel.

1927 REVISED PLANS FOR EVERGLADES MAIN DRAINAGE SYSTEM

The recommended Revised Plans for Everglades Main Drainage Canals are presented in paragraphs 12 to 15, inclusive below.

12. *1927 Revised Plan for Everglades Main Drainage Canal System.*

The Everglades Engineering Board of Review recom-

mends that the Board of Commissioners, Everglades Drainage District, now adopt a "1927 Revised Plan for Everglades Main Drainage Canal System," as outlined on the Map of Proposed Canals and Levees, Figure 2, herewith:

Subject to the following proviso:

The exact location of all new main drainage canals shown in Figure 2, shall be subject to some modification as found advisable when the results of actual location surveys and borings become available and definite decisions as to where water from sub-districts will be admitted.

13. *Basic Engineering Conditions and Assumptions Recommended for Adoption in the Design of Everglades Main Drainage Canals.*

The Everglades Engineering Board of Review recommends that Everglades main drainage canals shall be designed in accordance with the following basic engineering conditions and assumptions:

(a) *Function of Main Drainage Canals.*

The primary purpose of the Everglades Drainage District main drainage canals shall be to afford adequate drainage outlets for adjacent sub-drainage districts and individually owned tracts of land, each of which shall provide its own lateral canal system, and, if necessary, levee system and pumping unit, or units, without which adequate drainage cannot be anticipated.

(b) *Functions and General Control of Design and Operation of Sub-district and Private Drainage Works.*

The sub-drainage districts and the individual owners of adjacent lands not in sub-drainage districts must construct the lateral canals, levees and pumping units necessary for adequate drainage and delivery of drainage waters at outlet points on the main drainage canals, at their own expense, but subject to the drainage laws of Florida, and in accordance with plans submitted to and approved in advance of construction by Everglades Drainage District.



Commissioners, Everglades Drainage District, Revised Plan for Everglades Drainage System, as outlined on the maps, Figure 2, herewith:

new main drainage shall be subject to... when the... and borings... as to where... admitted.

and Assumptions... Design of Everglades

Review recommendations shall be... basic engineering

Drainage Districts and in which shall... necessary, levee... which adequate

Design and Operation of Drainage Works. Individual owners of... must construct... necessary for... waters at... at their own... of Florida, and in... approved in... Drainage District.

The operation of the lateral canals, levees and pumping units must be subject to general regulations protecting the general interests, prepared and administered by the Everglades Drainage District.

- (c) *Pumping Station Equipment for Sub-Drainage and Private Drainage Works Typical Everglades Drainage Requirement.*

Owing to the flat surface and low level of the lands in the Everglades much of the territory cannot be drained by gravity and in order to provide adequate drainage for the typical Everglades tract of land during periods of heavy precipitation pumps must be used to lift the water from the sub-district canals to the main drainage canal. Ample provision for subsidence of the land should be made in designing the pumping plants.

- (d) *Extensive Advance Provision for Subsidence of Flat and Muck Soils is Necessary.*

Adequate advance provision for such subsidence of peat and muck soils as can reasonably be expected within several years after their drainage and utilization by cultivation, should be made in the first construction of Everglades main drainage canals.

The Everglades Engineering Board of Review recommends that advance provision in the design of all Everglades main drainage canals shall be made for subsidence of peat and muck soils to the extent of 3 feet below existing levels where the existing thickness is 6 feet or more, with proportionate allowance for lesser thicknesses.

- (e) *Run-off Capacity Necessary for Everglades Main Drainage Canals.*

The Everglades Engineering Board of Review recommends that the new and the enlarged old Everglades main drainage canals shown on the map, figure 2, be designated with run-off capacity shown in the run-off diagrams given

in figure 19, which are in accordance with the run-off formula.

$$Q = 69.1 \sqrt{M} \quad 9.6$$

$$\sqrt{M}$$

Where

Q—Run-off, in cubic feet per second per square mile.

M—Tributary drainage area, in square miles.

(f) *Coefficients of Roughness "n."*

In designing Everglades main drainage canals for areas around and to the east of Lake Okeechobee, and northeast of the Miami Canal, and for similar conditions elsewhere, the Everglades Engineering Board of Review has used a value of 0.025 for the coefficient of ditch roughness "n" to use in Kutters formula. Smaller canals such as those of sub-districts should generally employ a value not less than .030.

(g) *Safety Margin of Capacity of Everglades Main Drainage Canals.*

In order to provide a reasonable safety margin of drainage capacity, the Everglades Engineering Board of Review recommends:

(1) That in general the Everglades main drainage canals be designed to deliver the run-off capacities specified in (e) above with a flow line nowhere higher than the grounds surface will be after subsidence to the extent for which advance provision is recommended in (d) above.

This means 3 feet below the present level of the muck soils for most of the work of the next several years.

(2) That each Everglades main drainage canal be provided with a continuous tight dyke, or levee, on each side, constructed and maintained with the excavated materials at a height of at least 5 feet above the surface of ordinary high water, so that in case of need the canals can run safely 4 feet above ordinary high water level.

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accordance with the run-off  
and per square mile.  
square miles.  
age canals for areas  
Okeechobee, and northeast  
conditions elsewhere,  
Review has used a  
roughness "n"  
als such as those  
a value not less  
Everglades Main  
margin of drain-  
Board of Review  
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capacities specified  
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levee, on each side,  
excavated materials  
e surface of ordinary  
canals can run safely  
el.

(3) That each sub-district (or private) pumping unit be designed to deliver at need up to a level at least 4 feet above ordinary high water level in the main drainage canal, from any level to which the water at the desired level in the lateral canals is likely to sink because of subsidence of the muck soils.

14. *1927 Revised Plans for Everglades Main Drainage Canal System for Areas North and East of Line Shown on Figure 2.*

The Everglades main drainage canals shown on the map, Figure 2, for the areas east of Lake Okeechobee, east and northeast of the Miami Canal, and immediately west and south of Miami, include most if not all the new main drainage canals whose construction can now be reasonably anticipated.

The new main drainage canals are designated herein as B to H, and J to U, inclusive, and include such portions of the existing West Palm Beach, Hillsboro, North New River, Miami, Cypress Creek, Snake Creek, Tamiami and Snapper Creek Canals as will need enlargement or improvement.

The system of main drainage canals outlined just above has been designed in accordance with the basic engineering conditions and assumptions outlined in Section 13, above. Its basic features are as follows:

- (a) *East and west system of main drainage canals recommended.*

An east and west system of main drainage canals is recommended by the Everglades Engineering Board of Review, in preference to the system of long diagonal main drainage canals planned in the Isham Randolph Commission Plan of 1913, for the following reasons:

For any required amount of drainage from any point in the area in question:

- (1) The distance to the outlet into the ocean is less by the east and west route than it would be by the diagonal

route, thereby decreasing materially the yardage of excavation for a channel of given cross sectional area.

(2) The "Hydraulic Slope", or available fall per mile, is considerably steeper on the east and west route, thereby increasing the velocities of flow, and the volumes of water discharged by channels of given cross sections.

(3) The rock necessary to be excavated averages softer on the east and west route, thereby materially decreasing the cost per cubic yard.

(b) *Large curtailment recommended of new excavation heretofore proposed for long diagonal canals.*

The Everglades Engineering Board of Review recommends omitting all proposed new excavation for the Hillsboro, North New River and Miami Canals in excess of the amounts required.

(1) To provide adequate capacities for proposed main drainage canals K, L and O.

(2) To provide for the construction of an adequate dyke along the west bank of the Miami Canal from the south end of Canal H to the intersection of the Miami and the South New River Canals.

Carrying out the above recommendations will save a large amount of expensive excavation.

Adoption of the above recommendation will not preclude the ultimate enlargement of such canals for navigation or irrigation if the expense should later be found justifiable for those purposes alone.

(c) *Control Works for Proposed Main Drainage Canals.*

The control works included in the estimates for the proposed main drainage canals are as follows:

(1) An Everglades Standard Type of movable control dam is provided at each main drainage canal outlet into the ocean not already provided with control works.

N.B. If later found justifiable for navigation purposes, Everglades Standard Locks can be added as required.

(2) A barrier dam of rock and earth is provided across the diagonal canal between adjacent intersections of east and west main drainage canals and diagonal canals.

(d) *Estimated Cost of Proposed New Construction for Main Drainage Canals.*

The total estimated cost of the new construction required for the proposed main drainage canal system, is as follows:

Canal B .....	\$ 723,750
C .....	451,950
D .....	549,000
E .....	1,834,380
F .....	1,066,400
G .....	634,000
H .....	1,624,000
J .....	227,000
K .....	4,047,750
L .....	2,450,000
M .....	2,695,350
N .....	268,750
O .....	1,642,800
P .....	1,162,800
Q .....	1,493,450
R .....	
S .....	90,000
T .....	233,250
U .....	432,000
Miami Canal Levee .....	525,000
Control Works .....	560,000
Totals.....	<hr/> \$22,711,630

15. *Engineering Data not yet Available for Planning Main Drainage Canals for the Southwest Everglades.*

The Everglades Engineering Board of Review recommends to the Board of Commissioners, Everglades Drainage District, that no official action be taken at this time adopting plans for a main drainage canal system for the

Everglades Drainage District areas west and southwest of the line shown on Figure 2, as the Board finds that sufficient engineering data are not yet available for the area in question to permit planning any system of main drainage canals which the Board is willing to take the responsibility of recommending at this time.

Furthermore, the conditions are such that it seems certain that a considerable number of years must elapse before the expense involved in main drainage for this area will be found justifiable or before the nature of development and the resultant drainage requirements are established. Hence the problem should be considered one for further study and accumulation of data.

The Board has given careful consideration to the plans for draining this region suggested by the Isham Randolph Everglades Drainage Commission in its 1923 report, and to the suggestions of the Chief Drainage Engineer, Everglades Drainage District, in his Biennial Report, dated January, 1927. It considers the Chief Drainage Engineer's suggestions in his Biennial Report for drainage of the southwestern Everglades by a system of main drainage floodways, combined with pumping stations for sub-drainage districts, to be of sufficient promise to justify further consideration as rapidly as the necessary additional engineering data of the region can reasonably be accumulated.

#### A 1927 PLAN FOR PROGRESSIVE EVERGLADES DRAINAGE

16. *Recommendation for adoption by the Board of Commissioners, Everglades Drainage District, of a 1927 Plan for Progressive Drainage of the Everglades.*

The Everglades Engineering Board of Review recommends that the Board of Commissioners, Everglades Drainage District, now adopt a "1927 Plan for Progressive Everglades Drainage" of successive areas of Everglades

lands, with corresponding construction of successive sections of the Everglades main drainage canals, as outlined hereafter, so far as existing conditions of settlement and development will permit.

While construction in one continuous project, within a limited period of years, of the entire system of main drainage canals shown on the map, Figure 2, is possible, it is decidedly inadvisable, as it would require large expenditure on which there would be little return for many years. A carefully developed plan of progressive drainage that would permit gradual development in accordance with the needs of the community will in our judgment more nearly meet the requirements of sound engineering and business principles and wise public policy than any other that can be developed, for the following reasons:

(a) The area of Everglades lands that will be given adequate outlet drainage by the main drainage canal system outlined herein is so great as to require a period of many years to bring it under actual occupation and successful cultivation. Past experience in the Everglades has demonstrated this.

(b) During the time which elapses between completion of adequate main drainage canals and actual profitable utilization of the lands, interest and principal payments on bonds must be met by taxes on lands not in an earning state enabling them to stand the burden.

(c) Drainage in advance of use is unwise as it encourages the growth of objectionable vegetation such as willows and myrtle and thus increases the costs of clearing, and it materially increases the danger of serious damage by fire.

(d) The drainage canals require a yearly expenditure to keep them in order.

(e) The bringing of excessive areas into cultivation in a short time would unbalance production, tend to make farming unprofitable and create an unsatisfactory condi-

tion. Orderly development in accordance with the needs for the land would to a large extent prevent that.

If sub-drainage districts are to prove successful it is essential that from the beginning of settlement they have adequate outlet drainage.

It is in the best interests of the land owner, the prospective settler and the district that the investment in such drainage be held as low as possible. A plan of progressive drainage meets this requirement admirably, as the proposed plan of drainage can be accomplished by developing ultimate canal sections by successive stages as additional lands are needed for development or by concentrating development along the lower reaches of canals and extending them as additional lands are needed, thus holding the cost of drainage to a minimum. The progress of sub-districts will depend to a large extent upon their keeping development cost as low as is consistent with good work and by keeping the expenditures for outlet drainage in proper proportion to the area in development.

It is the recommendation of the Everglades Engineering Board of Review that the policy of progressive drainage development be maintained as fully as may be practicable at all times as the basis of final action by Everglades Drainage District, both in the development and conduct of all programs for its own work and in its consideration for approval of all plans for development by sub-districts or individuals.

#### 17. *Initial Improvements.*

The Everglades Engineering Board of Review recommends that the Board of Commissioners, Everglades Drainage District, proceed immediately to organize and carry out the improvements recommended for immediate construction in Sections 16 and 17, substantially as follows:

##### (a) *Works for Control of Lake Okeechobee.*

(1) Enlargement of outlet canals to 7500 second feet capacity by improvement of St. Lucie Canal or Caloosahatchee River.



(2) Enlargement and revetment of Lake Okeechobee Levee.

(3) Construction of storm tide gates at entrance to Caloosahatchee, Miami, North New River and Hillsboro Canals.

(b) *Main Drainage Canals to be Included in Initial Improvement Program.*

The determination of the areas to be served at once by Main Drainage Canals should be made by the Board of Commissioners, Everglades Drainage District, after a series of conferences and possibly public hearings at which land owners, sub-district officials and others interested can have opportunity to present any statements that they may desire for the consideration of the commissioners.

In reaching a decision in regard to the areas to be served first by Main Drainage Canals, full consideration should be given to the economic importance of the principle of progressive drainage and of maintaining investment in canals in proportion to development. The Board of Commissioners, Everglades Drainage District, alone has or can secure full facts on which to determine the selection of areas to be served.

The program should include only those areas where reliable assurance can be secured that adequate lateral canals, levees, and pumping plants (where required) will be provided within a reasonable time after adequate outlet drainage is supplied.

The character of the soil, the character of proposed crops and the probable adequacy of markets therefor, the transportation of facilities which will be available, and the accessibility to adjacent centers of population, should all be given due weight.

(c) *Table Showing Estimated Costs of Works Recommended for Immediate Construction.*

(1) Completion of St. Lucie Canal to capacity of 5,000 c.f.s. . . . . \$ 723,880.00

(2) Protection of St. Lucie Canal.....	175,000.00
(3) Construction of Lake Okeechobee levee and wind tide gates.....	805,000.00
(4) Provision of 2,500 c.f.s. additional lake outlet capacity.....	1,224,000.00

Total .....\$2,927,880.00

(5) To the above approximate amount of \$3,000,000.00 should be added the cost of those main drainage canals which the Board of Commissioners of Everglades Drainage District determine, under the conditions previously set out in Section 16, to be necessary for immediate construction. The total estimated cost of improvements for immediate construction cannot be finally set up until the extent and consequent cost of such canals is ascertained as above provided. Pending its definite determination we would suggest that the total figure for the cost of all works in the program for immediate construction as finally developed will probably fall between the limits of \$5,000,000 and \$8,000,000.

18. *Recapitulation of Estimated Costs of 1927 Revised Plan for Everglades Drainage.*

Item of Work	Estimated Cost
Completion of St. Lucie Canal to 5,000 c. f. s. capacity .....	\$ 723,880
St. Lucie Canal protection .....	175,000
Lake levee, Figure 3, minimum section.....	725,000
Flood tide gates at lake .....	80,000
2,500 c. f. c. lake outlet by Caloosahatchee....	872,560
Main Drainage Canal System .....	22,151,630
Control works for canals .....	560,000
Total estimated cost for complete project.....	\$25,288,070

The total estimated cost will be increased to \$25,581,070 if the modified levee section presented by Figure 4 is sub-

stituted for the minimum section used in the tabulation above.

It will be increased to \$25,639,510 if the increased outlet capacity of 2,500 c. f. s. is provided by an enlargement of the St. Lucie Canal instead of by improvement of the Caloosahatchee as provided in the tabulation above.

It will be increased to \$25,932,510 under a program including the modified levee section and the enlargement of St. Lucie Canal for added outlet capacities, in place of the minimum levee section and the improvement of the Caloosahatchee as provided in the tabulation above.

#### ADMINISTRATIVE AND ENGINEERING ORGANIZATION.

19. *Enlarged and Remodelled Administrative and Engineering Organization Recommended.*

The Everglades Engineering Board of Review accepts, as an established fact, the plan that the general administration of Everglades Drainage District shall be by the present Board of Commissioners, whose duties as State officers require their residence at Tallahassee. The administrative question open for discussion is how the Board of Commissioners can best model their administrative and engineering organization to meet the requirements of Everglades Drainage District design, construction, maintenance and operation most effectively and economically.

The Everglades Engineering Board of Review recommends that the Board of Commissioners, Everglades Drainage District, proceed to remodel and enlarge its present administrative and engineering organization materially. This recommendation is made for the following reasons:

The work of the Everglades Drainage District has developed gradually, by yearly increments for 24 years, so that it is now difficult to realize the magnitude of the construction work already accomplished under many difficulties, or the extent of the resultant changes in Ever-

glades conditions or the urgency for a systematic organization of control of operations of the drainage works whereby effective co-operation with the inhabitants and other land owners is secured with certainty at all times. The Everglades Engineering Board of Review believes that conditions have now reached such a stage of development as to make enlargement and remodelling of the administrative and engineering organization advisable immediately.

The Board of Commissioners of the Everglades Drainage District and its administrative and engineering organization are laboring under serious handicaps.

On the one hand, they are required to administer from a distance of 500 miles a great construction program, and the operation of drainage works which already have cost nearly \$15,000,000, and in the operation of which questions arise daily on which prompt and correct decisions are of vital importance to the residents and land owners of the Everglades District. These difficulties could doubtless best be met by locating the organization headquarters for the work at some point actually within or on the border of the Drainage District.

On the other hand, a location of organization headquarters 500 miles away from Tallahassee would make it almost impossible for the Board of Commissioners, the men ultimately responsible for the entire work, to keep close touch with either the building or the operation of the great drainage works involved.

20. *Suggested Outline of Enlarged and Remodelled Everglades Drainage District Administrative and Engineering.*

The Everglades Engineering Board of Review submits the following outline for a possible enlargement and remodelling of the administrative and engineering organization, but wishes its suggestions to be considered as merely tentative, as a basis for study and improvement.

(a) Divide the organization into three departments, as follows:

- (1) A Department of Administration and Design, directly under the Chief Drainage Engineer.
- (2) A Department of Construction and Maintenance, under an Assistant Chief Drainage Engineer, qualified to serve as Acting Chief Drainage Engineer in emergencies.
- (3) A Department of Operations, under an Engineer of Operations, next in rank to the Assistant Chief Drainage Engineer, and qualified to decide all ordinary questions arising about the control of the operations of the drainage works.

(b) Maintain at Tallahassee general headquarters for the Department of Administration and Design, with suitable commodious quarters, with the Chief Drainage Engineer in charge, who, however, should spend as much time as possible actually on the work in the Drainage District.

It is believed that it will be wise to capitalize as much as practicable on the great value to all concerned of frequent personal contact between the Chief Drainage Engineer and the people residing in the Everglades Drainage District.

(c) Maintain at the best location in the Everglades Drainage District, or on its border, a sub-headquarters for the Everglades Drainage District, at which the Department of Construction and Maintenance, and of Operations, shall both be located, in suitable, commodious quarters.

The sub-headquarters should be under the Assistant Chief Drainage Engineer, with the Engineer of Operations next in rank, both of whom should be given extensive authority and responsibility for prompt action on ordinary questions, with still greater authority and responsibilities in emergencies, while at the same time constantly reporting to and receiving instructions from the Chief Drainage Engineer.

The Chief Drainage Engineer will, of course, keep in

constant touch with the Board of Commissioners of the Everglades Drainage District, which through him will direct the general policies of the District.

### RECOMMENDATIONS, FINDINGS AND CONCLUSIONS

#### B. FINDINGS

The 1st, 2nd, 4th and 6th paragraphs of the letter of instructions dated March 22, 1927, from the Board of Commissioners, Everglades Drainage District, to the Everglades Engineering Board of Review, read as follows:

"The Drainage Board desires you to review carefully and in detail the original plans made by Isham Randolph Commission, which this Board and past boards have been trying to carry out for the purpose of draining the Glades."

"Secondly, the Board desires you to check up carefully the work that has been done by this Board and previous boards and ascertain whether they have followed the Isham Randolph plan or not.

"Further, the Board desires you to go into every phase of the engineering work that has been done in the Glades and to report as to whether it has been done correctly and properly.

"Further, the Board desires you to check up the amount of work that has been done by this and previous boards and the money that has been spent in payment of this work and report whether it has been economically spent or not."

The above instructions call for a number of findings as to facts, and these findings are presented herewith in Sections 21 to 38 inclusive, as follows:

HISTORY OF FLORIDA EVERGLADES DRAINAGE PLANS AND WORK PRIOR TO 1913.

21. *The Inception of the Florida Everglades Drainage Project.*

The first real move toward a project for the drainage of the Everglades was made in 1903, when Governor W. S. Jennings took the steps necessary to secure for the State of Florida title to the Everglades lands. All lands owned by the State of Florida were then, and are now, in charge of the State "Board of Trustees of the Internal Improvement Fund."

In 1905, the Florida Legislature passed the first drainage law creating Everglades Drainage District and prescribing its officers, duties and powers. The District is administered by the "Board of Commissioners, Everglades Drainage District," with membership identical with that of the "Trustees of the Internal Improvement Fund," as follows:

The Governor of Florida, Ex-Officio Chairman; The State Treasurer, The State Comptroller, The Attorney General of Florida, The State Commissioner of Agriculture.

22. *Beginning of Actual Construction of Everglades Drainage Works, 1905-1909.*

The actual construction of Everglades drainage works began during the administration of Governor Napoleon B. Broward, January 1, 1905, to January 1, 1909, during which work was accomplished by district owned and operated dredges, as follows:

	Length	Excavation
North New River Canal . . .	6.52 miles	915,000 Cu. Yds.
South New River Canal . . .	6.7 miles	759,900 Cu. Yds.

23. *Everglades Drainage Works Construction 1909-1913.*

During the administration of Governor Albert W. Gilchrist, January 1, 1909, to January 1, 1913, award of part

of the construction work to contractors was inaugurated (in 1910). The construction accomplished during the 4 year period consisted mainly of excavation on the Hillsboro, North New River, South New River, Miami and Caloosahatchee Canals, and brought the total excavation up to 17,505,924 Cu. Yds. by January 1, 1913. Control locks and dams were built as follows: North New River No. 2, 1912; South New River No. 1, 1912; Miami No. 2, 1912-1913.

Mr. J. O. Wright was Chief Drainage Engineer 1910 to 1912, when Mr. F. C. Elliott succeeded him. Mr. Elliott has continued in charge of the work till the present time, serving as Acting Chief Drainage Engineer till 1914, and since then as Chief Drainage Engineer.

24. *Payment for Everglades Drainage Construction from the Internal Improvement Fund, and later reimbursement therefor by Everglades Drainage District.*

Until January 1, 1909, all the costs of Everglades drainage works were paid by the Trustees of the Internal Improvement Fund. From 1909 to January 1, 1917 payments for Everglades drainage works were divided between the Internal Improvement Fund and Everglades Drainage District.

All payments from the Internal Improvement Fund for Everglades drainage works were reimbursed later by Everglades Drainage District.

25. *Present Everglades Drainage Law Passed in 1913.*

In 1913 the Florida Legislature passed a new Everglades Drainage District Act, which, with subsequent amendments, is the Act under which the Everglades Drainage District now operates, administered by the ex-officio Board of Commissioners described in Section 21 above.



THE ISHAM RANDOLPH EVERGLADES DRAINAGE  
ENGINEERING COMMISSION AND REPORT  
OF 1913.

26. *The Isham Randolph Commission, and Report.*

The Isham Randolph Commission was employed April 30, 1913, by the Board of Commissioners, Everglades Drainage District, and the Trustees of the Internal Improvement Fund, to make the necessary surveys and other engineering investigations, and to "report upon the practicability of draining the Everglades and recommendations by which said drainage may be accomplished."

The membership of the Isham Randolph Commission was, Isham Randolph, Chairman, Marshall O. Leighton, and Edmund T. Perkins. George C. Perkins was Secretary to the Commission till June 28th, 1913, when he was succeeded by George B. Hills.

The report of the commission is dated October 25, 1913, and has been printed as Senate Document No. 379, 63rd Congress of the United States, 2nd Session, 1914.

The Isham Randolph Commission report stated without qualification:

"Our conclusion, based on our study of ascertained facts, is that the drainage of the Florida Everglades is entirely practicable and can be accomplished at a cost which the value of the reclaimed land will justify, the cost per acre being very small."

The report made definite recommendations as to the methods which should be used to accomplish the drainage of the Everglades. These recommendations have been used continuously since 1913 by the successive Boards of Commissioners, Everglades Drainage Districts, for general guidance in the construction of Everglades drainage works.

The recommendations of the Isham Randolph Commission, as presented in their report, constitute what is often

designated "Isham Randolph Everglades Drainage Plan", or simply "The Isham Randolph Plan".

27. *Basic General Features of the Isham Randolph Everglades Drainage Plan.*

The basic general features of the Isham Randolph Everglades Drainage Plan are as follows:

(a) *The control of Lake Okeechobee.*

The control of the maximum and minimum levels of Lake Okeechobee was recommended as an essential prerequisite to successful Everglades drainage.

(b) *The construction of a system of main drainage canals.*

The construction was recommended of a system of main drainage canals for the purpose of providing drainage outlets for adjacent lands.

(c) *A progressive drainage system preferred but not demanded.*

On Page 8 of the Randolph report preference is expressed for a plan of progressive drainage as,

"We believe . . . that the Everglades can be reclaimed progressively, as is now planned by your board; that the work can so proceed as to reclaim the lands only as fast as there is need for those areas as homesteads and food products."

While on Page 12 he adds:

"The existing system of canals contemplates the reclamation of a greater portion of the Everglades in the immediate future than will probably be justified by the demand for new lands. It would have been much better to provide for an orderly progression of reclamation in accordance with the demand and with due regard to market conditions and transportation facilities. The existing works and the conditions of land, ownership and settlement, seem now to be such as to necessi-

tate an earnest effort to reclaim in one continuous project and with the greatest possible expedition all the lands south and southeast of Lake Okeechobee, between the Miami Canal, the proposed West Palm Beach Canal, and the eastern boundary of the drainage district."

28. *Basic Details of the Isham Randolph Everglades Drainage Plan.*

The basic details of the Isham Randolph Everglades Drainage Plan, from which some deviations were to be expected during construction in the light of more extensive and accurate data, and as the result of years of experience, include the following:

(a) *Control of Lake Okeechobee.*

(1) *Controlled high and low stages.*

The control of Lake Okeechobee was recommended between stages 19.0 and 16.0 with possibility of emergency rises above 19.0, even nearly to stage 21.5, the level at which the lake then overflowed to the south.

(2) *St. Lucie Control Canal.*

Construction was recommended of a control canal with capacity of 7000 c. f. s. at Lake stage. 19.0 and 5000 c. f. s. at 16.0, located approximately on the line of the present St. Lucie Canal.

(3) *Use of the St. Lucie Canal for Power Purposes.*

The Randolph Commission recommended the construction of the St. Lucie Canal as a combined control, drainage and power canal, and that a power plant be constructed as an adjunct thereto.

(4) *Partial Use of Long Diagonal Canals for Control Canal Purposes.*

Recommendation was made for the partial use of the West Palm Beach, Hillsboro, North New River, Miami and Caloosahatchee main drainage canals for control canal purposes, except during periods of heavy rainfalls, thus in-

creasing the total control canal capacity to 9200 c.f.s. at lake stage 19.0 and 6000 c.f.s. at 16.0.

- (5) *Location of the Upper Locks in the Main Drainage Canals at Distances of 8¾ to 12 Miles from Lake Okeechobee.*

In order to enable drainage into Lake Okeechobee of the lands adjacent to the lake on the east and south, the Randolph Commission recommended that the upper locks on the West Palm Beach, Hillsboro, North New River and the Miami Canals be located at distances varying from 8¾ to 12 miles away from the lake.

- (b) *Randolph Commission Main Drainage Canal Details.*

- (1) *Basic Engineering Assumptions for Main Drainage Canal Design.*

The basic engineering assumptions reported by the Randolph Commission as used by it for the design of Everglades main drainage canals are as follows:

Run-off—0.6 inches depth per 24 hours. High water level—3 feet below 1913 land surface elevations. Used 0.035 as value of coefficient or roughness "n" for Kutter's formula.

- (2) *No Advance Provision for Subsidence of Muck Soils.*

The Randolph Commission made no advance provision in its design of main drainage canals for anticipated subsidence of muck soils, which it reported would be less than 8 inches.

- (3) *System of Long Diagonal Main Drainage Canals for District Between Miami Canal and West Palm Beach Canal.*

The Randolph Commission found the Miami, the North New River and the Hillsboro diagonal canals already partly constructed and the West Palm Beach Canal contracted for. It recommended 3 additional long diagonal main drainage canals to serve this region.

- (4) *Main Drainage Canals for Areas Northwest and Northwest of Lake Okeechobee and Areas Immediately South of Miami.*

Several main drainage canals were planned to serve the above areas.

- (5) *A System of Main Drainage Canals for the Southwest Everglades Roughly Outlined.*

The Randolph Commission stated that:

"It is impossible now to determine precisely the most advantageous method of making such extensions" (of main drainage canals into the southwest Everglades). "For this will be dependent upon the settlement and development of the areas first reclaimed." Nevertheless, the Commission roughly outline a possible system of main drainage canals to serve the area eventually.

- (c) *Isham Randolph Commission's Estimates of Costs of Everglades Drainage Works.*

The Isham Randolph Commission's estimates of the costs of the recommended Everglades drainage works, were as follows:

(1) <i>Control of Lake Okeechobee.</i>	
St. Lucie Control Canal.....	\$ 2,259,000.00
(2) Main Drainage Canals Exclusive of Southwest Everglades (Additional to Previous Costs).....	*\$ 5,608,000.00
Total, exclusive of southwest Everglades .....	* 7,867,000.00
(3) Main Drainage Canals for Southwest Everglades (Roughly Outlined only) ..	14,635,000.00
	<hr/>
Total, inclusive of Southwest Everglades .....	\$22,502,000.00

HISTORY OF FLORIDA EVERGLADES DRAINAGE  
PLANS AND CONSTRUCTION FROM 1913  
TO 1927.

29. *General Outline of Florida Everglades Drainage Progress from 1913 to 1927.*

The Randolph Commission Plan for Everglades Drainage has been followed as a general guide in Everglades drainage construction work, and deviations from it have been made only in details, not in basic general features. Even in details, deviations from the Randolph plan have been made only as the result of study of more accurate and extensive data, not available to the Randolph Commission, including the results of years of actual experience with the drainage works.

\*NOTE: The Randolph estimates did not include previous expenditures, which were \$1,668,658, for 17,505,924 Cu. Yds. of excavation. Neither did the Randolph estimates include the cost of the West Palm Beach Canal, for which he states "contract has been let." This contract was for 6,121,000 Cu. Yds., which cost 7.82 per Cu. Yd., or a total of \$479,000.

Hence the total costs of Everglades Drainage according to the Randolph commission estimates would be \$24,650,000.

From January 1, 1913, to January 1, 1917, during the administration of Governor Park Trammel, money for construction was obtained entirely from drainage taxes and the proceeds of sales of Everglades lands. Work was continued on the Miami, North New River and Hillsboro Canals, and was begun and continued actively on the West Palm Beach Canal. Construction on the St. Lucie Canal began actively in January, 1916. The total excavation during the four years was 12,780,146 Cu. Yds. During this period control lock and dam No. 1, North New River, was built.

From January 1, 1917, to January 1, 1921, during the administration of Governor Sidney J. Catts, money for construction was obtained in part by the sale of Everglades drainage bonds, beginning in 1917. The World War, however, intervened to interpose difficulties, in spite of which excavation amounted to 8,951,000 Cu. Yds. in 1917 and 1918, and to 5,321,000 Cu. Yds. in 1919 and 1920. The above work was mainly on the St. Lucie, West Palm Beach, South New River, Snake Creek, Miami, Snapper Creek, Caloosahatchee and Indian Prairie Canals. During this period control locks and dams were built as follows: West Palm Beach No. 1, 1918, No. 2, 1919-1920; Hillsboro No. 1, 1917, No. 2, 1919-1920; Miami No. 1, 1919-1922; Caloosahatchee No. 1, 1917-1918, No. 2, 1918, No. 3, 1918-1920.

From January 1, 1921, to January 1, 1925, during the administration of Governor Carey A. Hardee, work continued actively, mainly from the sales of additional bonds. Construction unit prices and costs were much higher than before the World War, corresponding to the general higher level of prices prevailing throughout the country. During these four years the excavation amounted to 17,598,813 Cu. Yds., mainly on the St. Lucie, West Palm Beach, Hillsboro, South New River, Miami, Snapper Creek, Caloosahatchee and Indian Prairie Canals, and the Lake Okechobee South Shore Levee. During this period control locks and dams were built as follows: St. Lucie Nos. 1 and 2, 1922 to 1924; North New River No. 2 rebuilt, 1921; South New River No. 1 rebuilt, 1921.

From January 1, 1925, to January 1, 1927, during the first half of the administration of Governor John W. Martin, additional bonds were sold, on the most favorable terms yet secured, and work was prosecuted at the highest rate yet attained. Excavation during the two-year period amounted to 9,255,061 Cu. Yds., mainly on the St. Lucie, West Palm Beach, Hillsboro, North New River, Caloosahatchee and Indian Prairie Canals, and the Lake Okechobee South Shore Levee. Some levee work was done on

the Junction Levee and the North Palm Beach Levee. No lock or dam construction was undertaken in 1925 or 1926.

During 1926 two disastrous hurricane storm tides occurred on the South Shore of Lake Okeechobee.

The St. Lucie Canal came into 70% operation early in October, 1926, shortly after the great September hurricane, and began for the first time to be effective in controlling the levels of Lake Okeechobee.

30. *Planning and Constructing St. Lucie Control Canal.*

Beginning as early as March, 1913, the Chief Drainage Engineer, under directions from the Board of Commissioners, Everglades Drainage District, began location surveys for St. Lucie Canal. Several routes were surveyed and examined carefully, and thousands of borings were made to determine rock and soil conditions. The Chief Drainage Engineer made a final report on location and plans under date of July 6, 1915, and active construction began in January, 1916.

The Randolph Commission had recommended that St. Lucie Canal be constructed as a combined control, drainage, navigation and power canal, with a single combined lock, dam and power house. As finally planned and constructed, the power feature was abandoned, and two control locks and dams were provided, No. 1 at Lake Okeechobee and No. 2 only one and two-thirds miles from the outlet into the St. Lucie River. A dredge pass and dry dock were added as a part of control lock and dam No. 2.

Construction has been prosecuted continuously since January, 1916. On January 1, 1917, the status of construction was as follows:

	Excavation	Cost
Completed to Jan. 1, 1917,	32,267,958 cu. yds.	\$4,482,454
Control Works (completed),		419,448
Still to do after Jan. 1,		
1917, .....	1,809,700 cu. yds.	723,880
Jan. 1, 1917, estimate of		
completed canal .....	24,077,658 cu. yds.	\$5,625,782



As constructed, the St. Lucie Canal has the following estimated control canal capacities (in addition to provision for drainage canal uses) :

Lake Stage	19.0	7,000 c. f. s.
Lake Stage	17.0	5,000 c. f. s.
Lake Stage	15.0	3,500 c. f. s.

St. Lucie Canal has been used for some control canal discharge from Lake Okeechobee since 1923. In 1926 the amount so discharged increased from 1,600 c. f. s., in July, to 2,200 c. f. s. in September and 3,500 c. f. s. early in October.

In 1924 a very severe storm washed a large amount of eroded materials into St. Lucie Canal, causing serious stoppage.

St. Lucie Canal has been quite effective for control canal capacities since October, 1926.

31. *Planning and Constructing Lake Okeechobee South Shore Levee.*

Continued subsidence of the muck soils around the south-east, south and southwest shores of Lake Okeechobee and increasing realization of the dangers from storm tides on Lake Okeechobee led to the construction of Lake Okeechobee South Shore Levee, beginning in 1921 and continuing to date, on which 3,033,527 cubic yards of excavation had been completed to January 1, 1927, at a cost of \$455,187.

This levee was extensively breached by the September 17th, 1926, storm tide at points near Moore Haven, on the southwest shore, causing a serious disaster. Since that date the levee has been rebuilt, but it is now proposed to reconstruct it on an enlarged scale.

32. *Construction Since 1913 of Main Drainage Canals.*

As already described in a general way in Section 29, above, work on the main drainage canal system has continued ever since 1913. With the exception of the new Indian Prairie Canal, practically all of the main drainage canal

construction has been directed toward completing the main drainage canals already begun when the Randolph Commission made its report. However, very large amounts of construction would still be required to complete these existing canals to the original plans, and no start has been made on any of the three long diagonal main drainage canals recommended by the Randolph Commission for the region northeast of Miami Canal.

#### GENERAL DATA OF EVERGLADES DRAINAGE WORKS

##### 33. *Historical Data of Progress of Everglades Drainage Construction.*

The table below shows with close approximation the general progress of Everglades construction from year to year.

##### PROGRESS DATA OF EVERGLADES DRAINAGE CONSTRUCTION

Date	Total Excavation to Date	Total Cost to Date
Jan. 1, 1903.....	.....	\$.....
Jan. 1, 1910.....	3,679,000 cu. yds.	469,485
Jan. 1, 1911.....	5,312,000 " "	645,380
Jan. 1, 1912.....	11,239,000 " "	1,098,615
Jan. 1, 1913.....	17,506,000 " "	1,668,658
Jan. 1, 1914.....	20,003,000 " "	1,974,514
Jan. 1, 1915.....	21,309,000 " "	2,107,488
Jan. 1, 1916.....	25,012,000 " "	2,465,264
Jan. 1, 1917.....	30,286,000 " "	3,014,574
Jan. 1, 1918.....	35,826,000 " "	3,489,945
Jan. 1, 1919.....	39,237,000 " "	3,978,420
Jan. 1, 1920.....	42,716,000 " "	4,596,379
Jan. 1, 1921.....	45,558,000 " "	5,358,905
Jan. 1, 1922.....	49,851,000 " "	6,885,854
Jan. 1, 1923.....	55,019,000 " "	8,903,379
Jan. 1, 1924.....	60,305,000 " "	10,304,543

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PROGRESS DATA OF EVERGLADES DRAINAGE CONSTRUCTION  
(CONTINUED)

Date	Total Excavation to Date	Total Cost to Date
Jan. 1, 1925 .....	63,156,000 cu. yds.	\$11,193,320
Jan. 1, 1926 .....	66,957,000 " "	12,663,157
Jan. 1, 1927 .....	72,312,000 " "	14,897,174
Not Distributed .....		6,680
Not Paid for by Dis- trict .....	1,081,000 " "	
Totals to Jan. 1, 1927..	73,393,000 cu. yds.	\$14,903,854

34. *Data of Annual Expenditures for Everglades Drainage Construction 1916 to 1926.*

Table Showing Annual Expenditures for Everglades Drainage Construction, 1916 to 1926.

EXPENDITURES.

Year	Construction	Maintenance	Engineering	Total
1916 .....	\$ 501,200	\$ 25,000	\$ 23,100	\$ 549,310
1917 .....	439,800	19,500	16,071	475,371
1918 .....	436,400	27,100	24,975	488,475
1919 .....	565,200	26,759	26,000	617,959
1920 .....	671,600	51,800	39,126	762,526
1921 .....	1,354,126	101,656	71,167	1,526,949
1922 .....	1,907,727	54,597	55,201	2,017,525
1923 .....	1,283,090	61,128	56,946	1,401,164
1924 .....	737,042	91,409	60,326	888,777
1925 .....	1,331,017	61,645	77,175	1,469,837
1926 .....	2,060,609	92,692	80,716	2,234,017

35. *Data of Unit Costs of Everglades Drainage Works.*

From 1910 to 1915 it cost 8 cents per Cubic Yard for excavating earth on the Hillsboro, North New River, South New River and Miami Canals and 7.82 cents per cubic yard on the West Palm Beach Canal while the cost of exca-

vating rock on the above canals was 20 cents per cubic yard. From 1923 the unit cost of excavating earth on the same canals has varied from 12 to 14 cents, while it has cost from 30 to 70 cents per cubic yard to excavate rock. In 1923-25 it cost 16 cents per cubic yard to excavate a portion of the Indian Prarie Canal. During the completion of the St. Lucie Canal in 1927 earth excavation cost 20 cents per cubic yard east of and 28 cents west of Lock No. 2. While rock excavation cost 65 cents per cubic yard. Unclassified excavation on the Caloosahatchee Canal from 1915-1918 cost 16.9 cents per cubic yard and from 1919 to 1921 excavation classed as 64% earth and 36% rock cost 23.4 cents per cubic yard.

36. *Proposed New East and West System of Main Drainage Canals Recommended by the Chief Drainage Engineer.*

In his biennial report dated January 1, 1927, the Chief Drainage Engineer recommends the adoption of a plan for a new system of east and west main drainage canals to serve the regions east and southeast of Lake Okeechobee, and northeast of Miami Canal. His estimates are for 55,278,300 cu. yds. of excavation on ten new canals at an estimated cost of \$13,979,515, besides 9,243,520 cu. yds. for completing existing main drainage canals, at an estimated cost of \$3,998,945.

37. *Data of Actual and Proposed Everglades Drainage Works.*

TABLE OF DATA OF EVERGLADES DRAINAGE WORKS CONSTRUCTION, ACTUAL AND AS PROPOSED BY CHIEF DRAINAGE ENGINEER, JANUARY 1, 1927.

	EXCAVATION			
	Length Miles	Completed Cu. Yds.	Proposed Cu. Yds.	Total Cu. Yds.
St. Lucie Canal . . . . .	25.00	22,267,958	1,809,700	24,077,658
West Palm Beach Canal . . . . .	40.90	10,439,985	1,157,720	11,597,705
Hillsboro Canal . . . . .	50.00	8,147,393	3,834,800	11,882,193
Cypress Creek Canal . . . . .	12.20	768,288		768,288
North New River Canal . . . . .	59.20	7,819,311	1,766,000	9,585,311
South New River Canal . . . . .	25.00	3,693,207		3,693,207
Dania Canal . . . . .	5.95	1,169,019		1,169,019
*Snake Creek Canal . . . . .	14.30	292,346		292,346
Miami Canal . . . . .	78.70	8,211,169	2,485,000	10,696,169
*Tamiami Canal . . . . .	5.52	419,577		419,577
*Snapper Creek Canal . . . . .	21.03	900,937		900,937
Caloosahatchee Canal . . . . .	28.00	3,128,664	1,200,000	4,328,664
Indian Prairie Canal . . . . .	20.83	1,668,705		1,668,705
*Miscellaneous Canals . . . . .	45.74	1,352,234		1,352,234
<hr/>				
Total Existing Canals . . . . .	432.37	70,278,793	12,253,220	82,532,013
Lake Okeechobee Levee . . . . .		3,033,527	11,491,600	14,525,127
Junction and North Palm Beach Levees . . . . .				
Control Works . . . . .		80,720		80,720
Miscellaneous . . . . .				
<hr/>				
Total Levees and Existing Canals . . . . .		73,393,040	23,744,820	97,137,860
10 New East and West Main Drainage Canals . . . . .			55,278,300	55,278,300
<hr/>				
GRAND TOTALS . . . . .		73,393,040	79,023,120	152,416,160

NOTE: Work marked \* paid for wholly or in part by others.

TABLE OF DATA OF EVERGLADES DRAINAGE WORKS CONSTRUCTION ACTUAL AND AS PROPOSED BY CHIEF DRAINAGE ENGINEER JANUARY 1, 1917.

## COSTS.

Control Works	Actual	Proposed	Total
St. Lucie Canal.....\$	419,448	\$ 723,880	\$ 5,625,782
West Palm Beach Canal...	157,000	173,655	1,804,722
Hillsboro Canal.....	118,000	1,150,440	2,514,691
Cypress Creek Canal.....	40,476	.....	40,476
North New River Canal....	74,000	1,059,600	2,655,509
South New River Canal....	29,000	.....	1,221,874
Dania Canal.....	44,540	.....	44,540
*Snake Creek Canal.....	.....	.....	.....
Miami Canal.....	83,000	1,615,250	3,789,832
*Tamiami Canal.....	.....	.....	.....
*Snapper Creek Canal.....	.....	.....	.....
Caloosahatchee Canal....	146,000	300,000	121,261
Indian Prairie Canal.....	.....	.....	602,891
*Miscellaneous Canals....	.....	.....	277,143
Total Existing Canals..\$	1,026,448	\$ 5,022,825	\$ 19,144,721

Under Construction..... \$ 4,000,000  
 Finished and Stored..... 30,000  
 Branch Levees..... 30,000  
 Control Works..... 30,000  
 Miscellaneous..... 30,000

	\$ 455,187	\$ 1,581,098	\$ 2,036,285
Lake Okeechobee Levee.....\$.....			
Junction and North Palm.....			
Beach Levees.....	39,053		39,053
Control Works.....			
Miscellaneous.....	287,718		287,718
<hr/>			
Total Levees and Existing Canals.....\$ 1,026,448	\$13,877,406	\$ 6,603,923	\$21,507,777
10 New East and West Main Drainage Canals 275,000		13,704,515	13,979,515
Grand Totals.....\$ 1,301,448	\$13,877,406	\$20,308,438	\$35,487,292
<hr/>			
Total Expenditures to January 1, 1927.....			\$14,903,854
Total Future Expenditures proposed by Chief Drainage Engineer, January 1, 1927, (Estimated) ..			20,583,436
			<u>\$35,487,292</u>

\*NOTE: Work marked "\*" paid for wholly or in part by others.

RESULTS TO DATE ATTAINED BY EVERGLADES  
DRAINAGE.38. *Results of Everglades Drainage Works Construction.*

The construction of Everglades drainage works has proceeded over so many years, at a rate so slow in proportion to the magnitude of the completed undertaking, that it is hard for those now visiting the Everglades and even for residents within or adjacent to their borders to realize the vast changes which Everglades drainage works already constructed have produced.

One of the members of Everglades Engineering Board of Review made a survey in 1913 from West Palm Beach to Lake Okeechobee, through a marsh covered with water practically all the way, through which progress could be made only at a snail's pace, by extreme physical exertion. This Engineering Board of Review travelled in March, 1927, over very much the same territory in about an hour, on a paved road whose existence was possible only because of Everglades drainage construction.

Until October, 1926, the St. Lucie Canal, constructed for the control of Lake Okeechobee levels, was incomplete and practically not in operation. Hence, the advantages to be obtained by Lake Okeechobee control have not been attainable till now.

The system of main canals required for the reliable provision of drainage outlets adequate at all times for the full needs of sub drainage districts in the areas east and southeast of Lake Okeechobee is less than half completed. Consequently sub drainage districts are yet as subject to danger of flooding in times of severe, long continued storms, with the result that their agricultural efforts and investments have so far been subject to the vicissitudes of chance.

For these reasons the acreage of Everglades lands under actual successful cultivation in 1927, after 22 years of Everglades drainage works construction, is comparatively