SFWMD

TECHNICAL PUBLICATION 74-4

June, 1974

SUPPLEMENTAL WATER USE IN THE EVERGLADES AGRICULTURAL AREA

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

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CENTRAL AND SOUTHERN FLORIDA FLOOD CONTROL DISTRICT

Technical Publication: No. 74-4

Supplemental Water Use in the Everglades Agricultural Area

by

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Central and Southern Florida
Flood Control District
West Palm Beach, Florida
1974

This publication was produced at an annual cost of $150.00 or $.30 per copy to inform the public.
500 890 Produced on recycled paper.

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ABSTRACT

Supplemental water use in a portion of the Everglades Agricultural Area for the period 1961 through 1972 is examined. In this study, only supplemental water use for the normal irrigation season, November through May, is considered. Supplemental water is taken to be that water released from Lake Okeechobee into the study area. The released water is equated with applied irrigation water to meet crop growth requirements, although other uses for water released from the Lake are acknowledged and discussed. A comparison is made between monthly and seasonal water releases into the study area and theoretical crop supplemental water demand on a gross area-wide basis.

Also examined, for the same period, are the annual volumes of surplus water discharged from the study area to Lake Okeechobee and these are compared with the annual volumes of water released from the Lake to meet supplemental water requirements.

This investigation finds that, on a gross area-wide basis;

1. There is no significant over-application of supplemental water with respect to beneficial use as represented by theoretical crop requirements;
2. There is no apparent waste of water from the Lake Okeechobee-study area system which, in effect, functions as a "closed system";
3. There has been no abuse of the District's criteria established for the present water use permitting system.

It is consequently concluded that existing permits for water use in the Everglades Agricultural Area can be converted, and new permits can be issued, under Chapter 373, Florida Statutes, on a short-term basis without modifying the present basic criteria for permit issuance.

All permits in the study area should be reexamined at one time and no later than approximately mid-1977, prior to which time supplemental water use criteria will again be evaluated.

INTRODUCTION

The Everglades Agricultural Area of western Palm Beach County and eastern Hendry County is by far the largest single block of land area within the Central and Southern Florida Flood Control District which is devoted to intensive agricultural use. This area is shown on the map of Figure 1.

Area-wide water control, for the most part, is provided by the levees, canals, pumping stations and control structures of the Central and Southern Florida Project system. Excess surface water runoff is removed from the area, and supplemental water requirements are introduced into the area, by means of this system. The exceptions to this are several drainage districts adjacent to Lake Okeechobee which discharge runoff directly to, and withdraw supplemental water requirements directly from, the Lake. This present study is limited to the Project system-dependent portion of the Everglades Agricultural Area. The study area is outlined on Figure 1.

Agriculture in the Everglades Agricultural Area is a major consumer of water. Supplemental water requirements for crop growth vary, dependent upon the timing and amount of natural water availability from rainfall. However, in some dry years this requirement for supplemental water will exceed the total annual potable water consumption of the combined populations of Palm Beach, Broward, and Dade Counties.

The source of this supplemental water is Lake Okeechobee. It is introduced from the Lake into the four Project canals traversing the study area (West Palm Beach, Hillsboro, North New River, and Miami Canals) by way of three Hurricane Gate structures in the south shore levees (HGS 3, 4, and 5). Individual agricultural operators or drainage districts then withdraw supplemental water from the primary canal system.

The District has been issuing permits for surface water withdrawals from its system in the study area for a number of years. The basis for those permits is a permissible average daily supplemental water application rate of 0.25 inches/acre, or a maximum monthly application of 7.5 inches/acre.

The purpose of the present study is to determine, on a gross area-wide basis, the actual usage of supplemental water in the study area and thus evaluate the performance of the water use permitting approach now in effect.

This will be accomplished by establishing the relationships between water released from the Lake into the study area as supplemental water and crop water needs based on evapotranspiration requirements. The study period is 1962 through 1971, and only the normal "irrigation season", November through May, is considered.

BASIC DATA

Applied supplemental water (Table I) was considered to be the sum, over each month, of all releases through each hurricane gate that did not pass through the discharge structure at the downstream end of its respective canal the same day. These values were converted to an equivalent depth in inches over the irrigated areas by dividing the irrigation volume by the area under irrigation.

Precipitation (Table II) is the weighted average, by the Thiessen method, of thirteen rainfall stations distributed over the agricultural area.

Pan Evaporation (Table III) is the weighted average of four Class A evaporation pans; Everglades Experiment Station - Belle Glade, Clewiston, S-7 and S-5A. Weightings were also determined by the Thiessen method.

Basic land use data (Table IV) was derived from acreages under production in cane, pasture, and truck crops in Palm Beach County for the years 1962-63, 1965-66, 1972-73, plus land use maps for Palm Beach County for 1968 and 1970. Supplemental data based on production figures were obtained from the Palm Beach County Agricultural Extension Agent. These figures were modified on the basis of the land use maps, to exclude the part of the agricultural area which receives its water directly from Lake Okeechobee rather than from the main canal system and to include the part of the Agricultural Area in Hendry County which receives water from the Miami Canal. The acreage in cane supplied by the County Extension Agent was based on cane harvested whereas approximately twenty percent of the cane is replanted yearly and is not harvested during that season. The cane acreages reported were, therefore, multiplied by 1.25. The annual increments of acreage under production agree reasonably well with values derived from irrigation permits issued during this period.

Cumulative applied supplemental water (Figure 3) was calculated as described above with the exception that successive values were added through the entire period of record and the values corresponding to the end of each calendar year were plotted.

Cumulative volume of water pumped to Lake Okeechobee (Figure 4) was calculated as the summation of all daily flow volumes flowing toward Lake Okeechobee at the gauging stations below S-3 and S-2 which did not enter the respective downstream structure the same day. The plotted points represent the values corresponding to the end of each calendar year.

Cumulative volume pumped out of the Agricultural Areas was calculated from the values derived for volume of water pumped to Lake Okeechobee described above, plus the summation of daily flow out of the Everglades Agricultural Areas at pump stations S-8, S-7, S-6, and the gauging station upstream of S-5A, which did not enter the respective hurricane gates the same day.

METHODOLOGY

A survey of available literature on evapotranspiration resulted in selecting a coefficient K (for the relationship ET = K x pan evaporation) of 0.80 for sugar cane. This was subsequently modified to 0.70 to allow for cultural practices.

The value of 0.80 for cane, on the basis of 100% of cane land in full production, was selected from lysimeter studies of the Agricultural Experiment Station - Belle Glade, 1942-1945, and substantiated with data from experiments on sugar cane in Hawaii.

The value of 0.65 for truck crops was selected from data for bell peppers, string beans, and corn at the Ft. Lauderdale Experiment Station, 1954-56. Since these crops comprise only a part of the normal truck crops, the Blaney-Criddle formula with the crop coefficients for small vegetables given in SCS-TR21 was used as a check. Very good agreement was found between the two methods on a long term basis.

The values for pasture and sod were selected from a simplification of the linear regression equation, ET = 0.678 x pan evaporation - 0.270, derived by Stewart and Mills, 59th Annual Meeting, ASAE, 1966. That equation was derived from data on St. Augustine grass and Tifway Bermuda grass grown in lysimeters at the Plantation Field Laboratory - Ft. Lauderdale. The simplification of 0.58 times pan evaporation incorporates both constants into a single constant to facilitate evaluating an average K based on cropping pattern. This simplification fits the data very well for the irrigation season.

Values were found for the Everglades peaty muck soil under fallow conditions from work at the Everglades Experiment Station - Belle Glade, 1934-37. These agreed reasonably well with the values for pasture given above.

These lysimeter values are representative of the actual evapotranspiration in irrigated muck for pasture and sod, fallow, and truck crops due to the soil type and cultural practices. It is necessary, however, to correct the value for sugar cane because of cultural practices and a significant portion of harvested cane left fallow over part of the irrigation season. Based on local farming practices supplied by the U.S. Sugar Company and the County Extension Agent, an average value of 0.70 was selected for cane as representative during the growing season.

A weighted pan coefficient (Table V) was then derived for each year, based on the amount of land devoted to each crop during that year.

The method used for this study assumes that crop water requirement is equivalent to evapotranspiration as represented by pan evaporation multiplied by the appropriate pan coefficient "K". The difference between evapotranspiration (crop requirement) and actual rainfall is termed "ET deficit". The constraint that ET deficit cannot be less than zero was imposed under the assumption that all rainfall in excess of the ET requirement is discharged as runoff. This assumption ignores the fact that water tables are fluctuated as a water management practice.

For the study period, the monthly values for ET deficit are tabulated in Table V. The weighted pan evaporation coefficients used, based on acres planted in the three crop categories, are listed for each year. ET deficit values for each season are listed, recognizing the constraint noted earlier that monthly negative values are not included in the seasonal summation.

Figures 2a through 2d plot, for each of the eleven (11) irrigation seasons examined, cumulative ET deficit with cumulative supplemental water releases from the Lake against time.

The monthly and seasonal differences between these cumulative curves are tabulated in Table VI. Negative values indicate less supplemental water released than required to meet ET requirements.

Figure 3 plots seasonal supplemental water releases from the Lake minus

ET deficit against seasonal ET deficit. Supplemental water releases are equated with applied irrigation. The seasonal values are listed on Table I. Seasonal ET deficit values are listed on Table V. The values in parentheses on the plot of Figure 3 are the seasonal precipitation amounts, taken from Table II.

COMMENTARY ON METHODOLOGY

The methodology used for this study, in which supplemental water releases from the Lake are equated with applied irrigation to meet crop requirements, is recognized to be an approximation since there are other water requirements in addition to evapotranspiration. In the study area, the principal additional requirement is control of water table stages for the purpose of (a) fire control when burning sugar cane, (b) disease control, (c) frost protection, and (d) to some extent, prevention of excessive subsidence of the muck soils due to oxidation.

In addition to the above requirements, the difference between applied irrigation and ET requirements may also include seepage into or out of the area, regulatory losses, and some flow into or out of undeveloped areas. Since none of these factors were considered to be significant, they were not considered in the analysis.

On the basis of soil moisture desorption and adsorption curves for Everglades peaty muck, described in ARS 41-40, 1960, raising the water table from two feet below ground surface to one foot below ground surface is the equivalent of adding 3.75 inches of free water. This would normally occur on roughly eighty percent of the land devoted to cane in any given year as the remaining twenty percent is replanted prior to each irrigation season and is treated differently. Raising the water table from eighteen inches to six inches below ground surface is equivalent to adding 1.2 inches of free water. Assume that this is done once each year for frost protection of pasture crops. Assume all water table control for disease control in vegetables is done entirely from rainfall excess. On the basis of 46% of irrigated land being in cane and 35% in pasture an annual amount of nearly two (2) inches of free water is required for water table control. Part or all of this amount may be supplied by excess rainfall if it occurs at opportune times.

The supplemental water required for processing sugar cane is also included in the water diverted for irrigation in the agricultural area and thus tends to make the difference between applied irrigation and irrigation required larger.

Free water evaporation from canal surfaces and changes in canal storage were omitted from consideration as the maximum contribution of each is on the order of .5%

The method used for calculating the ET deficit on the basis of monthly values introduces an error by not considering the time distribution of rainfall. Essentially, it considers all rainfall which is less than the evapotranspiration demand as being utilized by plants and all that greater as being discharged from the system. This is true only if the precipitation is distributed fairly evenly throughout each month. If most of the rain occurred in one large storm, much of the water might have been discharged to prevent flooding. Further, if the precipitation occurred at the end of the month, none of it would actually go toward satisfying the crop needs during that month. On the other hand, small isolated rains may evaporate from the surface of the plants or soil without satisfying the crop demand. Cumulative values were used to minimize this effect. Intuitively, it might be expected, at least in wet years, that the present method of analysis would tend to make the predicted ET deficit too low and thus the difference between applied irrigation and ET deficit too large.

INPUT-OUTPUT RELATIONSHIPS

As an adjunct to the examination of supplemental water releases from the Lake in relation to theoretical water requirements for crop growth, the input-output relationship between the Lake and study area was examined.

In any irrigation water supply system, questions of irrigation efficiency are both pertinent and important. Overall efficiency has two components; project efficiency and on-the-land efficiency. Assume on-the-land efficiency to be poor; that is, application amounts exceed beneficial use as determined by crop requirement. If project configuration is such that surplus irrigation return water is discharged (lost) from the system, then overall efficiency is poor. On the other hand, if project configuration is such as to retain a large portion of the surplus (runoff as well as return water) within the system, overall efficiency is enhanced.

Surplus water from the study area are discharged both to Lake Okeechobee and the Conservation Areas. For the purpose of this study, discharges to the Conservation Areas are considered to be "lost" from the limited system under investigation although they can contribute to meeting downstream water requirements.

Figure 4 is a set of mass curves for the period 1962-1971 showing accumulated discharges from the study area to Lake Okeechobee and the Conservation Areas, and accumulated supplemental water releases from the Lake into the study area.

DISCUSSION

The cumulative curves on Figures 2a through 2d show that from season to season there are variations both in the total amount of supplemental water applied and in the amount applied with respect to making up the ET deficit.

With respect to total amount of water applied the data are, of course, supportive of the known fact that crop needs, and hence supplemental water requirements, increase with a decrease in natural water availability. For the study period, the 1970-71 season and 1966-67 were the most severely deficient in rainfall and approximately 15.5 inches of supplemental water per irrigated acre were applied. Rainfall in 1969-70 was the most abundant for the period examined and the supplemental water requirement dropped to about 6.5 inches per irrigated acre.

Figure 3 indicates strongly that in "dry" irrigation seasons, although total water use increases, less supplemental water is applied than is needed to meet theoretical crop requirements. The single exception to this is the 1966-67 season which was substantially deficient in rainfall, but in which more supplemental water was applied than theoretically required. A possible explanation for this lies in the fact that Lake Okeechobee stages through the 1966-67 season ranged from 15.8 feet on November 1, 1966 to 11.8 feet on June 1, 1967. Irrigation release practices, irrigation stages maintained in the primary canal system, and local irrigation withdrawals undoubtedly reflected the actuality and perception of ample water availability in Lake Okeechobee.

This relationship between water use and the actual as well as perceived water availability in the Lake seems to be borne out by the cumulative curves for 1970-71 on Figure 2d. Through February, applied irrigation closely matched ET deficit. From March onward, reduced irrigation stages were held in the primary canals and this, together with the probable perception of a continued reduction in water availability, played some part in increasing the disparity between actual application and theoretical crop requirements.

Other factors which undoubtedly play a part in the "dry" irrigation season disparity between water application and crop needs are related to crop type and associated irrigation systems. It is quite likely that irrigation systems for pasture lands are not as capable of delivering full crop requirements during periods of stress as are the more sophisticated systems for cane and truck crops.

Figure 3 also seems to indicate that there is a tendency to over-irrigate during "wet" irrigation seasons. This, however, may be more apparent than real due to the method used in this study for calculating ET deficit on the basis of monthly values. Much of the rainfall during such periods would not go to satisfy ET requirements but, rather, would be rejected by the system and appear as runoff discharge out of the study area. However, it is believed that during "wet" irrigation seasons actual applications would tend to be somewhat greater than needed to meet crop requirements primarily, again, because of probable higher stages in the Lake and the general perception of ample water supply availability.

Finally, in consideration of the probability (substantiated by the data from this study) that there is a tendency toward over-application of supplemental water in "wet" irrigation seasons, the input-output study takes on a degree of significance. The mass curves, on Figure 4, for discharges into and releases from Lake Okeechobee over the period examined show that the Lake Okeechobee study area unit functions essentially as a "closed system". In such a system, "over-application" is not necessarily synonymous with "waste".

In terms of the approach which has been used by the District in the issuance of water use permits, this study indicates that on an area-wide basis there has been no misuse of the permit system. The maximum monthly application rate was approximately 3.9 inches in April, 1967 (see Table I), with a maximum seasonal rate of about 15.7 inches in 1966-67. Moreover, during seasons of critically deficient rainfall, actual application rates fall short of those rates required to meet theoretical crop needs.

Attached as an appendix to this report is irrigation use data from two drainage districts (Pahokee and East Shore Drainage Districts) for the period 1948-1964. The basic data were furnished the Central and Southern Florida Flood Control District by the U.S. Sugar Corporation in 1965. These data were analyzed by the Flood Control District and placed in the form shown in the Appendix.

The interested reader can compare the data in the Appendix with that presented in the main body of this report. After allowance is made for the smaller areas involved and the more homogeneous cropping pattern in the drainage district study, it will be seen that the procedure used for analysis yields comparable results for the study area on the one hand and the drainage districts on the other.

CONCLUSIONS

The findings of this investigation are:

1. Since the early 1960's, the application of supplemental water in that portion of the Everglades Agricultural Area which takes water from the primary canal system has been, during "dry" irrigation seasons, at rates less than those needed to meet theoretical crop growth requirements.
2. During the same period, supplemental water applications during "wet" irrigation seasons have tended to be at rates greater than those needed to meet crop growth requirements.
3. For the same period, maximum monthly supplemental water application rates, for both "wet" and "dry" irrigation seasons, are substantially below the application rates permissible under the Districts' present water withdrawal permit system.
4. Since the early 1960's, cumulative supplemental water releases from the Lake into the study area very closely approximate the accumulated discharge of surplus water into the Lake from the study area.

The above findings are applicable to the study area as a unit. There is no implication that these findings are necessarily applicable to either individual blocks of land or to crop categories. Taken together, however, these findings indicate that on a gross area-wide basis, there is no significant over-application of water with respect to beneficial use as represented by crop requirements, no apparent waste of water from the system, and no abuse of the present water allocation criteria.

Accordingly, it is concluded that:

1. Existing valid water use permits in the Everglades Agricultural Area can be converted to permits under Chapter 373, Florida Statutes, without immediately changing the basic criteria;

2. New water use permits in the Everglades Agricultural Area under Chapter 373, Florida Statutes, can be issued on a short-term basis using the same basic criteria as now in effect and use.
3. All permits in the study area should be reexamined at one time and no later than approximately mid-1977, prior to which time supplemental water use criteria will again be evaluated.

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"AGRICULTURAL AREA" - APPLIED SUPPLEMENTAL WATER

IRRIGATION SEASON	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	SEASON	AREA UNDER PRODUCTION (ACRES)
1961-1962									368,000
CFS-Days			8,456	12,576	18,256	9,546	16,793	65,627	
Inches			.55	.81	1.18	.62	1.09	4.25	
1962-1963									372,000
CFS-Days	5,731	16,820	8,814	2,219	19,083	42,520	11,719	107,906	
Inches	.36	1.08	.62	.14	1.22	2.72	.75	6.89	
1963-1964									377,000
CFS-Days	7,173	9,517	3,530	6,688	12,875	20,339	24,432	84,554	
Inches	.45	.60	.21	.42	.81	1.28	1.54	5.31	
1964-1965									398,000
CFS-Days	4,732	5,252	20,573	7,928	13,834	37,345	52,486	142,150	
Inches	.28	.31	1.23	.47	.83	2.23	3.13	8.48	
1965-1966									400,000
CFS-Days	8,998	22,262	4,542	8,338	21,098	28,374	25,252	118,815	
Inches	.53	1.32	.27	.49	1.25	1.69	1.50	7.05	
1966-1967									400,000
CFS-Days	24,413	38,558	25,525	13,461	35,210	56,543	59,523	265,223	
Inches	1.44	2.28	1.69	.80	2.08	3.87	3.52	15.68	

TABLE I

"AGRICULTURAL AREA" - APPLIED SUPPLEMENTAL WATER

IRRIGATION SEASON	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	SEASON	AREA UNDER PRODUCTION (ACRES)
1967-1968									400,000
CFS-Days	36,827	27,876	19,229	11,899	9,769	35,054	9,650	150,304	
Inches	2.19	1.66	1.14	.70	.58	2.09	.57	8.93	
1968-1969									400,000
CFS-Days	8,075	28,705	12,338	20,371	14,517	33,586	19,336	136,928	
Inches	.48	1.71	.73	1.21	.86	1.99	1.15	8.13	
1969-1970									400,000
CFS-Days	1,076	2,575	13,249	9,305	2,874	28,601	52,779	110,549	
Inches	.06	.15	.78	.55	.17	1.70	3.14	6.55	
1970-1971									411,000
CFS-Days	34,652	38,359	24,450	11,521	31,931	42,216	14,105	197,234	
Inches	1.99	2.21	1.41	.67	1.84	2.44	.81	11.37	
1971-1972									464,000
CFS-Days	16,977	25,646	11,714	11,015	23,620	15,069	1,184	105,225	
Inches	.86	1.31	.60	.56	1.20	.77	.06	5.36	

TABLE I (cont.)

"AGRICULTURAL AREA" - PRECIPITATION (INCHES)

IRRIGATION SEASON	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	SEASON
1961-1962		.24	1.37	1.04	2.63	3.54	2.66	11.48
1962-1963	1.30	.27	1.21	3.60	1.15	.57	7.16	15.26
1963-1964	2.30	5.48	1.89	2.18	2.33	3.86	2.53	20.57
1964-1965	1.13	2.84	.25	3.36	2.36	.99	1.57	12.50
1965-1966	.27	1.18	4.29	2.15	.59	2.58	3.34	14.40
1966-1967	.27	.83	1.15	3.51	1.07	0	2.05	8.88
1967-1968	.13	2.01	.60	3.03	1.33	1.40	9.50	18.00
1968-1969	1.64	.09	1.68	1.74	4.53	2.75	5.70	18.13
1969-1970	2.41	1.41	2.98	2.36	12.37	.15	6.99	28.67
1970-1971	.07	.30	.70	1.70	.54	.15	4.57	8.03
1971-1972	3.22	1.28	1.10	1.75	3.82	6.67	6.36	24.20

TABLE II

"AGRICULTURAL AREA" - PAN EVAPORATION (INCHES)

IRRIGATION SEASON	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	SEASON
1961-1962			3.05	3.88	5.37	6.09	6.95	25.34
1962-1963	3.26	2.76	3.08	3.06	5.59	6.91	5.99	30.65
1963-1964	3.36	2.76	2.26	3.66	4.91	6.22	5.96	29.13
1964-1965	3.14	2.89	3.28	3.82	5.46	6.61	7.35	32.55
1965-1966	3.44	2.97	2.64	3.24	4.86	6.02	6.16	29.33
1966-1967	3.64	2.83	3.12	3.40	5.34	6.97	7.67	32.97
1967-1968	3.62	3.06	3.10	3.56	5.62	6.35	5.48	30.79
1968-1969	3.17	2.96	2.62	3.91	4.21	5.55	5.64	28.06
1969-1970	3.51	3.01	2.85	3.44	4.81	6.64	6.74	31.03
1970-1971	3.89	3.30	3.37	4.00	6.46	7.17	7.83	36.02
1971-1972	3.34	3.25	3.19	3.81	5.77	6.18	5.86	31.40

TABLE III

EVERGLADES AGRICULTURAL AREA
Excluding Areas Receiving Water Directly From Lake Okeechobee
AREA UNDER IRRIGATION BY CROPS (ACRES)

IRRIGATION SEASON	CANE	TRUCK	PASTURE	TOTAL
1961-1962	134,000	74,000	160,000	368,000
1962-1963	138,000	78,000	156,000	372,000
1963-1964	143,000	79,000	155,000	377,000
1964-1965	188,000	75,000	135,000	398,000
1965-1966	196,000	70,000	134,000	400,000
1966-1967	203,000	66,000	131,000	400,000
1967-1968	200,000	69,000	131,000	400,000
1968-1969	196,000	73,000	131,000	400,000
1969-1970	192,000	80,000	128,000	400,000
1970-1971	208,000	77,000	126,000	411,000
1971-1972	256,000	83,000	125,000	464,000

TABLE IV

"AGRICULTURAL AREA" - EVAPOTRANSPIRATION DEFICIT (INCHES)

IRRIGATION SEASON	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	SEASON	WEIGHTED PAN EVAPORATION COEFFICIENT
1961-1962			.58	1.44	.81	.36	1.79	4.98	.64
1962-1963	.78	1.49	.76	-1.64	2.43	3.85	-3.32	9.31	.64
1963-1964	-.15	-.371	-.44	.16	.81	.12	1.28	2.37	.64
1964-1965	.91	-.96	1.88	-.87	1.89	3.31	3.21	11.20	.65
1965-1966	1.96	.75	-2.57	-.04	2.56	1.33	.66	7.26	.65
1966-1967	2.09	1.01	.87	-1.30	2.40	4.53	2.94	13.84	.65
1967-1968	2.22	-.02	1.41	-.71	2.32	2.73	-5.93	8.68	.65
1968-1969	.42	1.83	.02	.80	-1.79	.86	-2.03	3.93	.65
1969-1970	-.13	.55	-1.13	-.12	-9.24	4.16	-2.60	4.71	.65
1970-1971	2.46	1.84	1.49	.90	3.65	4.51	.52	15.37	.65
1971-1972	1.04	.83	.97	.73	-.07	-2.65	-2.55	3.57	.65

TABLE V

"AGRICULTURAL AREA" - APPLIED IRRIGATION (-) E.T. DEFICIT (INCHES)

IRRIGATION SEASON	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	SEASON
1961-1962			-.03	-.63	.37	.26	-.70	-.73
1962-1963	-.42	-.41	-.14	.14	-1.21	-1.13	.75	-2.42
1963-1964	.45	.60	.21	.16	0	1.16	.26	2.84
1964-1965	-.63	.31	-.65	.47	-1.06	-1.08	-.08	-2.72
1965-1966	-1.43	.57	.27	.49	-1.31	.36	.84	-.21
1966-1967	-.65	1.27	.82	.80	-.32	-.66	.58	1.84
1967-1968	-.03	1.66	-.27	.70	-1.74	-.64	.57	.25
1968-1969	.06	-.12	.71	.41	.86	1.13	1.15	4.20
1969-1970	.06	.40	.78	.55	.17	-2.46	3.14	2.64
1970-1971	-.47	.37	-.08	-.23	-1.81	-2.07	.29	-4.80
1971-1972	-.18	.48	-.37	-.17	1.20	.77	.06	1.79

TABLE VI

- Less irrigation supplied by Project than required by ET

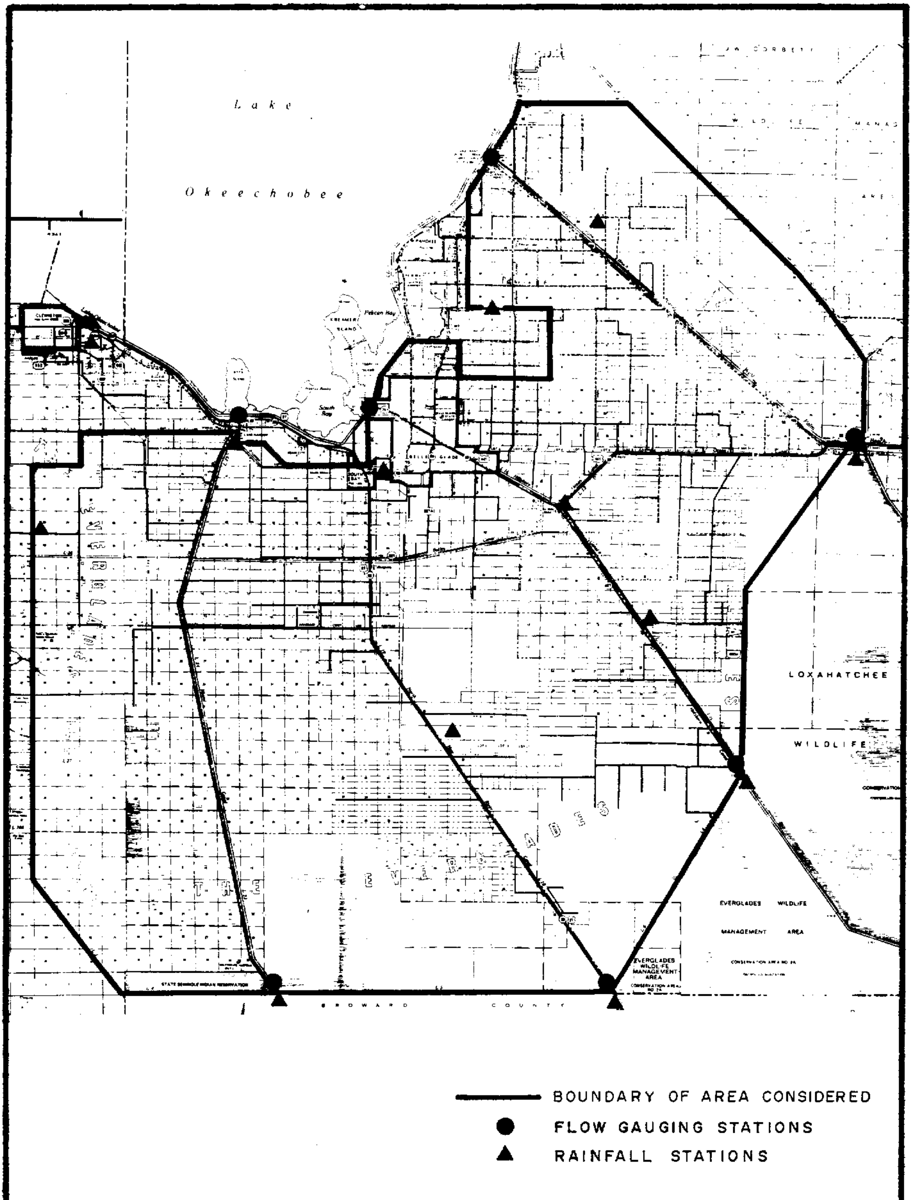
SUPPLEMENTAL WATER REQUIREMENTS INCLUDING
ESTIMATE FOR WATER TABLE CONTROL

	IRRIGATION REQUIRED	IRRIGATION APPLIED	IRRIGATION APPLIED -IRRIGATION REQUIRED**	
			INCH	ACRE-FEET
1962-1963	10.91	6.89	-4.02	-123,000
1963-1964	3.17	5.31	+2.14	+ 66,000
1964-1965	12.40	8.48	-3.92	-123,000
1965-1966	8.46	7.05	-1.41	- 46,000
1966-1967	15.44	15.68	+ .24	8,000
1967-1968	9.88	8.93	- .95	- 32,000
1968-1969	5.53	8.13	2.60	+ 87,000
1969-1970	5.11	6.55	1.44	+ 48,000
1970-1971	17.37	11.37	-6.00	-205,000
1971-1972	5.17	5.36	+ .19	+ 7,000
Mean	9.34	8.38	- .97	- 31,300

TABLE VII

* ET DEFICIT + (The portion of an estimated 2 inches of free water required for water table control apportioned equally to the months November through March which was not satisfied by rainfall excess during each respective month).

** A minus sign indicates less supplemental water applied than is required for optimum crop growth.



EVERGLADES AGRICULTURAL AREA

FIGURE 1

APPLIED IRRIGATION AND E.T. DEFICIT
EVERGLADES AGRICULTURAL AREA

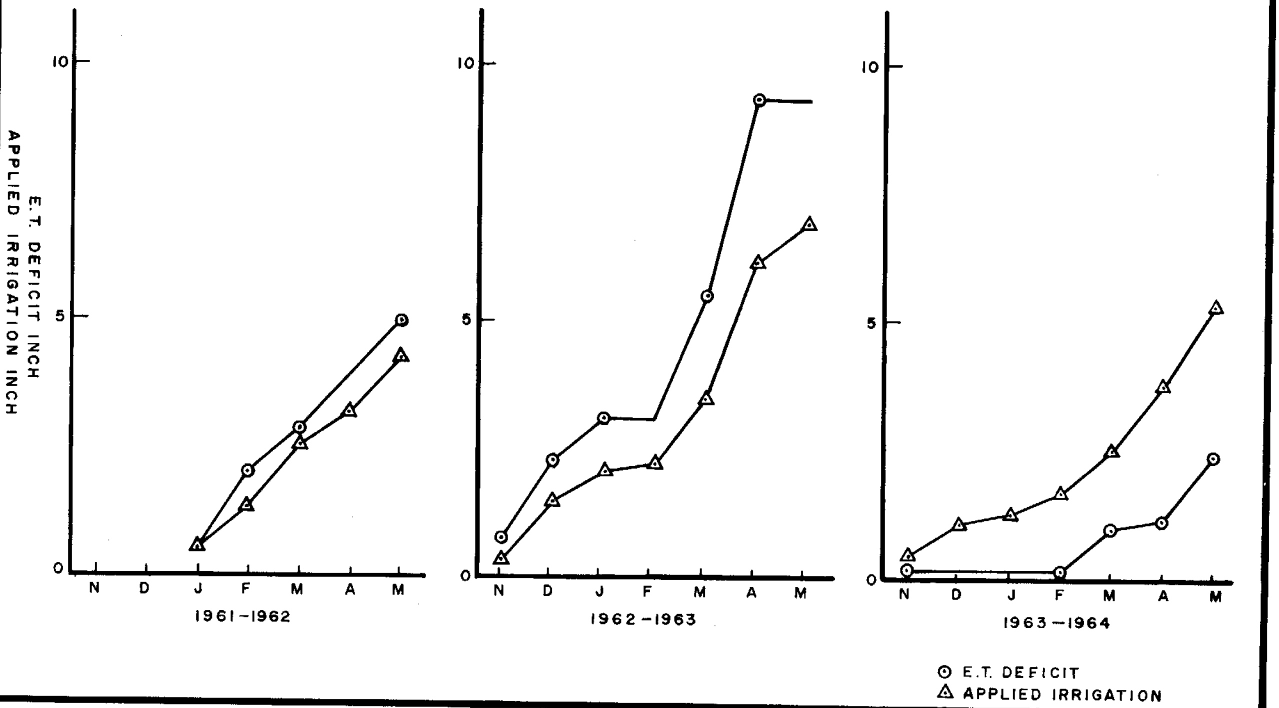
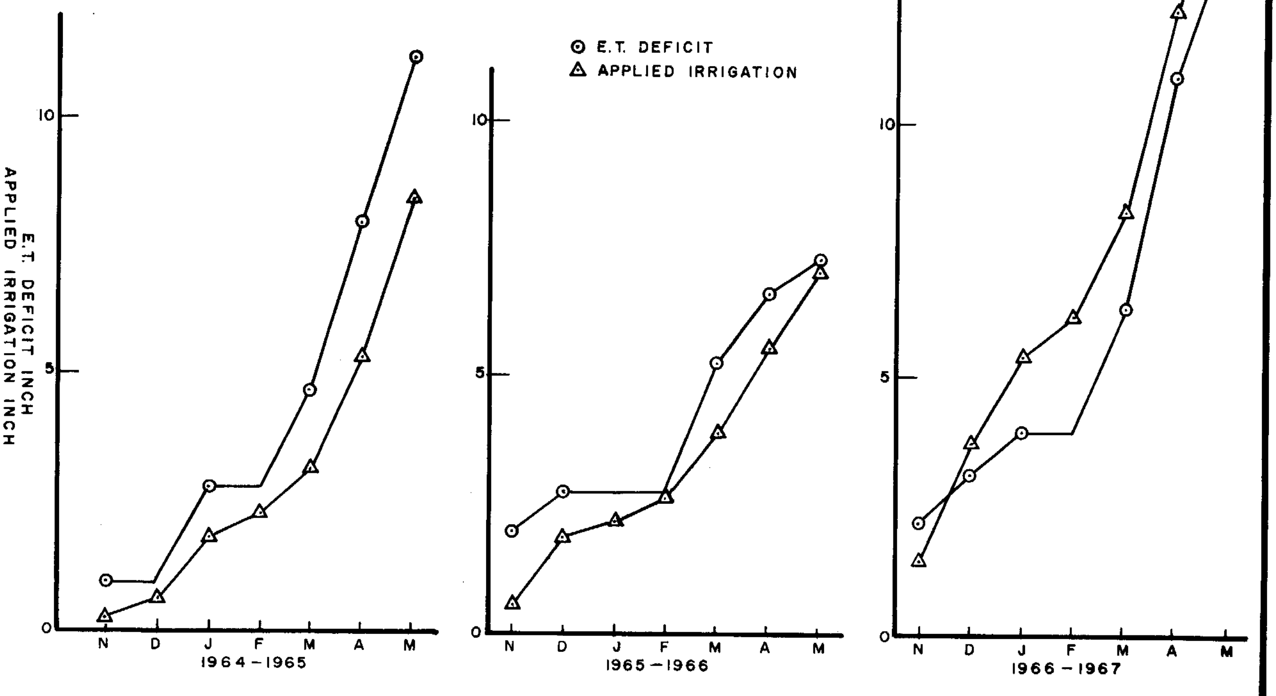


FIGURE 2A

APPLIED IRRIGATION AND E.T. DEFICIT EVERGLADES AGRICULTURAL AREA



APPLIED IRRIGATION AND E.T. DEFICIT
EVERGLADES AGRICULTURAL AREA

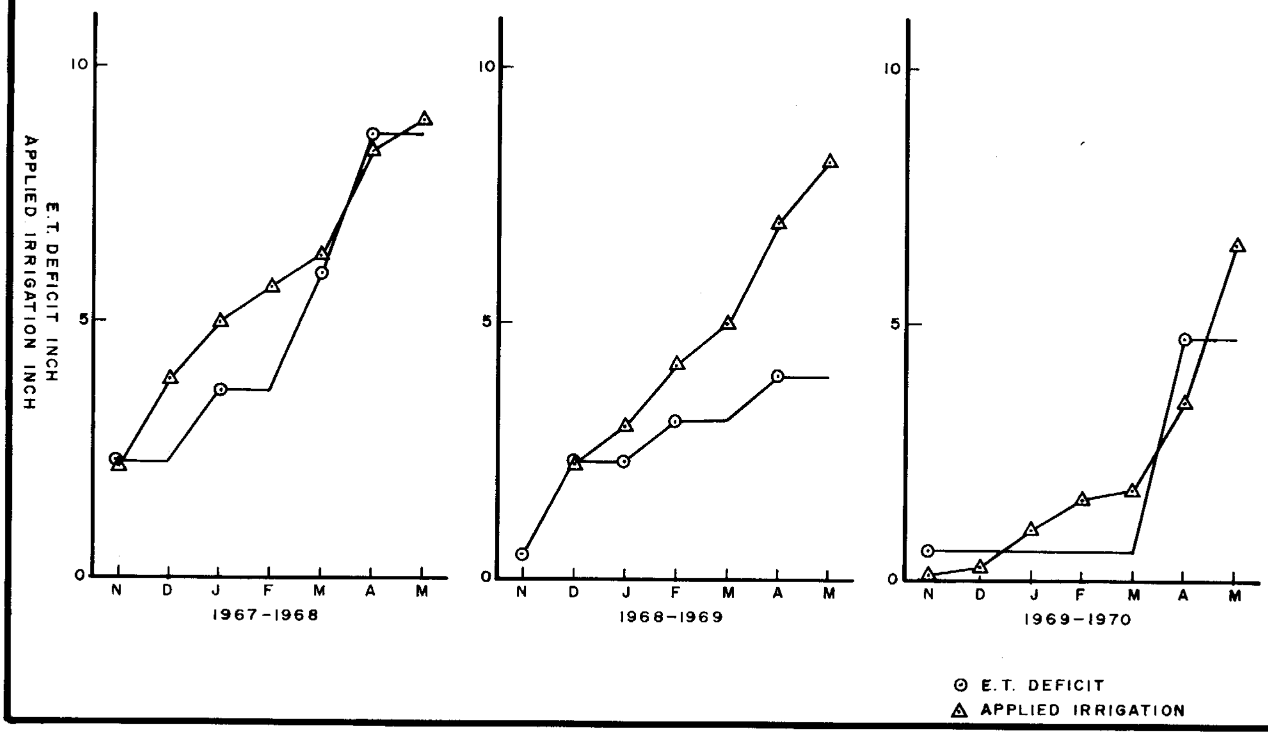
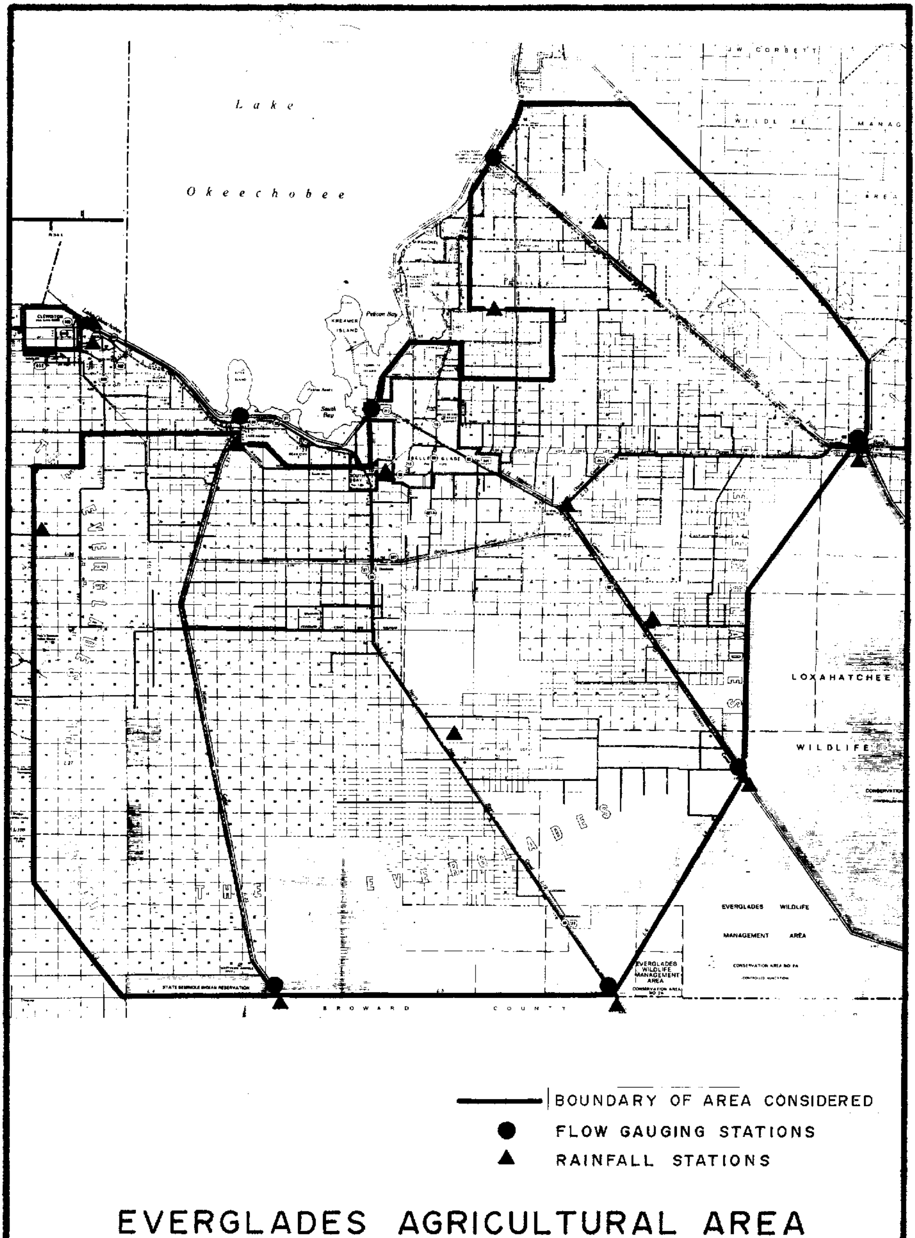


FIGURE 2C



EVERGLADES AGRICULTURAL AREA

FIGURE I

APPLIED IRRIGATION AND E.T. DEFICIT EVERGLADES AGRICULTURAL AREA

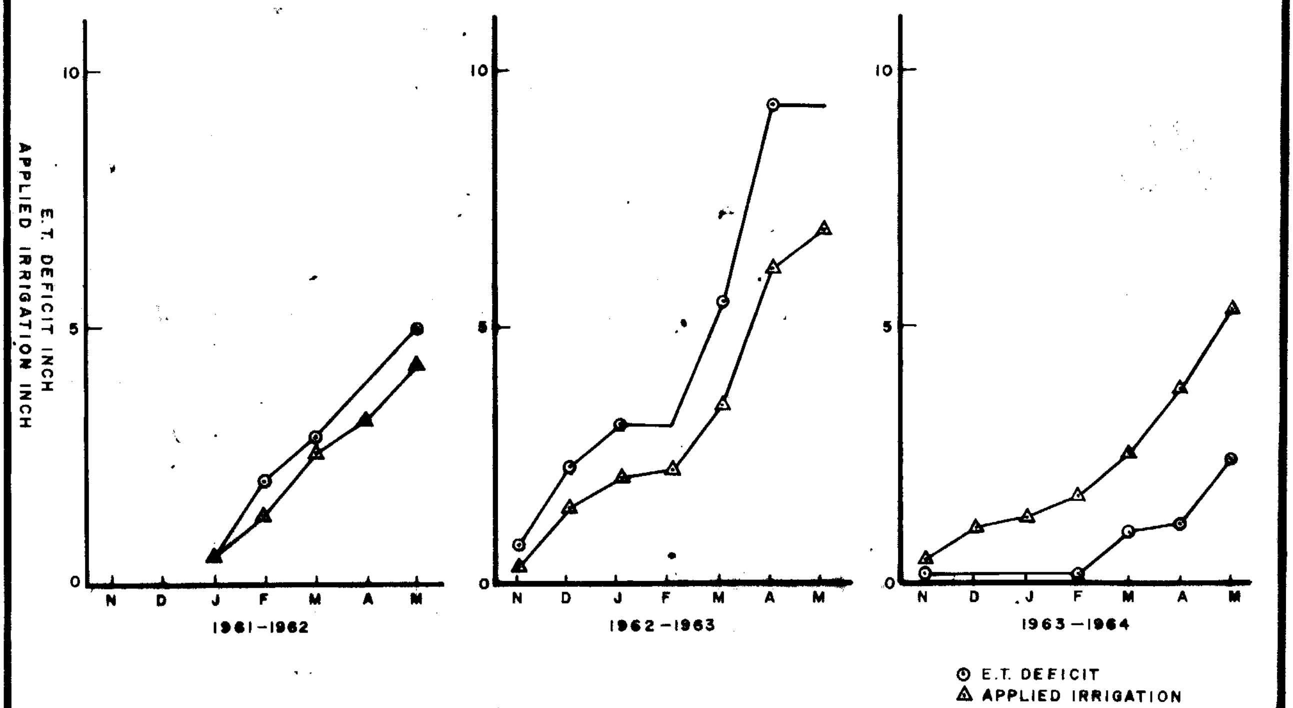


FIGURE 2A

APPLIED IRRIGATION AND E.T. DEFICIT EVERGLADES AGRICULTURAL AREA

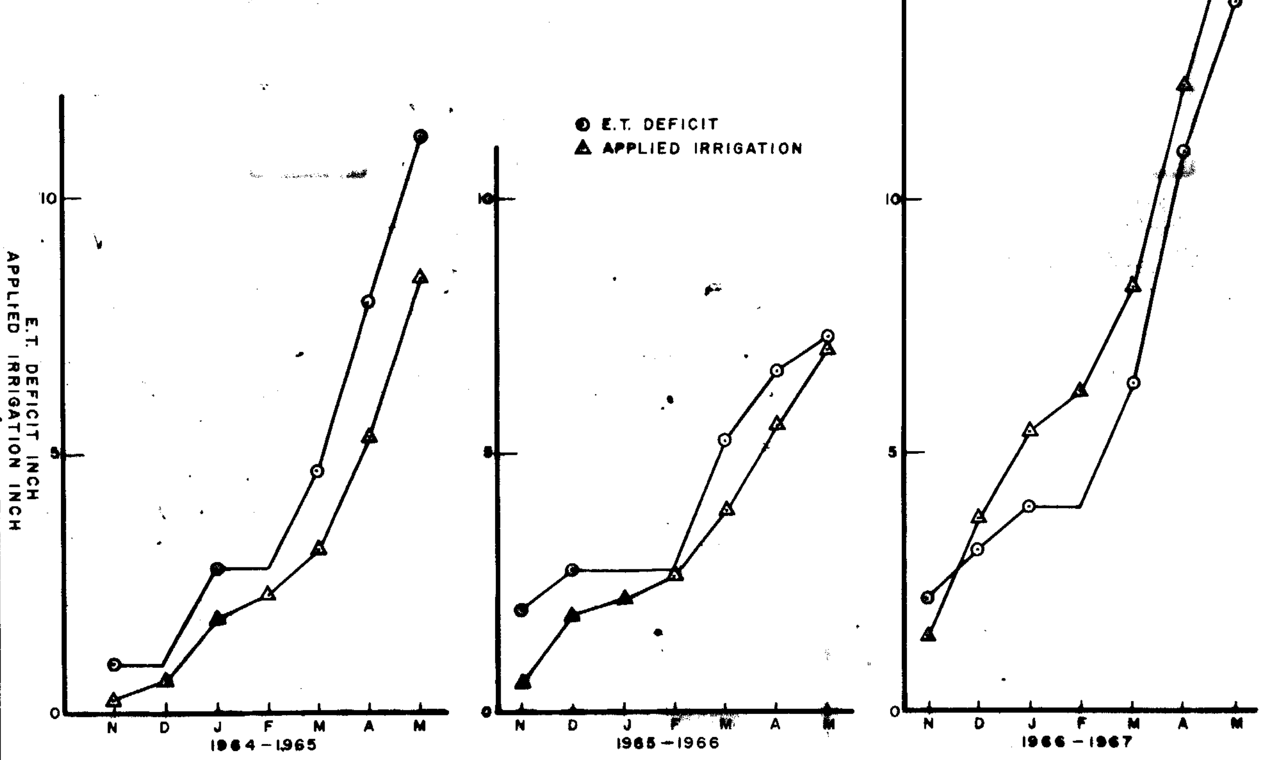


FIGURE 28

APPLIED IRRIGATION AND E.T. DEFICIT
EVERGLADES AGRICULTURAL AREA

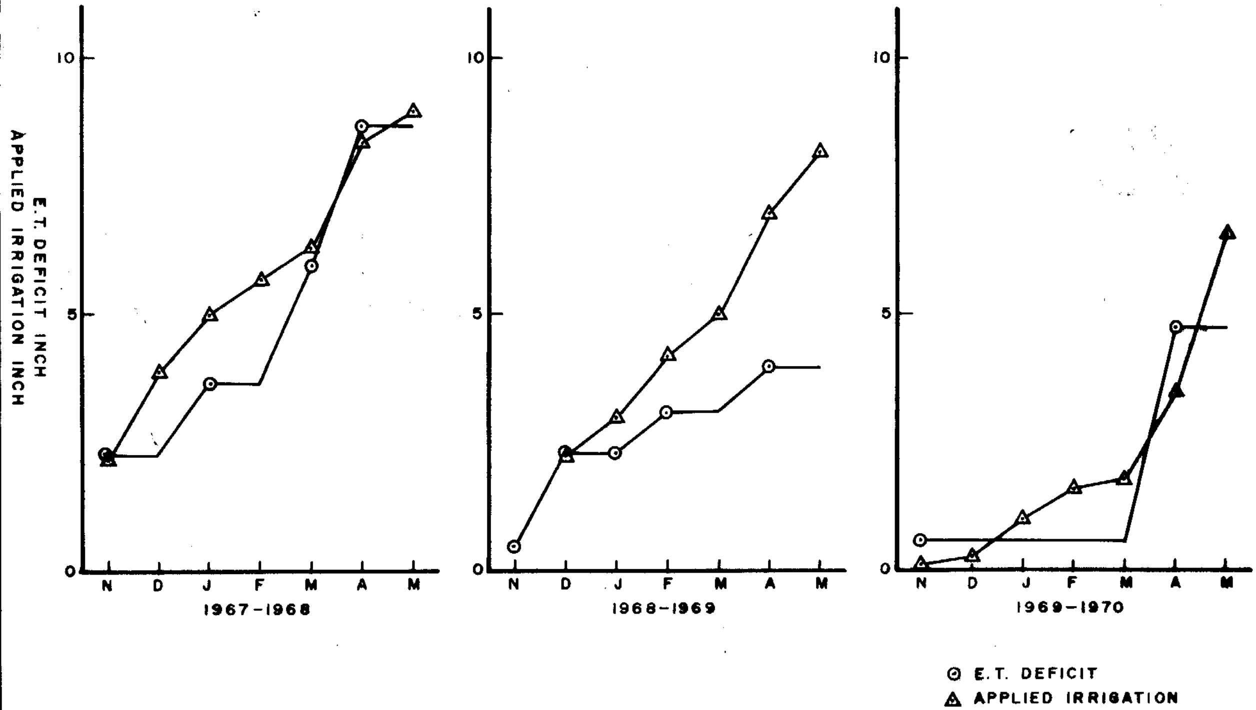


FIGURE 2C

KVS

M E M O R A N D U M

9-1-3 September 13, 1974

TO: R. Grafton

FROM: W. V. Storch

SUBJECT: Rules and Regulations for Water Use in the Everglades Ag Area

The approach we have elected to take for the seperable water supply/water use areas is to prepare Rules and Regulations covering only the following items:

1. Minimum flows.

2. Minimum levels for;

   (a) lakes
   (b) canals

3. Permit classification as to;

   (a) source
   (b) use

4. Water shortage plan.

The Rules and Regulations do not spell out specific values for allocable volumes of water.

Therefore, for the Everglades Ag Area, the following observations and recommendations are made with respect to the items listed above:

1. All flows out of this area are directed either to Lake Okeechobee or to the Conservation Areas, all of which are Project water storage facilities. The entire area receives its supplemental water supply, for all practical purposes, from the Lake.

   The establishment of minimum flows serves three purposes:

   (a) to maintain a desirable downstream condition for environmental reasons, water quality control, etc.;

   (b) to maintain a viable Project storage component; for example, minimum flows in Arbuckle and Josephine Creeks to maintain Lake Istokpoga storage, and

   (c) to establish a volume of water (the total basin yield minus the minimum flow value) which is permissible for diversion, capture and storage in off-line impoundments.

In the case of the Ag Area, reason (a) does not exist. However, at this point it appears necessary to maintain the present outflow volumes from a water supply/water storage standpoint. If such values were established the net effect would be to eliminate the possibility of establishment of off-line impoundments. A more positive way to accomplish this same objective would simply be to prohibit the creation of off-line impoundments in this area; then it would not be necessary to establish minimum flow values - there would be no choice but to dispose of runoff in excess of irrigation needs by discharge to the Project storage areas. From a quantity standpoint this is desirable since it is more efficient to store surplus in the Lake than in a number of individual reservoirs with a larger total surface area. From a practical standpoint no irrigator in the area is going to put in a reservoir anyhow with the Lake so handy.

On the other hand, water quality considerations must be taken into account. It may prove desirable in terms of water quality control to require on-site retention or detention of surplus runoff. This could change inflow volumes and timing from the existing.

Since there is no over-riding need to establish minimum flow values at this time for the three reasons listed, whereas there are compelling reasons for not doing so, it is recommended that minimum canal flow values for the area not be established.

2. (a) Minimum Lake Okeechobee level (below which no further withdrawals for irrigation water supply would be permitted) is governed by physical constraints imposed by the Lake outlets into the service area. I see no reason at this time to officially set this level. It will be investigated further, however, within the next two weeks.

   (b) Minimum canal stages are governed by minimum Lake stage. If minimum Lake stage is not set, there is no reason to set minimum canal stages.

3. Recommend using the same classification system as used in the Caloosahatchee Basin.

4. Must use the same water shortage plan as is used in the Calooshatchee Basin.

W. V. Storch, Director
Resource Planning Department

WVS:et

cc: Executive Director
Mr. J.Maloy
Mr. J.B.Jackson
Mr. Z.C.Grant [illegible]

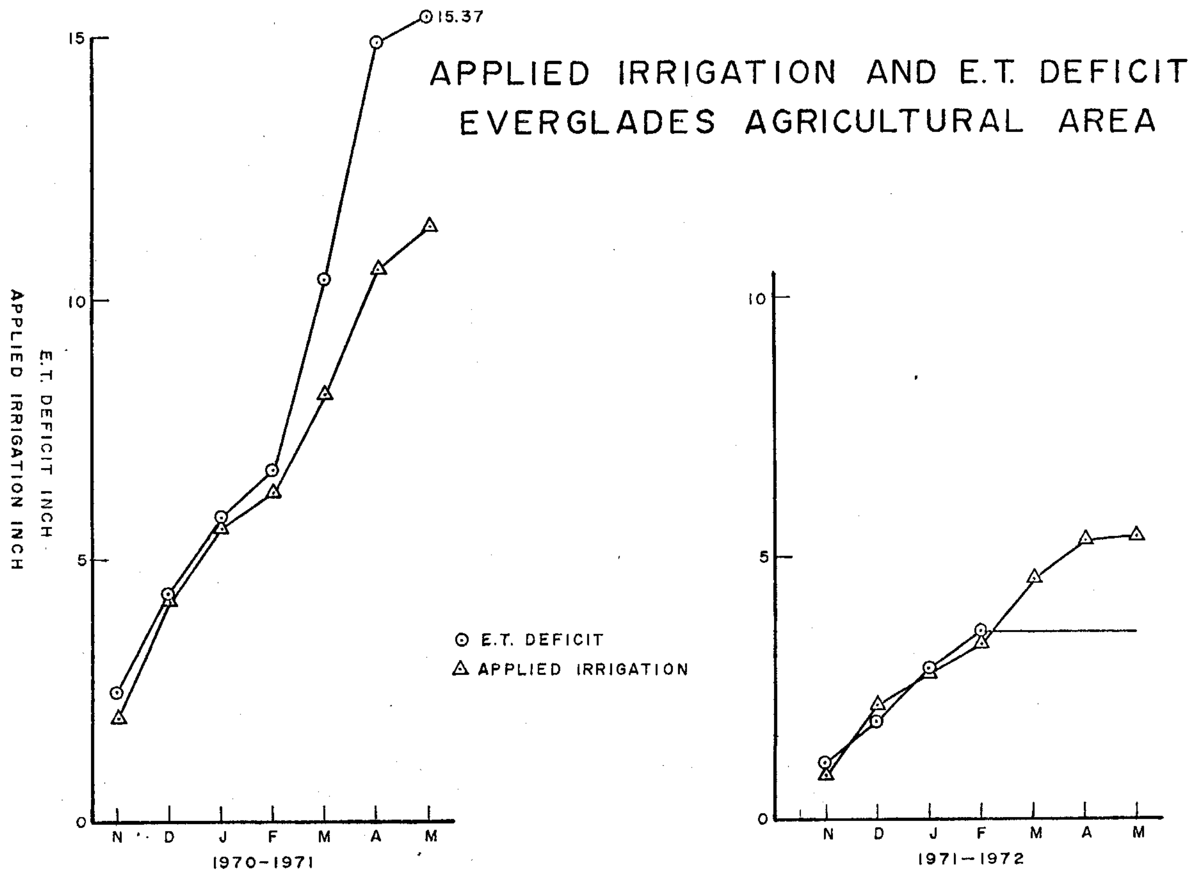

APPLIED IRRIGATION AND E.T. DEFICIT
EVERGLADES AGRICULTURAL AREA
15.37
15
10
5
0
E.T. DEFICIT INCH
APPLIED IRRIGATION INCH
N D J F M A M
1970-1971
E.T. DEFICIT
APPLIED IRRIGATION
10
5
0
N D J F M A M
1971-1972

FIGURE 2D

SEASONAL DIFFERENCE BETWEEN APPLIED IRRIGATION AND E. T. DEFICIT VERSES E.T. DEFICIT EVERGLADES AGRICULTURAL AREA

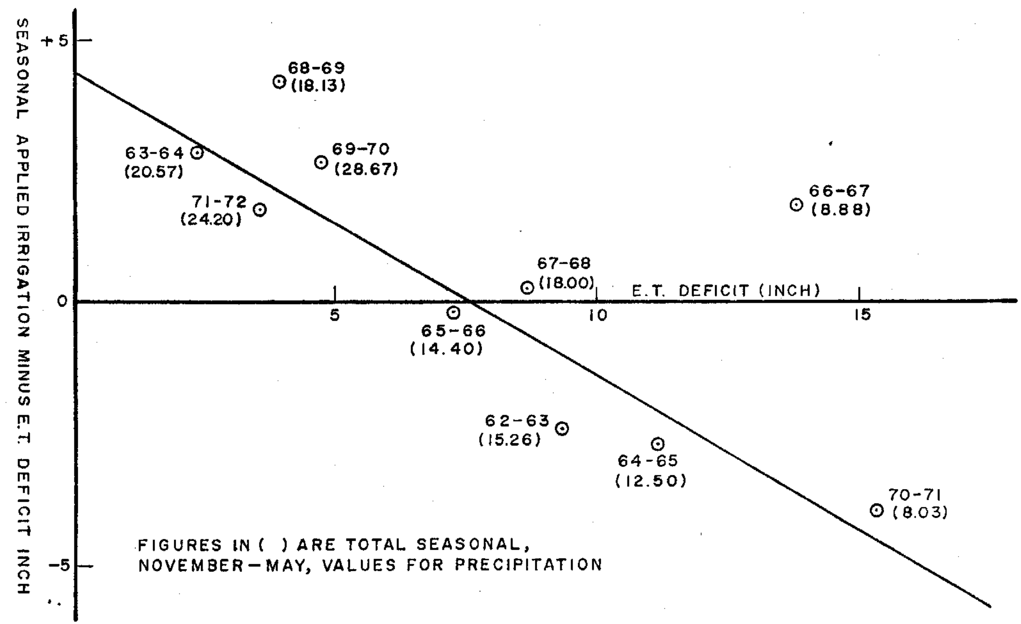


FIGURE 3

MASS CURVE COMPARISON OF ANNUAL VOLUME PUMPED OUT OF EVERGLADES AGRICULTURAL AREA, ANNUAL WATER RELEASES FROM LAKE OKEECHOBEE, AND ANNUAL VOLUME PUMPED TO THE LAKE

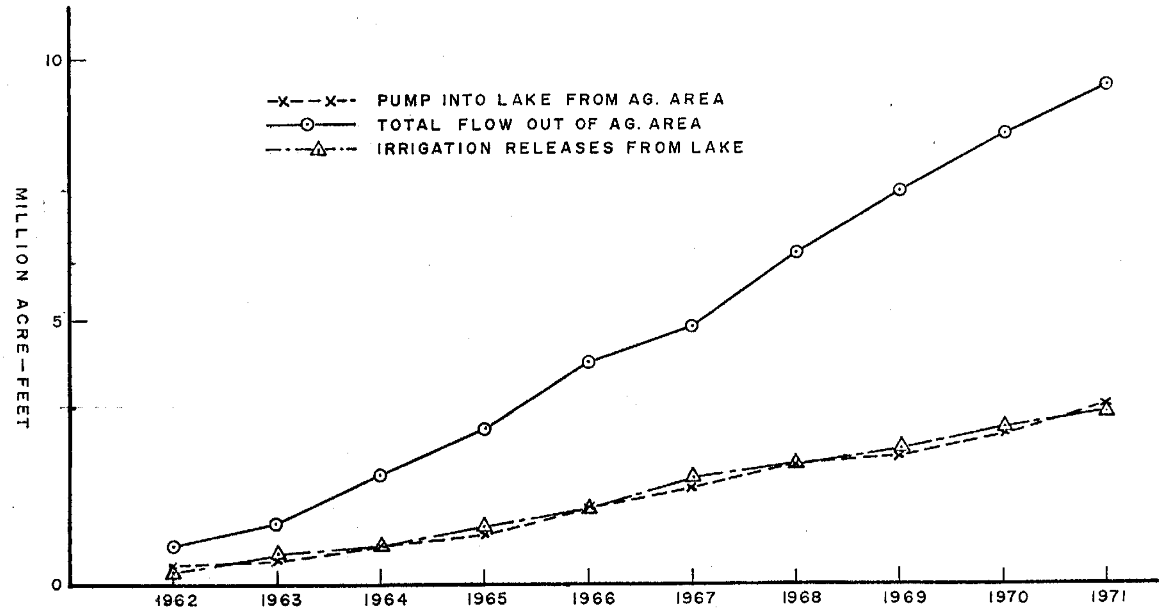


FIGURE 4

APPENDIX

Data for two discrete drainage districts, Pahokee and East Shore, were analyzed in a manner similar to that used in the main body of this study for a comparison of the effect of size of the area, and to study the effect of a more homogeneous cropping pattern.

The basic flow records and rainfall for 1949-1964 were transmitted by the U.S. Sugar Corporation on June 30, 1965. The flow records were subsequently modified by considering the siphoning rate 70% of the pumping rate as described in a letter to the Corps of Engineers from the District on October 22, 1965. Pan evaporation records were compiled from the U.S. Weather Bureau Station at Belle Glade.

Although documentation is poor, there appears to have been a land use change that occurs circa 1956. It was assumed that this change was from improved pasture to sugar cane in 1955.

It is noteworthy that a comparison of the two sets of data indicate very much the same trends. The Pahokee - East Shore data indicate higher water requirements, which may be due to the cropping pattern and to some extent the smaller size of the areas.

"PAHOKEE AND EAST SHORE" - APPLIED IRRIGATION

Irrigation Season	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Season	K
1948-49			1.65	1.70	2.70	2.10	2.15	10.30	
1949-50	0	2.25	0	1.45	1.25	2.20	3.05	10.20	
1950-51	.20	.15	1.65	.50	1.80	1.75	1.80	7.85	
1951-52	.20	.55	1.90	.05	1.30	2.85	1.90	8.75	
1952-53	0	1.55	.20	0	1.60	1.60	3.75	8.70	
1953-54	0	.35	.70	1.30	.05	.40	.90	3.70	
1954-55	1.30	.60	.85	.35	1.60	1.35	3.60	9.65	
1955-56	3.60	.60	1.70	1.05	4.05	3.10	2.25	16.35	
1956-57	2.35	1.90	1.35	.60	0	.05	0	6.25	
1957-58	1.25	1.35	0	.05	.10	0	.45	3.20	
1958-59	1.60	.40	.45	1.05	.95	1.15	1.70	7.30	
1959-60	0	0	1.25	.20	.60	.60	2.45	5.10	
1960-61	.55	1.40	.60	.75	1.05	2.60	3.35	10.30	
1961-62	1.75	4.40	.95	2.30	2.45	.85	2.55	15.25	
1962-63	1.05	1.80	1.35	.30	.70	4.10	1.15	10.45	
1963-64	1.05	1.15	0	0	.75	2.60	1.75	7.30	

TABLE I-I

"PAHOKEE AND EAST SHORE" - PRECIPITATION

Irrigation Season	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Season	K
1948-49			.06	.50	.37	2.78	1.76	5.47	.58
1949-50	1.29	8.88	.38	.60	1.78	2.02	3.63	18.58	
1950-51	1.60	1.09	.09	2.21	.60	4.83	4.45	14.87	
1951-52	1.47	.42	1.26	5.54	.91	3.54	5.22	18.36	
1952-53	.22	.37	2.19	2.16	1.76	4.01	1.08	11.79	
1953-54	1.45	2.31	.87	2.49	2.91	6.24	6.22	22.49	
1954-55	1.24	1.40	1.54	1.89	2.09	2.97	2.24	13.37	.58
1955-56	.55	3.54	1.11	2.29	.33	2.24	3.17	13.23	.70 X
1956-57	.29	.58	4.65	3.45	3.61	5.54	10.06	28.18	
1957-58	1.41	6.25	8.73	.61	6.32	4.74	6.94	34.73	
1958-59	.94	6.00	1.99	.36	6.41	3.61	9.31	28.62	
1959-60	3.93	1.28	.08	3.78	1.49	4.46	3.53	18.55	
1960-61	1.88	.73	3.13	.85	4.02	1.37	9.95	21.93	
1961-62	1.13	.17	1.83	.49	2.93	4.46	2.23	13.24	
1962-63	1.37	.26	.99	3.77	.70	.07	7.83	14.99	
1963-64	2.15	5.50	2.91	2.12	1.37	3.48	2.35	19.88	.70

TABLE I-II

"PAHOKEE AND EAST SHORE" - PAN EVAPORATION

Irrigation Season	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Season	K
1948-49			3.59	4.75	6.00	6.41	7.04	27.79	.58
1949-50	3.57	3.61	3.23	3.51	5.83	6.42	6.97	33.14	
1950-51	3.46	3.03	3.14	3.75	5.58	5.54	8.01	32.51	
1951-52	4.02	3.74	3.71	4.29	5.88	7.17	7.24	36.05	
1952-53	4.14	3.67	3.49	3.99	6.30	6.93	8.71	37.23	
1953-54	3.35	2.89	3.55	4.30	5.58	5.89	6.58	32.14	
1954-55	3.93	3.47	3.94	4.36	6.24	6.91	7.10	35.95	.58
1955-56	4.53	3.01	3.65	4.10	6.40	6.71	7.14	35.54	.70
1956-57	4.36	3.93	3.73	3.91	5.54	6.47	6.35	34.29	
1957-58	4.22	3.40	3.00	4.01	5.15	5.77	6.71	32.26	
1958-59	3.62	2.75	2.84	3.78	4.75	6.14	6.40	30.28	
1959-60	3.81	3.05	3.91	4.12	5.92	6.13	7.05	33.99	
1960-61	3.21	3.14	3.20	3.82	6.01	7.09	7.08	33.55	
1961-62	3.62	3.11	3.24	4.21	5.70	6.37	7.23	33.57	
1962-63	3.00	2.85	3.26	3.26	5.94	6.99	6.49	31.79	
1963-64	3.86	3.17	2.39	4.04	5.36	6.74	6.43	31.99	.70

TABLE I-III

SUPPLEMENTAL WATER REQUIREMENTS INCLUDING
ESTIMATE FOR WATER TABLE CONTROL

YEAR	IRRIG. REQUIRED	APPLIED IRRIG.	APPLIED - REQUIRED
1949-1950	8.11	10.20	2.09
1950-1951	6.59	7.85	1.26
1951-1952	7.57	8.75	1.18
1952-1953	10.98	8.70	-2.28
1953-1954	2.56	3.70	1.14
1954-1955	8.65	9.65	1.00
1955-1956	15.33	16.35	1.02
1956-1957	6.87	6.25	-.62
1957-1958	4.85	3.20	-1.65
1958-1959	6.23	7.30	1.07
1959-1960	9.23	5.10	-4.13
1960-1961	9.65	10.30	.65
1961-1962	12.67	15.25	2.58
1962-1963	14.26	10.45	-3.81
1963-1964	8.69	7.30	-1.39
MEAN	8.82	8.69	1.75
	3.43	3.67	1.11

For irrigation required, add 2.81/5 = .56" to all ET deficit for months November through March, unless there is an excess over .56".

TABLE I-IV

"PAHOKEE AND EAST SHORE" - EVAPO-TRANSPIRATION DEFICIT

Irrigation Season	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Season
1948-49			2.02	2.25	3.11	.94	2.32	10.64
1949-50	.78	-6.78	1.49	1.44	1.60	1.70	.14	7.15
1950-51	.41	.66	1.73	-.03	2.63	-1.62	.20	5.63
1951-52	.86	1.74	.89	-3.05	2.50	.62	-1.02	6.61
1952-53	2.18	1.76	-.17	.15	1.89	0	3.97	9.95
1953-54	.49	-.63	1.18	0	.32	-2.82	-2.40	1.99
1954-55	1.03	.61	.74	.64	1.52	1.04	1.87	7.45
1955-56	2.62	-1.43	1.45	.58	4.15	2.46	1.83	13.09
1956-57	2.76	2.17	-2.03	-.71	.26	-1.01	-5.61	5.19
1957-58	1.54	-3.87	-6.63	2.19	-2.71	-.70	-2.24	3.73
1958-59	1.59	-4.07	0	2.28	-3.08	.68	-4.83	4.55
1959-60	-1.26	.85	2.65	-.89	2.65	-.16	1.40	7.55
1960-61	.36	1.46	-.89	1.82	.18	3.59	-4.99	7.41
1961-62	1.40	2.00	.43	2.45	1.06	0	2.83	10.17
1962-63	.73	1.73	1.29	-1.48	3.45	4.82	-3.28	12.02
1963-64	.55	-3.28	-1.23	.70	2.38	1.23	2.15	7.01

TABLE I-V

"PAHOKEE AND EAST SHORE" - (DIFFERENCE) APPLIED IRRIGATION - E.T. DEFICIT

Irrigation Season	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Season
1948-49			-.37	-.55	-.41	-4.31	-4.89	-.34
1949-50	-3.57	-1.36	-3.23	-2.06	-4.58	-4.22	-3.92	3.05
1950-51	-3.26	-2.88	-1.49	-3.25	-3.78	-3.79	-6.21	2.22
1951-52	-3.82	-3.19	-1.81	-4.24	-4.58	-4.32	-5.34	2.14
1952-53	-4.14	-2.12	-3.29	-3.99	-4.70	-5.33	-4.96	-1.25
1953-54	-3.35	-2.54	-2.85	-3.00	-5.53	-5.49	-5.68	1.71
1954-55	-2.63	-2.87	-3.09	-4.01	-4.64	-5.56	-3.50	2.20
1955-56	-.93	-2.41	-1.95	-3.05	-2.35	-3.61	-4.89	3.44
1956-57	-2.01	-2.03	-2.38	-3.31	-5.54	-6.42	-6.35	1.06
1957-58	-2.97	-2.05	-3.00	-3.96	-5.05	-5.77	-6.26	-.53
1958-59	-2.02	-2.35	-2.34	-2.73	-3.80	-4.99	-4.70	2.75
1959-60	-3.81	-3.05	-2.66	-3.92	-5.32	-5.53	-4.60	-2.45
1960-61	-2.66	-1.74	-2.60	-3.07	-4.96	-4.49	-3.73	2.89
1961-62	-1.87	1.29	-2.29	-1.91	-3.25	-5.52	-4.68	5.08
1962-63	-1.95	-1.05	-1.91	-2.96	-5.24	-2.89	-5.34	-1.57
1963-64	-2.81	-2.02	-2.39	-4.04	4.61	-4.14	-4.68	.29
MEAN	-2.79	-2.41	-2.38	-3.12	-3.69	-4.23	-4.48	1.52
STAND. DEV.	.90	1.06	.95	.98	2.58	1.98	1.72	2.51
MAXIMUM	-.93	1.29	-.37	-.55	4.61	-2.89	-3.50	5.08
MINIMUM	-4.14	-3.19	-3.29	-4.24	-5.54	-6.42	-6.35	-2.45

TABLE I-VI

APPLIED IRRIGATION AND E.T. DEFICIT PAHOKEE AND EAST SHORE DRAINAGE DISTRICTS

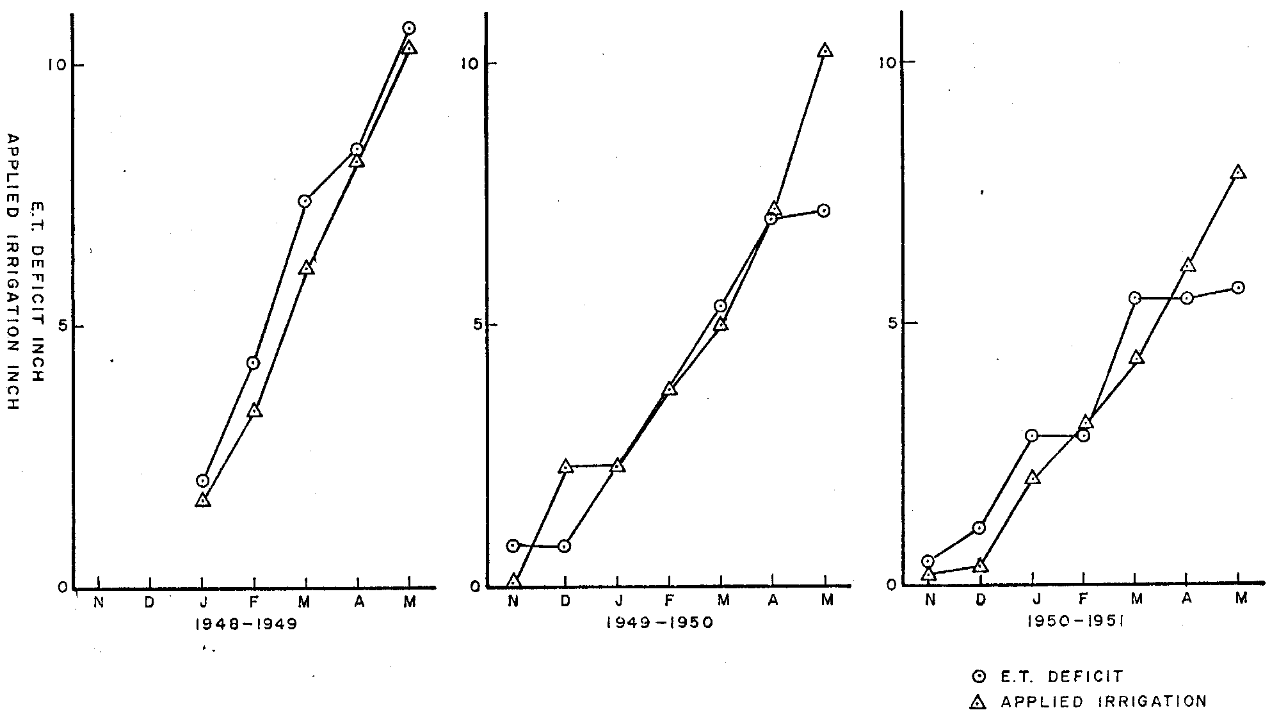


FIGURE I-1A

APPLIED IRRIGATION AND E.T. DEFICIT
PAHOKEE AND EAST SHORE DRAINAGE DISTRICTS

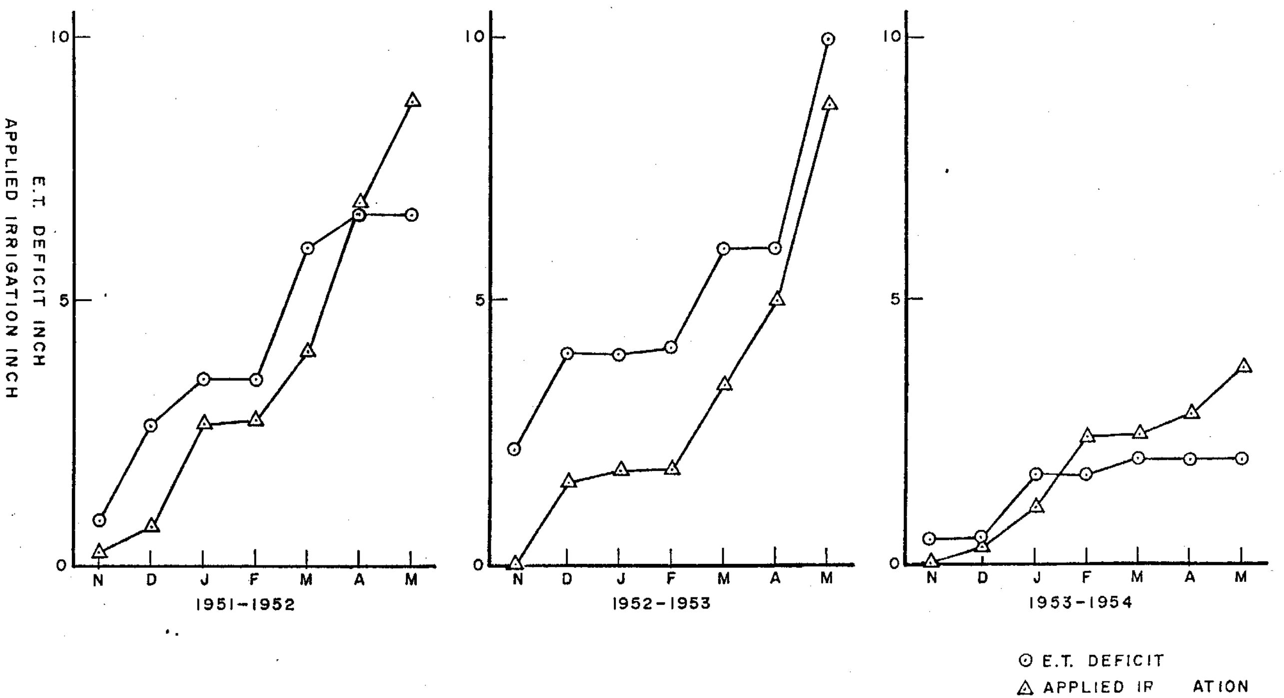


FIGURE I-1B

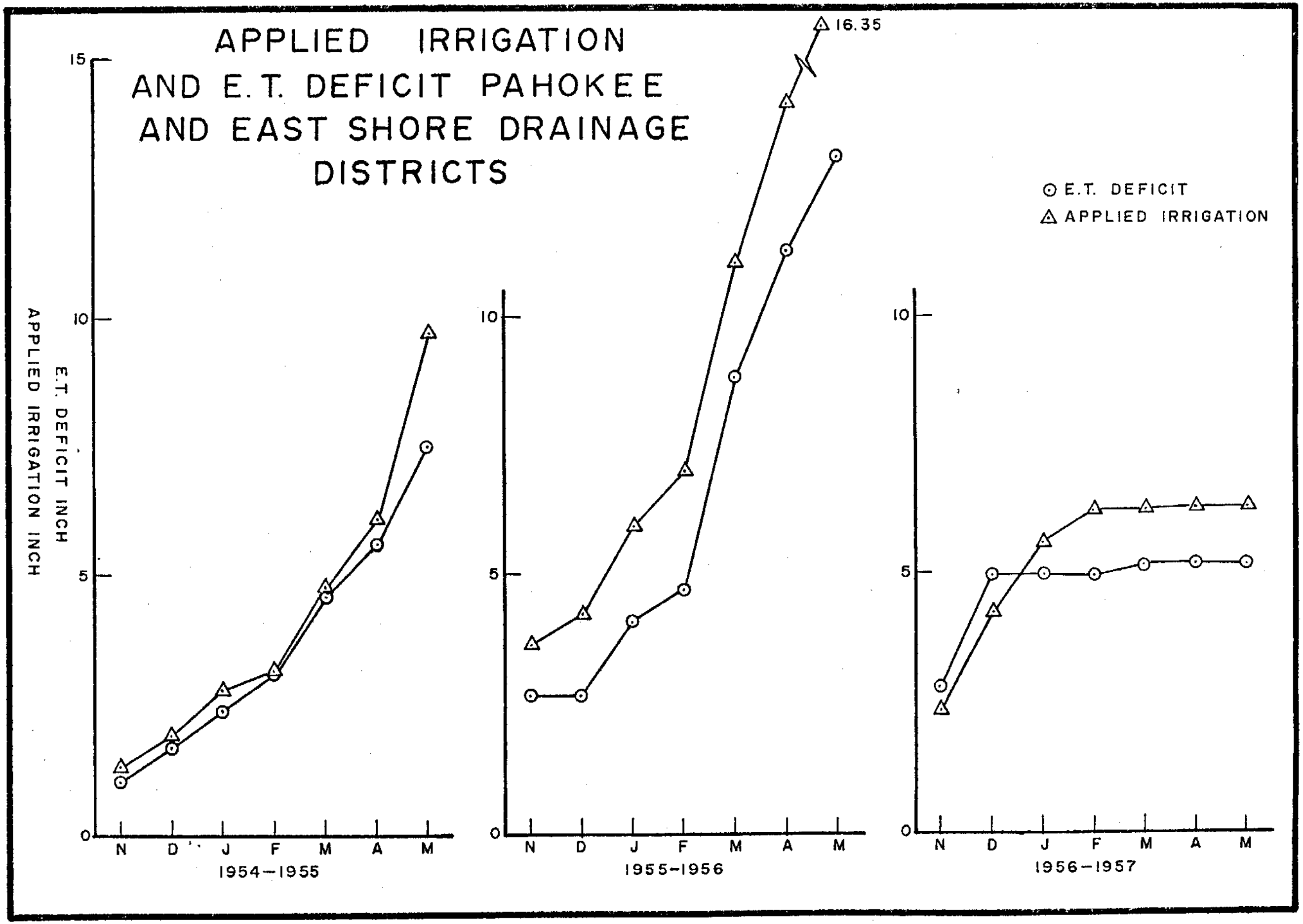
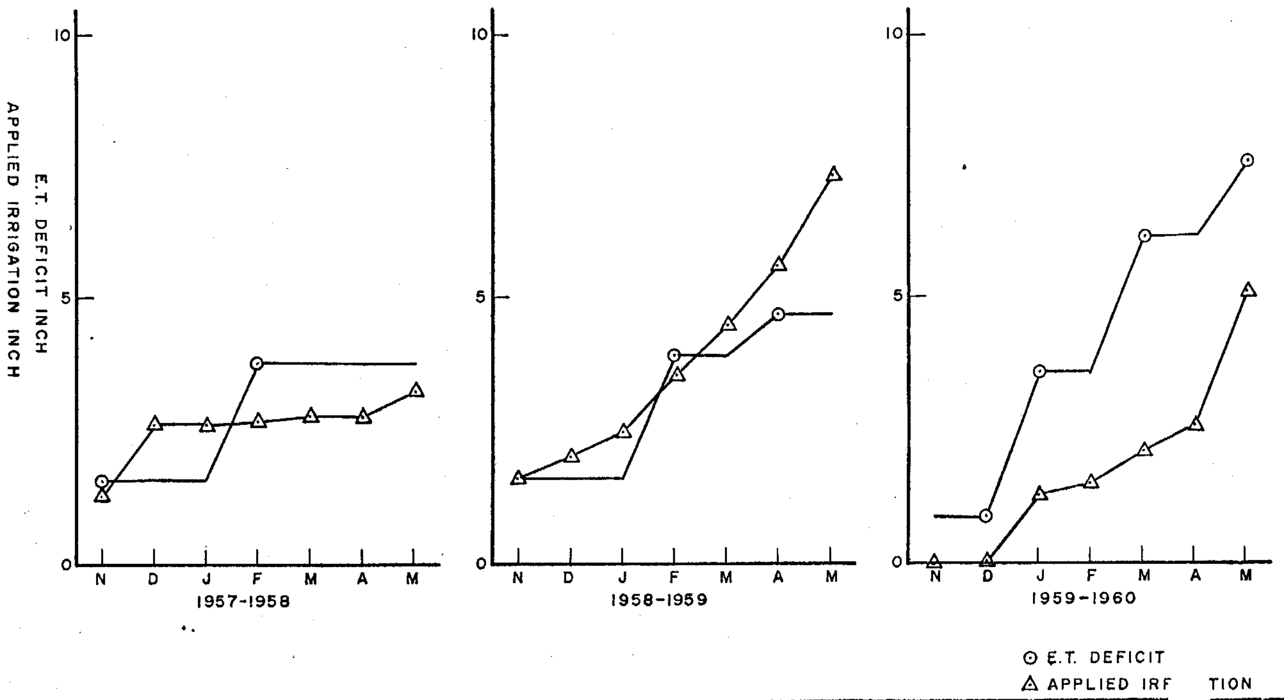

APPLIED IRRIGATION AND E.T. DEFICIT PAHOKEE AND EAST SHORE DRAINAGE DISTRICTS
E.T. DEFICIT
APPLIED IRRIGATION
E.T. DEFICIT INCH
APPLIED IRRIGATION INCH
0
5
10
15
16.35
N
D
J
F
M
A
M
1954–1955
1955–1956
1956–1957

FIGURE I–IC

APPLIED IRRIGATION AND E.T. DEFICIT
PAHOKEE AND EAST SHORE DRAINAGE DISTRICTS



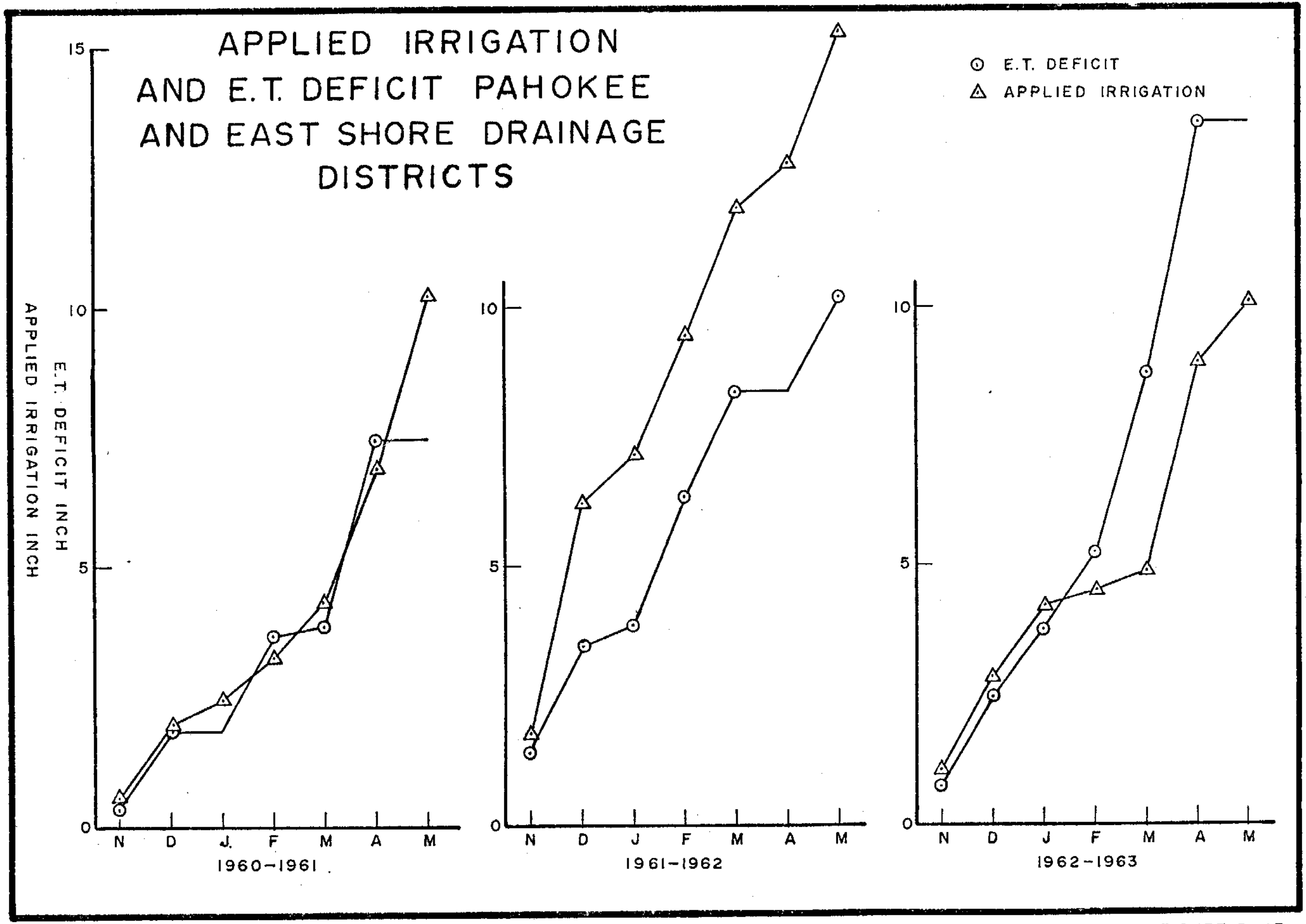
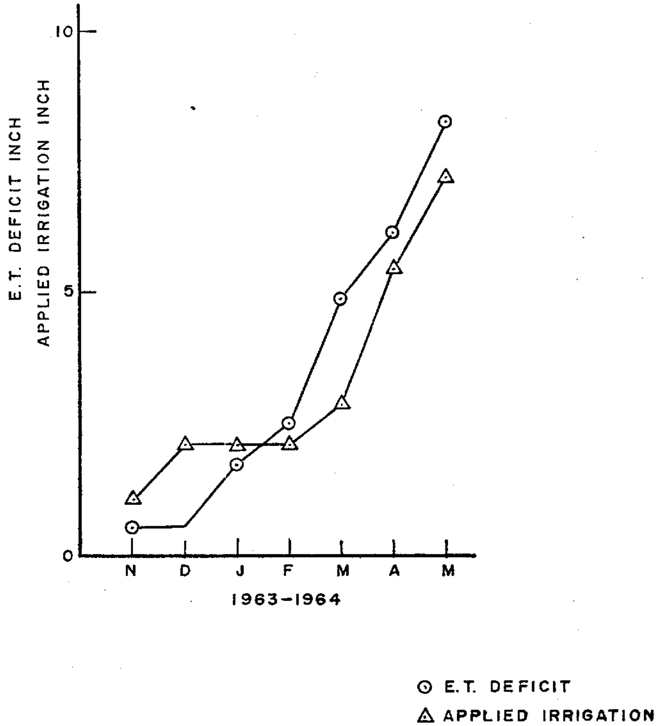
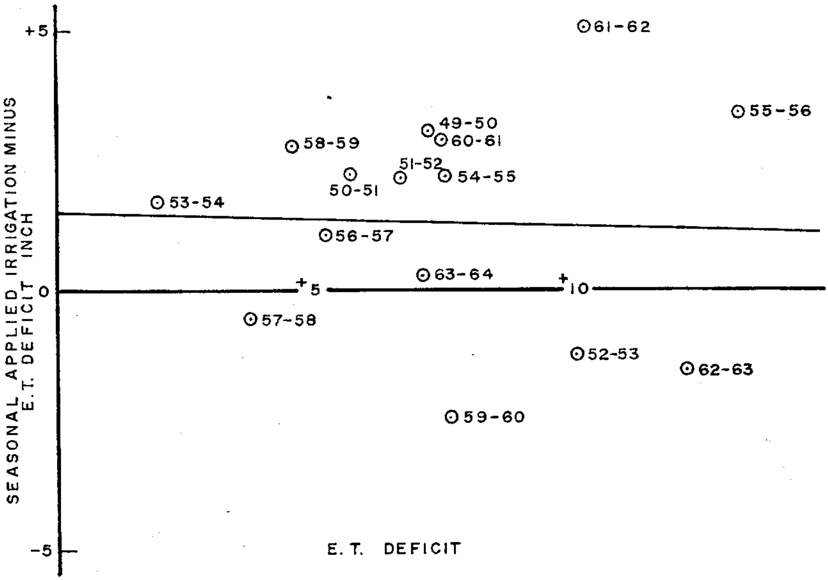

APPLIED IRRIGATION AND E.T. DEFICIT PAHOKEE AND EAST SHORE DRAINAGE DISTRICTS
E.T. DEFICIT
APPLIED IRRIGATION
E.T. DEFICIT INCH
APPLIED IRRIGATION INCH
0
5
10
15
N D J. F M A M
1960–1961
N D J F M A M
1961–1962
N D J F M A M
1962–1963

FIGURE I–IE



APPLIED IRRIGATION AND E.T. DEFICIT
PAHOKEE AND EAST SHORE DRAINAGE
DISTRICTS

FIGURE I-15



SEASONAL DIFFERENCE BETWEEN APPLIED IRRIGATION AND E.T. DEFICIT VERSES E.T. DEFICIT PAHOKEE AND EAST SHORE DRAINAGE DISTRICTS

FIGURE I-2