IMPACT OF UPLAND MARSH ON WATER QUALITY

IIA. DYE STUDY

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IIC. QUALITY SAMPLING

by

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Preliminary Information Subject to Revision

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IMPACT OF UPLAND MARSH ON WATER QUALITY, I: PRELIMINARY REPORT

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Introduction:

The Kissimmee River Basin has been altered by the channelization which was constructed over the last ten years. The impact of channelization on water quality is difficult to assess since water quality data prior to channelization is sparse. The U.S.G.S. - F.C.D. cooperative study for 1971 to 1973 indicated an increase in nutrient loadings as you move downstream in C-38. Current studies by the F.C.D. have determined that great variation exists in concentrations of nutrients in the water entering C-38 from its tributaries. An effort is being made to relate those differences to land practices.

A major change in the flood plain that occurred with channelization was the reduction in marsh land. However, water from upland areas still flows through marshes before entering C-38 in some tributaries. The impact of marshes on water quality is undefined. It is possible to investigate this impact using existing marsh flow patterns where the nutrient content of the water is high.

Objectives:

A pilot area of marsh and swamp will be used to investigate the following phenomena:

1. To determine rate and quantity of nutrient uptake in marsh and swamp under natural uncontrolled flow conditions.
2. To provide a data point in the study of area vs. water quantity and quality.
3. To study the interaction of travel time - travel distance - flow depth - quality. (residence time vs. quality).
4. To investigate flow pattern in marsh and swamp.

5. Survey of major plant constituents in marsh and swamp.

6. To determine the nutrient input from rainwater.

A limited investigation of nutrient sources will be conducted in the following manner:

1. To determine the interaction between drainage ditch density and nutrient source in two portions of the drainage basin, Cypress slough and Chandler slough.

2. To determine the interaction of land practices, animals numbers and fertilizer application rates on nutrient input.

Meeting the above objectives will provide information on the effect of marsh on water quality but additional study will be needed to provide:

1. Manning's N determination.

2. Design criteria for marsh treatment of storm water, if present results indicate the feasibility of such a practice.

3. A definitive answer to P, and N uptake and release cycle.

Study Area:

The marsh located at Chandler slough is used in this study. Four sampling sites identified as number 1300, 1301, 1302 and 1303 are shown in Figure 1. The travel distance from stations 1301 and 1302 to 1300 is near 3.5 miles. A swamp area along the lower end of Cypress slough is also used for this study. The travel distance in this swamp area is about 0.8 miles. The drainage from Cypress slough flows through site 1301. This drainage area of 65 sq. miles will be referred to as the east area. The land use in this east area is improved pasture. The drainage from Ash slough and Gore slough flows through site 1302. This drainage area of about 40 sq. miles will be referred to as the west area. The land use in this west area includes improved pasture and marsh. The detail land use pattern in both areas will be investigated further.

Sources of Nutrient Input:

The nutrient input in this study area has three main sources:

1. Rainfall: As shown in Table 1, rain is not the pristine water some believe it to be, but contains impurities found in the atmosphere due to both man and nature. After rainwater falls to the ground, it is either transported over the surface or through the ground as it seeks to again reach the river. That which passes over the surface erodes away material by either mechanical force or chemical action.

2. Natural Contamination: Runoff may also be subject to the addition of organic and inorganic material derived from leaves, branches, pollen and wildlife residues.

3. Agricultural Waste: The waste from agriculture may be a significant cause for water quality degradation in the lower Kissimmee Basin. The source of these wastes may be categorized as animal wastes, processing wastes, and agricultural chemicals.

Animal wastes are similar in quality constituents to human wastes, but the practice of using high-density animal feed lots and dairy cause greatly concentrated loadings.

A major problem in agricultural areas is the runoff from lands using excess quantities of fertilizers. The runoff can transport concentrations of nitrogen and phosphorus into streams and lakes causing overenrichment of the aquatic system.

The problem caused by pesticides may be acute. When pesticide concentrations of sufficiently high levels are allowed to enter the aquatic system, acute toxicity may occur and immediately harm various aquatic organisms.

More intensive drainage associated with increased agricultural use may raise the input of nutrients to adjacent waterways. Thus a combination of changes may work together to change water quality not directly attributable to any single factor.

Quality Calculation:

An example used to calculate the quality uptake by marsh or swamp is shown as follows:

(1) The case of swamp:

$$QUAL_S = (QA_3)\ Q_3 + (QA_S)\ Vol_S - (QA_1)Q_1 \qquad (1)$$

(2) The case of marsh:

$$QUAL_M = (QA_1)\ Q_1 + (QA_2)\ Q_2 + (QA_M)\ Vol_M - (QA_0)Q_0 \qquad (2)$$

in which

Q_0 = flow at station 1300, let it equal to $0.62Q_1 + 0.38Q_2 - ET + R$,

Q_1 = flow at station 1301, to be measured,

Q_2 = flow at station 1302, to be measured,

R = rainfall for the period of study

Q_3 = flow at station 1303, let it equal to $Q_1 + ET - R$,

QA_0 = quality at station 1300, to be measured,

QA_1 = quality at station 1301, to be measured,

QA_2 = quality at station 1302, to be measured,

QA_3 = quality at station 1303, to be measured,

QA_S = quality input to swamp area except from QA_3,

QA_M = quality input to marsh area except from QA_1 & QA_2.

Vol_S = volume of input to swamp except Q_3,

Vol_M = volume of input to marsh except Q_1 and Q_2.

The other techniques such as statistical analysis, time series analyses, and mathematical model will also be involved in the final analyses.

First Cut of Results:

The water quality sampling program of this study was initiated on 23 July, 1974 and was also continued by two more days. From the first analysis of this sampling data, the following results and conclusions are indicated:

(1) The flow rate in the marsh is about 0.1 or 0.2 ft/sec as measured.

(2) The stream flow entering Chandler slough under SR-98 was 152 cfs for

the North bridge, i.e. Q_2 and 250 cfs for the South bridge, i.e. Q_1, measured by Robert Taylor, Chief of Hydrology on July 23.

(3) Based on the flow rate, specific conductance, and chloride concentrations; the travel time in the marsh was calculated to be 2 days.

(4) The Orth-PO_4 and Tot-PO_4 concentrations versus time were plotted in Figure 2. The nutrient input through the 1302 bridge seems more stable and less enriched than that at 1301. This may imply that the land use affected the nutrient input.

(5) The phosphate content at 1300 is less than at stations 1301 and 1302. This implies that the marsh has a potential to reduce the phosphate concentration.

(6) The average of three days of phosphate data are shown in Table 2. As can be seen from Table 2, the ortho-phosphate average was 30% lower below the marsh as compared with that above the marsh. The ratio of Orth-PO_4 to Tot-PO_4 increased 6% in marsh and 5% in swamp. These results imply that both the marsh and swamp may have the capability to cleanse the Org-PO_4 and Particulate - PO_4. The total Org-PO_4 and total Part-PO_4 were reduced about 64% in marsh and 15% in swamp.

(7) The effect of a two day lag time on phosphate data in the marsh is shown in Table 3. The phenomena is similar to that shown in Table 2 and can be explained in the same way.

(8) The effect of a two day lag on nitrogen values in marsh area is shown in Table 4. The NH_4, TKN, NO_2 and NO_3 were reduced about 45%, 5%, 20% and 64% respectively.

We know this first cut information is not enough from which to draw any conclusion. However, the results do imply that the marsh and swamp have an impact on water quality. Therefore, further study of this area will be continued along the following lines:

Next Steps:

In order to obtain the more detailed data required to reach the objectives as previously mentioned, the following steps are needed:

1. Determine the discharge hydrograph at stations 1301 and 1302.
2. Rainfall data, both quantity and quality.
3. Cross section survey of marsh. Three locations are recommended. One cross section is also suggested in the swamp.
4. Flow rate and depth at marsh and swamp are needed. The flow rate can be performed by flow meter or by dye. The dye method is suggested because the general flow pattern in marsh and swamp also can be observed.
5. Vegetation conditions in marsh and swamp.
6. Land use in both areas of east and west.
7. Drainage density needs to be calculated for the drainage areas.
8. Quality sampling programs will be conducted two more times this year and the time interval suggested is 3 to 4 hours in three day sampling.
9. After this year of study, a detail procedure and objectives will be recommended for next year's program.
10. This program will involve personnel from the divisions of environmental sciences, hydrology, land use, and water planning.

Table 1. Surface Rainfall Quality From Mid-Peninsula (NOAA Datum 1973)

Constituent	PPM
NO_2 ppm	< .004
NO_3 "	0.222
NH_4 "	0.23
O-PO_4 ppm	0.005
N_a ppm	0.34
K ppm	0.061
M_g ppm	0.054
C_a ppm	0.63
F_e ppm	< 0.2
Cl ppm	0.3
SO_4 ppm	< 3.0
pH	5.9

Table 2. Average of Three Days Data of Phosphate

Station No.	Case	Average Ortho-P (1) ppm	Average Total -P (2) ppm	Ratio (1)/(2)	Percentage $\frac{(2) - (1)}{(1)}$	Diss - P and Part - P ppm (2) - (1)
1300	1(10)*	0.367	0.398	0.922	8.5	0.031
1301	2(15)	0.582	0.692	0.842	18.8	0.110
1302	3(4)	0.450	0.498	0.905	10.5	0.048
1303	4(3)	0.495	0.625	0.792	26.3	0.130
0.38(1302) + 0.62(1303)	5	0.532	0.618	0.861	16.1	0.086
$\frac{\text{Case5-Case1}}{\text{Case 5}}$		31%	35.6%			64.0%

* Represents the number of sample

Table 3. Analysis of Two Day Lag on Phosphate Data in Marsh Area

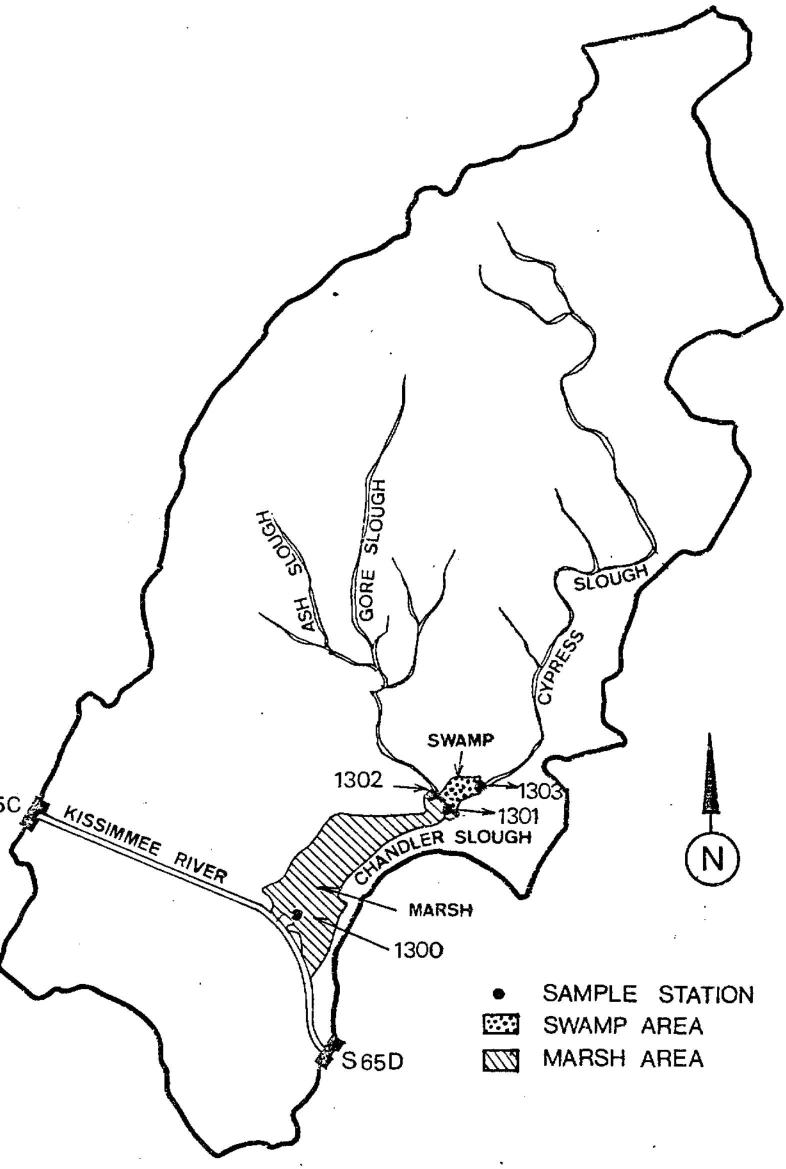
Station No.	Case	Orth-P ppm (1)	Total-P ppm (2)	Ratio (1)/(2)	Percentage $\frac{(2) - (1)}{(1)}$	Diss - P and Part - P ppm (2) - (1)
1300	1(2)*	0.443	0.490	0.904	10.6	0.047
1301	2(5)	0.642	0.744	0.863	15.9	0.102
1302	3(2)	0.458	0.490	0.935	7.0	0.032
1301 + 1302	4	0.571	0.645	0.885	13.0	0.074
$\frac{\text{Case4-Case1}}{\text{Case 5}}$		22.4%	24.0%			36.5%

* Represent the number of sample

Table 4. Analysis of Two Day Lag on Nitrogen Data in Marsh Area.

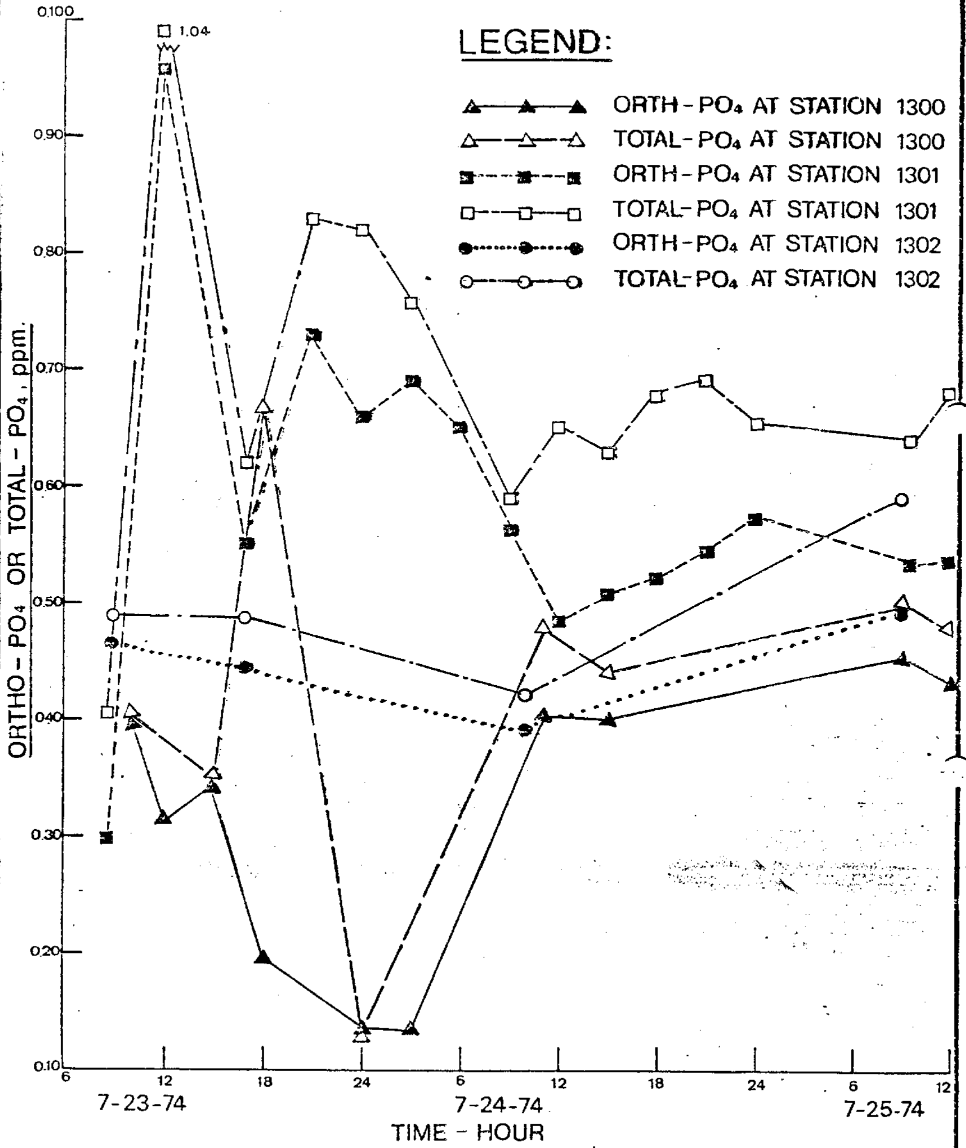
Station No.	Case	NH_4 ppm (1)	TKN ppm (2)	Ratio (1)/(2)	Diss-org-N Part-org-N ppm	NO_2 ppm	NO_3 ppm
1300	1(2)*	0.024	1.445	0.0166	1.421	0.004	0.004
1301	2(5)	0.043	1.530	0.0281	1.487	0.005	0.008
1302	3(2)	0.044	1.510	0.0291	1.466	0.005	0.017
1301 + 1302	4	0.044	1.523	0.0289	1.479	0.005	0.011
$\frac{\text{Case4-Case1}}{\text{Case 4}}$		45.5%	5.1%		3.9%	20%	63.6%

* Represents the number of sample.



LAYOUT OF STUDY AREA

FIGURE 1



PHOSPHATE - CHANGING WITH TIME

FIGURE 2

File No: 9-5-2H(57,59)

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IIA. DYE STUDY

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IIA. DYE STUDY

INTRODUCTION

The flow velocity in the marsh and the swamp area is very low and also changes with water depth, season and location. For example, stream flow in Chandler Slough area has been measured as low as 0.03 to 0.1 ft/sec. The water space is filled by a variety of plants which makes it impossible to use a flow meter in velocity measurement, especially during low flow periods. The authors attempted to use dye to obtain the flow characteristics in marsh and swamp during low flow conditions in September.

OBJECTIVES

There are six objectives involved in this study:

(1) To obtain the flow velocity in marsh and swamp area.

(2) To investigate the flow pattern through marsh and swamp area.

(3) To observe the possible rate of diffusion.

(4) To relate the flow velocity to different vegetation.

(5) To establish a relationship among flow velocity, water depth, vegetation characteristics and season.

(6) To suggest the type of dye which can be used in other areas of study.

VEGETATIONS

As Figure 1 shows, the study area is separated into four pools based on vegetation and water depth. Pools I, II and III are marsh areas, and pool IV is a swamp area. The vegetational changes with season in different pools will be described as follows:

1. Wet Season:

The wet season in South Florida is generally defined between May and October. The wet season is very important for this study,thus, three subseasons need to be described:

a. The beginning of wet season

b. Middle of wet season

c. End of wet season

2. Dry Season:

The description of vegetation types and density measurements were not a part of the program for the portion of the study just completed, but will be a portion of the study during the current fiscal year. Jim Milleson will be doing the Vegetation Studies. His input will be most valuable in providing a more complete description of the study area.

Observations during the recent wet season provided a new perspective on seasonal changes of vegetation. At the time of the July water quality sampling the vegetation was not dense in Pool II compared with the September study. (The difference can be seen from slides). There was enough open water 2 ft. deep to use a Price current meter. However, the larger bushes present provided obstructions to flow. These variations in flow could not be evaluated by the current meters.

In Pool IV the water hyacinths increasingly filled the area. By September there was very little open water. This area has a thick stand of Cypress which drop their needles in October-November.

DYE EXPERIMENTS

The dye studies reported here were conducted on September 25, 1974. Five experimental locations as shown in Figure 1 were chosen. The original plans were to use aerial photography but the density of vegetation prevented this at 3 of 5 sites.

1. DI Site:

The water depth averaged 0.5 ft. at DI. The width of marsh was about 4700 ft. The water volume filled by plant stems was roughly estimated to be 20%. The detail ratio will be estimated this coming dry season and wet season. The average height of vegetation was three feet above ground. Fluorescein Dye was used. The dye was introduced in powdered form and followed downstream. Distances of 110 feet, 210 feet and 310 feet were used to observe time and width of flow. The results are plotted in Figures 1 and 2A. The following observations were made from the sampling trip and slides:

(1) The dye flow pattern which was traced from both sides and marked at the above distances formed a zig-zag shape.

(2) The flow belongs to a type of laminar flow. In general, the laminar flow is defined as a type of flow in a stream of water in which each particle moves in a direction parallel to every other particle.

(3) A distinct boundary between dye and clear water was observed.

(4) The highest concentrations of dye observed occurred at the same time as the maximum width based on estimation.

(5) Based on increase in width at each observation point, the rate of lateral diffusion was about 0.0023 ft/sec.

(6) The flow pattern of Figure 2A was partitioned into three portions. The area of each portion was also measured. The average of three measurements indicated that 10% of dye moved 100 ft. in 28 minutes, 60% of the dye moved 100 ft in 36 minutes and 30% in 45 minutes. Combining these results, the average velocity of flow was 0.045 ft/sec.

(7) Based on the velocity of 0.045 ft/sec, the travel time from sampling sites 1301 and 1302 to 1300 was calculated to be 4.5 days.

(8) The recorded discharge on September 21 was 84 cfs. The calculated velocity which was based on the effective area, discharge and the assumption that no charge in water storage occurred in the marsh, was

about 0.045 ft/sec.

(9) A comparison of the dye study results with calculated results shows close agreement.

II. D2 Site:

The average water depth is 0.75 ft. The width of marsh is about 2600 ft. The cross section area filled by vegetation was estimated to be about 15%. The average height of vegetation was estimated at about four and half ft. Fluorescein dye was used. Three time measurements were made at intervals of 100 feet. The results are plotted in Figures 1 and 2b. As can be seen from those figures, the following observations were made:

(1) to (4) are similar to the results indicated in D1 Site.

(5) The rate of diffusion was about 0.0027 ft/sec.

(6) The same techniques as described in D1 was used to analyze flow rate. Ten percent of the dye flowed 100 feet in 28 minutes, 60% in 42 minutes, and 30% in 60 minutes. Thus, the average velocity was 0.038 ft/sec. The velocity at D2 was lower than D1. The cause may be attributed to vegetation differences. More Pickerel weed was observed at D2 which can trap dye and slowly release it as shown on the slide.

(7) Based on 0.038 ft/sec velocity, the travel-time from sampling sites 1301 and 1302 through Pool II is about 3.5 days.

(8) The discharge measured on September 22 was 72 cfs. Velocity calculated from effective area and discharge are about 0.043 ft/sec.

(9) Comparing the results from the dye study directly with the calculated results give a slight difference. The reason may be that the estimates of vegetation density and marsh cross section are not quite reliable.

III. D3 Site:

This site was located at the North Bridge on SR98. According to the record of stage and discharge, there was no flow on September 25, but, 155 minutes after applying Dupont Rhodamine WT dye on the west side of the bridge, the leading edge of the dye moved 2,000 feet. This indicated that there was still some flow under the North Bridge even though stream gaging at the bridge indicated no flow. The flow was visible in a channelized area downstream of the bridge. This indicates that discharge measurements during low flow will need to be made in the channelized section downstream of the bridge.

IV. D4 Site:

This site is located at the South bridge. There was 53 cfs discharge on September 25. Fluorescein Dye was used. One hundred seventy-five minutes after applying the dye, the trailing edge of the green dye could be seen clearly at 2600 feet. The leading edge was hidden beneath the hyacinths.

V. D5 Site:

This site is located at the East bridge. Dupont Rhodamine WT dye was used. The dye was not visible because the water surface was covered by hyacinths.

Fluorescein dye was more visible than the rhodamine dye in the marsh area. The red color of Rhodamine dye did not standout in the darkly stained water. The low flow and high flow in the beginning, middle and end of the wet season should be studied in the next wet season. Velocity measurements are also nedded at two sites located at pool I and IV.

MATHEMATICAL MODELS DEVELOPMENT

Two mathematical models are introduced:

Model 1: Residence time, velocity, depth and stage related to discharge

$$x = a + \ln Q^{b+c \ln Q} \qquad (1)$$

in which x is residence time, velocity, depth, or stage

Q is discharge

a, b, c are constants

Model II: Discharge related to the Stage of the South bridge or North bridge

$$Q = e^{k_1 \pm \sqrt{k_2 + k_3 S}}$$

in which Q is discharge

S is stage

k_1, k_2 and k_3 are some constants

If the data is a convex form, the minus sign should be used, otherwise, the positive sign is used. The detailed description of those two models related to the physical system will be included in the final report.

Flow Velocity:

As indicated in the introduction section, the flow velocity is less than 0.1 ft/sec. Therefore, direct measurement with a flow meter cannot be used to the lowest limit of detection which is 0.08 ft/sec with a Price Current meter. On July 23 flow could not be measured in the lower 1 foot of the water column. However, a low flow portion is present most of the time in the marsh because of increased friction near the ground surface. Therefore, an indirect method such as the dye method should be used, especially, in low flow cases. Based on the results of the flow meter measurement on July 23, the dye study on September 25, and stage discharge records at the North and South bridges, a series of velocities related to discharges on both marsh and swamp has been estimated. The results are shown in Table 1 and also plotted on Figure 4. After applying the equation 1 model to the velocity, the coefficients of a, b and c are shown in Table 2. The simulated results are also plotted on Figure 4. The correlation coefficients, r^2, are all greater than 0.9. This indicates that the model 1 equation is an applicable tool to simulate the flow velocity. In order to obtain more reliable solutions, more data are required.

Water Depth:

Based on the data obtained on July 23, September 25, and stage records of the two bridges, a series of flow depth was estimated as Table 1 and Figure 3 shows. The coefficients of a, b and c are also shown in Table 2 and the simulated results are plotted on Figure 3. As can be seen from Figure 3, the model 1 equation is a useful tool to simulate the flow depth related to the discharge. As with the flow velocity, more data is required to obtain more reliable coefficients of a, b and c.

Residence Time:

The applicability of residence time and travel time to the marsh and swamp area is introduced in this study in order to estimate the time of flow. The travel time is defined as the time required for water to flow from one point to any other point or location. The residence time of an element, τ, can be defined as the average time which it remains in the water before removal by some process.

$$\tau = \frac{Q}{(dQ/dt)} \qquad (3)$$

in which Q is the total amount of the element in solution.

dQ/dt is the amount introduced

The residence time can be applied based on the following two assumptions:

(1) A steady state system in which the amount of an element entering per unit time was compensated by the removal of an equivalent amount.

(2) There is a complete mixing of the element in a time which is short compared with the residence time.

After applying the equation 3 to the marsh and swamp area in which Q is the total volume of water in the marsh and dQ/dt is the flow through the bridge. The results of residence time in each pool are shown in Table 1. Total residence time in the marsh and swamp related to discharge are also plotted on Figure 4. The coefficient a, b and c for equation 1 model are given in Table 2. As can be seen from Figure 4, the equation 1 model is also an applicable tool to simulate the residence time related to discharge in the marsh and swamp area. Comparing the results of residence time with the travel time indicate that the residence time is very similar to the travel time. Additional data and study are required.

Discharge:

The discharge related to the stage record had been settled on the North and South bridge and the data are shown in Table 1 and also plotted in Table 3. The coefficients of k_1, k_2 and k_3 for equation 2 model are shown in Table 2. As can be seen from Figure 3, the discharge related to the stage in the South bridge is a convex form, so a minus sign should be used in equation 2. The data of the North bridge is a concave form, so a positive sign is used. The equation 2 model also gives quite a good relationship between the discharge and stage in both bridges.

Groundwater:

Groundwater data on the sampling side are required. The dye study also can be applied to study the hydraulic conductance. The program will be initiated at this coming dry season.

Table 1. Stage, Discharge, Depth, Residence Time, and Velocity.

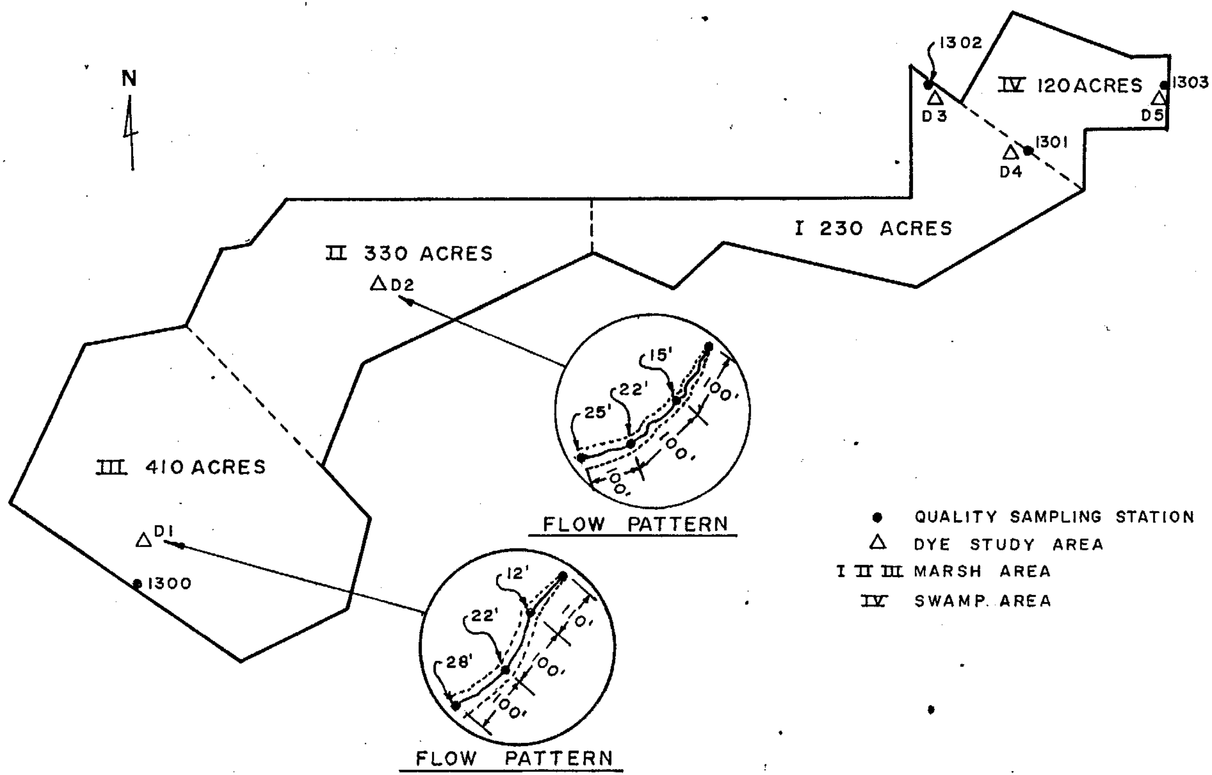
Pool No.					Pool I		Pool II		Pool III		Marsh			Swamp		
Area, (acre)					230		330		410		970			120		
Flow Length (Ft.)					7300		6600		3800		17700			3600		
Date	N. Bridge Stage ft.	N. Bridge Discharge cfs	S. Bridge Stage ft.	S. Bridge Discharge cfs	Depth ft.	Time day	Depth ft.	Time day	Depth ft.	Time day	Depth ft.	Time day	Velocity ft/sec	Depth ft.	Time day	Velocity. ft/sec.
7-23	6.47[a]	152	5.45[b]	250	2.15	0.62	1.90	0.78	1.65	0.85	1.85	2.25	0.091	2.65	0.64	0.065
9-13	5.00	10	4.98	74	1.09	1.42	0.79	1.55	0.54	1.32	0.74	4.29	0.048	1.54	1.25	0.033
9-14	5.27	33	5.19	84	1.16	1.14	0.91	1.28	0.66	1.16	0.86	3.58	0.057	1.06	1.19	0.035
9-15	5.67	67	5.17	83	1.31	0.94	1.06	1.09	0.81	1.04	1.01	3.07	0.067	1.81	1.31	0.032
9-16	5.60	61	4.99	75	1.22	1.03	0.97	1.18	0.72	1.09	0.92	3.30	0.062	1.72	1.38	0.030
9-17	5.52	54	4.93	73	1.19	1.08	0.94	1.22	0.69	1.11	0.89	3.41	0.060	1.69	1.39	0.030
9-18	5.52	54	4.87	69	1.18	1.10	0.93	1.25	0.68	1.13	0.88	3.48	0.059	1.68	1.46	0.029
9-19	5.41	45	4.84	68	1.14	1.16	0.89	1.30	0.64	1.16	0.84	3.62	0.057	1.64	1.45	0.029
9-20	5.20	27	4.80	66	1.07	1.32	0.82	1.46	0.57	1.26	0.77	4.04	0.051	1.57	1.43	0.029
9-21	5.12	20	4.75	64	1.04	1.42	0.79	1.55	0.54	1.32	0.74	4.29	0.048	1.54	1.44	0.029
9-22	5.03	12	4.66	60	1.00	1.60	0.75	1.72	0.50	1.42	0.70	4.74	0.043	1.50	1.50	0.028
9-23	4.92	3	4.59	57	0.96	1.84	0.71	1.95	0.46	1.57	0.66	5.36	0.038	1.46	1.54	0.027
9-24	4.81	0	4.54	55	0.94	1.96	0.69	2.07	0.44	1.64	0.64	5.67	0.036	1.44	1.57	0.027
9-25	4.81	0	4.52	53	0.93	2.02	0.68	2.12	0.43	1.66	0.63	5.80	0.035	1.43	1.62	0.026
9-26	4.87	0	4.65	59	0.95	1.85	0.70	1.96	0.45	1.56	0.65	5.37	0.038	1.45	1.48	0.028

[a]Add 26.72 ft. to the stage to obtain mean sea level elevation

[b]Add 27.83 ft. to the stage to obtain mean sea level elevation

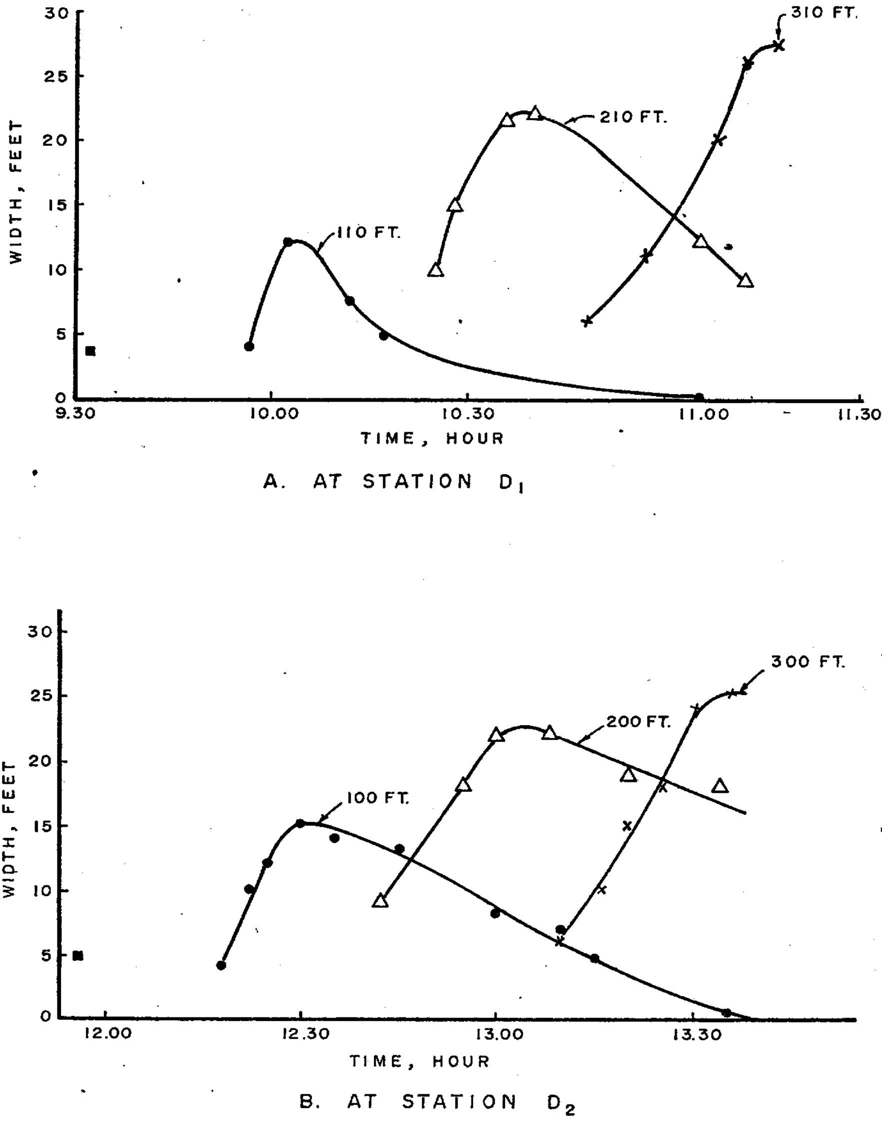
Table 2. The Coefficients for Residence Time, Velocity, Depth and Stage Related to Discharge.

Coefficients	Marsh Area				Swamp Area			
	Residence Time	Velocity	Depth	Discharge N. Bridge	Residence Time	Velocity	Depth	Discharge S. Bridge
a	32.762257	-0.097901	4.574009	4.892462	6.697311	0.121116	-0.512839	-14.542703
b	-10.171297	0.037005	-2.035849	-0.223403	-1.758129	-0.059055	0.264171	7.770842
c	0.848344	-0.000913	0.263560	0.099578	0.119697	0.008856	0.055856	-0.751456
k_1				1.121749				5.170524
k_2				-47.873637				7.381614
k_3				10.042379				-1.330750
r^2	0.998405	0.999420	0.998482	0.960896	0.965760	0.990694	0.967279	0.987305



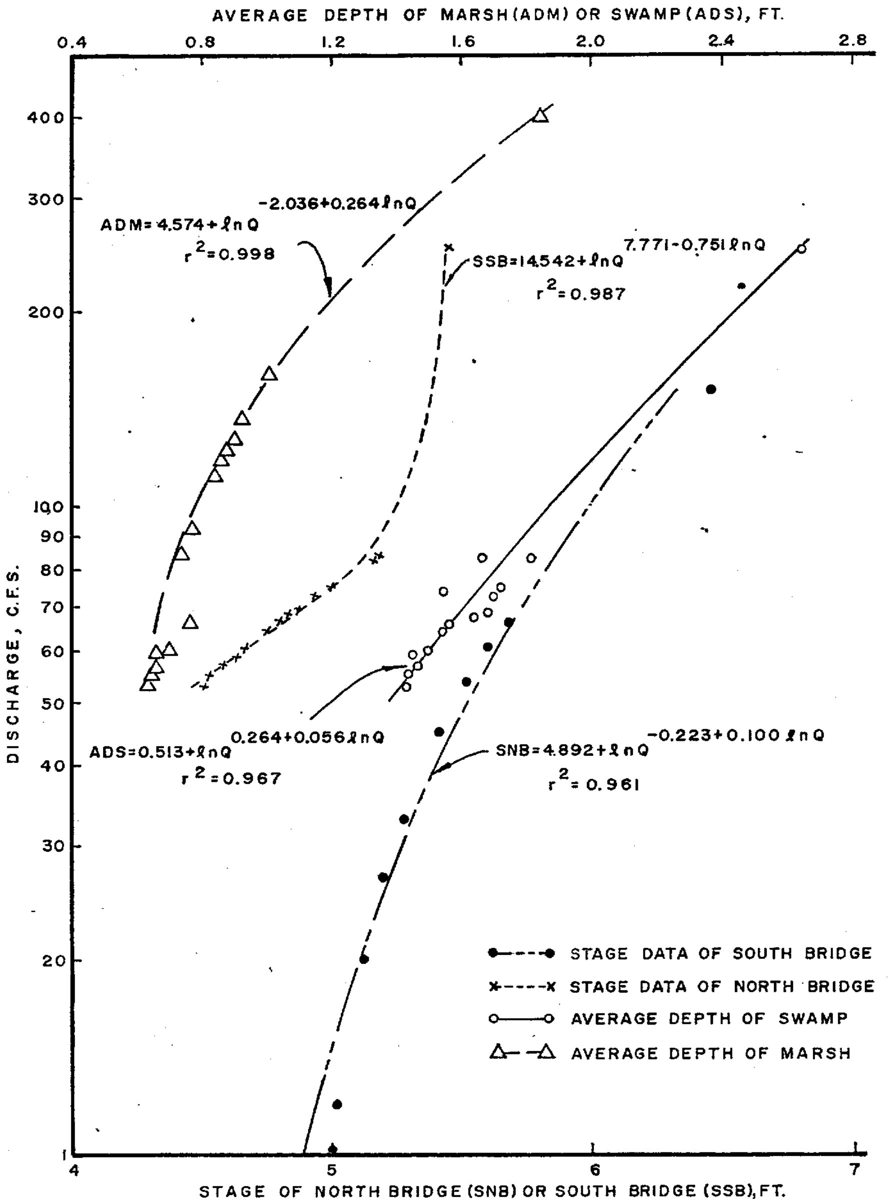
LAYOUT OF CHANDLER SLOUGH AREA

FIGURE 1



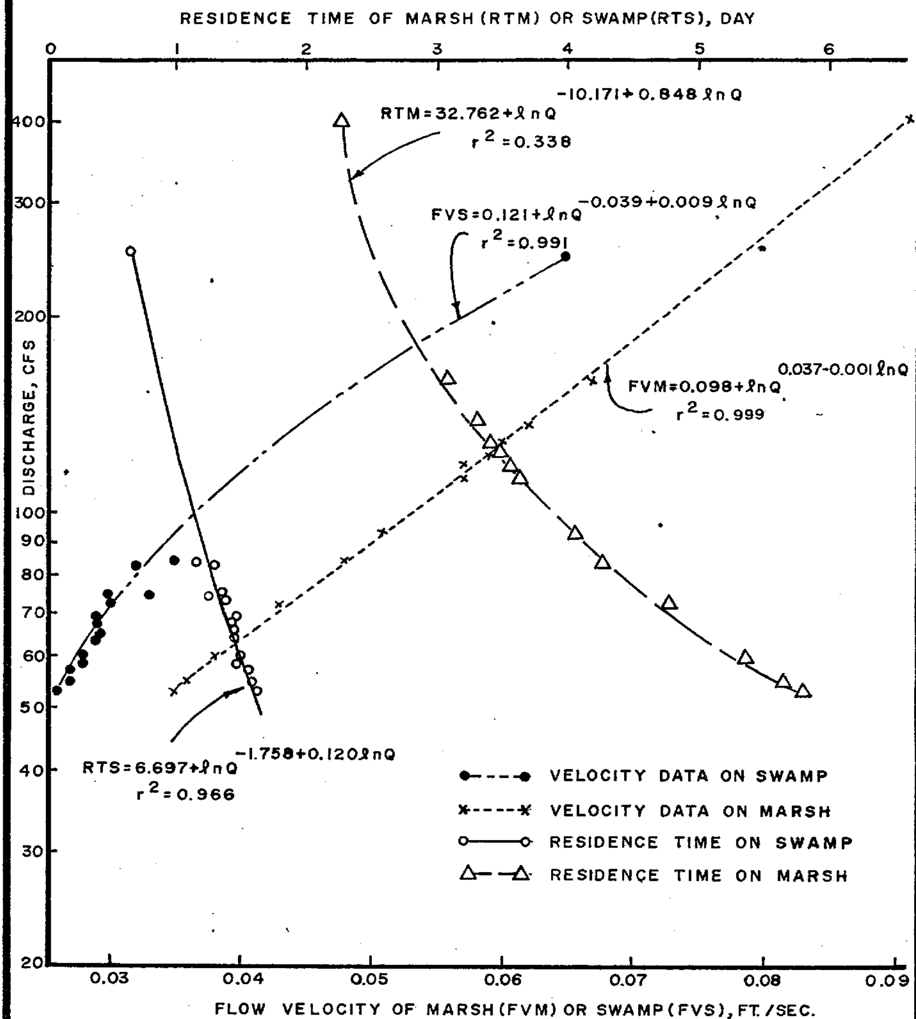
FLOW PATTERN OF DYE

FIGURE 2



STAGE AND AVERAGE DEPTH RELATED TO DISCHARGE

FIGURE 3



RESIDENCE TIME AND VELOCITY RELATED TO DISCHARGE

FIGURE 4

File No: 9-5-2H(57,85)

IMPACT OF UPLAND MARSH ON WATER QUALITY
II.B ROUGHNESS COEFFICIENTS

by

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November, 1974

IMPACT OF UPLAND MARSH ON WATER QUALITY
IIB. ROUGHNESS COEFFICIENTS

INTRODUCTION

The flow condition in Chandler Slough is a combination of the classical definitions of overland and channel flow. The water is too deep to fit the definition for overland flow and is restricted by vegetation which prevents its study using channel flow concepts. The marsh of Chandler Slough is similar to the floodplain in the Kissimmee River, thus the study of flow in the slough will provide an understanding of the lower marsh flow in the river plain.

The amount of water that is carried by marsh flow is governed by width and depth of flow, the slope of the surface, the characteristics of the surface which are dependent on vegetation and maintenance such as grazing or mowing, and on the volume of water entering the marsh. A major problem in predicting marsh flow occurs in the determination of the roughness coefficient which varies with season and depth of water. Information on values of this coefficient for different vegetation is sparse. The resistence coefficient values used in marsh flow generally considered as values obtained from conservation area (Shih, Hallett, Hamrick, 1974) determinations which evaluated the flow depth but not the other variables. there is a great need for more relevant experimental data in order to better describe the processes involved.

The purpose of this study is to determine the nature of the variation of Manning's n for different vegetation types, seasonal variation, and flow depth, with the aim of making a contribution to better understanding.

MARSH FLOW EQUATION

Accurate estimates of discharge in marsh require the use of a flow equation together with an estimate of the degree of retardance, expressed by a coefficient of roughness.

There are two major formulas for computing discharge in open channels. The first developed by Chezy in 1775 is the equation:

$$V = C\sqrt{RS}$$

where

V = velocity of flow,

S = slope of channel,

R = hydraulic raduis of the channel,

C = coefficient of roughness.

The second formula which is widely used in the United States is Manning's formula first introduced in 1891, and now a classic formation stone of modern open channel hydraulics. Manning proposed an equation which was later developed into

$$V = \frac{1.486}{n} R^{2/3} S^{1/2} \qquad (2)$$

where

V = velocity of flow in feet a second,

R = hydraulic radius, or ratio of cross section area to wetted perimeter (in the case of marsh flow R corresponds essentially to the mean depth).

n = coefficient of resistance depending on relative roughness of the surface over which the flow occurs,

S = slope of the energy gradient but is used herein as slope of the water surface

The formula is a modification of the Chezy formula, wherein, the friction coefficient C is equal to $\frac{1.486}{n} R^{1/6}$.

In marsh flow, the hydraulic radius can be performed by two cases.

Case I: The hydraulic radius is assumed equal to the depth of flow because the value of wet perimeter is very close to the width of marsh. Using Manning's value for the coefficient C and considering R as the depth, D and W as the width of the cross section, then:

$$Q = WD \frac{1.486}{n} D^{1/6} D^{1/2} S^{1/2}$$

$$\text{or} = W \frac{1.486}{n} D^{5/3} S^{1/2} \qquad (3)$$

showing that the discharge in the marsh is a function of the depth to the 5/3 power. Sufficient data from heavily vegetated areas are not yet available to determine definitely whether Manning's fromula would be applicable for all ranges of depths and different growth seasons.

Case II: The hydraulic radius is related to vegetation and depth of flow. Let D represent the depth of flow, W_i the width of $_i$th subchannel, M the number of subchannels which are performed by vegetations. The hydraulic radius R can be expressed as:

$$R = \frac{\text{Area}}{\text{Wet Perimeter}}$$

$$= \frac{W_1 D + \ldots + W_m D}{(W_1 + 2D) + \ldots + (W_m + 2D)}$$

$$= \frac{D \sum_{i=1}^{m} W_i}{\sum_{i=1}^{m} W_i + 2mD}$$

$$= \frac{D}{1 + \frac{2mD}{\sum_{i=1}^{m} W_i}} \qquad (4)$$

As can be seen from equation 4, if the factor $2mD/\sum_{i=1}^{m} W_i$ is near zero, then the Case 2 equals Case 1. The possibility of that factor approached zero is the condition that the total cross section area $\sum_{i=1}^{m} W_i$ is much greater than 2mD, otherwise, the R is not equal to D. If the subchannel is assumed to be the same width, then the equation 4 can be rewritten as

$$R = \frac{D}{1 + \frac{2D}{W_i}} \qquad (5)$$

For example, four stems with averaged diamter 0.1 ft. are grown in square feet area. This implied that ten stems are needed in per subchannel or said 2.5 ft. width of marsh can create a subchannel. The width of subchannel is 2.4 ft. The hydraulic radius will be equal to

$$R = \frac{1.2D}{1.2+D} \qquad (6)$$

If the depth of flow, D, is 0.5 ft., then R is 0.35 ft. It is obvious that the R is not equal to D and also is always smaller than D because the terms of $2mD/\sum_{i=1}^{m} W_i$ or $2D/W_i$ is never less than zero in this case II study. The technique used in this example is just only for the purpose of demonstration on how the equation 5 works. The detailed experimental procedures will be settled before the coming wet season. The same primary technique will be initiated in this dry season.

METHODOLOGICAL DESCRIPTION

The detailed experimental procedure for vegetation grown in marsh area will be written in another memorandum. The following studies have been initiated to evaluate resistance factors, comparable to Manning's n, for marsh flow in the heavily vegetated Chandler Slough and Boney Marsh areas. After collecting the proper data, the following three methods will be used to evaluate the n values.

1. Water Surface Profile Method:

Water surface profile computation has been presented by several investigators In almost all the methods of hydraulic exponents or some form of varied flow function or both has been used to render the equation more tractable for solution. However, no single method has been found to be suitable for all applications in South Florida because of the flat surface and low velocity of flow. A useful technique to calculate the channel cross section has been developed by Shih and Hamrick (1974), and a modified integration of flow profile function has been developed by Shih (1974). The rating curves for the South and North bridge must be developed (a preliminary rating curve for those two bridges was introduced by Shih and Hallett, 1974). The roughness coefficient varied until the elevation of the computed water surface at the South and North bridges duplicated the elevation obtained for the same discharge from the rating curve for the outlet at that point. The discharge should also be concerned with the ET loss.

The differential equation of gradually varied flow is

$$\frac{dy}{dx} = \frac{S_o - S_e}{1 - \frac{\alpha Q^2 W}{g A^3}} \qquad (7)$$

in which

y = the depth of flow in marsh;

x = the distance along the marsh bed;

S_o = the slope of the marsh bed;

S_e = the energy gradient;

α = the velocity head coefficient;

Q = the discharge;

W = the top width of the marsh section;

g = acceleration due to gravity; and

A = the cross section area of the marsh.

When Manning's formula is used, the energy slope, S_e is

$$S_e = \frac{n^2 V^2}{2.2082\ R^{4/3}} \qquad (8)$$

in which V = the velocity of flow;

n = Manning's roughness coefficient; and

R = the hydraulic radius

<u>For Case 1:</u> Let $V = \frac{Q}{A}$ and $R = Y$, the equation 8 is

$$S_e = \frac{n^2 Q^2}{2.2082\ Y^{10/3}} \qquad (9)$$

Substituting equation 9 into equation 7 yields

$$\frac{dy}{dx} = \frac{S_o - \dfrac{n^2 Q^2}{2.2082\ Y^{10/3}}}{1 - \dfrac{\alpha Q^2}{g Y^3 W^2}} \qquad (10)$$

A modified integration of equation 10 which can be used in South Florida area has been developed by Shih, 1974.

<u>For Case 2:</u> Let $V = \frac{Q}{A}$ and $R = \frac{Y}{1 + KY}$, the equation 8 is

$$S_e = \frac{n^2 Q^2}{2.2082 \left(\frac{Y}{1 + KY}\right)^{10/3}} \qquad (11)$$

in which $K = 2m / \sum_{i=1}^{m} W_i$

m = the number of subchannels;

i = index of subchannel; and

W_i = the width of $_i$th subchannel.

Substituting equation 11 into equation 7 yields

$$\frac{dy}{dx} = \frac{S_o - \dfrac{n^2Q^2}{2.2082\left(\dfrac{Y}{1 + KY}\right)^{10/3}}}{1 - \dfrac{\alpha\, Q^2}{gy^3\left(\sum\limits_{i=1}^{m} W_i\right)^2}} \tag{12}$$

The integration of equation 12 which had never been solved will be developed by Shih in the near future.

II. Vegetation Investigation:

For mean velocity in a heavily vegetated area, the Chezy formula is $V = C\sqrt{RS}$ in which C equals $F\sqrt{\frac{2g}{abe}}$. If the Manning formula is used, the Chezy coefficient changes to $\frac{1.486D^{1/6}}{n}$, from which

$$n = \frac{1.486D^{1/6}}{F\sqrt{\dfrac{2g}{abe}}} \tag{13}$$

in which F = the proportion of the total cross section effective for flow;

e = a drag coefficient depending on the type or shape of the vegetation;

a = a factor representing the project area normal to flow of each stalk of vegetation;

b = a factor representing the density of the vegetation.

The expression of equation (8) shows that Manning's n would vary separately with depth and velocity, since the factor, a, would be affected by high velocities and the factors F and b vary with depth. Estimates of the probable values of those factors indicate that n will decrease as depth increases up to the point of submergence of the vegetation, and decrease at a greater rate as depths and velocities further increase.

III. Velcoity Measurement:

Equation 3 can be rewritten as for Case 1.

$$n = \frac{1.486}{V} D^{2/3}S^{1/2} \tag{14}$$

for case 11,

$$n = \frac{1.486}{V} \left(\frac{D}{1 + KD}\right)^{2/3} S^{1/2} \qquad (15)$$

The K value is the same as introduced in equation 11.

It is obvious that if the values of V, D, K and S can be obtained, then the n value can be calculated based on equation 14 or 15. According to the results of the dye study reported by Shih and Hallett (1974) at D2 Site in Chandler Slough, the V = 0.0381, when D = 0.75 ft. and V = 0.1 ft/sec when D = 2 ft. At the present time, the value of S is not available. However, we know the stage of S65D pool is about 27 feet msl and the U.S.G.S. map of Chandler Slough near downstream of the South bridge is 32 feet in elevation.[1] Therefore the difference in ground elevation is 5 feet over a length of 17,700 feet of marsh i.e., S = 0.000282. If the water surface elevation is used to calculate the slope S = 0.000332. Two more ranges of S = 0.000395 and S = 0.00005 are also used to investigate the n value variation with slope. The results of n related to flow depth in the four different slopes are shown in Figure 2. The results of n value used in conservation area by the Corps of Engineers, which were also used by Shih, Hamrick and Hallett (1974) in the Kissimmee Marsh Area, are also plotted on Figure 2. As can be seen from Figure 2, the slope is significantly affected by slope of ground. Comparing these results with the Corps of Engineers results, indicates that the shapes of n versus depth of flow is similar in both cases. The values are different in both cases because most data of Chandler Slough are obtained at the present time by estimation, thus more reliable data is required for this study. However, this study does imply that the velocity measurement is an applicable tool to calculate the Manning's n value.

1. Data provided by R. Taylor 12/3/74 provided msl elevation at 1301, 1302. This data confirms the estimates used. See page 9 in II.A.

DISCUSSION

The methods of water surface computation, vegetation investigation and velocity measurement will all be involved in this study to establish firmly the variation of n with depth, velocity and season. Two areas, Chandler Slough and Borney Marsh, will be used to establish the variation of n with depth for conditions of flow and vegetation. This information can then be applied in the analysis of flow in similar areas under the similar environmental conditions. Two cases of hydraulic radius determination will also be included in this study. Finally, a practical and applicable case will be recommended.

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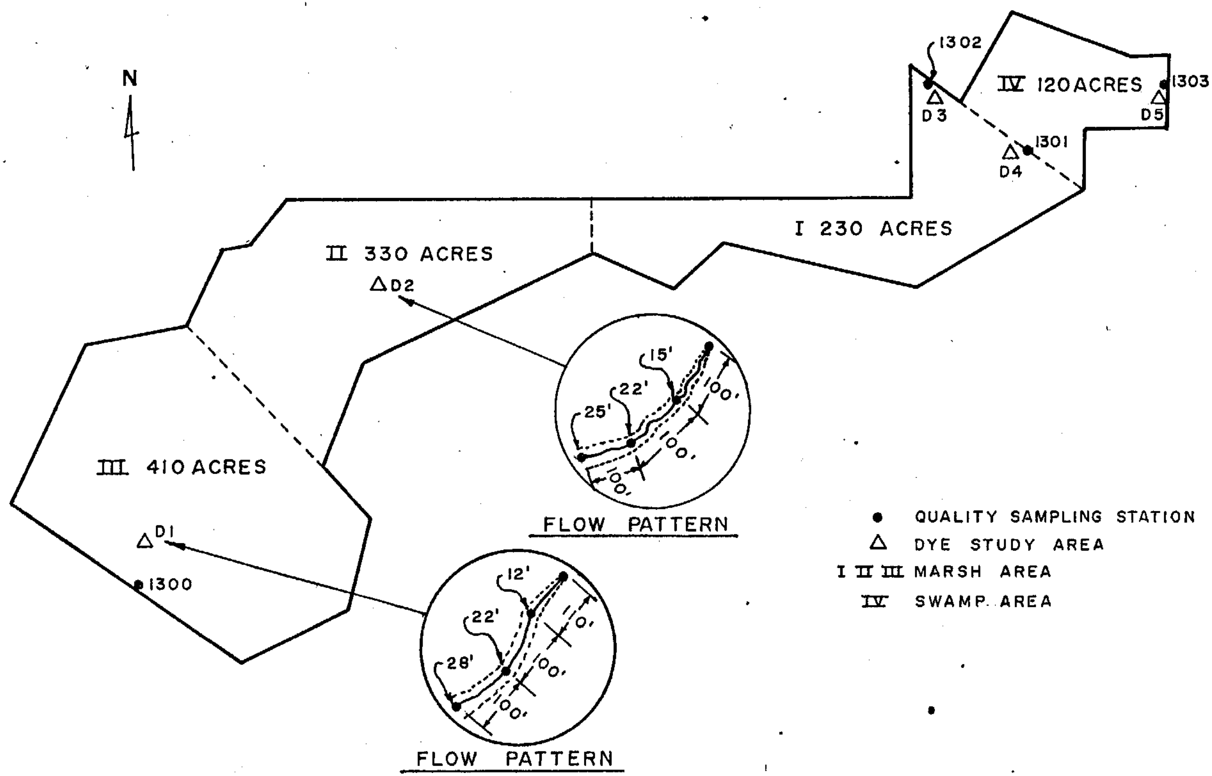
4. Sun-Fu Shih, D. W. Hallett and R. L. Hamrick, 1974. Analysis of Kissimmee River Flows for Water Quality Control. Proceedings of International Seminar Exposition on Water Resources Instrumentation, International Water Resources Association.



LAYOUT OF CHANDLER SLOUGH AREA

FIGURE 1

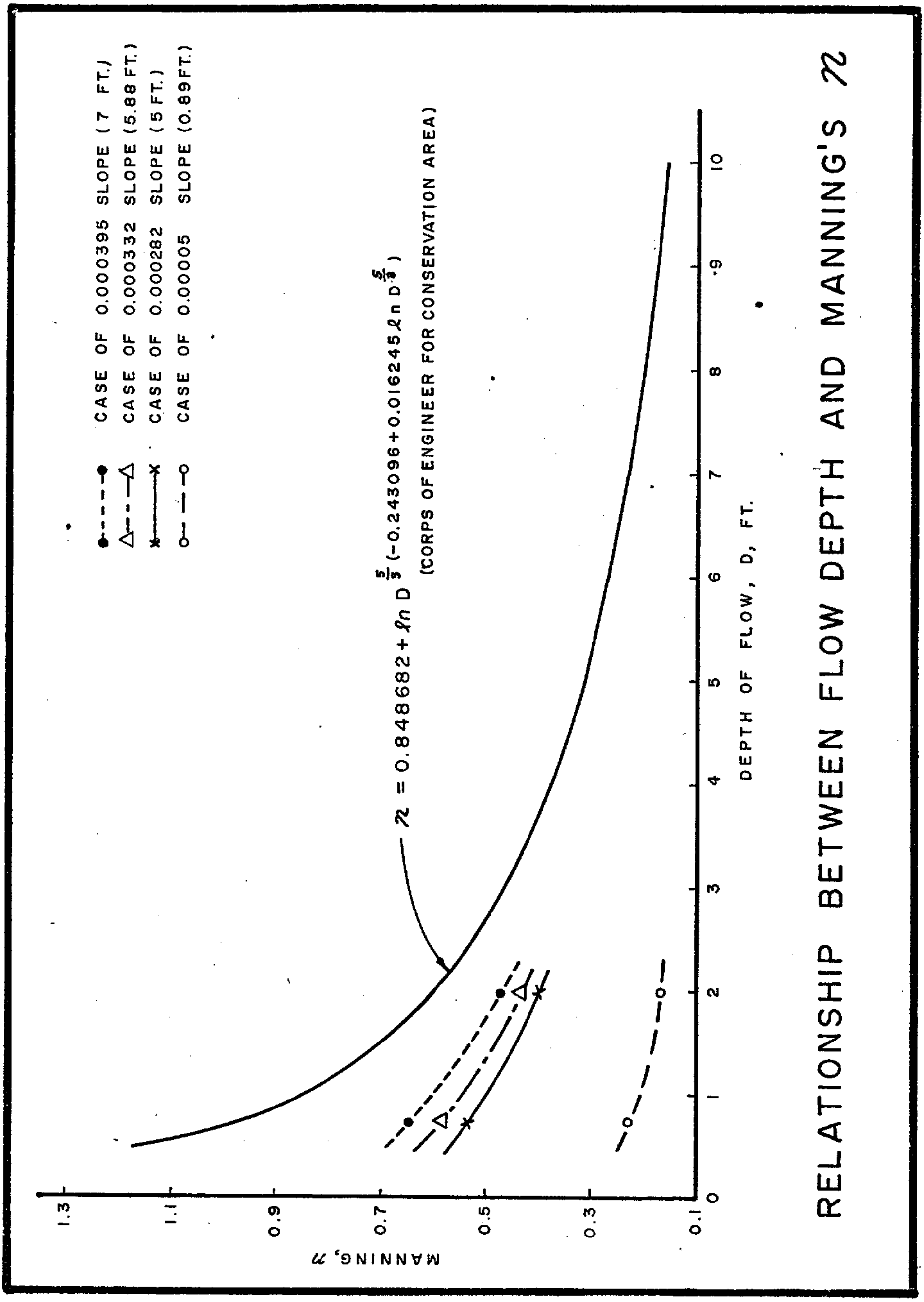

RELATIONSHIP BETWEEN FLOW DEPTH AND MANNING'S n
CASE OF 0.000395 SLOPE (7 FT.)
CASE OF 0.000332 SLOPE (5.88 FT.)
CASE OF 0.000282 SLOPE (5 FT.)
CASE OF 0.00005 SLOPE (0.89 FT.)
n = 0.848682 + ln D^(5/3) (−0.243096 + 0.016245 ln D^(5/3))
(CORPS OF ENGINEER FOR CONSERVATION AREA)
MANNING, n
DEPTH OF FLOW, D, FT.
0.1
0.3
0.5
0.7
0.9
1.1
1.3
0
1
2
3
4
5
6
7
8
9
10

FIGURE 2

File No. 9-5-11J

IMPACT OF UPLAND MARSH ON WATER QUALITY
IIC. QUALITY SAMPLING

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November, 1974

IMPACT OF UPLAND MARSH ON WATER QUALITY
IIC. QUALITY SAMPLING

SAMPLING PROGRAM

The second quality sampling program for the wet season was conducted September 16 through 20, 1974. Four sampling stations are shown in Figure 1. The water sampling programs at each of the stations is described briefly as follows:

Station 1300 - This station is located at the lower end of the marsh near an Oxbow in Pool D. The automatic sampler was set to collect water at one hour intervals with four samples accumulated in each bottle. The sampling period was started at 0800 September 18th and ended at 1600 September 20th. Fourteen separate water samples were analyzed. A temporary stage marker was placed in site to determine stage fluctuations at this location. The water level decreased 2 cm from September 18th to September 19th and an additional 6 cm by September 20th. The stage decrease over the sampling period was approximately .26 ft. The stage records of Pool D for September 18, 19 and 20 were 27.39 ft above msl, 27.39 and 27.13 respectively. The difference in stage for these three days was approximately 0.26 ft. which is consistent with the record of temporary stage at site 1300. This indicates that the outflow stream stage of Chandler Slough is a function of the stage of Pool D.

Station 1301 - This station is located at the South bridge crossing of U.S. 98 over Chandler Slough. The automatic sampler was set to collect samples at 1 hour intervals with 4 samples accumulated in one bottle. The sampling period was started at 0630 September 16th and ended at 1400 September 19th. Total number of bottles collected was 18.

Station 1302 - This station is located at the North Bridge cross of U.S. 98 over Chandler Slough. The automatic sampler was set for two hour intervals and two samples were accumulated in one bottle. The sampling period was started at 0630 September 16th and ended at 1000 September 18th. Total number of bottles collected was 13.

Station 1303 - This station is located approximately 8/10's of a mile east of site 1301. The automatic sampler was set to collect at one hour intervals with 4 samples accumulated in one bottle, thus reducing the number of individual analyses while obtaining an average for the 4 hours. The sampling period started at 0640 September 16th and ended at 0600 September 18th. Twelve samples were collected at this location.

RESULTS

The samples were analyzed for the following parameters: nitrate, nitrite, ammonia, ortho-phosphate, total phosphate, fluoride, silicate, laboratory pH and specific conductivity. A summary of the data is presented in Tables 1 through 4 and graphical presentation in Figures 2, 5 and 6. Two approaches are used in analyzing the data. The first evaluates the marsh and swamp impact upon water quality and the second evaluates water quality variations with time.

A. THE IMPACT ON WATER QUALITY OF THE SWAMP AND MARSH

In order to determine the amount of elements removed by the marsh and swamp an assessment of water loss was made because discharge measurements were made only at stations 1301 and 1302. The estimated ET is 0.15 inches per day. The total ET loss from the marsh was calculated to be 6 cfs and a negligible amount for the swamp. The 6 cfs ET loss was deducted from the final outflow of the marsh in determining elemental loads in the water coming out of the lower end of the marsh (Table 6).

The daily averages of the parameters studied are listed in Table 1-4. The water sampling was conducted over a several day period in an attempt to take into account the residence time of the water in the marsh and the swamp. Because of the internal mixing, a balance for conservative elements such as chloride was not obtained. Using the assumption that there had not been a large scale fluctuation in elemental concentrations prior to the sampling period, which would significantly alter the composition of the water detained in the marsh, an assessment of elemental loadings entering and leaving the marsh is made.

Phosphate

The mean concentration of all samples collected at 1303 for ortho-P and total P was 436 and 449 ppb respectively. At site 1301, 0.8 miles downstream the concentrations were reduced to 215 and 286 parts per billion P for ortho and total phosphate. A 51% reduction in ortho-P and a ~~48%~~ 36% reduction in total P occurred. Chloride for the same period shows a 4% increase in concentration. This data indicates a significant removal of ortho and total P from the water on the dates sampled for this section of swamp. An aerial survey of this area was used in evaluating the vegetation. Water hyacinths are the dominant plant growing among the cypress trees.

An evaluation of the removal of phosphate in the marsh area was made by making the inflow concentrations proportional to discharges at sites 1301 and 1302. Based on the proportion of flow through each bridge the weighted concentrations of ortho and total P at the marsh inflow site were 227 and 304 ppb respectively. The outflow concentrations determined at site 1300 were 100 and 138 ppb, ortho and total P. There was 56% and 55% reduction in concentrations.

Discussion of Phosphate Removal

The total amount of phosphate uptake in marsh and swamp is proportional to the amount of input. This may have two causes: First, the ortho-phosphate may be absorbed by marsh vegetations. Second, the particulate phosphate may be sedimented to the bottom of marsh and swamp. The sedimentary form of phosphate may revert to dissolved phosphate if the pH becomes very acid.

However, the pH data shown in Table 3 indicate that water in both swamp and marsh is only slightly acidic. Therefore, the sedimentary phosphate will either transpose to groundwater or settle on the sediment surface. The detail investigation of groundwater nutrient content and soil sampling of the study area should be done as soon as possible during this coming dry season. The portion of phosphate absorbed by plants also need to be studied during this coming dry season and wet season.

Table 6 presents the loadings in pounds per day which takes into account loss of water by ET. The rate of removal in pounds per acre per day is also tabulated. This rate of removal, approximately 0.5 lbs. per acre, per day in July /to 0.1 in September is only a preliminary indication of the marsh utilization of nutrients. A yearly evaluation of uptake will require data from additional sampling periods.

Marsh-Swamp Impact on N, SiO_2, Cl^- Specific Conductance

There was a 25% reduction in ammonia in both the swamp and marsh. Nitrate-nitrite, chloride and silicate show a reduction of 12 to 16%. This reduction may be a result of mixing with water in the marsh which has a lower concentration of these elements or may be due to actual removal by the marsh, though it is difficult to explain a mechanism for removing chloride from the water.

Specific conductance is a measure of the ability of a water to conduct an electrical current and is expressed in micromhos per centimeter at 25°C. Specific conductance is related to the type and concentration of ions in solution and can be used for approximately the dissolved-solids content of the water. Commonly, the concentration of dissolved solids in mg/l is about 65% of the specific conductance (in micromhos). This relation is not constant from area to area, and it may even vary in the same source with changes in the composition of the water. The specific conductance variation with time at the sampling stations is plotted in Figure 5. As can be seen from Figure 5, the conductance changes in the marsh area has less variation than other areas. This may imply that the marsh system is more uniformly mixed than other areas.

B. WATER QUALITY VARIATION WITH TIME

The ortho-phosphate and total phosphate concentrations are plotted versus time in Figure 2 for the stations sampled. The following observations are made:

Station 1303: The phosphate values at this location averaged 550 ppb, total P and 437 ppb ortho-P. Seventy-nine percent of the phosphorus was in an inorganic state, 21% was in the organic phase. Peak concentrations of total P were reached at 1800 and 2200 hours on two consecutive days. The ortho-phosphorus concentrations were erratic and did not show a daily cycle.

Station 1301: The P values at this station averaged 287 and 216 ppb, total and ortho-P respectively. Seventy-five percent of the phosphorus was inorganic and 25% organic. Peak concentrations of total P occurred at 2300, 1000 and 0600 hours with no peak values occurring on one of the four days of sampling. There is a slight indication of daily cycles being present for the ortho-P concentrations at this location. Peak values are obtained in the early morning hours on the days sample.

Station 1302: The P values at this station averaged 327 and 240 ppb total and ortho-P. Seventy-three percent of the phosphorus was inorganic and 27% organic. The data do not indicate a daily cycle for Total P, however, there is a slight indication again at this station of a daily cycle for the ortho-P with the peak concentration occurring in the early morning hours.

Station 1300: The P values at station 1300 at the downstream end of the marsh averaged 138 and 100 ppb total and ortho P. Seventy-two percent of the phosphorus was in the inorganic state and 28% organic at this site. A daily cycle is evident with peak concentrations of ortho-P occurring at about 0800 hours and low values at approximately 1600 hours. These results imply that the marsh system is mixed uniformly and the phosphate absorbed by the vegetation is proportional to the daily activity of photosynthesis.

The high and low concentrations of phosphate at stations 1301, 1302 and 1303 have a time lag as compared with station 1300. The reason seems to be that the plants upland of these stations are hyacinths and big cypress trees. The roots of hyacinths extend about 0.5 feet below the water surface. Between 0.5 feet and the ground, about 1.5 feet of water belongs to a diffusion and sedimentation zone. Below the ground surface is a root zone of cypress trees. The combination of these complicated zones may cause a time lag and an irregular fluctuation.

The shape of phosphate concentration curve in the 1300 station has less variation than that in stations 1301 and 1302. Similarly, 1301 station has less varitation than 1303 station. This result may imply that the marsh area has a better potential as a media to control quality than the swamp area.

Discussion of Ortho-Phosphate Total Phosphate Relationship

The percent inorganic P variation with time at four sampling stations is plotted in Figure 3. As can be seen from Figure 3, the following observations were made:

(1) The percent of inorganic P in the 1300 station is less than in the 1301 station. This implies that the vegetation growing in the marsh area absorbed more ortho-phosphate than that in the swamp area.

(2) In the marsh area, the time of highest percentage of inorganic P is at 1200 noon and lowest is at 1600. This implies that the time lag between photosynthetic action on leaves and phosphate absorption by roots was about 4 hours. The optimum time of growth may be at 1200 because the ratio after 1600 is rising again. The reason for

plant retardation may be due to the higher temperature in the afternoon (about 82° F) preventing growth. This will need to be evaluated next wet season by determining daily temperature curves. In the general case, the optimum temperature for plant growth is 72°F (Shih and Huang, 1971).

(3) In the swamp area, a plot of the ortho P/Total P versus time does not show the periodic variation that occurred in the marsh. This may be because the three zones introduced in the previous section which occur in a cypress and hyacinth system have a time lag between photosynthetic action on leaves and root absorption of phosphate.

The silicate concentrations for the samples collected are plotted in Figure 4. No cycles of a daily nature are evident in this graph. The plot of specific conductance in Figure 5 indicates a random variation and does not indicate a daily cycle. The nitrogen values are not plotted but a purusal of the information indicates a lack of any cyclical variation in concentrations.

SUMMARY

Based on this sampling study, the results indicate that the marsh and swamp have a high capability as a water quality control system. More detailed investigation and data collection should be done in this pilot area to obtain the following unknown parameters:

(1) This study showed that the marsh has a high capability to uptake the nutrient especially the phosphate. The phosphate sedimented on the ground whould be determined at different depths of soil in different pools to confirm or reject phosphate deposition in marsh and swamp.

(2) The nutrient absorbed by vegetation also need to be observed in different root depths to determine the function of plant-root

nutrient absorption.

(3) Groundwater quality model must be built up because the nutrient transposed under the ground is still unknown. (The Monte Carlo simulation model will be used).

(4) Finally, a mathematical model related to quality-quantity-land use will be built up in this pilot area from which the technique can also be used in other areas.

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Table 1. Orth-PO_4 and Total-PO_4 Data

Date	Orth-PO_4					Total-PO_4				
	1303	1301	1302	Weighted Input 1301 & 1302	1300	1303	1301	1302	Weighted Input 1301 & 1302	1300
9-16	0.457	0.242	0.245	0.243		0.558	0.341	0.346	0.344	
9-17	0.462	0.214	0.247	0.228		0.604	0.285	0.322	0.301	
9-18	0.390	0.202	0.235	0.216	0.094	0.486	0.267	0.313	0.287	0.133
9-19		0.203		0.219	0.101		0.253		0.283	0.139
9-20					0.104					0.142
Avg.	0.436	0.215	0.242	0.227	0.100	0.549	0.286	0.327	0.303	0.138

Table 2. NH_4 and NO_x

Date	NH_4,ppm					NO_x,ppm				
	1303	1301	1302	Weighted Input 1301 & 1302	1300	1303	1301	1302	Weighted Input 1301 & 1302	1300
9-16	0.033	0.023	0.040	0.031		0.033	0.017	0.019	0.018	
9-17	0.021	0.013	0.024	0.018		0.012	0.008	0.049	0.025	
9-18	0.022	0.012	0.010	0.011	0.020	0.011	0.016	0.011	0.014	0.063
9-19		0.029		0.027	0.022		0.105		0.071	0.021
9-20					0.010					0.000
Avg.	0.025	0.019	0.025	0.022	0.017	0.019	0.036	0.019	0.032	0.028

Table 3. pH and Chloride

Date	pH					Chloride, ppm				
	1303	1301	1302	Weighted Input 1301 & 1302	1300	1303	1301	1302	Weighted Input 1301 & 1302	1300
9-16	6.74	6.64	6.69	6.66		17.05	18.0	16.37	17.27	
9-17	6.70	6.49	6.79	6.62		19.53	19.35	18.73	19.08	
9-18	6.74	6.80	6.63	6.73	6.83	21.30	20.17	18.97	19.64	16.65
9-19		6.78		6.75	6.69		22.35		20.62	17.53
9-20					6.60					17.20
Avg.	6.73	6.68	6.70	6.69	6.71	19.29	19.97	18.02	19.15	19.13

Table 4. Silica and Specific Conductance

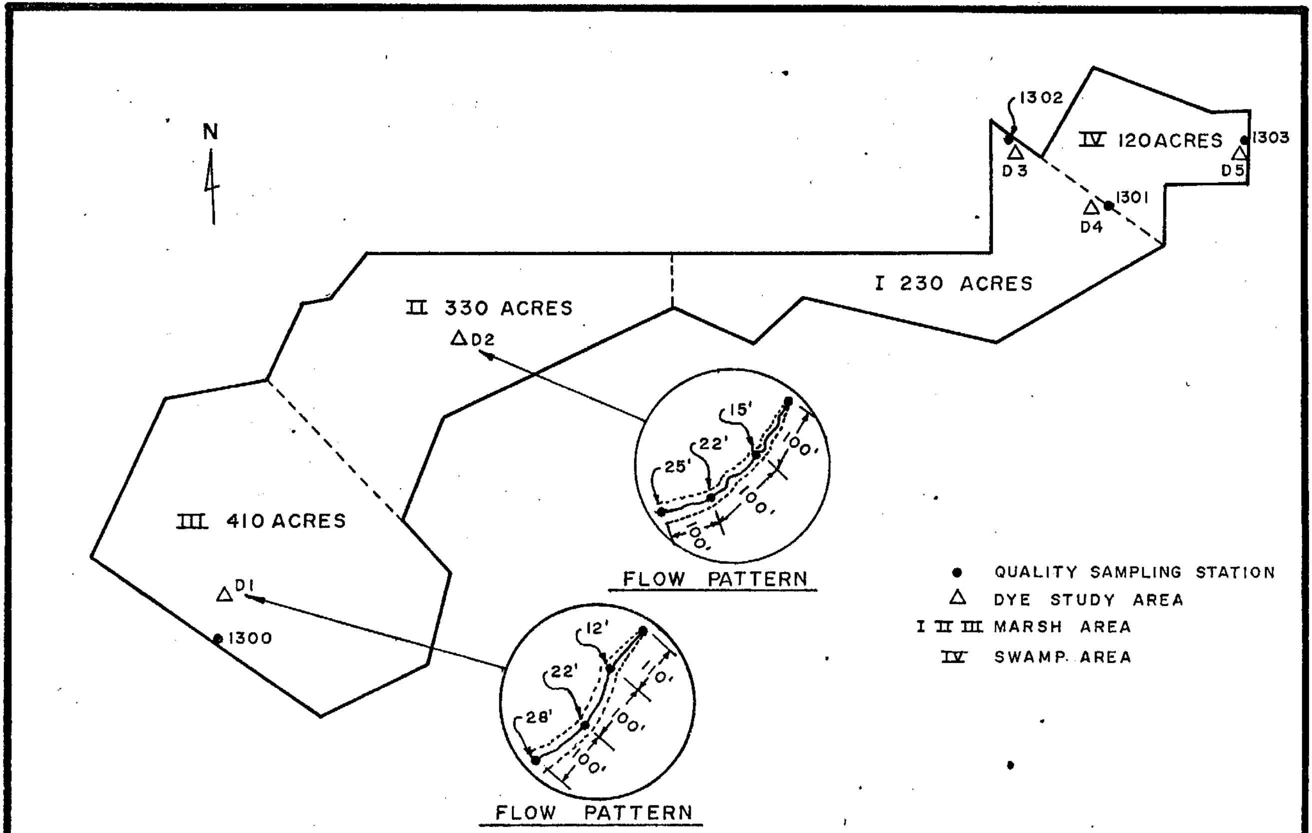
Date	S_iO_2, ppm					Specific Conductance				
	1303	1301	1302	Weighted Input 1301 & 1302	1300	1303	1301	1302	Weighted Input 1301 & 1302	1300
9-16	4.9	6.53	5.13	5.90		131	135	146	140	
9-17	4.9	6.28	5.23	5.83		136	137	149	142	
9-18	5.9	5.37	5.52	5.44	5.14	142	157	125	143	120
9-19		5.78		5.58	5.15		160	137	151	126
9-20					5.46					128
Avg.	5.3	6.0	5.3	5.7	5.3	136	147	139	144	125

Table 5. Analyses of Orth-PO_4 and Total-PO_4 Data

Items	Dates	A 1303	B 1301	C 1302	D 1301 & 1302	E 1300
Ratio of Orth-PO_4 (1) to Total-PO_4 (2)	9-16	0.8204	0.7086	0.7098	0.7082	
	9-17	0.7644	0.7509	0.7652	0.7574	
	9-18	0.8035	0.7567	0.7508	0.7547	0.7085
	9-19		0.8034		0.7742	0.7302
	9-20					0.7309
	Avg.	0.7948	0.7517	0.7405	0.7470	0.7233
Percentage of $\frac{(2) - (1)}{(2)}$	9-16	17.96	29.14	29.21	29.18	
	9-17	23.56	24.91	23.48	24.26	
	9-18	19.65	24.33	24.92	24.53	29.15
	9-19		19.66		22.58	26.98
	9-20					26.91
	Avg.	20.51	24.83	25.95	25.30	27.67
Org Phosphate (2) - (1)	9-16	0.1002	0.0996	0.1013	0.1004	
	9-17	0.1425	0.0710	0.0758	0.0731	
	9-18	0.0955	0.0650	0.0780	0.0705	0.0390
	9-19	0	0.0498		0.0639	0.0375
	9-20					0.0383
	Avg.	0.1127	0.0712	0.0850	0.0769	0.0383

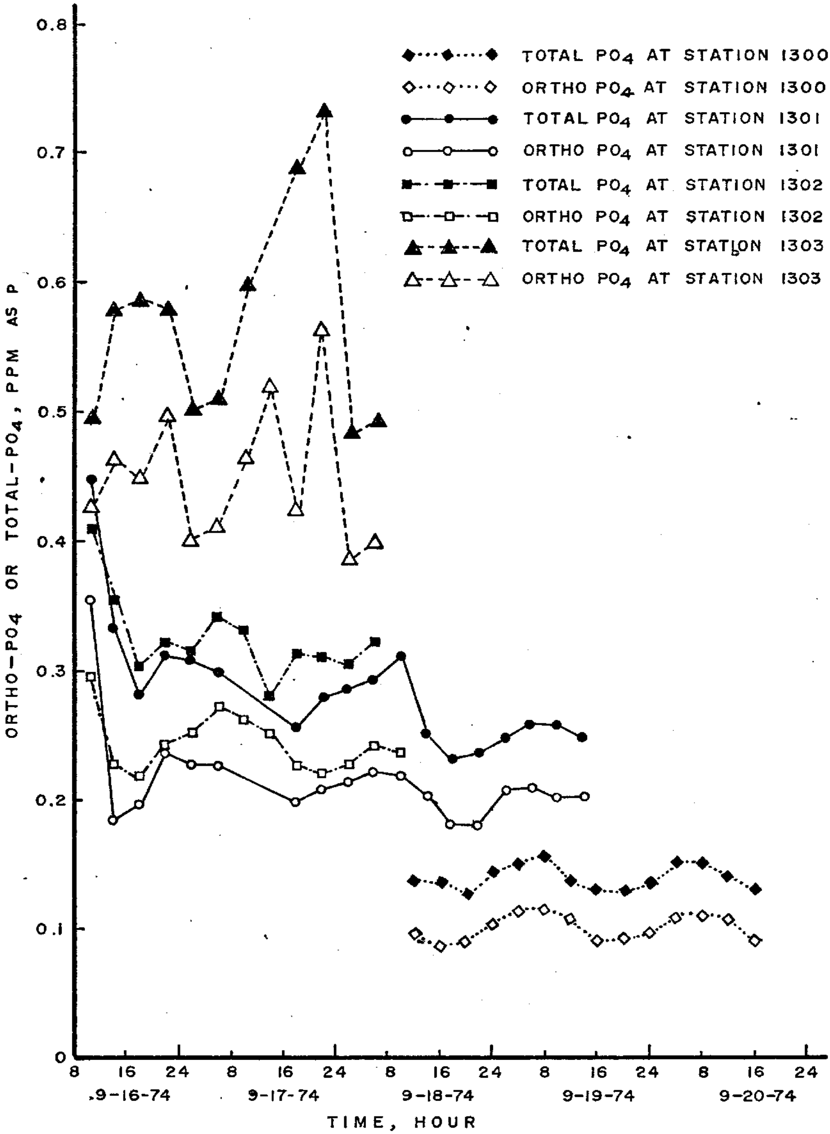
Table 6. Amount of Nutrient Uptake in Marsh and Swamp Areas.

Areas	Date	Water Quality Parameters	North Bridge #/day	South Bridge #/day	Upstream #/day	Down-Stream #/day	Uptake #day	% of Uptake	Uptake #/day/acr
		Station	1302	1301	Weighted 1302&1301	1300			
Marsh	Jul.. 23,24 & 25	Ortho-PO_4	368	783	1152	783	369	32	0.380
		Total-PO_4	407	932	1338	849	489	36	0.504
		Org-P	39	148	186	66	120	64	0.124
		NH_4	36	58	95	51	44	46	0.045
		TKN	1236	2061	3299	3082	215	6	0.222
		Org-N	1200	2003	3203	3031	171	5	0.176
		NO_2	4	7	11	8	2	21	0.002
		NO_3	14	11	24	8	15	64	0.015
	Sept. 16,17 18,19 & 20	Orth-PO_4	74	83	153	64	89	58	0.092
		Total-PO_4	99	110	204	88	110	56	0.120
		Org-P	26	27	52	24	27	52	0.028
		NH_4	8	7	15	11	4	25	0.004
		NO_x	6	14	22	18	4	16	0.004
		Chloride	5469	7666	12781	10959	1911	14	1.970
		S_iO_2	1605	2299	3824	3359	465	12	0.479
		Station			1303	1301			
Swamp	Sept. 16,17 18,19 &20	Orth-PO_4			168	83	85	51	0.708
		Total-PO_4			211	110	101	48	0.840
		Org-P			43	27	16	37	0.134
		NH_4			10	7	2	24	0.020
		NO_x			7	14	-	-	-
		Chloride			7404	7666	-	-	-
		S_iO_2			2026	2292	-	-	-



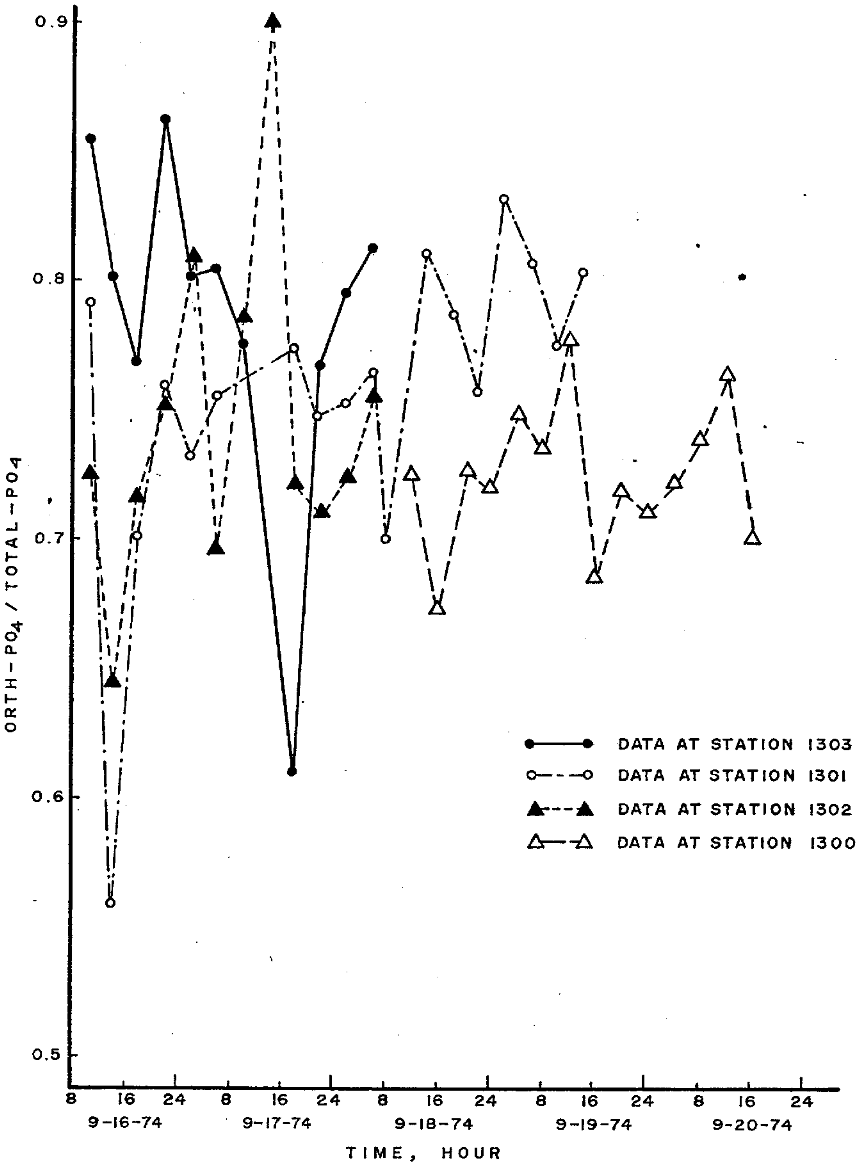
LAYOUT OF CHANDLER SLOUGH AREA

FIGURE 1



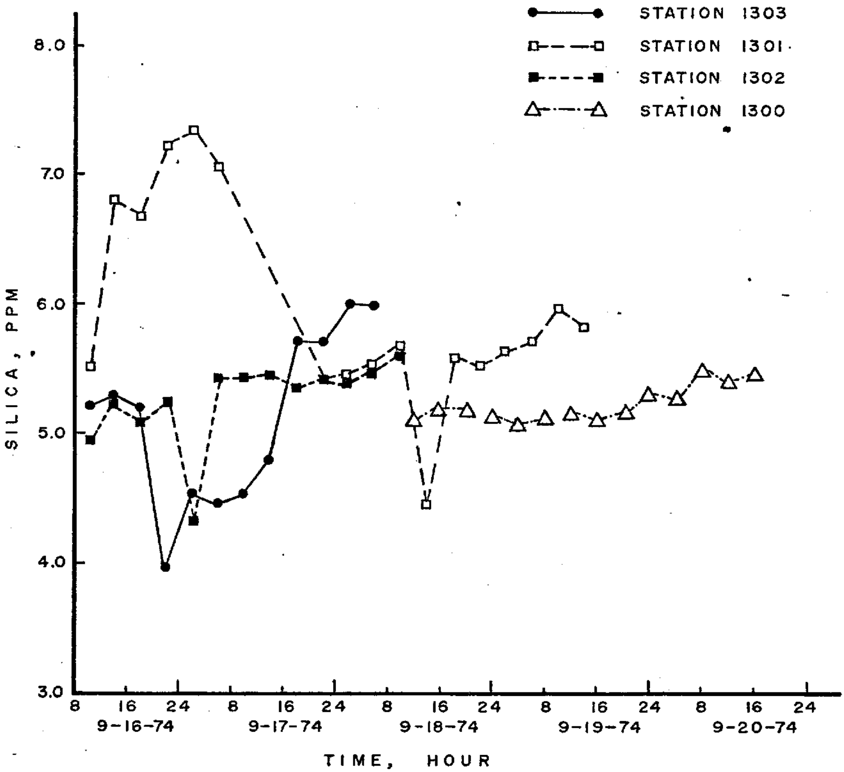
PHOSPHATE CHANGING WITH TIME

FIGURE 2



THE RATIO OF ORTH-PO_4 TO TOTAL-PO_4 CHANGING WITH TIME

FIGURE 3



SILICA CHANGING WITH TIME

FIGURE 4