GREEN BAY PILOT STUDY

GREEN BAY, WISCONSIN

Prepared by
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GREEN BAY PILOT STUDY

INTRODUCTION

The Green Bay area is one of eight sites in the Great Lakes selected by the U. S. Army Corps of Engineers for joint study with FWPCA of alternate procedures for the disposal of polluted dredging materials and the effects of these disposal techniques on water quality. This report covers the 1967 FWPCA sampling study in Green Bay.

As part of the pilot program, the channel from the C&NW Railroad Bridge to Long Tail Point was deepened under a contract that commenced on November 8, 1966 and was completed September 26, 1967. Under this contract, 632,000 cubic yards of dredgings were used (1) to fill a 380 acre diked land spoil site at Atkinson Marsh, and (2) to construct a dike inclosing a 230 acre bay spoil area adjoining the entrance channel in the bay, northeast of Grassy Island (see Figure 1). Material dredged from the Fox River channel by two clamshell dredges was placed in a temporary spoil area in the bay, then pumped to the land spoil area by a hydraulic dredge. The temporary spoil area consisted of a sump, 200 ft. by 750 ft., dredged to a depth of approximately 25 feet below the natural bottom of the bay. The hydraulic dredge, working in the channel from the mouth of the river to Grassy Island, pumped directly to the diked land spoil area. The dike in the bay was constructed by hydraulic dredge with material taken from the channel between Grassy Island and Long Tail Point.

1967 SAMPLING PROGRAM

Bottom sediments and water samples from the channel and sump area and water samples from the diked land spoil area were collected for the study. Water samples were also collected in the ditches on each side of

Tower Road, south of the diked land spoil area to determine if there was seepage through the dike. No samples were collected from the 230 acre diked area in the bay. Sampling points are shown in Figures 2 to 5.

CONCLUSIONS

1. Bottom sediments in the channel and sump have a high chemical oxygen demand and high concentration of oil and grease, total phosphorus, soluble phosphorus and total nitrogen.

2. Dredging operations in the sump area caused significant increase in conductivity, alkalinity, turbidity, total phosphorus, nitrogen and suspended solids, in the overlying water.

3. Turbidity and suspended solids were effectively reduced by detention in the land spoil area. Concentrations of other constituents in the overflow were generally equivalent to or higher than concentrations inside the spoil area, based on one set of comparative samples.

4. Based on the information available, it appears that there was very little seepage of pollutants through the dike inclosing the land spoil area.

CHRONOLOGY

April 13, 1967	Season's dredging operations started in the Fox River.
May 4, 1967	Dredging continues in the river. Nine bottom sediment samples collected, seven from the river and one each from the sump and a scow. Eight water samples collected from river and sump area.

May 18, 1967	Hydraulic dredge started operating in the sump area.
July 17, 1967	Dredging operations continue in the river and sump area. Six bottom sediment samples collected from the sump area.
July 18, 1967	Dredging operations continue on the river and sump area. Three water samples collected of overflow from the diked land spoil area.
July 31, 1967	Dredging operations continue in the river and in the channel north of Grassy Island. Two water samples collected from the overflow from the land spoil area.
August 3, 1967	Dredging operations in the river completed. Construction of dike in bay north of Grassy Island continues.
August 17, 1967	Seven water samples collected at the diked land spoil area, one from the outlet pipe, two from the land spoil area and four from two ditches south of the spoil area.
(2) September 29, 1967	All dredging operations completed for the season.
October 11, 1967	Nine water samples collected at the land spoil area, three from inside the dike and six in the two ditches south of the spoil area. There was no overflow from the area.

DISCUSSION OF DATA

Bottom Sediments. Figures 6 - 10 show graphically most of the data obtained from analyses of bottom sediments in the river and bay channel, the sump area in Green Bay and from one scow load of dredgings. This data has also been tabulated and is shown in Tables 1 and 3.

At River Mile (RM) 1, all the chemical and physical constituents in Figures 6 - 10, except total solids, are considerably lower than the concentrations shown at each River Mile immediately above and below this point. Although dredging operations started on April 13, 1967 in the vicinity of RM 1, the area was not sampled until May 4, 1967. It is apparent from the low concentrations shown that the sample at RM 1 was collected after the area had been dredged. Therefore, these data have been omitted from the following discussion.

(when compared to clean lake bottom sediment)

Bottom sediments in the channel have a high chemical oxygen demand and high concentrations of oil and grease, total phosphorus, soluble phosphorus and total nitrogen. The concentrations were generally highest up river at RM 3 and decreased fairly uniformly into the bay to Bay Mile (BM) 3.

The following is a summary of May 4, 1967 bottom sediment data for the river and bay channel: does not include (RM) 1

Parameter	Unit (Dry Weight)	Maximum	Minimum
Total Solids	% of sample	30.5	13.0
Volatile Solids	% of total solids	23.7	14.8
Oil and Grease	mg/k	46,200	4,600
Total Phosphorus-P	mg/k	6,500	2,683
Soluble Phosphorus-P	mg/k	138	18.6
Chemical Oxygen Demand	mg/k	300,000	179,000
Total Nitrogen	mg/k	10,130	4,950

Parameter	Unit (Dry Weight)	Maximum	Minimum
Nitrogen (NO_3)	mg/k	16.2	9.9
Nitrogen (NH_3)	mg/k	1,240	60
Organic Nitrogen	mg/k	9,450	4,020
Sulfide	mg/k	830	240
Phenols	micrograms/gram	7.8	0.75
Immediate Dissolved Oxygen Demand	mg/k	94,600	21,400

Bottom sediments were collected in the sump area in Green Bay on May 4, 1967 and again on July 17, 1967. River dredgings were deposited in the sump routinely after April 13, and the hydraulic dredge had operated intermittently in the sump after May 18. A comparison of the samples collected on May 4 and July 17 is presented below. As would be expected, the data are similar to those shown above for the river sediments. It should be noted that on July 17, only two samples were taken from within the sump area (see Figure 3), with two samples takenon either side. The data (Table 3) show higher values in the sump for only ammonia nitrogen and soluble phosphorus.

BOTTOM SEDIMENT DATA IN THE SUMP AREA

Parameter	Unit (Dry Weight)	May 4, 1967 (one sample)	July 17, 1967 (Average of 6 samples)
Total Solids	% of sample	41.3	29.1
Volatile Solids	% of total solids	13.4	15.3
Oil and Grease	mg/k	4,200	13,855
Total Phosphorus-P	mg/k	1,910	1,165
Soluble Phosphorus-P	mg/k	45	7.8
Chemical Oxygen Demand	mg/k	122,000	167,350
Total Nitrogen	mg/k	2,690	-

Parameter	Unit (Dry Weight)	May 4, 1967 (one sample)	July 17, 1967 (Average of 6 samples)
Nitrogen NO_3	mg/k	4.4	8.5
Nitrogen NH_3	mg/k	660	469
Organic Nitrogen	mg/k	2,350	3,526

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Water Quality. Figures 11-19 show graphically most of the data obtained from analyses of water samples collected from the river and bay channel, the sump in the bay and the diked land spoil area. This data is also tabulated and is shown in Tables 2 and 4-6.

Water Quality in the Sump Area. On May 4, 1967, water samples were collected in the river and at the sump area. Analyses of these samples, Table 2 and Figures 11-19 shows that water quality in the sump area after the disposal of dredging materials was much worse than water quality in the river or bay channel. The dredging operation had a noticeable effect on conductivity, alkalinity, turbidity, total phosphorus, nitrogen and suspended solids; all increased significantly as might be expected. There was a particularly significant increase in ammonia and total nitrogen which is to be expected when waters are first contaminated by organic matter in an anaerobic state.

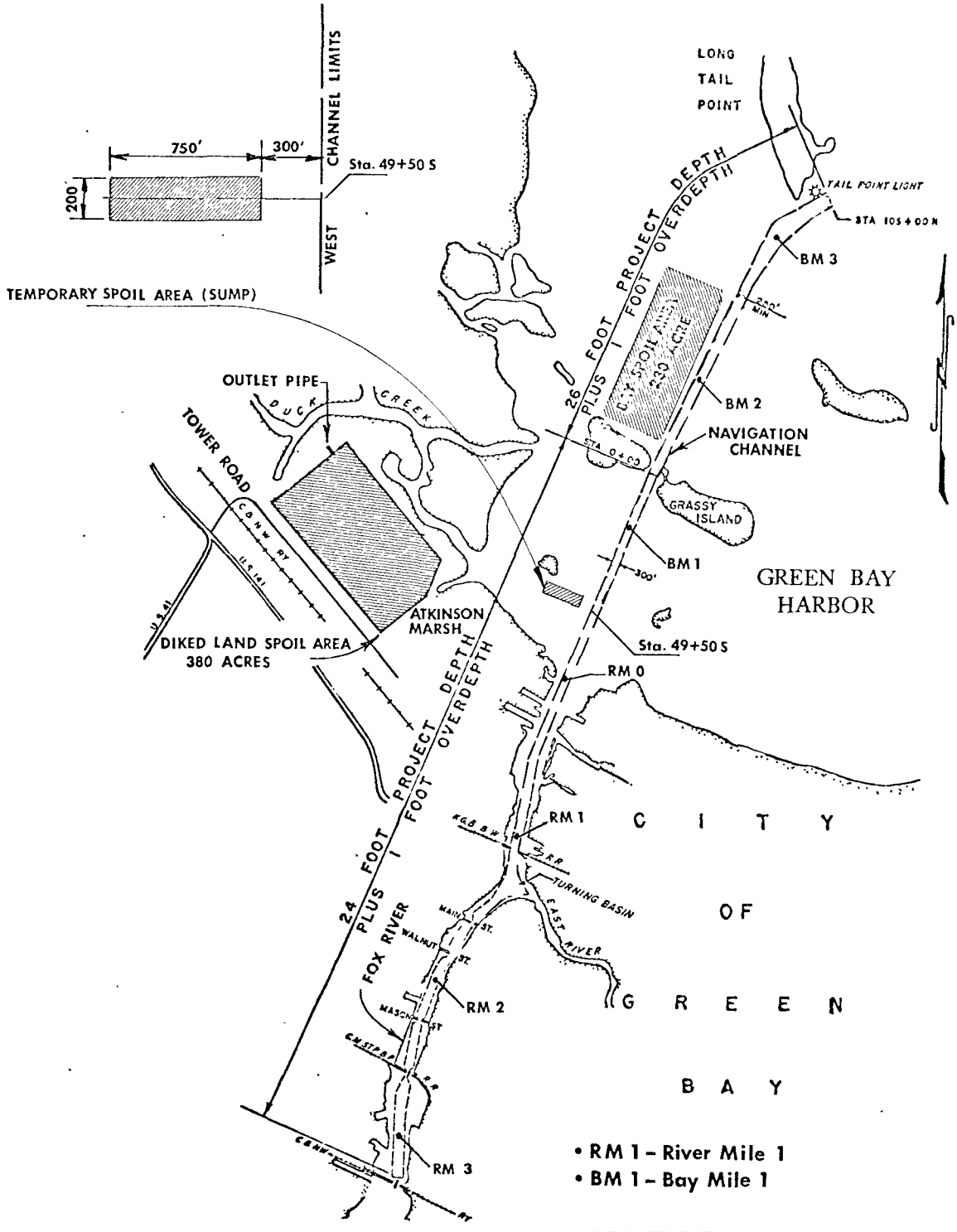
Water Quality in the Land Spoil Area. Water samples were collected at the land spoil area to determine the effectiveness of the dike to retain the various chemical and physical constituents in the dredging materials placed in the spoil area by the hydraulic dredge. Water samples were collected on July 17, 18 and 31 and on August 1 and 17, 1967. Analyses

of these samples (Figures 11-19 and Tables 2 and 4-6) shows a considerable variation of effects on the quality of water discharging from the dike through the outlet pipe. The data collected on August 17, 1967 which compares water quality inside the diked area, at the overflow pipe, and in the ditches illustrates the effectiveness of the dike to retain the various constituents of the bottom sediments. A comparison of concentrations inside the dike to those flowing through the outlet pipe are summarized below:

Parameter	Units	Inside Dike at 2 points	Outlet Pipe
Turbidity	APHA	24 - 10.0	9.0
Total Phosphorus-P	mg/l	0.59 - 0.28	0.72
Soluble Phosphorus-P	mg/l	0.18 - 0.12	0.18
Nitrogen NO_3	mg/l	2.9 - 2.1	1.9
Nitrogen NH_3	mg/l	5.8 - 4.7	6.9
Nitrogen, Organic	mg/l	4.2 - 3.6	6.1
Dissolved Solids	mg/l	386 - 420	406
Suspended Solids	mg/l	117 - 38	92
Chemical Oxygen Demand	mg/l	98 - 78	107

The above data shows that only turbidity was effectively controlled by the dike and that some of the chemical constituents of the dredgings such as total phosphorus, ammonia nitrogen, organic nitrogen and chemical oxygen demand were higher at the outlet pipe than inside the dike. A comparison of chemical and physical concentrations inside the dike with those in the ditches on each side of Tower Road for August 17, 1967, show

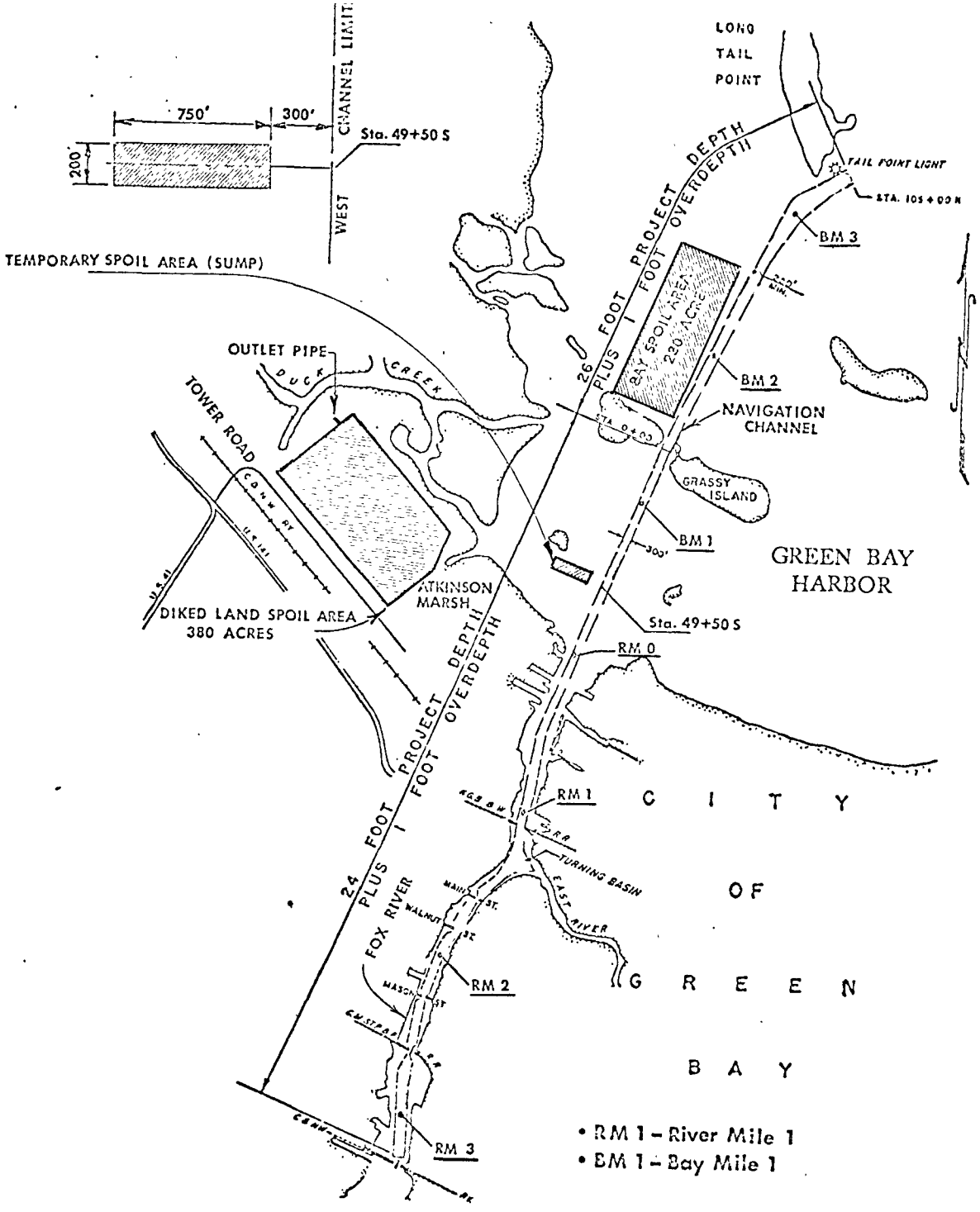
that with the exception of dissolved solids, the concentrations inside the dike were considerably higher than those in the ditches, indicating very little seepage of constituents through the dike. On October 11, 1967, 9 samples were collected both inside and outside the diked area (Figure 5). The analytical results are shown in Table 6. Excluding the results from sampling station number 6, the phosphorus and nitrogen levels, suspended solids and turbidity are all generally higher inside the diked area which indicates again the effectiveness of the dike in limiting seepage through the dike.



GREEN BAY HARBOR

STUDY AREA

FIGURE 1



Sample No.	Location	Analysis
1	RM 3	Sed. - Water
2	RM 2	Sed. - Water
3	RM 1	Sed. - Water
4	RM 0	Sed. - Water
5	BM 1	Sed. - Water
6	BM 2	Sed. - Water
7	BM 3	Sed. - Water
8	Sump	Sed. - Water
9	Scow in River	Sed.

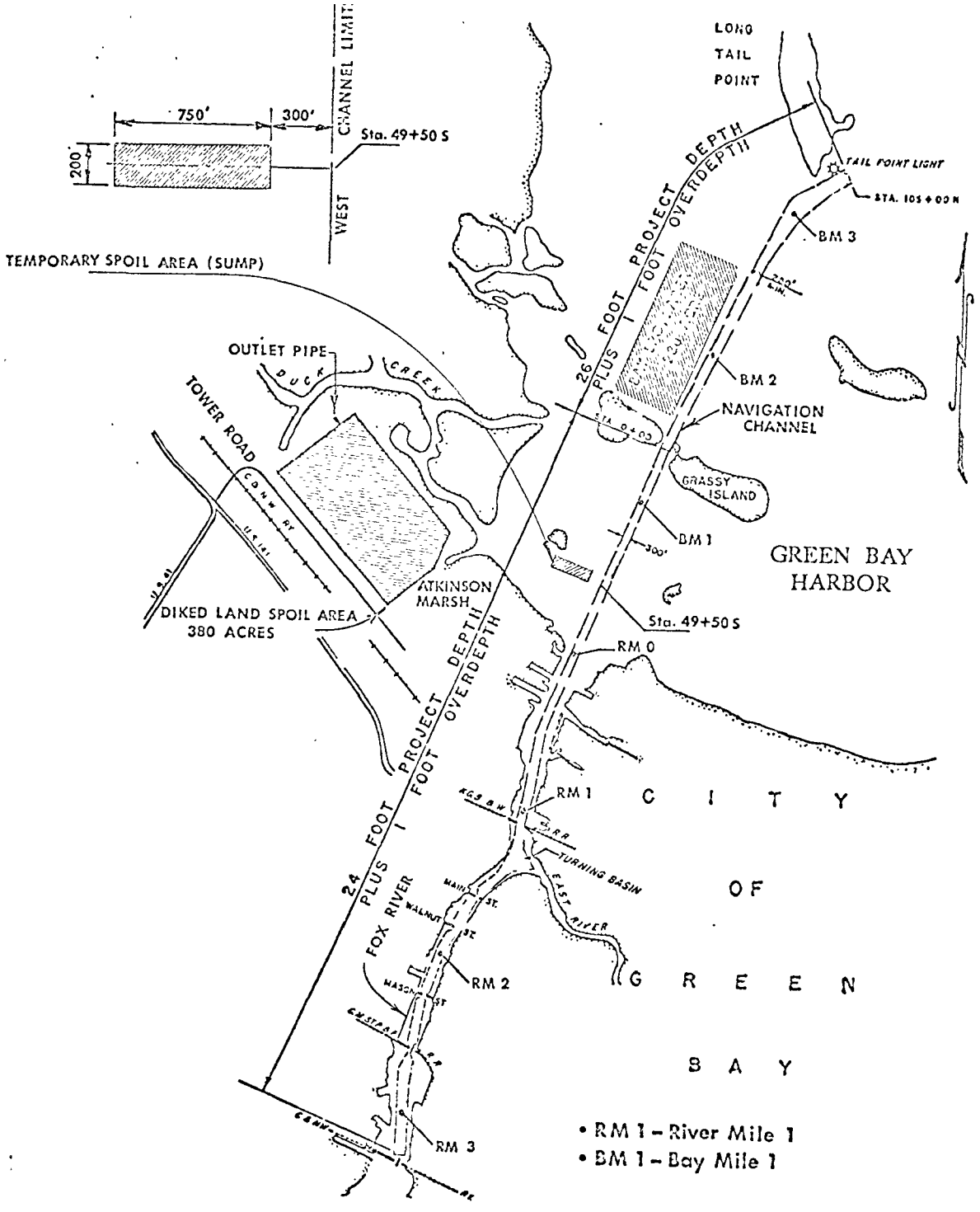
GREEN BAY HARBOR

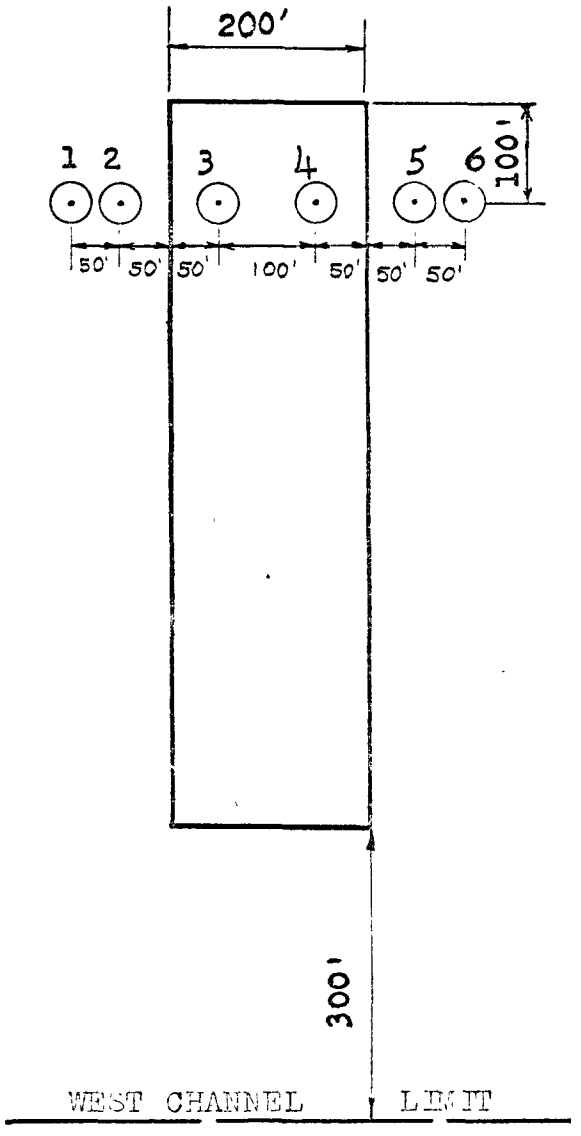
SAMPLING LOCATIONS

Bottom Sediments & Water

May 4, 1967

FIGURE 2



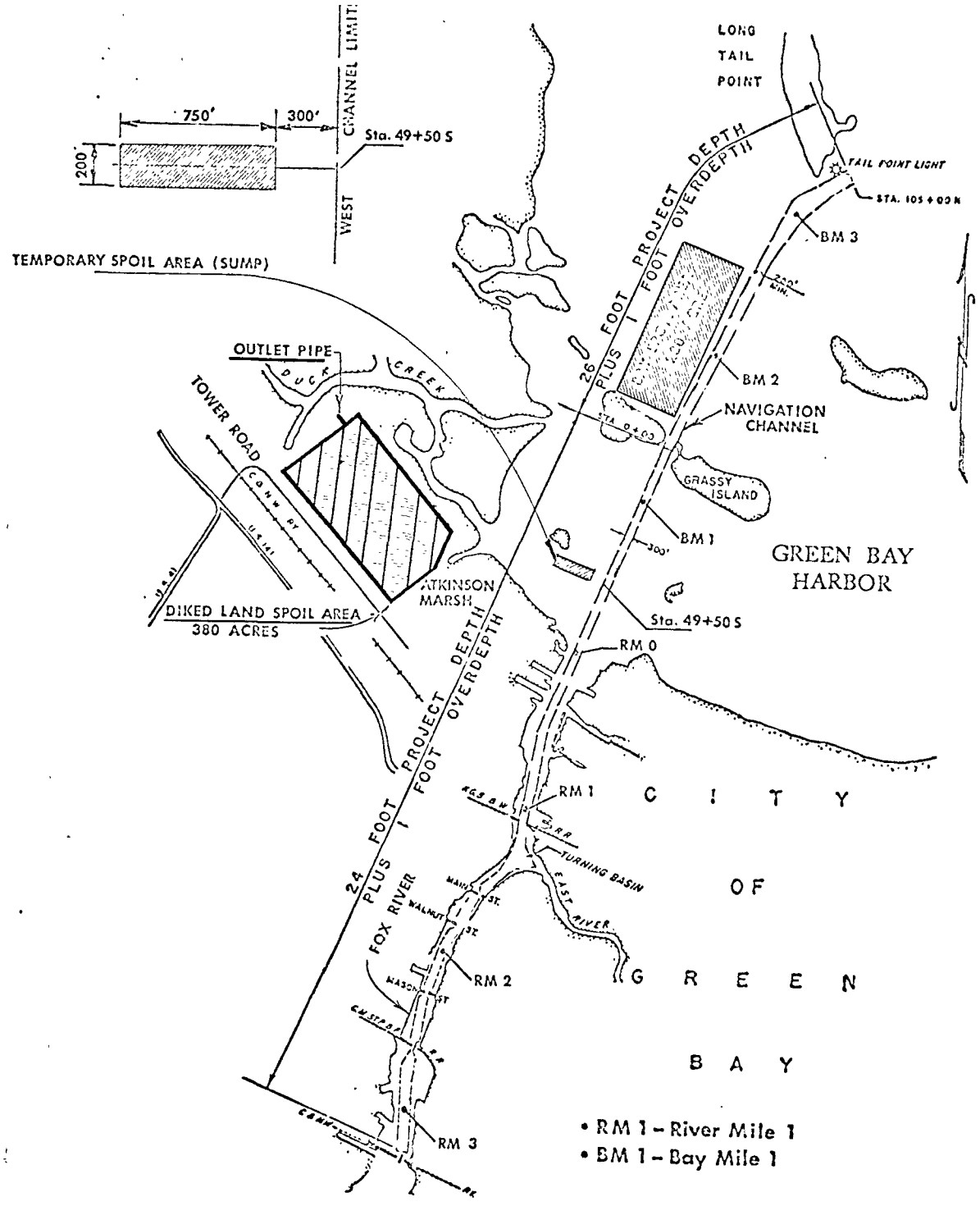


SUMP

GREEN BAY HARBOR

SAMPLING LOCATION
SUMP BOTTOM SEDIMENTS
JULY 17, 1967

FIGURE 3



OUTLET PIPE

July 17-18, 1967

Sample No.	Date	Time
1	Jul 17	9:15 AM
2	Jul 17	3:00 PM
3	Jul 18	8:00 AM

JULY 31-AUGUST 1, 1967

Sample No.	Date	Time
1	Jul 31	7:00 AM
2	Aug 1	8:00 AM

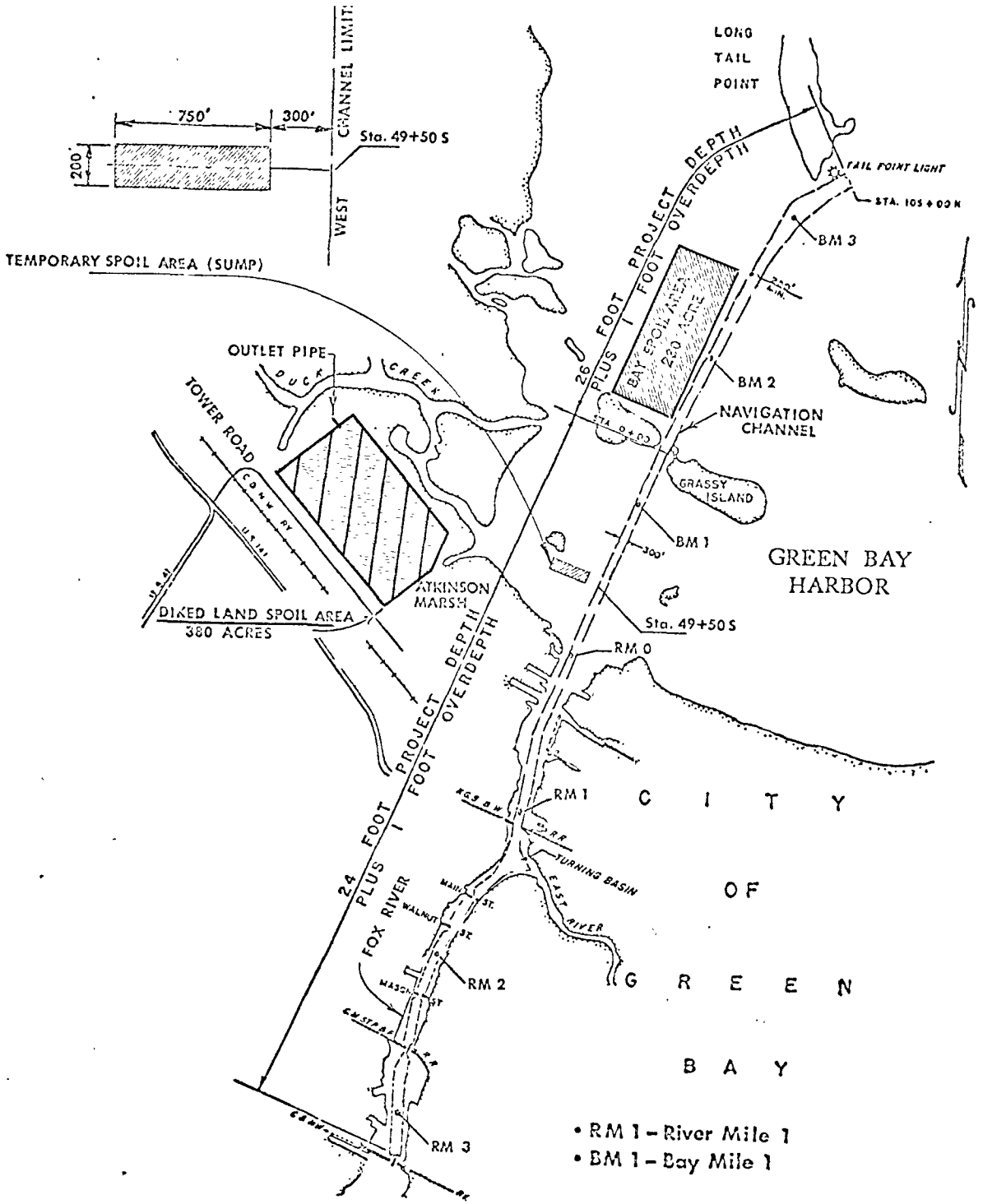
GREEN BAY HARBOR

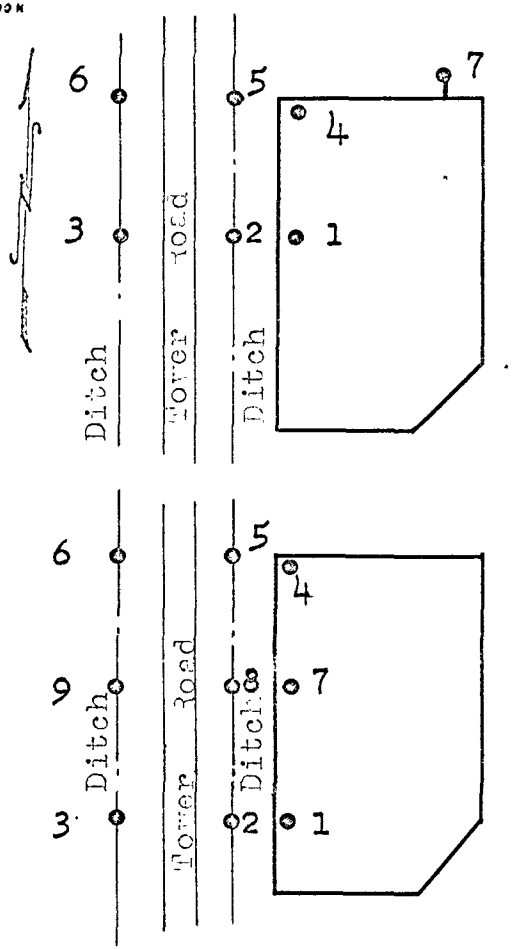
SAMPLING LOCATIONS

WATER, OUTLET PIPE

DIKED LAND SPOIL AREA

FIGURE 4



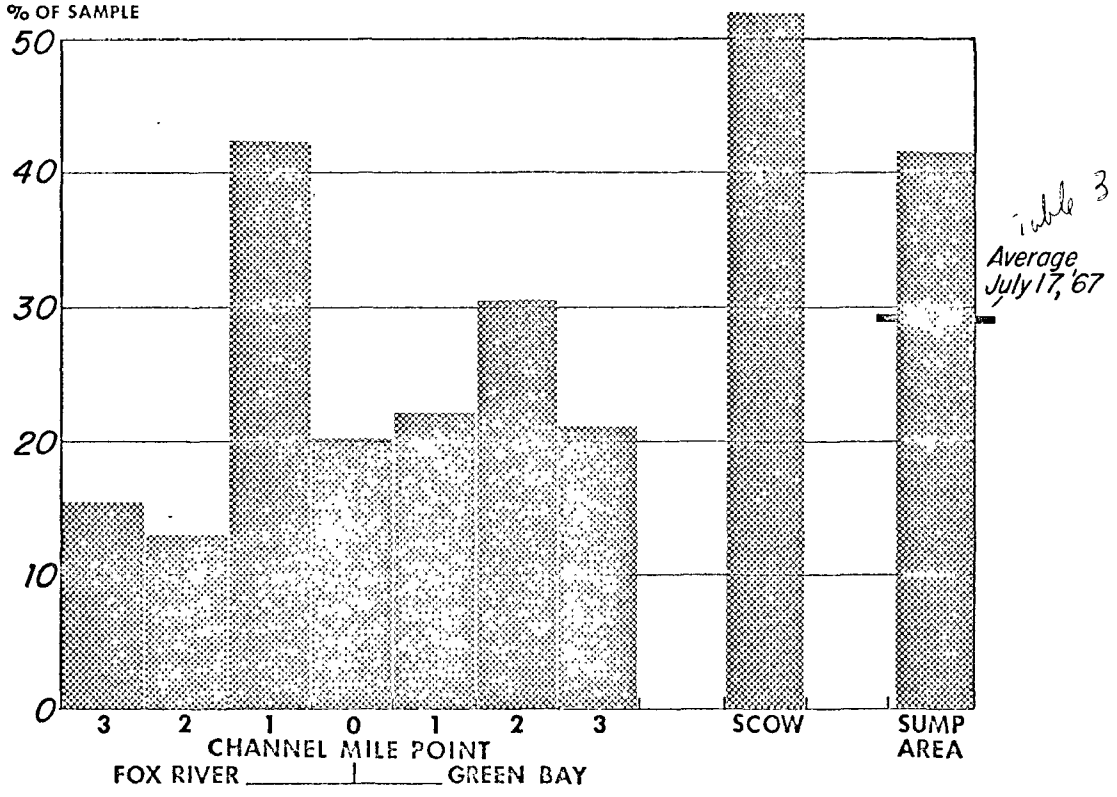


GREEN BAY HARBOR
SAMPLING LOCATIONS
WATER
DIKED LAND SPOIL AREA

FIGURE 5

FOX RIVER-GREEN BAY SEDIMENT DATA, May 4, 1967

TOTAL SOLIDS



VOLATILE SOLIDS

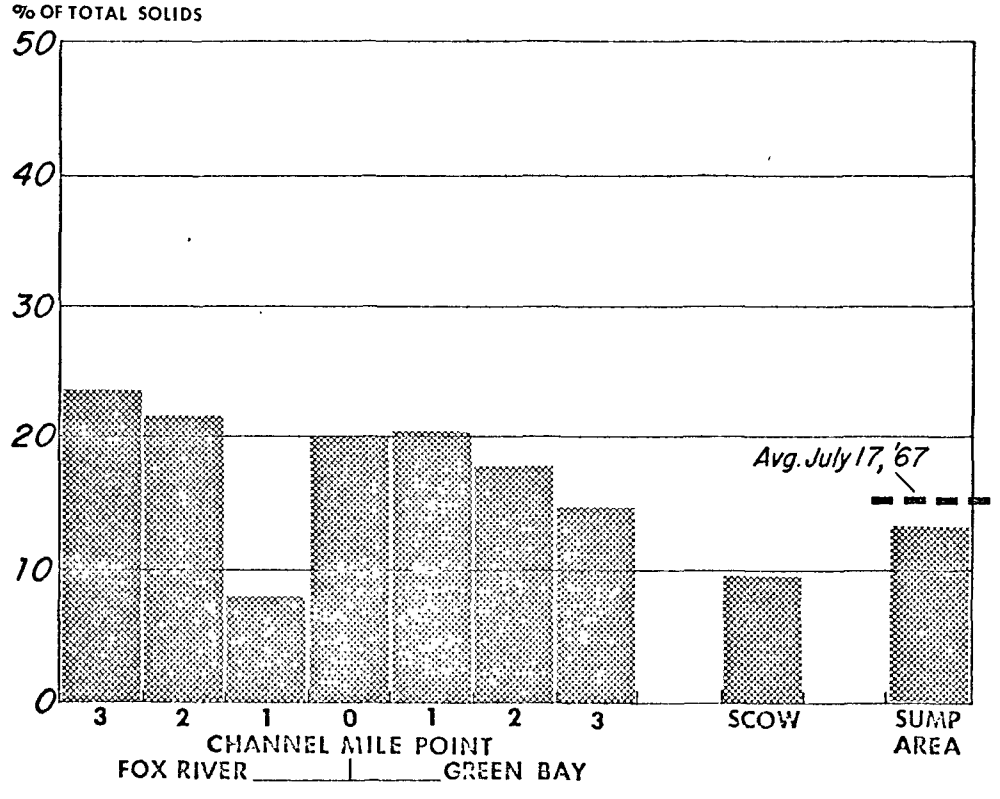
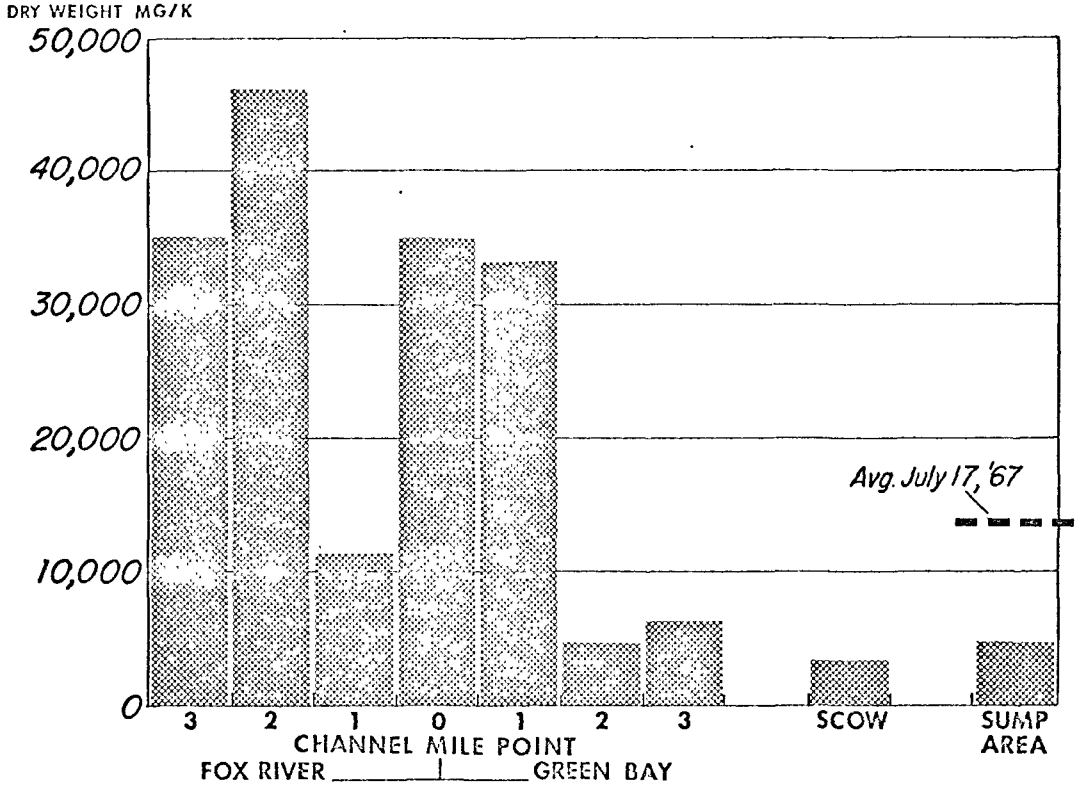


FIGURE 6

FOX RIVER-GREEN BAY SEDIMENT DATA, May 4, 1967

OIL & GREASE



TOTAL PHOSPHORUS - P

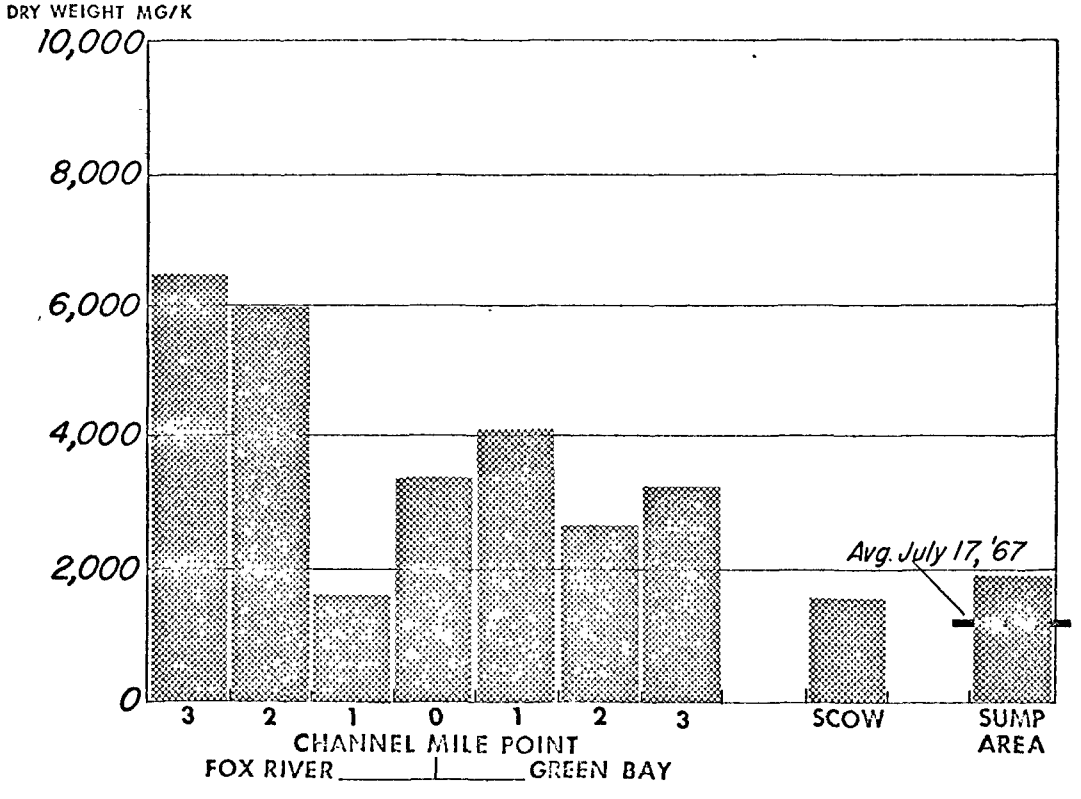
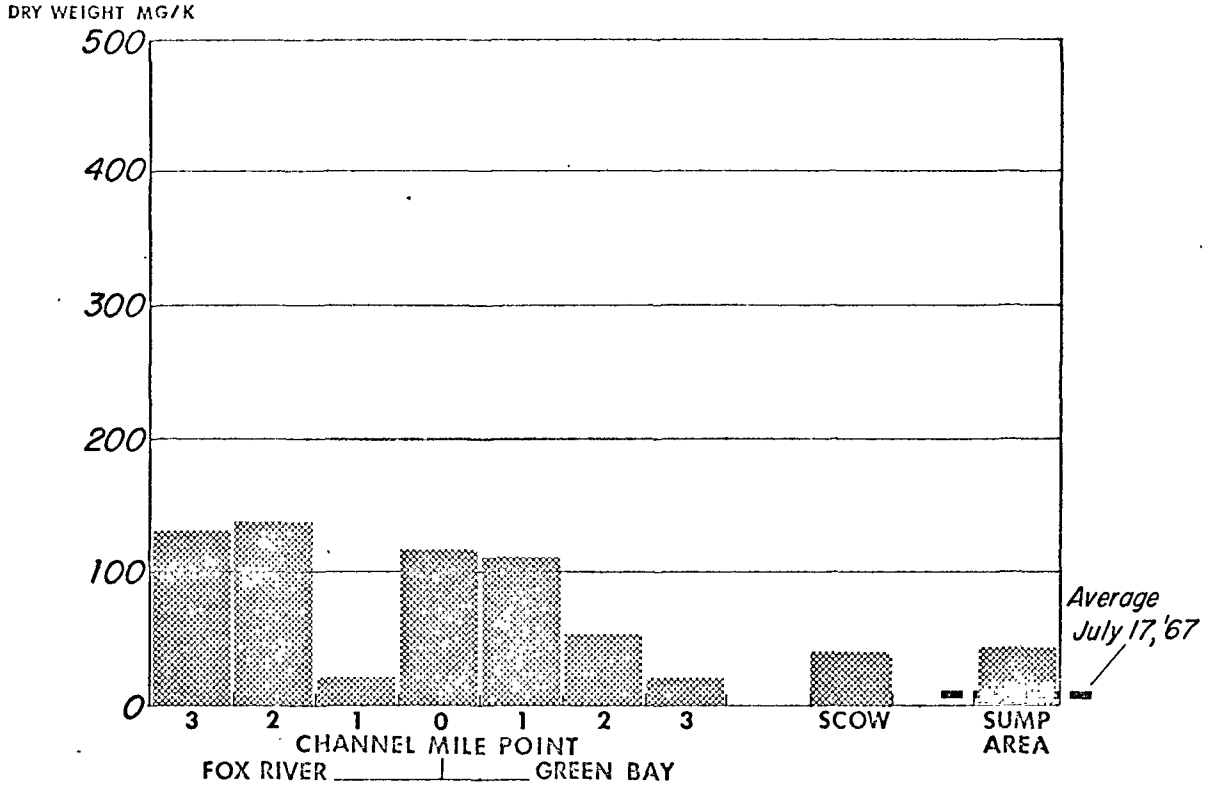


FIGURE 7

FOX RIVER-GREEN BAY SEDIMENT DATA, May 4, 1967

SOLUBLE PHOSPHORUS-P



CHEMICAL OXYGEN DEMAND

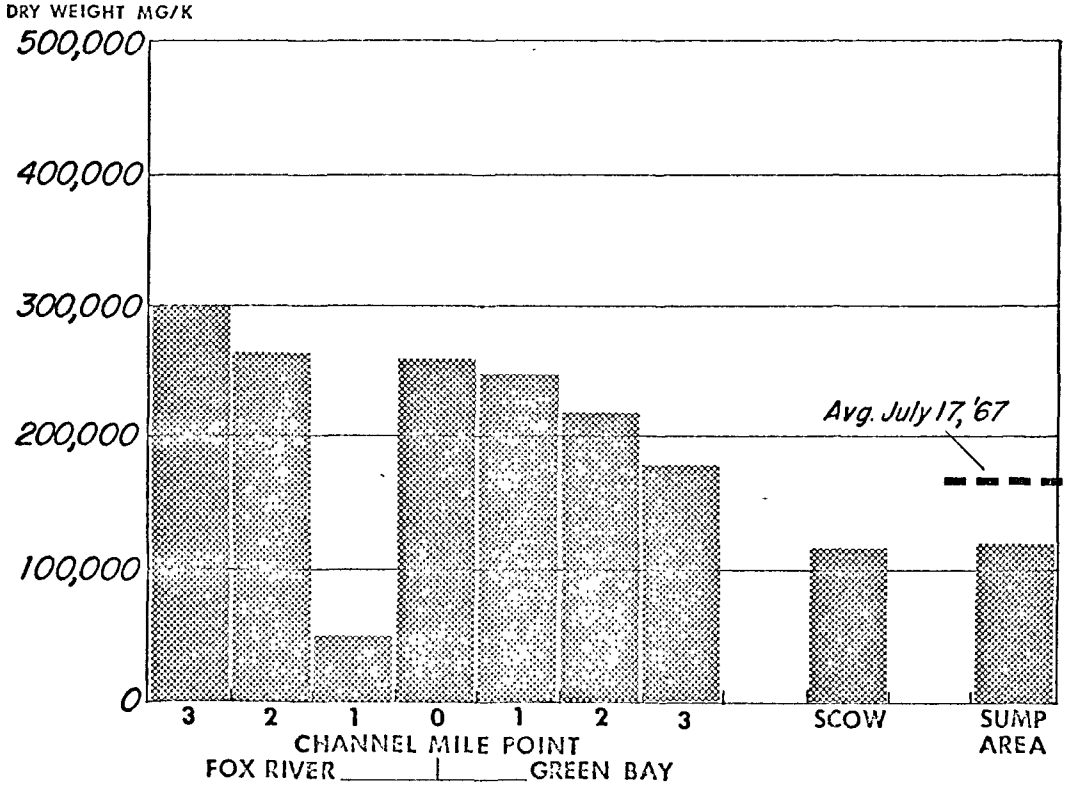
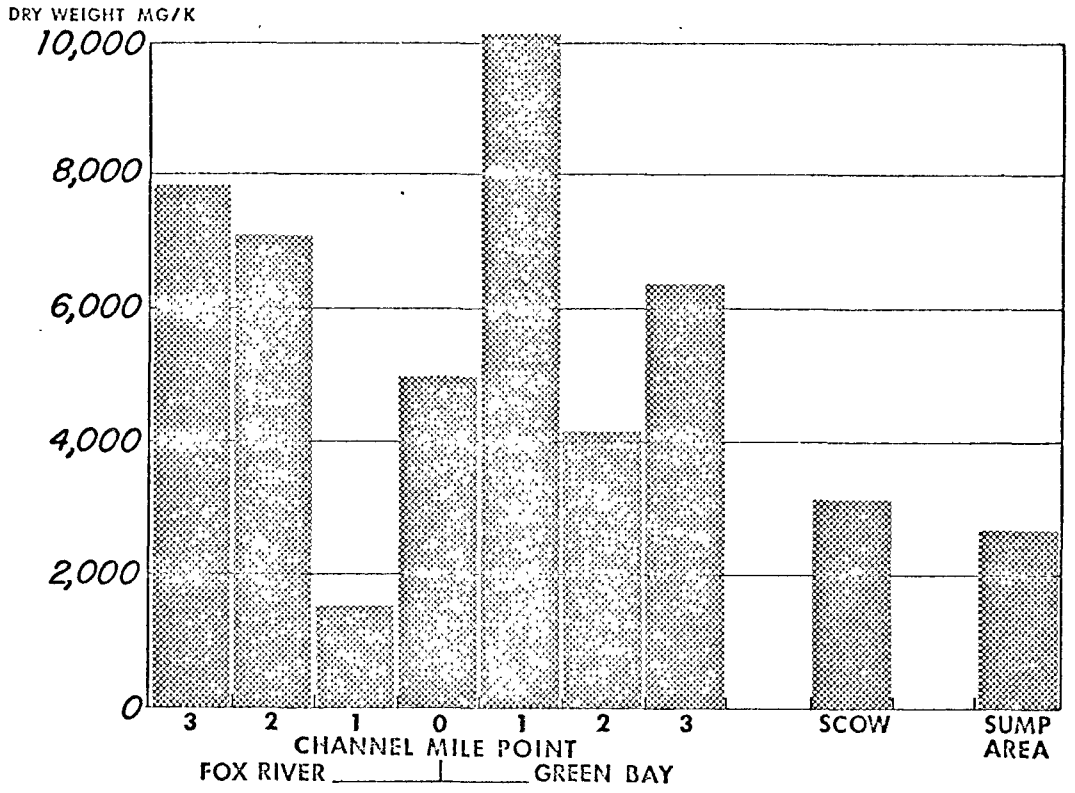


FIGURE 8

FOX RIVER-GREEN BAY SEDIMENT DATA, May 4, 1967

TOTAL NITROGEN



NITROGEN (NO_3)

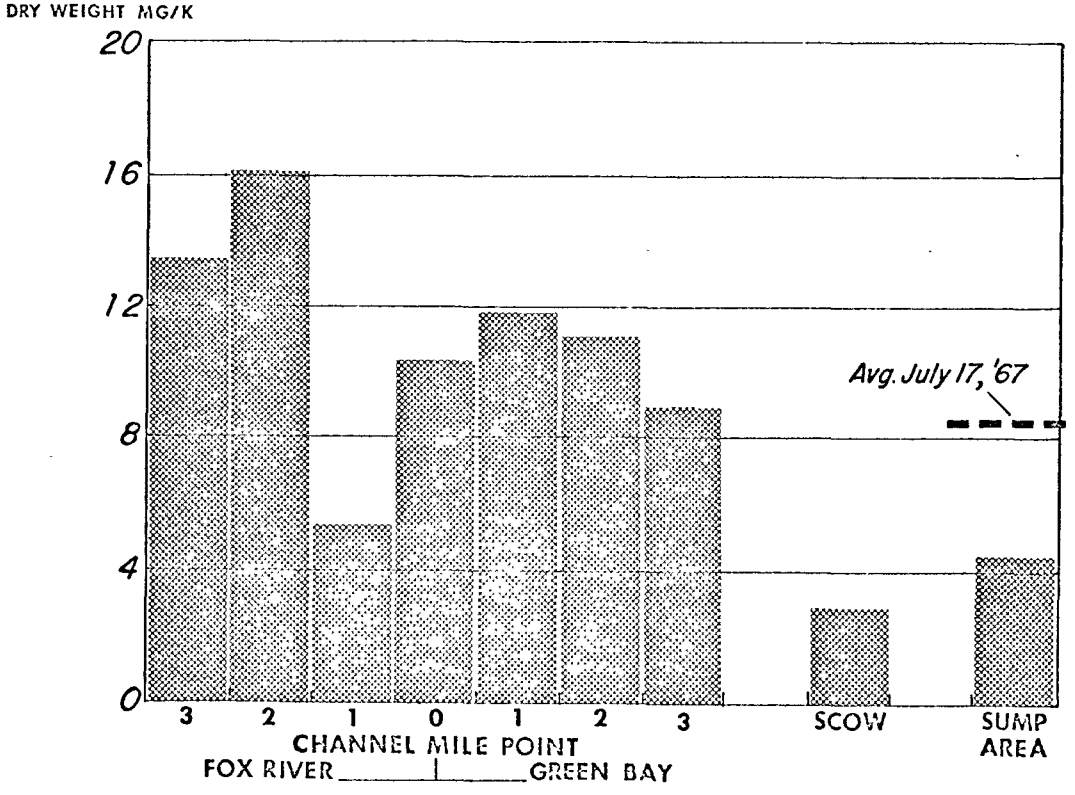
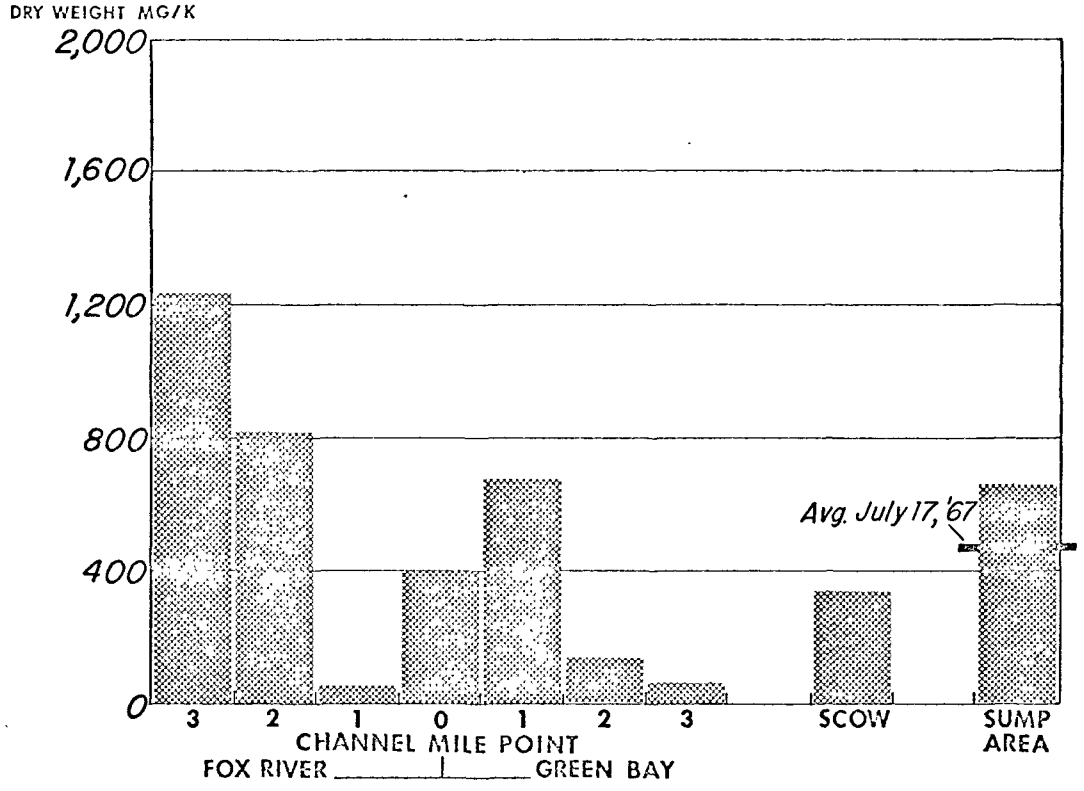


FIGURE 9

FOX RIVER-GREEN BAY SEDIMENT DATA, May 4, 1967

NITROGEN (NH_3)



ORGANIC NITROGEN

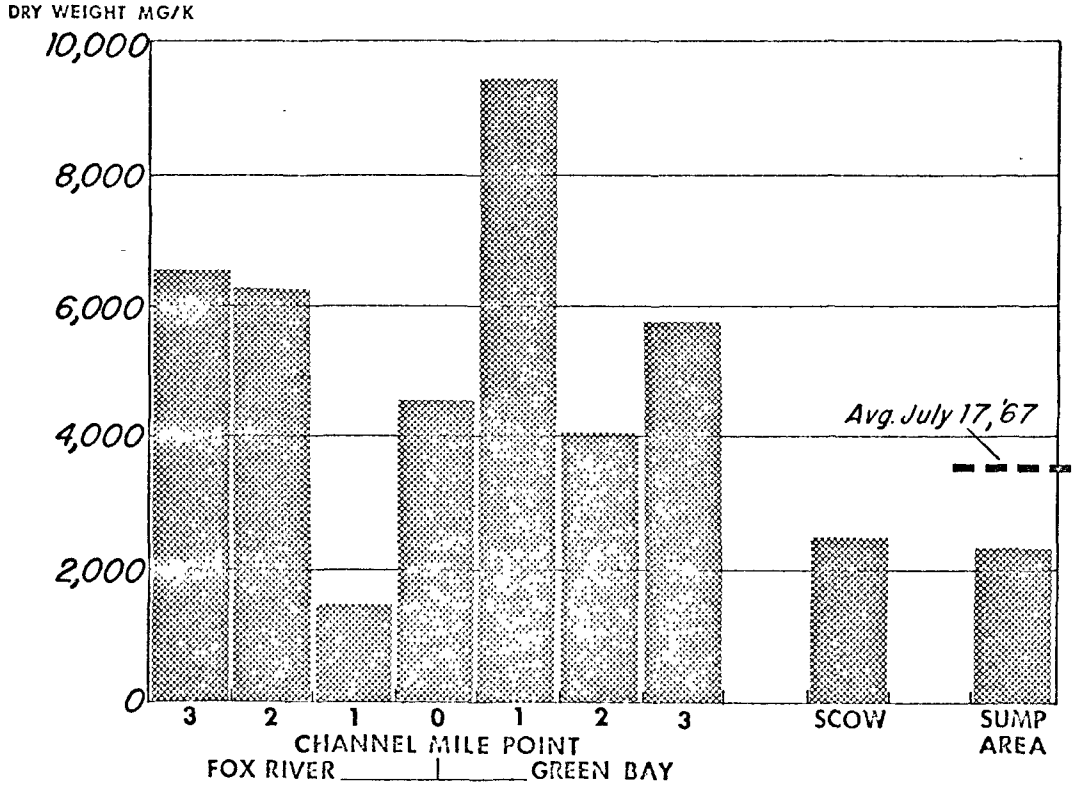


FIGURE 10

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA

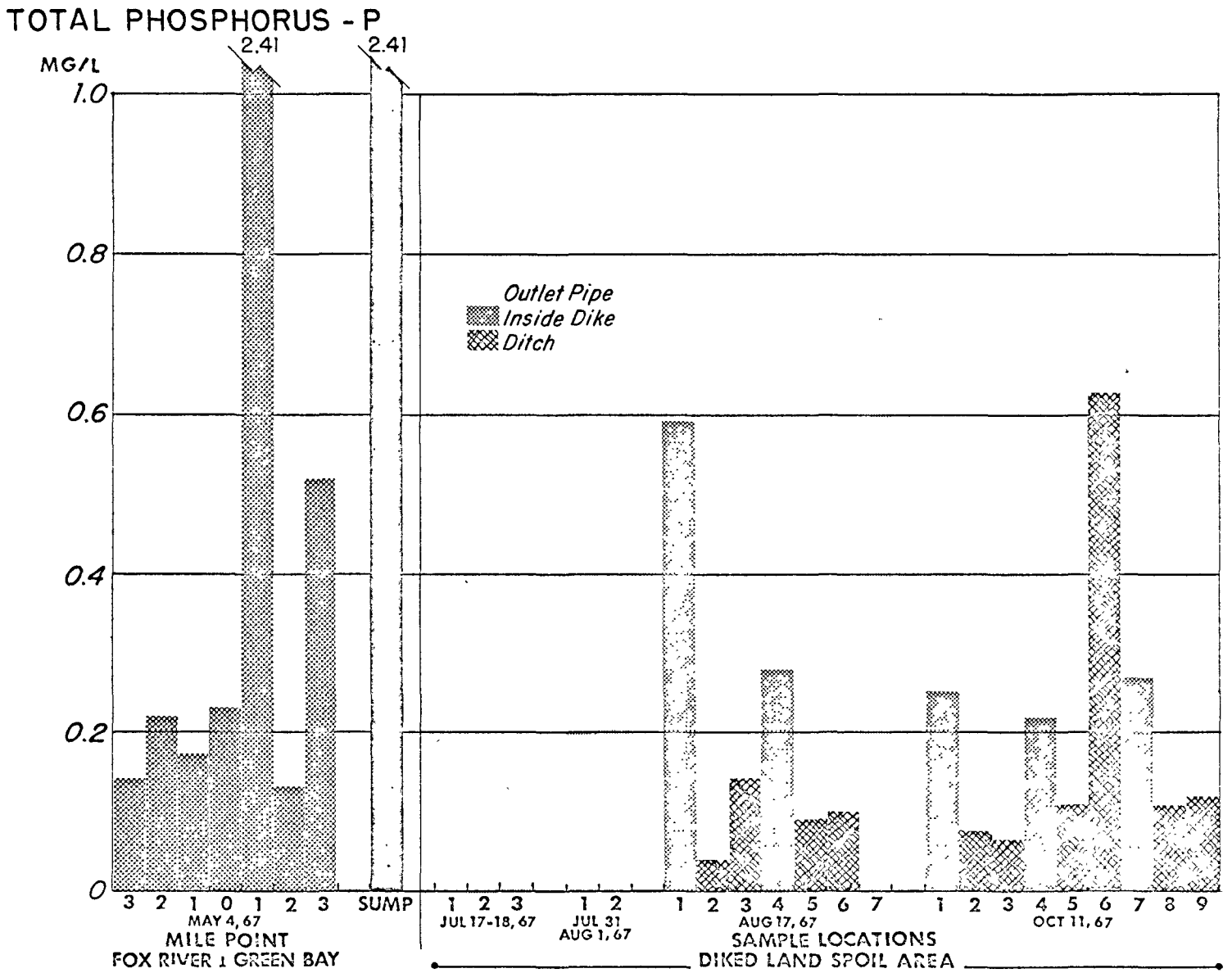


FIGURE 11

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA

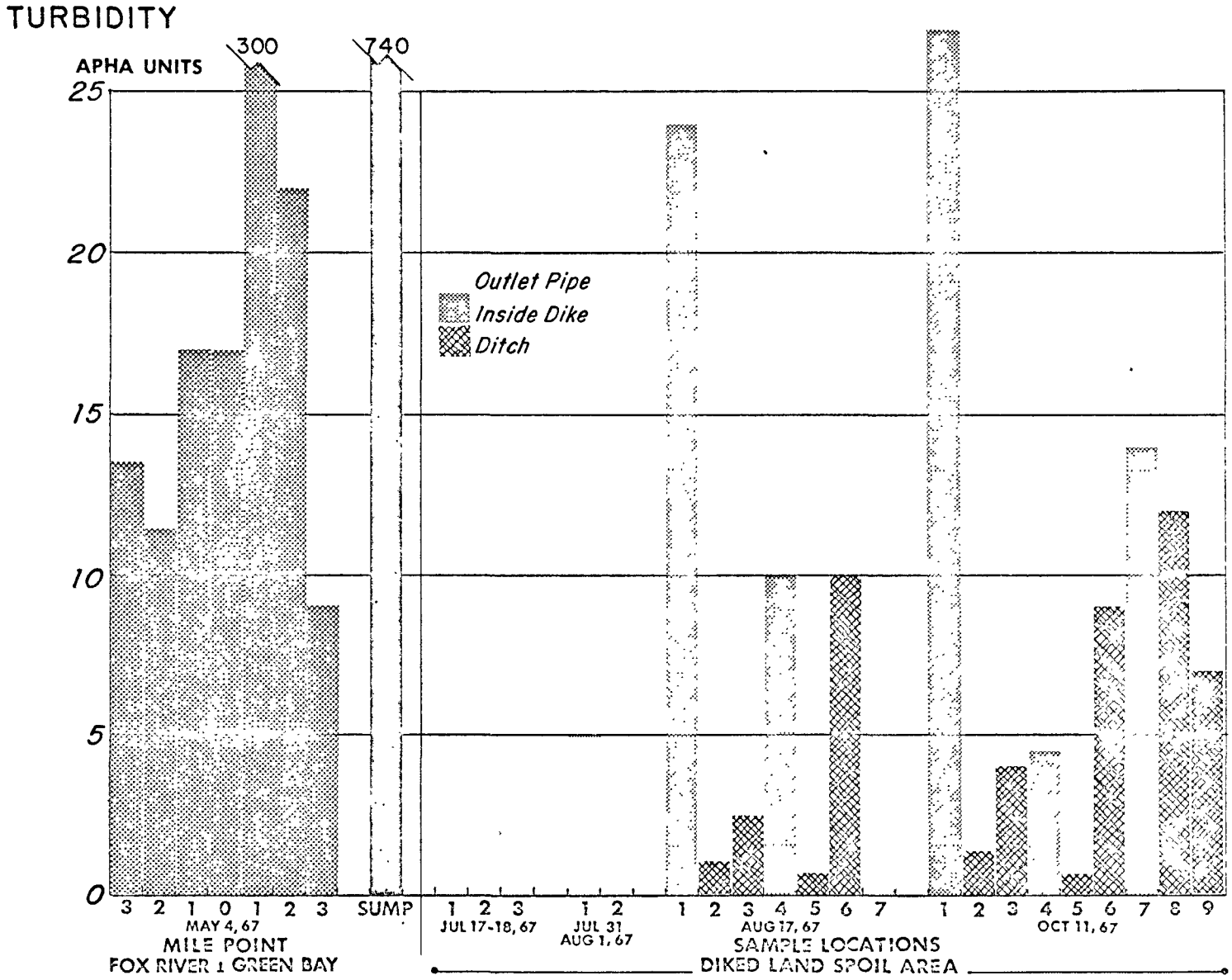


FIGURE 12

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA

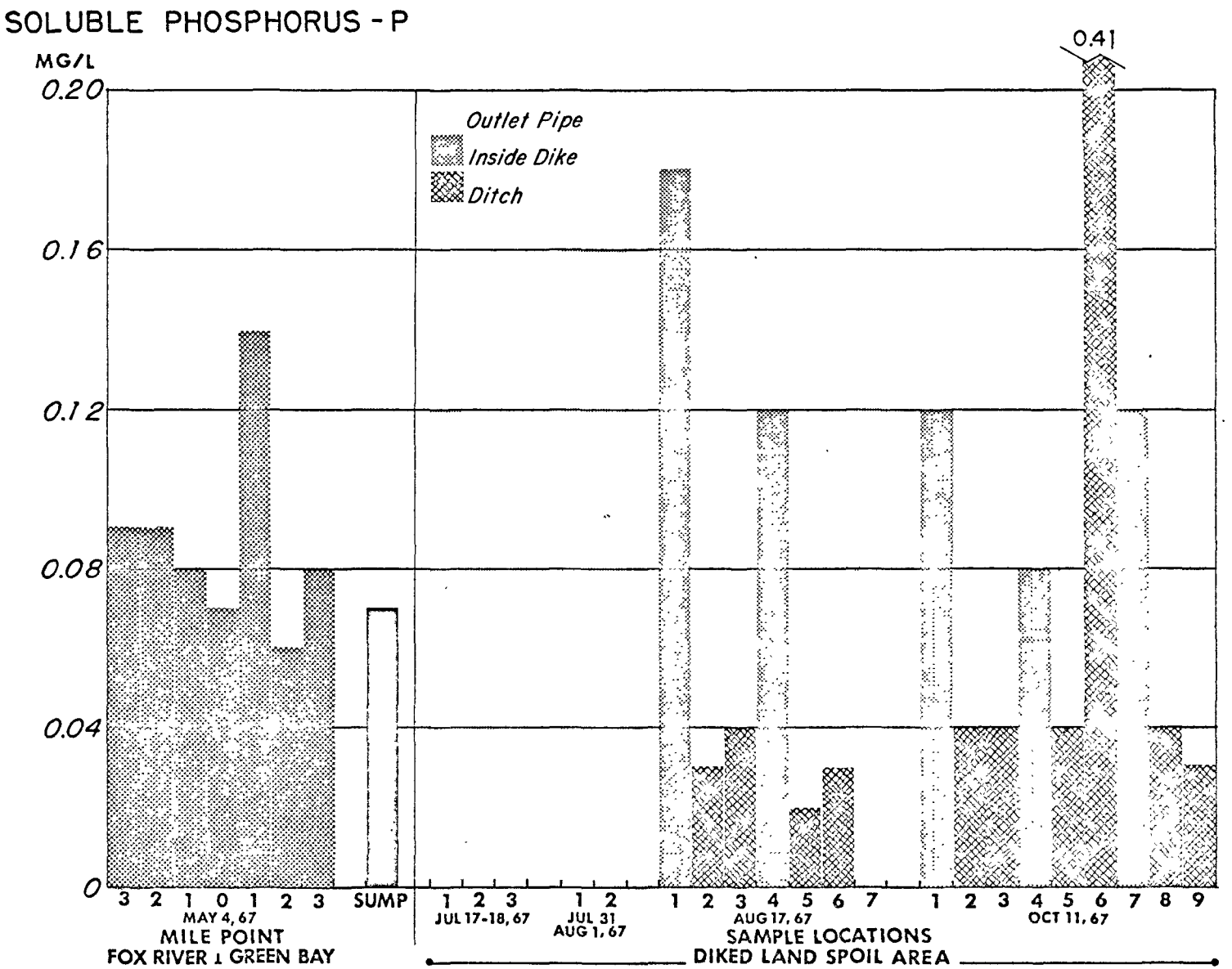


FIGURE 13

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA

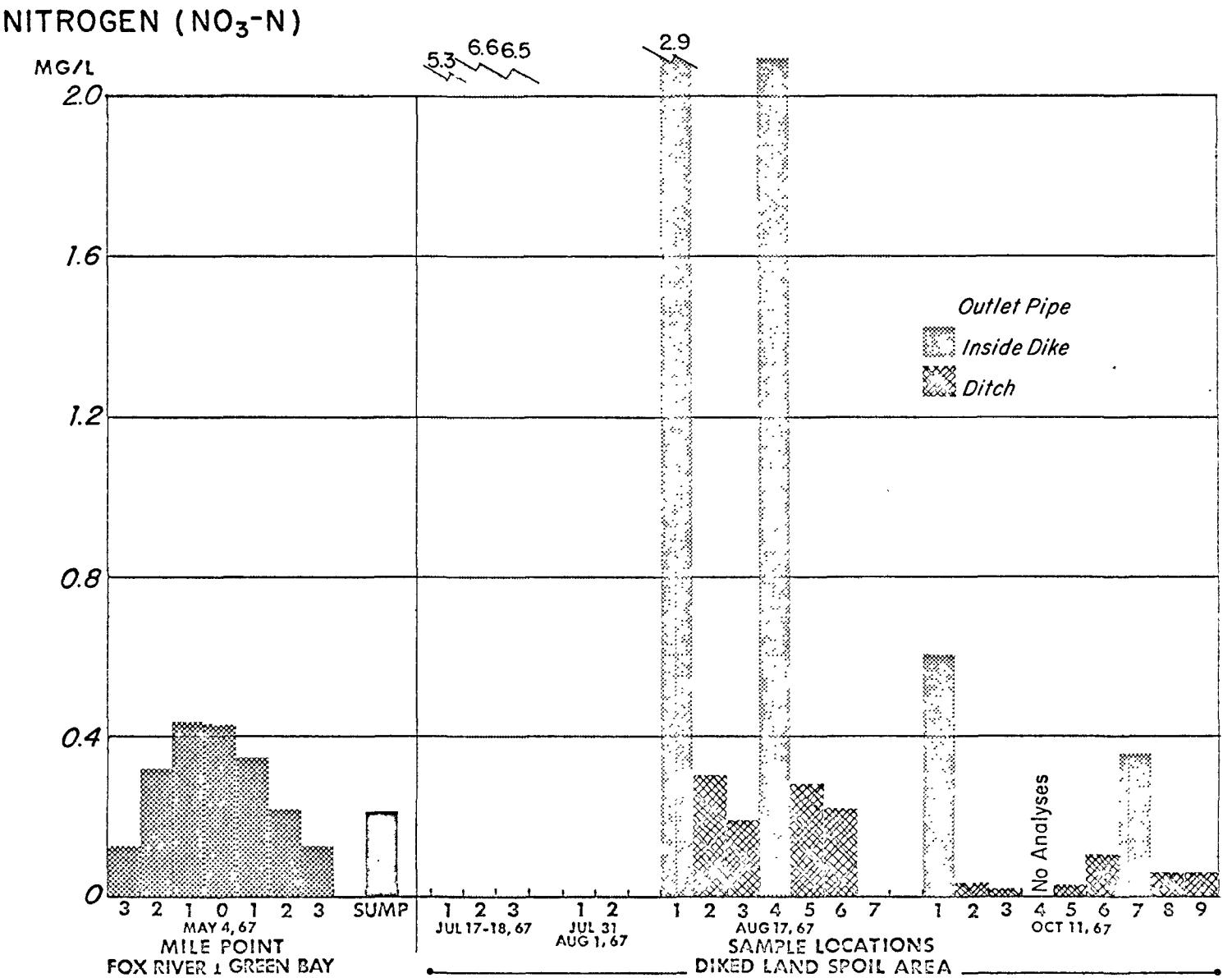


FIGURE 14

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA

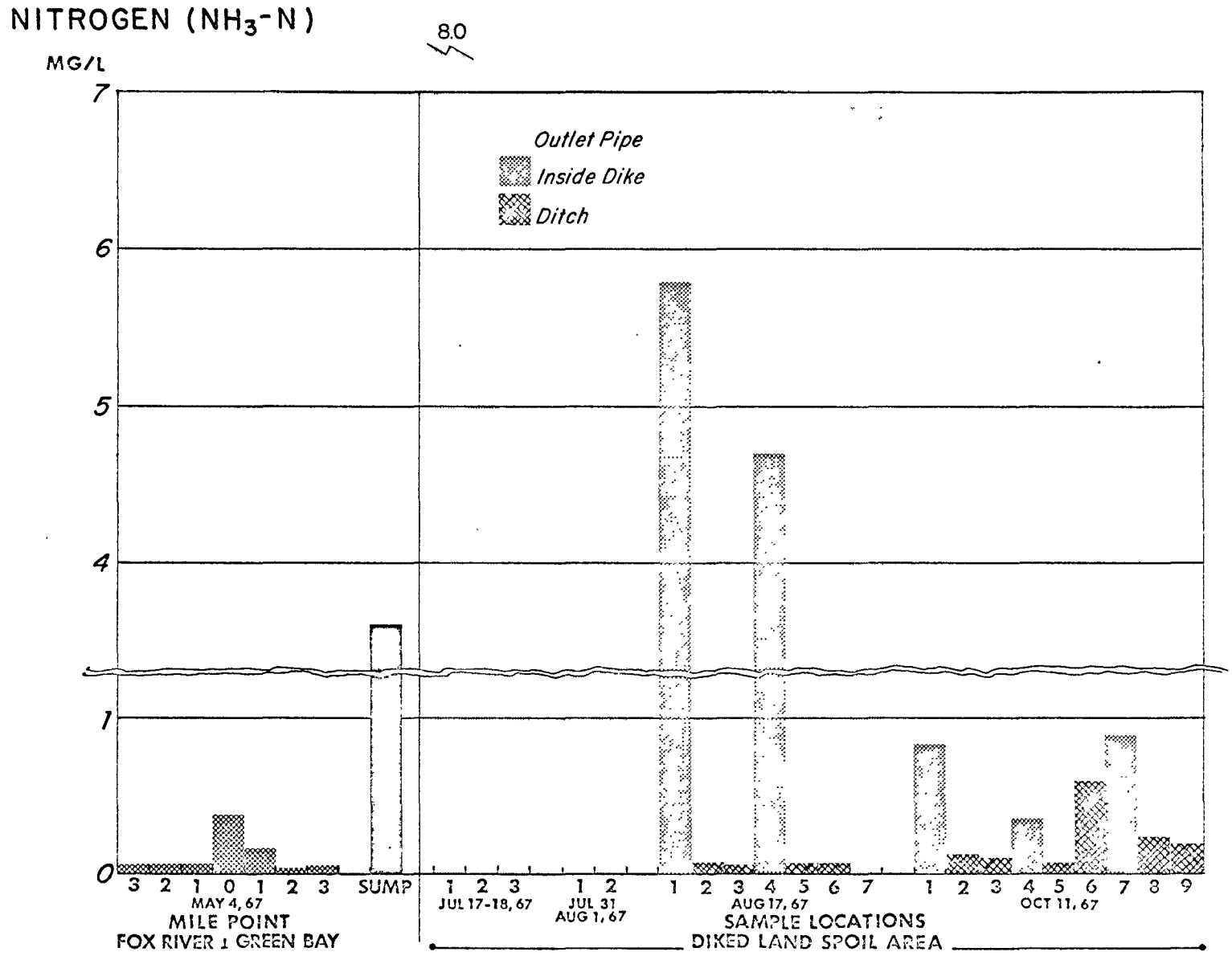


FIGURE 15

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA

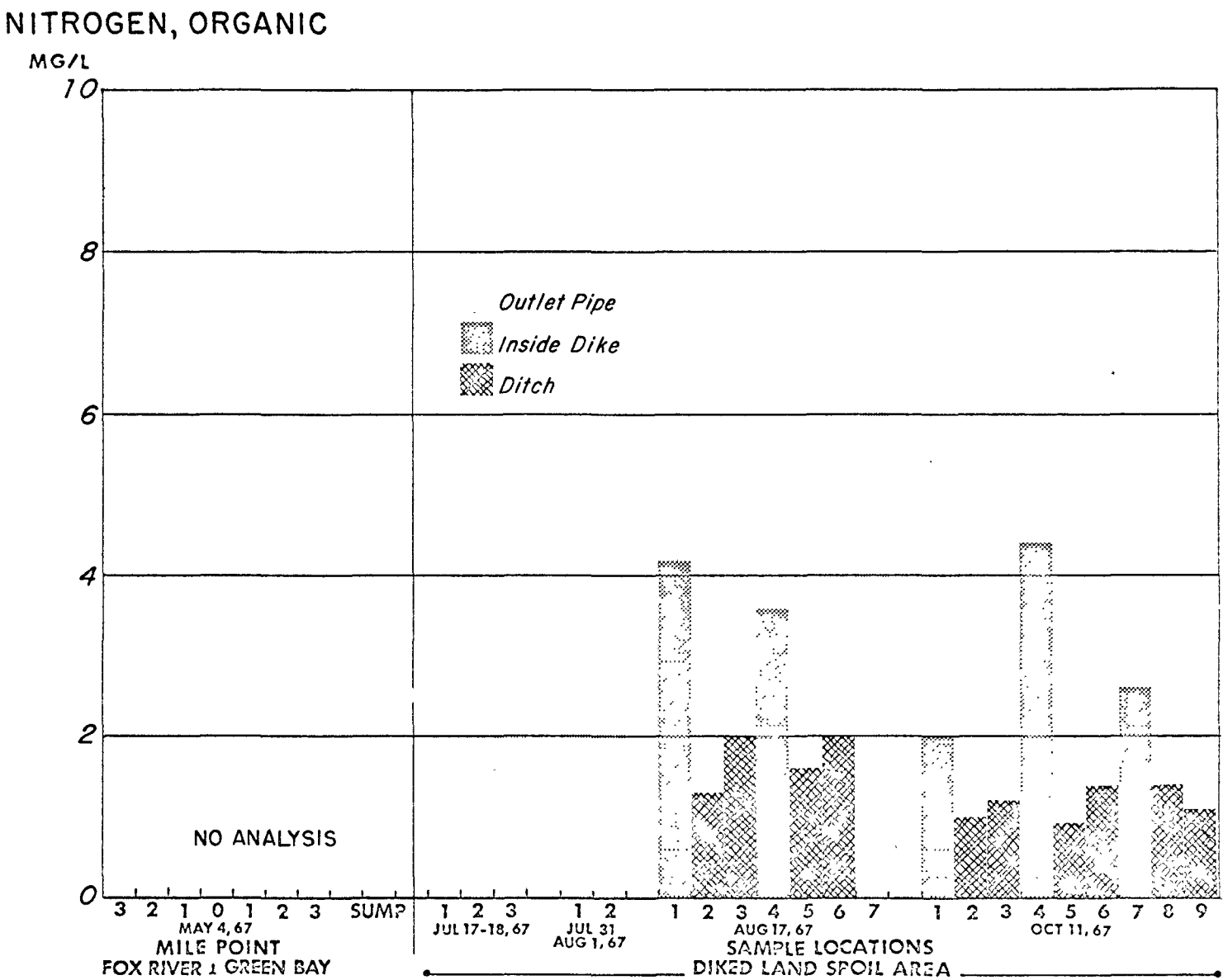


FIGURE 16

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA

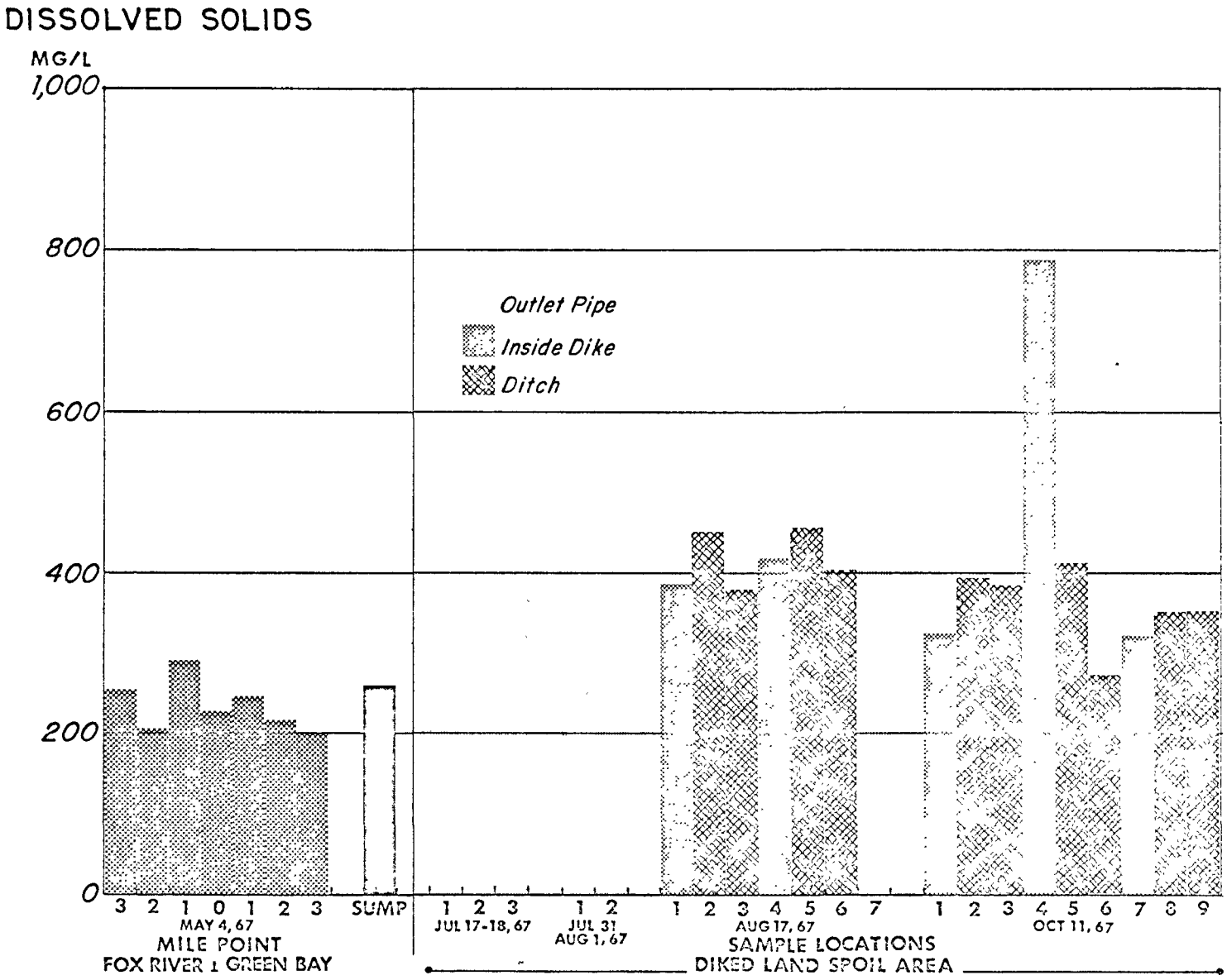


FIGURE 17

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA

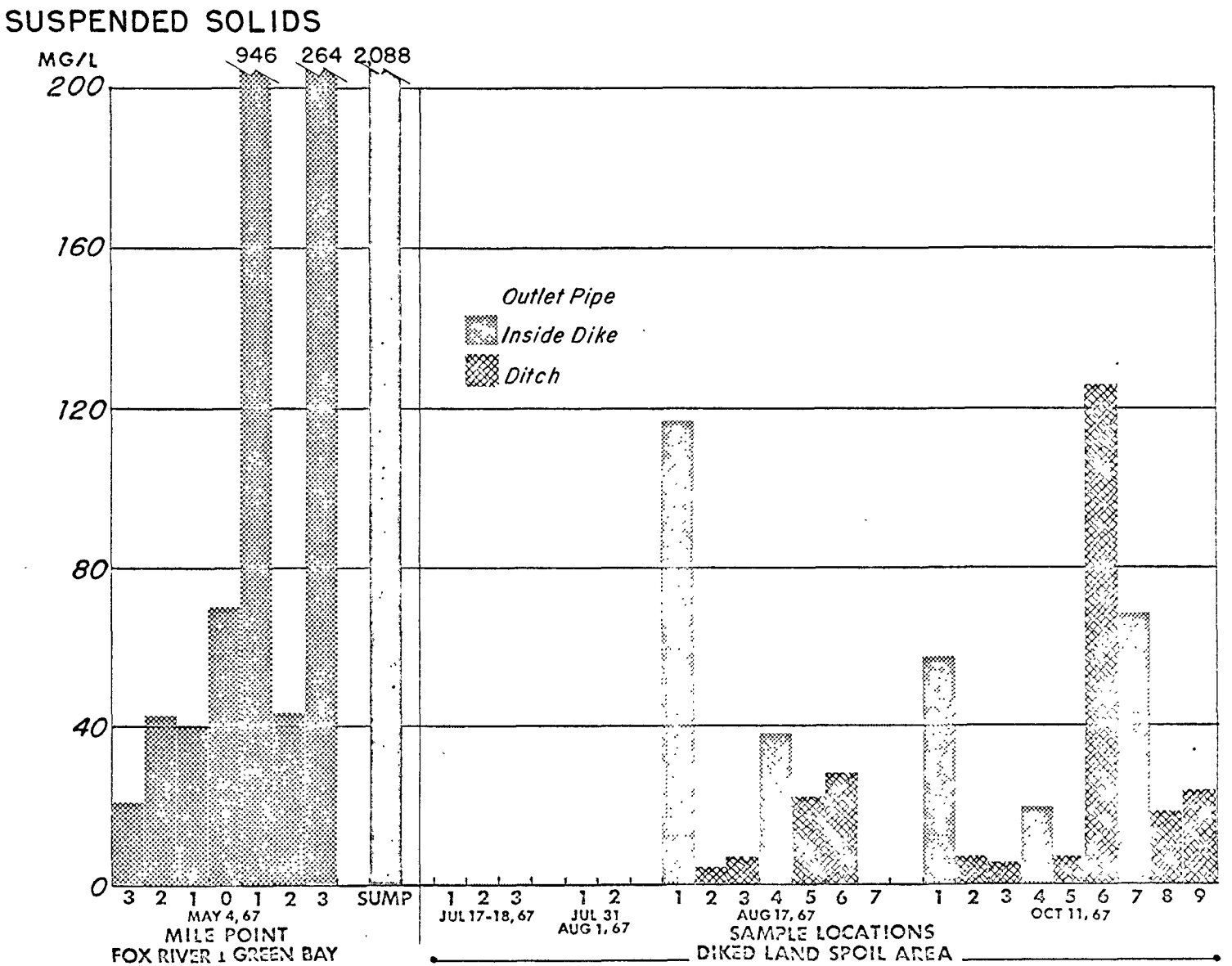


FIGURE 18

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA

CHEMICAL OXYGEN DEMAND

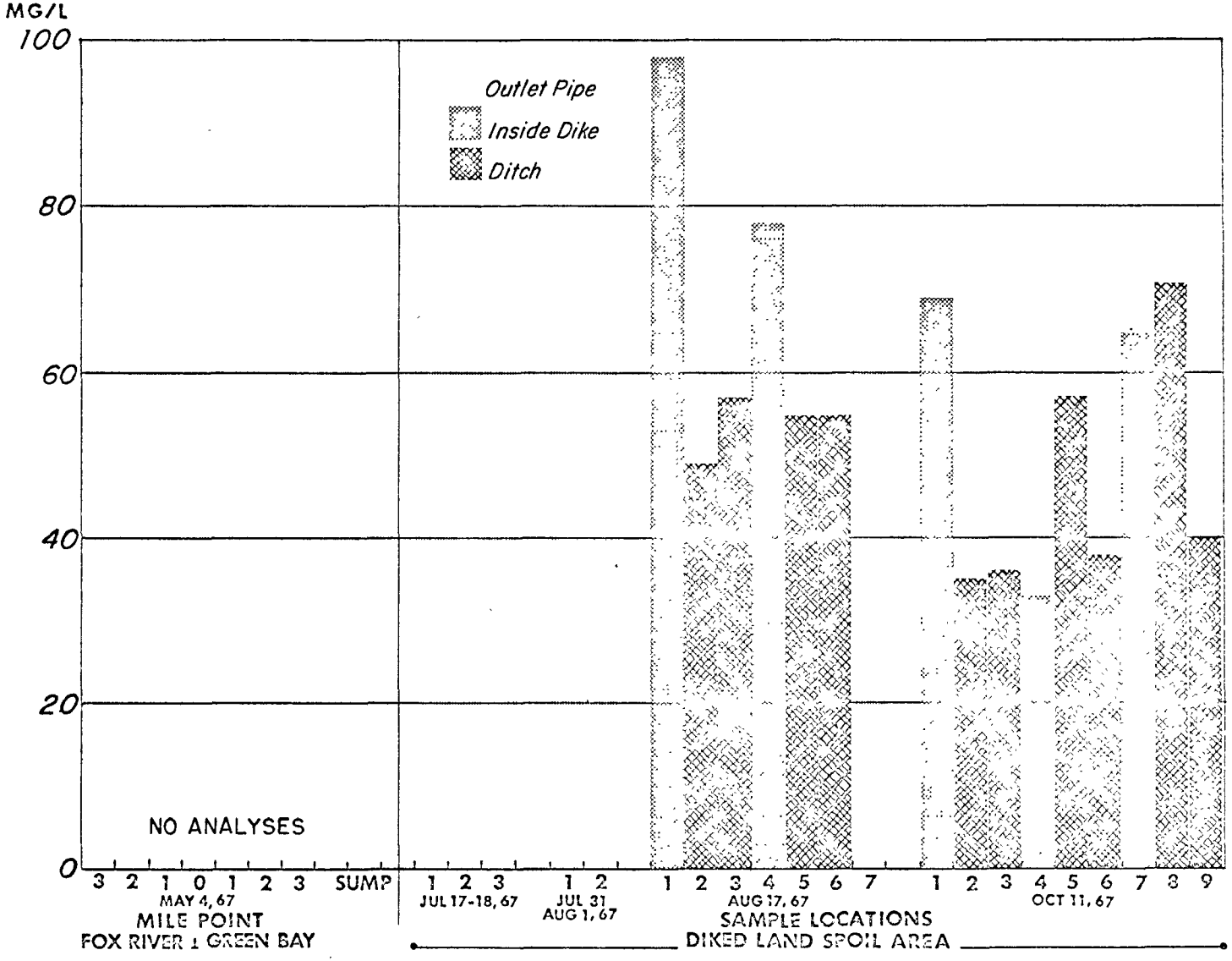


FIGURE 19

ANALYTICAL RESULTS

GREEN BAY BOTTOM SEDIMENT SAMPLES (Continued)

SAMPLING DATE - MAY 4, 1967

Sample No.	Location	Organic Nitrogen mg/k Wet	Organic Nitrogen mg/k Dry	C.O.D. mg/k Wet	C.O.D. mg/k Dry	Oil and Grease * mg/k Wet	Oil and Grease * mg/k Dry	Sulfide mg/k Wet	Sulfide mg/k Dry	Phenols µg/g Wet	Phenols µg/g Dry	IDOD mg/k Wet	IDOD mg/k Dry
1	Fox R. Mile 3	1,030	6,580	46,700	300,000	5,500	35,300	130	830	1.22	7.8	12,800	82,100
2	Fox R. Mile 2	810	6,260	34,600	266,000	6,000	46,200	116	890	0.39	3.0	12,300	94,600
3	Fox R. Mile 1	630	1,480	20,200	47,600	4,800	11,300	134	320	0.14	3.3	9,100	21,400
4	Fox R. Mile 0	920	4,550	52,600	261,000	7,100	35,100	139	690	0.45	2.2	13,500	66,900
5	Green Bay Mile 1	2,080	9,450	54,500	248,000	7,300	33,200	120	550	0.72	3.3	15,300	69,500
6	Green Bay Mile 2	1,230	4,020	66,600	218,000	1,400	4,600	74	240	0.23	0.75	14,800	48,600
7	Green Bay Mile 3	1,220	5,770	37,900	179,000	1,400	6,600	71	330	0.72	3.4	13,800	65,000
8	Sump, Green Bay	970	2,350	50,400	122,000	1,700	4,200	134	320	0.59	1.4	13,900	33,600
9	Scow	1,290	2,490	61,100	117,000	1,900	3,600	328	630	0.22	0.42	16,400	31,400

*Hexane Analysis

Table 1

ANALYTICAL RESULTS

GREEN BAY BOTTOM SEDIMENT SAMPLES

SAMPLING DATE - MAY 4, 1967

Sample No.	Location	Total Solids % of Sample	Vol. Solids % of Total Solids	Total Phosphorus -P mg/k		Soluble Phosphorus-P mg/k		NO_3 - Nitrogen mg/k		NH_3 - Nitrogen mg/k		Total Nitrogen mg/k	
				Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
1	Fox R. Mile 3	15.6	23.7	1,014	6,500	20.5	132.0	2.1	13.5	194	1,240	1,220	7,820
2	Fox R. Mile 2	13.0	21.7	779	5,992	18.0	138.0	2.1	16.2	107	820	920	7,080
3	Fox R. Mile 1	42.5	8.0	691	1,627	9.1	21.5	2.3	5.4	19	50	650	1,530
4	Fox R. Mile 0	20.2	20.0	681	3,374	23.4	116.0	2.1	10.4	81	400	1,000	4,950
5	Green Bay Mile 1	22.0	20.3	903	4,104	24.1	109.5	2.6	11.8	149	680	2,230	10,130
6	Green Bay Mile 2	30.5	17.6	818	2,683	16.3	53.5	3.4	11.1	41	140	1,270	4,160
7	Green Bay Mile 3	21.2	14.8	694	3,276	3.9	18.6	2.1	9.9	127	600	1,350	6,370
8	Sump in Green Bay	41.3	13.4	789	1,910	18.6	45.0	1.8	4.4	143	340	1,110	2,690
9	Scow	52.1	9.5	815	1,565	20.5	39.5	1.5	2.9	346	660	1,640	3,150

(Continued)

Table 1

ANALYTICAL RESULTS

GREEN BAY WATER SAMPLES

SAMPLING DATE - MAY 4, 1967

Sample No.	Location	Conductivity	Alkalinity mg/l	Turbidity APHA units	Total Phosphorus -P mg/l	Sol. P mg/l	NO_3-Nitrogen mg/l	NH_3-Nitrogen mg/l	Total Nitrogen mg/l	Dissolved Solids mg/l	Suspended Solids mg/l	Chloride mg/l	Sulfate mg/l
1	Fox R. Mile 3	320	112	13.5	0.14	0.09	0.13	0.05	1.4	254	21	16	30
2	Fox R. Mile 2	325	121	11.5	0.22	0.09	0.32	0.05	1.3	204	43	15	32
3	Fox R. Mile 1	310	116	17.0	0.17	0.08	0.44	0.05	1.3	290	40	13	33
4	Fox R. Mile 0	350	113	17.0	0.23	0.07	0.43	0.38	3.1	226	70	19	43
5	Green Bay Mile 1	370	140	300.0	2.41	0.14	0.35	0.17	18.0	244	946	18	34
6	Green Bay Mile 2	330	113	22.0	0.13	0.06	0.22	0.04	1.3	217	53	15	34
7	Green Bay Mile 3	275	107	9.0	.52	0.08	0.13	0.06	1.2	200	264	11	22
8	Sump Green Bay	400	228	740.0	2.41	0.07	0.19	3.60	53.0	260	2,088	21	46

Table 2

ANALYTICAL RESULTS

GREEN BAY BOTTOM SEDIMENTS SAMPLES - SUMP AREA (mg/k)

July 17, 1967

Station	% Total Solids	% T. Vol. Solids	NH_3-N		NO_3-N		Org-N		T.Sol. P		Phosphorus-P
			Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	
1	27.0	14.8	100	370	1.6	5.9	1085	4020	1.06	3.8	
2	27.7	16.7	97	350	2.2	7.9	913	3300	1.66	6.0	
3	26.0	18.2	194	745	3.2	12.3	1026	3955	3.11	12.0	
4	22.2	17.8	150	675	2.0	9.0	960	4325	2.94	13.4	
5	32.6	14.6	117	360	3.6	11.0	1008	3090	2.16	6.5	
6	39.3	9.4	131	315	2.0	5.1	959	2465	2.01	5.0	
Average	29.1	15.3		469		8.5		3526		7.8	

Station	Total Phosphorus-P		COD		Oil & Grease*	
	Wet	Dry	Wet	Dry	Wet	Dry
1	408	1509	48,200	178,500	6,930	25,667
2	301	1088	37,500	135,100	4,270	15,411
3	284	1091	36,000	138,500	2,815	10,827
4	408	1835	37,100	167,000	1,465	6,599
5	301	924	91,600	281,000	6,510	19,963
6	213	541	40,800	104,000	1,835	4,663
Average		1165		167,350		13,855

*Hexane Analysis

Table 3

ANALYTICAL RESULTS

GREEN BAY WATER SAMPLES -- OUTLET PIPE, DIKED LAND SPOIL AREA (mg/l)

JULY 17-18, 1967

Station	Time and Date	Dis. Solids	Susp. Solids	NH_3-N	NO_3-N	Org-N	T. Sol. Phos-phorus-P	Total Phosphorus -P	COD	Turb.*	Phenol**
1	9:15 a.m. 7/17	328	40	8.0	5.3	1.3	0.12	0.19	67	4.0	
2	3:00 p.m. 7/17	366	16	5.0	6.6	0.9	0.11	0.13	61	2.0	
3	8:00 a.m. 7/18	368	10	3.5	6.5	2.9	0.11	0.13	63	2.0	
JULY 31 - AUGUST 1, 1967											
1	7:00 p.m. 7/31	350	14	3.5	0.92	2.4	0.16	0.20	70	5.0	1
2	8:00 a.m. 8/1	340	18	3.6	0.71	2.2	0.16	0.21	65	3.6	3

* Turbidity expressed in APHA units (equal to Jackson units)
** Phenols expressed in micrograms per liter

Table 4

ANALYTICAL RESULTS

GREEN BAY WATER SAMPLES -- DIKED LAND SPOIL AREA (mg/l)

AUGUST 17, 1967

Sample	Time	NH_3-N	NO_3-N	Org-N	T. Sol. Phos-phorus-P	Total Phosphorus-P	Dis. Solids	Susp. Solids	Turb.*	COD
1 - Dike (Inside)	12:00 N	5.8	2.9	4.2	0.18	0.59	386	117	24.	98
2 - Ditch along Dike	"	0.08	0.30	1.3	0.03	0.04	452	4	1.1	49
3 - Ditch across Road	"	0.06	0.19	1.9	0.04	0.14	378	7	2.5	57
4 - Dike (Inside)	2:00 P.M.	4.7	2.1	3.6	0.12	0.28	420	38	10.	78
5 - Ditch (along Dike)	"	0.07	0.28	1.6	0.02	0.09	458	22	0.6	55
6 - Ditch across Road	"	0.07	0.22	2.0	0.03	0.10	403	28	10.	55
7 - Dike - Outlet Pipe	11:00 A.M.	6.9	1.9	6.1	0.18	0.72	406	92	9.0	107

*. APHA Units = Jackson Candle Turbidity Units

Table 5

GREEN BAY

ANALYTICAL RESULTS OF WATER FROM DIKED LAND SPOIL AREA

mg/l

OCTOBER 11, 1967

Type of Sample:	WATER								
Station	1	2	3	4	5	6	7	8	9
Parameter									
T. Sol.-P	0.119	0.037	0.039	0.086	0.044	0.414	0.123	0.040	0.032
Total-P	0.252	0.074	0.063	0.224	0.109	0.629	0.273	0.105	0.119
NH_3-N	0.84	0.12	0.10	0.36	0.07	0.59	0.90	0.23	0.20
NO_3-N	0.61	0.03	0.02	-	0.03	0.11	0.36	0.06	0.06
Org-N	2.0	1.0	1.2	4.4	0.91	1.4	2.6	1.4	1.1
Sus. Solids	57	7	5	19	7	126	68	18	24
Dis. Solids	327	393	385	789	415	274	324	353	354
Turbidity	27	1.4	4.0	4.5	0.7	9.0	14	12	7.7
COD	69	35	36	33	57	38	65	71	40

Table 6