A REASSESSMENT OF SEDIMENT CONTROL STRUCTURES #1 AND #3 IN THE LAKE HERMAN WATERSHED

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ABSTRACT

The Lake Herman Model Implementation Program (MIP) was initiated in 1978 as a demonstration for interagency cooperation and interaction. The MIP was a joint effort by various Federal, State and local organizations to control nonpoint sources of pollution. A number of land treatment measures were implemented, including the construction of three sediment control structures. These structures were intended to decrease the amount of sediments (and possibly nutrients) that could enter Lake Herman.

This report is a reassessment of the effectiveness of two of the sediment control structures in controlling sediments and nutrients during 1984. The results indicated sediment control structure #1 was effective in reducing ammonia, total phosphate and orthophosphate concentrations during spring runoff (up until June 7, 1984) but ineffective after that date. Turbidity levels were not effected by the structure. Sediment control structure #3 was not effective in reducing turbidity levels or concentrations of ammonia, total phosphates and orthophosphates.

A discussion exploring the reasons for the structures' ineffectiveness is presented. It was hypothesized that algae could play a major role by utilizing incoming nutrients and obscuring any decrease in turbidity due to settling of incoming sediments. The operational procedures of the ponds were partially assessed and it was recommended that the lower level outflow gates be kept closed at all times and that water releases be minimized during the summer. Recommendations for future monitoring included: Quantifying algae in the ponds, constructing hydrologic budgets, separating suspended solids into organic and inorganic fractions, and measuring dissolved fractions of nutrients.

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INTRODUCTION

During the Lake Herman Model Implementation program three sediment control structures (SCS) were built in the Lake Herman watershed (Figure 1). These structures were intended to reduce the amount of nutrients and sediments that enter Lake Herman from the watershed. From 1980 to 1983 various water quality parameters were monitored upstream and downstream from the structures to assess their effectiveness and the results were variable (Table 1).

This variability was attributed to incorrect operational procedures of the structures' outflows. According to operational procedures, all outflow valves are to remain closed until water stops flowing behind the structures. After flow cessation, material in the water is allowed to settle for 72 hours and then the upper water level valve is opened. Once the water level has dropped below the upper gates, another 72 hour settling period is initiated. A second layer of water is then evacuated. The valves, however, have been discovered open when water was still flowing into the structures and suspended material may not have had enough time to settle out.

This study began in May 1984 and was intended to provide additional data so that the structures' effectiveness in reducing sediments and nutrients could be reassessed under more strict attention to operational procedures.

MATERIALS AND METHODS

Two of the sediment control structures, SCS#1 and SCS#3, were monitored during the spring and summer of 1984. Water samples were collected upstream from the ponded areas behind the structures, at the water surface and near the bottom of the ponds, and from either the outflow pipes or immediately downstream from the pipes if high flows prevented sampling from the pipes.

The water samples were analyzed for orthophosphates, total phosphates, ammonia nitrogen, and turbidity with a Model DR-EL/2 Hach Kit. Orthophosphates were analyzed with the ascorbic acid-Phos Ver III method. Total phosphates were analyzed by oxidation to orthophosphate. The Nessler method was used to determine ammonia nitrogen. Turbidity was determined with an adsorptometric method and reported as Formazin Turbidity Units (FTU). Water temperatures were measured with a centigrade thermometer.

The sampling regime was variable and depended upon the availability of equipment and personnel. Appendices A and B present the original data and sampling times.

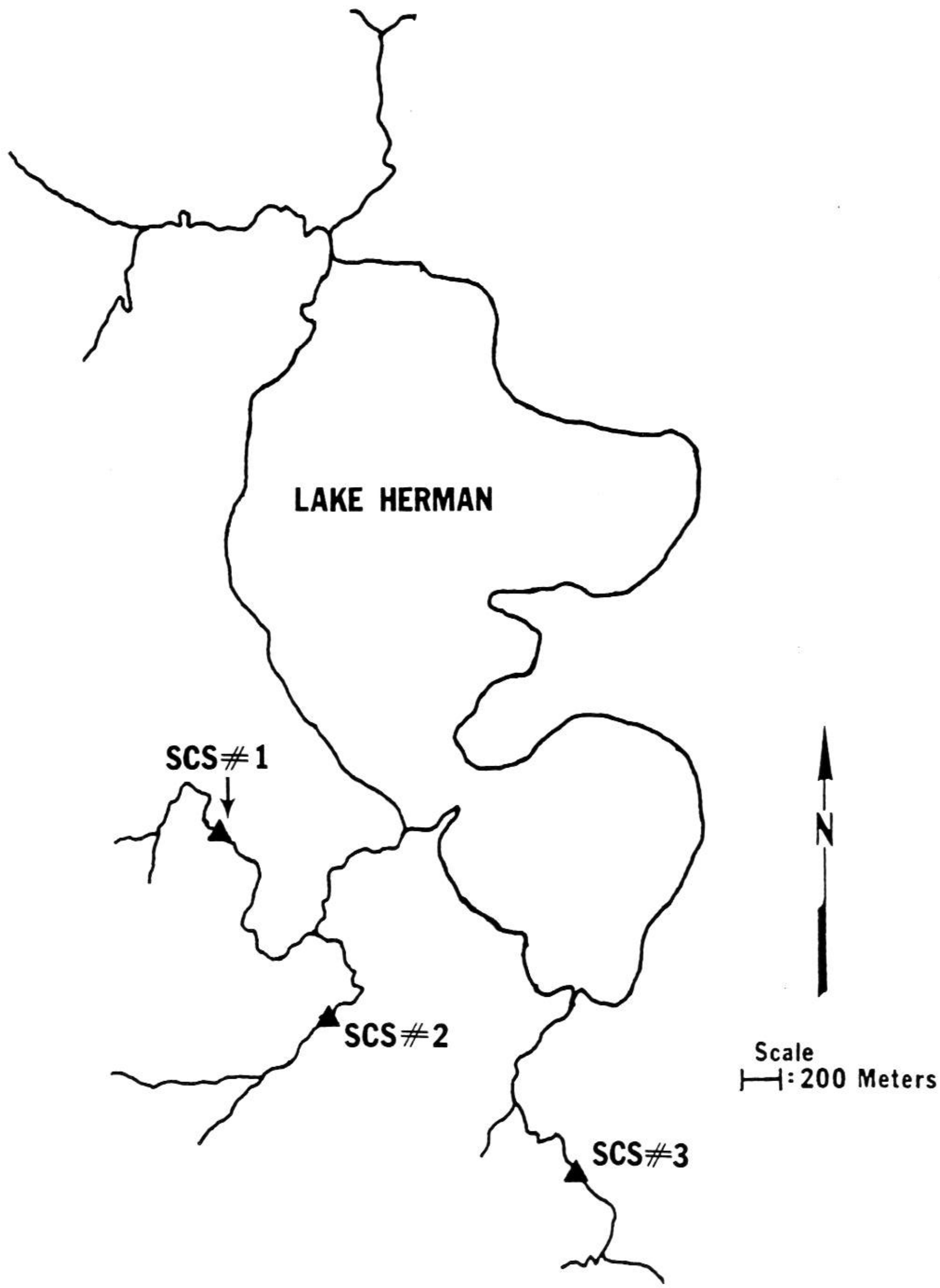

Figure 1. Sediment control structures within the Lake Herman watershed.

TABLE 1. THE RESULTS OF TUKEY-KRAMER METHOD FOR MULTIPLE COMPARISONS AMONG PAIRS OF MEANS BASED ON UNEQUAL SAMPLE SIZES

	Sediment Control Structure #1			Sediment Control Structure #2			Sediment Control Structure #3		
Year: Parameter	1980	1982	1983	1980	1982*	1983	1980	1982	1983
Total Phosphorus	NS	NS	U	NS		NS	NS	U	U
Inorganic N	NS	NS	NS	NS		NS	NS	NS	NS
Organic N	NS	NS	NS	NS		NS	NS	NS	NS
Total Solids	NS	NS	D	NS		NS	NS	U	NS
Suspended Solids	NS	NS	U	NS		NS	NS	NS	NS
Dissolved Solids	NS	NS	D	NS		NS	NS	U	NS

* Data not collected because of no flow.
NS No significant difference demonstrated.
U Upstream greater than downstream (P<.05).
D Downstream greater than upstream (P<.05).

RESULTS AND DISCUSSION

Sediment Control Structure #1

The operational procedures and water quality data for SCS#1 are summarized in Figures 2-5. The outflow gates of the structures were closed (but leaking) until June 12, 1984. On that day the upper gates were opened to prevent water from spilling over the structure even though water was still flowing into the ponded area behind the structure. The upper gates were opened twice more during the study; June 25, 1984 and July 2, 1984. The bottom gate was opened once on July 5, 1984 and left open until July 11, 1984. Inflows to the pond occurred until June 29 and afterwards, inflows rarely occurred and were dependant upon storm events.

Initial comparisons of the data were made between the surface and bottom samples taken from the pond. Parameter concentrations at the two locations were compared with the nonparametric Mann-Whitney U test at a five percent significance level. Differences between pond location with respect to the four parameters were not demonstrated and so for comparisons with upstream and downstream locations, the pond surface and bottom data were averaged for each date.

To assess the effectiveness of SCS#1 in decreasing parameter concentrations, all three locations (upstream site, pond, and dowstream site) were tested for similarity with the Kruskal-Wallis one-way analysis by ranks at the five percent significance level. The null hypothesis is that all samples come from the same population and there is no difference in parameter mean concentrations between the locations. Figures 4 and 5 suggest the possibility that the locations may be different with respect to turbidity and total phosphates up until June 7, 1984 and relatively similar after that date. Therefore, the data were separated into two time periods for statistical analysis.

A significant difference in turbidity between the locations could not be demonstrated for either time period and further paired comparisons with turbidity data were not attempted. Significant differences between location, however, were detected for total phosphates, orthophosphates, and ammonia nitrogen. Paired comparisons between locations were then performed with the Mann-Whitney U test at the fine percent level.

The results (Table 2) indicate that at least until June 7, 1984 SCS#1 was effective in decreasing the concentrations of all parameters but turbidity. This conclusion, however, is based on the assumption that water leaking from the outflow gate is similar in nutrient concentrations as the effluent water would be if the gates are opened. After that date,

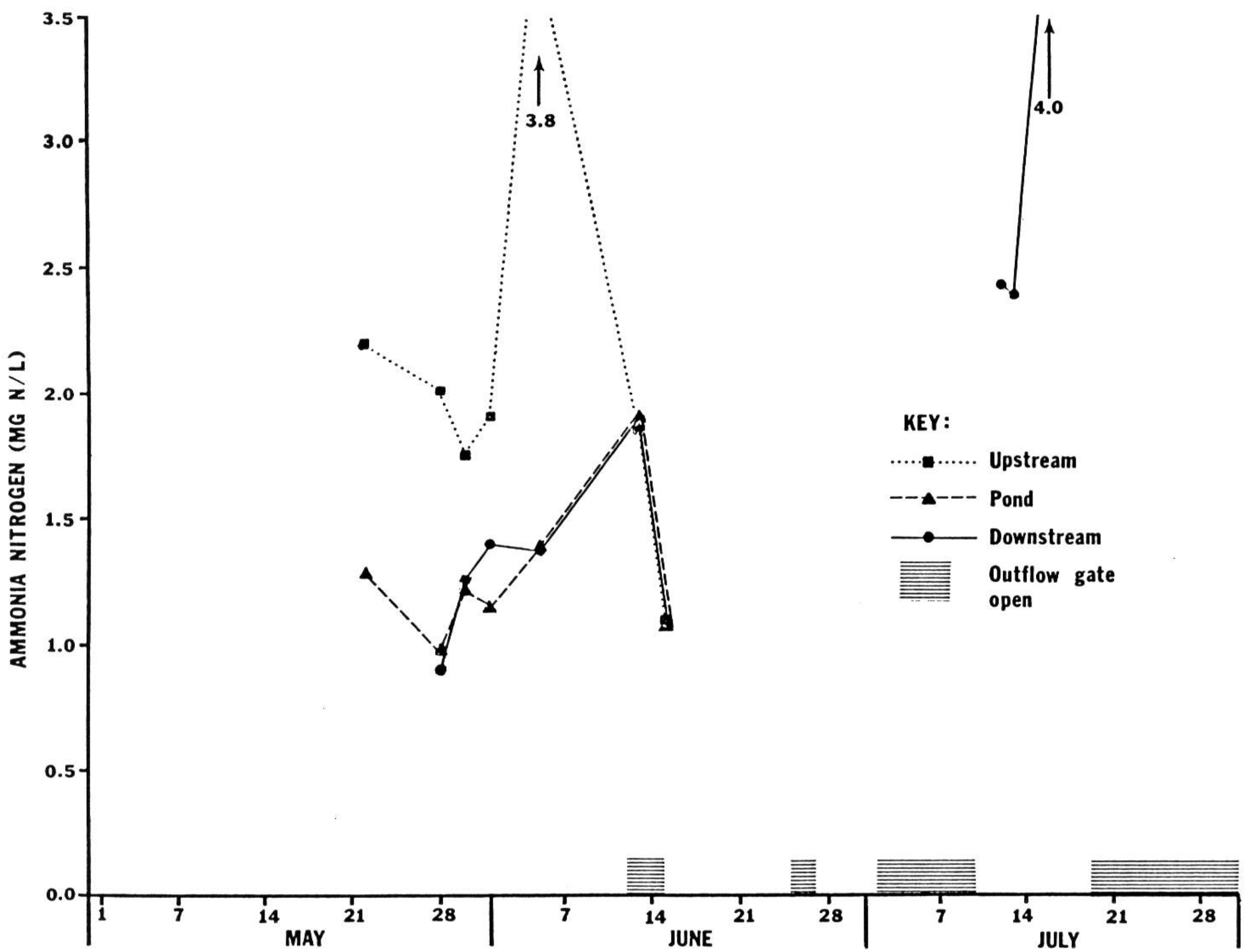

Figure 2. Ammonia nitrogen (MG/L) and operational regime for SCS#1.

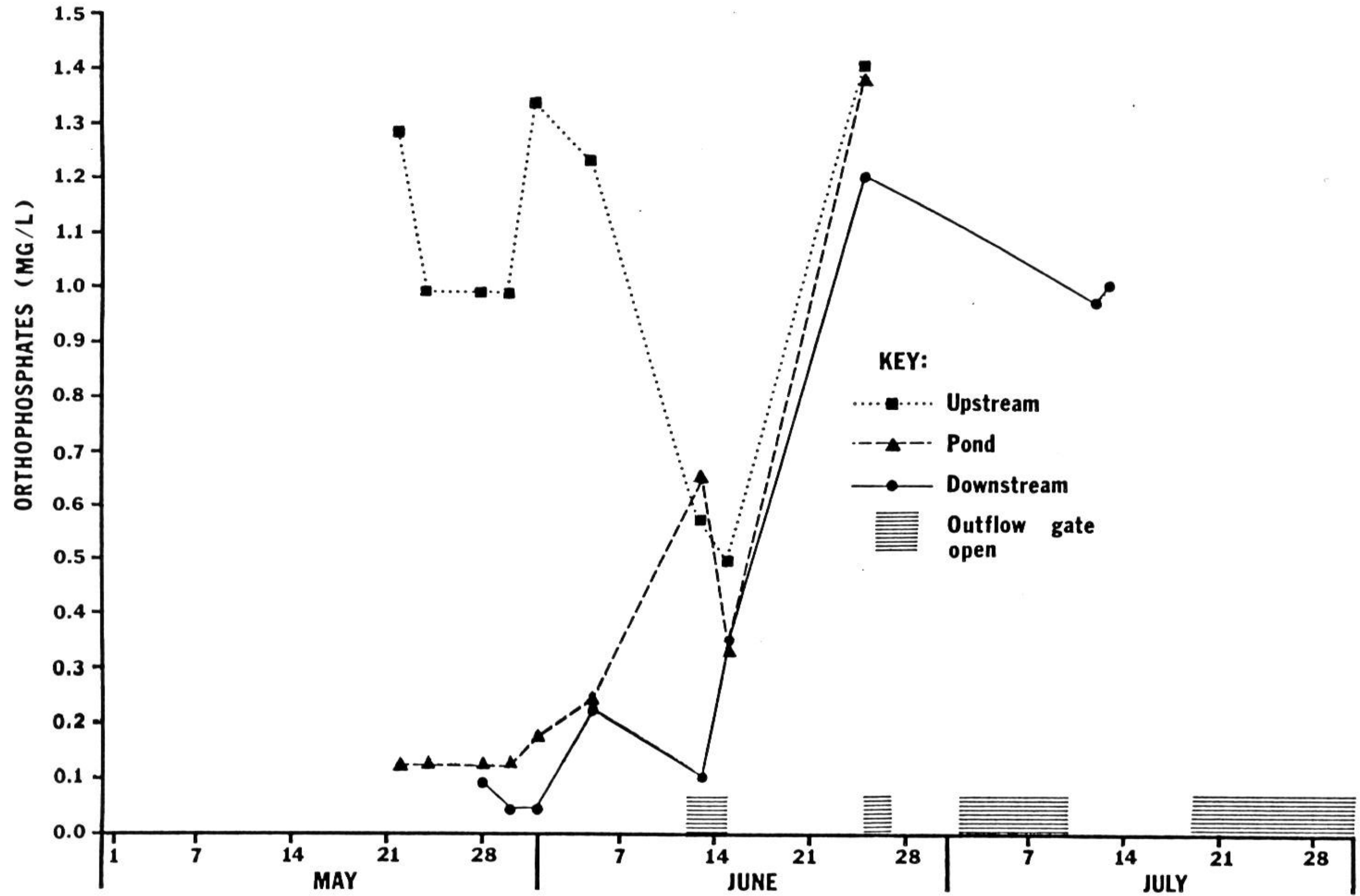

Figure 3. Orthophosphates (MG/L) for SCS#1.

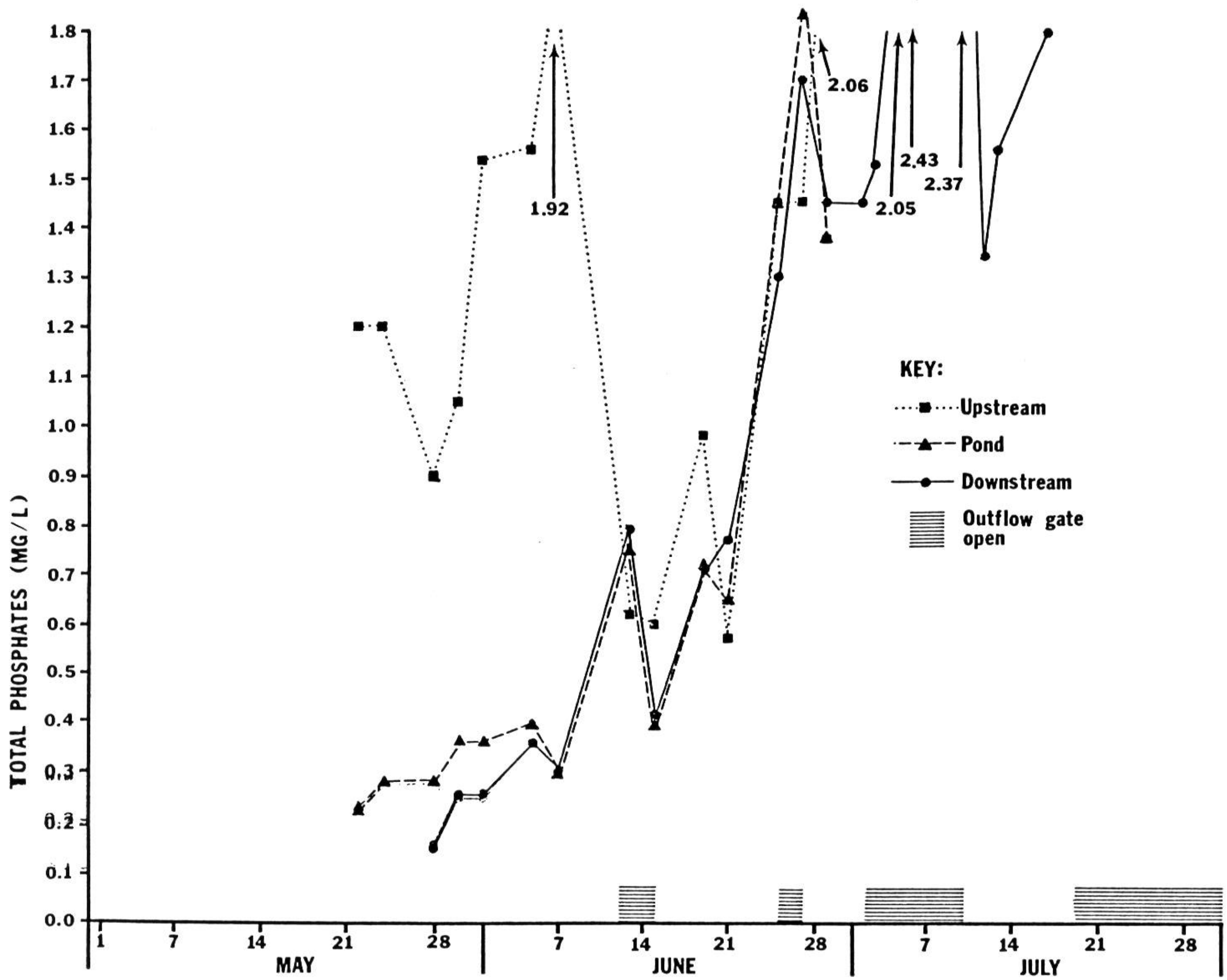

Figure 4. Total phosphates (MG/L) for SCS #1.

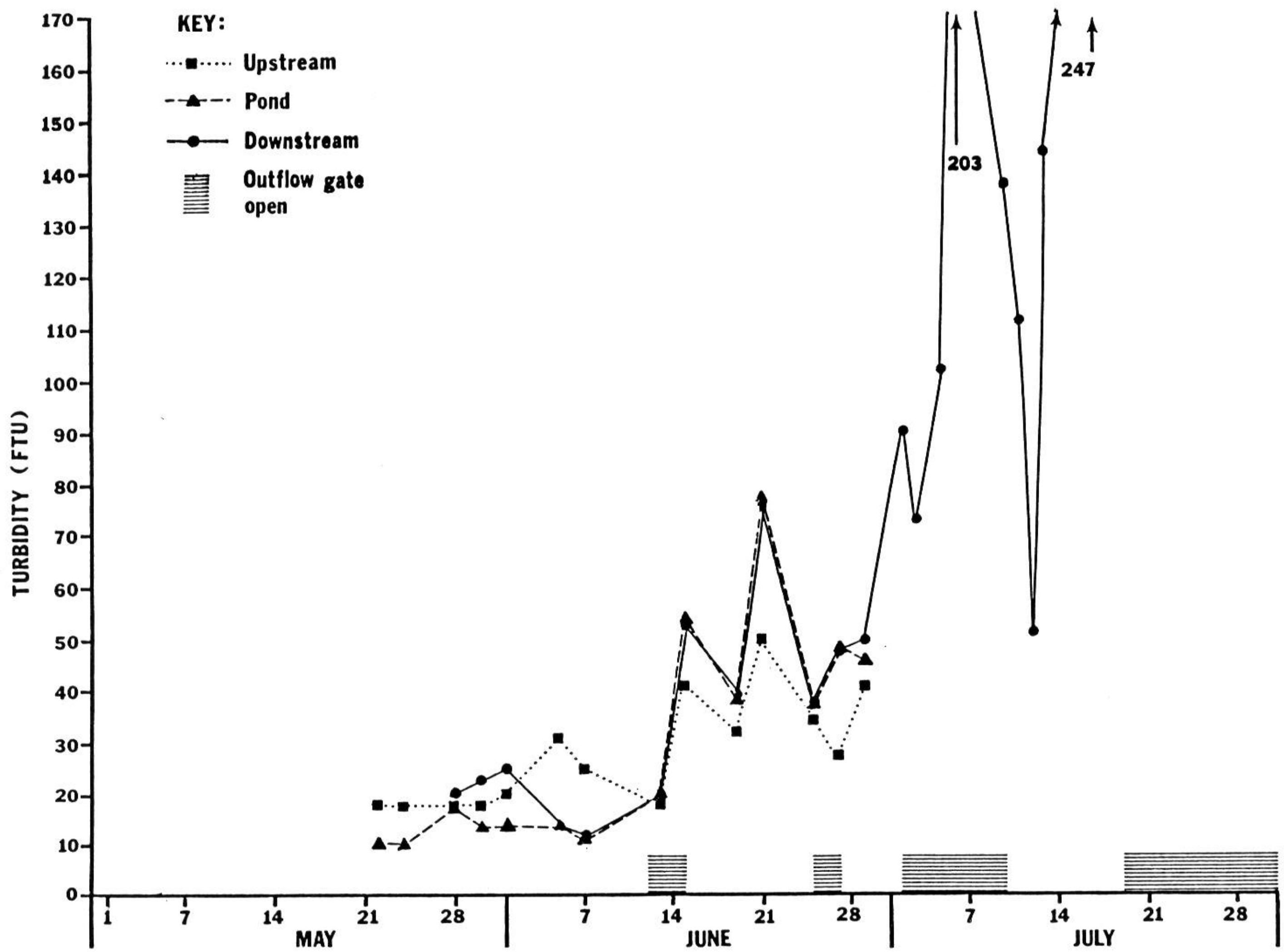

Figure 5. Turbidity (FTU) for SCS#1.

TABLE 2. SUMMARY STATISTICS OF THE MANN-WHITNEY U TEST FOR SCS#1

Parameter (MG/L)	Significant Difference between Sites	Median Difference in Parameter Concentration
Total Phosphates (sampled before 6/13/84)	upstream > pond	0.97
	upstream > downstream	1.22
Orthophosphates (sampled before 6/13/84)	upstream > pond	0.91
	upstream > downstream	0.93
Ammonia Nitrogen (sampled before 6/13/84)	upstream > pond	0.92
	upstream > downstream	0.83

orthophosphate and ammonia nitrogen data were not adequate for statistical analysis. Significant differences between locations were not detected for total phosphate data collected after June 7.

Without additional information it is difficult to define the cause for the differences in parameter concentrations although algae in the pond could be a major factor. The field technician noted increased algae population levels in the pond through time and these algae could be utilizing some of the nutrients from the inflows. The presence of algae could also offset any decrease in turbidity that is do to settling of incoming sediments. Turbidity is caused by biotic and abiotic suspended matter so even if SCS#1 causes incoming suspended material to settle out, algae are included in the measurement of turbidity and they could mask the detection of settling sediments.

After June 29, 1984, inflows were absent except during major storm events and because the outflows generally reflected conditions in the pond only the outflow was monitored. Total phosphates and turbidity levels were generally higher in the outflow after June 29 (Figures 4 and 5). The relatively high values of turbidity and total phosphates in early July most likely occurred because the bottom outflow gate was opened.

Sediment Control Structure #3

The operational procedures and water quality data for SCS#3 are summarized in Figures 6-9. The outflow gates of the structure were closed until July 2, 1984. The inflows, however, were so great that water was constantly spilling over the structure before July 2.

The water quality data were statistically analyzed with the same statistics and comparisons as those used for SCS#1. Statistically significant differences were not demonstrated for any comparison and these results suggest SCS#3 was not effective in decreasing parameter concentrations under its operational regime. It is possible that the pond (when full and spilling over) does on provide for sufficient time for incoming sediments to settle out.

CONCLUSIONS AND RECOMMENDATIONS

Sediment Control Structure #1

SCS#1 was effective in decreasing nutrient concentrations during spring runoff but not effective after June 7. Turbidity levels were not decreased by SCS#1 during the study. The reasons for these results are not known but it is hypothesized that algae in the pond are a major factor. Algae could be utilizing some of the incoming nutrients and

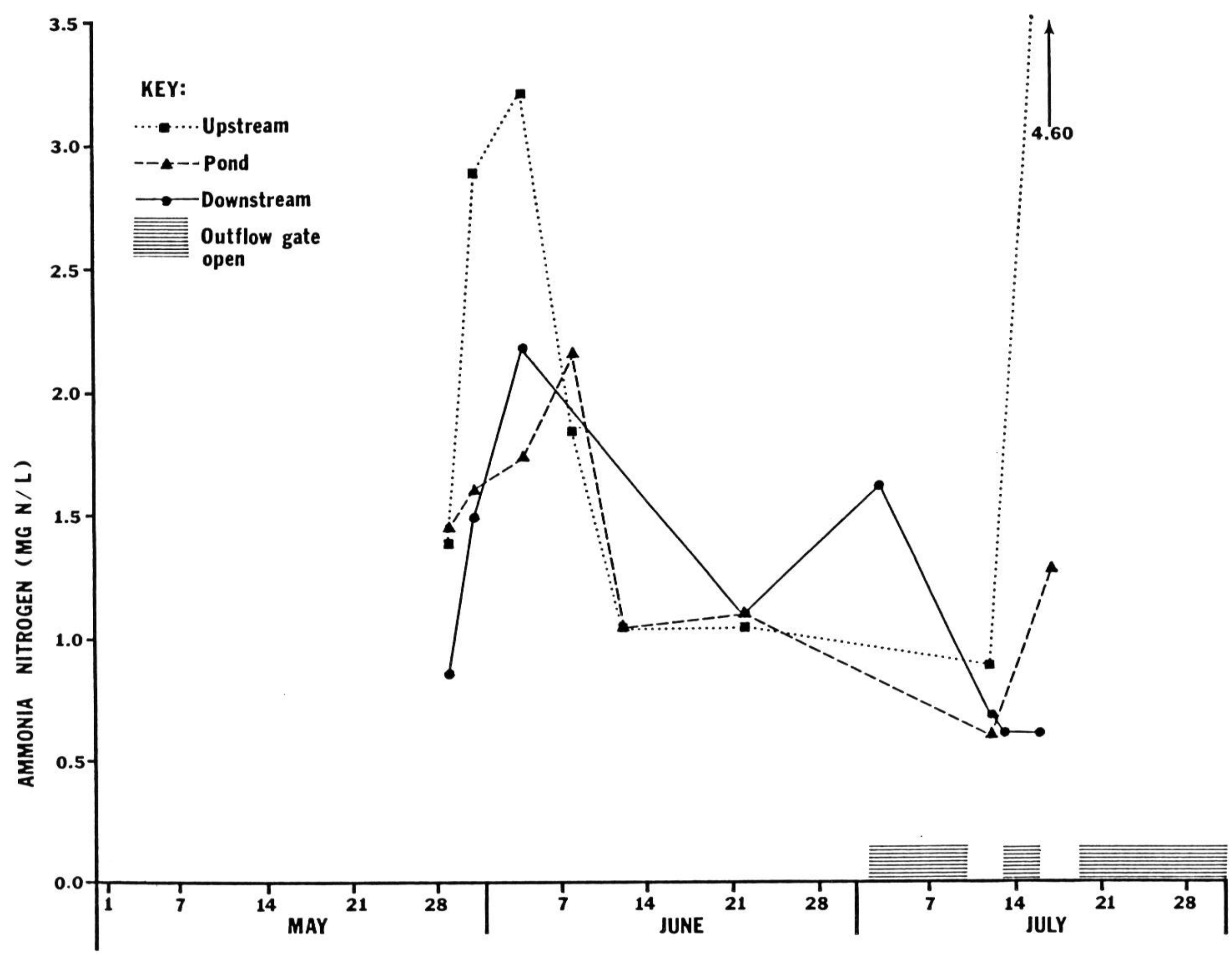

Figure 6. Ammonia nitrogen (MG N/L) for SCS#3.

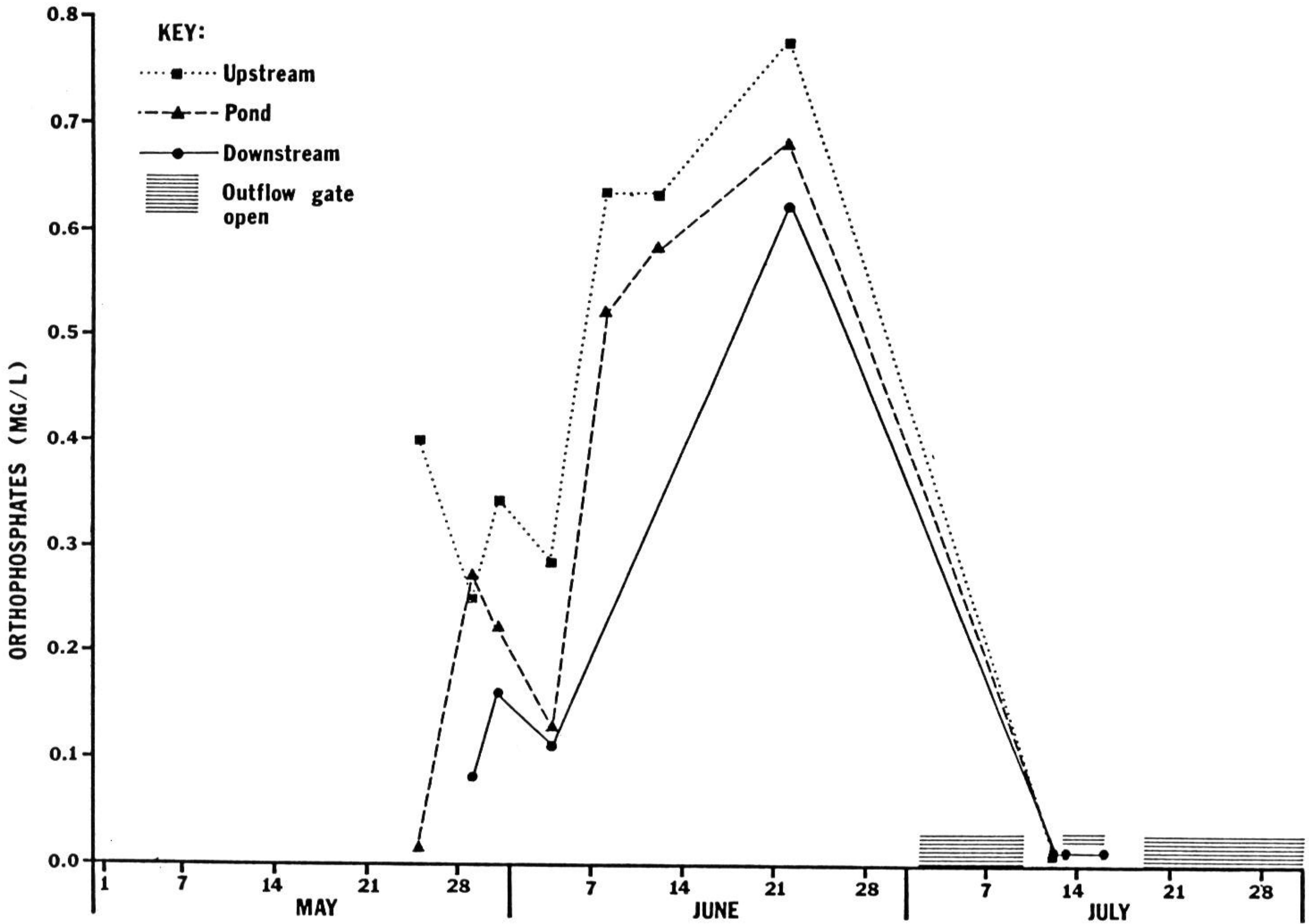

Figure 7. Orthophosphates (MG/L) for SCS#3.

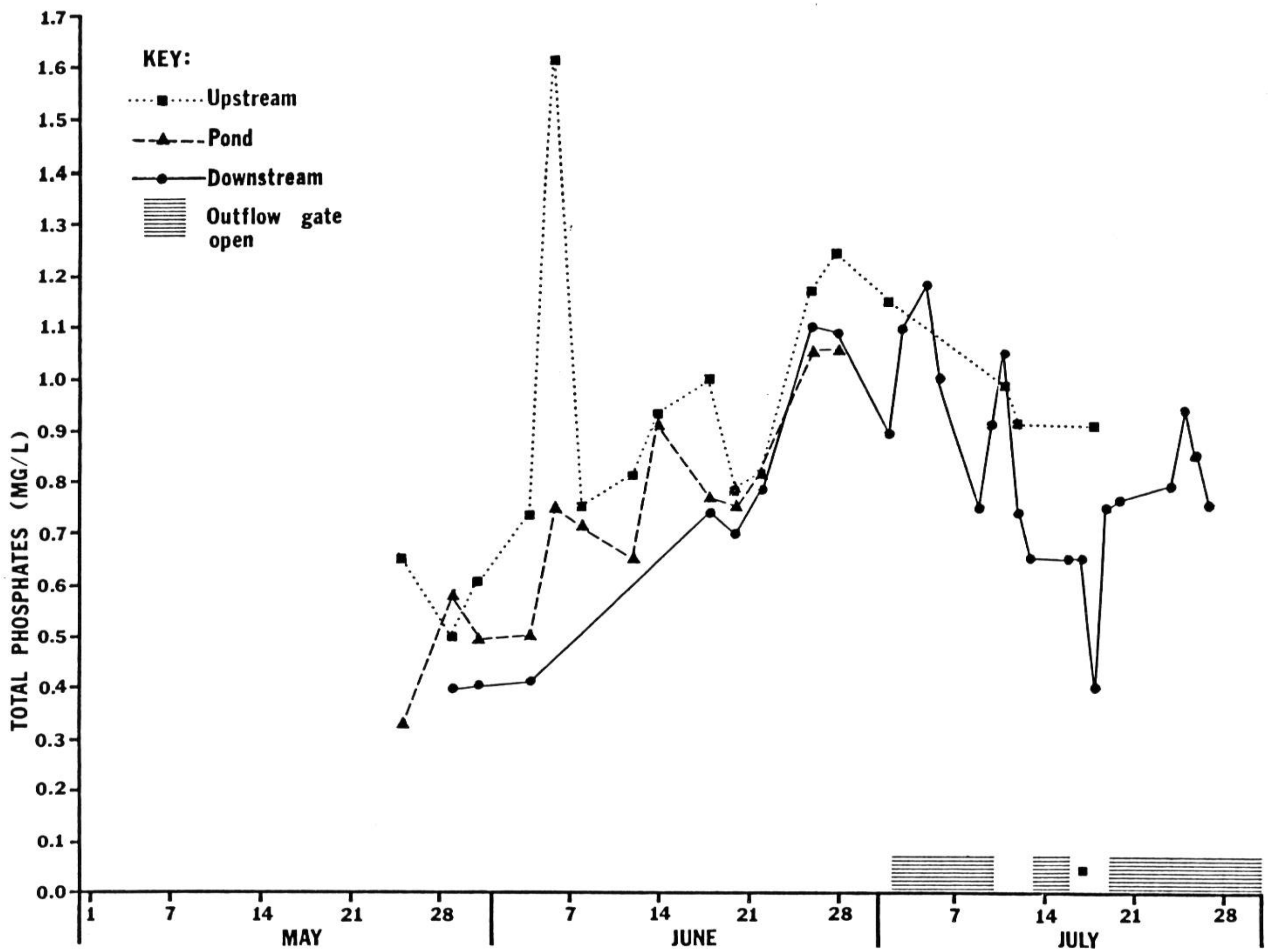

Figure 8. Total phosphates (MG/L) for SCS#3.

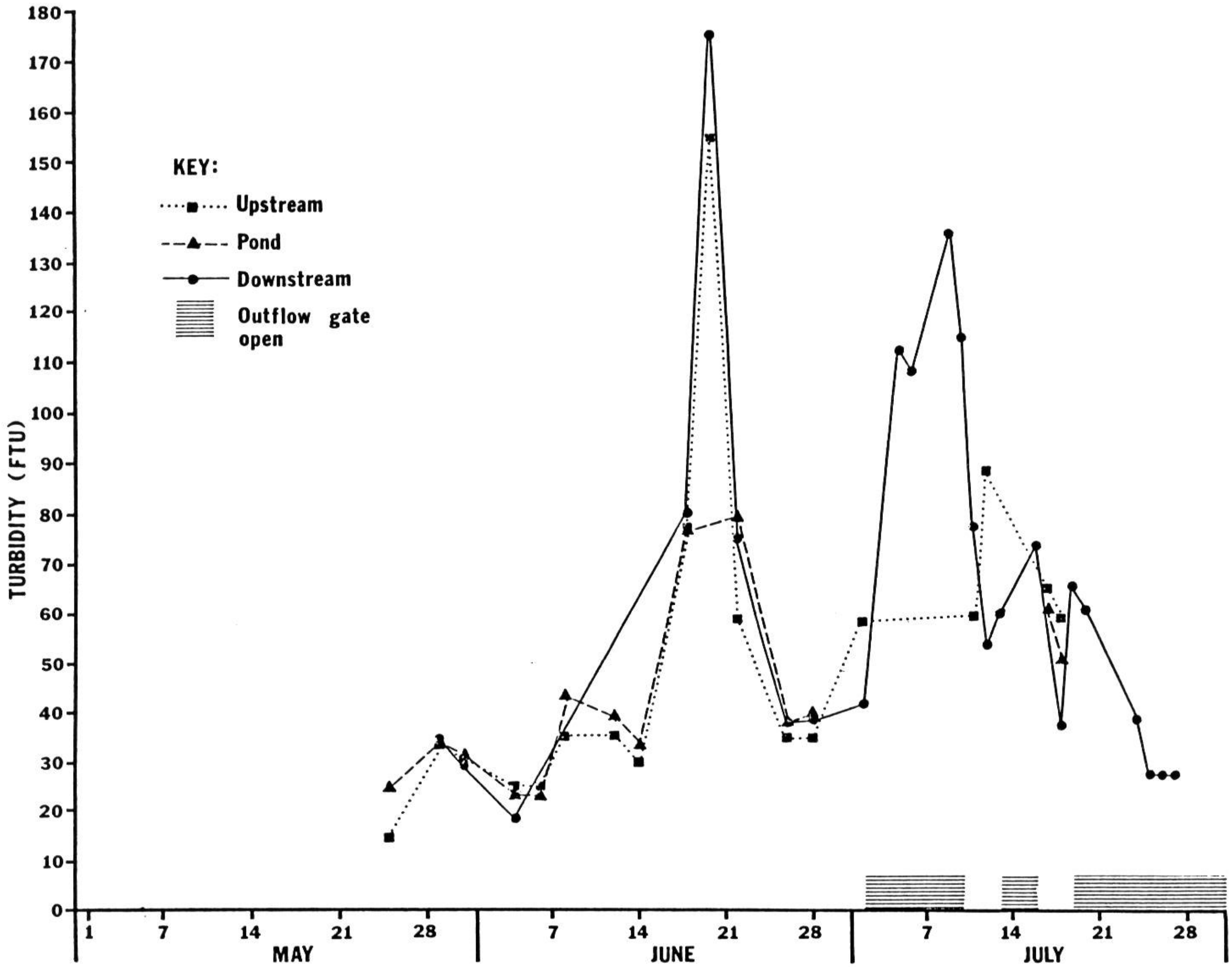

Figure 9. Turbidity (FTU) for SCS#3.

the presence of algae in the pond (included in turbidity measurements) may mask any changes in turbidity due to settling of incoming ~~nutrients~~ SEDIMENTS.

It is recommended that algae in the pond be quantified by either enumeration or chlorophyll a analysis. Since algae (and other biota) are included in turbidity measurements, it is recommended that suspended particulate matter at the sampling sites be separated and measured as two components: volatile and nonvolatile suspended solids. Although this does not necessarily distinguish between living and nonliving matter, it should partially account for the effect of algae on total suspended solids measurements. Imhoff cones could also be used to quantify settleable matter. It is also recommended that nutrient analysis be expanded to include total and dissolved fractions because of the possibility that SCS#1 may have no net effect on dissolved nutrients.

A hydrologic budget should also be constructed. The amount (mass) of nutrients that could potentially be introduced into Lake Herman should be quantified because it may be used to predict changes in lake trophic state. In addition, quantification of nutrient and sediment masses in the inflows and outflows of SCS#1 will provide for a more accurate assessment of the effectiveness of SCS#1 in reducing nutrients and sediments. Without flow data, nutrient mass loadings cannot be calculated.

The operation of SCS#1 should be modified. After June 7, SCS#1 was not effective in reducing nutrient concentrations and so water releases should be minimized during the summer. The nutrient concentrations and turbidity levels in the outflow were relatively high during July when the "bottom" outflow gate was open. Although speculation, it is possible that opening the "bottom" gate simply flushes out nutrient and silt laden water closely associated with the pond sediments. Consideration should be given towards keeping the "bottom" outflow gates of SCS#1 closed at all times.

<u>Sediment Control Structure #3</u>

SCS#3 was not effective in reducing nutrient concentrations or turbidity levels during the study. The structure was full and spilling over during much of the study and it is hypothesized that there was insufficient time to allow settling of incoming sediments. Algae, as in the case of SCS#1, may also be a factor.

Many of the recommendations for SCS#1 are applicable to SCS#3. These include; quantifying algae, separating suspended solids into organic and inorganic fractions, measuring dissolved fractions of nutrients, constructing a hydrologic budget, and leaving the bottom outflow gates closed at all times.

APPENDIX A
ORIGINAL DATA FOR SCS#1

TABLE 3. WATER TEMPERATURE (^{o}C) FOR SCS#1

	upstream	pond surface	pond bottom	downstream
5-24-84		16	16	
5-28-84	11	11	10	12
5-30-84		15	14	16
6-01-84	18	19	19	19
6-05-84	19	19	18	19
6-07-84	19	20	19	19
6-15-84	18	18	17	18
6-19-84	19	22	21	19
6-21-84	19	20		20
6-25-84	22	21	21	22
6-27-84	18	21	20	21
6-29-84		22	21	22
7-05-84				19
7-06-84				15
7-10-84	18			17
7-11-84	20			21
7-12-84				21
7-17-84		18		

TABLE 4. AMMONIA (MG N/L) FOR SCS#1

	upstream	pond surface	pond bottom	downstream
5-22-84	2.20	1.27	1.29	
5-28-84	2.05	1.00	0.95	0.90
5-30-84	1.75	1.16	1.31	1.27
6-01-84	1.91	1.18	1.14	1.40
6-05-84	3.81	1.35	1.41	1.36
6-13-84	1.85	1.94	1.94	1.91
6-15-84	1.10	0.96	1.09	1.07
7-12-84				2.44
7-13-84				2.38
7-17-84				4.00

TABLE 5. ORTHOPHOSPHATE (MG/L) FOR SCS#1

	upstream	pond surface	pond bottom	downstream
5-22-84	1.28	0.14	0.11	
5-24-84	0.95	0.12	0.13	
5-28-84	0.90	0.10	0.17	0.09
5-30-84	0.88	0.13	0.16	0.04
6-01-84	1.33	0.18	0.19	0.05
6-05-84	1.23	0.24	0.24	0.22
6-13-84	0.57	0.66	0.66	0.10
6-15-84	0.48	0.27	0.39	0.36
6-25-84	1.40	1.38	1.37	1.20
7-12-84				0.97
7-13-84				1.03

TABLE 6. TOTAL PHOSPHATES (MG/L) FOR SCS#3

	upstream	pond surface	pond bottom	downstream
5-22-84	1.20	0.20	0.26	
5-24-84	1.19	0.29	0.27	
5-28-84	0.90	0.30	0.27	0.15
5-30-84	1.05	0.34	0.38	0.26
6-01-84	1.53	0.39	0.34	0.27
6-05-84	1.58	0.35	0.43	0.36
6-07-84	1.92	0.26	0.33	0.31
6-13-84	0.62	0.75	0.75	0.79
6-15-84	0.60	0.36	0.41	0.42
6-19-84	0.98	0.83	0.61	0.71
6-21-84	0.57	0.65		0.77
6-25-84	1.45	1.45	1.45	1.30
6-27-84	1.46	1.80	1.87	1.70
6-29-84	2.06	1.42	1.34	1.45
7-02-84				1.44
7-03-84				1.53
7-05-84				2.05
7-06-84				2.43
7-10-84	2.51			2.37
7-11-84				1.99
7-12-84				1.34
7-13-84				1.56
7-17-84				1.81

TABLE 7. TURBIDITY (FTU) FOR SCS#1

	upstream	pond surface	pond bottom	downstream
5-22-84	18	10	10	
5-24-84	17	10	9	
5-28-84	17	18	17	20
5-30-84	17	13	16	23
6-01-84	22	15	16	25
6-05-84	31	12	16	13
6-07-84	25	12	11	12
6-13-84	18	20	20	20
6-15-84	41	57	51	52
6-19-84	32	37	38	39
6-21-84	50	77		76
6-25-84	34	35	39	38
6-27-84	28	46	50	47
6-29-84	41	43	50	50
7-02-84				90
7-03-84				72
7-05-84				102
7-06-84				203
7-10-84				137
7-11-84				111
7-12-84				51
7-13-84				141
7-17-84				247

APPENDIX B
ORIGINAL DATA FOR SCS#3

TABLE 8. WATER REMPERATURE (°C) FOR SCS#3

	upstream	pond surface	pond bottom	downstream
5-25-84		16	14	
5-29-84		14	12	
5-31-84		15	14	16
6-04-84	17	17	17	17
6-06-84	21	21	20	
6-08-84	15			
6-12-84	17	17	17	
6-14-84	19	20	20	
6-18-84	22	24	20	22
6-20-84	24	24	19	23
6-22-84	19	19	19	19
6-26-84	26	26	21	25
6-28-84	21	23	19	23
7-02-84	22			23
7-05-84				17
7-06-84				17
7-09-84				23
7-10-84				19
7-11-84	23			
7-12-84	26	24		
7-16-84				27
7-17-84	22	22		
7-18-84	21	22		21
7-19-84				22
7-20-84				23
7-25-84				19
7-26-84				18
7-27-84				18

TABLE 9. AMMONIA (MG N/L) FOR SCS#3

	upstream	pond surface	pond bottom	downstream
5-29-84	1.44	1.94	0.94	0.86
5-31-84	2.87	1.55	1.65	1.49
6-04-84	3.21	1.78	1.71	2.18
6-08-84	1.84		2.16	
6-12-84	1.04	1.05	1.04	
6-22-84	1.03	1.04	1.18	1.12
7-03-84				1.62
7-12-84	0.89	0.61		0.69
7-13-84				0.62
7-16-84				0.62
7-17-84	4.60	1.27		

TABLE 10. ORTHOPHOSPHATE (MG/L) FOR SCS#3

	upstream	pond surface	pond bottom	downstream
5-25-84	0.40	0.03	0.04	
5-29-84	0.25	0.13	0.41	0.08
5-31-84	0.34	0.21	0.24	0.16
6-04-84	0.28	0.14	0.13	0.11
6-08-84	0.63		0.52	
6-12-84	0.62	0.58	0.57	
6-22-84	0.77	0.66	0.70	0.62
7-12-84	0.02	0.03		0.03
7-13-84				0.04
7-16-84				0.03

TABLE 11. TOTAL PHOSPHATES (MG/L) FOR SCS#3

	upstream	pond surface	pond bottom	downstream
5-25-84	0.66	0.35	0.31	
5-29-84	0.50	0.50	0.65	0.40
5-31-84	0.61	0.43	0.56	0.41
6-04-84	0.73	0.46	0.55	0.43
6-06-84	1.62	1.04	0.45	
6-08-84	0.75		0.72	
6-12-84	0.82	0.68	0.63	
6-14-84	0.93	0.92	0.90	
6-18-84	1.00	0.70	0.85	0.74
6-20-84	0.78	0.79	0.71	0.70
6-22-84	0.82	0.76	0.88	0.78
6-26-84	1.17	1.06	1.05	1.10
6-28-84	1.24	1.07	1.04	1.08
7-02-84	1.15			0.89
7-03-84				1.11
7-05-84				1.18
7-06-84				1.01
7-09-84				0.75
7-10-84				0.92
7-11-84	0.98			1.05
7-12-84	0.92			0.73
7-13-84				0.66
7-16-84				0.65
7-17-84	0.07			0.65
7-18-84	0.91			0.40
7-19-84				0.74
7-20-84				0.76
7-24-84				0.79
7-25-84				0.94
7-26-84				0.85
7-27-84				0.75

TABLE 12. TURBIDITY (FTU) FOR SCS#3

	upstream	surface	bottom	downstream
5-25-84	15	21	30	
5-29-84	33	38	29	35
5-31-84	31	32	33	29
6-04-84	25	21	24	18
6-06-84	24	22	22	
6-08-84	36		43	
6-12-84	36	38	40	
6-14-84	30	30	36	
6-18-84	77	68	85	80
6-20-84	154	161	257	175
6-22-84	58	73	84	75
6-26-84	35	38	38	38
6-28-84	34	39	42	39
7-02-84	57			42
7-05-84				112
7-06-84				108
7-09-84				136
7-10-84				114
7-11-84	59			77
7-12-84	87			53
7-13-84				60
7-16-84				73
7-17-84	65	61		
7-18-84	58	51		37
7-19-84				66
7-20-84				61
7-24-84				38
7-25-84				27
7-26-84				26
7-27-84				27