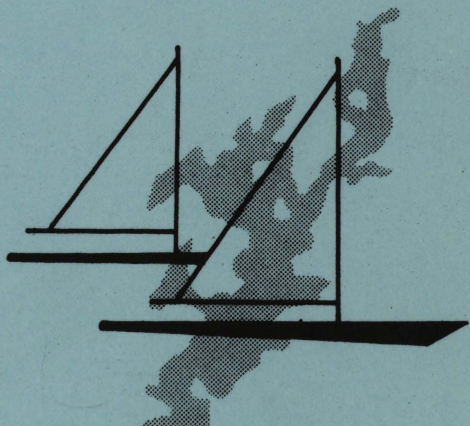
LAKE HOPATCONG

REGIONAL

PLANNING BOARD



1975

WATER QUALITY SURVEY

Lake Hopatcong Regional Planning Board

1975 LAKE TESTING PROGRAM

June 1978

Clifford R. Lundin

1975 LAKE TESTING PROGRAM

Table of Contents

Table of Contents (Continued)

Table of Contents (Continued)

Appendices

Acknowledgments

This is the second in a series of reports dealing with water quality in Lake Hopatcong. The survey program was authorized in late 1973 by the Lake Hopatcong Regional Planning Board to determine trends in the water quality of the Lake and to allow the Board to make meaningful recommendations to State, county and local officials to protect and maintain this important resource.

The actual design of the water testing program was undertaken by Mr. Frank Bolton, Marine Fisheries Specialist with the N.J. Department of Environmental Protection, Division of Fish and Game, in conjunction with Clifford R. Lundin, a member of the Lake Hopatcong Regional Planning Board, Hopatcong Borough Environmental Commission and a graduate environmental scientist, and Harvey S. Moskowitz, PP/AIP, Lake Hopatcong Regional Planning Board consultant. The testing program was begun in 1974.

The actual collection of water for the various analyses, as well as the Hach kit tests, DO tests, water and air temperatures, and pH determination were done by the Planning Board consultant. The chemical and bacteriological analyses were undertaken by the Lakeland Laboratories of Wharton (formerly in Jefferson Township). This report including the initial preparation of all charts and graphs was written by Clifford R. Lundin and edited by Harvey S. Moskowitz, PP/AIP.

As with the 1974 report, the recommendations contained at the beginning of this report are not necessarily those of the Lake Hopatcong Regional Planning Board although the Board has concurred with and discussed similar recommendations over the past year. However, no formal action has ever been taken by the Board offocially adopting these recommendations as the policy of the Board.

Abstract

Lake Hopatcong in northern New Jersey was subjected to annual water quality sampling in 1974 and 1975. This report summarizes the results of the 1975 study. Six sites were studied for temperature, oxygen, chlorides, nitrates, ammonia, phosphate and fecal coliform. Samples were taken throughout the year and before and after heavy use weekends, before and after a heavy storm and during a regularly scheduled drawdown of water levels. The lake was found to be eutrophic and subject to large blooms of aquatic vegetation. Phosphorous was found to be the limiting nutrient. Point sources contributed the largest source of this nutrient.

Between 1974 and 1975, there was no statistically significant change in quality. There were, however, significant changes after heavy recreational use and storms. Drawdown effects appeared to be localized.

This report also discusses ongoing studies as well as recommendations to preserve and enhance water quality.

Summary and Conclusions

1. Lake Hopatcong in general follows normal temperate lake principles.
2. The lake can be classified as "culturally eutrophied" -- starting the dying process. This is essentially due to man's practices including nutrient input, overdevelopment of the basin, and overutilization of the water.
3. Lake water quality and levels can be changed rapidly as a result of natural and man-made activity including storm runoff and heavy recreational use.
4. Water quality in all parts of the lake follows the same basic pattern except that areas near the shore are subject to higher levels of organic pollution.
5. Station 3 (Church Lane Landing) seems most representative of total lake conditions.
6. pH in the lake undergoes an annual cycle of alkalinity in the spring and gradually decreasing during the summer and fall.

   This is probably due to photosynthesis activity in the lake.
7. Dissolved oxygen becomes depleted in the lower levels during the annual summer stratification.
8. Ammonia is rapidly oxydized to nitrate in the lake.
9. Nitrate and phosphate are rapidly used by aquatic vegetation in the lake.
10. Phosphorous appears to be the limiting nutrient throughout the majority of the year.

11. Fecal coliform in the lake usually is in a low residual level. Massive increases can be seen after heavy recreational use weekends and after heavy storms.

12. There is an annual accumulation of plant nutrients (nitrogen and phosphorous) each year. This will only hasten the eutrophication process and eventually kill the lake.

13. Nutrient input into the lake must be controlled both for point sources and nonpoint sources.

14. There are at least four point sources of treated sewage effluent entering the lake.

15. Chlorides in the lake undergo a yearly cycle with highest levels in the spring and lowest in early fall. This would suggest road salts as the primary source.

16. Station 2 (River Styx) appears to be receiving some raw waste, probably septic waste, and should be investigated by the local board of health.

17. Heavy recreational use weekends can have a significant detrimental effect on water quality including increased phosphate, higher fecal coliform and lower dissolved oxygen.

18. Stormwater runoff has a detrimental effect on water quality by lowering dissolved oxygen saturation and significantly raising fecal coliform.

19. Drawdown effects include a lakewide lowered pH and several localized effects which, while not detrimental to overall water quality, may be in the local area.

20. The results of the L.H.R.P.B. study seem compatible with other recent studies.

Recommendations

I. For Lake Hopatcong

A. Nutrient control is the highest priority in any lake management program. It should include the following actions:

1. Encourage and promote the investigation of sewage treatment facilities or septic management districts. If a regional sewerage system is proposed, it should discharge below the lake and not significantly decrease the water available to the lake. Any water losses from the basin should be compensated by adjusting the flow at the dam.

2. Future testing programs should include an analysis of the bottom sediment to determine amount of nutrient material available.

3. A program of monitoring and stringent regulation of existing point sources into the basin is needed. This program should include:

   a. The L.H.R.P.B. becoming involved in the NPDES permit process by requesting copies of all discharge reports of facilities discharging into the lake.

   b. The Board should act as a watchdog over the EPA and State agencies and insure that all appropriate State and federal regulations are met.

   c. The Board should request that all discharges into the basin should monitor for nutrients and include compliance schedules placed in the permits for phosphorous removal.

4. The Board must take steps to encourage nonpoint pollution source control. This includes:
   a. Need for soil erosion and sedimentation and surface water management control ordinances in all Lake Hopatcong area municipalities.
   b. Ban septic installation within 100 feet of the lake.
   c. Initiate a program to systematically determine through dye tests the effectiveness of septic tanks around the lake.
   d. Conduct an inventory and investigation of all pipes of any kind entering the lake.
   e. Ban sale of phosphate detergents in towns surrounding the lake.
   f. Ban soap bathing in the lake.
   g. Encourage treatment of storm water and discourage the discharge of storm water into the coves of the lake.
   h. Legislate against any filling in of the lake basin for whatever purpose by anyone.
   i. Encourage limiting impervious surface to not more than 10-20 percent to encourage ground recharge.
5. The L.H.R.P.B. should investigate the feasibility of lake dredging during the next regularly scheduled draw-down in the fall of 1980. It is recommended that the following areas be given the highest priority in any dredging program:
   a. River Styx Cove
   b. Ingram Cove
   c. Kings Cove

d. Landing Channel

e. Woodport Cove

This program would serve the purpose of permanent nutrient removal from the basin as part of the aquatic weed control program. Funding may be available as a demonstration grant under Section 104 h(A) of the Federal Water Pollution Control Act Amendment of 1972 (PL 92-500) to determine if the autrophication process can be reversed.

B. The L.H.R.P.B. should closely investigate the dissolved oxygen in the hypolimnia in future studies to determine the need for possible aerators in the main lake to aerate the hypolimnia. These aerators should by of the type which will not destratify the lake.

C. The Lake Hopatcong Regional Planning Board should maintain close cooperation with the 208 Planning Agency and the 201 Planning Agency. Joint meetings should be held periodically at frequent intervals.

D. The Lake Hopatcong Regional Planning Board should seek to establish a master data base file of all published information on Lake Hopatcong and similar lakes.

E. The Lake Hopatcong Regional Planning Board should request of its constituent municipalities the right to review and comment upon all major subdivisions and site plans involving over 20 units and/or over five acres in area within the watershed.

F. The Lake Hopatcong Regional Planning Board should seek designation by the State as the official water quality agency in the watershed and provide input on all State actions affecting the lake.

G. The Lake Hopatcong Regional Planning Board should embark on a program of public participation in the water quality planning process and maintain contact with all Lake Hopatcong citizen groups.

II. To Improve Sampling Program

It is recommended in early 1978 a review be given to the 1976 and 1977 data to determine if the trends for the third year again parallel those of 1974 and 1975. If it does, a modified sampling schedule should be proposed with (1) less frequent sampling at all stations; and (2) more intense sampling during problem areas or areas of special interest.

These special areas include:

A. Tests of water quality before and after the weed program.

B. Bacterial tests at swimming beaches.

C. Influent streams to the lake.

D. DO stratification in the main lake.

E. Point source influent data.

F. Storm water effects.

Introduction

Lake Hopatcong, located in northern New Jersey, consists of approximately 2,500 surface acres and almost 40 miles of shoreline. Being on the outskirts of the metropolitan New York area, the lake is subject to intense shoreline development and heavy recreational use.

In 1964, the Lake Hopatcong Regional Planning Board was formed as the central coordinating lake advisory body. One of the prime functions of the Board is to undertake studies dealing with lake usage and quality.

In late 1973, the Lake Hopatcong Regional Planning Board authorized the initiation of a long-term water quality study on Lake Hopatcong. Previously, several one-time tests had been undertaken by various agencies and groups. No long-term comprehensive study had ever been undertaken. The purposes of the survey were:

1. to establish base line water quality conditions in the lake upon which future changes could be determined;
2. to observe yearly and seasonal trends in water quality;
3. to determine the effect of heavy recreational use on water quality;
4. to determine effects of stormwater runoff on water quality and use as a basis for determining nonpoint source pollution;
5. to describe the effect on water quality of various point sources of pollution; and
6. to coordinate and correlate study findings to other existing water quality data.

A report entitled, 1974 Water Quality Survey (Lundin, 1975) was released by the Board in October of 1975 and dealt with the findings and conclusions during the 1974 calendar year.

The sampling sites during the 1975 sampling survey remained the same as in 1974 (for a description of the sites and the reasons for their selection, see Lundin 1975), and were as follows:

1. Hopatcong State Park;
2. River Styx Bridge;
3. Church Lane Landing (near Sunrise Point);
4. Lorretecong Road (at outlet of Lake Winona);
5. Oak View Park; and
6. Main Lake (on a line between Chestnut Point and Elba Point).

(See Figure 1.)

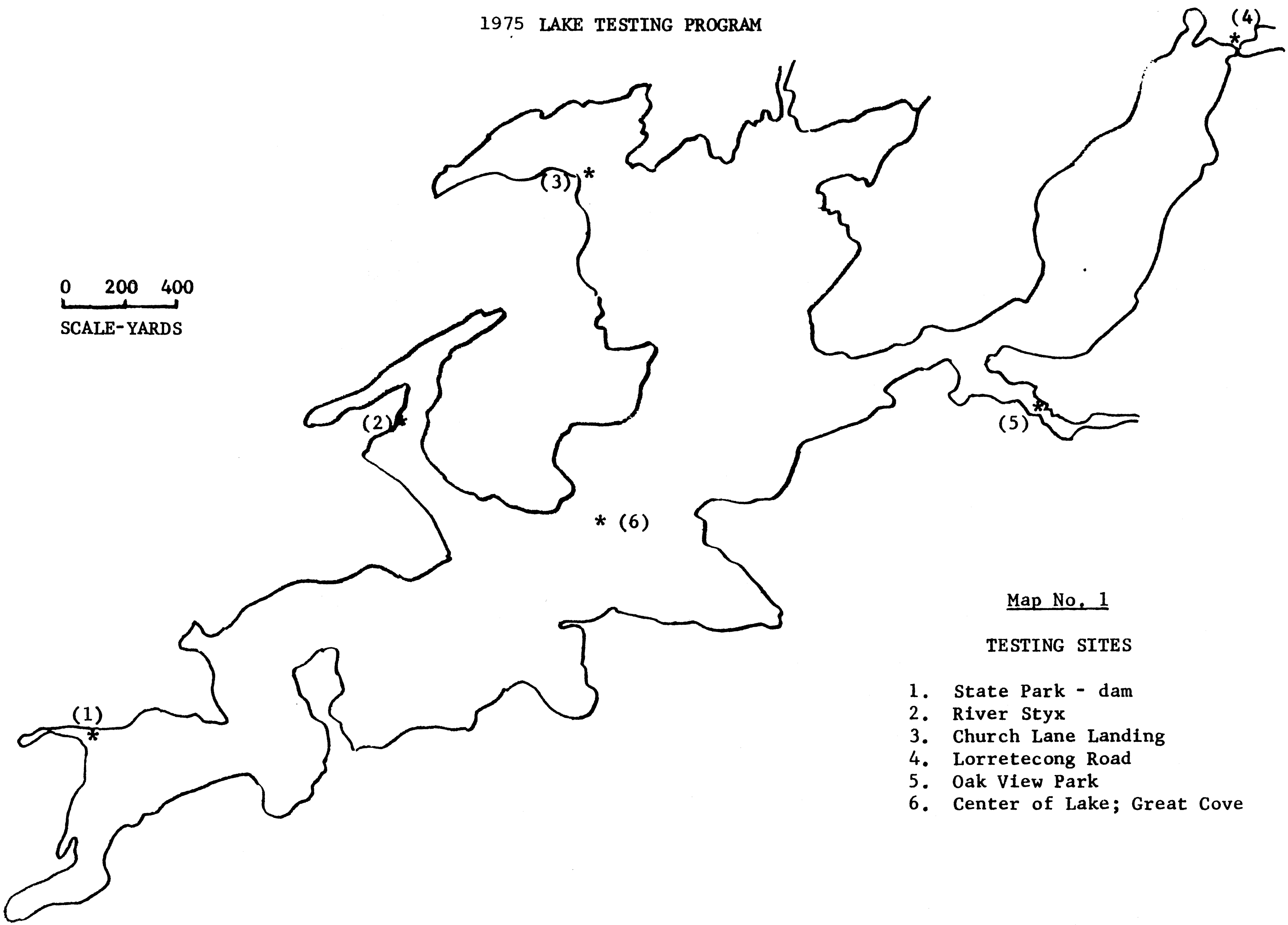
In 1975, samples were taken on the following dates:

1. 21 April, 1975
2. 5 May, 1975
3. 27 May, 1975
4. 1 July, 1975 — To plot changes, if any, over the July 4 weekend. (4 and 5)
5. 7 July, 1975
6. 14 July, 1975 — To plot changes, if any, over a heavy storm period 11 July, 1975 to 14 July, 1975. (5 and 6)
7. 28 August, 1975 — To plot changes, if any, over the Labor Day weekend. (7 and 8)
8. 2 September, 1975
9. 10 November, 1975
10. 15 December, 1975.

The dates chosen for the sampling closely approximated the 1974 dates with continued emphasis on the summer season but with samples taken throughout the year when the lake was free of ice.

Lake Hopatcong Regional Planning Board

1975 LAKE TESTING PROGRAM



Map No. 1

TESTING SITES

1. State Park - dam
2. River Styx
3. Church Lane Landing
4. Lorretecong Road
5. Oak View Park
6. Center of Lake; Great Cove

The regularly scheduled five-year drawdown of lake waters was also undertaken in 1975. The drawdown drops the level of the lake a maximum of eight feet and allows repairs to docks and other structures. In 1975, the dam at Station 1 underwent major repairs.

A graph of lake levels during 1975 can be seen as Figure 2 with the 0 base as the top of the dam. On November 10, 1975 the lake was 7 feet below normal and by December 15 it was 7.5 feet below dam level. Samples taken on these dates were used to determine any effect of the drawdown on water quality.

Discharge records for the water year 1975 (October 1, 1975 to September 30, 1975) are shown in Table 1, as determined by U.S. Geological Survey (1976).

At each station, the following parameters were recorded:

1. Station number;
2. Date and time of sample;
3. Air and water temperature in degrees F and C;
4. Dissolved oxygen (DO) in mg/liter;
5. pH in standard pH unit (-log $[H^+]$);
6. Phosphate (PO_4) in mg/liter (ortho);
7. Nitrate (NO_3) reported in mg/liter of nitrogen;
8. Ammonia (NH_3) reported in mg/liter of nitrogen;
9. Chloride (Cl^-) in mg/liter;
10. Fecal coliform in colony forming units per 100 ml.
11. Visible pollutants at site and in the sample;
12. Lake level as determined by J.S.G.S. guage height at Station 1;
13. Weather for preceding three days.

Table 1

DISCHARGE, IN CUBIC FEET PER SECOND,

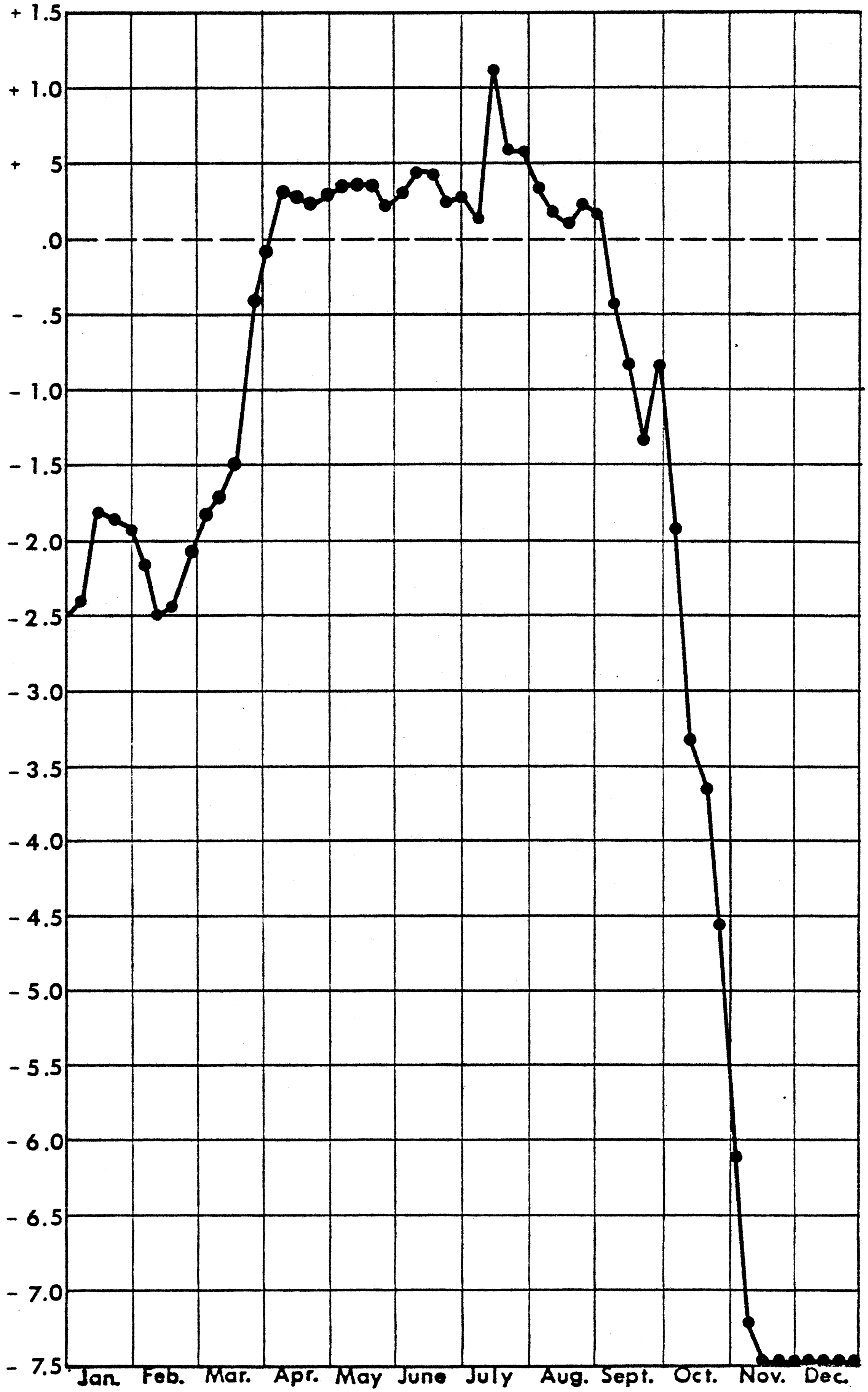
WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975,

MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	80	116	30	44	124	38	7.8	49	54	49	89	26
2	80	116	30	24	124	37	7.8	51	53	39	55	52
3	80	115	51	15	124	37	21	48	47	36	50	72
4	80	80	59	16	123	37	48	56	44	33	45	68
5	79	27	59	16	123	37	59	68	44	28	53	96
6	79	27	59	15	123	37	63	63	99	27	51	120
7	79	26	59	16	123	18	63	71	123	26	46	120
8	78	26	59	15	122	9.2	62	66	119	22	41	118
9	78	26	105	27	122	9.8	59	61	109	21	35	118
10	77	26	123	38	71	9.4	56	57	92	20	30	117
11	75	25	123	38	37	9.4	55	51	78	17	28	117
12	75	15	123	55	37	9.4	52	49	88	16	26	116
13	75	6.2	132	63	37	9.2	48	76	106	138	23	117
14	75	6.6	138	63	37	8.2	44	109	100	290	21	117
15	74	6.0	136	63	37	6.7	43	98	88	329	19	116
16	89	5.9	149	94	37	6.9	44	103	79	309	20	116
17	117	5.9	163	110	37	8.0	41	99	76	261	19	116
18	136	8.2	163	109	37	9.4	37	88	65	254	19	138
19	135	8.4	163	109	37	7.1	42	81	63	176	16	147
20	134	8.4	162	110	37	5.5	40	72	67	141	14	146
21	133	20	160	109	37	6.9	39	68	57	199	12	146
22	133	31	159	109	37	8.2	32	59	47	193	11	159
23	115	31	158	109	37	8.2	31	56	40	163	11	174
24	101	31	156	109	38	8.4	37	58	37	145	11	163
25	101	31	158	109	72	8.2	59	53	36	228	34	100
26	111	31	156	109	86	8.0	71	39	31	220	39	122
27	118	30	85	109	87	8.0	65	36	31	167	37	147
28	118	30	44	121	57	8.0	59	33	39	151	31	163
29	117	30	44	126	---	8.0	56	28	57	158	27	163
30	117	30	44	126	---	7.8	51	28	62	147	31	163
31	117	---	44	126	---	7.8	---	35	---	129	31	---
TOTAL	3056	975.6	3294	2302	2000	436.7	1392.6	1909	2031	4132	975	3653
MEAN	98.6	32.5	106	74.3	71.4	14.1	46.4	61.6	67.7	133	31.5	122
MAX	136	116	163	126	124	38	71	109	123	329	89	174
MIN	74	5.9	30	15	37	5.5	7.8	28	31	16	11	26

CAL YR 1974 TOTAL 20994.7 MEAN 57.5 MAX 205 MIN 2.4
WTR YR 1975 TOTAL 26156.9 MEAN 71.7 MAX 329 MIN 5.5

1975 LAKE FLUCTUATIONS



From this data, the following were also derived:

1. Dissolved oxygen percent saturation defined as;

$$\frac{\text{DO recorded value}}{\text{DO saturation value for specific temperature}} \times 100$$

2. Nitrogen and phosphorous ratio defined for this particular study as;

$$\frac{\text{moles of } NH_3\text{-N per liter} + \text{moles of } NO_3\text{-N per liter}}{\text{moles of } PO_4 \text{ as P per liter}} = NP$$

It also must be noted on test dates 27 May, 28 August, tests for fecal streptococci bateria were performed and recorded in colony forming units/100 ml.

For a discussion of the importance of each parameter, see (Lundin, 1975).

Dissolved oxygen measurements were taken at the site using a portable Hach test kit #01612 which utilizes a revised Winkler Titration Method.

All water samples were taken at a depth of six inches (except Station 6) in pre-cleaned and pre-sterilized 1 liter bottles provided to the Board by independent testing laboratory (Lakeland Labs). At Station 6 a sample was taken at 6 inches for all parameters and at 40 feet for dissolved oxygen.

All water samples were analyzed at Lakeland Labs, a state-certified lab at Lake Hopatcong, New Jersey, using techniques found in Standard Methods for the Examination of Water and Wastewater, 13th edition.

The 1974 study had insufficient data to determine the effects of heavy recreational use and stormwater runoff. In 1975, additional data was obtained regarding these factors. This study will attempt to undertake statistical analyses using both 1974 and 1975 data to determine the relationship between these factors and water quality. This study also takes data from the fall of 1974 and compares it with the fall of 1975 data to determine the relationship of the lake drawdown to water quality.

In addition, in 1973 the United States Environmental Protection Agency as part of the National Eutrophication Survey sampled point sources, inflows and outflow and water quality in the lake. This data has recently become available. Several of the sampling locations in the EPA study (1976) parallel L.H.R.P.B. sampling sites and will be compared with the Board's data as part of this report.

Results

The actual raw score water quality results obtained in this study during 1975 with the mean value for that particular parameter can be seen as Tables 2-7. Table 8 presents data from the 40-foot depth and Table 9 presents special sampling results.

Table 10 shows the data as a mean value of all sampling locations for each sample date. N/P ratios are also shown. Table 11 shows the data as a mean value of all samples taken during the 1975 calendar year at each sample site. Also included is the nitrogen/phosphorous ratio for each station.

The data can also be seen in graphic form by individual stations and as a lake mean (by sampling date) in the appendix of this report.

SUMMARY OF TESTS -- Table 2

Site # 1 Location DAM - STATE PARK

Test #	1975 Date	Temperature Water °F	Air °F	DO	pH	Phosphates	Chlorides	% O_2 Sat.	NO_3-N Nitrate	NH_3-N Ammonia	Fecal Coliform	Fecal Strep.	FC/FS
1	4/21	33	52	14	7.8	<.1	54	97.2	<.05	2.9	0		
2	5/5	38	52	13	7.6	<.1	32	97.7	<.05	<.15	248		
3	5/27	54	70	11	7.9	<.1	30	101.8	<.05	.13	0	12	0
4	7/1	59	79	10	7.9	<.1	32	98	<.1	.3	34		
5	7/7	76	80	9	7.5	<.1	32	105.8	<.1	.05	8		
6	7/14	74	80	7	7.1	<.1	29	80.4	<.1	.07	400		
7	8/28	74	74	9	7.0	<.1	28	103.4	<.05	.23	4	224	.017
8	9/2	69	67	8	7.2	<.1	30	87.9	<.05	.1	4		
9	11/10	56	63	9	7.0	<.1	27	84.9	.1	.14	6		
10	12/15	40	49	10	6.5	<.1	28	80.7	.05	.1	2		
11	Mean	57.3	66.6	10.05	7.35	<.1	32.2	93.78	<.07	.417	70.6	118	.0085
12													
13													
14													
15													
16													

SUMMARY OF TESTS -- Table 3

Site # 2 Location RIVER STYX

Test #	1975 Date	Temperature Water	Air	DO	pH	Phosphates	Chlorides	% O_2 Sat.	NO_3-N Nitrates	NH_3-N Ammonia	Fecal Coliform	Fecal Strep.	FC/FS
		°F	°F										
1	4/21	34	50	12	7.8	<.1	51	84.5	<.05	.13	0		
2	5/5	39	52	13	7.5	<.1	33	98.4	<.05	.10	20		
3	5/27	54	72	9	7.4	<.1	32	83.3	.1	.22	12	690	.02
4	7/1	60	83	11	7.4	<.1	33	108.9	<.1	.15	28		
5	7/7	76	75	8	6.8	<.1	32	94.1	.1	-	8		
6	7/14	76	82	5	7.1	<.1	28	58.8	<.1	.10	240		
7	8/28	74	72	9	6.5	<.1	30	103.4	.1	.40	100	440	.227
8	9/2	69	69	7	7.1	<.1	27	76.9	.15	.03	0		
9	11/10	62	60	6	7.1	<.1	83	61.2	.1	.26	180		
10	12/15	48	50	3	6.1	<.1	97	25.8	2.3	.05	0		
11	Mean	59.2	66.1	8.3	7.08	<.1	44.6	79.53	.315	.16	274.8	565	.1235
12													
13													
14													
15													
16													

SUMMARY OF TESTS -- Table 4

Site # 3 Location CHURCH LANDING

Test #	1975 Date	Temperature Water	Air	DO	pH	Phosphates	Chlorides	% O_2 Sat.	NO_3-N Nitrates	NH_3-N Ammonia	Fecal Coliform	Fecal Strep.	FC/FS
		°F	°F										
1	4/21	31	52	14	7.8	< .1	44	95.8	<.05	.23	0		
2	5/5	38	55	13	7.3	< .1	28	97	.1	.45	0		
3	5/27	56	72	10	7.4	< .1	29	95.2	.05	.21	0	4	0
4	7/1	60	83	11	7.6	< .1	30	108.9	<1	.1	8		
5	7/7	76	76	9	7.4	< .1	29	105	<1	.03	2		
6	7/14	76	76	7	7.3	< .1	27	82.3	<.1	.06	116		
7	8/28	74	74	8	6.8	< .1	26	93	.05	.07	0	20	0
8	9/2	71	65	8	7.1	< .1	26	85.1	<.05	.03	4		
9	11/10	58	64	10	6.8	< .1	25	105.2	.2	.13	4		
10	12/15	42	51	10	6.5	< .1	25	89.2	.05	.18	2		
11	Mean	58.2	66.8	10	7.2	< .1	28.9	95.67	.085	.149	13.6	12	0
12													
13													
14													
15													
16													

SUMMARY OF TESTS -- Table 5

Site # 4 Location LORRETACONG ROAD (LAKE WINONA)

Test #	1975 Date	Temperature Water °F	Air °F	DO	pH	Phosphates	Chlorides	% O_2 Sat.	NO_3-N Nitrates	NH_3-N Ammonia	Fecal Coliform	Fecal Strep.	FC/FS
1	4/21	38	57	13	7.8	<.1	47	97	.1	.9	6		
2	5/5	41	55	13	7.6	<.1	16	101.5	<.05	.17	12		
3	5/27	53	68	9	7.2	.4	22	82.5	.2	1.2	18	4	4.5
4	7/1	58	79	10	7.2	<.1	12	97	<.1	.6	184		
5	7/7	74	76	9	7.2	<.1	18	104.6	.1	.5	122		
6	7/14	66	76	9	6.9	<.1	9	96.7	.2	.45	1000		
7	8/28	71	71	8	6.9	<.1	11	89.8	.2	.42	320	960	.375
8	9/2	68	67	8	7.1	<.1	18	86.9	.1	.26	350		
9	11/10	58	64	9	6.6	<.1	13	87.3	.3	.24	8		
10	12/15	41	50	10.5	6.6	<.1	12	82.0	.2	.25	0		
11	Mean	56.8	66.3	9.85	7.11	<.13	17.8	92.53	.155	.449	202	482	2.4375
12													
13													
14													
15													
16													

SUMMARY OF TESTS -- Table 6

Site # 5 Location OAK VIEW PARK

Test #	1975 Date	Temperature Water °F	Air °F	DO	pH	Phosphates	Chlorides	% O_2 Sat.	NO_3-N Nitrates	NH_3-N Ammonia	Fecal Coliform	Fecal Strep.	FC/FS
1	4/21	39	58	12	7.7	<.1	43	40.2	<.05	.3	0		
2	5/5	42	58	12	7.5	<.1	17	95.2	<.1	.17	22		
3	5/27	56	68	9	7.2	<.1	15	85.7	.1	.40	24	110	.2
4	7/1	63	83	9	7.2	<.1	13	92.7	<.1	.3	72		
5	7/7	76	78	7	7.0	<.1	13	82.3	<.1	.8	8		
6	7/14	70	79	6	6.5	<.1	10	66.6	.15	.32	2200		
7	8/28	75	75	8	6.9	<.1	18	94.1	.1	.32	40	40	1
8	9/2	68	65	7	7.0	<.1	15	76.0	.15	.27	8		
9	11/10	58	65	7	6.4	<.1	12	67.9	.2	.23	36		
10	12/15	40	53	10.5	6.5	<.1	11	80.7	.05	.17	2		
11	Mean	58.7	68.2	8.75	6.99	<.1	16.7	83.14	.11	.378	241.2	75	.6
12													
13													
14													
15													
16													

SUMMARY OF TESTS -- Table 7

Site # 6 Location GREAT COVE - MIDDLE OF LAKE (SURFACE)

Test #	1975 Date	Temperature Water °F	Air °F	DO	pH	Phosphates	Chlorides	% O_2 Sat.	NO_3-N Nitrates	NH_3-N Ammonia	Fecal Coliform	Fecal Strep.	FC/FS
1	4/21		N O	T E S T									
2	5/5	37	50	14	7.6	<.1	29	10.29	<.05	.01	0		
3	5/27	54	70	10	7.5	<.1	29	92.5	<.05	.12	0	16	0
4	7/1	72	84	10	7.5	<.1	29	113.6	<.1	.13	6		
5	7/7	78	76	10	7.4	<.1	29	130.4	<.1	.15	0		
6	7/14		N O	T E S T									
7	8/28	74	74	9	7.3	<.1	27	104.6	<.05	.15	0	4	
8	9/2	70	66	8	7.1	<.1	27	81.0	.05	.1	0		
9	11/10		N O	T E S T									
10	12/15		N O	T E S T									
11	Mean	64.16	70	10.1	7.4	<.1	28.3	103.33	.06	.11	1	10	
12													
13													
14													
15													
16													

SUMMARY OF TESTS -- Table 8

Site # 7 Location GREAT COVE (40' DEPTH)

Test #	1975 Date	Temperature Water °F	Temperature Air °F	DO	pH	Phosphates			Chlorides			Nitrates			Ammonia			Fecal Coliform			Fecal Strep	FC/FS
1	4/21	N O	T E S T																			
2	5/5			13																		
3	5/27			9																		
4	7/1			5																		
5	7/7			3																		
6	7/14	N O	T E S T																			
7	8/28			2																		
8	9/2	70		4																		
9	11/10	N O	T E S T																			
10	12/15	N O	T E S T																			
11																						
12																						
13																						
14																						
15																						
16																						

SUMMARY OF TESTS -- Table 9

Location MISCELLANEOUS TESTS

Location	1975 Date	Temperature Water °F	Temperature Air °F	DO	pH	Phosphates	Chlorides	% O_2 Sat.	NO_3-N Nitrates	NH_3-N Ammonia	Fecal Coliform	Fecal Strep.	FC/FS
Mt. Arlington Public Beach	5/27				7.6	<.1	30		<.05	.18	29	92	.3
Seylaz Property	5/27				7.8	<.1	30		<.05	.13	4	8	.5
Shore Hills Beach Club	8/28	72	70	9	7.0	<.1	35		<.01	.36	8	100	
Knights of Columbus	8/28	-	-	-	7.1	<.1	32		.1	.17	40	240	.16
New School - Mt. Arlington	Note remarks noted on septic odor -- Probably Mt. Arlington Knights of Columbus												
Shore Hills Beach Club	9/2	70	68	-	7.5	<.1	39		.4	.17	4		
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													

SUMMARY OF TESTS -- Table 10

LAKE MEANS

Test #	1975 Date	Temperature Water °F	Temperature Air °F	DO	pH	Phosphates	Chlor-ides	% O_2 Sat.	NO_3-N Nitrates	NH_3-N Ammonia	Fecal Coliform	Fecal Strep.	FC/FS
1	4/21	35	53.8	13	7.78	<.1	47.8	92.94	<.05	.27	1.2		
2	5/5	39.16	53.6	13	7.51	<.1	25.8	97.11	<.06	.175	50.3		
3	5/27	54.5	70	9.66	7.43	<.15	26.1	90.16	<.091	.38	9	129.3	.78
4	7/1	62	81.8	10.16	7.46	<.1	24.8	103.18	<.1	.263	55.3		
5	7/7	76	76.8	8.6	7.21	<.1	25.33	102.03	<.1	.306	24.6		
6	7/14	72.4	78.6	6.8	6.98	<.1	20.6	76.96	<.13	.2	1223.2		
7	8/28	73.6	73.3	8.5	6.9	<.1	23.3	98.05	<.09	.265	773	281.3	.26
8	9/2	69.1	65.8	7.66	7.1	<.1	23.8	83.1	<.091	.131	61		
9	11/10	58.4	63.2	8.2	6.78	<.1	32	81.3	.18	.2	46.8		
10	12/15	42.2	50.6	8.9	6.44	<.1	37	71.68	.53	.15	1.2		
11	Mean of Means	59.06	67.3	10.1	7.18	<.1	28.08	91	<.1325	.28	133.8	210.3	.52
12													
13													
14													
15													
16													

SUMMARY OF TESTS -- Table 11

WATER QUALITY MEANS BY STATION

Station #	Date	Temperature Water °F	Air °F	DO	pH	Phosphates	Chlorides	% O_2 Sat.	NO_3-N Nitrates	NH_3-N Ammonia	Fecal Coliform	Fecal Strep.
1		57.3	66.6	10.05	7.35	<.1	32.2	93.78	<.07	.417	70.6	118
2		59.2	66.1	8.3	7.08	<.1	44.6	79.53	.315	.16	274.8	565
3		58.2	66.8	10	7.2	<.1	28.9	95.67	.085	.149	13.6	12
4		56.8	66.3	9.85	7.11	<.13	17.8	92.53	.155	.449	202	482
5		56.7	68.2	8.75	6.99	<.1	16.7	83.14	.11	.378	241.2	75
6		64.16	70	10.1	7.4	<.1	28.3	103.33	.01	.11	1	10
7				6								
8												
9												
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Discussion of Results

A. Discussion of 1975 Sampling Data

Water Quality. In general, water quality in the Lake Hopatcong basin remained safe for all recreational uses in 1975. At most locations and for most parameters, state drinking water standards appear to have been met. The lake, as evidenced both by aquatic vegetation and nutrient levels, appears to be undergoing a "cultural eutrophication" process in which nutrients as fertilizers increase "weed" growths. The results clearly show that water quality can change extremely quickly in response to a number of different factors. The L.H.R.P.B. Water Quality Survey has been designed to obtain both a generalized picture of water quality as well as to gauge the specific effect of these events.

Air Temperature and Water Temperature. Looking at the air temperature and water temperature curves, one can see that the lake followed a seasonal trend. Water temperature tended to lag behind air temperature. The water temperature, while usually more stable than the air temperature, still is subject to great change. For example, over a six-day period between July 1 and July 7 water temperature increased by over 14 degrees.

As expected, water temperature was usually lower than air temperature for any given date.

pH. The pH readings during 1975 started in early spring as slightly alkaline (in the basic area of the pH scale) and gradually decreased over the year. This could be due to increased photosynthetic activity by plants which would release CO_2 into the water, thus increasing the carbonic acid and bicarbonate concentrate in the lake. In all cases during 1975 the pH remained in the normal range.

Dissolved Oxygen. Dissolved oxygen also followed a normal lake pattern. The dissolved oxygen concentration is inversely proportional to the temperature. Thus, as the water temperature increased dissolved oxygen decreased. It is desirable to have the lake as close to 100 percent saturation of dissolved oxygen as possible. A percent saturation value higher than 100 percent could indicate that intensive photosynthetic activity is occurring with possible eutrophic activity. On the other hand, a low DO percent saturation could indicate large amounts of reduced organic matter (BOD) in the water consuming oxygen.

However, in discussing dissolved oxygen, the use of surface water data only could be misleading. Several studies (Lundin 1973, EPA 1976, Lundin 1975) have shown that Lake Hopatcong tends to undergo thermal stratification during the summer months. In the summer, the lake separates into three layers, the epilimnion (the upper 10-17 feet), the thermocline (the next 8-12 feet), and the hypolimnion. The hypolimnion waters are not exposed to the surface at any time during the stratification. Thus, oxygen may be depleted in this layer through normal biological respiration and through decomposition of organic matter. If enough depletion occurs, the hypolimnion can become devoid of oxygen and become anaerobic. Extremely low levels of DO and DO percent saturation in the lower levels of a lake during the summer can indicate advanced eutrophication.

In Lake Hopatcong during 1975 the DO in the lower levels as evidenced at the depth of 40 feet dropped to 2 mg/l. This is 3 mg/l less than the standard for propogation and survival of fish. While no temperature figures are available at this depth, the aturation can be assumed to be less than 20 percent. This would indicate an oxygen deficiency at the lower levels which demands closer study in the future.

It is strongly recommended that in future studies, temperature versus depth profiles versus DO concentration be investigated at least four times a year to determine (1) depth of thermocline; and (2) nature of DO depletion.

Chlorides. Chlorides in Lake Hopatcong again appeared to be within a normal range. The curve seems to suggest that the largest source to the lake of this specie is road salts.

Nitrates. Nitrates seemed to stay at a relatively low and normal level. However, a large increase was noticed in the fall of the year. This would appear to be due to a process called nitrification in which decaying organic matter; i.e., weeds and bottom muck in the lake basin, are oxidized by lake bacteria. There was some evidence during 1975 that the fall drawdown may have enhanced this process and increased nitrate in the basin.

Nitrate as a form of nitrogen will be discussed in more detail in the nutrient section of this report.

Ammonia. Ammonia is a reduced form of nitrogen. Ammonia usually enters the basin as raw wastes. The levels found were extremely lower than normal and were lowest in the fall. Ammonia is usually oxidized by lake bacteria to nitrate. The low fall level of ammonia would be consistent with the high levels of NO_3 previously discussed.

Phosphates. Phosphates are one form of phosphorous, an essential plant nutrient.

During the 1975 study year the level of phosphate in the lake was consistently at the lower limit of the test used (0.1 mg/l). However, such low levels can be deceiving, because vast amounts may be tied up in both the bottom sediment and in plant life.

It is recommended in future testing programs that a lower level test for phosphates be used and the test conducted to ascertain the total amount of phosphorous tied up in weed matter and in the bottom sediment.

Fecal Coliform. Fecal coliform in 1975 appeared to remain at low residual levels throughout the year. The level was substantially increased over the summer storm period. Fecal streptococci tests were run on two occasions during 1975. The fecal coliform/fecal strep ratio can be used to determine the source of fecal waste entering a water body. In most cases, fresh raw human sewage has a FC/FS value of around 4.

It is recommended in future years FS tests be run at least five times during the year at all stations.

As stated earlier, for most parameters, and at most locations the lake as a whole cannot be classified as polluted. Pollution must be defined in terms of the ultimate use to which the water will be put. None of the levels of any of the water quality indicators measured would interfere with recreational use. In addition, the lake water would be suitable for drinking after treatment.

B. Discussion of Results at Each Sampling Station

In general, the results of the individual stations reflected the findings of the lake in general.

Site 1 -- State Park. This site paralleled the lake as a whole for the parameters of water temperature, air temperature, DO and DO percent saturation, ammonia, phosphate, and fecal coliform. The pH at station 1 was slightly higher than the rest of the lake though still in the normal range.

Station 1 differed from the main lake in that nitrate did not tend to increase in the fall as in 1974 and in the rest of the lake. The fall upturn in nitrate is probably due to the decomposition of the lake vegetation. In 1975, the water at site 1 was constantly being changed due to the drawdown and the nitrate could not concentrate as in non-drawdown years.

Likewise, the chloride level at site 1 did not rise in the fall as the rest of the lake, again probably due to outflow during the drawdown.

Site 2 -- River Styx Bridge. At Station 2 the water quality basically paralleled the mean for the rest of the lake during most of the year for all parameters. Major differences were noted during the fall drawdown.

DO and DO percent saturation throughout the entire year as well as ammonia and fecal coliform showed extreme variability. This would strongly suggest the presence of an organic pollution source somewhere in the vicinity of station 2. It is recommended that local health authorities be made aware of this situation.

As stated above, in the fall of 1975 water quality varied radically from the means of the rest of the lake as shown in the November and December readings listed below.

	Stations 1,3,4,5,6 Mean for lake November	December	Station 2 Reading November	Station 2 Reading December
Air temp.	63.2	50.6	60	50
Water temp.	57	42.2	62	48
DO	8.64	10.8	6	3
% Sat.	85.32	80.8	61.2	25.8
pH	6.716	9.650	7.1	6.1
PO_4	.1	.1	.1	.1
Cl	21.8	25	83	97
NO_3	.196	.176	.1	2.3
NH_3	.188	.17	.26	.05
FC	20.16	1.44	180	0

Large differences for the November test are seen in DO percent saturation, DO, pH, chlorides, and fecal coliform. The December test indicates a higher water temperature, much lower DO and DO percent saturation, a lower pH, extremely high chlorides, much higher nitrate and much lower ammonia.

The differences for this station can probably be explained through two processes:

1. The decomposition of organic matter (it has already been suggested that this area receives organic waste); and
2. Nitrification in which the waste is being converted using oxygen from ammonia to nitrate generating heat.

Site 3 -- Church Lane Landing. This site presents almost a mirror image of the lake means as a whole. The data presented seems to indicate that this site is probably the most representative of total water quality conditions in the surface water of the lake.

Site 4 -- Lorretecong Road. Site 4, Lorretecong Road, appeared basically to follow the same pattern as the majority of the lake. However, for three parameters, extreme variability is shown suggesting the possibility of some type of organic pollution (i.e., septic) in the area. These parameters are ammonia, phosphates, and fecal coliform. The same observation was noted in the 1974 Water Quality Survey (Lundin, 1975).

This does not necessarily mean the organic waste is human in origin. On four occasions on the sampling sheet it was noted that a family of ducks had been nesting in the area. These should be investigated as a possible localized source causing the variability noted above.

Site 5 -- Oak View Park. This site paralleled the means of the lake on most parameters. The highest fecal coliform at this station occurred after the heavy summer rains.

Site 6 -- Main Lake. This station is located the furthest from shore and hence the most distant from any source of contamination. It showed the least variability over the study period. In general, this appears to be the "cleanest" station from a pollution standpoint. The fecal coliform level (used as an indicator of fecal pollution) was almost nil throughout the sample period.

The deep depth information from this station as discussed earlier shows that the lake stratifies during the summer months.

It can be seen that most stations behaved similarly during the period of study. Several localized effects of the drawdown were noted. Station 3 appears to be the most representative of total water quality in the lake.

C. Nutrient Data for 1975 and Point Source Inserts

Nutrients are often used to determine the extent of eutrophication in a lake basin. (For a discussion of nutrients, eutrophication and the limiting nutrient concept, see 1974 Water Quality Survey, Lundin 1975.)

As part of the 1975 study the N/P rate was again calculated. The graph of the data can be seen in the appendix of this report. As can be seen from the various tables, phosphorous continues to be the limiting nutrient in the Lake Hopatcong basin during the 1975 sampling program. On two occasions during May and September (paralleling the overturn and "purging" periods of the lake), nitrogen appears to be limiting. The EPA study (1976) also found phsophorous limitation throughout the year, with nitrogen limitation in the fall.

It is strongly recommended that in future monitoring programs a test for "potential for primary production" using spiked water samples be conducted at least four times a year to confirm the hypothesis of phosphorous limitation.

The nutrient data presented combined with the apparently severe aquatic weed control problems strongly suggest that nutrient input into the lake should be reduced. The EPA study showed a net accumulation each year in Lake Hopatcong of 580 kg P/year and 22,555 kg N/year. (This accumulation ratio would again suggest phosphorous as the limiting nutrient.) More importantly the additional weed growth each year could mean approximately 70,000 additional kg or 154,000 additional pounds of aquatic vegetation per year!

The conclusion is obvious. The weed growth and subsequent advanced and rapid rate of eutrophication will become a more serious problem unless the nutrient input to the lake basin is controlled.

The sources of nitrogen and phosphorous are (a) nonpoint sources; and (b) point sources. Nonpoint sources include septic tank leachings, erosion, lawn fertilizer washed into the lake, soaps, detergents, street runoff, and dead plant matter deposited in the lake.

Controls on nonpoint sources include:

1. soil erosion ordinances;
2. legislation banning fill into lake basin;
3. use of detention basins for storm water;
4. treatment of storm water;
5. bans on phosphate detergents;
6. installation of sanitary sewers;
7. regulating design of septic tanks; and
8. regulating density of residential development.

In general, nonpoint sources are diffuse and generally difficult to control. Point sources are generally industries or sewage treatment plants which discharge through a specific pipe into a specific waterway. All point source discharges in the United States must obtain a permit from the U.S. Environmental Protection Agency in accordance with the National Pollutant Discharge Elimination System (NPDES). Also, the point source discharger must meet certain State requirements.

Each NPDES permit specifies effluent limitations which must be met by all discharges. In addition, each permit specifies monitoring requirements for the effluent. This data must be summarized on a periodic basis and submitted to EPA. The permit effluent limitations are based on guidelines set by the EPA. On all permits the

State environmental agency can place more stringent requirements based on the receiving water characteristics. If the plant cannot meet its effluent limitation, then the permit specifies a compliance schedule for the upgrading of the facility.

On Lake Hopatcong there are four dischargers into the basin:

1. <u>Mount Arlington Sanitation Corporation</u> (Mt. Arlington Knolls and Apartment) package plant installed in 1964 with a design capacity of 35,000 gallons per day. Provides secondary treatment through extended aeration, sand filtration, and chlorination. The plant has been issued NPDES permit number NJ 0026212 with the following effluent limitations:

Flow	0.035 mgd
Fecal Coliform	200 org/100 ml - 30 day geometric mean
Fecal Coliform	400 org/100 ml - 7 day geometric mean
pH	6.0-9.0
BOD_5	8.8 lbs./day or 30 mg/l - 30 day average
	13.2 lbs./day or 45 mg/l - 7 day average
	minimum average 90% removal 30 day mean
Suspended Solid	8.8 lbs./day or 30 mg/l - 30 day average
	13.2 lbs./day or 45 mg/l - 7 day average
	85% minimum removal 30 day mean

Floating Solids or Visible Foam - None.

2. <u>Our Lady of the Lake School in Mount Arlington</u> with a package plant installed in 1961, capacity of 5,000 gpd, and providing secondary treatment with extended aeration, sand filter and chlorination. The plant has been issued NPDES permit number NJ 0026239 with the following effluent limitations:

Flow	0.005 mgd
Fecal Coliform	200 org/100 ml - 30 day geometric mean
Fecal Coliform	400 org/100 ml - 7 day geometric mean
pH	6.0-9.0
BOD_5	1.25 lbs./day or 30 mg/l - 30 day average
	1.87 lbs./day or 45 mg/l - 7 day average
	minimum average 90% removal 30 day mean

Suspended Solid	1.25 lbs./day or 30 mg/l - 30 day average
	1.87 lbs./day or 45 mg/l - 7 day average
	minimum average 85% removal 30 day mean

Floating Solids or Visible Foam - None.

3. Consolidated School in Jefferson. The package plant was installed in 1961 with a capacity of 7,500 gpd and provides secondary treatment through extended aeration and chlorination.

NPDES permit number NJ 0021156 has been issued with the following limitations:

Flow	0.0075 mgd
Fecal Coliform	200 org/100 ml - 30 day geometric mean
	400 org/100 ml - 7 day geometric mean
pH	6.0-9.0
BOD	1.9 lbs./day or 30 mg/l - 30 day average
	2.8 lbs./day or 45 mg/l - 7 day average
	minimum 90% removal 30 day average
Suspended Solid	1.9 lbs./day or 30 mg/l - 30 day average
	2.8 lbs./day or 45 mg/l - 7 day average
	minimum 90% removal 30 day average

Floating Solids or Visible Foam - None.

4. Stanlick School in Jefferson Township. The capacity of the plant is 13,000 gpd. It was installed in 1963 and provides secondary treatment through activated sludge through aeration and chlorination. NPDES permit number NJ 0021105 has been issued with the following limitations:

Flow	0.013 mgd
Fecal Coliform	200 org/100 ml - 30 day geometric mean
	400 org/100 ml - 7 day geometric mean
pH	6.0-9.0
BOD	3.3 lbs./day or 30 mg/l - 30 day average
	4.9 lbs./day or 45 mg/l - 7 day average
	90% minimum removal
Suspended Solids	3.3 lbs./day or 30 mg/l - 30 day average
	4.9 lbs./day or 45 mg/l - 7 day average
	90% minimum removal.

All permits must monitor the following: (1) flow; (2) BOD influent and effluent; (3) suspended solids influent and effluent;

(4) pH influent and effluent; (5) settleable solids influent and effluent; (6) residual chlorine - effluent; (7) fecal coliform - effluent; and (8) temperature - effluent.

None of the permits has any compliance schedule for upgrading. None has any limitation on aquatic plant nutrients. Based on a request from the Lake Hopatcong Regional Planning Board, EPA revised all permits in September 1976 to require monitoring of the following additional effluent characteristics: Nitrate-N, Ammonia-N, Total Kjeldahl Nitrogen and Phosphate.

Using the data submitted to the EPA by the discharge monitoring reports, the four plants have been performing as listed below:

	Mt. Arlington Sanitation	Stanlick	Consolidated	Our Lady of the Lake
Flow	.02208	.0093	.0013	.0015
pH influent	7.02	7.0	7.0	7.22
pH effluent	6.93	4.715	6.2	6.43
BOD lbs./day influent	48.35	7.10	.28	2.75
BOD mg/l influent	266	91.2	26	220
BOD lbs./day effluent	1.33	.1019	.05655	.1167
BOD mg/l effluent	7.25	6.45	5.1775	9.33
BOD percent removal	97			95.76
Suspended solids lbs./ day influent	13.51	16.7	.86	1.75
Suspended solids mg/l effluent	72	2.5	75	140
Suspended solids lbs./ day effluent	.87	.0457	.02838	.098
Suspended solids mg/l effluent	4.68	2.11	3.5325	7.83
Suspended solids percent removal	95			94.4
Settleable solids ml/l influent	9.07	.9	.1	.81
Settleable solids ml/l effluent	0	.1	.1	0
Residual chlorides mg/l effluent	1.6	1.253	1.715	2.78
Temperature °C effluent	15.65			0
Fecal coliform org/ ml effluent	1530			0

	Mt. Arlington Sanitation	Stanlick	Consoli- dated	Our Lady of the Lake
Nitrate-N mg/l	5.25	1.2	6.5	5.0
Nitrite-N mg/l	.13	.0015	.015	.01
Ammonia-N mg/l	20.25	0	0	.2
Total kjeldahl-N mg/l	37.61	1.4	1.4	17.02
Phosphate mg/l	8.42	1.4	.48	10.54

Both the Stanlick School and Consolidated School were in violation of their permit requirements since all the required monitoring was not being performed. The Stanlick School also appeared to be in violation of its pH minimum limit and was discharging acidic waste. EPA in October of 1977 notified the Jefferson Township Board of Education of these violations. The Board responded on November 11, 1977 and corrected the violations.

The EPA study of 1973 also discussed the nutrient loadings from these plants. These results are summarized below.

Parameter	Our Lady of the Lake mg	Our Lady of the Lake lbs.	Mt. Arlington Sanitation mg	Mt. Arlington Sanitation lbs.
Flow	.001 mgd		.019 mgd	
Ammonia	2.75	.023	4.178	.685
Nitrite	.01	.0001	.068	.0113
Nitrate	24.68 mg/l	.205	7.09	1.163
Total kjeldaln N	10.5	.08	10.31	1.69
Total phosphates	3.05	.025	6.02	.987
Phosphates dissolved ortho	2.56	.0214	5.5	.904

The EPA study, using only the data from Consolidated School, Our Lady of the Lake, and Mt. Arlington Sanitation Co., projected that 26.7 percent of the total annual influent phosphorous comes from all point sources and 2.1 percent of the total annual influent nitrogen comes from these point sources.

More interesting, however, using the EPA figures, if all influent phosphorous and nitrogen from the four point sources were eliminated then 59.5 percent of the total annual phosphorous accumulation and 4.7 percent of the total annual nitrogen accumulation would be eliminated.

Obviously, a large portion of the vegetative nutrients flowing into the lake is due to point sources. It is therefore suggested that:

1. The Regional Planning Board request that duplicate copies of all monitoring reports be submitted to it as well as to EPA.

2. All permitees should be mandated to meet permit limitations.

3. The Jefferson plants should be made to meet their monitoring requirements.

4. EPA should require the Stanlick School to meet its pH limitations.

5. The Regional Board should actively seek the State DEP and EPA to modify permits to include limitations on vegetation nutrients.

D. Comparison of 1975 Results With 1974

As part of this study the 1975 data was compared to the equivalent data from 1974 to see if there had been any significant change in water quality over one year's time. The t test is a statistical test designed to test significance between distribution of scores around a mean. The t test formula is:

$$t = \frac{\bar{X}_2 - \bar{X}_2}{\sqrt{\frac{SS_1 + SS_2}{N_1 + N_2 - 2}(1/N_1 + 1/N_2)}}$$

Where: $\bar{X}$ = arithmetic mean

N = sample size

SS = sum of squares = $\Sigma x^2 - \frac{(\Sigma x)^2}{N}$

where Σx^2 = sum of the squares of all scores
Σx = sum of the score
N = number of score

Tables 12 and 13 summarize the distribution of scores for each parameter during the 1974 and 1975 calendar years, respectively.

Table 14 shows the t values obtained in comparing the two years. A positive t indicates a higher value for the particular parameter during 1975 (a negative value higher in 1974). The differences are only significant if the two populations of scores differ at the 95 percent or 0.05 level of confidence. (That is, the differences which could only have occurred by chance 1 time out of 20.)

As can be seen in Table 14, chlorides and nitrates were significantly lower in 1975 than in 1974 while pH was significantly higher in 1975 than in 1974.

These significant differences are probably due to a number of factors. The major source of chlorides in Lake Hopatcong appears to be runoff from roads salted in winter. The lower level in 1975 could be due to this factor. In a personal communication with Mr. Calvin Bender, Superintendent of the Department of Public Works of the Borough of Hopatcong, approximately 360 less tons of road salt were used during November 1974-March 1975 than in an equivalent period in the winter of 1973-1974.

The lower level of nitrates could be due to one of two factors: (1) less inflow of nitrogen products into the lake; (2) more nitrogen tied up in other forms (other than NO_3) during the 1975 season. There is no evidence to indicate less influent nitrate to the lake in 1975. Rather, with increasing development in the Lake Hopatcong Watershed influent nitrogen should logically be increasing. Therefore, the other alternative should be considered.

Table 12

1974 RESULTS

Parameter	N	Σx	$\bar{X}$	Σx^2	$(\Sigma x)^2$	SS
DO	58	580	10	6,124	336,400	324
FC	52	3,249	62.48	185,732	10,556,001	1,654,321
DO % Saturation	56	5,453	97.375	547,277	29,735,209	16,291
PO_4	40	5.6	.14	2.9375	31.36	2.1535
Cl	40	1,426	35.65	56,206	2,033,476	5,363.1
NH_3	40	11.81	.29525	4.7164	139.4761	1.2294
pH	58	401.6	6.934	2,782.9	161,282.56	2.17
NO_3	40	19.2	.48	19.32	368.64	10.104

Table 13

1975 RESULTS

Parameter	N	Σx	$\bar{X}$	Σx^2	$(\Sigma x)^2$	SS
DO	58	506.5	9.740	5,184	256,542.25	250.496
FC	49	4,571	93.28	432,471	20,894,041	6,062
DO % Saturation	51	1,912	37.49	390,208	3,655,744	318,526.75
PO_4	56	5.8	.1035	.71	33.64	.10928
Cl	56	1,572	28.07	57,790	2,471,184	13,661.72
NH_3	55	15.53	.2823	13.5413	241.1809	9.156193
pH	57	408.9	7.1736	2,995.11	167,199.21	8.951
NO_3	56	7.75	.138	5.985	60.0625	4.915

Table 14

T TESTS, 1974(-) VS. 1975(+)

Parameter	T	df	Significant (*) at 95%
DO	- 1.644	108	
FC	- .9072	101	
% Saturation DO	- 1.42	103	
PO_4	- 1.136	94	
Cl^-	- 2.5737	94	*
NH_3	- .186	93	
pH	+ 4.6169	133	*
NO_3	- 4.1332	94	*

If one looks at the phosphate data it can be seen that all values (except one) for the year were recorded as $< .1$ (the lower limit of the test procedure used). This would appear to suggest (when also considered with the N/P ratio) that more N and P were tied up in increased aquatic vegetation and algae growth in 1975 than in 1974. This would account for the lower NO_3 levels. However, additional data is necessary to verify this conclusion.

Much of the 1974 pH test cannot be considered reliable due to testing procedure used in the earlier part of the year. Therefore, an adequate discussion of differences for the year cannot be made at this time.

This analysis has shown that water quality in Lake Hopatcong has not significantly changed from 1974 to 1975 except that nitrates have decreased probably due to increases in organic growth in 1975 and chlorines have decreased probably due to a milder winter in 1975 requiring less use of road salts.

In looking at the graphics of the various water quality results, it can be seen, however, that the lake water temperature increased later in 1975 than in 1974 and tended to stay warmer later in the fall than in 1974. The air temperature curve, however, was very similar to 1974.

Looking at the pH curves, a marked difference from 1974 can be seen. In 1974, the lake was slightly acidic in the early spring, became slightly basic during the summer and then slightly acidic again in the fall. In 1975, however, the curve shows the lake as alkaline in the spring, and slowly decreasing over the summer and becoming slightly acidic in the fall.

Upon investigation it was determined that different testing methods were used for pH during the 1974 season (the method switched in late spring) and that the early test method was performed using the incorrect amount of reagent. Thus, the earlier data of 1974 which differs from 1975 must be discounted. It must be noted that the data curve from 1975 closely parallels that of the EPA study in 1973 (EPA, 1976).

The dissolved oxygen curve for 1975 is very similar to that of 1974. However, no large upturn in DO is seen in the fall of 1975 as in 1974. This, however, is due to the fact that the lake remained warmer later in the fall in 1975. This conclusion appears reinforced when one sees the DO percent saturation curve which, when the summer storm is excluded, closely parallels 1974.

The chloride curve for 1975 again parallels 1974 except at a lower level. The chloride content is higher in the spring and gradually decreases over the summer and fall.

The nitrate curve for 1975 peaked later than in 1974. This could be due to (1) increased temperature in early fall of 1975 preventing aquatic weeds from dying and therefore decomposing and releasing nutrients back into water as in 1974; or (2) effect of drawdown. A combination of both factors is probably the cause.

The phosphate, ammonia and fecal coliform curves all closely parallel the curves of the respective parameters from 1974.

The nitrogen/phosphorous ratio for 1975 appears to follow the same general trend as in 1974. Phosphorous remains the limiting nutrient in 1975 except through two periods (May and September). This also parallels the findings of the EPA (1976) study. The difference between the numbers in 1974 and 1975 is due to two different (yet equally valid) methods of calculations of the ratio. It should be pointed out that this ratio was calculated using only the concentrations of the species of nitrogen and phosphorous measured in this study and thus is only an approximation of the actual N/P ratios.

As with the means for the entire lake, the water quality curves for the individual stations paralleled their 1974 counterparts. All the water quality curves at Station 1 for 1975 paralleled the curves of 1974 except those of phosphate and nitrates. In 1974 these two parameters showed a marked increase in the fall which did not occur in 1975. The fall increase in 1974 was attributed to the decomposition of aquatic vegetation in the area -- consequently raising these species. This would not be seen in the 1975 results since the water at Site 1, being the outlet of the lake during the drawdown, was constantly being flushed by new water from the main lake and all nutrients released through degradation flowed through the dam and left the basin.

Likewise, Site 2 also paralleled the curves of 1974 except in the fall. This will be discussed under drawdown effects.

The 1975 curves of water quality at Sites 3, 4, 5, and 6 closely parallel those of 1974, and the reader is referred to the 1974 (Lundin, 1975) report for further analysis.

Thus, on the whole, water quality in Lake Hopatcong has not varied significantly over the first two years of study for most parameters and most areas.

E. Effects of Holidays and Heavy Recreational Use on Water Quality

As part of this study, water samples were taken, both in 1974 and 1975, before and after heavy recreational use weekends. These were defined as Memorial Day, July 4th, and Labor Day. Any holiday weekends in which rains occurred or which were unseasonably cold (so as to limit recreational use) were eliminated from consideration.

As discussed earlier, t tests of statistical significance were performed on all holiday weekend data for 1974 and 1975.

The results are summarized in Tables 15, 16, and 17. Table 15 is a summary of the data and its distribution before the holiday weekend, and Table 16 is a data summary following the holiday weekend. Table 17 is a summary of the t values obtained.

After a holiday weekend significantly higher values were found for water temperature, phosphates and fecal coliform. Significantly lower values were found for air temperature, dissolved oxygen and pH.

Table 15

HOLIDAY EFFECTS - STATISTICAL SUMMARY BEFORE HOLIDAY

Parameter	N	Σx	$\bar{X}$	Σx^2	$(\Sigma x)^2$	SS
Water Temp.	17	1,173	69	81,593	1,375,929	656
Air Temp.	18	1,497	83.16	1,250.27	2,241,009	526.5
DO	19	167	8.78	1,503	27,889	35.1577
pH	18	130	7.2	944.21	16,900	5.3812
PO_4	18	1.3	.072	.175	1.69	.0812
Cl^-	18	557	30.94	19,271	310,249	2,034.945
NO_3	18	8.9	.494	9.39	79.21	4.9895
NH_3	17	5.38	.316	2.3094	28.9444	.6068
FC	18	612	34	90,700	374,544	69,892
% Saturation	17	1,698	99.8	171,328	9,960.04	170,742.12

Table 16

HOLIDAY EFFECTS - STATISTICAL SUMMARY AFTER HOLIDAY

Parameter	N	Σx	$\bar{X}$	Σx^2	$(\Sigma x)^2$	SS
Water Temp.	17	1,251	73.5	92,823	1,565,001	764.12
Air Temp.	18	1,336	74.22	100,204	1,784.896	1,043.12
DO	19	145	7.63	1,151	21,025	44.4211
pH	18	126.7	7.03	892.71	16,052.89	.8828
PO_4	18	5.0	.27	3.105	25	1.7162
Cl^-	18	555	30.8	19,739	308,025	2,626.5
NO_3	18	8.9	.494	8.98	79.21	4.58
NH_3	17	6.5	.382	3.3656	42.25	.8804
FC	18	2,761	153.3	1,805,512	7,623,121	1,382,005.3
% Saturation	17	1,543	90.7	143,789	8,226.49	143,405.09

Table 17

T TEST, BEFORE(-) OR AFTER(+) HOLIDAYS

Parameter	T	df	Significant (*) at 95%
Water Temp.	+ 2.319	32	*
Air Temp.	- 4.354	34	*
DO	- 2.384	36	*
pH	- 1.188	34	
PO_4	+ 2.5834	34	*
Cl^-	- .0358	34	
NO_3	0	34	
NH_3	+ .8925	32	
FC	+21.76	34	*
% Saturation DO	- .267	32	

The results were all significant at the 95 percent confidence level. The air and water temperature difference is quite interesting. While the air temperature decreased, the water temperature actually increased. While the air temperature difference was probably due to chance, the rise in water temperature could probably be attributed to a combination of the following factors:

(1) increase wave action during the weekend tending to expose more water molecules to the atmosphere and thus warming action;

(2) temperature of the people using the water and possible human waste discharges into the water; and

(3) use of water as engine coolant in boats.

The increased wave action over the weekend would lead to the hypothesis that DO should increase. However, this did not occur -- rather just the opposite occurred -- the DO decreased. When one looks at the DO percent saturation figure it is seen that the difference here is not only non-significant but almost nil. Since DO is inversely proportional to the temperature, it appears that the DO decrease was due primarily to the temperature increase.

If the DO percent saturation significantly decreases also, this would be evidence that the holiday weekends place a heavy organic demand on the lake. Fortunately, this was not the case.

Phosphates significantly increased over the weekends. Since large amounts of phosphorous are tied up in the bottom sediments this increase can probably be attributed to the boats and recreational use stirring up the lake bottom and resuspending phosphates in the waters. This hypothesis can be explored in future studies by taking turbidity measurement before and after the weekends.

The fecal coliform results were extremely significant. This indicates that the amount of either animal or human waste increases over the heavy recreation weekends. How this waste enters the water and its sources should be investigated.

Thus, there seems to be a relationship between heavy recreational use and water quality. Future studies must determine the nature and extent of this relationship.

F. Effect of Heavy Storms on Water Quality

In 1975, the period of July 10th through July 14th consisted of heavy, and in some instances, record rains. During 1975, as seen in the U.S.G.S. figures (Table 1 of this report), the largest discharge of the 1975 year

(329 c.f.s.) occurred after these rains on July 15th. This is 27.5 times the normal summer discharge of 12 c.f.s. Also, the highest level of the lake during 1975 -- 10.14 feet with a storage of 8,424,000,000 gallons -- occurred on July 15th after this storm.

This major storm permitted an excellent opportunity to gauge the effect of heavy storms on water quality. Fortunately, a regularly scheduled monitoring date of July 7th had occurred just prior to the storm. (The date being the test scheduled immediately after the July 4th weekend.)

On July 14, 1975 at 9:00 a.m., three hours after the cessation of the rain, a special test program was authorized. All stations except Station 6 were tested for the usual parameters.

T tests for significant differences between the means were performed on the data. Two sets of t tests were performed. One contrasted water quality results between test dates 5 and 6 (July 7, 1975 and July 14, 1975) and between test dates 4 and 6 (July 1, 1975 and July 14, 1975), with the first set to determine the specific effect of the storm.

Since July 7th was a post heavy recreation use weekend test, the second set of tests were needed to isolate the weekend as an interfering variable.

However, the two sets of test data showed the same results and the holiday weekend was eliminated as an interfering variable. Since the results of both sets of tests were consistent only the data of July 7th and 14th will be discussed further.

These results are summarized in Tables 18, 19, and 20. Tables 18 and 19 are summaries of the data sets (before and after storm). Table 20 is a list of the t values obtained. Due to the restricted amount of data, larger t values were necessary to be considered significant at the 95 percent confidence level.

As can be seen in Table 20 significantly higher values were obtained for the parameter of fecal coliform (over a 40-fold increase) and significantly lower values were obtained for dissolved oxygen percent saturation. An interesting item, while not statistically significant, showed that while air temperature increased after the storm period, the water temperature actually decreased.

It is also interesting to note that while the DO percent saturation difference is significant the DO difference is not. This again is due to changing temperature of the water and reinforces the use of DO percent saturation as an indicator of possible water quality change.

The fact that DO percent saturation and fecal coliform levels were significantly changed over the storm period strongly suggests that the storm water runoff carries a heavy organic loading which can introduce large amounts of pollutants into a water body.

The origins of this material are:

(1) septic tank leaching;

(2) animal wastes;

(3) heavy metal oils and other material usually found on roadways;

(4) decaying vegetation;

(5) silt and sediment.

The findings indicate that storm water runoff can have as detrimental an effect on water quality as other sources of pollution. Storm water sunoff is not necessarily clean. Thus, consideration

Table 18

STATISTICAL SUMMARY BEFORE STORM

Parameter	N	Σx	$\bar{X}$	Σx^2	$(\Sigma x)^2$	SS
Water Temp.	5	378	75.6	28,580	142,884	3.2
Air Temp.	5	385	77	29,661	148,225	16
DO	5	42	8.4	356	1,774	3.2
pH	5	35.9	7.18	258.15	1,288.8	.39
PO_4	5	$<.5$	$<.1$	.05	.25	0
Cl^-	5	124	24.8	3,382	15,376	306.8
NO_3	5	.5	$<.1$	.05	.25	0
NH_3	4	1.38	.345	.8934	1.9044	.4173
FC	5	148	29.6	15,080	21,904	10,699.2
DO % Saturation	5	491	98.2	48,635	241,081	418.8

Table 19

STATISTICAL SUMMARY AFTER STORM

Parameter	N	Σx	$\bar{X}$	Σx^2	$(\Sigma x)^2$	SS
Water Temp.	5	362	72.4	26,284	131,044	75.2
Air Temp.	5	393	78.6	30,917	154,449	27.2
DO	5	34	6.8	240	1,156	8.8
pH	5	34.9	6.98	243.97	1,218.01	.368
PO_4	5	$<$.5	$<$.1	.05	$<$.25	0
Cl^-	5	103	20.6	2,535	10,609	413.2
NO_3^-	5	.65	.13	.0925	.4225	.008
NH_3	4	.9	.225	.3134	.81	.1109
FC	5	6,116	1,223.2	11,773,456	37,405,456	4,292,365
DO % Saturation	5	385	77	30,503	148,225	858

Table 20

T TEST BEFORE AND AFTER STORM - TEST DATES 5 & 6
(-) (+)

Parameter	T	df	Significant (*) at 95%
Water Temp.	- 1.616	8	
Air Temp.	+ 1.08866	8	
DO	- 2.032	8	
pH	- 1.027	8	
PO_4	0	8	
Cl^-	- .6999	8	
NO_3^-	+ 1.5	8	
NH_3	- .571	6	
FC	+ 2.573	8	*
% Saturation DO	- 2.6533	8	*

must be given to either treating or controlling storm water before it enters the lake. It is recommended that:

(1) Municipalities adopt and enforce soil erosion and surface water management controls in ordinances.

(2) Any large direct connections of storm water drains to the lake should be subject to environmental impact guidelines. (If these are permitted to discharge, it should be to the main lake rather than stagnant coves where effects will be magnified.)

(3) Municipalities should prohibit direct connection between septic tanks and storm drains and undertake a regular dye test program to locate these connections.

(4) Municipalities should limit impervious cover on a lot to 10-20 percent to increase ground percolation of storm water

rather than facilitate runoff.

(5) That on future storm water projects consideration should be given to the use of detention basins to (a) slow down flow; (b) facilitate recharge; and (c) allow water to purify itself before it reaches the lake.

G. Effect of Drawdown on Water Quality

The year 1975 was unique in that the lake level was dropped in the fall a total of over 7 feet to allow repair to docks and to the dam at Site 1. To study the drawdown effect, tests were conducted in October and December of 1974 and in November and December of 1975. Thus, the sample dates between 1974 and 1975 were generally comparable.

T tests for significant differences between means were run on three sets of data:

(1) comparing October 1974 with November 1975;

(2) comparing December 1974 with December 1975; and

(3) Comparing data from two dates in 1974 combined with two dates in 1975 combined.

Tables 21, 22, and 23 summarize the analysis for the comparison of October 1974 with November 1975. Tables 21 and 22 summarize the data for the respective dates while Table 23 shows the t values. At the time of the November 1975 tests, the lake level was 7.0 feet below the top of the dam and 6.0 feet below the level of the October 1974 date.

As can be seen in Table 23, 1975 had significantly higher values for both water and air temperatures and lower values for DO.

The fall of 1975 was warmer than the fall of 1974 and this would account for all three differences. Thus, for early fall, on a lake-wide basis, there does not appear to be any significant effect on water quality.

The data between December 1974 and December 1975 is summarized in Tables 24, 25 and 26. Tables 24 and 25 show the data summarized for the respective dates. Table 26 shows the t values obtained. In 1975, there were significantly higher values in air and water temperatures, but significantly lower values in fecal coliform and pH. In December 1975 the water level was 7.5 feet below the top of the dam and 5.4 feet lower than in 1974.

The pH difference indicates that the lake was more acidic in December of 1975 than in 1974. Several of Lake Hopatcong studies (EPA, 1976; and Lundin, 1975) have shown the pH to decrease in the fall. In 1975, this effect seems to have been heightened by the drawdown. The lower fecal coliform level could be due to local conditions or to the fact that the lower lake level could have contributed to a lower water table in the surrounding areas and possibly prevented septic systems from overflowing. These results need further study before any firm conclusions are reached.

Table 21

CONTRAST FOR DRAWDOWN EFFECTS - LATE OCTOBER 1974

Parameter	N	Σx	$\bar{X}$	Σx^2	$(\Sigma x)^2$	SS
Water Temp.	5	243	48.6	11,836	59,049	36.8
Air Temp.	5	279	55.8	15,605	77,841	36.8
DO	5	53	10.6	563	2,809	1.2
pH	5	35.4	7.08	250.74	1,253.16	.108
PO_4	5	.25	.05	.0125	.0625	0
Cl	5	161	32.2	5,341	25,921	156.8
NO_3	5	1.2	.24	.5	1.44	.212
NH_3	5	.3	.3	.665	2.25	.215
FC	5	24	4.8	344	576	228.8
DO % Saturation	5	457	91.4	41,869	208,849	97.2

Table 22

CONTRAST FOR DRAWDOWN EFFECTS - EARLY NOVEMBER 1975

Parameter	N	Σx	$\bar{X}$	Σx^2	$(\Sigma x)^2$	SS
Water Temp.	5	292	58.4	17,072	85,264	19.2
Air Temp.	5	316	63.2	19,986	99,856	14.8
DO	5	41	8.2	347	1,681	10.8
pH	5	33.9	6.78	230.17	1,149.21	.328
PO_4	5	.5	.1	.05	.25	0
Cl^-	5	160	32	8,556	25,600	3,436
NO_3	5	.9	.18	.19	.81	.028
NH_3	5	1.0	.2	.2146	1.0	.0146
FC	5	234	46.8	33,812	54,756	22,860.8
DO % Saturation	5	406.5	81.3	34,252.19	165,242.25	1,203.74

Table 23

T TEST DRAWDOWN - EARLY FALL

1974(-) to 1975(+)

Parameter	T	df	Significant (*) at 95%
Water Temp.	+ 6.504	8	*
Air Temp.	+ 4.607	8	*
DO	- 3.098	8	*
pH	- 2.0318	8	
PO_4	0		
Cl	- .014922	8	
NO_3	- .5477226	8	
NH_3	- .9333	8	
FC	+ .1184416	8	
% Saturation DO	- 1.2513	8	

Table 24

CONTRAST FOR DRAWDOWN EFFECTS - EARLY DECEMBER 1974

Parameter	N	Σx	$\bar{X}$	Σx^2	$(\Sigma x)^2$	SS
Water Temp.	5	156	31.2	4,874	24,336	6.8
Air Temp.	5	182	36.4	6,636	33,124	11.2
DO	5	61	12.2	749	3,721	4.8
pH	5	34	6.8	231.36	1,156	.16
PO_4	5	145	29	4,543	21,025	338
NO_3	5	.25	.05	.0125	.0625	0
NH_4	5	1.19	.238	.3895	1.4161	.10628
FC	5	200	40	13,320	40,000	5,320

Table 25

CONTRAST FOR DRAWDOWN EFFECTS - EARLY DECEMBER 1975

Parameter	N	Σx	$\bar{X}$	Σx^2	$(\Sigma x)^2$	SS
Water Temp.	5	211	42.2	8,949	44,521	44.8
Air Temp.	5	253	50.6	12,811	64,009	9.3
DO	5	44.5	8.9	439.75	1,980.25	43.7
pH	5	32.2	6.44	207.52	1,036.84	.152
PO_4	5	.5	.1	.05	.25	0
Cl	5	173	34.6	11,083	29,929	5,097.2
NO_3	5	2.65	.53	5.3375	30,225	3.933
NH_3	5	.75	.15	.1363	.5625	.0238
FC	5	6	1.25	12	36	4.8
% Saturation DO	5	358.4	71.68	28,371.26	128,450.51	2,681.15

Table 26

T TEST DRAWDOWN - LATE FALL

1974(-) to 1975(+)

Parameter	T	df	Significant (*) at 95%
Water Temp.	+ 6.8483	8	*
Air Temp.	+14.0601	8	*
DO	- 2.1191	8	
pH	- 2.8823	8	*
PO_4	0	8	
Cl	+ .3396993	8	
NO_3	+ 1.0824	8	
NH_3	- 1.09	8	
FC	- 2.375	8	*
% Saturation DO	- .9580	8	

Table 27

CONTRAST OF DRAWDOWN - TOTAL FALL 1974

Parameter	N	Σx	$\bar{X}$	Σx^2	$(\Sigma x)^2$	SS
Water Temp.	10	399	39.9	16,710	159,201	789.9
Air Temp.	10	461	46.1	22,241	212,521	988.9
DO	10	114	11.4	1,312	12,996	12.4
pH	10	69.4	6.94	482.1	4,816.36	.464
PO_4	10	.5	.05	.025	.25	0
Cl^-	10	306	30.6	9,884	93,636	520.4
NO_3	10	1.45	.145	.5125	2.1025	.30225
NH_3	10	2.69	.269	1.0548	7.2361	.33089
FC	10	224	22.4	13,664	50,176	8,646.4
% Saturation DO	10	873	87.3	76,691.0	762,129	478.1

Table 28

CONTRAST OF DRAWDOWN - TOTAL FALL 1975

Parameter	N	Σx	$\bar{X}$	Σx^2	$(\Sigma x)^2$	SS
Water Temp.	10	503	50.3	26,021	253,009	720.1
Air Temp.	10	569	56.9	32,797	323,761	420.9
DO	10	85.5	8.55	786.15	7,310.25	55.725
pH	10	66.1	6.61	437.69	4,369.21	.769
PO_4	10	1	.1	.1	1	0
Cl^-	10	333	33.3	19,639	110,889	8,550.1
NO_3	10	3.55	.355	5.5275	12.6025	4.26725
NH_3	10	1.75	.175	.3509	3.0625	.04465
FC	10	240	24	33,824	57,600	28,064
% Saturation DO	10	764.9	76.49	62,623.45	585,072.01	4,116.249

Table 29

TOTAL FALL DRAWDOWN EFFECT

1974(-); 1975(+)

Parameter	T	df	Significant (*) at 95%
Water Temp.	+ 2.5390	18	*
Air Temp.	+ 2.7287	18	*
DO	- 3.2757	18	*
pH	- 2.8193	18	*
PO_4	0	18	
Cl^-	+ .2689	18	
NO_3	+ .9139	18	
NH_3	- 1.4552	18	
FC	- .07922	18	
% Saturation DO	- 1.5129	18	

The results of the analysis between the fall of 1974 and the fall of 1975 can be seen in Tables 27, 28, and 29. Tables 27 and 28 summarize the data for the respective years and Table 29 shows the t value obtained. The significantly higher water temperature and lower DO values of 1975 can be attributed to the warmer air temperature. Therefore, the only difference on a lakewide basis between the two years appears to be a lower pH during the drawdown year, which is actually an intensification of a normal trend.

On a lakewide basis there does not appear to be any major detrimental effect on water quality as a result of the drawdown. Whatever effects which do occur are localized.

It has already been noted that in at least two sampling sites (Site 1 and Site 2) differences can be attributed to the drawdown. At Site 1 there was no fall increase in NO_3 or chloride as expected due to the drawdown continually circulating the water and diluting it with nutrient-free main lake water.

At Site 2 extreme localized effects of the drawdown were noted. These include an increase in the conversion of ammonia to nitrate and the degradation of organic matter leading to warmer water temperature and an extremely lower level of dissolved oxygen. These localized effects will require additional study during the next drawdown.

H. Comparison of Results With EPA Data

As part of this study the 1975 results were compared with the results obtained in the 1973 EPA sampling of water in the lake (EPA, 1976). Four of the EPA sites roughly paralleled the Lake Hopatcong Regional Planning Board stations. These are seen below:

L.H.R.P.B. Station #	E.P.A. Station #
1	3415A1 & 55500
3	341504
5	3415B1
6	341502 & 341503

In general, the results were comparable at all stations. However, the EPA study found more exact phosphate levels due to the lower limit of the test used in the L.H.R.P.B. study. It is recommended that the L.H.R.P.B. utilize a more exact phosphate test in future programs.

B. Other Ongoing Studies

During 1974, the State of New Jersey Department of Environmental Protection, Division of Fish, Game & Shellfish, Bureau of Fisheries Lab, at the request of the Hopatcong Environmental Commission, conducted a survey of the fish in Lake Hopatcong, The results of this study can be seen as Table 30.

During 1975, Dr. John Koppen of the Botany Department of Rutgers University conducted a survey of algae in the lake. Dr. Koppen's study shows that the lake, from an algae viewpoint, is rich in nutrients and rapidly undergoing cultural eutrophication. Dr. Koppen compared a 1974-1975 algae assay with an assay of 50-100 years ago.

Dr. Koppen is seeking funding for an intensive algae survey of the lake. It is recommended that the L.H.R.P.B. schedule a meeting with Dr. Koppen to discuss his results in the near future.

In July of 1976, the Sussex County Board of Chosen Freeholders was awarded a grant from the U.S. Environmental Protection Agency to conduct an area-wide waste-water management study under Section 208 of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 72-500). This study will include both nonpoint and point sources of water pollution in the Lake Hopatcong area. It is recommended that the L.H.R.P.B. maintain close communication with the 208 Policy Advisory Committee.

In the summer of 1976 the Musconetcong Sewerage Authority, whose service area includes Lake HOpatcong, was awarded a 201 - Step 1 grant for Engineering and Facilities planning under Section 201 of the FWPCAA of 1972 for waste water planning and environmental impact planning for the Lake Hopatcong region. It is recommended that a meeting be held between the M.S.A. and the L.H.R.P.B. as soon as possible to discuss the data to be used and the environmental impacts to be determined.

Kettelle and Uttormark (1971) classified Lake Hopatcong as a problem lake of the U.S. due to the aquatic vegetation problem and recommended complete dredging as the permanent solution.

There appears to be a concensus among the various agencies that Lake Hopatcong has problems which must be studied and solved. The next few years are crucial for the future of the lake.

Table 30

SURVEY OF FISH IN LAKE HOPATCONG

Rainbow trout	(Salmo gairdneri)
Brown trout	(Salmo trutta)
Brook trout	(Salvelinus fontinalis)
Eastern mudminnow	(Umbra pygmaea)
Redfin pickerel	(Esox amerianus americanus)
Chain pickerel	(Esox niger)
Carp	(Cyprinus carpio)
Golden shiner	(Notemigonus crysoleucas)
Satinfin shiner	(Notropis analostanus)
Bridle shiner	(Notropis bifrenatus)
Common shiner	(Notropis cornutus)
Spottail shiner	(Notropis hudsonfus)
Fathead minnow	(Pimephales promelas)
Creek chubsucker	(Erimyzon oblongus)
White catfish	(Ictalurus catus)
Brown bullhead	(Ictalurus nebulosus)
Channel catfish	(Ictalurus punctatus)
Tadpole madtom	(Noturus gyrinus)
Banded killifish	(Fundulus diaphanus)
White perch	(Morone americanus)
Mud sunfish	(Acantharchus pomotis)
Rock bass	(Ambloplites rupestris)

Table 30 (Continued)

Bluespotted sunfish	(Enneacanthus gloriosus)
Redbreast sunfish	(Lepomis auritus)
Pumpkinseed	(Lepomis gibbosus)
Bluegill	(Lepomis macrochirus)
Largemouth bass	(Micropterus salmoides)
Smallmouth bass	(Micropterus dolomieui)
Black crappie	(Pomoxis nigromaculatus)
Johnny darter	(Etheostoma nigrum)
Yellow perch	(Perca flavescens)
Walleye	(Stizostedion vitreum vitreum)
Alewife	(Alosa pseudoharengus)

Also stocked in the lake are the hybrid tiger trout and a color variation of the rainbow trout, known commonly as the golden rainbow trout (this is not the recognized golden trout, _Salmo aquabonita_, of the Sierra Nevada). The tiger trout and the golden rainbow trout are not recognized as distinct species.

Additional species, not previously mentioned, that are found in the tributaries of Lake Hopatcong are:

Blacknose dace	(Rhinichthys atratulus)
Longnose dace	(Rhinichthys cataractae)
Creek chub	(Semotilus atromaculatus)
White sucker	(Catostomus commersoni)
American eel	(Anguilla rostrata)

APPENDIX

WEATHER:

1.	4/21	partly sunny, windy windy & blustery, partly sunny cloudy & windy, cool cloudy & windy
2.	5/5	bright, sunny, windy heavy rain sunny, warm 70's cloudy, cool
3.	5/27	sunny, warm, muggy, hazy cloudy, cool cloudy, cool, scattered showers hot, 93° F.
4.	7/1	clear, sunny clear, sunny, warm cloudy, variable cloudy, windy
5.	7/7	warm, humid, partly cloudy heavy thunderstorm sunny, clear, 85-90 sunny, clear, 85-90
6.	7/14	heavy rain heavy rain record rain partly cloudy
7.	8/28	sunny, cool, dry sunny, cool, dry warm, humid, scattered showers hot, humid, scattered showers
8.	9/2	cloudy, cool cloudy, cool, scattered showers cloudy, cool, scattered showers cloudy, cool, scattered showers
9.	11/10	rain sunny, warm sunny, warm slight rain
10.	12/10	hazy light rain, overcast light rain, overcast overcast

BIBLIOGRAPHY

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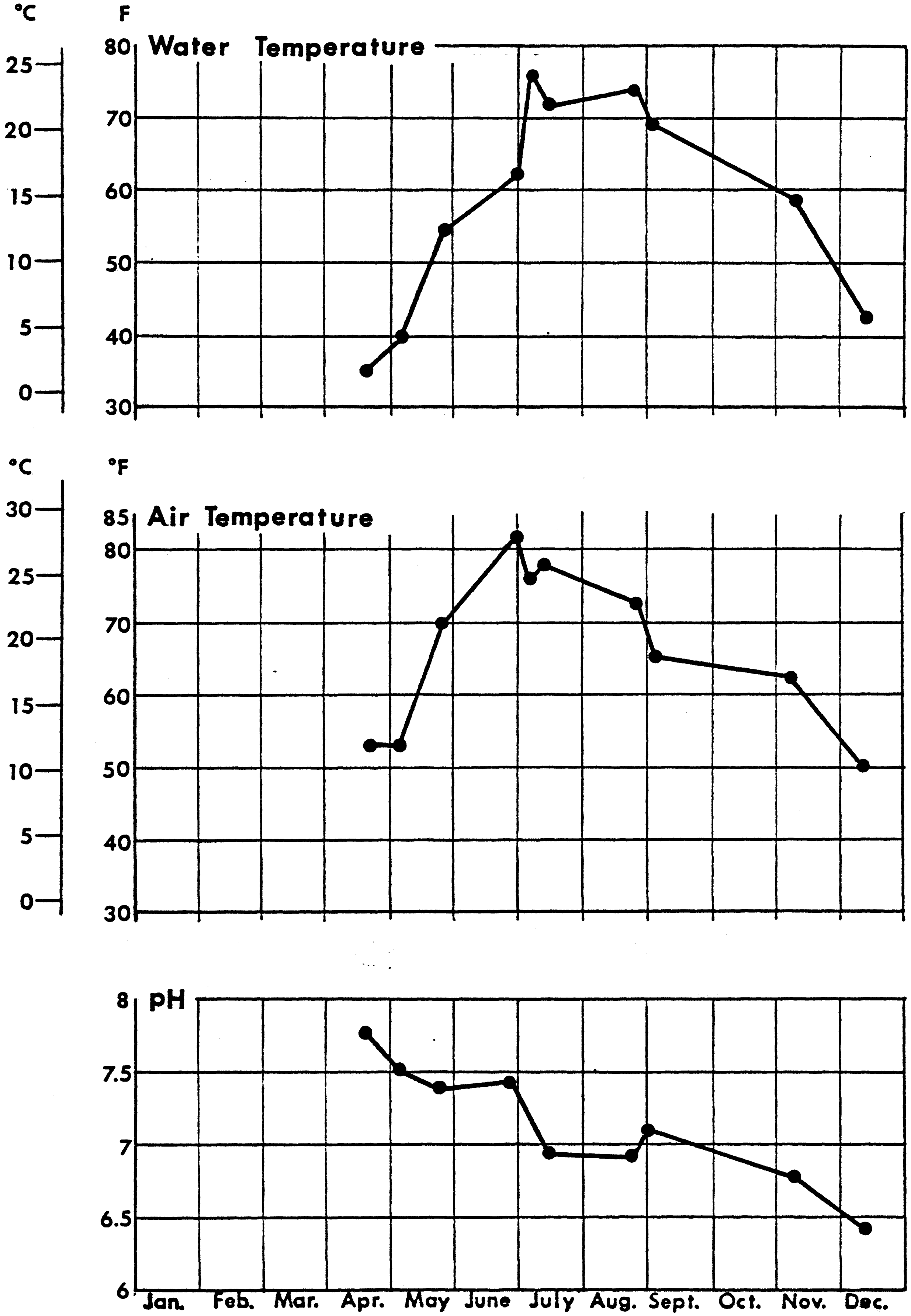
9. United States Geological Survey, Water Resource Data for New Jersey for 1975, U.S. Department of Interior, Trenton, N.J., 1976.

LAKE MEANS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F
Water Temperature
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60
50
40
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25
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15
10
5
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°C
°F
Air Temperature
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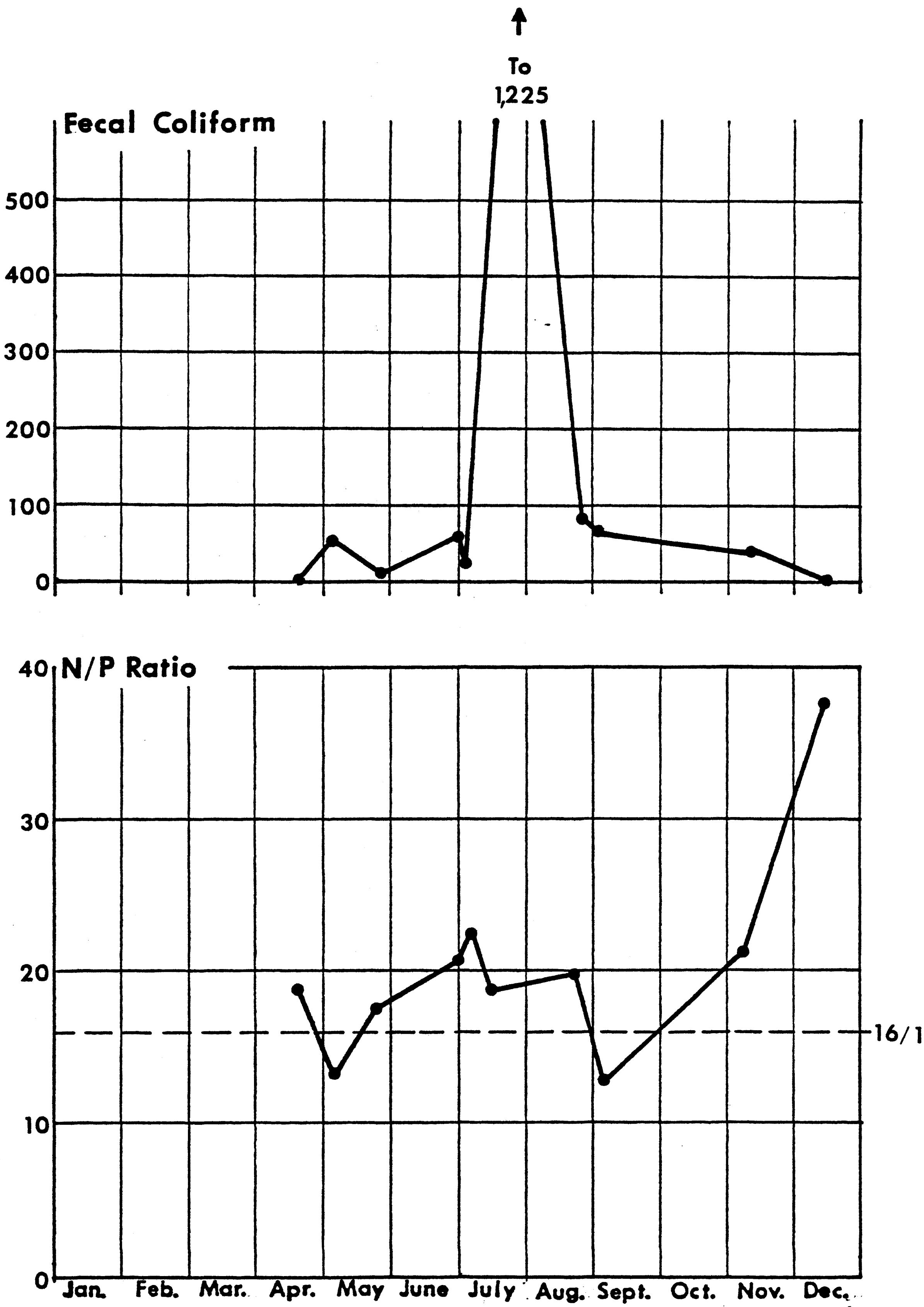
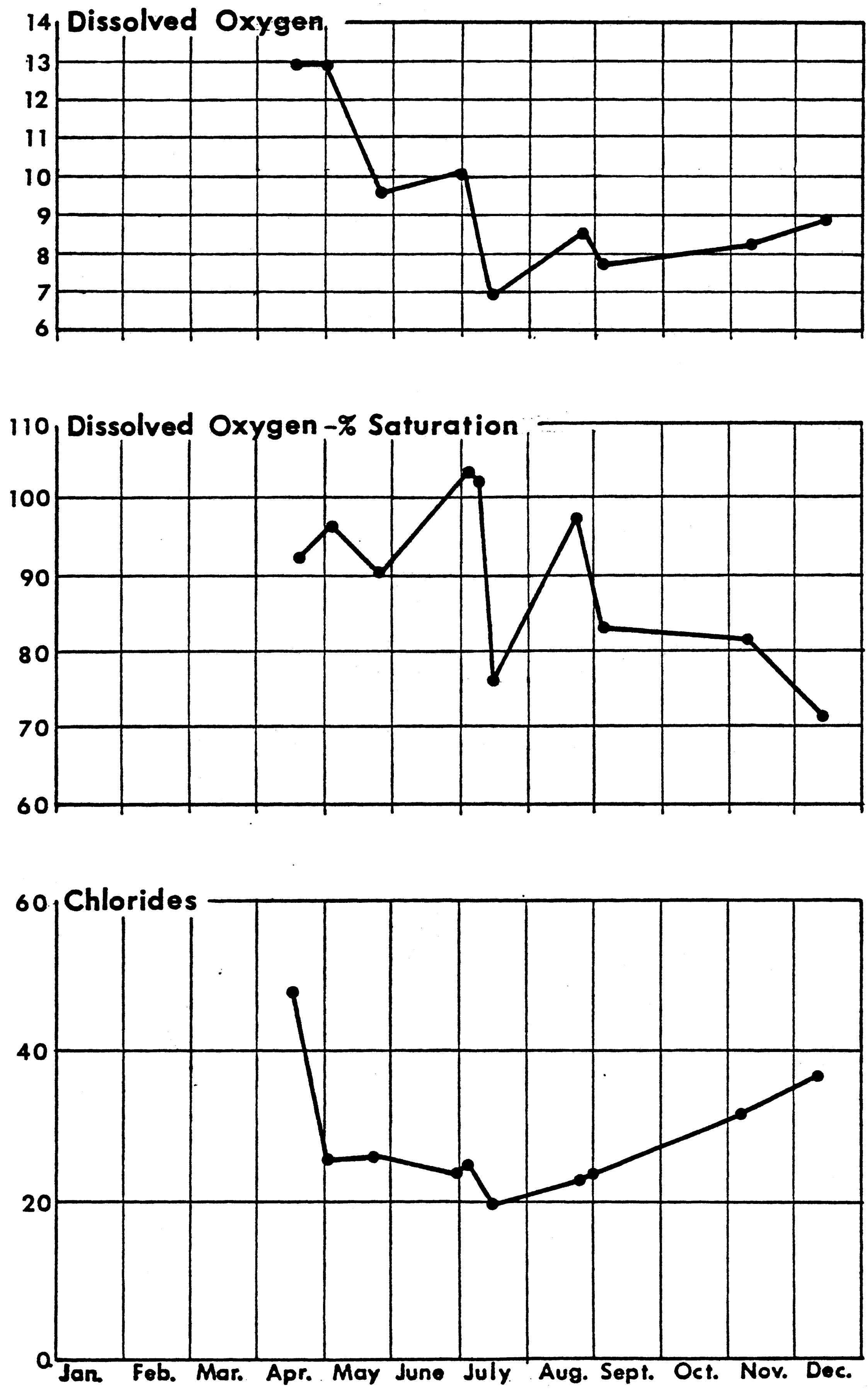
80
70
60
50
40
30
30
25
20
15
10
5
0
pH
8
7.5
7
6.5
6
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

LAKE MEANS

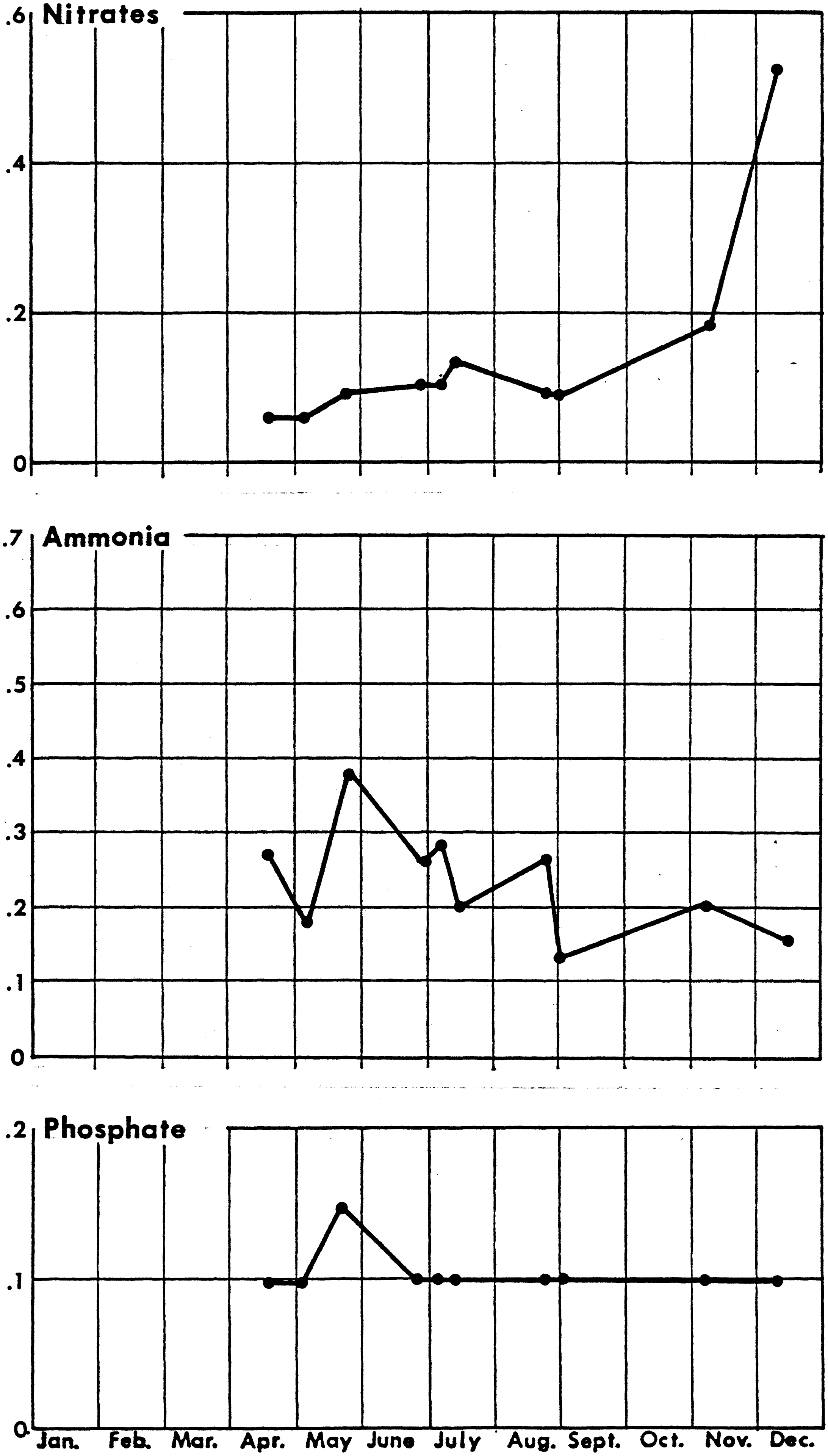

To
1,225
Fecal Coliform
500
400
300
200
100
0
40
N/P Ratio
30
20
16/1
10
0
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

LAKE MEANS



Dissolved Oxygen
14
13
12
11
10
9
8
7
6
Dissolved Oxygen -% Saturation
110
100
90
80
70
60
Chlorides
60
40
20
0
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

LAKE MEANS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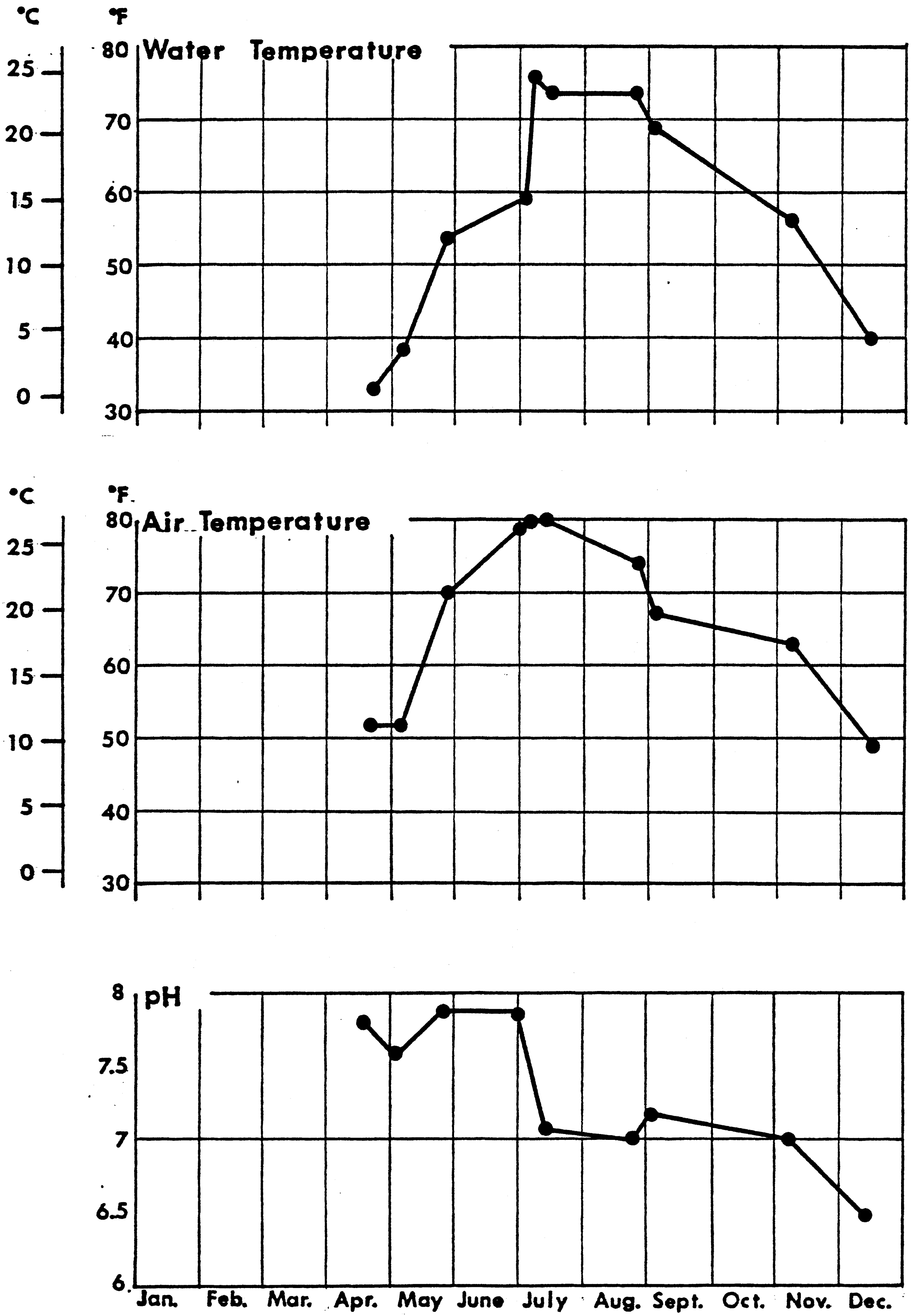
.4
.2
0
Ammonia
.7
.6
.5
.4
.3
.2
.1
0
Phosphate
.2
.1
0
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

SITE 1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°F
Water Temperature
80
70
60
50
40
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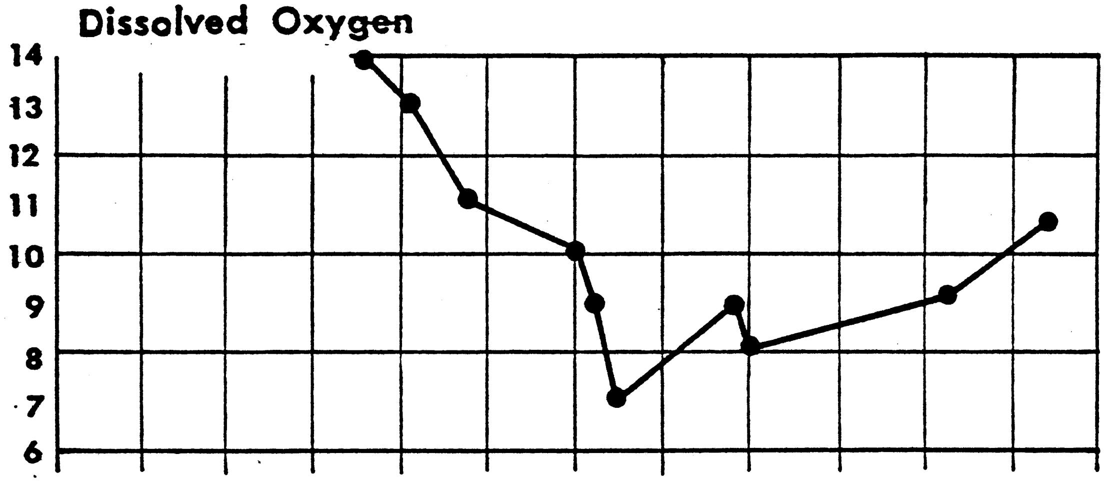
25
20
15
10
5
0
°C
°F
Air Temperature
80
70
60
50
40
30
25
20
15
10
5
0
pH
8
7.5
7
6.5
6
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

SITE 1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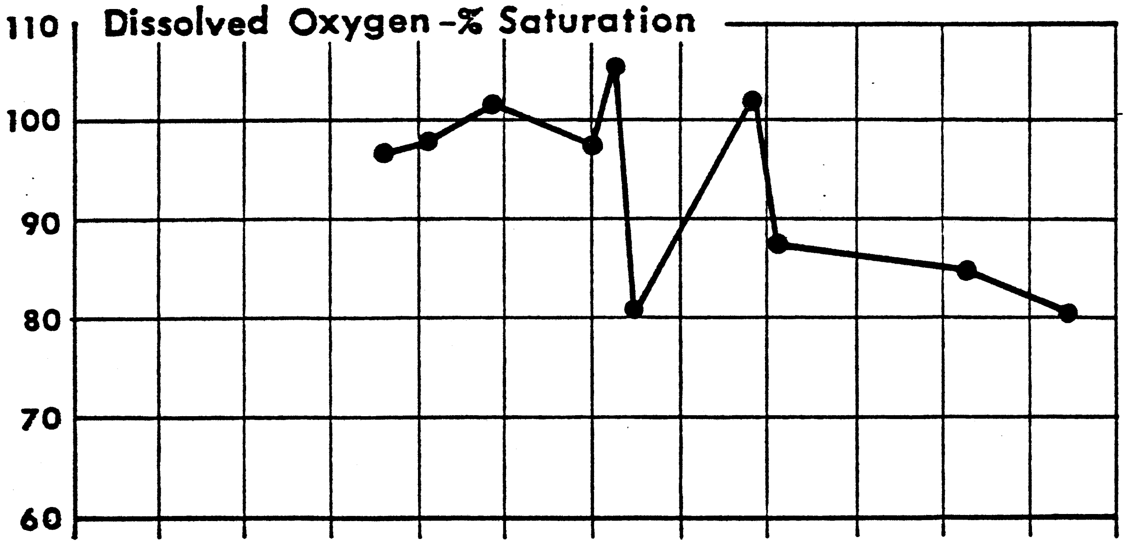
12
11
10
9
8
7
6


Dissolved Oxygen -% Saturation
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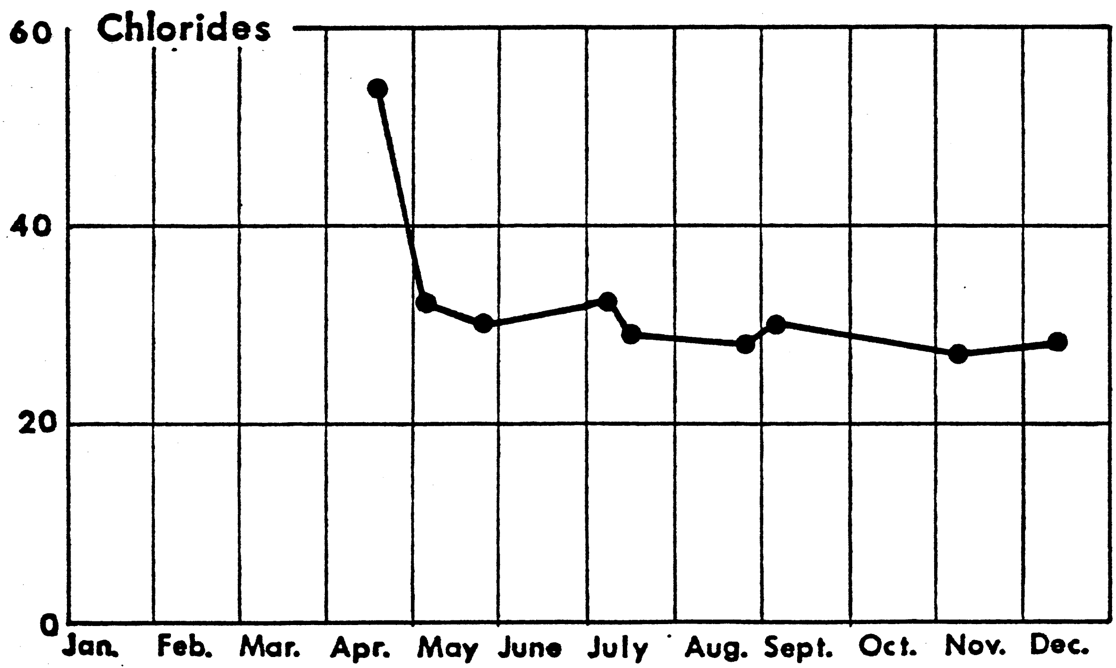
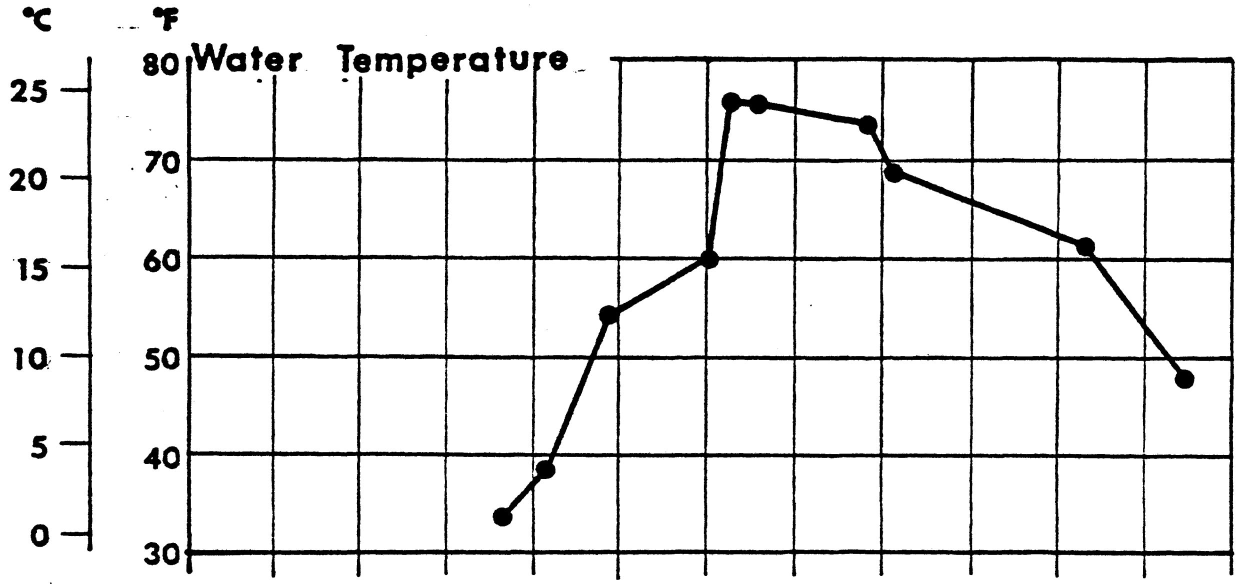
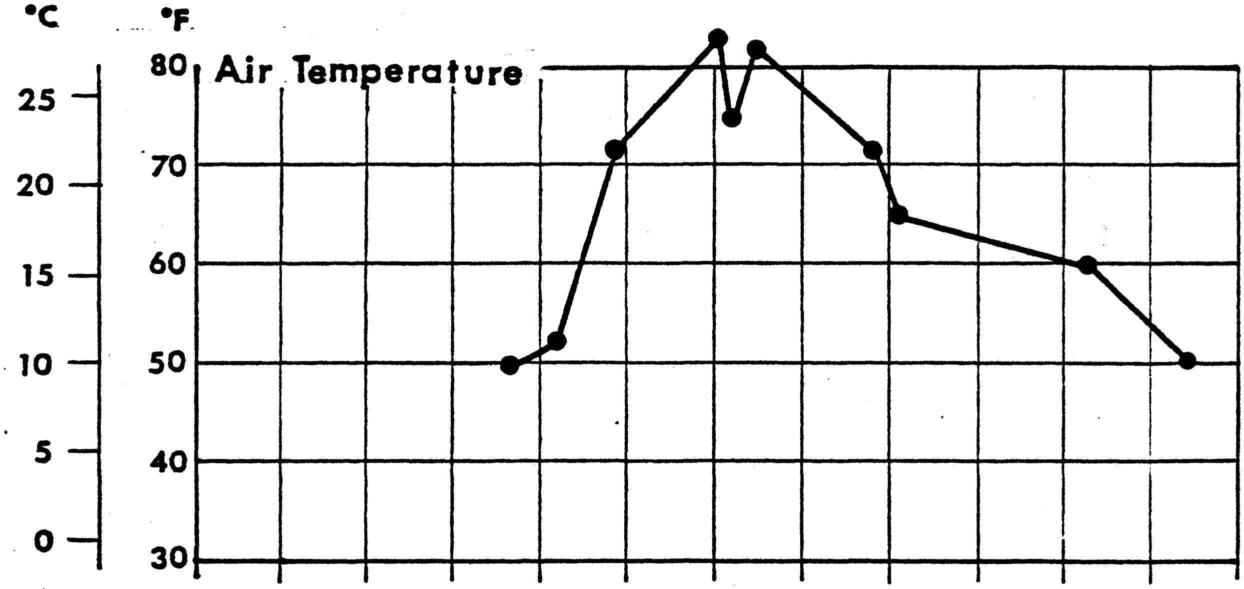
100
90
80
70
60


Chlorides
60
40
20
0
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

SITE 2


°C
°F
Water Temperature
25
20
15
10
5
0
80
70
60
50
40
30


°C
°F
Air Temperature
25
20
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5
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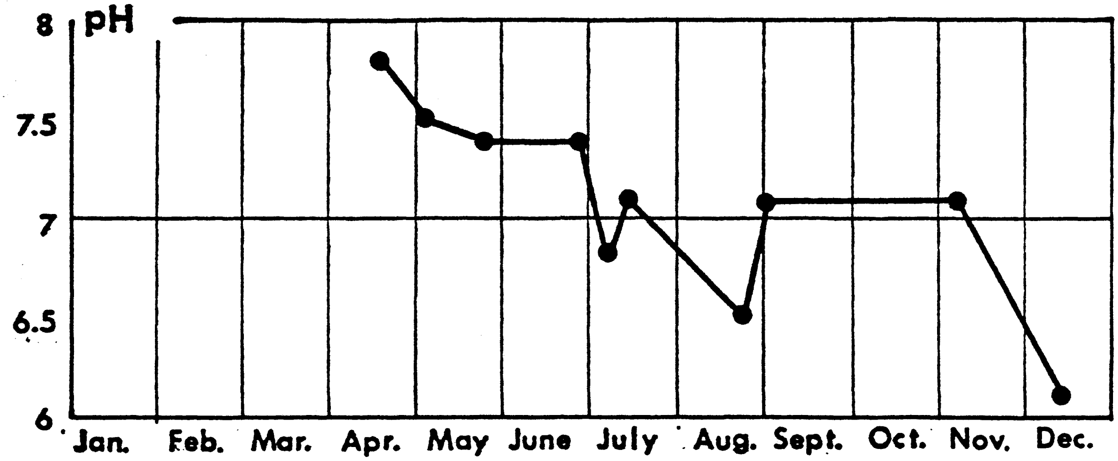
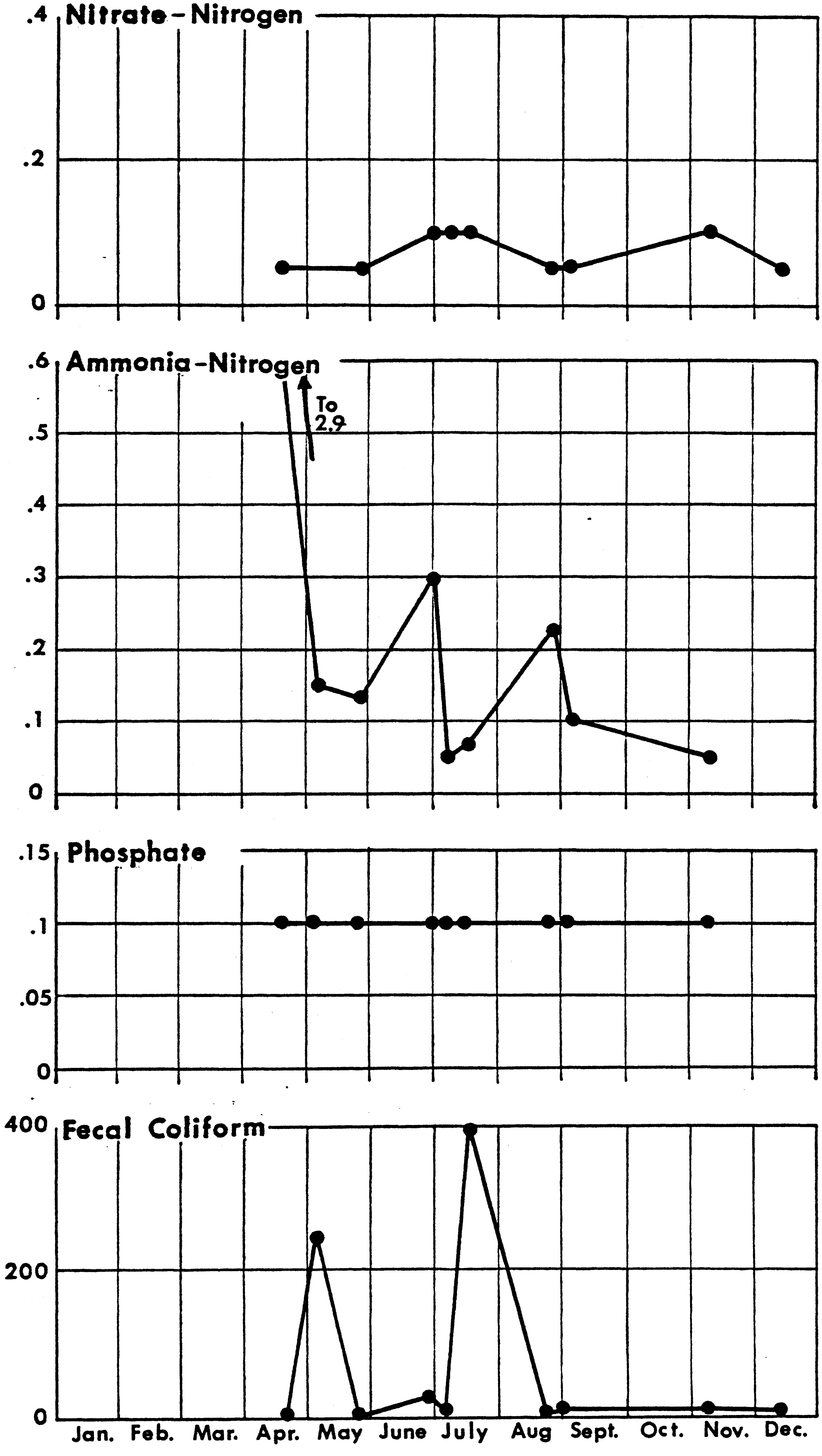
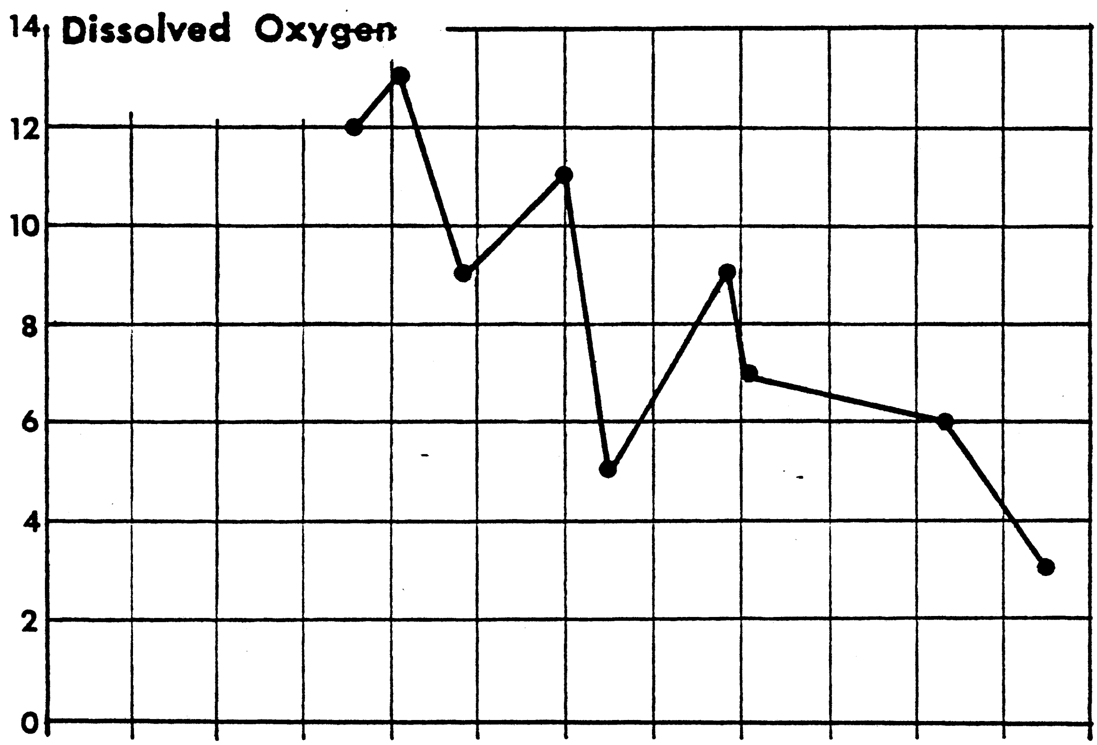
80
70
60
50
40
30


pH
8
7.5
7
6.5
6
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

SITE 1


Nitrate-Nitrogen
.4
.2
0
Ammonia-Nitrogen
To
2.9
.6
.5
.4
.3
.2
.1
0
Phosphate
.15
.1
.05
0
Fecal Coliform
400
200
0
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug
Sept.
Oct.
Nov.
Dec.

SITE 2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10
8
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4
2
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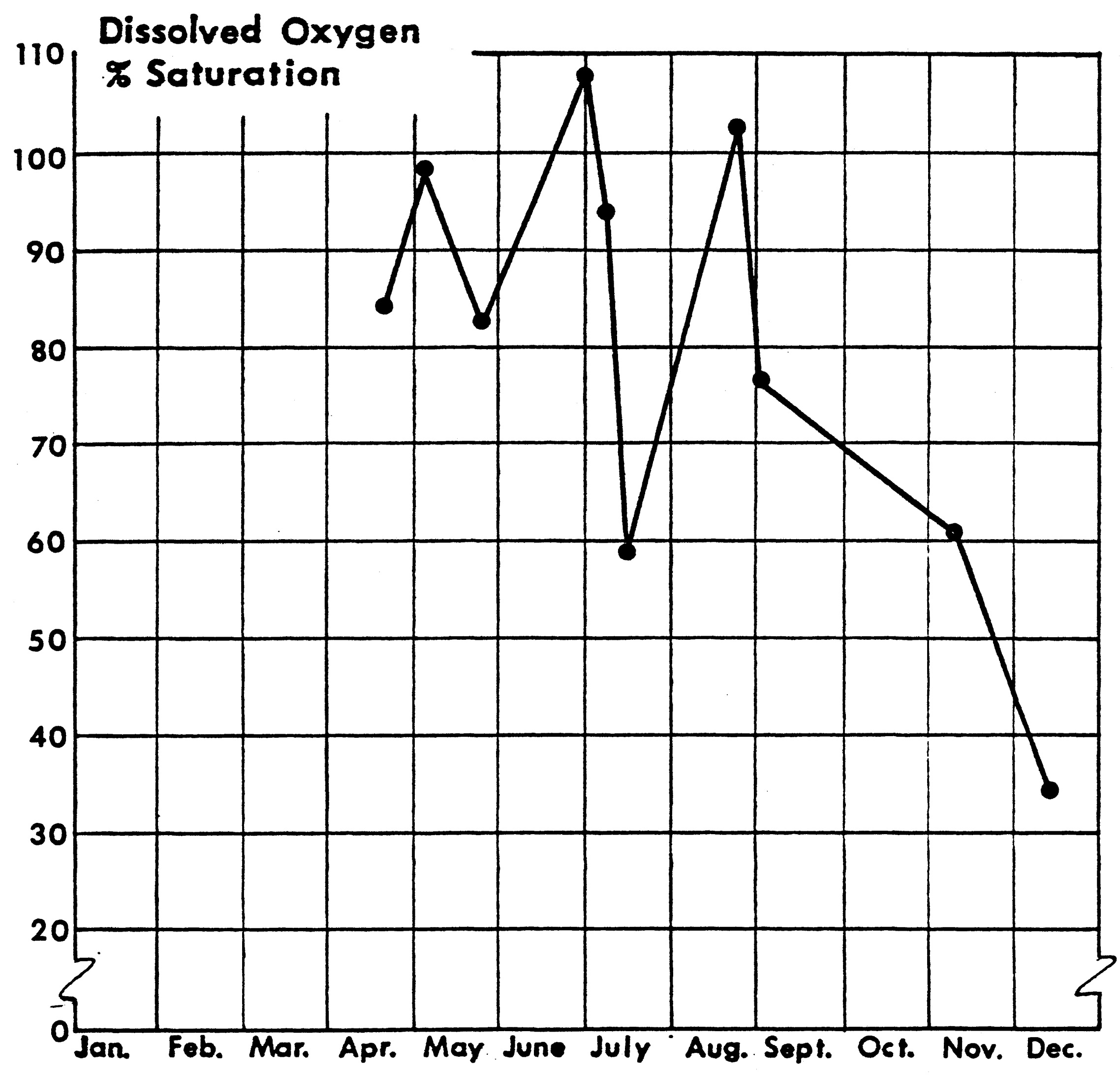
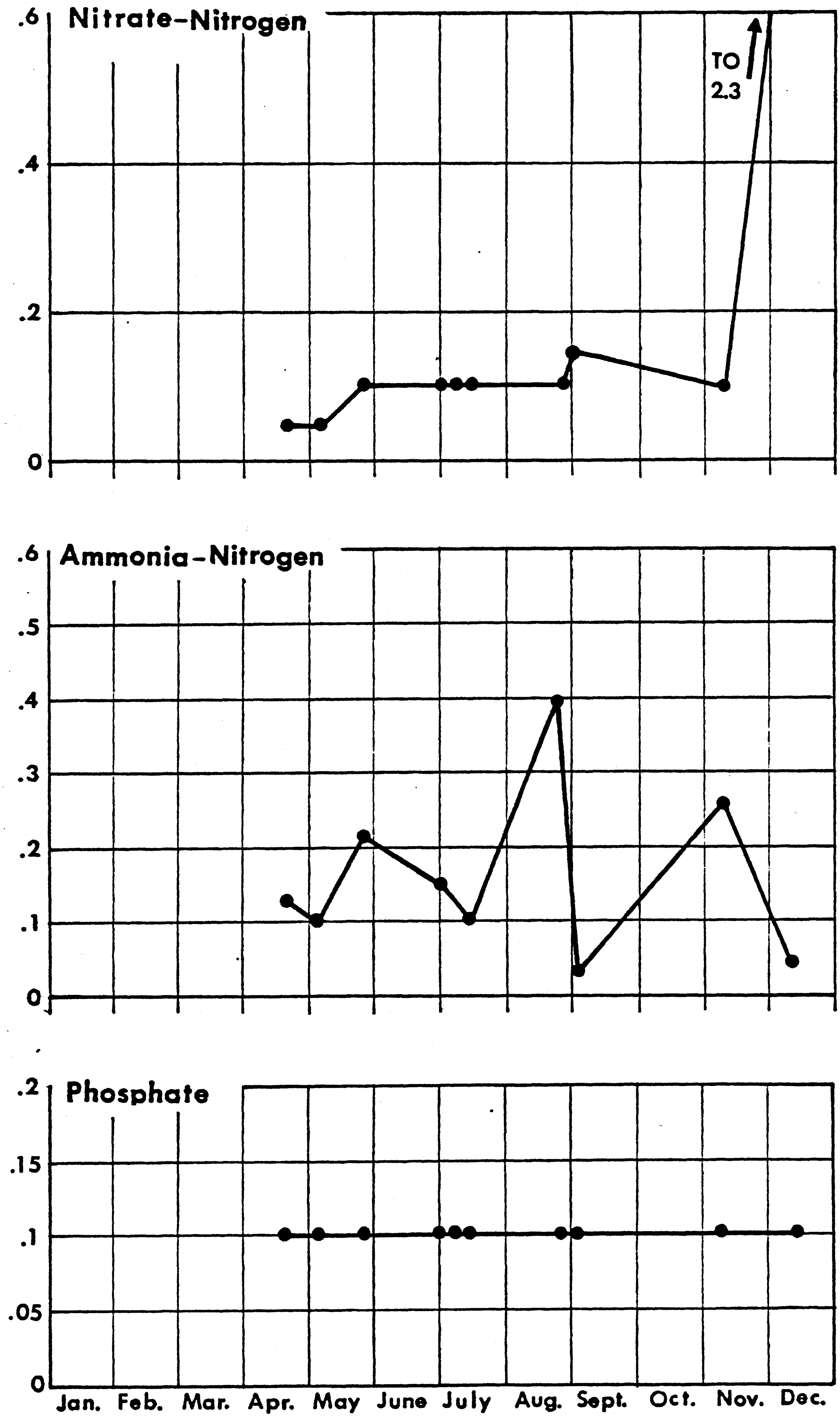
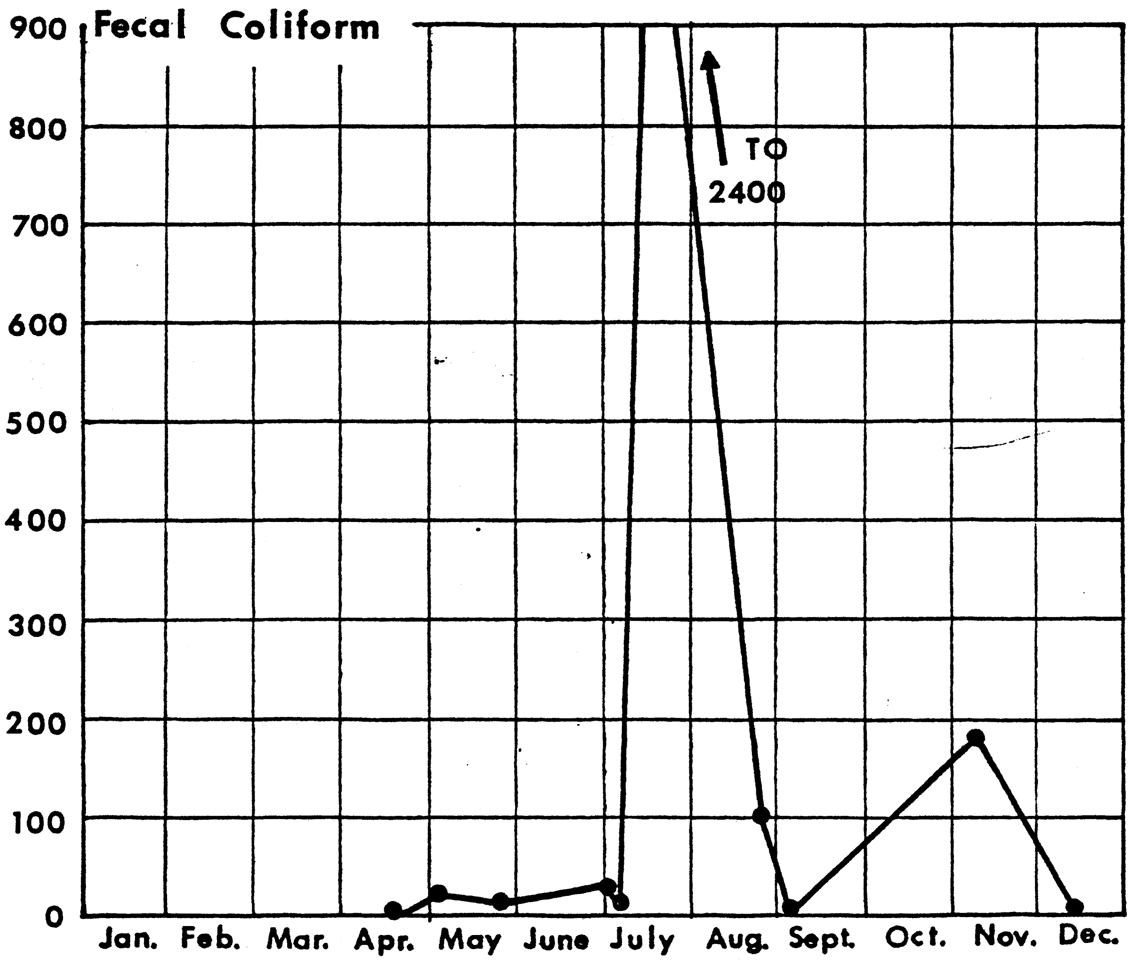

Dissolved Oxygen
% Saturation
110
100
90
80
70
60
50
40
30
20
0
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

SITE 2


Nitrate-Nitrogen
.6
.4
.2
0
TO 2.3
Ammonia-Nitrogen
.6
.5
.4
.3
.2
.1
0
Phosphate
.2
.15
.1
.05
0
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

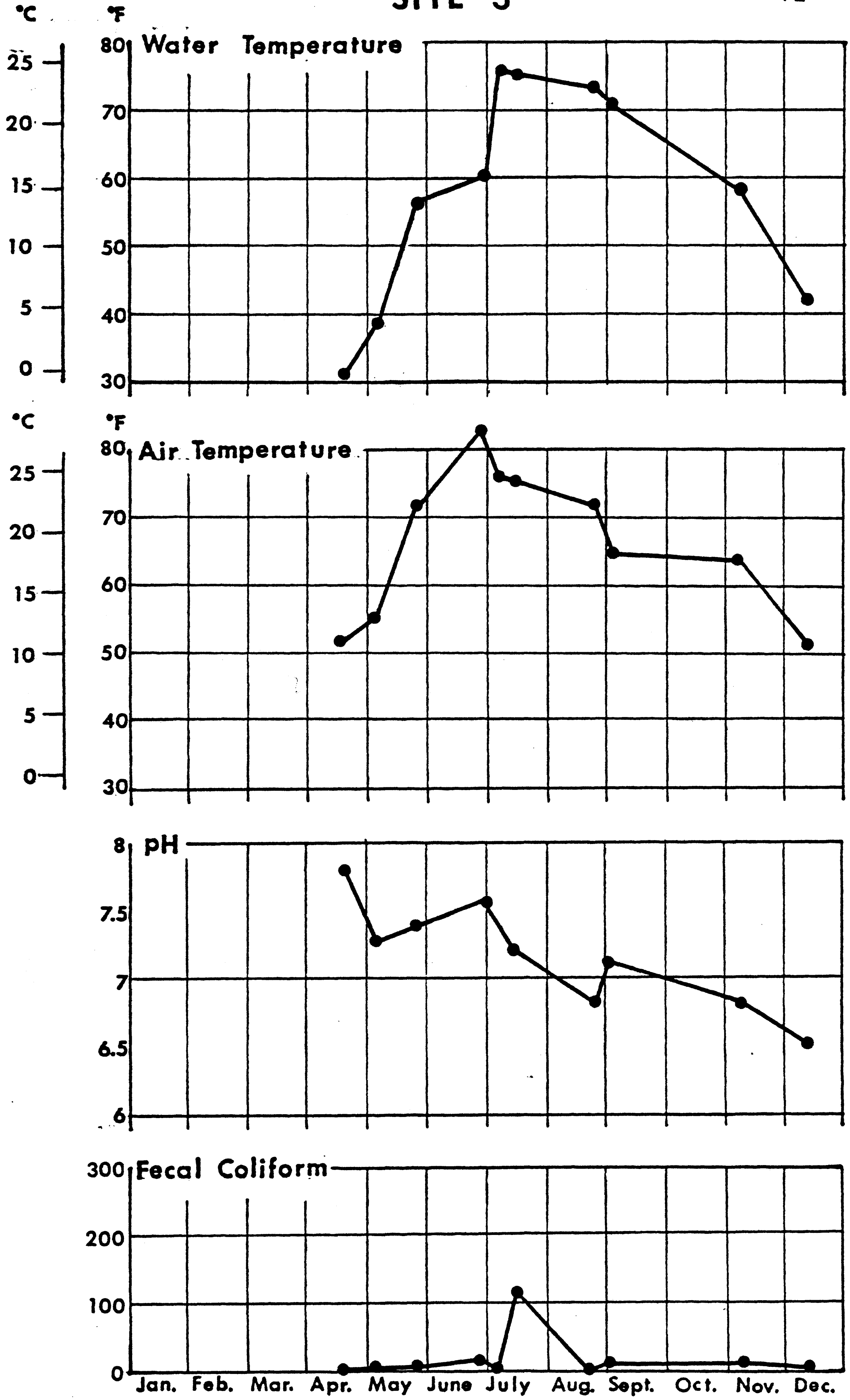
SITE 2

Chlorides
100
90
80
70
60
50
40
30
20
10

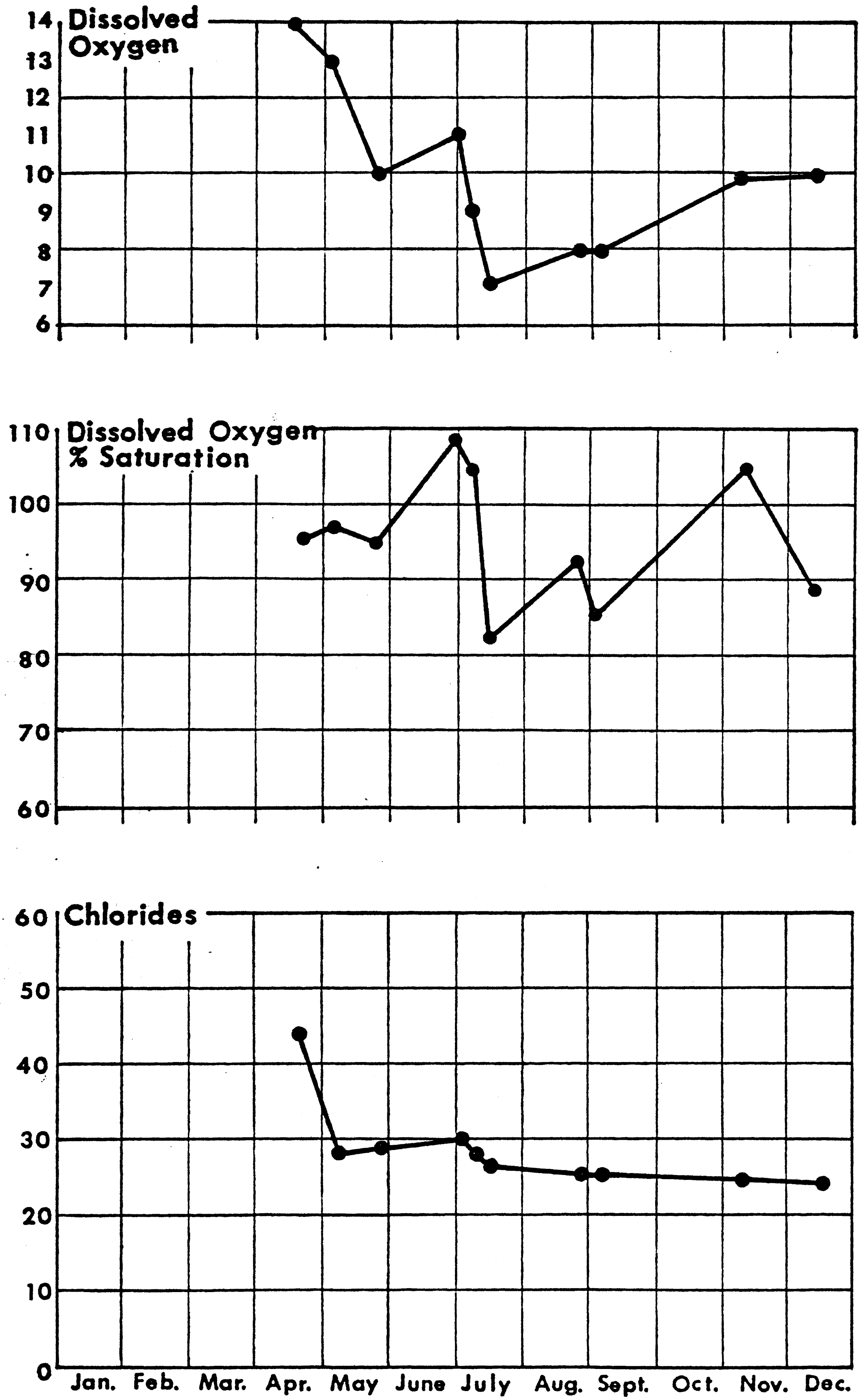


Fecal Coliform
900
800
700
600
500
400
300
200
100
0
TO
2400
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

SITE 3

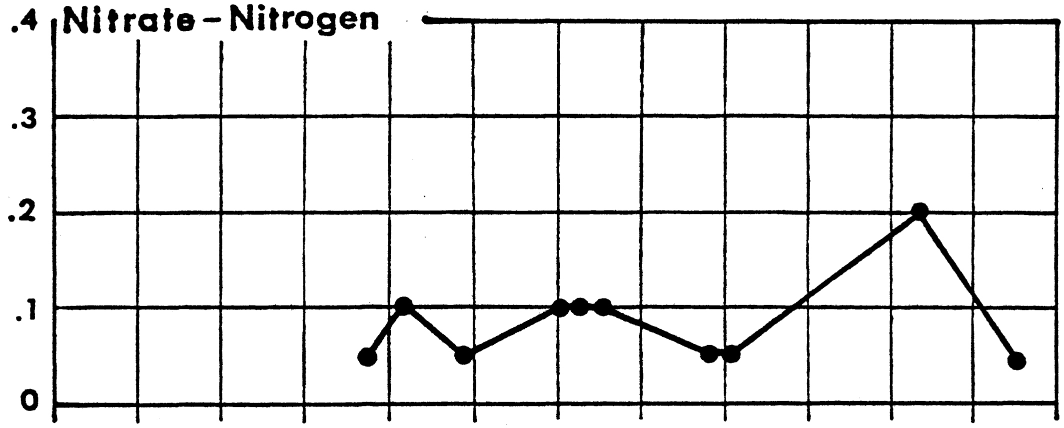

°C
°F
Water Temperature
25
20
15
10
5
0
80
70
60
50
40
30
°C
°F
Air Temperature
25
20
15
10
5
0
80
70
60
50
40
30
pH
8
7.5
7
6.5
6
Fecal Coliform
300
200
100
0
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

SITE 3



Dissolved Oxygen
14
13
12
11
10
9
8
7
6
Dissolved Oxygen % Saturation
110
100
90
80
70
60
Chlorides
60
50
40
30
20
10
0
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

SITE 3


Nitrate – Nitrogen
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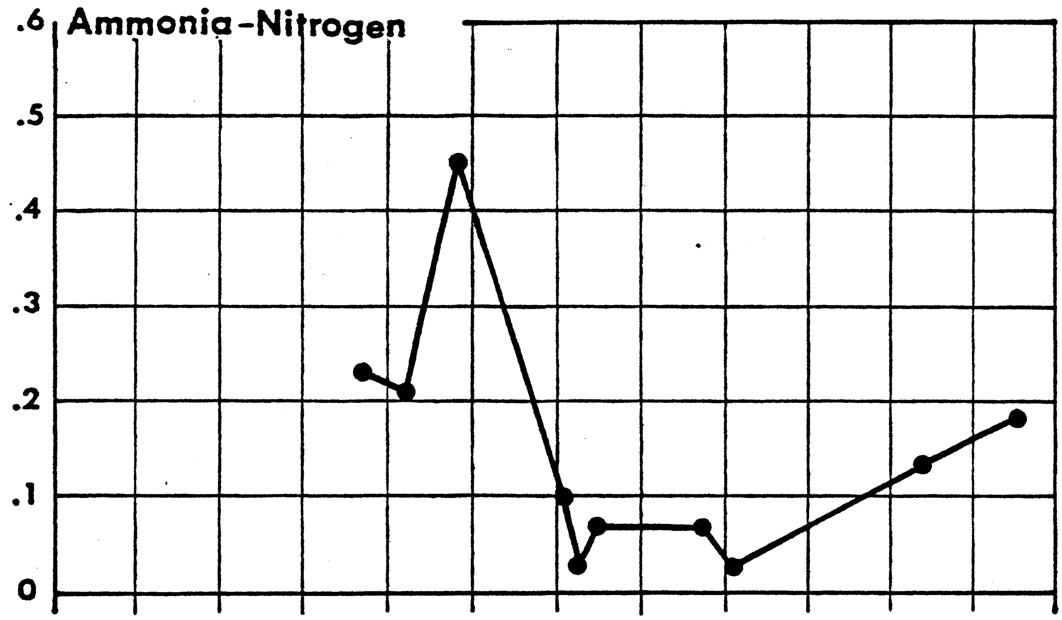
.3
.2
.1
0


Ammonia – Nitrogen
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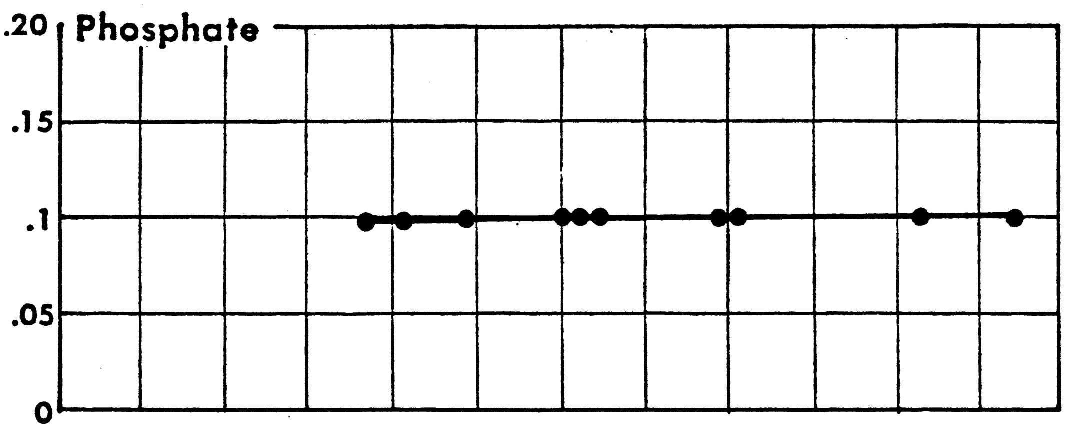
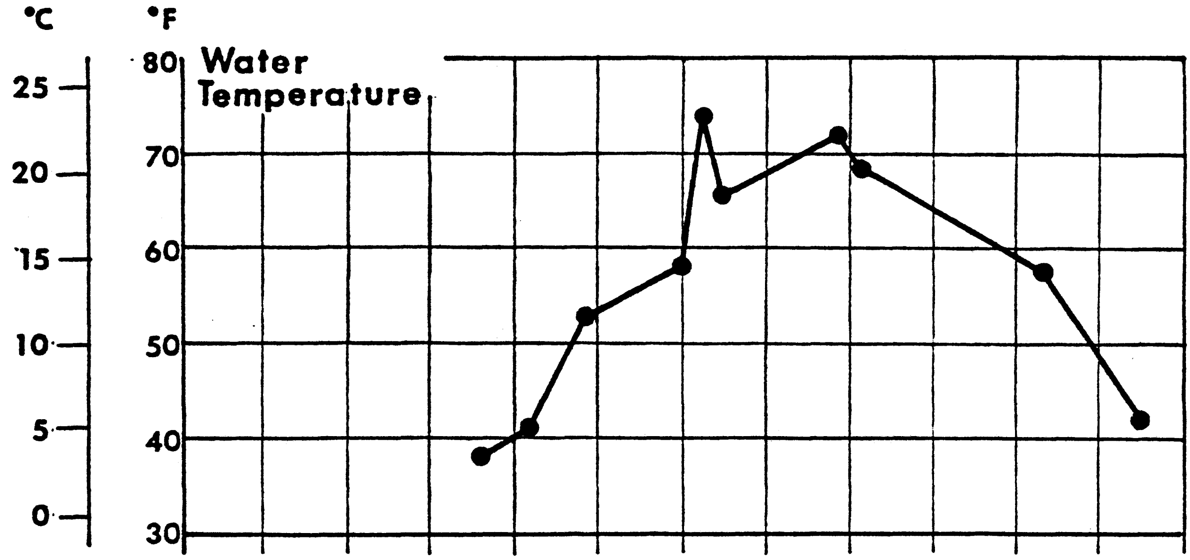
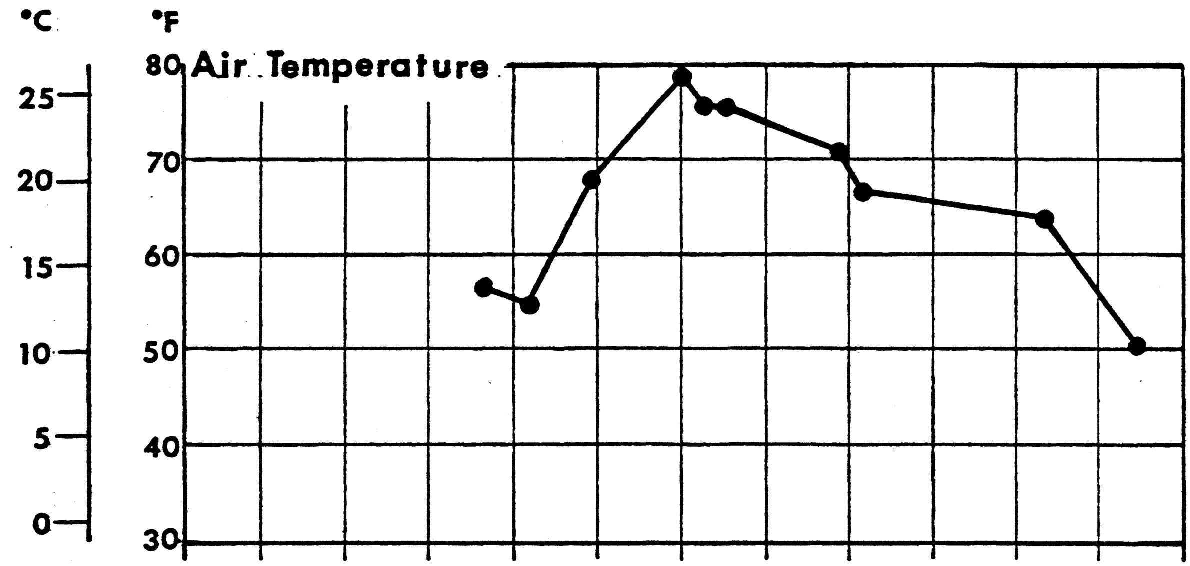
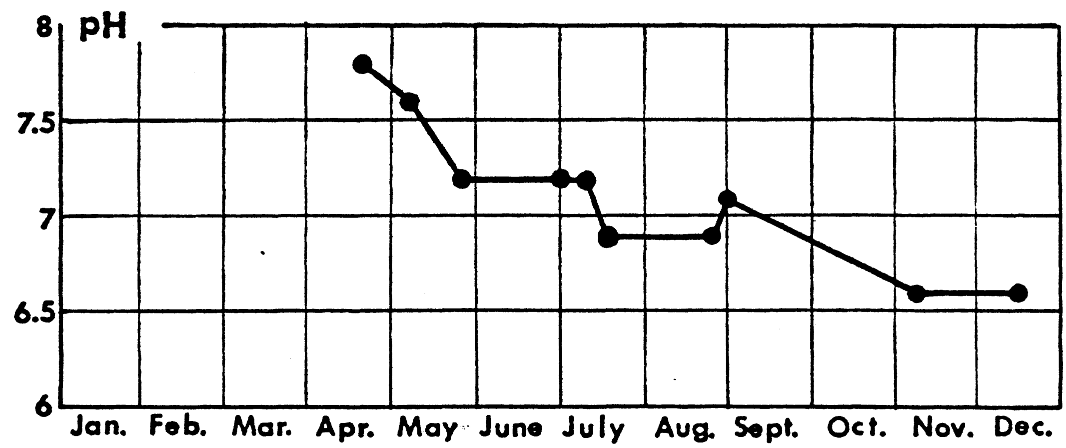
.5
.4
.3
.2
.1
0


Phosphate
.20
.15
.1
.05
0

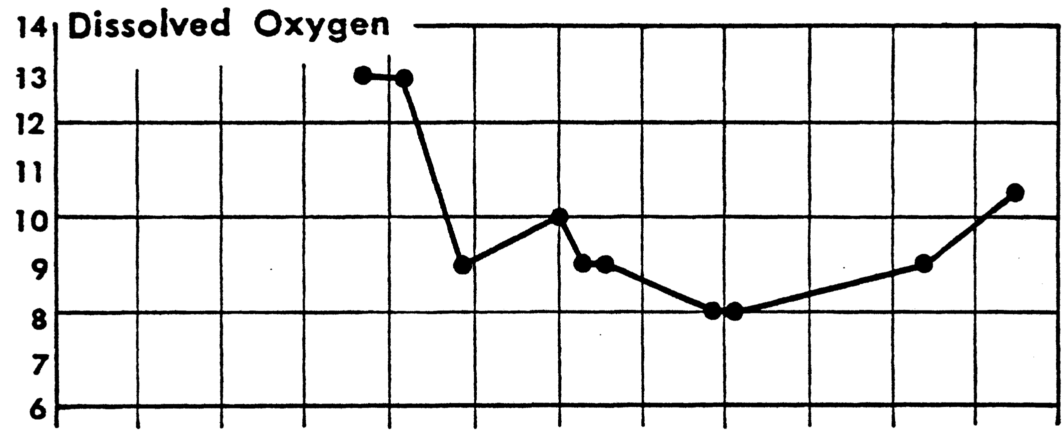
SITE 4

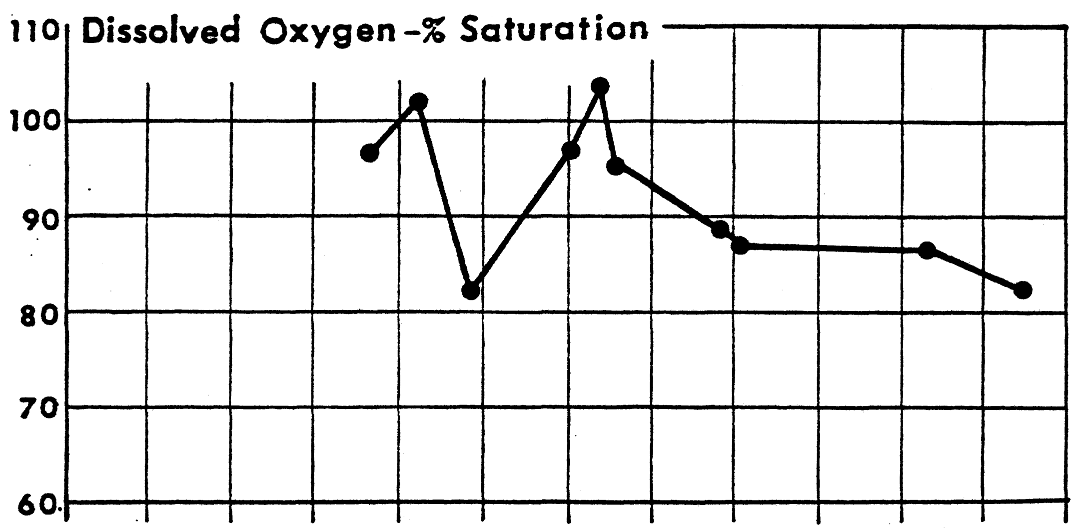

°C
°F
Water Temperature
25
20
15
10
5
0
80
70
60
50
40
30

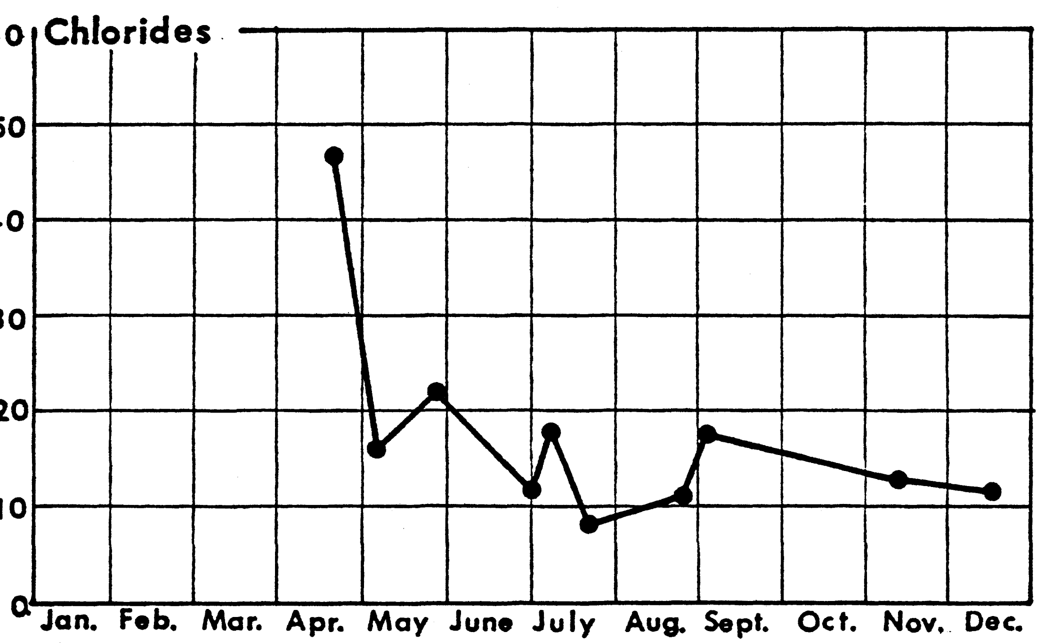

°C
°F
Air Temperature
25
20
15
10
5
0
80
70
60
50
40
30


pH
8
7.5
7
6.5
6
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

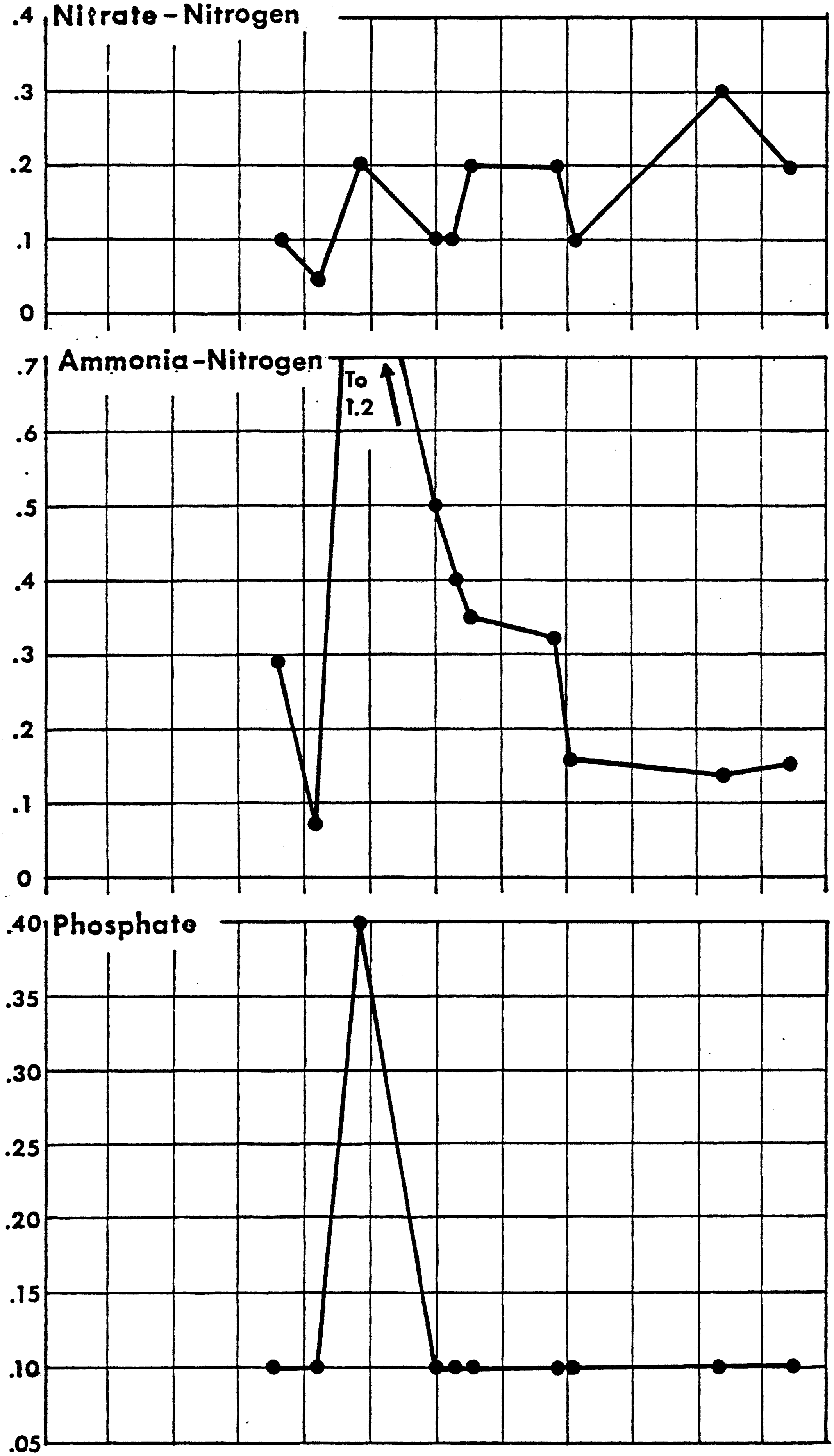
SITE 4


Dissolved Oxygen
14
13
12
11
10
9
8
7
6

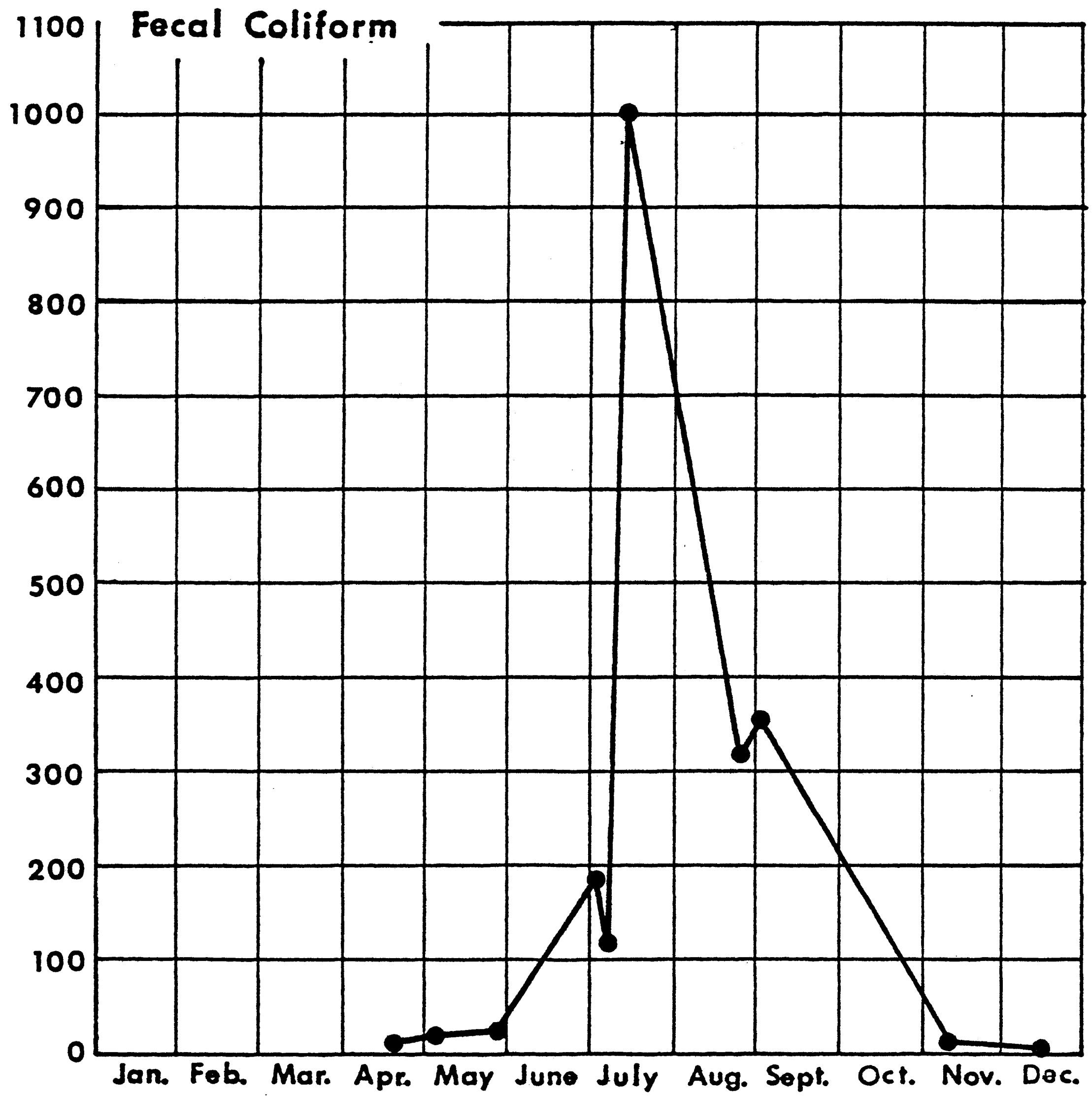

Dissolved Oxygen -% Saturation
110
100
90
80
70
60


Chlorides
60
50
40
30
20
10
0
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

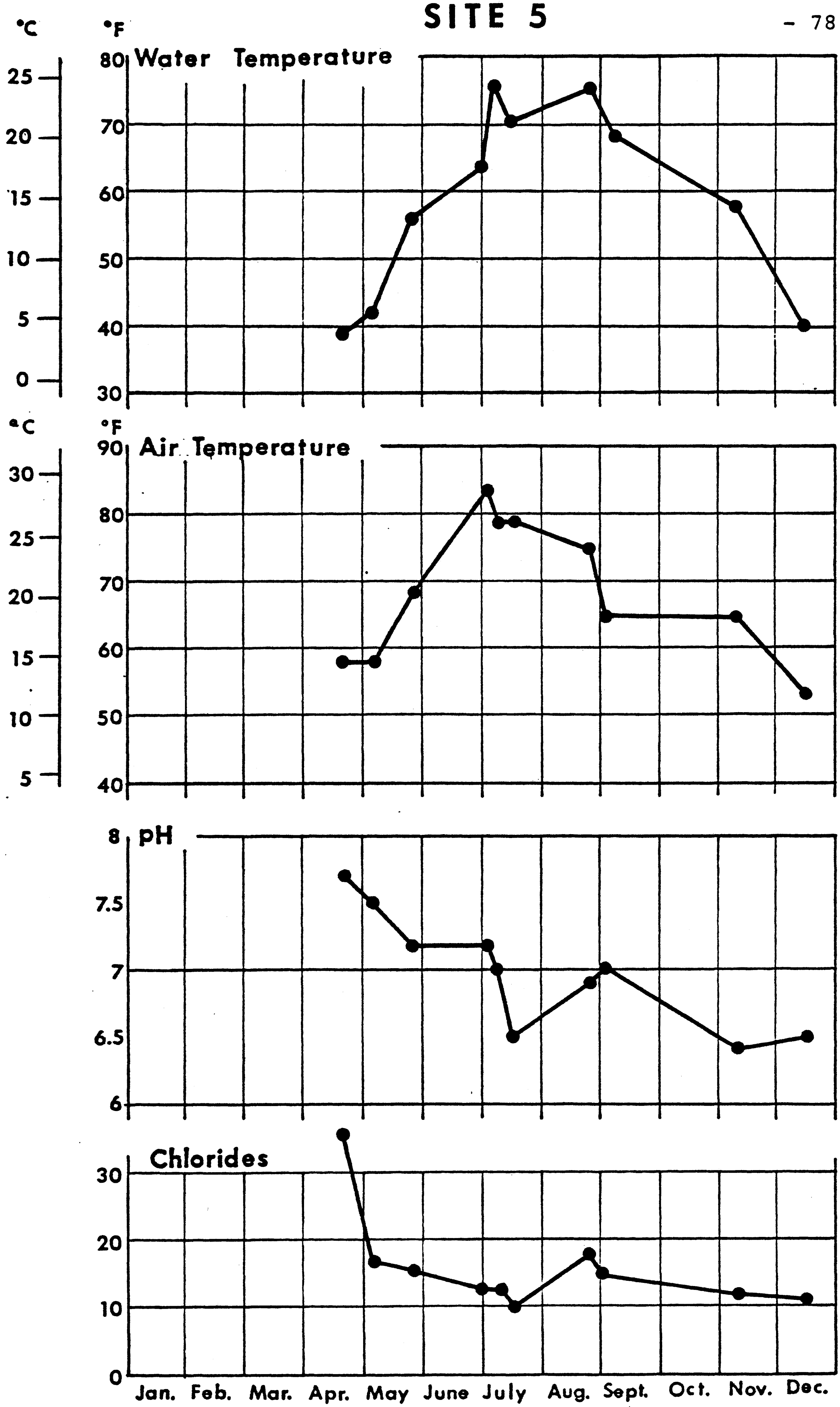
SITE 4


.4
.3
.2
.1
0
Nitrate - Nitrogen
.7
.6
.5
.4
.3
.2
.1
0
Ammonia - Nitrogen
To 1.2
.40
.35
.30
.25
.20
.15
.10
.05
Phosphate

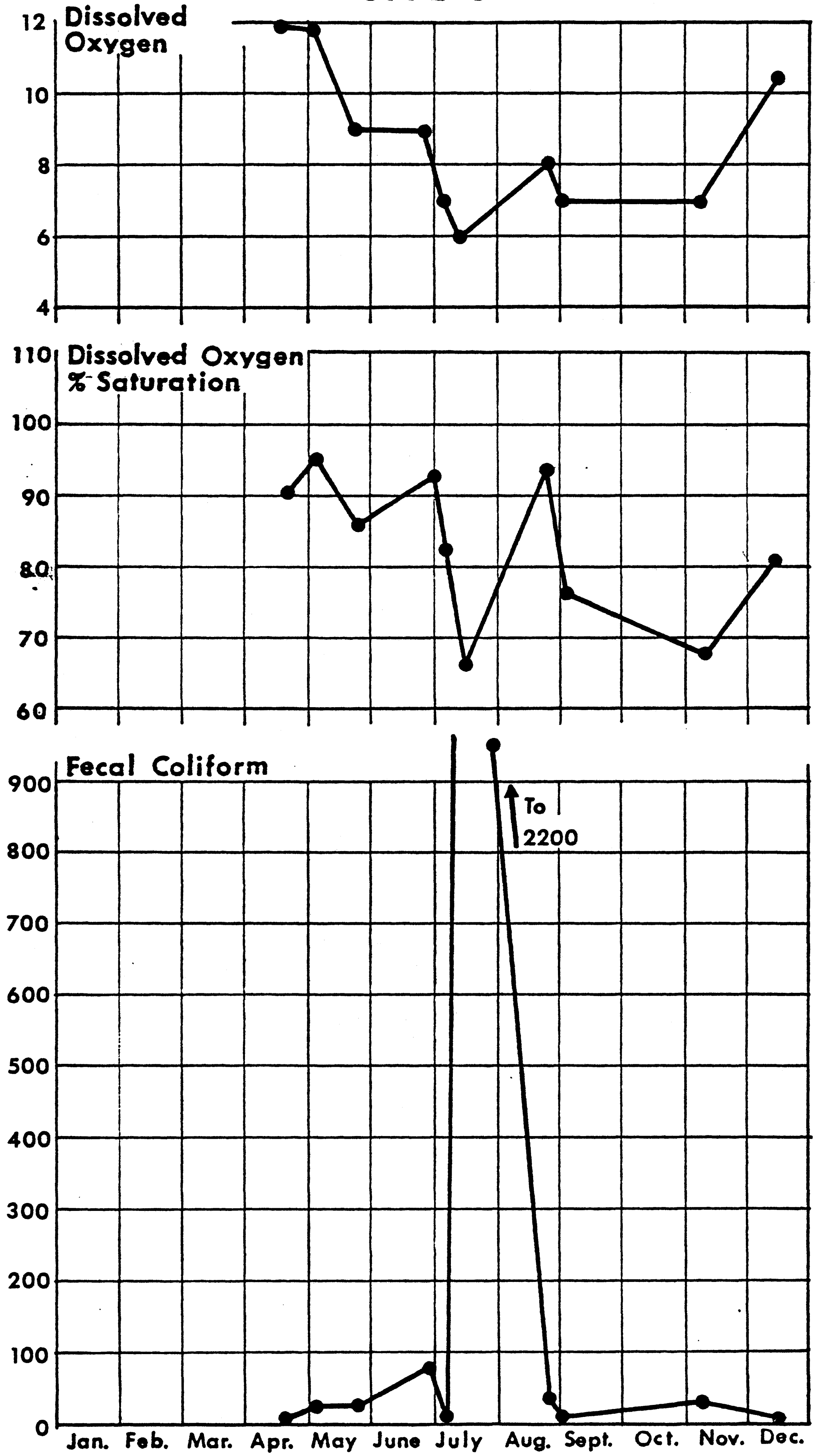
SITE 4


Fecal Coliform
1100
1000
900
800
700
600
500
400
300
200
100
0
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

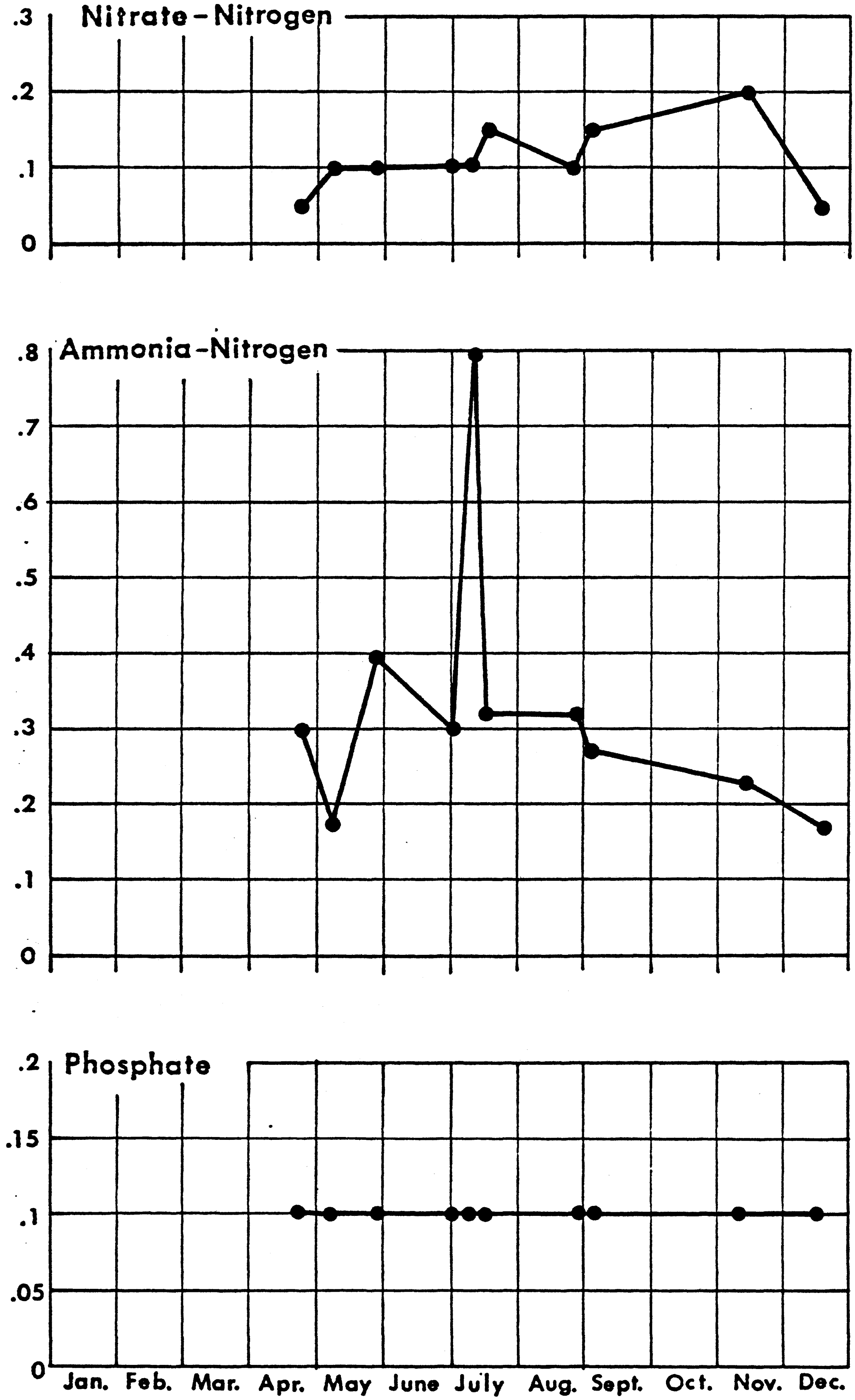
SITE 5


°C
°F
Water Temperature
25
20
15
10
5
0
80
70
60
50
40
30
°C
°F
Air Temperature
30
25
20
15
10
5
90
80
70
60
50
40
pH
8
7.5
7
6.5
6
Chlorides
30
20
10
0
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

SITE 5

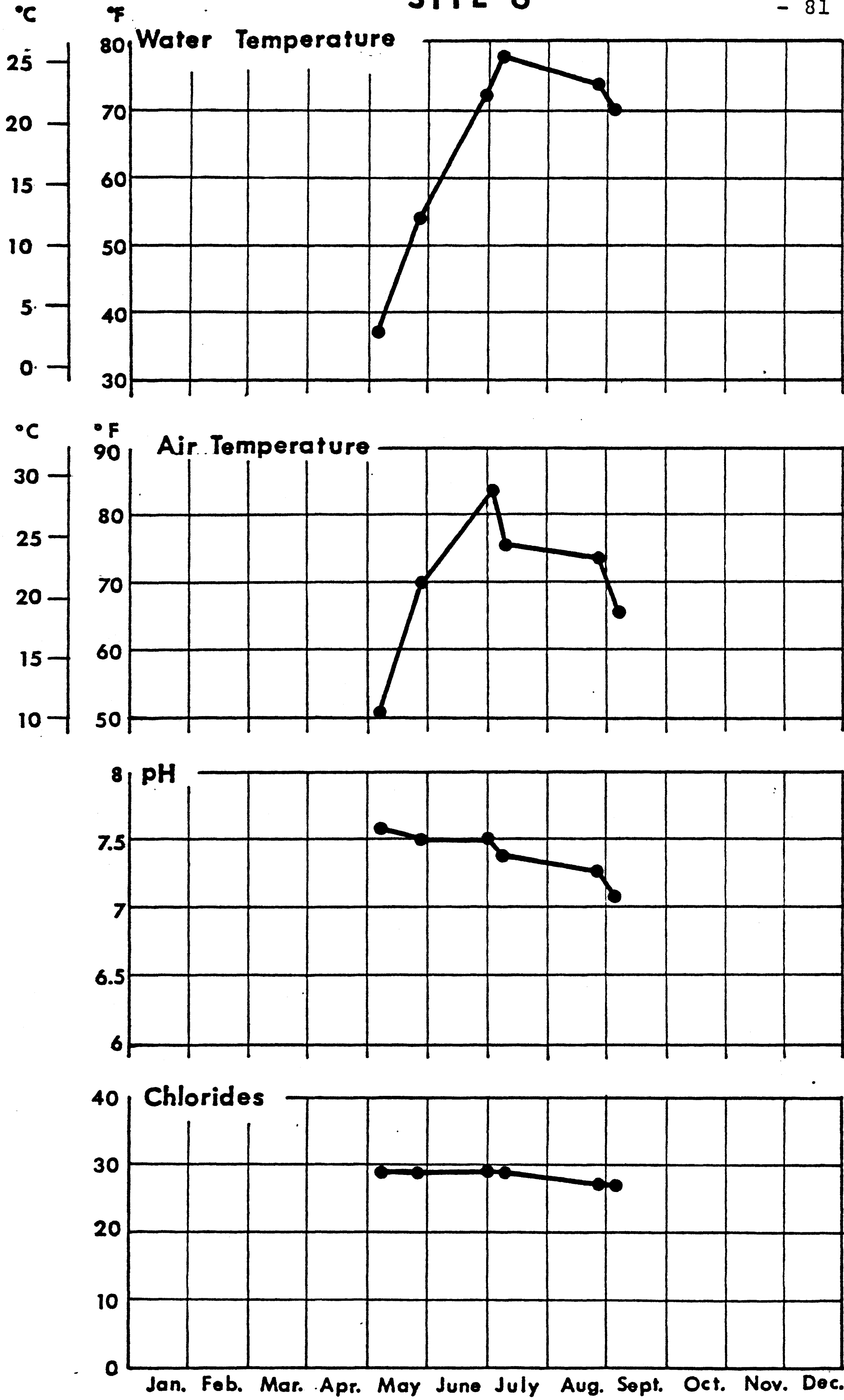

Dissolved Oxygen
12
10
8
6
4
Dissolved Oxygen % Saturation
110
100
90
80
70
60
Fecal Coliform
900
800
700
600
500
400
300
200
100
0
To 2200
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

SITE 5

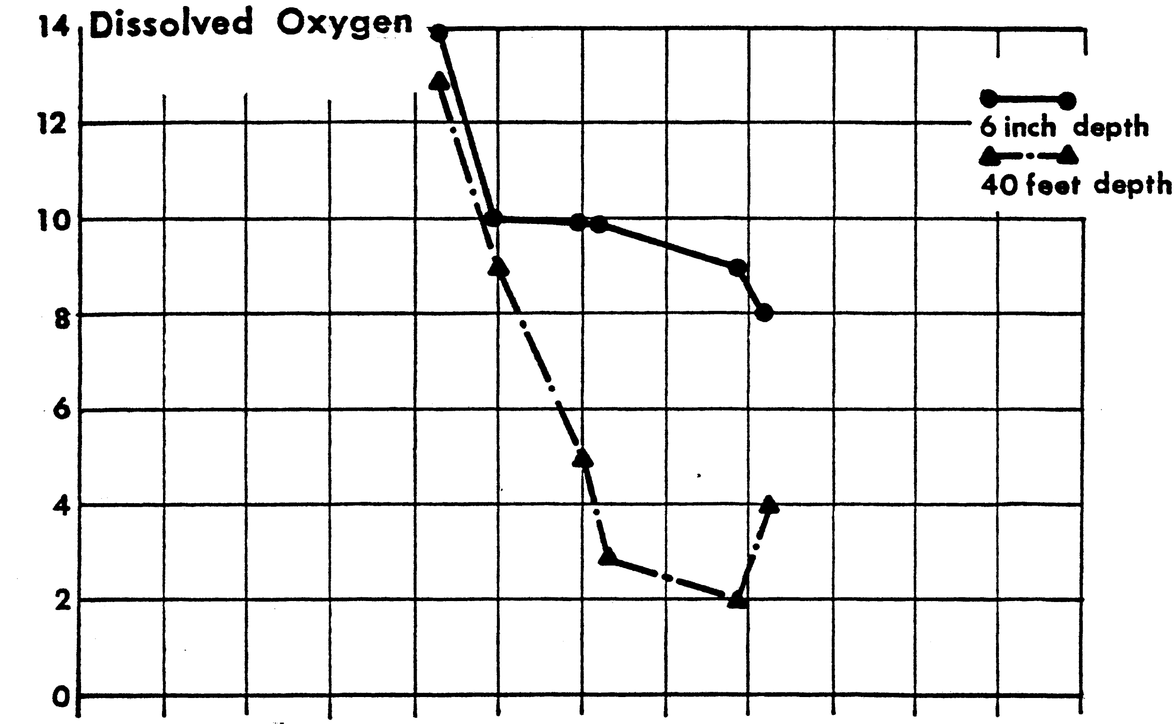


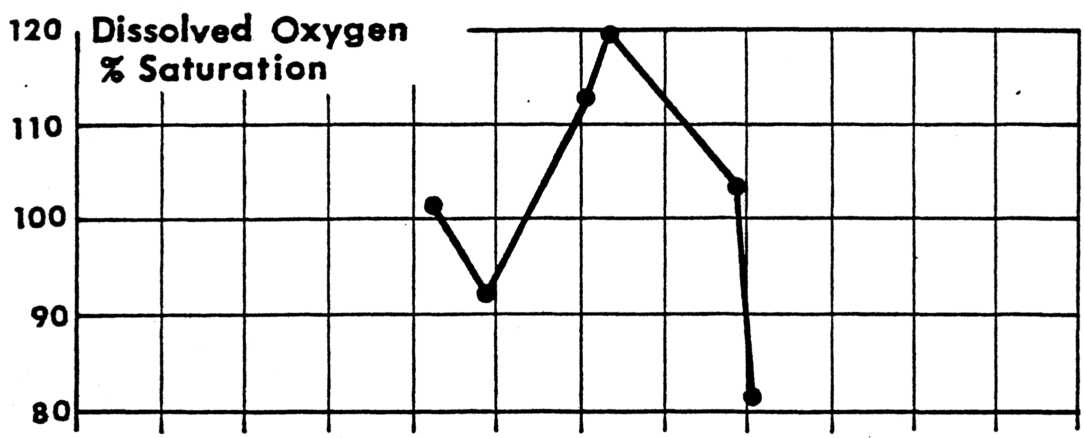
Nitrate-Nitrogen
.3
.2
.1
0
Ammonia-Nitrogen
.8
.7
.6
.5
.4
.3
.2
.1
0
Phosphate
.2
.15
.1
.05
0
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

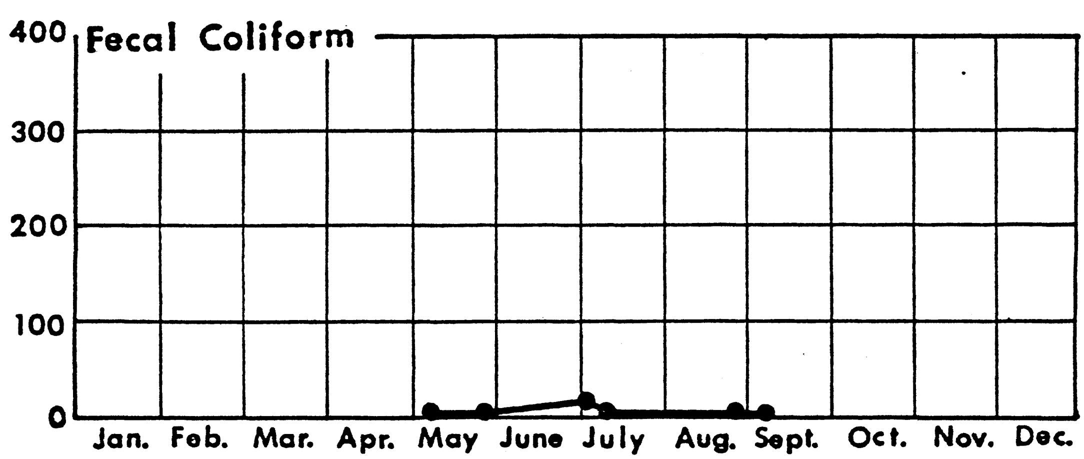
SITE 6


°C
°F
Water Temperature
80
70
60
50
40
30
25
20
15
10
5
0
°C
°F
Air Temperature
90
80
70
60
50
30
25
20
15
10
pH
8
7.5
7
6.5
6
Chlorides
40
30
20
10
0
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

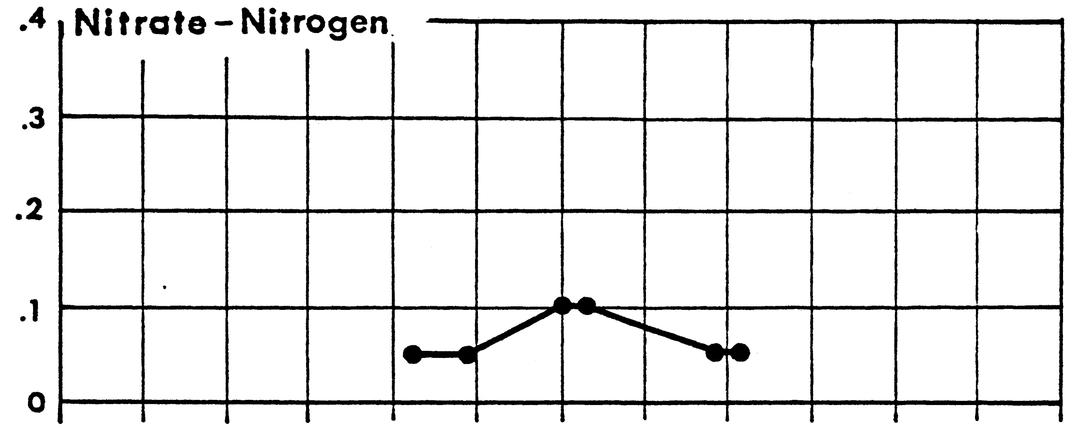
SITE 6


Dissolved Oxygen
14
12
10
8
6
4
2
0
6 inch depth
40 feet depth

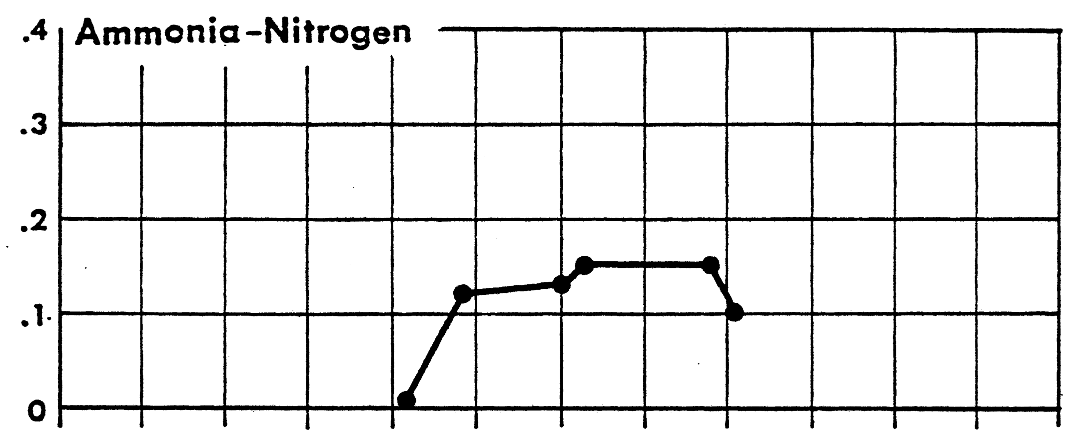

Dissolved Oxygen
% Saturation
120
110
100
90
80


Fecal Coliform
400
300
200
100
0
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

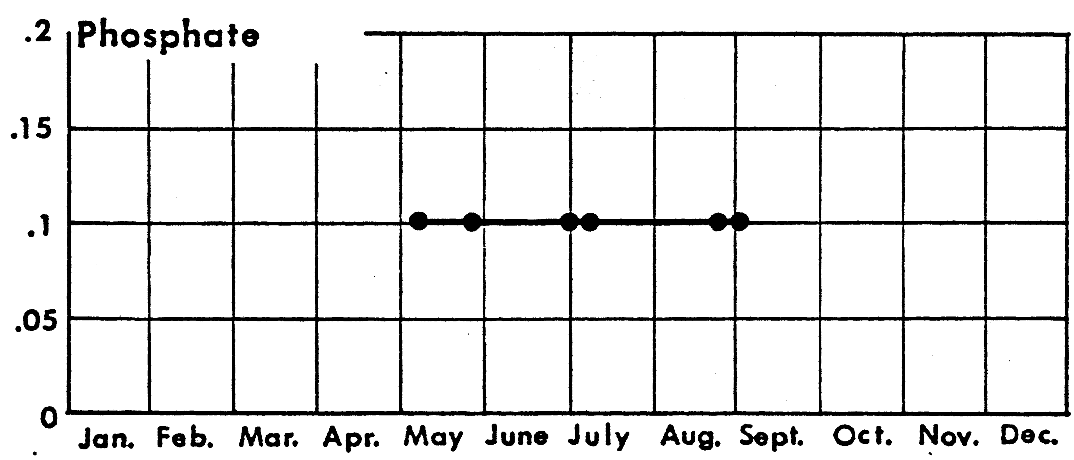
SITE 6



.4
.3
.2
.1
0
Nitrate – Nitrogen



.4
.3
.2
.1
0
Ammonia-Nitrogen



.2
.15
.1
.05
0
Phosphate
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

DELAWARE RIVER BASIN

01455500 Musconetcong River at outlet of Lake Hopatcong, N.J.

LOCATION -- Lat 40°55'00", long 74°59'55", Morris County, on left bank just upstream of highway bridge and 300 ft. (91 m) downstream from Lake Hopatcong Dam in Landing.

DRAINAGE AREA -- 25.6 mi^2 (66.3 km^2).

PERIOD OF RECORD -- July 1928 to September 1975 (discontinued).

GAGE -- Water-stage recorder and concrete control. Prior to Aug. 24, 1967, concrete control at site 40 ft. (12 m) downstream. Datum of gage is 904.99 ft. (275.841 m) above mean sea level (New Jersey Geological Survey bench mark).

AVERAGE DISCHARGE -- 47 years, 45.6 ft^3/s (1.55 m^3/s), unadjusted.

EXTREMES -- Current year: Maximum discharge 340 ft^3/s (9.63 m^3/s), July 14 (gage height, 4.11 ft. or 1,253 m); minimum daily, 5.5 ft^3/s (0.16 m^3/s) Mar. 20.
Period of record; Maximum discharge, 795 ft^3/s (22.5 m^3/s) Aug. 20, 1955 (gage height, 3.85 ft. or 1.175 m), from rating curve extended above 300 ft^3/s (8.50 m^3/s); maximum gage height, 3.96 ft. (1.207 m) Aug. 5, 1969; no flow many days in some years.

REMARKS -- Records excellent. Flow regulated by Lake Hopatcong (see Delaware River Basin, reservoirs in).

COOPERATION -- Water-stage recorder inspected by employees of Morris Canal and Banking Company.

REVISIONS (WATER YEARS) -- WSP 781; 1928(M), Drainage area. WSP 1051: 1944-45.

DELAWARE RIVER BASIN

01455400 LAKE HOPATCONG -- Lat 40°55'00", long 74°39'50", Morris County, in gatehouse of Lake Hopatcong Dam on Musconetcong River at Landing. Drainage area, 25.6 $mi.^2$ (66.3 km^2). Period of record, February 1887 to current year. Monthend contents only prior to October 1950, published in WSP 1302. Gage, water-stage recorder. Prior to June 24, 1928, daily readings obtained by measuring from high-water mark to water surface converted to gage height, present datum. Datum of gage is 914.57 ft. (278.761 m) above mean sea level (New Jersey Geological Survey datum). Extremes for current year: Maximum contents, about 5,424,000,000 gal. (31.88 hm^3) about July 15 (gage height e10.14 ft); minimum, about 5,427,000,000 gal. (20.54 hm^3) about Dec. 27 (gage height e6.48 ft). Extremes for period of record: Maximum contents, 8,532,000,000 gal (32.29 hm^3) June 24, 1972 (gage height 10.27 ft. or 3.130 m); minimum, 1,525,000,000 gal (5.77 hm^3) Dec. 29, 1960 (gage height 0.65 ft. or 0.198 m).

Lake is formed by concrete spillway and earthfill dam completed about 1828. Crest of spillway was lowered 0.11 ft. (0.034 m) in 1925. Usable capacity, 7,459,000,000 gal (28.25 hm^3) between (gage height -2.6 ft. or -0.792 m, sills of gates and 9.00 ft. or 2,745 m, crest of spillway). Flow regulated by four gates (3 by 5 ft. or 0.914 by 1.524 m), also by one 24-inch (0.610 m) pipe with gate valve to recreation fountain 250 ft. (76.2 m) downstream from dam. Dead storage about 8,117,000,000 gal (30.72 hm^3). Figures given herein represent usable capacity. Lake used for recreation.

MONTHEND ELEVATION AND CONTENTS, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

Date	Gage Height (feet)	Contents (million gallons)	Change in contents (equivalent in cfs)
	01455400 Lake Hopatcong†		
Sept. 30	a8.86	7,343	-
Oct. 31	e6.86	5,724	-80.8
Nov. 30	e6.90	5,756	+1.7
Dec. 31	*6.48	5,427	-16.4
CAL YR 1974	-	-	-7.1
Jan. 31	7.08	5,897	+23.5
Feb. 28	7.10	5,913	+.9
Mar. 31	9.30	7,711	+89.7
Apr. 30	9.24	7,661	-2.6
May 31	9.30	7,711	+2.5
June 30	9.28	7,694	-.9
July 31	9.33	7,736	+2.1
Aug. 31	9.16	7,593	-7.1
Sept. 30	8.18	6,783	-41.8
WTR YR 1975	-	-	-2.4

† Elevation at gage height at 2400 hours.
a Observed.
e Estimated.
* Elevation at 0900 hours.