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Stockpile Leaching and Chemical Transport at the Erie Mining Company Dunka Site: A Data Summary for 1976- 1979

Minnesota Department of Natural Resources

Division of Minerals

1980

Stockpile Leaching and Chemical Transport at the Erie Mining Company Dunka Site: A Data Summary for 1976 - 1979

Paul Eger
Kim Lapakko

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

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FOREWORD

The purpose of this report is to summarize and present all the data that has been collected from 1976 through 1979. There is essentially no discussion of the data in this report, since detailed discussion of much of the data has already been presented elsewhere or will be presented in reports in preparation. (1-23).

ACKNOWLEDGEMENTS

We would like to thank Erie Mining Company for their cooperation in this study. Their willingness to allow us access to their property, their assistance in the field and their analyses of our many "special" samples have added greatly to the data in this report. Special thanks go to Larry Peterson for his constant complaining, good insights, and help in the field (at least on sunny days).

The data from 1976 - 1977 were collected as part of the Minnesota's Environmental Quality Board's Regional Copper-Nickel Study. Data since 1977 have been collected under a joint DNR-Erie study. Bruce Johnson and Ann Weir have been responsible for our data collection efforts and they have done an outstanding job. All our student workers and laborers have also provided much appreciated assistance. Special thanks also goes to the U. S. Geological Survey,Grand Rapids, for their continued assistance with our many field and data problems.

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1. INTRODUCTION

Water quality and flow have been monitored at the Erie Mining Company Dunka Site from 1976 to present as a joint study involving Erie Mining Company, the Regional Copper-Nickel Study (1976-1977), and the Minnesota Department of Natural Resources (DNR). The objective of this report is to present a brief summary of the data collected from 1976 through 1979. Data continues to be collected under a joint program with Erie and the DNR. The report focuses on the release of trace metals from mining stockpiles and their subsequent transport through Unnamed Creek.

Additional information on this study, and related information regarding regional background data, gabbro leaching, chemical transport, stockpile hydrology, and mitigation is availabe in other references (1-23).

2. SITE DESCRIPTION

The Dunka Mine is an open pit taconite operation. The pit is approximately 4,000 m long, 400 m wide and 110 m deep. The contact between the Duluth gabbro complex and the iron formation occurs in the mine and to remove the underlying taconite, Erie has stockpiled $\sim 20 \times 10^6$ tons of gabbro material along the eastern boundary of its pit (Figure 1). Waste rock stockplies contain less than 0.2% Cu and lean ore stockpiles greater than 0.2% Cu. The stockpiles contain from 4-10 million tons of gabbro and cover from 0.11 to 0.62 km^2 (Table 1). The entire watershed area is 1.14 km^2.

Mine dewatering and runoff from the stockpiles flow into Unnamed Creek and subsequently into Bob Bay on Birch Lake. The mine dewatering discharges are denoted as the 011 and 012 dis-

Figure 1

DUNKA PIT STUDY

STOCKPILE AND SAMPLING SITE LOCATIONS

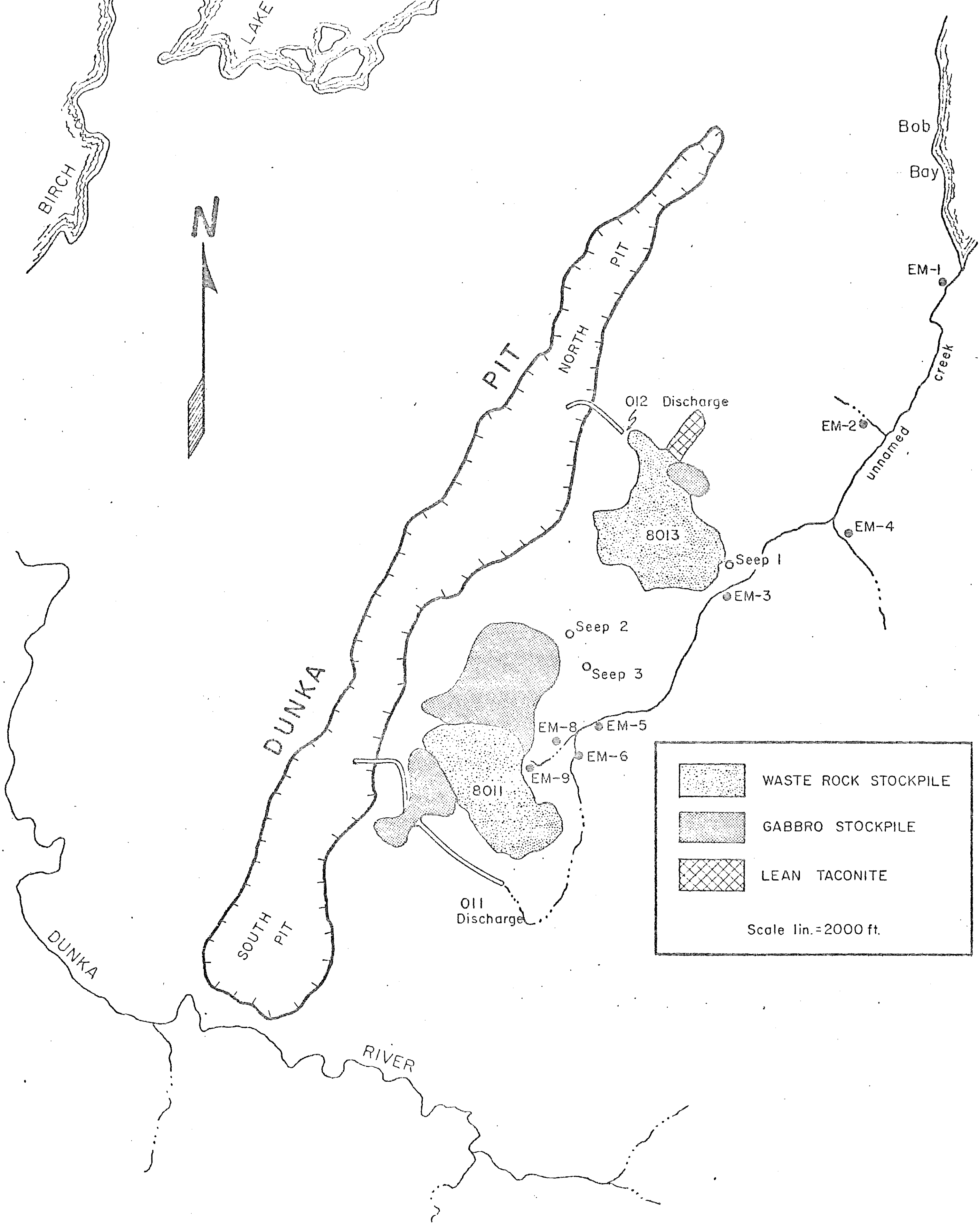


TABLE 1

Stockpile Mass and Composition, Dunka Pit *

Seep	Material	Date Started	Tons Gabbro	Area (km^2)	Composition Cu	Ni
EM-8	Waste Rock	12/1965	9,976,107	0.62	0.057	0.014
Seep 1	Waste Rock	4/1967	5,578,465	0.11	0.043	0.014
Seep 3	Lean Ore	6/1967	4,190,806	0.11	0.29	0.08

* As of January 1977

charges; waste rock seepages are denoted Em-8 and Seep 1, and lean ore seepage, Seep 3 (Figure 1). The lean ore seepage flows through a white cedar bog prior to its discharge into Unnamed Creek (Figure 1). Two stations, EM-9 and Em-8, were originally monitored, with EM-8 slightly downstream from the point of seepage discharge, Em-9. It was found that the difference in water quality and flow between those two stations was negligible, therefore, the Em-9 station was deleted. Six stream stations (Em-1 - Em-6) were established with numbering increasing with distance upstream.

Eight stations (3-1 to 3-8) were established across the Seep 3 bog where shallow water wells and piezometers were installed. (Figure 2). The shallow water wells consisted of a perforated PVC pipe (D=10.2 cm, 1=46 cm) sealed at the top with duct tape to prevent surface water leakage. The piezometers (1.5 m depth) were constructed of PVC, with a flange and a bentonite seal to prevent leakage. Peat samples were collected throughout the bog and organic bank and clastic sediment samples were collected in Unnamed Creek.

3. METHODS

Mine dewatering (011, 012) was monitored monthly by Erie Mining Company and analyzed for Cu, Ni, SO_4, and pH. Other parameters, such as oil and suspended solids, were also measured but are not discussed in this report.

The three seeps (Em-8, Seep 1, Seep 3) and stream stations were monitored on a biweekly basis. During 1976 and 1977 six stream stations were monitored. In subsequent years, stations Em-2 through Em-6 were deleted as more emphasis was placed on chemical output from the watershed rather than transport within it. Water quality samples were analyzed for trace metals (Cu

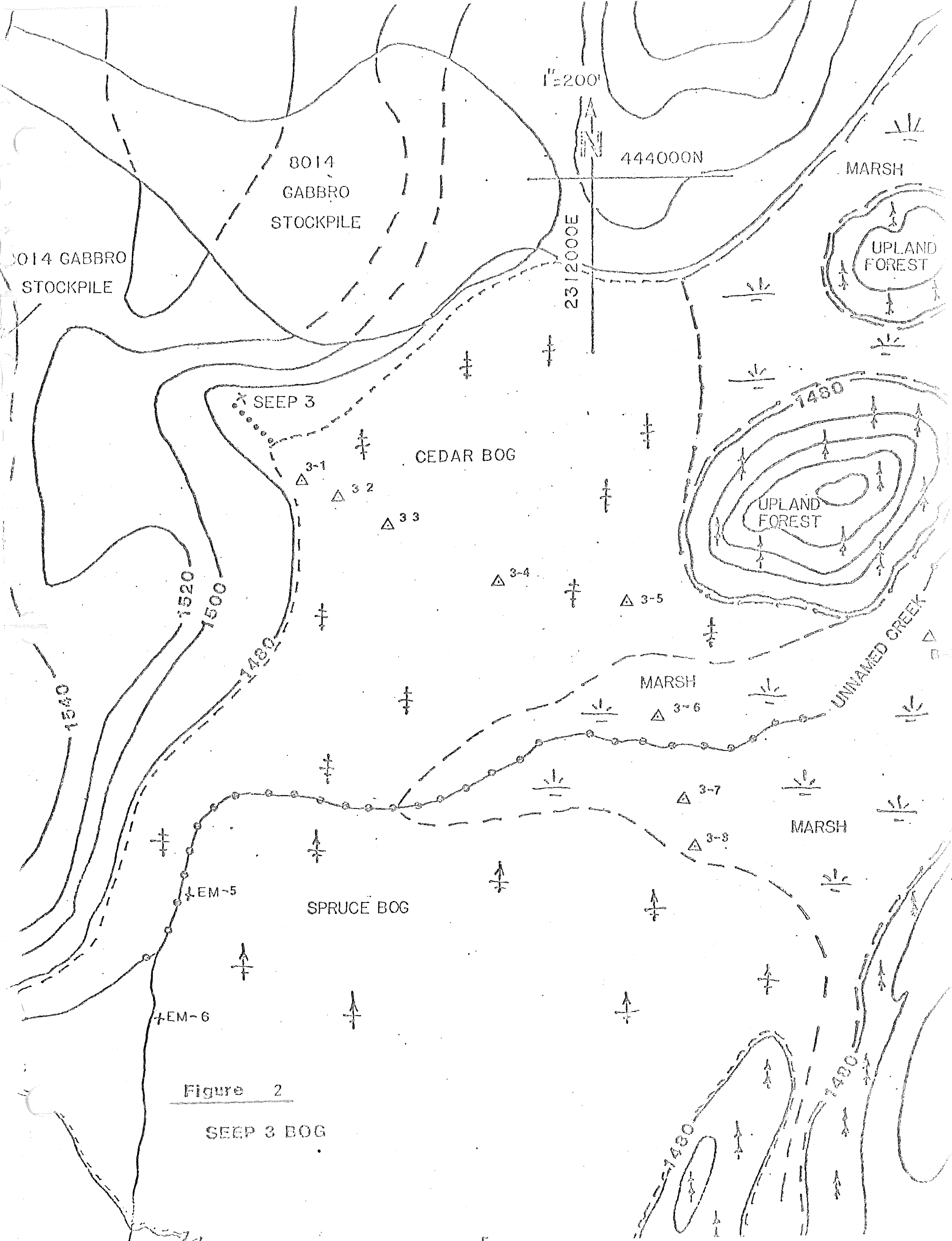


Figure 2

SEEP 3 BOG

Ni, Co, Zn, Fe, Mn), major cations (Ca, Mg, and in 1978, Na), Al (in 1979), SO_4, Cl, pH, alkalinity, dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), specific conductance, and temperature. Initially both total and filtered metals were measured, but filtered metals analyses were deleted as there was no significant difference between total and filtered measurements. Nitrogen and phosphorous were analyzed in selected samples and stage readings were taken to quantify flow. More time intensive studies were conducted and are described in another report (14).

Continuous flow measurements were made during the open water (unfrozen) period at Em 8, Em 1 (1976 - present); Em 3(1976-1977); Em 5 (1977) and Seep 3 (1979 - present). Periodic flow measurements were made at Seep 1 (1976 - present); Seep 3 (1976 - 1979); Em 2 and Em 4 (1976 - 1977), and Em 5 (1976).

The bog was studied from July 1976 to August 1977 (12, 13). Water levels at the surface and in wells and piezometers were recorded, and drawdown tests were conducted at the eight piezometers. Trace metals and specific conductance were analyzed at the surface and in the wells and piezometers. At each site composite peat samples were collected from the top 20 cm and analyzed for trace metals by EDTA and acid extraction. At four stations (3-1, 3-2, 3-5, 3-8) and two control sites, trace metal concentrations were determined at approximately 25 cm depth intervals.

4. RESULTS

Several references related to this report are available to augment the comparatively brief summary which follows. These references discuss laboratory leaching studies (3, 4, 5, 6, 7), field leaching and transport studies (1, 7-15,19-23), stockpile hydrology (16-18), stockpile reclamation (19-21), regional data (1), and transport through the Seep 3 bog (12, 13) and Unnamed Creek (14). Reports are presently being prepared on transport in Bob Bay (15), sediment data from Birch Lake and other regional lakes (22), and trace metal concentrations in aquatic vegetation (23).

4.1 STOCKPILE RUNOFF

4.1.1 Discharge

The stockpile seepages typically flowed from April to November. The median flows based on periodic measurements, at Em 8, Seep 1, and Seep 3 were 5, 1.2 and 2 l/sec, respectively (Figure 4). Additional information on stockpile hydrology is available in other reports (16-18)

4.1.2 pH

Over the first four years of the study the median pH at Em 8 (7.16) and Seep 3 (7.10) was comparable, but was significally lower at Seep 1 (6.70). The pH at the seeps varied seasonally but was gnerally within about 0.3 units of the yearly median (Figure 5). There was a tendency for pH to decrease over the course of the study (Figure 6).

4.1.3 Copper, Nickel, Cobalt, and Zinc

Median trace metal (Cu, Ni, Co, Zn) concentrations observed in the Erie stockpile leachate ranged from 10 to 10,000 times natural background levels of streams in the area (Table 2). Metal concentrations varied with stockpile composition, the chemistry of the individual metal, and time, but were generally independent of flow. Trace metal concentrations were higher in seepage from lean ore piles than waste rock leachate (Figure 7, Table 2). An exception was zinc, which had higher concentrations at Seep 1 than Seep 3. Cobalt concentrations at Seep 3 were also

Figure 3 - Interpretation of Box Plot Figures

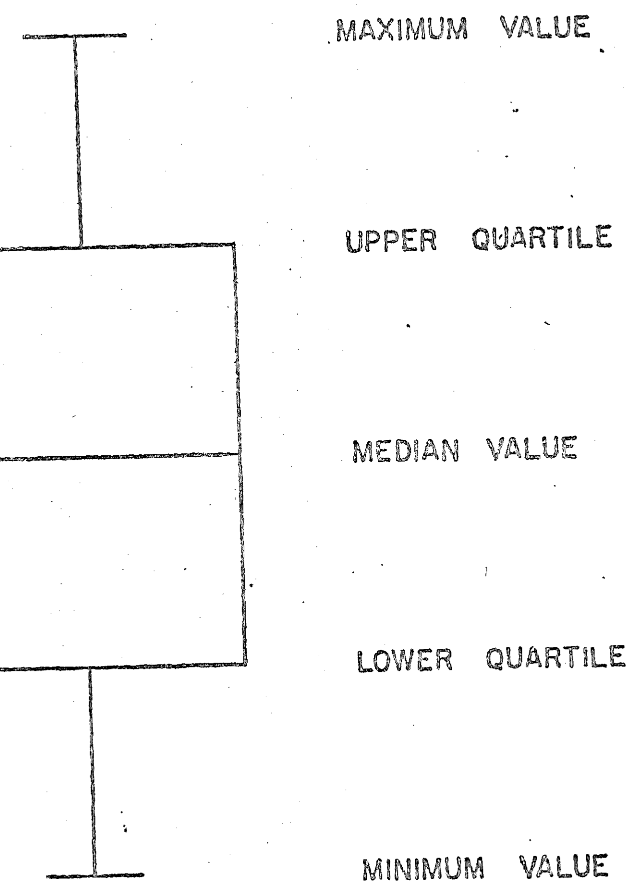
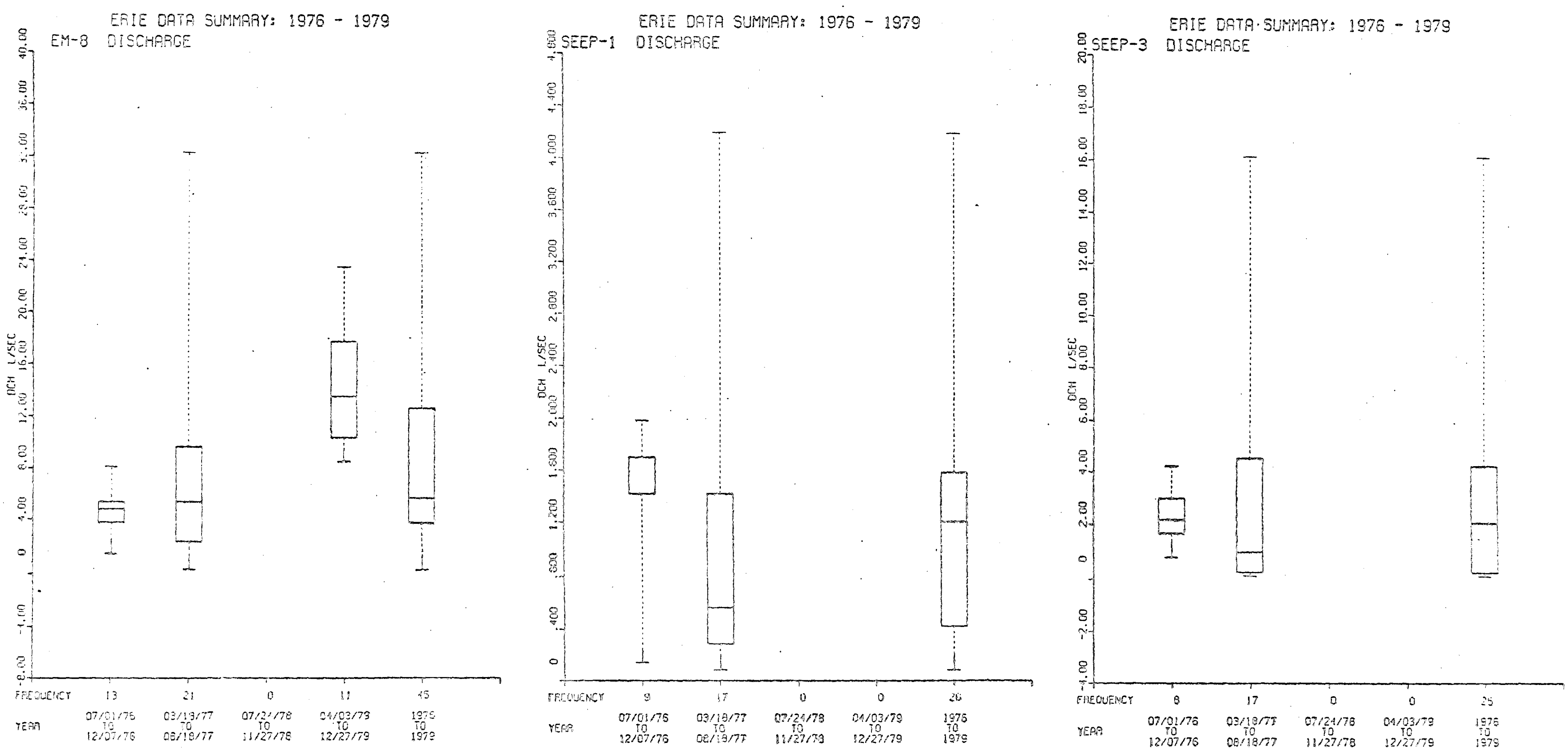


FIGURE 4



Plots are based on periodic measurements
Con... flow records exist for Em-8 (1976-present) and Seep 3 (1979-present)

FIGURE 5

SEEP 1.-TOTAL COPPER, TOTAL NICKEL, TOTAL IRON, pH

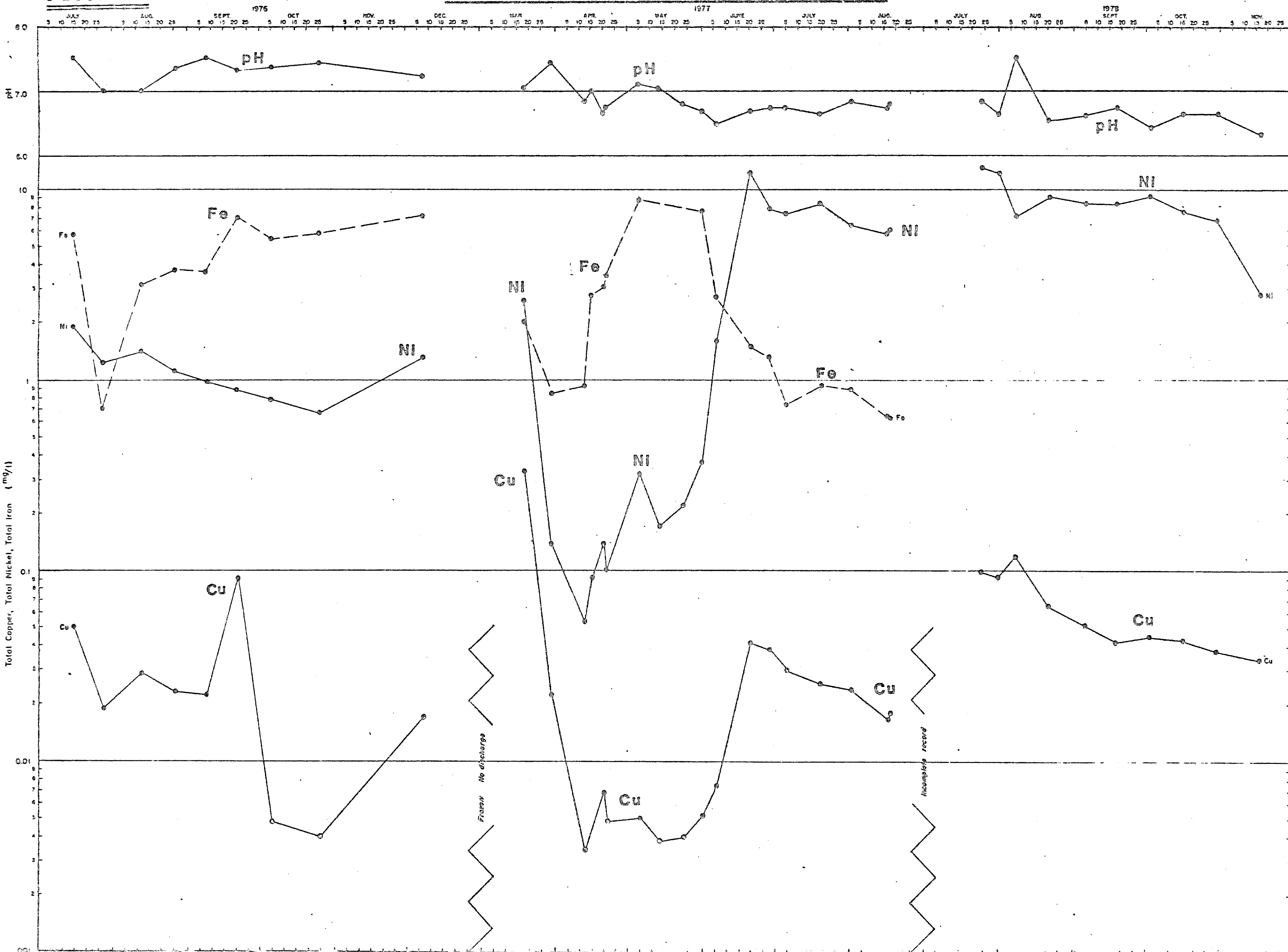


FIGURE 6

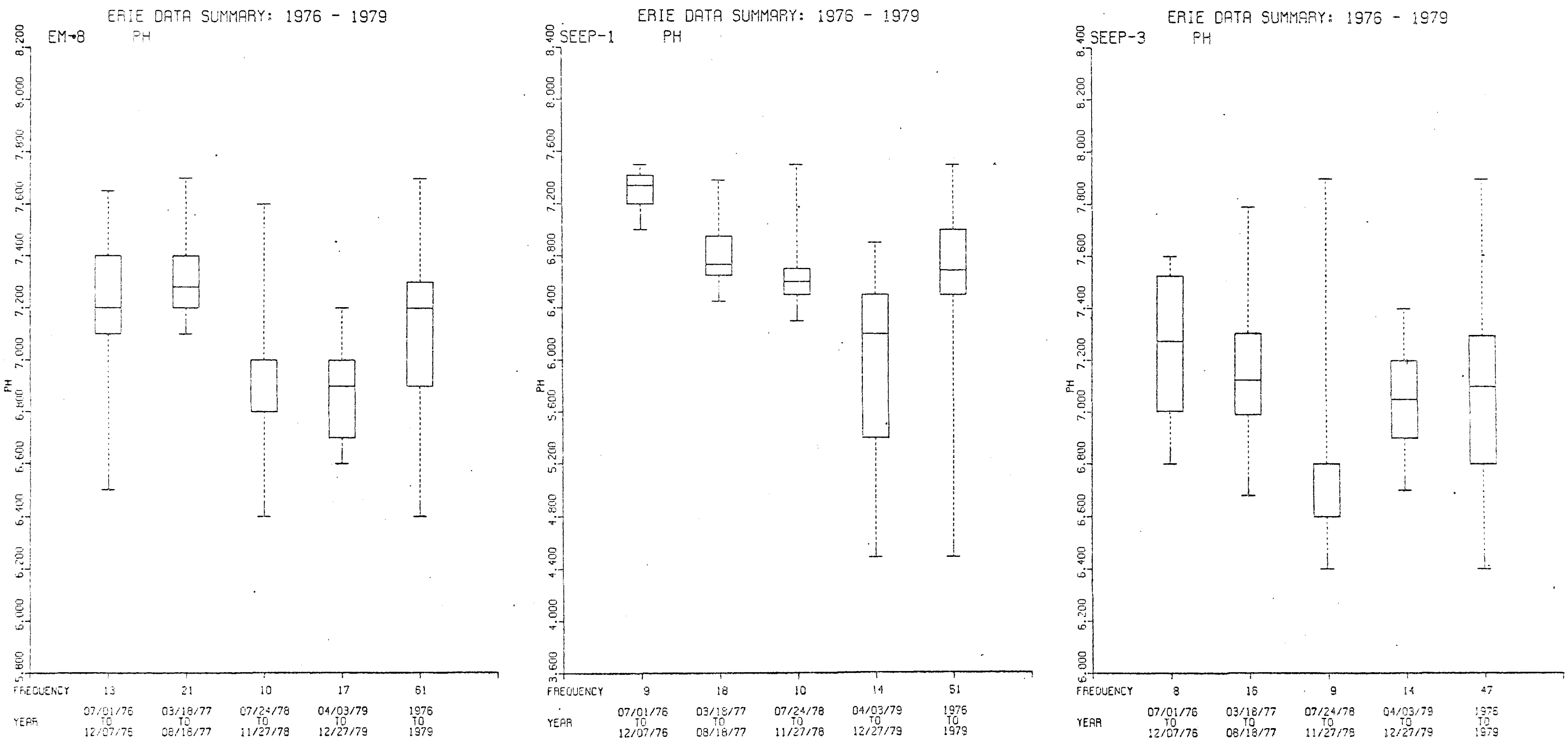

ERIE DATA SUMMARY: 1976 - 1979
EM-8 PH
PH
FREQUENCY 13 21 10 17 61
YEAR 07/01/76 TO 12/07/76 03/18/77 TO 08/18/77 07/24/78 TO 11/27/78 04/03/79 TO 12/27/79 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-1 PH
PH
FREQUENCY 9 18 10 14 51
YEAR 07/01/76 TO 12/07/76 03/18/77 TO 08/18/77 07/24/78 TO 11/27/78 04/03/79 TO 12/27/79 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-3 PH
PH
FREQUENCY 8 16 9 14 47
YEAR 07/01/76 TO 12/07/76 03/18/77 TO 08/18/77 07/24/78 TO 11/27/78 04/03/79 TO 12/27/79 1976 TO 1979

Figure 7

(Cu), (Ni) IN ERIE STOCKPILE SEEPAGE : 1976-1979

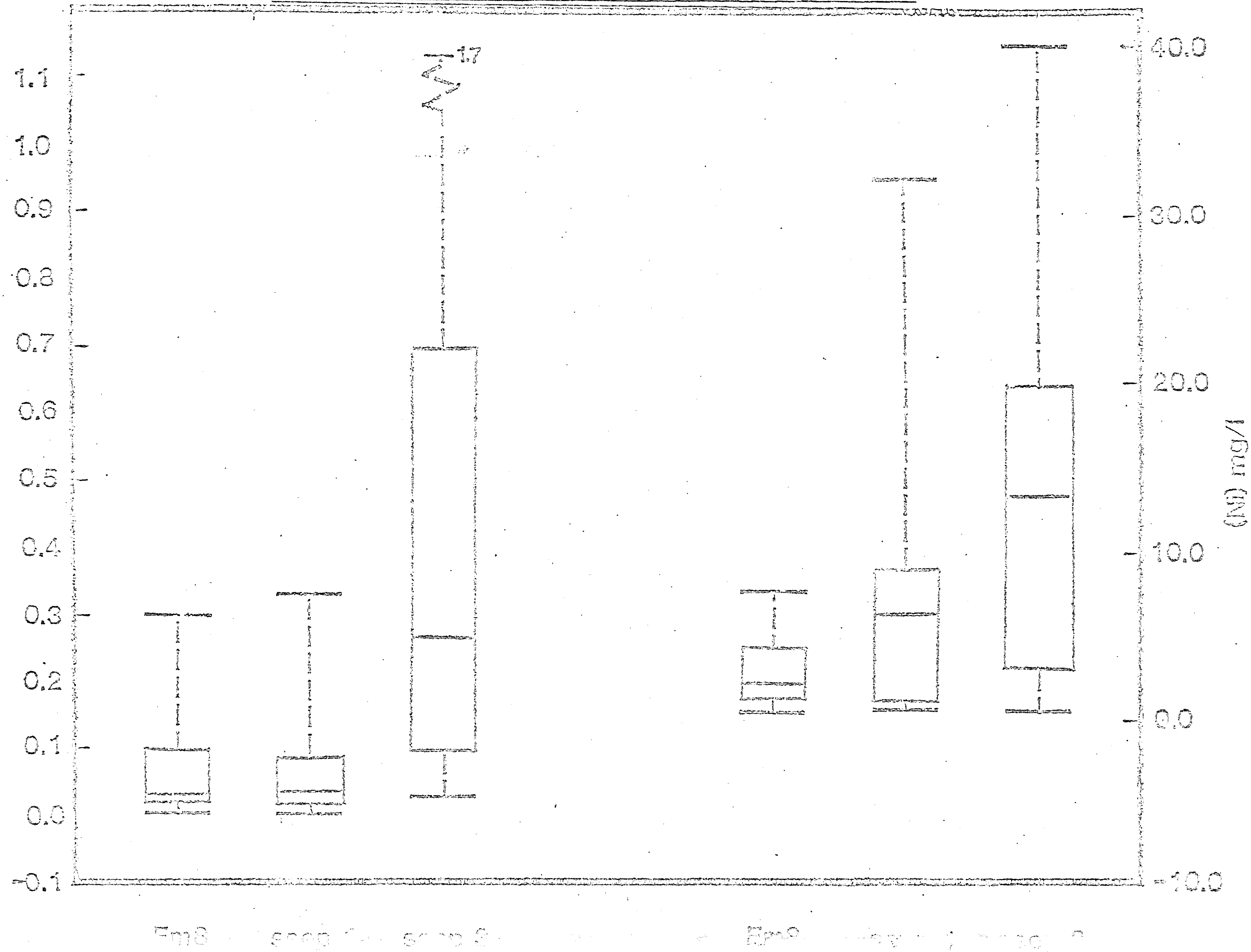


TABLE 2

COMPARISON OF SEEP WATER QUALITY WITH NATURAL BACKGROUND:

MEDIAN VALUES[1] 1976-1979

Parameter	Waste Rock EM 8	Waste Rock Seep 1	Lean Ore Seep 3	Natural[2]
pH	7.16 (59)[3]	6.70 (51)	7.10 (48)	6.9
Sulfate	1200. (50)	3400. (42)	1364. (42)	6.6
Copper[4]	0.030 (67)	0.036 (48)	0.270 (50)	0.0013
Nickel	2.14 (62)	6.13 (50)	13.3 (51)	0.001
Cobalt	0.195 (14)	0.64 (19)	0.790 (19)	0.004
Zinc	0.10 (33)	1.45 (35)	0.18 (37)	0.002

[1]Concentrations in mg/l

[2]Regional Copper-Nickel Study

[3]Numbers in parentheses indicate number of samples

[4]Metal concentrations as total metal

significantly higher at Seep 1 than in the waste rock leachate at Em 8.

The seasonal variation of seep water quality was greatest from March to the beginning of June, prior to and during thaw. (Figures 5, 8, 9, in particular 1977 data). After this period concentrations of Cu, Ni, Co and Zn were less subject to wide fluctuation. The variation over the course of the study was not consistent. At Em 8 and Seep 1, trace metal concentrations increased, but at Seep 3 concentrations decreased (Figures 10-12).

4.1.4 Sulfate, calcium, and magnesium

The median sulfate concentration at Seep 1 was higher than those at Em 8 and Seep 3 (3400 vs 1200 and 1360 mg/1). Sulfate concentrations at Em 8 increased steadily during the 1976 season, varied widely in 1977, and were relatively stable in 1978 (Figure 13)). Seep 1 concentrations varied widely in 1977 but were relatively stable in 1976 and 1978 (Figure 14). Sulfate concentrations at Seep 3 varied widely during all three years. (Figure 15). Despite the wide seasonal fluctuations median sulfate concentrations at each of the three seeps was relatively constant over the course of the study (Figures 16-18).

From 1976 - 1978 *, median calcium concentrations were highest at Seep 3, but magnesium concentrations were highest at Seep 1 (Table 3). Calcium concentrations exceeded magnesium concentrations at Em 8 and Seep 3, but the opposite was true at

*Calcium and magnesium date reported for 1979 was anomolous due to a faulty analytical technique. (Appendix)

Figure

EM-8 TOTAL COPPER, TOTAL NICKEL, TOTAL IRON, pH

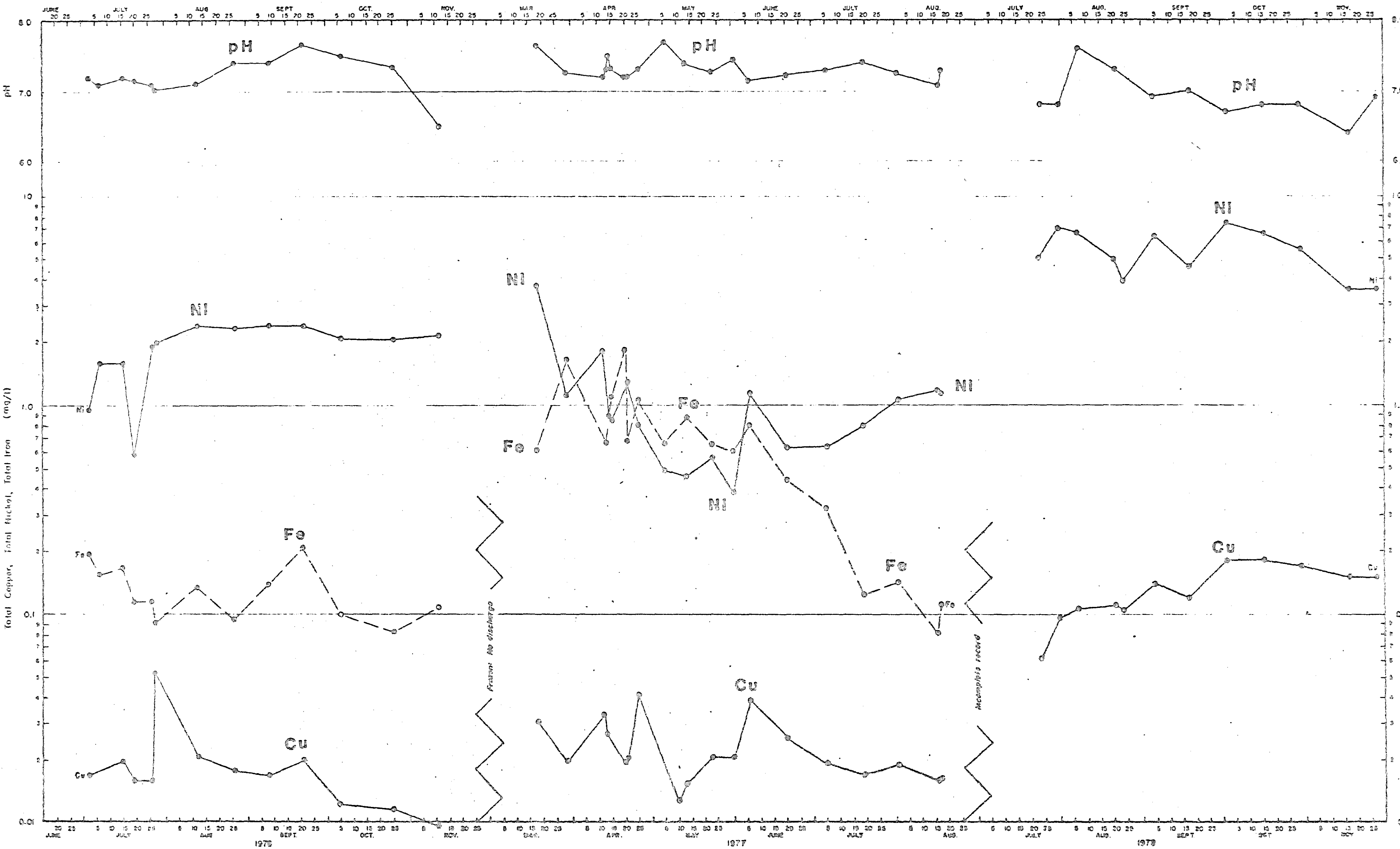


Figure 9

SEEP 3.-TOTAL COPPER, TOTAL NICKEL, TOTAL IRON, pH

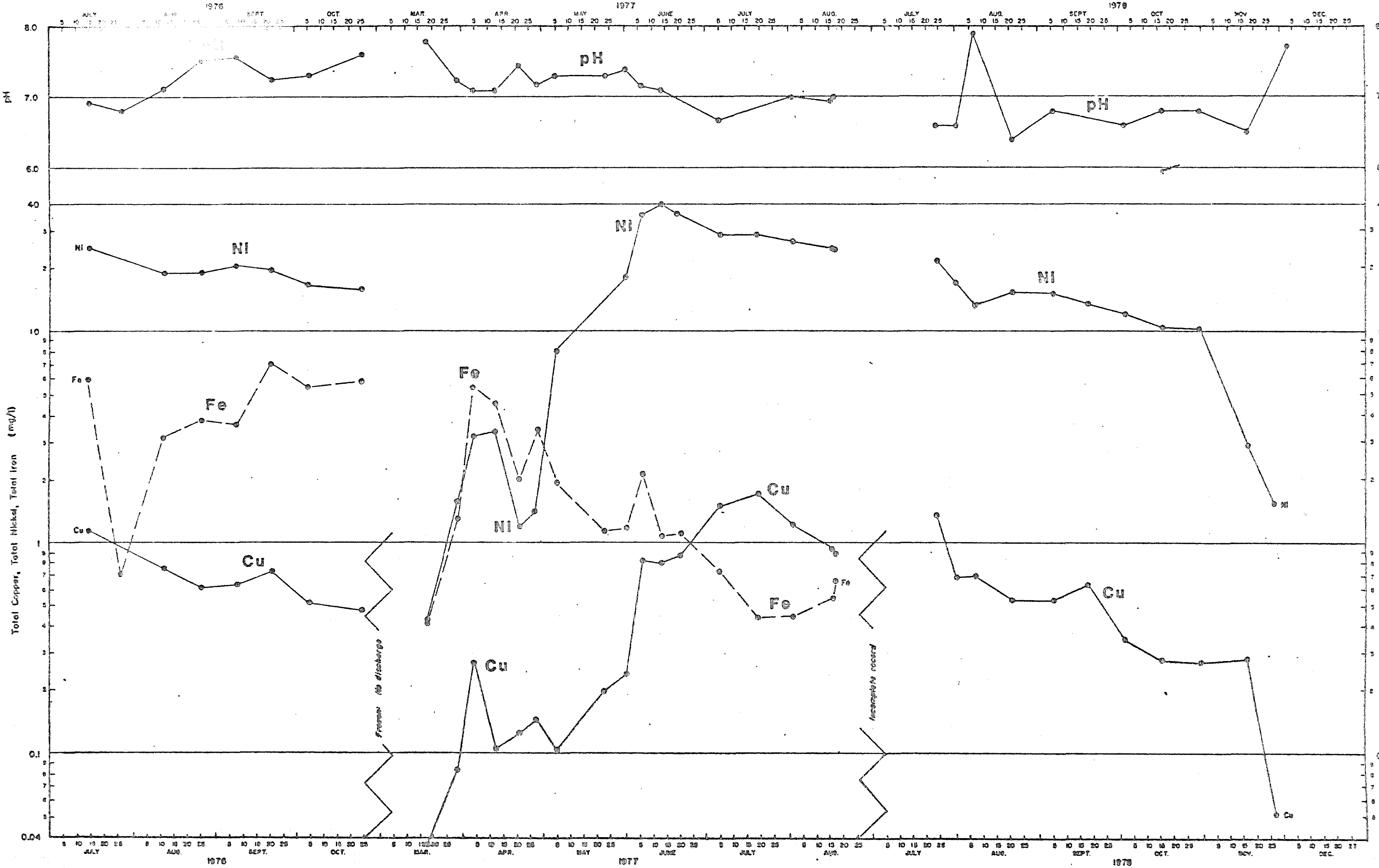


FIGURE 10

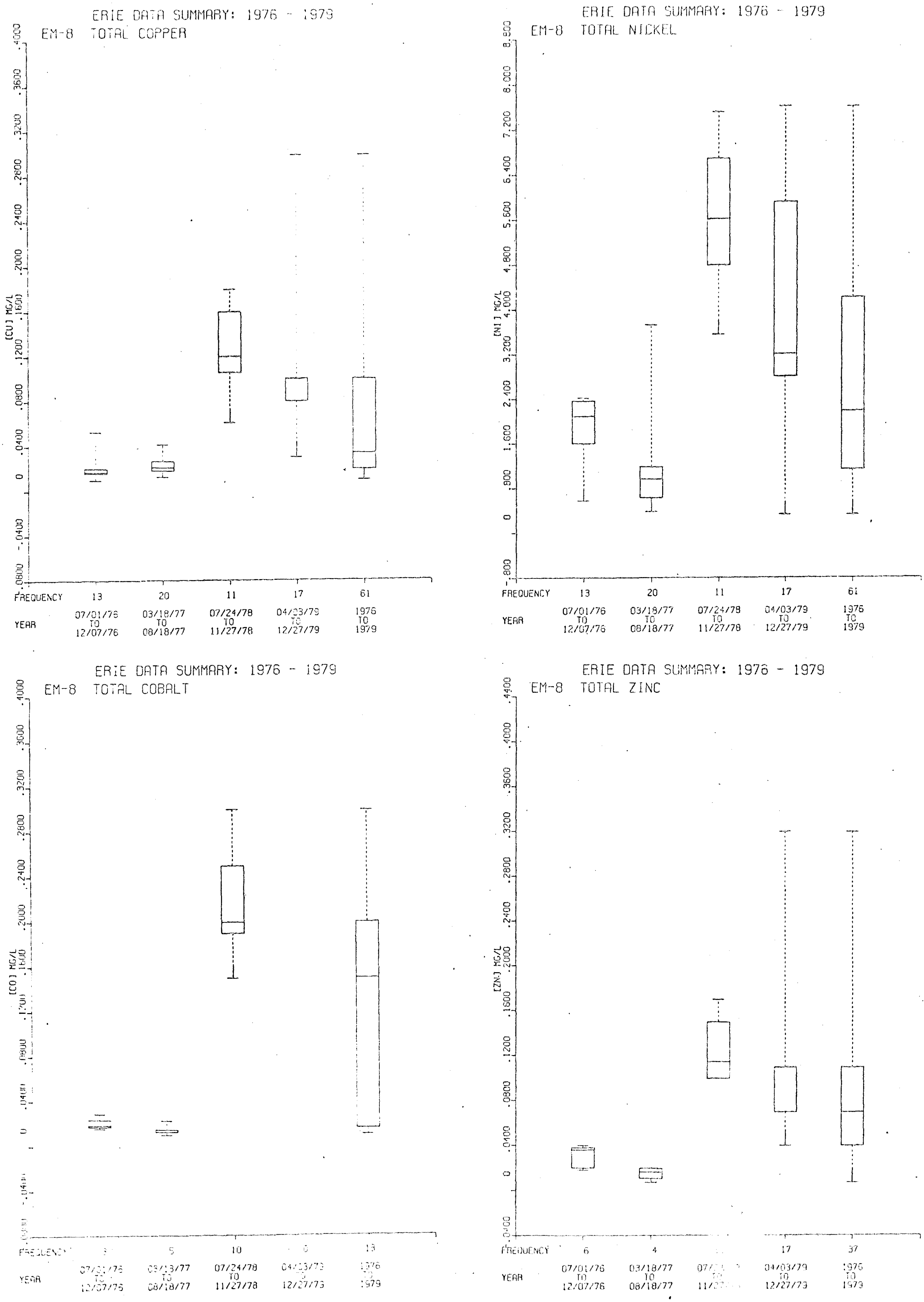

ERIE DATA SUMMARY: 1976 - 1979
EM-8 TOTAL COPPER
[CU] MG/L
FREQUENCY 13 20 11 17 61
YEAR 07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-8 TOTAL NICKEL
[NI] MG/L
FREQUENCY 13 20 11 17 61
YEAR 07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-8 TOTAL COBALT
[CO] MG/L
FREQUENCY 5 10 13
YEAR 03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-8 TOTAL ZINC
[ZN] MG/L
FREQUENCY 6 4 17 37
YEAR 07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
04/03/79 TO 12/27/79
1976 TO 1979

FIGURE 11

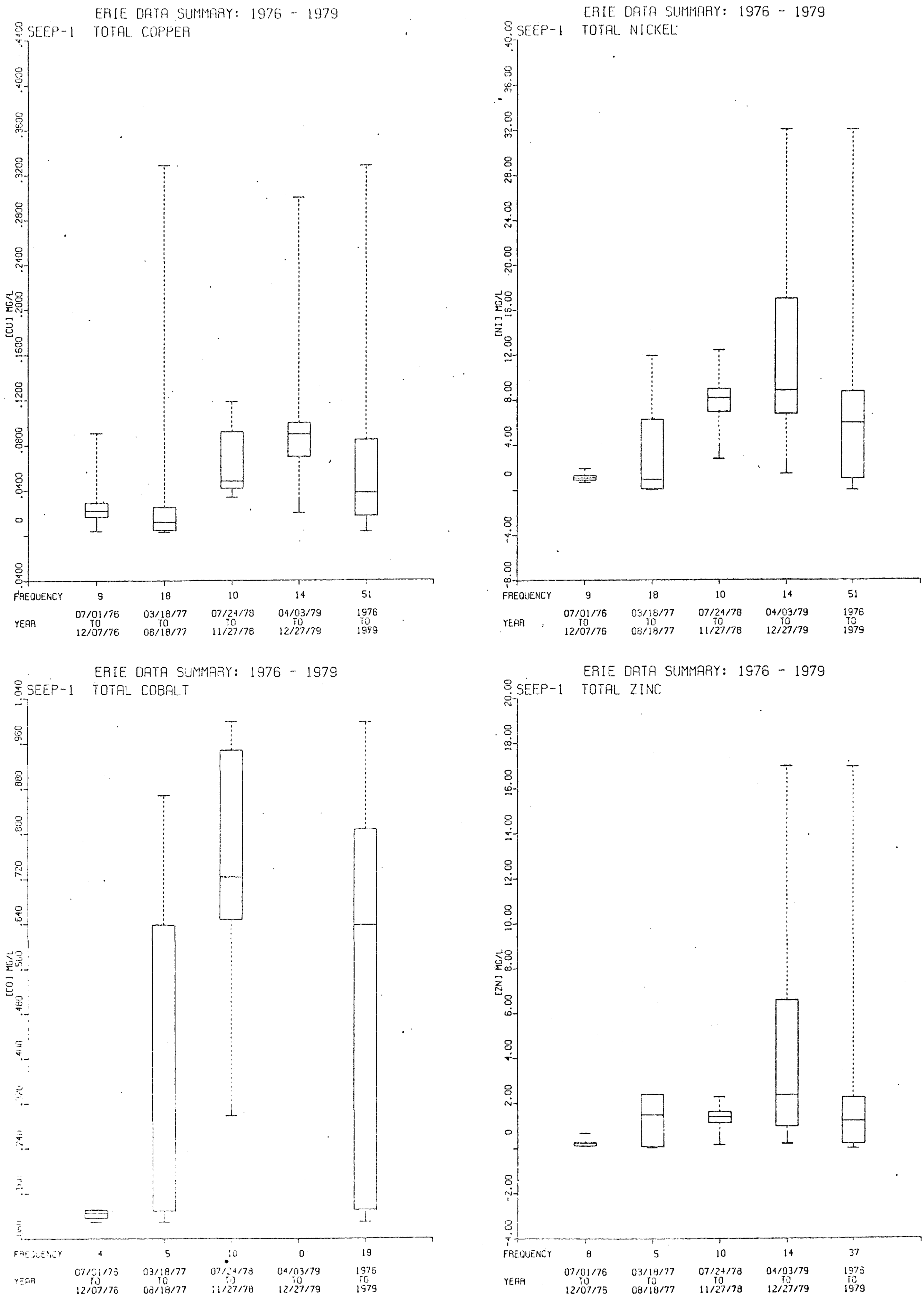
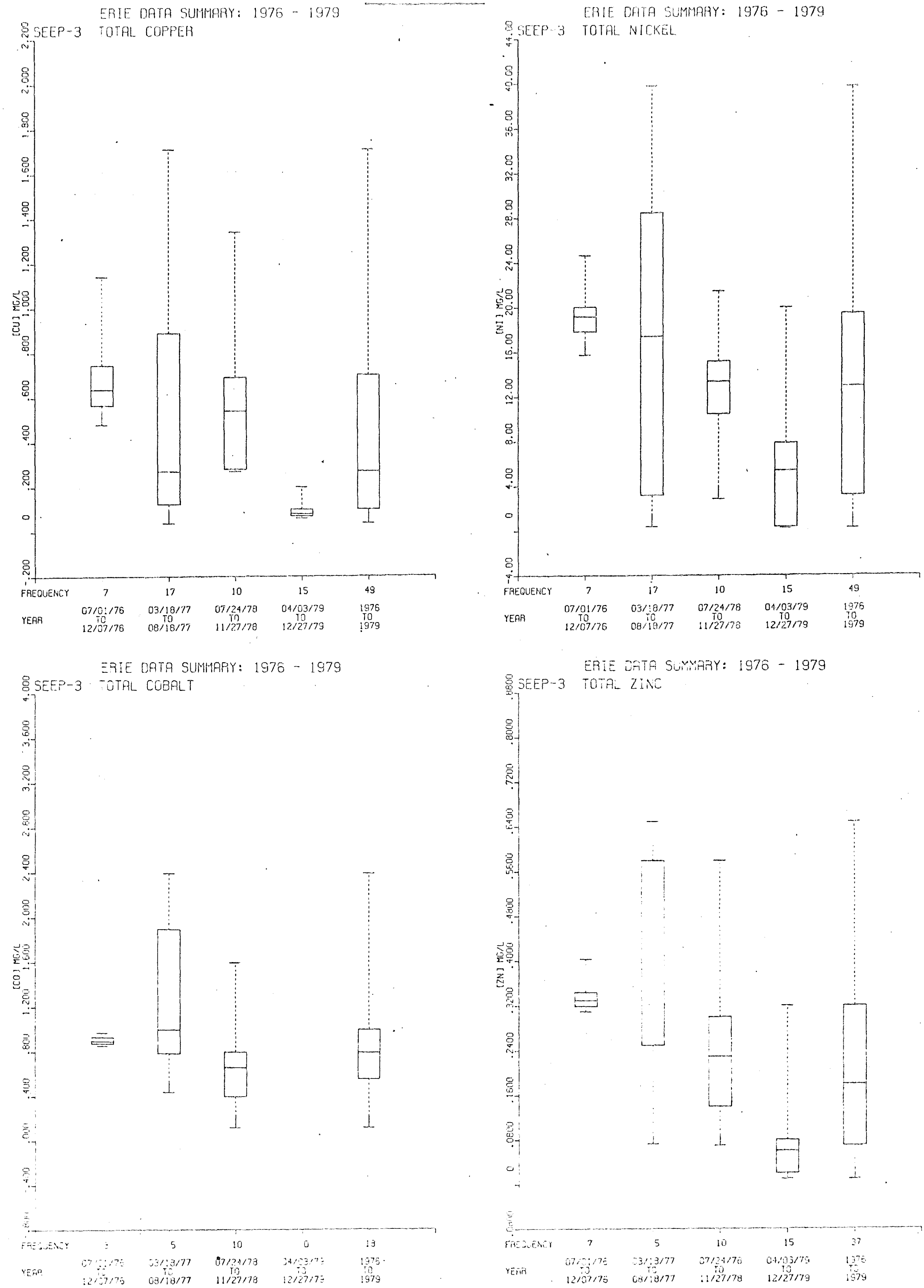

ERIE DATA SUMMARY: 1976 - 1979
SEEP-1 TOTAL COPPER
[CU] MG/L
.4400 .4000 .3600 .3200 .2800 .2400 .2000 .1600 .1200 .0800 .0400 0 -.0400
FREQUENCY 9 18 10 14 51
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-1 TOTAL NICKEL
[NI] MG/L
40.00 36.00 32.00 28.00 24.00 20.00 16.00 12.00 8.00 4.00 0 -4.00 -8.00
FREQUENCY 9 18 10 14 51
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-1 TOTAL COBALT
[CO] MG/L
1.040 .960 .880 .800 .720 .640 .480
FREQUENCY 4 5 10 0 19
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-1 TOTAL ZINC
[ZN] MG/L
20.00 18.00 16.00 14.00 12.00 10.00 8.00 6.00 4.00 2.00 0 -2.00 -4.00
FREQUENCY 8 5 10 14 37
YEAR
07/01/76 TO 12/07/75
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979

FIGURE 12


ERIE DATA SUMMARY: 1976 - 1979
SEEP-3 TOTAL COPPER
[CU] MG/L
FREQUENCY 7 17 10 15 49
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-3 TOTAL NICKEL
[NI] MG/L
FREQUENCY 7 17 10 15 49
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-3 TOTAL COBALT
[CO] MG/L
FREQUENCY 5 10 0 13
YEAR 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-3 TOTAL ZINC
[ZN] MG/L
FREQUENCY 7 5 10 15 37
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979

EM-8 CALCIUM, MAGNESIUM, SULFATE

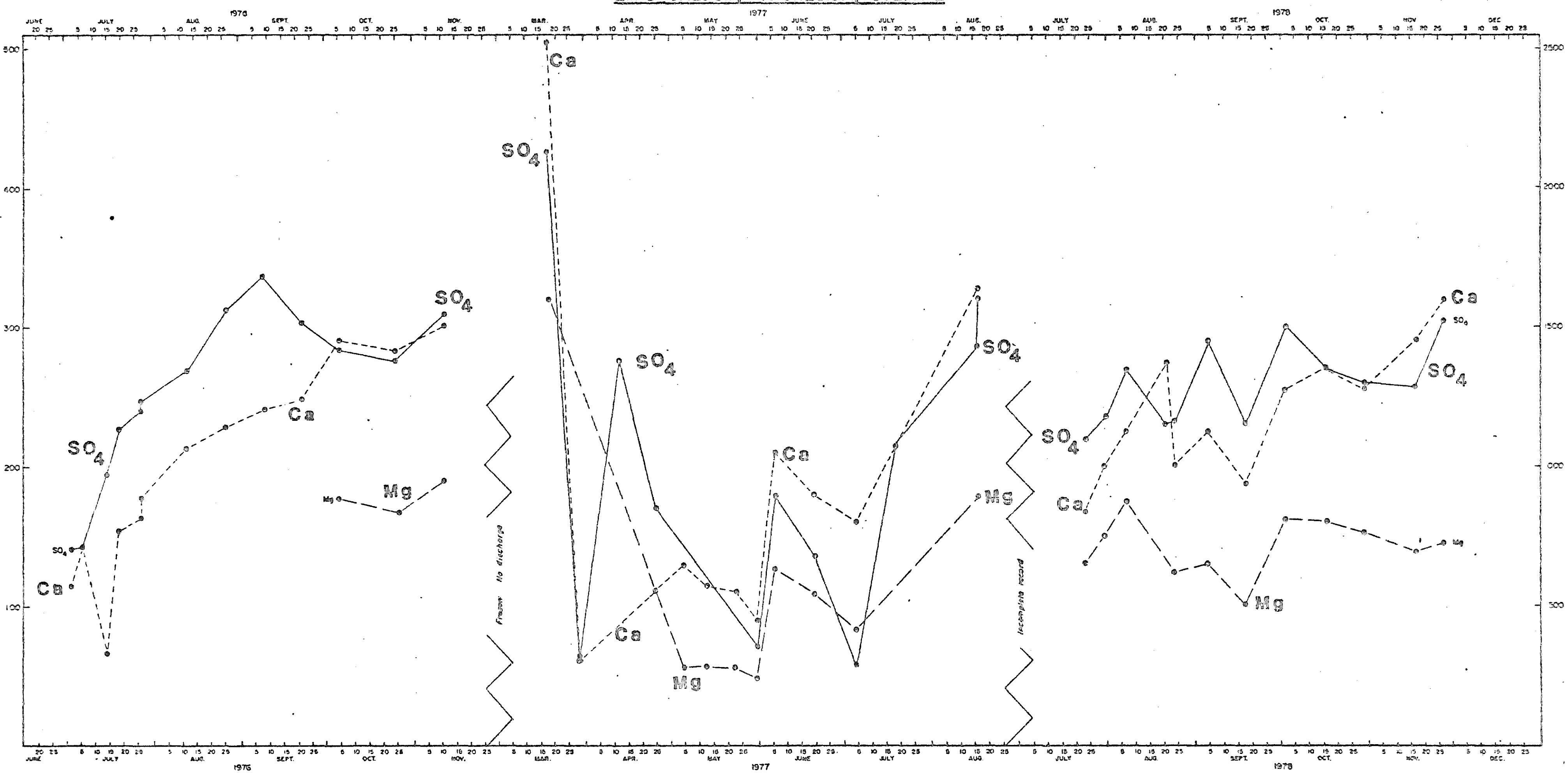


FIGURE 13

SEEP I. — CALCIUM, MAGNESIUM, SULFATE

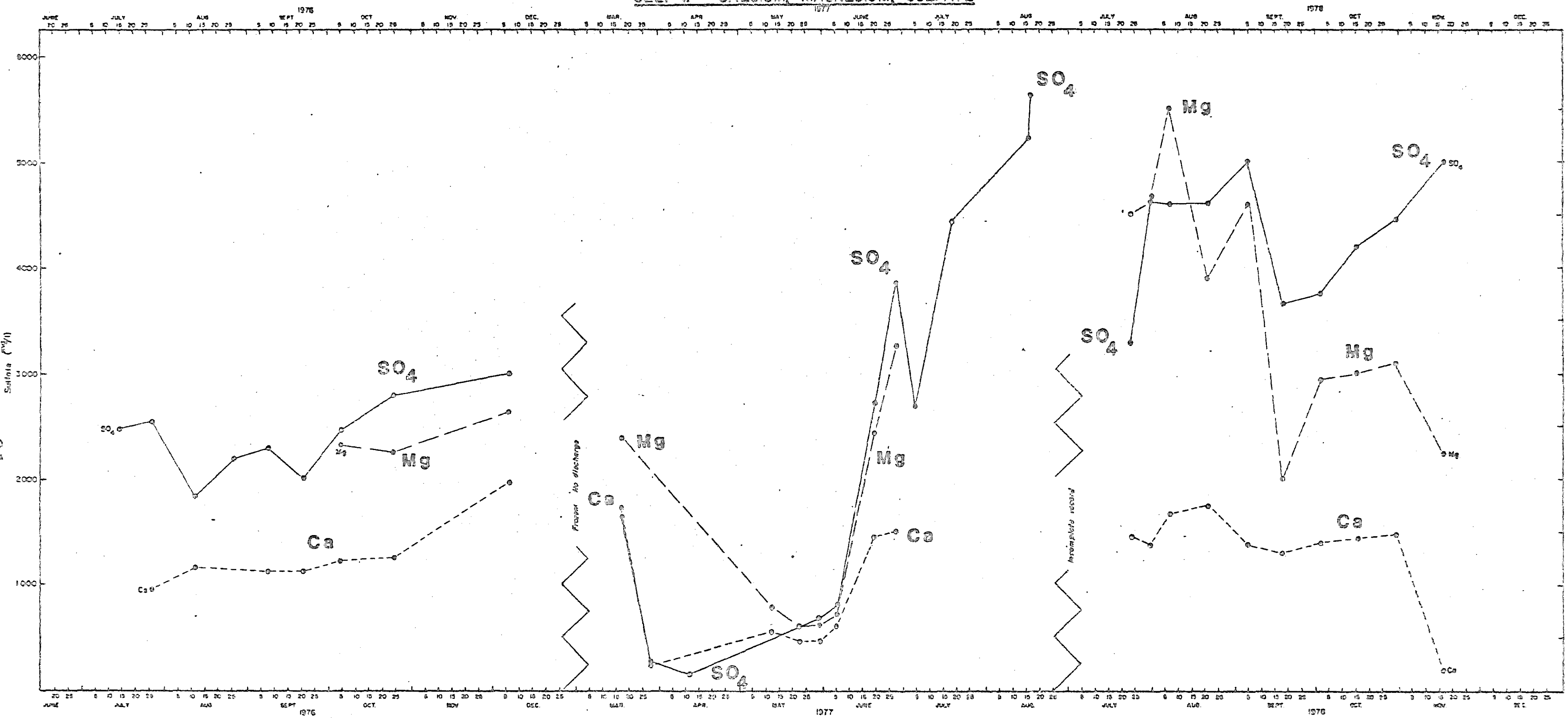


FIGURE 14

SEEP 3. - CALCIUM, MAGNESIUM, SULFATE

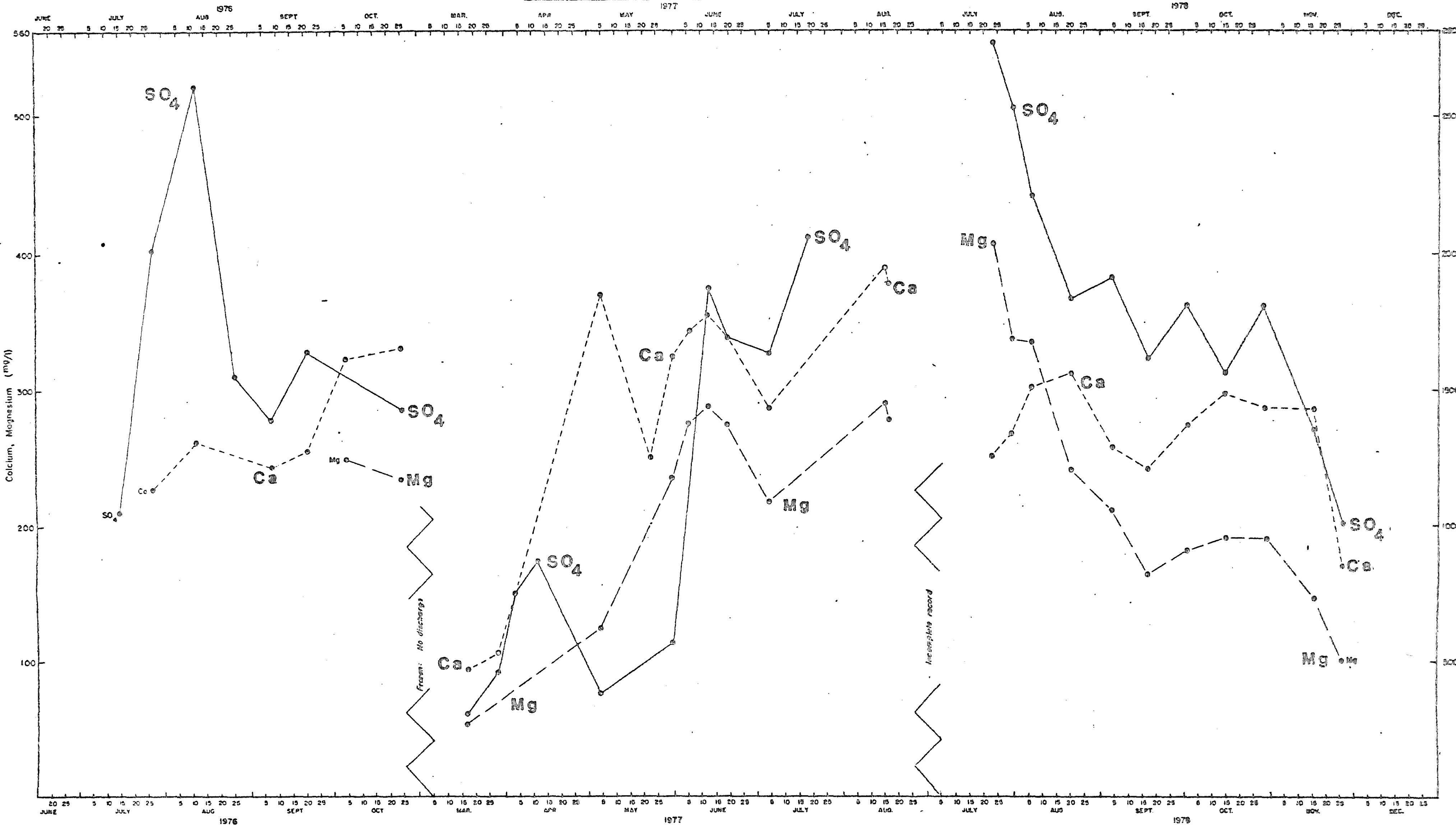
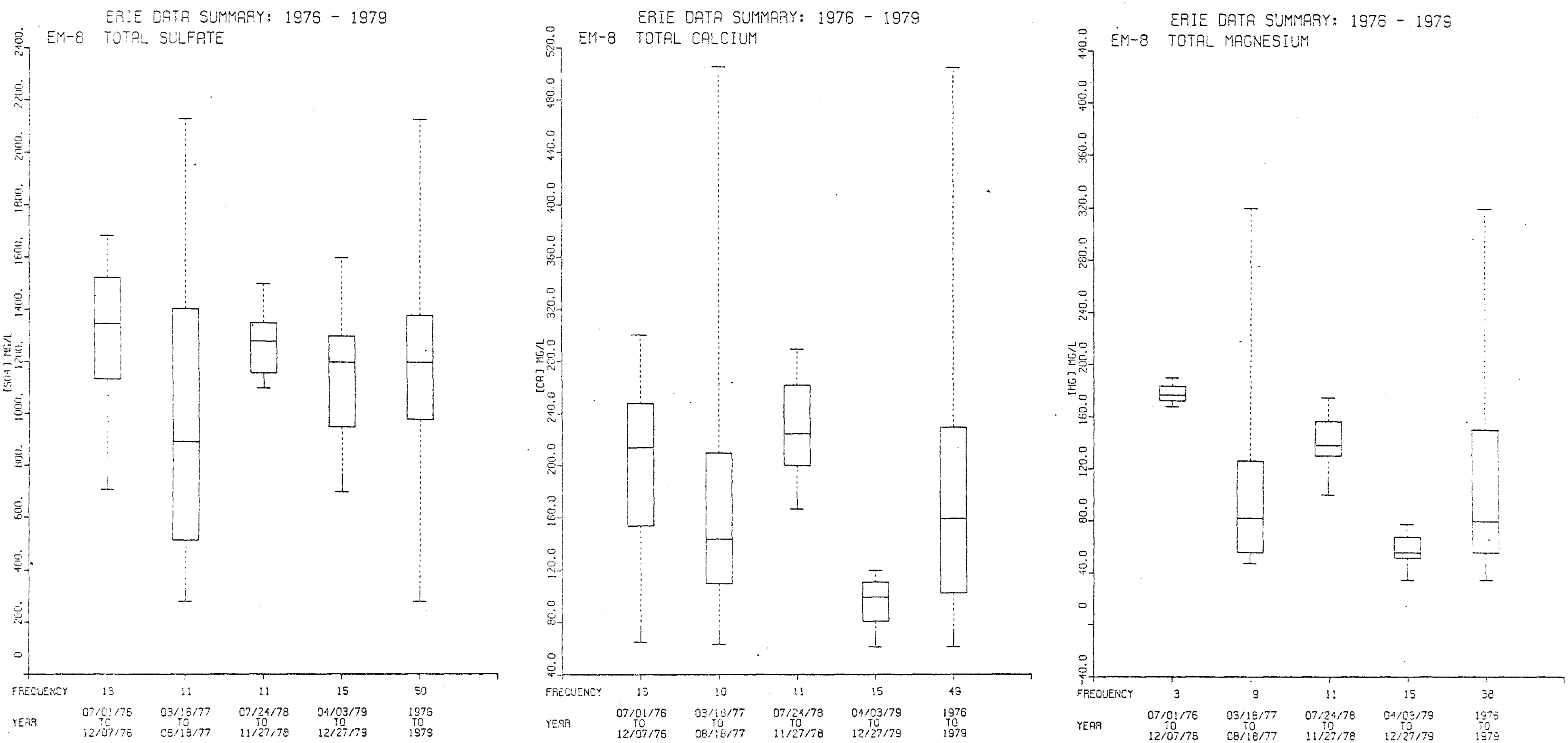


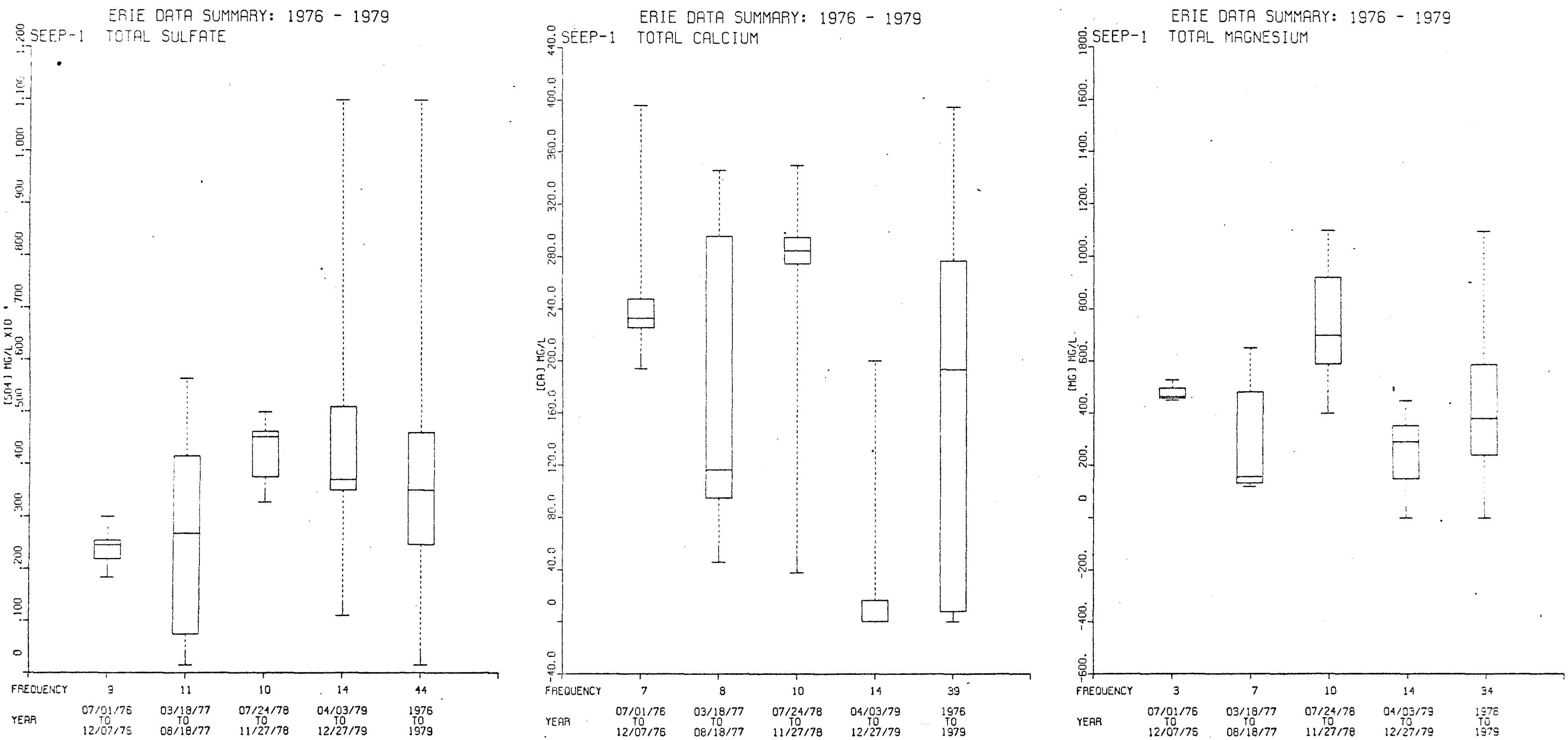
FIGURE 15

FIGURE 16



ERIE DATA SUMMARY: 1976 - 1979
EM-8 TOTAL SULFATE
[SO4] MG/L
0
200.
400.
600.
800.
1000.
1200.
1400.
1600.
1800.
2000.
2200.
2400.
FREQUENCY 13 11 11 15 50
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-8 TOTAL CALCIUM
[CA] MG/L
40.0
80.0
120.0
160.0
200.0
240.0
280.0
320.0
360.0
400.0
440.0
480.0
520.0
FREQUENCY 13 10 11 15 49
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-8 TOTAL MAGNESIUM
[MG] MG/L
-40.0
0
40.0
80.0
120.0
160.0
200.0
240.0
280.0
320.0
360.0
400.0
440.0
FREQUENCY 3 9 11 15 38
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979

FIGURE 17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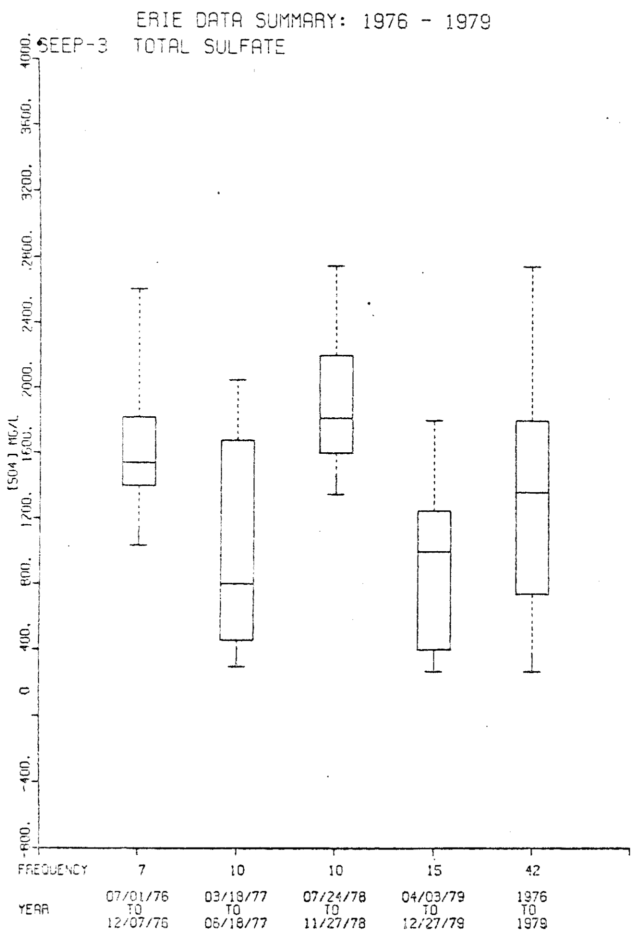
SEEP-1 TOTAL SULFATE
[SO4] MG/L X10
FREQUENCY 9 11 10 14 44
YEAR 07/01/76 TO 12/07/76 03/18/77 TO 08/18/77 07/24/78 TO 11/27/78 04/03/79 TO 12/27/79 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-1 TOTAL CALCIUM
[CA] MG/L
FREQUENCY 7 8 10 14 39
YEAR 07/01/76 TO 12/07/76 03/18/77 TO 08/18/77 07/24/78 TO 11/27/78 04/03/79 TO 12/27/79 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-1 TOTAL MAGNESIUM
[MG] MG/L
FREQUENCY 3 7 10 14 34
YEAR 07/01/76 TO 12/07/76 03/18/77 TO 08/18/77 07/24/78 TO 11/27/78 04/03/79 TO 12/27/79 1976 TO 1979

FIGURE 18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SEEP-3 TOTAL SULFATE
[SO4] MG/L
FREQUENCY 7 10 10 15 42
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
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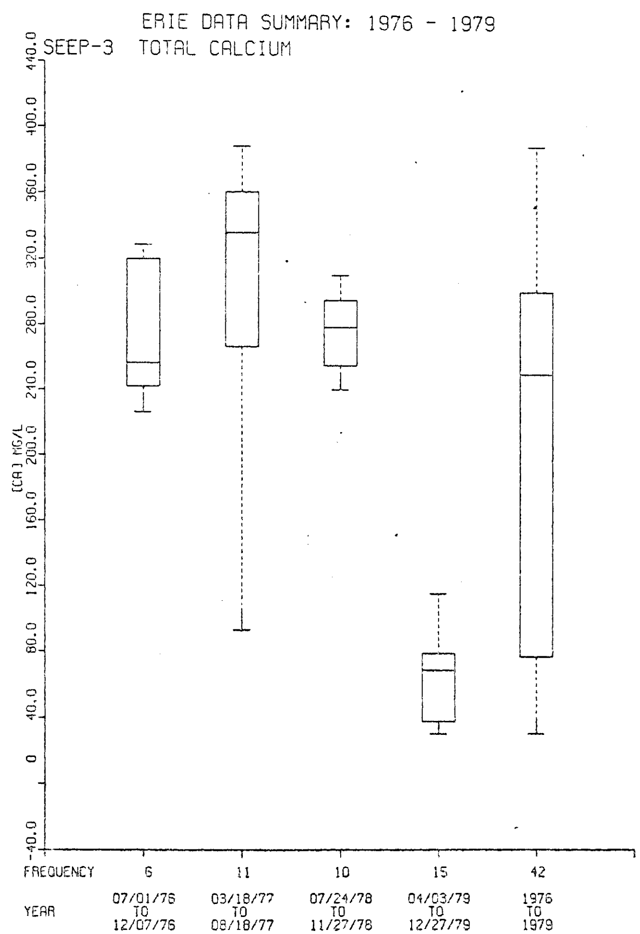
04/03/79 TO 12/27/79
1976 TO 1979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SEEP-3 TOTAL CALCIUM
[CA] MG/L
FREQUENCY 6 11 10 15 42
YEAR
07/01/76 TO 12/07/76
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1976 TO 1979

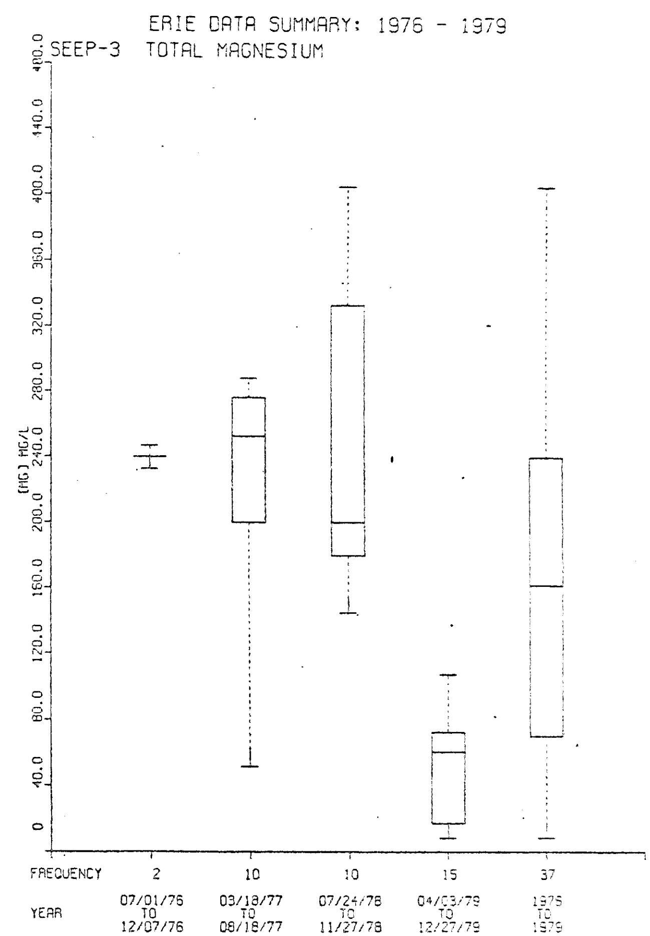

ERIE DATA SUMMARY: 1976 - 1979
SEEP-3 TOTAL MAGNESIUM
[MG] MG/L
FREQUENCY 2 10 10 15 37
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979

TABLE 3

Median calcium and magnesium concentrations in stockpile runoff, 1976-1978

	Em-8	Seep 1	Seep 3
Ca	160	195	250
Mg	80	385	160

Seep 1. Despite these variations concentrations of both calcium and magnesium tended to parallel those of sulfate (Figures 13-16). This is because calcium and magnesium are released to solution by reaction with hydrogen ions, which are generated by iron sulfide oxidation.

4.1.5 Iron, manganese, and dissolved organic carbon

Median iron concentrations ranged from about 0.3 mg/l at Em 8 to 2.4 mg/l at Seep 1 (Figures 19-21). Median manganese concentrations ranged from 1.6 mg/l at Em 8 to 8.0 mg/l at Seep 1. The depressed pH at Seep 1 most likely was a factor contributing to the elevated iron and manganese concentrations. Dissolved organic carbon (DOC) concentrations were also higher at Seep 1 (approximately 25 mg/l) than at Em 8 or Seep 3 (approximately 16 mg/l). An increase in the concentration of complexing organics, would increase the trace metal concentrations.

4.1.6 Specific conductance, TAlk T, Cl, P, NO_2-NO_3

Specific conductance is an indicator of the total ionic content of the water. In the case of stockpile runoff, it reflects the concentrations of sulfate, calcium, and magnesium, since these are the major components of the runoff. Consequently, the specific conductance is highest at Seep 1 where sulfate, calcium and magnesium concentrations are highest (Figures 22-24, 16-18, Table 3).

Alkalinity was relatively constant, approximately 130 mg/l, at Em 8 (Figure 26). The alkalinity at Seep 1 decreased over the four year period, as did the pH at the site (Figures 27, 6). At Seep 3 the alkalinity was relatively constant at about 100 mg/l.

Temperatures at the seeps were typically less than 5°C throughout the summer months (Figures 23-25). The temperatures

FIGURE 19

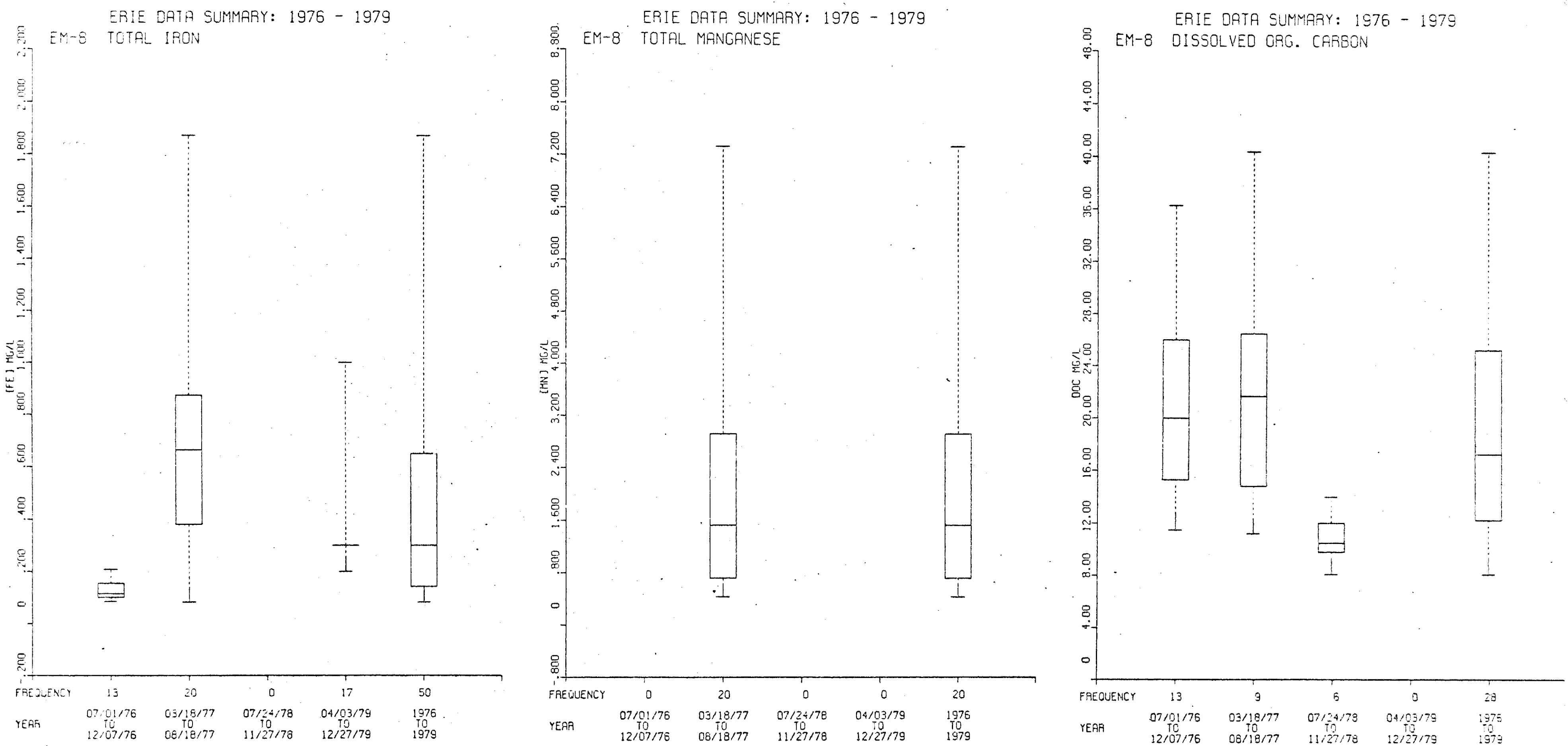

ERIE DATA SUMMARY: 1976 - 1979
EM-8 TOTAL IRON
[FE] MG/L
FREQUENCY 13 20 0 17 50
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-8 TOTAL MANGANESE
[MN] MG/L
FREQUENCY 0 20 0 0 20
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-8 DISSOLVED ORG. CARBON
DOC MG/L
FREQUENCY 13 9 6 0 28
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979

FIGURE 20

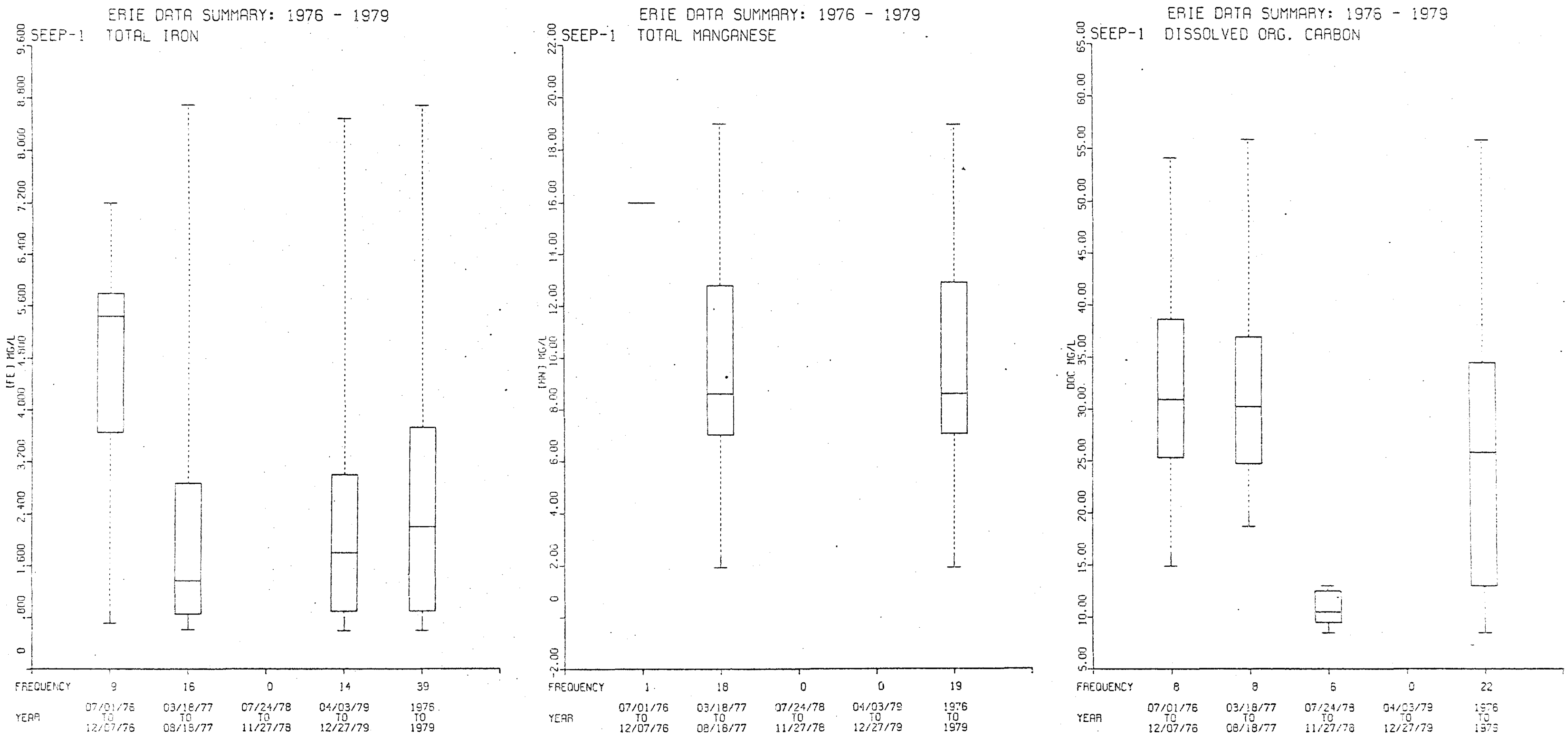

ERIE DATA SUMMARY: 1976 - 1979
SEEP-1 TOTAL IRON
[FE] MG/L
FREQUENCY 9 16 0 14 39
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-1 TOTAL MANGANESE
[MN] MG/L
FREQUENCY 1 18 0 0 19
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-1 DISSOLVED ORG. CARBON
DOC MG/L
FREQUENCY 8 8 6 0 22
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979

FIGURE 21

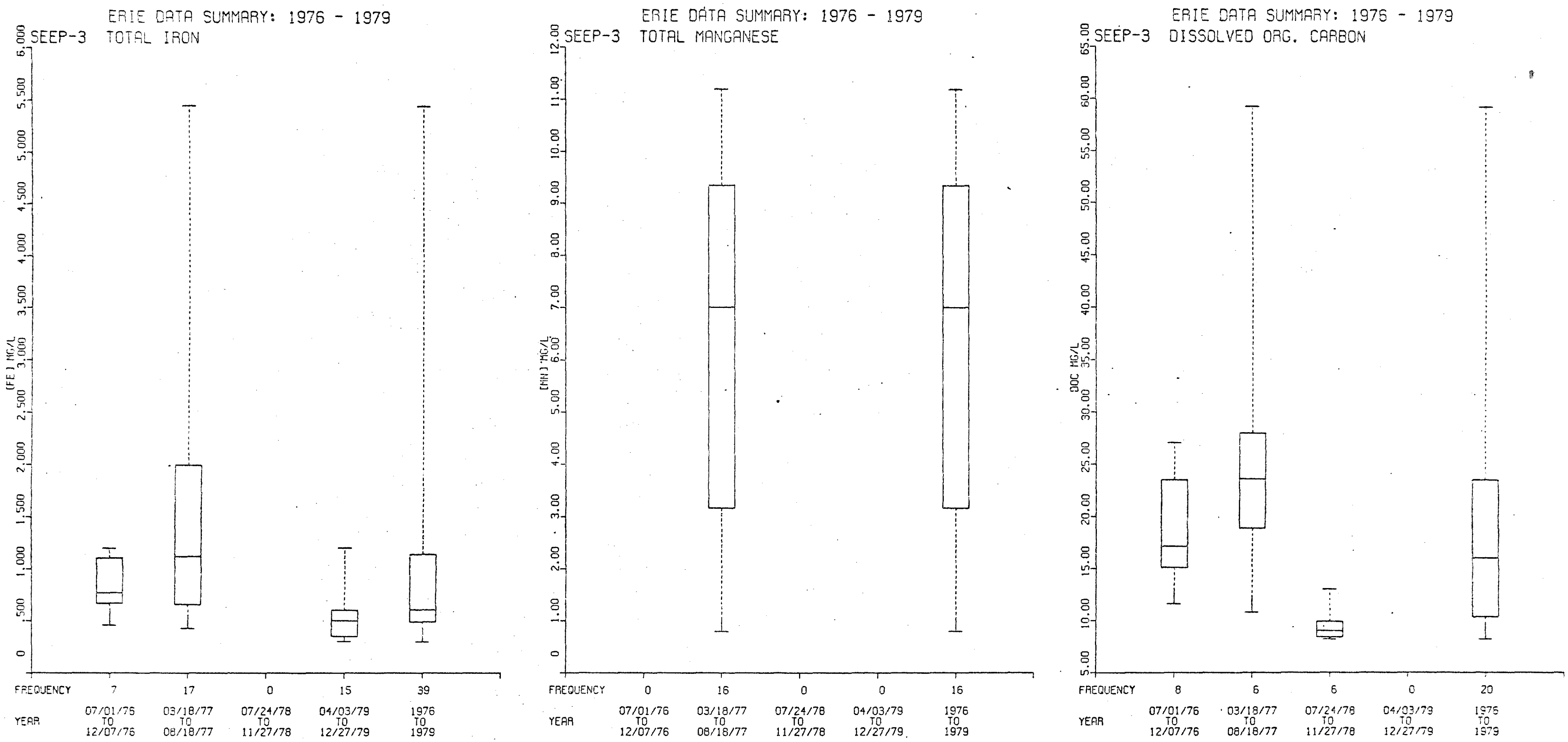
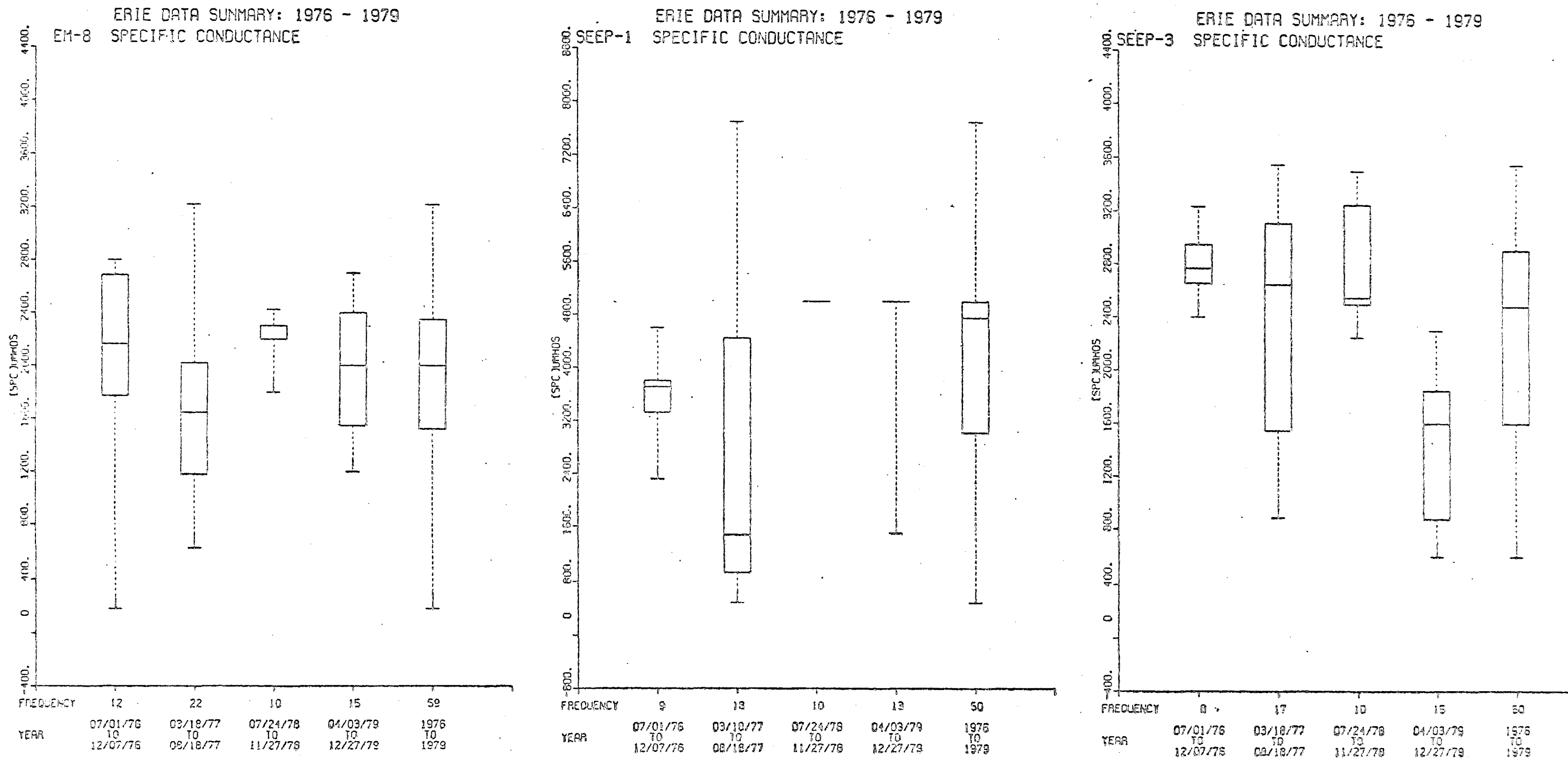

ERIE DATA SUMMARY: 1976 - 1979
SEEP-3 TOTAL IRON
[FE] MG/L
0
.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000
FREQUENCY 7 17 0 15 39
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-3 TOTAL MANGANESE
[MN] MG/L
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
FREQUENCY 0 16 0 0 16
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-3 DISSOLVED ORG. CARBON
DOC MG/L
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
FREQUENCY 8 6 6 0 20
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979

FIGURE 22



Seep 1, 1978-1979, specific conductance in many of the samples was greater than 5000 which exceeded the range of the meter.

FIGURE 23

EM-8 DISCHARGE, SPECIFIC CONDUCTANCE, ALKALINITY, TEMPERATURE

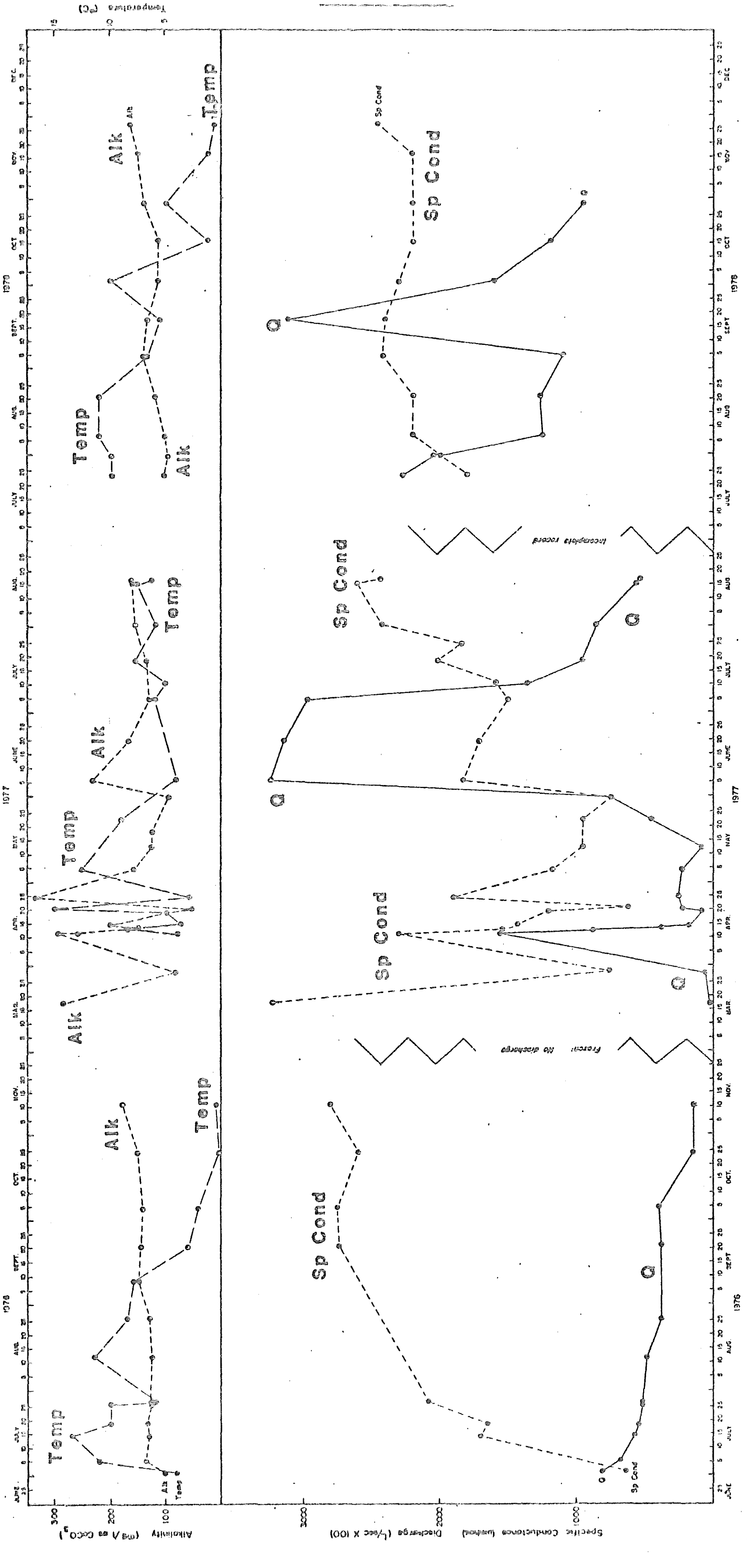


FIGURE 24

SEEP I. – DISCHARGE, SPECIFIC CONDUCTANCE, ALKALINITY, TEMPERATURE

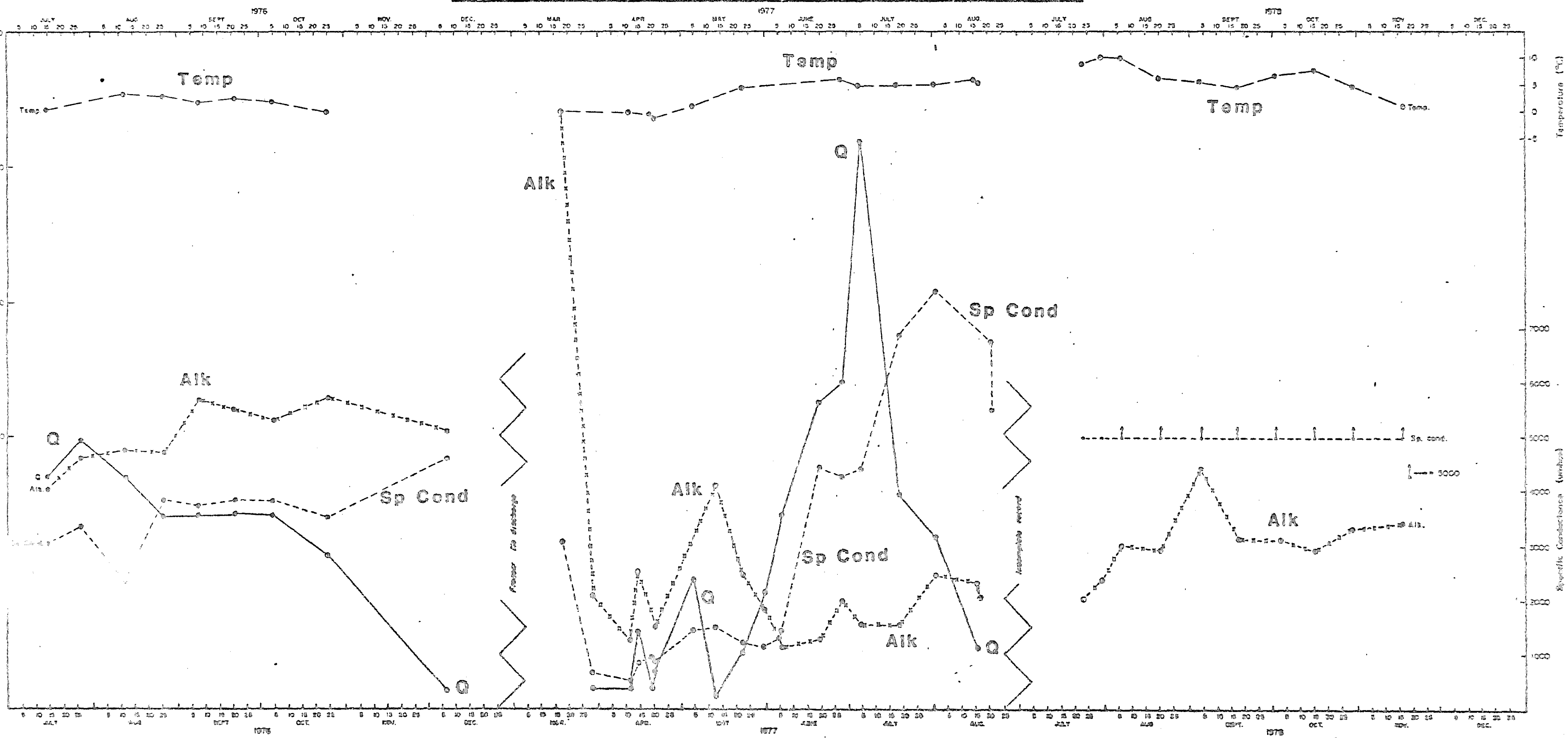


FIGURE 25

SEEP 3.-DISCHARGE, SPECIFIC CONDUCTANCE, ALKALINITY, TEMPERATURE

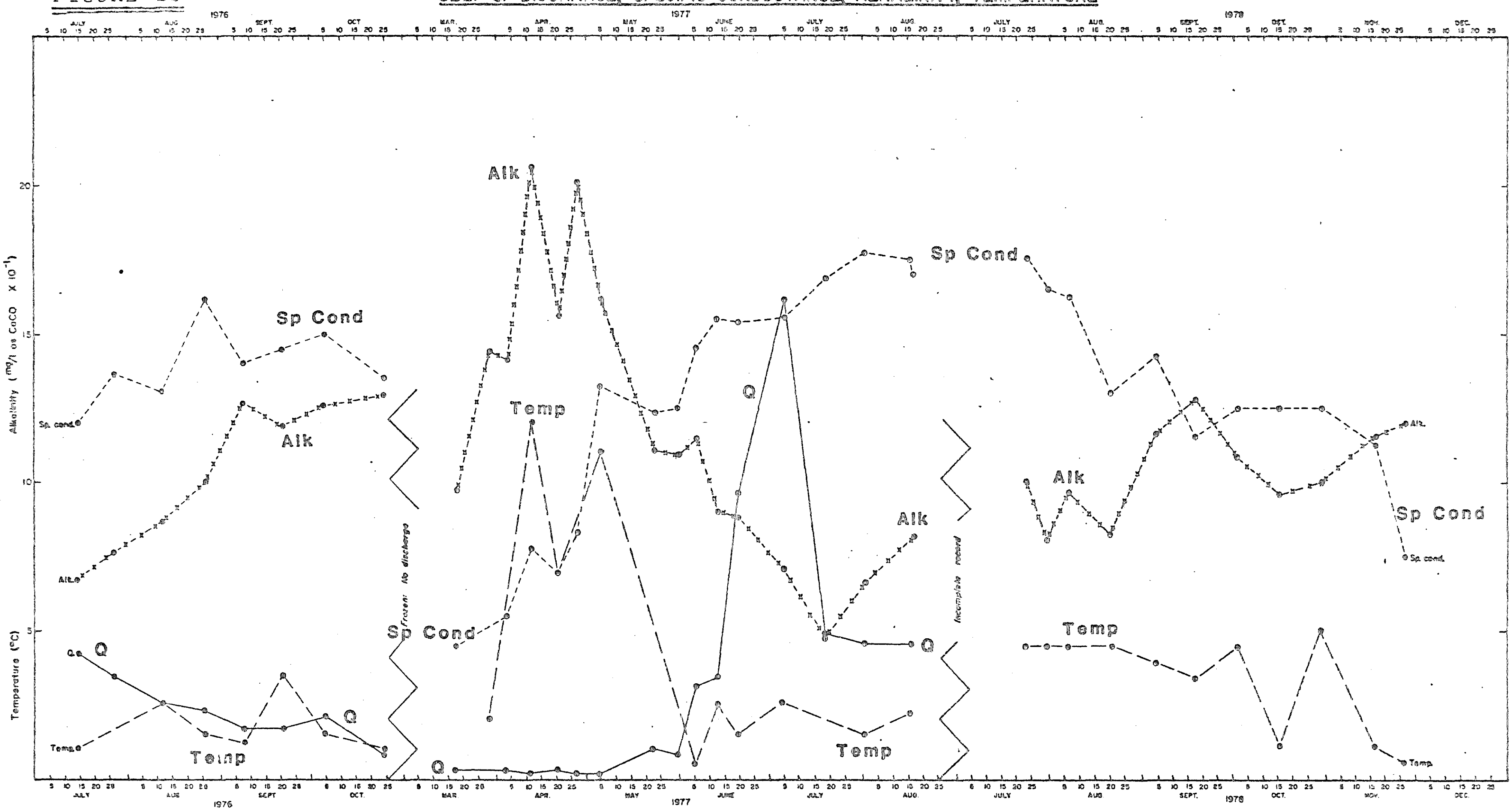


FIGURE 26

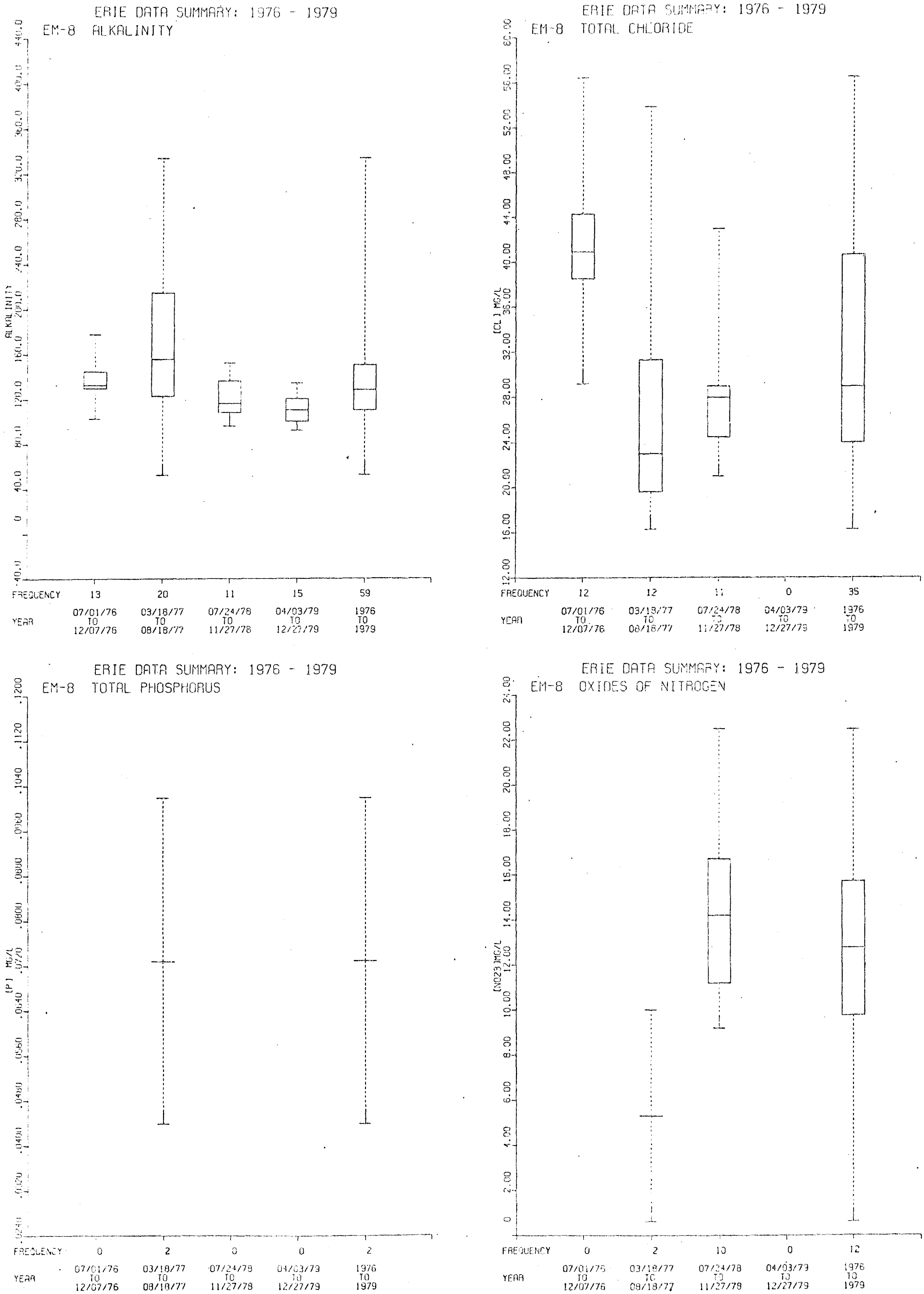
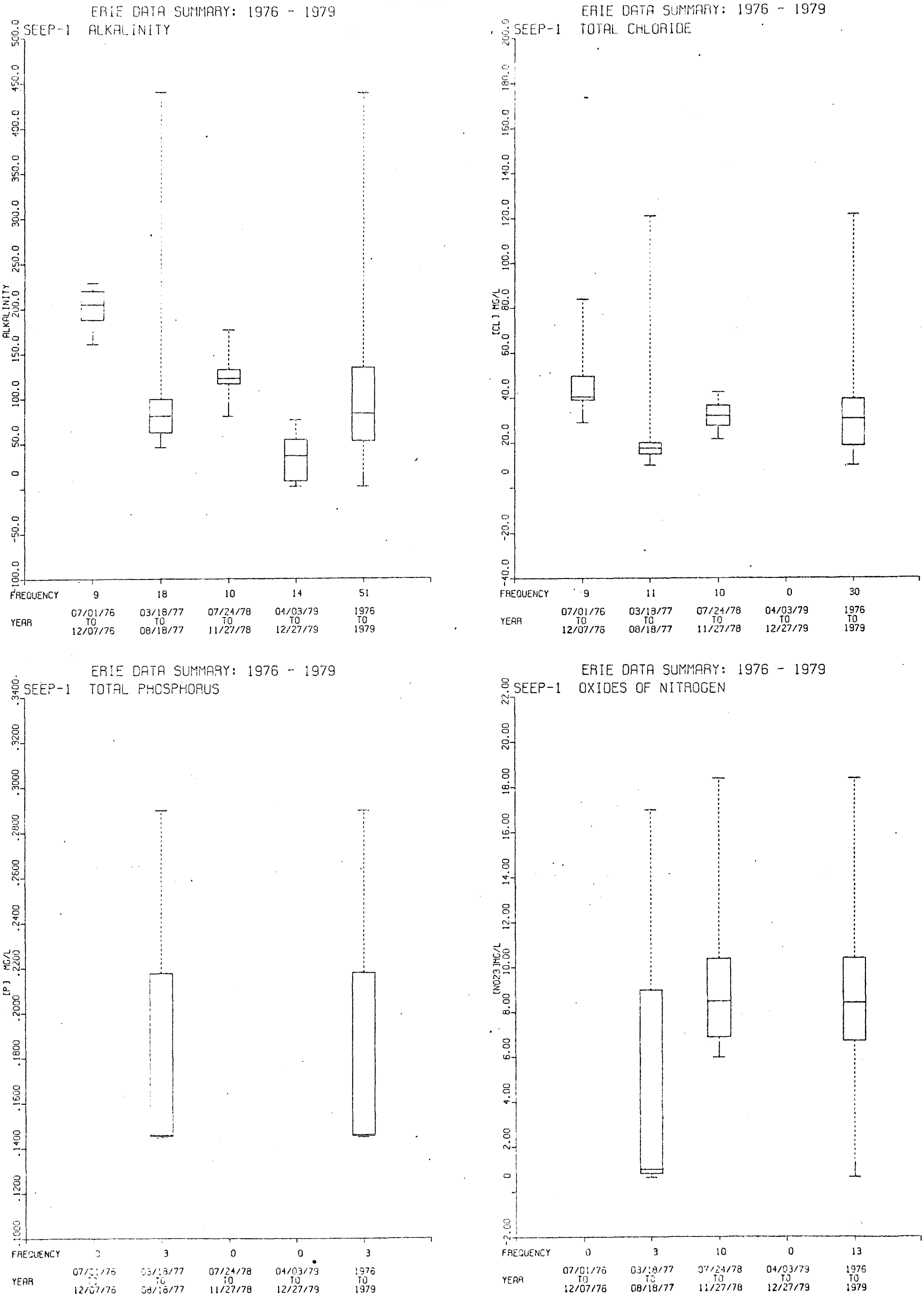

ERIE DATA SUMMARY: 1976 - 1979
EM-8 ALKALINITY
ALKALINITY
FREQUENCY 13 20 11 15 59
YEAR 07/01/76 TO 12/07/76 03/18/77 TO 08/18/77 07/24/78 TO 11/27/78 04/03/79 TO 12/27/79 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-8 TOTAL CHLORIDE
[CL] MG/L
FREQUENCY 12 12 11 0 35
YEAR 07/01/76 TO 12/07/76 03/18/77 TO 08/18/77 07/24/78 TO 11/27/78 04/03/79 TO 12/27/79 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-8 TOTAL PHOSPHORUS
[P] MG/L
FREQUENCY 0 2 0 0 2
YEAR 07/01/76 TO 12/07/76 03/18/77 TO 08/18/77 07/24/78 TO 11/27/78 04/03/79 TO 12/27/79 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-8 OXIDES OF NITROGEN
[NO23]MG/L
FREQUENCY 0 2 10 0 12
YEAR 07/01/76 TO 12/07/76 03/18/77 TO 08/18/77 07/24/78 TO 11/27/78 04/03/79 TO 12/27/79 1976 TO 1979

FIGURE 27


ERIE DATA SUMMARY: 1976 - 1979
SEEP-1 ALKALINITY
ALKALINITY
FREQUENCY 9 18 10 14 51
YEAR 07/01/76 TO 12/07/76 03/18/77 TO 08/18/77 07/24/78 TO 11/27/78 04/03/79 TO 12/27/79 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-1 TOTAL CHLORIDE
[CL] MG/L
FREQUENCY 9 11 10 0 30
YEAR 07/01/76 TO 12/07/76 03/18/77 TO 08/18/77 07/24/78 TO 11/27/78 04/03/79 TO 12/27/79 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-1 TOTAL PHOSPHORUS
[P] MG/L
FREQUENCY 0 3 0 0 3
YEAR 07/01/76 TO 12/07/76 03/18/77 TO 08/18/77 07/24/78 TO 11/27/78 04/03/79 TO 12/27/79 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-1 OXIDES OF NITROGEN
[NO23] MG/L
FREQUENCY 0 3 10 0 13
YEAR 07/01/76 TO 12/07/76 03/18/77 TO 08/18/77 07/24/78 TO 11/27/78 04/03/79 TO 12/27/79 1976 TO 1979

at Em 8 were somewhat warmer since this station was located about 100 meters downstream of the point of discharge from the stockpile. The discharge from the stockpiles was colder than ambient temperatures because the stockpiled rock acted as an insulator.

The median chloride concentration for the study period was about 30 mg/1 at each of the stockpiles. Chloride concentrations decreased over the study period, a trend most apparent at Seep 3 (Figure 28). Data on phosphorus were too limited to warrant discussion. Observed concentrations ranged from 0.04 - 7 mg/1.

Median NO_2-NO_3 concentrations at the stockpiles ranged from 6 to 13 mg/1. (Figures 26-28). Residual nitrate from blasting materials may have contributed to the total NO_2-NO_3 release.

4.2 STREAM STATIONS

The stream stations were monitored in 1976 and 1977 except for Em 1 which has been monitored up to the present. The stations included two flows from mine dewatering (Em 6, Em 2), one source of natural runoff (Em 4), and three stations along the main stream branch (Em 5, Em 3, Em 1, Figure 29). A summary of the observed median concentrations and flows for 1976-1977 is presented in Table 4. The range of concentrations and flows, and mass fluxes at the various stations is presented in Figure 30.

4.2.1 Mine dewatering

Mine dewatering discharges, 011 and 012, flow through stations Em 6 and Em 2, respectively, and provide flow input an order of magnitude higher than the input from stockpile runoff (Figure 30). The median pH values at both Em 6 and Em 2 was approximately 7.6, and median sulfate concentrations were 110 and 340 mg/1, respectively (Figures 31, 32). Copper and nickel

FIGURE 28

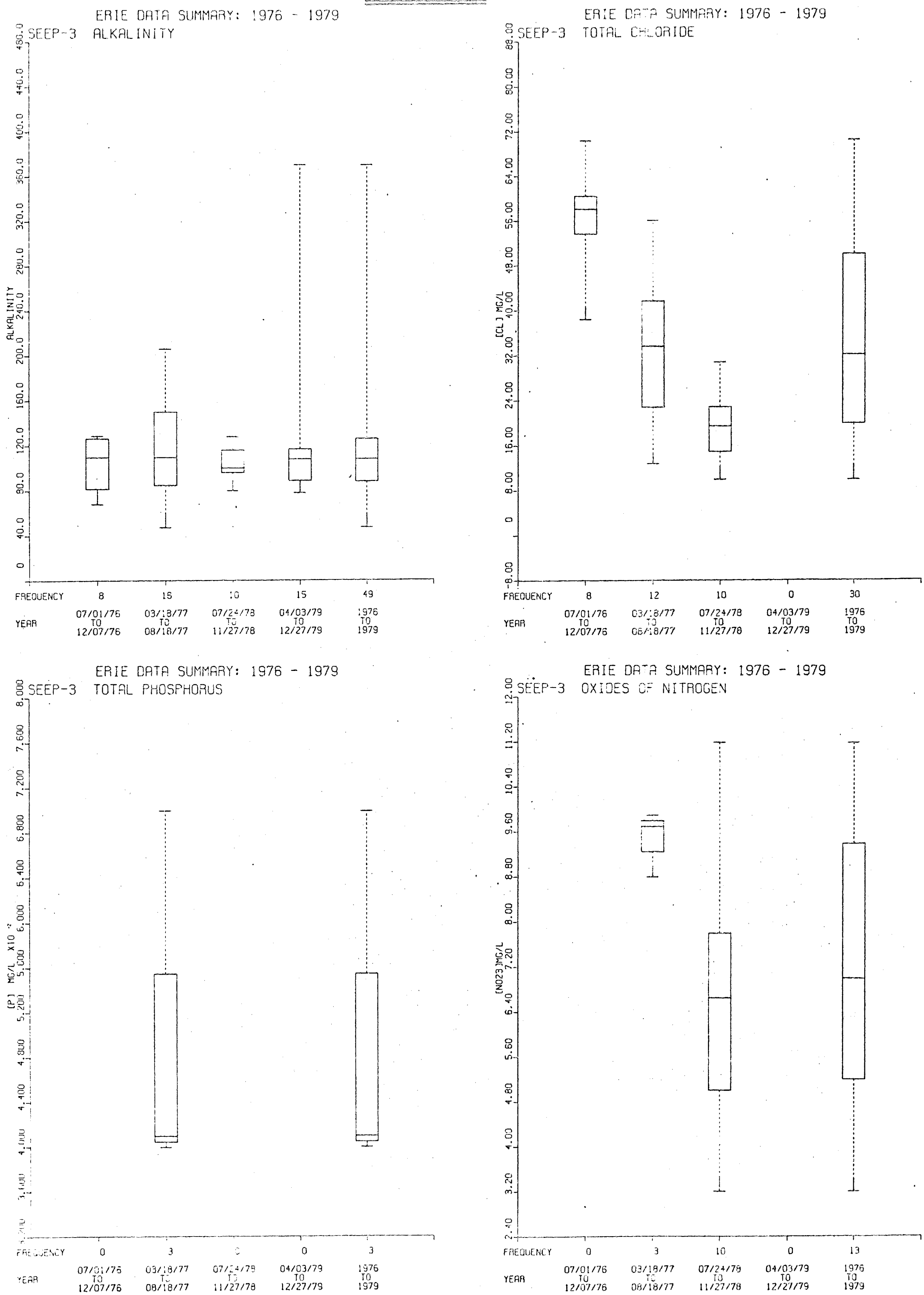

ERIE DATA SUMMARY: 1976 - 1979
SEEP-3 ALKALINITY
ALKALINITY
FREQUENCY 8 15 10 15 49
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-3 TOTAL CHLORIDE
[CL] MG/L
FREQUENCY 8 12 10 0 30
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-3 TOTAL PHOSPHORUS
[P] MG/L X10
FREQUENCY 0 3 0 0 3
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
SEEP-3 OXIDES OF NITROGEN
[NO23]MG/L
FREQUENCY 0 3 10 0 13
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979

FIGURE 29 - Stream sampling sites.

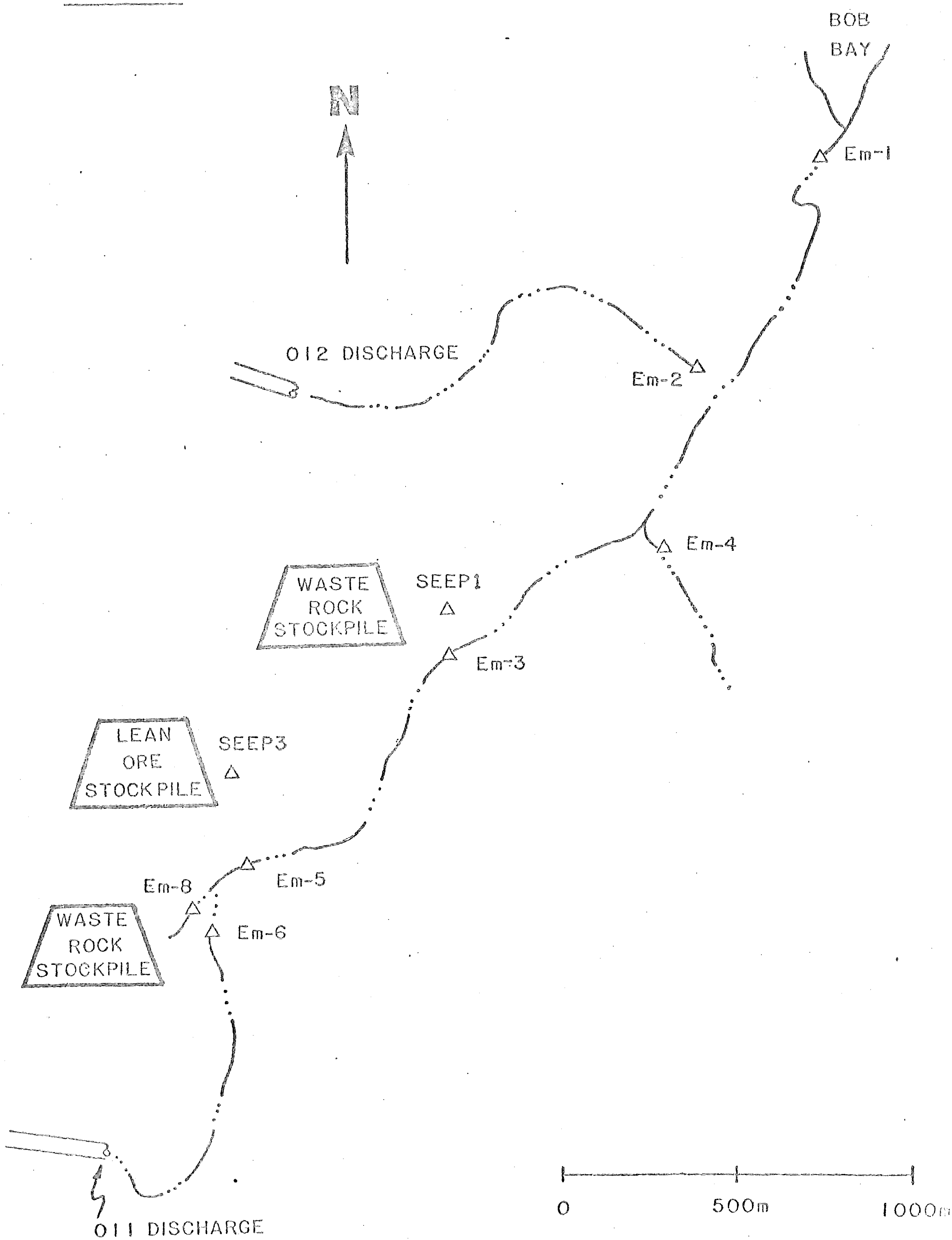
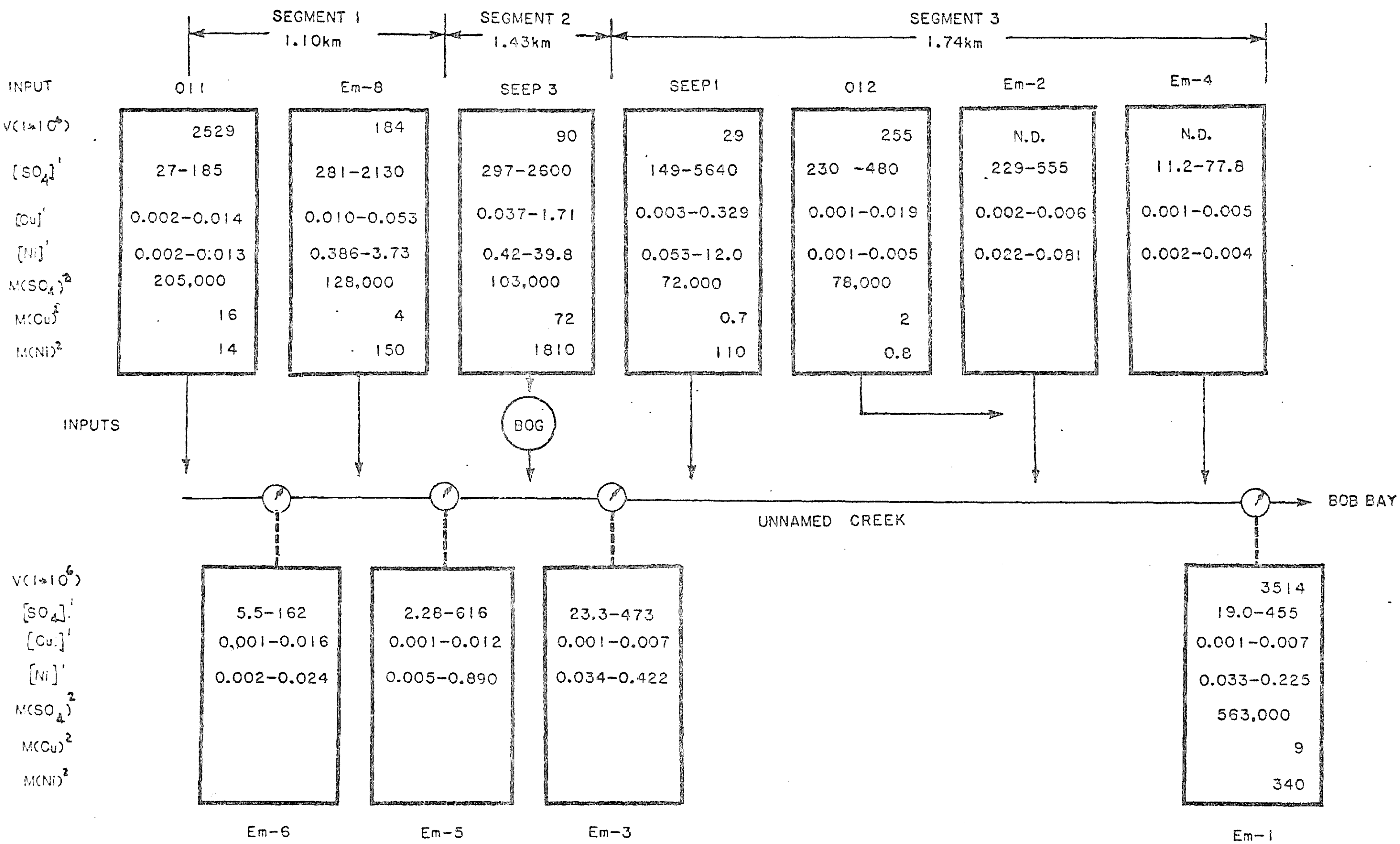


Figure 30. Concentrations and mass flux for Unnamed Creek inputs and stream stations (not to scale)



1. mg/l, range of concentrations, total metals

2. mass flux(kg) from 7/76-8/77

FIGURE 31

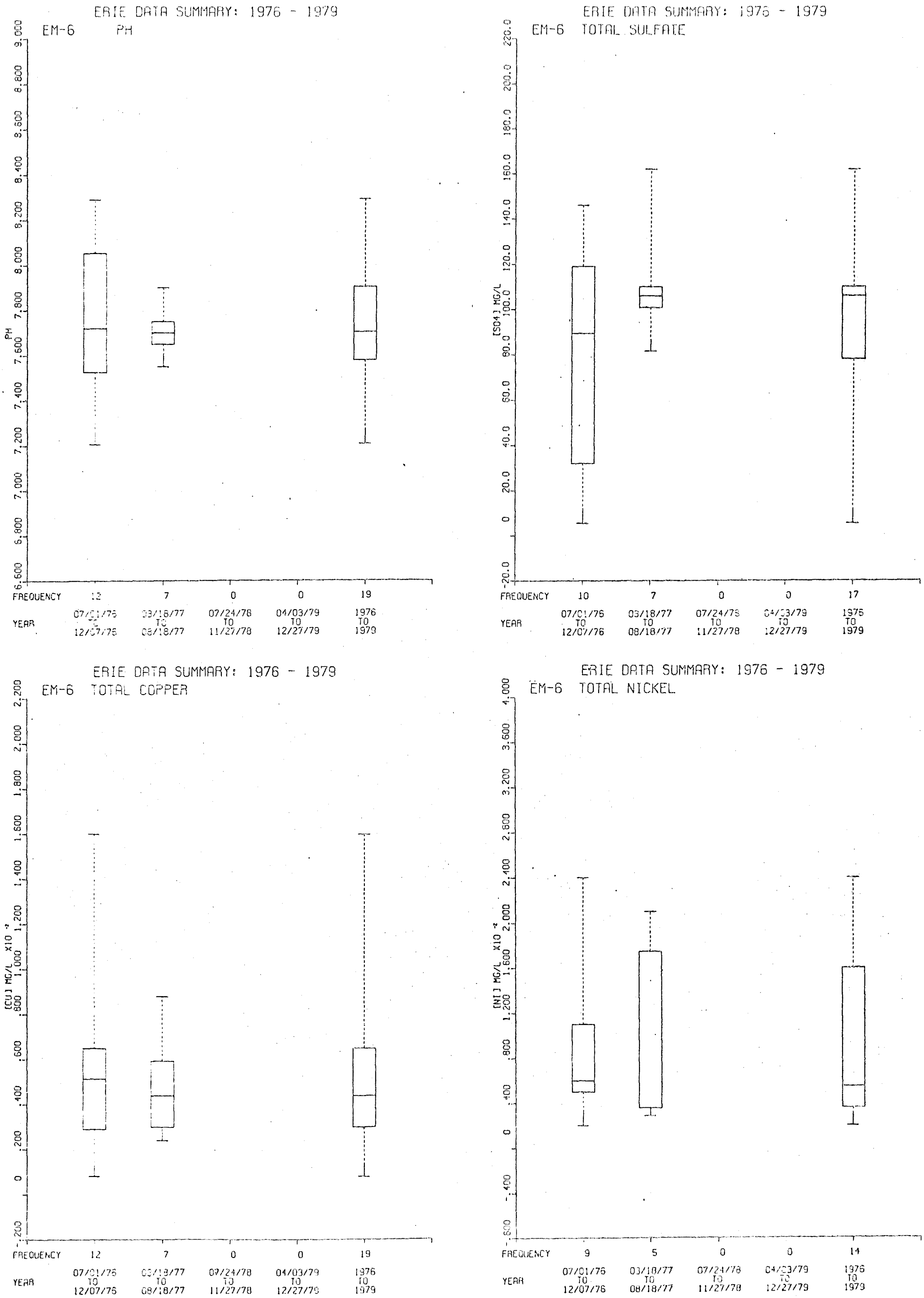
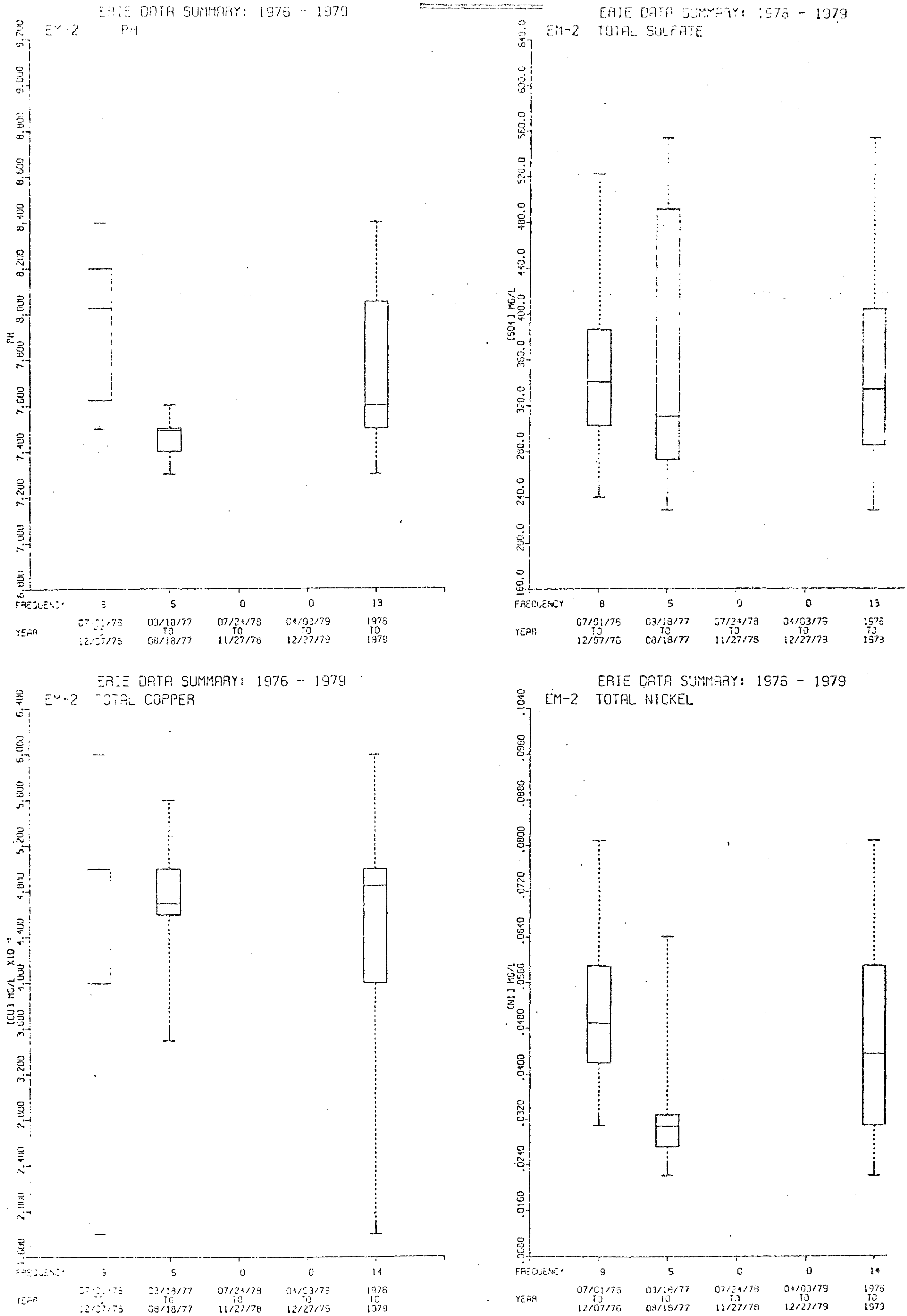

ERIE DATA SUMMARY: 1976 - 1979
EM-6 PH
PH
FREQUENCY 12 7 0 0 19
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-6 TOTAL SULFATE
[SO4] MG/L
FREQUENCY 10 7 0 0 17
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-6 TOTAL COPPER
[CU] MG/L X10 -2
FREQUENCY 12 7 0 0 19
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-6 TOTAL NICKEL
[NI] MG/L X10 -2
FREQUENCY 9 5 0 0 14
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979

FIGURE 32


ERIE DATA SUMMARY: 1976 - 1979
EM-2 PH
PH
FREQUENCY 9 5 0 0 13
YEAR
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-2 TOTAL SULFATE
[SO4] MG/L
FREQUENCY 8 5 0 0 13
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-2 TOTAL COPPER
[CU] MG/L X10⁻³
FREQUENCY 9 5 0 0 14
YEAR
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-2 TOTAL NICKEL
[NI] MG/L
FREQUENCY 9 5 0 0 14
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979

concentrations were quite low in comparison with the stockpile runoff. Median copper concentrations at both sites were 4-5 μg/1, but nickel concentrations were significantly higher at Em 2 (40μg/1) than at Em 6 (5μg/1, Figures 31, 32).

4.2.2. Natural runoff

Station Em 4 was intended to represent a natural runoff input. This objective was not attained because backwater conditions occurred and affected the water quality at the site. Few data were collected at this site, the maximum number of data points being 8.

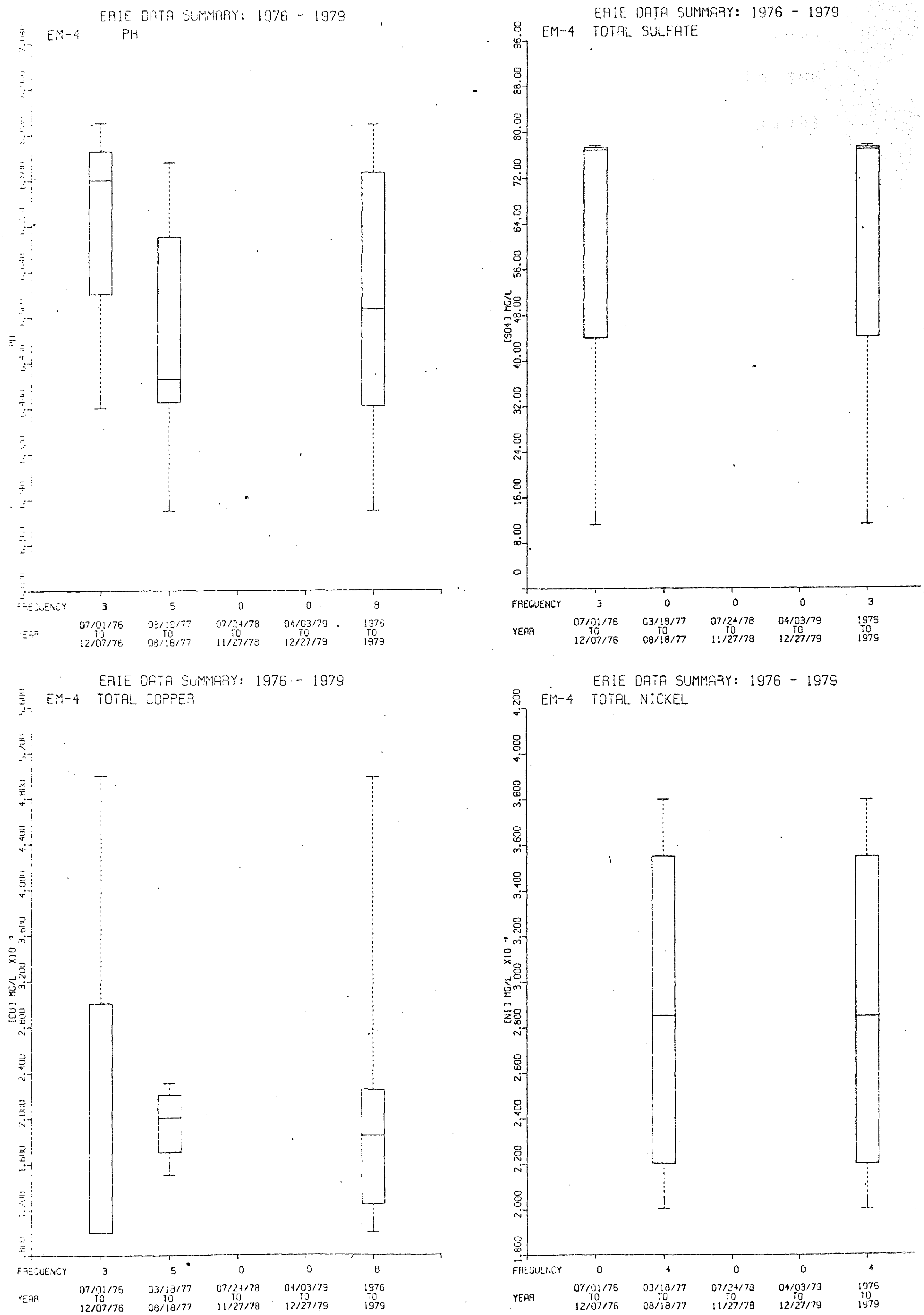
The pH at Em 4 was lower than in the stockpile runoff and mine dewatering. The median pH from 1976 to 1977 was about 6.6 (Figure 33). The three sulfate samples analyzed were all above background levels (Figure 33, Table 2). Median copper and nickel concentrations were 2 and 3 μg/1, respectively.

4.2.3 Stations along the main stream branch

Three stations were located along the main branch of Unnamed Creek. Em 5 was located at the confluence of waste rock stockpile runoff (Em 8) and a mine dewatering discharge (Em 6, Figure 29). Em 3 was located about 1.4 km downstream from Em 5 and received flow from Seep 3 (lean ore stockpile runoff) in addition to the flow from Em 5 and natural runoff. Em 1 was located at the mouth of Unnamed Creek, about 1.7 km downstream from Em 3. In addition to the flow from Em 3, Em 1 also received waste rock stockpile runoff from Seep 1, natural runoff from Em 4 and other parts of the watershed, and mine dewatering from Em 2.

Going downstream from Em 5 to Em 3 and Em 1 the median flow

FIGURE 33


ERIE DATA SUMMARY: 1976 - 1979
EM-4 PH
PH
FREQUENCY 3 5 0 0 8
YEAR 07/01/76 TO 12/07/76; 03/19/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-4 TOTAL SULFATE
[SO4] MG/L
96.00 88.00 80.00 72.00 64.00 56.00 48.00 40.00 32.00 24.00 16.00 8.00 0
FREQUENCY 3 0 0 0 3
YEAR 07/01/76 TO 12/07/76; 03/19/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-4 TOTAL COPPER
[CU] MG/L X10⁻³
FREQUENCY 3 5 0 0 8
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-4 TOTAL NICKEL
[NI] MG/L X10⁻³
4.200 4.000 3.800 3.600 3.400 3.200 3.000 2.800 2.600 2.400 2.200 2.000 1.800
FREQUENCY 0 4 0 0 4
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979

rate increased from 30 to 90 to 110 l/s (Table 4). The pH at all three sites was about the same, with median pH values ranging from 7.5 to 7.65 (Figures 34, 35, 37). Median sulfate concentrations at the three sites were 122, 155, and 160 mg/l. Mass balance calculations indicated that virtually 100% of the sulfate input was transported to the mouth of the creek (14). Copper concentrations were low at all three sites (Figures 34, 35, 37). Median concentrations at Em 5, Em 3, and Em 1 were 5, 3, and 2 µg/l. Median nickel concentrations were 51, 110, and 87 µg/l. Mass transport calculations indicated that nickel transport through the system was more efficient than copper transport (14). The majority of input metal removal occurred as flow from Seep 3 passed through a bog, and was the result of trace metal sequestration by peat (12-14).

4.2.4. Transport from the creek: Data from Em 1

As was previously mentioned, the median flow at Em 1 was 110 l/s during 1976 and 1977. This flow had an elevated ionic content as is indicated by the specific conductance (Figure 36). The high specific conductance is the result of high concentrations of sulfate, calcium, and magnesium (Figure 37). Concentrations of copper (3 µg/l and nickel (160 µg/l) were elevated above background levels (Figure 38, Table 2). Cobalt and zinc concentrations were typically in the range of 1-2.5 µg/l. Median iron and manganese concentrations were 0.2 and 0.05 mg/l, and the median DOC concentration was 12 mg/l (Figure 39). The alkalinity at Em 1 was about 100 mg/l as $CaCO_3$, and typical chloride concentrations ranged from 20-30 mg/l. The three phosphorus analyses ranged from 0.02 to 0.12 mg/l and the NO_2-NO_3 values from 6-14 mg/l (Figure 40).

Table 4 Median Values At Erie Sites, 1976-1977[1]

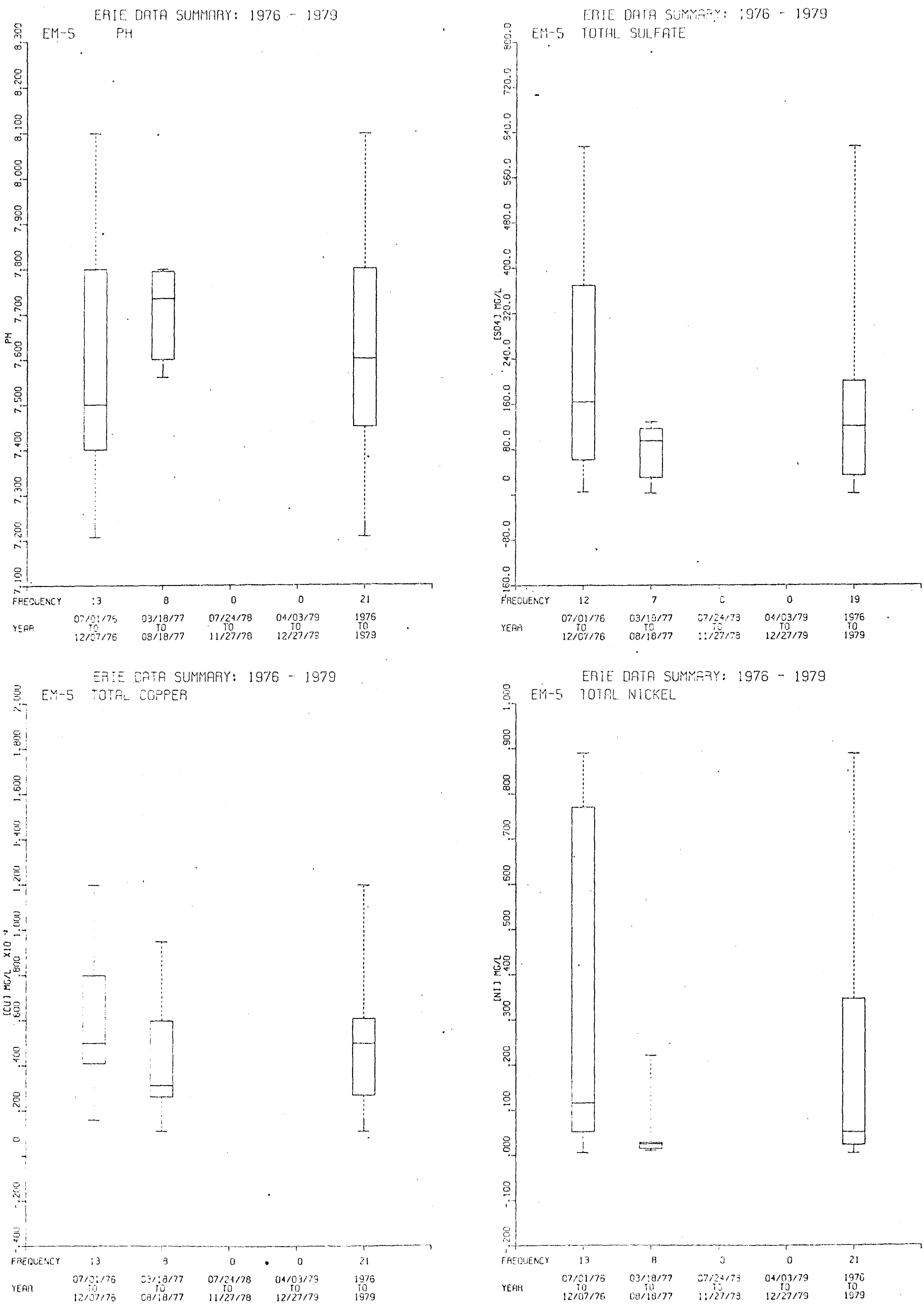
Site	Q	N	SO_4	N	Cu	N	Ni	N	Co	N	Zn	N	pH	N	DOC	N	DIC	N	TALK	N
011[2]			72	14	0.004	14	0.005	14												
EM-6	26.6[3]	19	106	17	0.004	19	0.005	14	0.002	1	0.003	1	7.70	19	9.4	14	17.9	13	94	18
EM-8	4.82	34	1140	24	0.019	33	1.18	33	0.015	8	0.020	10	7.26	34	20.1	22	24.7	22	142	33
EM-5	31.4	21	122	19	0.005	21	0.051	21	0.005	5	0.009	3	7.63	21	12.2	12	20.1	11	101	21
Seep 3	2.10	25	1420	17	0.617	24	19.0	24	0.910	8	0.331	12	7.16	24	19.0	14	28.2	14	109	24
EM-3	93.4	26	155	25	0.003	28	0.110	27	0.002	3	0.009	2	7.65	27	10.5	17	19.8	16	96	27
Seep 1	1.15	26	2470	20	0.018	27	1.10	27	0.130	9	0.249	13	6.95	27	28.0	16	25.2	15	98.8	27
012[2]			250	7	<0.003	7	0.002	7												
EM-4	14.2	8	77.0	3	0.002	8	0.003	4	-	0	-	0	6.46	8	20.3	7	4.3	7	14.1	8
EM-2	2.62	14	335	13	0.005	14	0.042	14	0.002	1	-	0	7.60	13	11.0	10	16.6	10	96.6	14
EM-1	110	37	159	35	0.002	37	0.087	35	0.002	5	0.010	2	7.50	38	12.7	19	18.5	19	88.0	36

1 Q in liters/sec, concentrations in mg/1, DOC and DIC in mg/1 as C, TALK in mg/ℓ as Ca CO_3

2 Data from Erie Mining Company

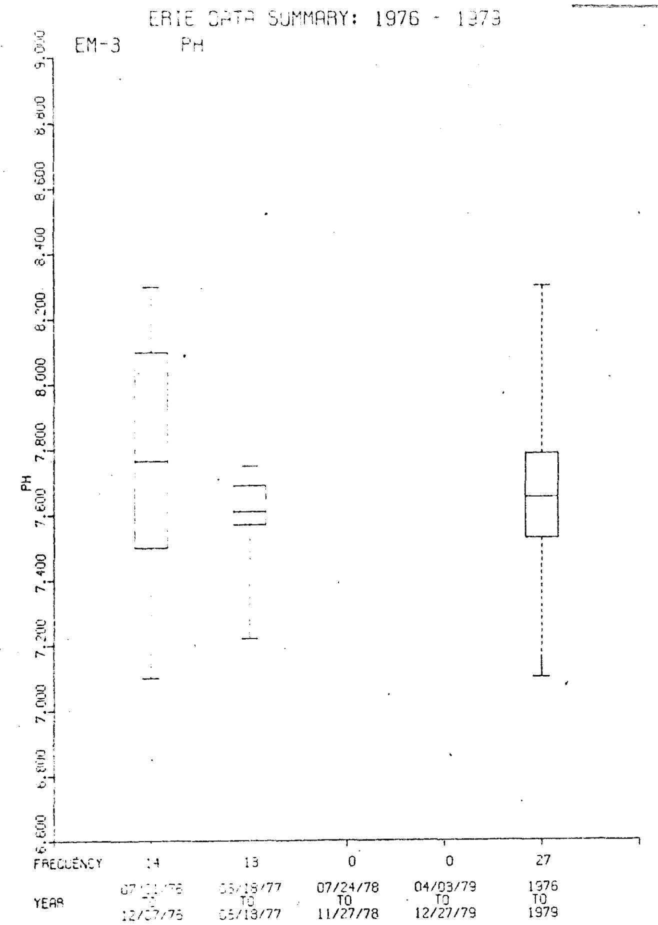
3 Calculated from data at EM-8 and EM-5

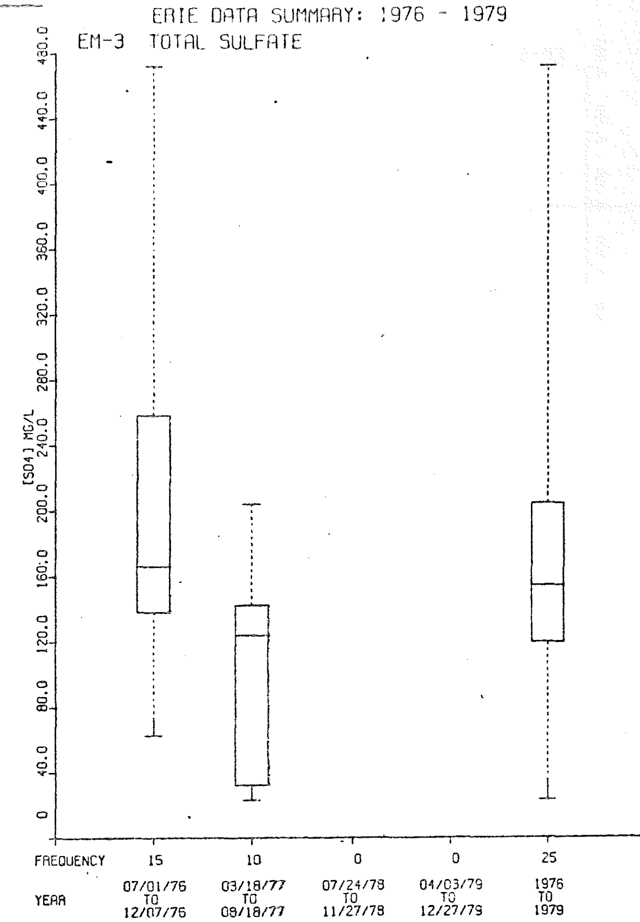
FIGURE 34

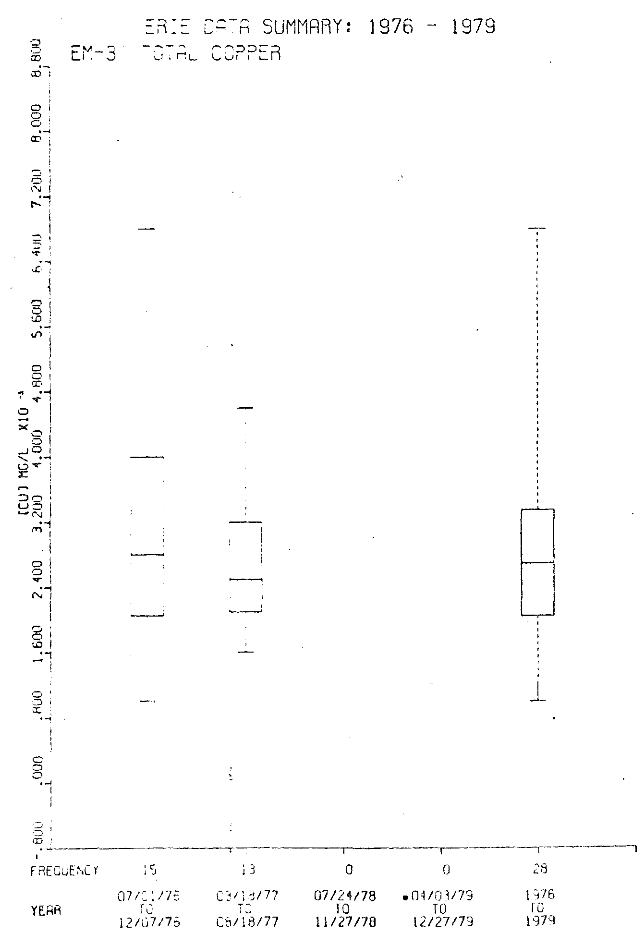


ERIE DATA SUMMARY: 1976 - 1979
EM-5 PH
PH
FREQUENCY 13 8 0 0 21
YEAR 07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-5 TOTAL SULFATE
[SO4] MG/L
FREQUENCY 12 7 0 0 19
ERIE DATA SUMMARY: 1976 - 1979
EM-5 TOTAL COPPER
[CU] MG/L X10 -2
FREQUENCY 13 8 0 0 21
ERIE DATA SUMMARY: 1976 - 1979
EM-5 TOTAL NICKEL
[NI] MG/L
FREQUENCY 13 8 0 0 21

FIGURE 35


ERIE DATA SUMMARY: 1976 - 1979
EM-3 PH
PH
9.000
8.800
8.600
8.400
8.200
8.000
7.800
7.600
7.400
7.200
7.000
6.800
6.600
FREQUENCY 14 13 0 0 27
YEAR
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979


ERIE DATA SUMMARY: 1976 - 1979
EM-3 TOTAL SULFATE
[SO4] MG/L
480.0
440.0
400.0
360.0
320.0
280.0
240.0
200.0
160.0
120.0
80.0
40.0
0
FREQUENCY 15 10 0 0 25
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979


ERIE DATA SUMMARY: 1976 - 1979
EM-3 TOTAL COPPER
[CU] MG/L X10 -3
8.800
8.000
7.200
6.400
5.600
4.800
4.000
3.200
2.400
1.600
.800
.000
-.800
FREQUENCY 15 13 0 0 28
YEAR
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979

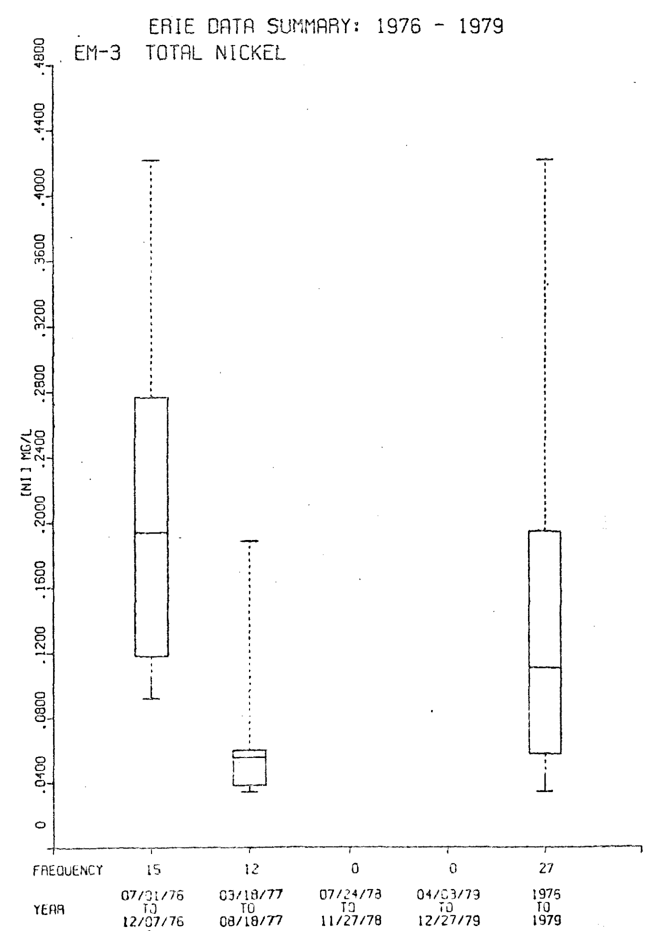
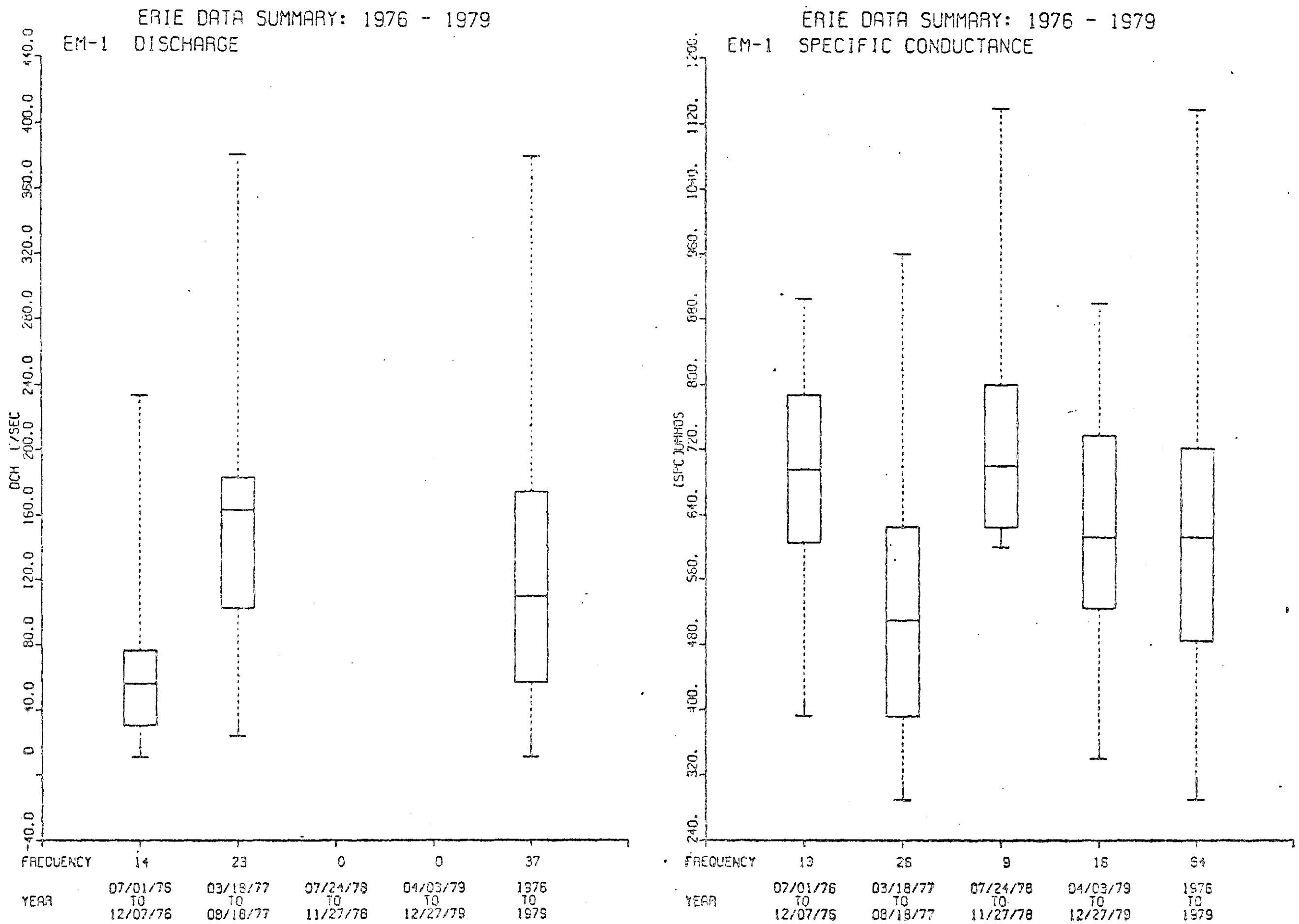

ERIE DATA SUMMARY: 1976 - 1979
EM-3 TOTAL NICKEL
[NI] MG/L
.4800
.4400
.4000
.3600
.3200
.2800
.2400
.2000
.1600
.1200
.0800
.0400
0
FREQUENCY 15 12 0 0 27
YEAR
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
1976 TO 1979

FIGURE 36



Based on periodic measurements

FIGURE 37

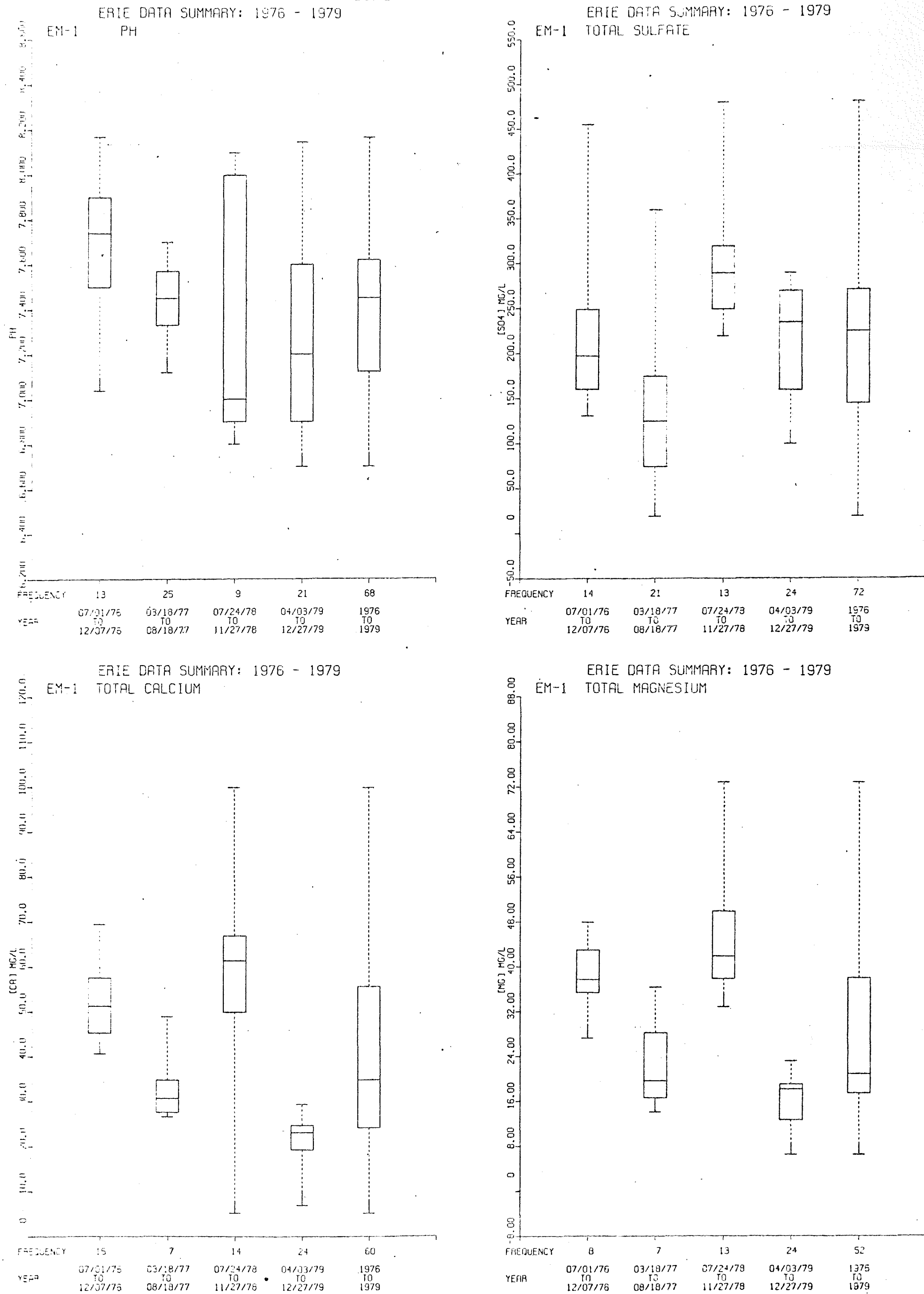

ERIE DATA SUMMARY: 1976 - 1979
EM-1 PH
PH
FREQUENCY 13 25 9 21 68
YEAR 07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-1 TOTAL SULFATE
[SO4] MG/L
550.0 500.0 450.0 400.0 350.0 300.0 250.0 200.0 150.0 100.0 50.0 0 -50.0
FREQUENCY 14 21 13 24 72
YEAR 07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-1 TOTAL CALCIUM
[CA] MG/L
FREQUENCY 15 7 14 24 60
YEAR 07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-1 TOTAL MAGNESIUM
[MG] MG/L
88.00 80.00 72.00 64.00 56.00 48.00 40.00 32.00 24.00 16.00 8.00 0 -8.00
FREQUENCY 8 7 13 24 52
YEAR 07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979

FIGURE 38

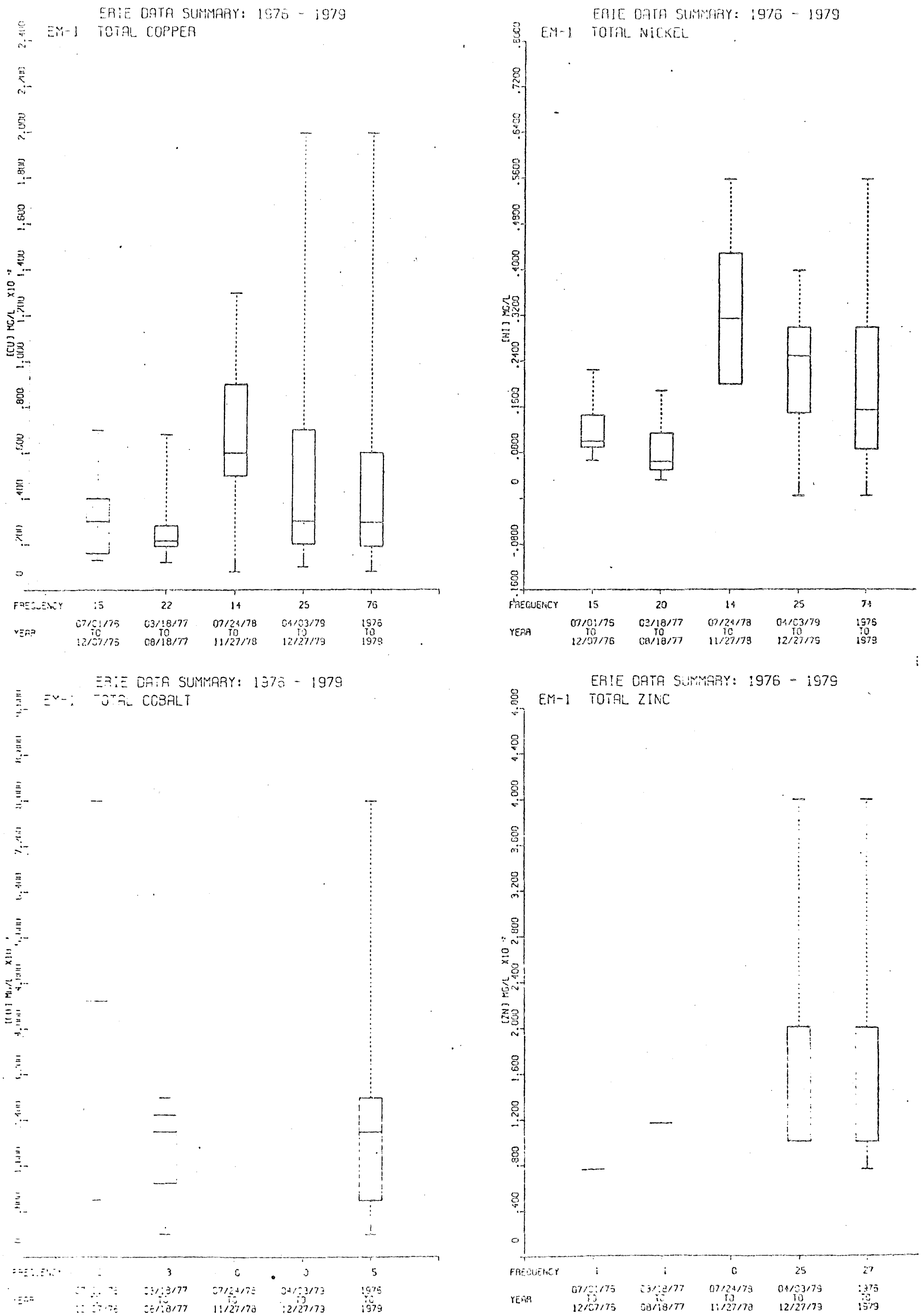
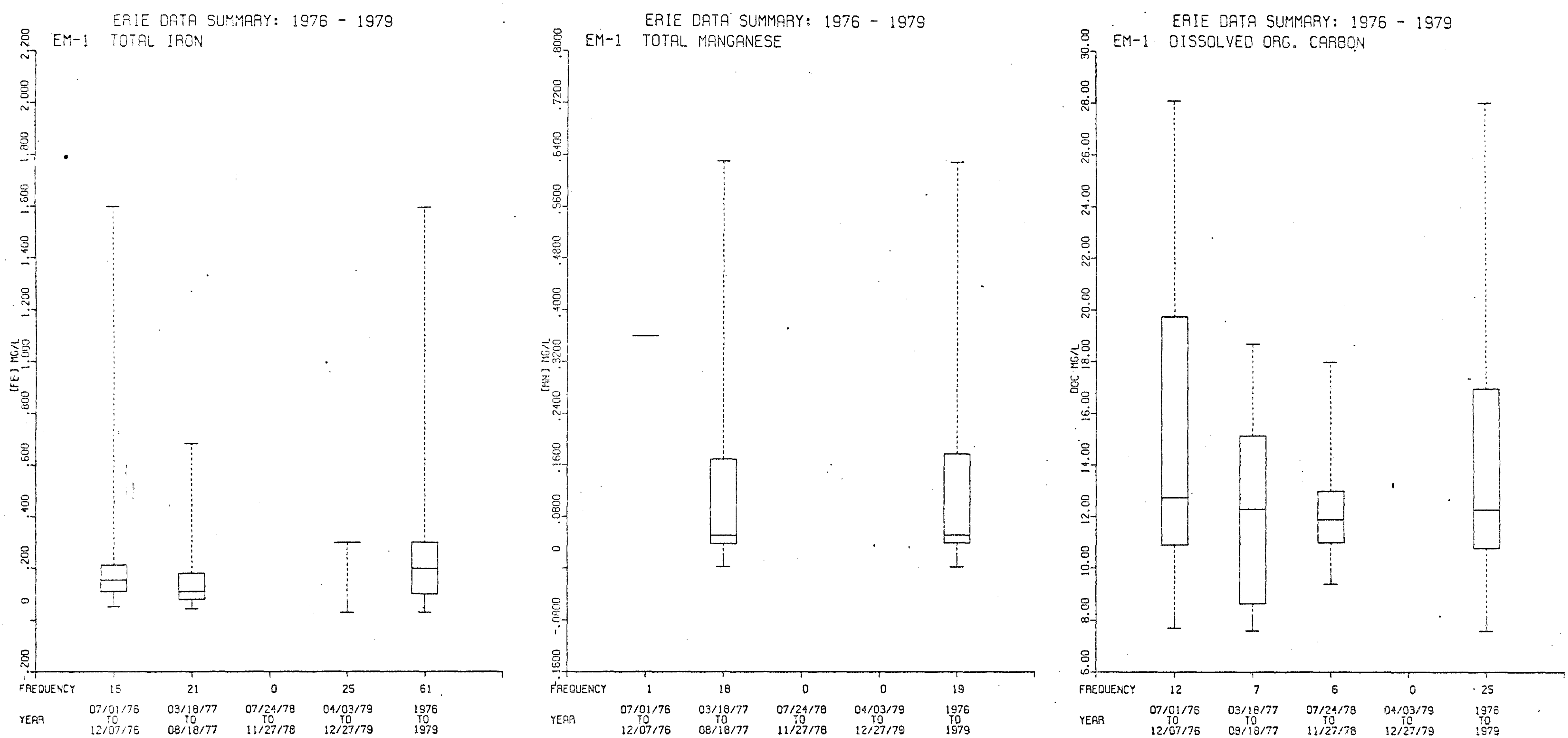
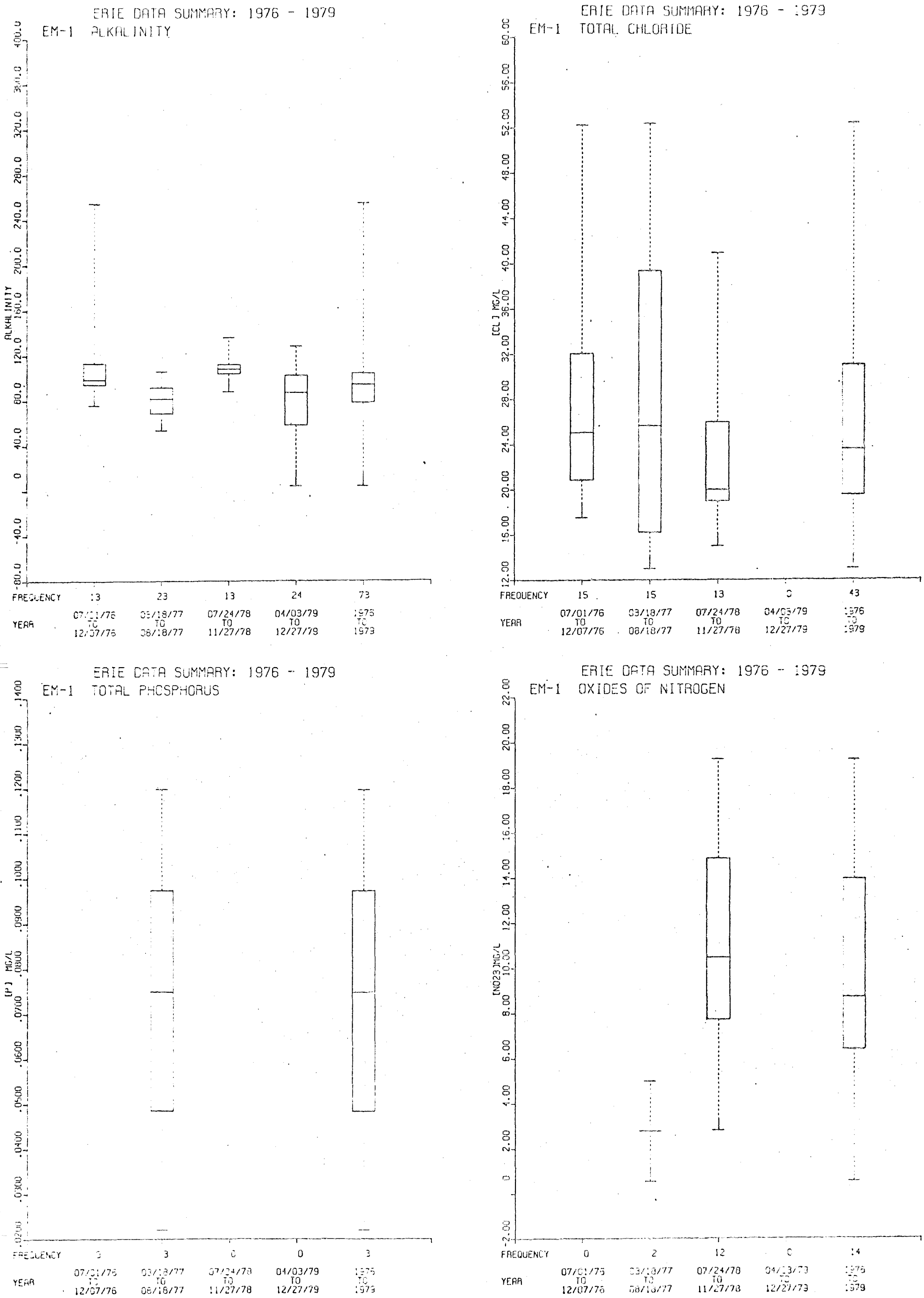

ERIE DATA SUMMARY: 1976 - 1979
EM-1 TOTAL COPPER
[CU] MG/L X10
FREQUENCY 15 22 14 25 76
YEAR 07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-1 TOTAL NICKEL
[NI] MG/L
FREQUENCY 15 20 14 25 74
YEAR 07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
TOTAL COBALT
FREQUENCY 3 0 0 5
YEAR 03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-1 TOTAL ZINC
[ZN] MG/L X10
FREQUENCY 1 1 0 25 27
YEAR 07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979

FIGURE 39



ERIE DATA SUMMARY: 1976 - 1979
EM-1 TOTAL IRON
[FE] MG/L
2,200
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
200
FREQUENCY 15 21 0 25 61
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-1 TOTAL MANGANESE
[MN] MG/L
.8000
.7200
.6400
.5600
.4800
.4000
.3200
.2400
.1600
.0800
0
-.0800
.1600
FREQUENCY 1 18 0 0 19
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-1 DISSOLVED ORG. CARBON
DOC MG/L
30.00
28.00
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
FREQUENCY 12 7 6 0 25
YEAR
07/01/76 TO 12/07/76
03/18/77 TO 08/18/77
07/24/78 TO 11/27/78
04/03/79 TO 12/27/79
1976 TO 1979

FIGURE 40


ERIE DATA SUMMARY: 1976 - 1979
EM-1 ALKALINITY
ALKALINITY
FREQUENCY 13 23 13 24 73
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-1 TOTAL CHLORIDE
[CL] MG/L
FREQUENCY 15 15 13 0 43
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-1 TOTAL PHOSPHORUS
[P] MG/L
FREQUENCY 0 3 0 0 3
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979
ERIE DATA SUMMARY: 1976 - 1979
EM-1 OXIDES OF NITROGEN
[NO23]MG/L
FREQUENCY 0 2 12 0 14
YEAR 07/01/76 TO 12/07/76; 03/18/77 TO 08/18/77; 07/24/78 TO 11/27/78; 04/03/79 TO 12/27/79; 1976 TO 1979

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APPENDIX I

RAW DATA

Table A1.1 Em-8 raw data, 1976-1979

SITE= EM8
YEAR= 1976

DATE	07/02	07/06	07/15	07/19	07/26	07/27	08/12
PH	7.20	7.10	7.20	7.15	7.09	7.01	7.10
ALK	103.	136.	128.	133.	130.	133.	124.
SP COND*	629.		1695.	1846.	1980.	2079.	2253.
T CENT	4.0	11.0	13.5	10.0	10.0	6.0	11.5
SO4	708.	714.	980.	1134.	1203.	1237.	1346.
CU T	.017	.018	.020	.016	.016	.053	.021
NI T	.963	1.580	1.600	.580	1.890	1.970	2.400
CO T							
ZN T					.020	.018	.035
FE T	.19	.16	.17	.11	.11	.09	.13
CU F	.016	.015	.018	.015	.015	.018	.020
NI F	.950	.498	1.560	.570	1.940	2.100	2.400
FE F	.10	.01	.06	.09	.07	.04	.04
CA	94.	143.	65.	154.	163.	178.	214.
MG							
DOC	14.5	24.5	26.0	26.3	19.0	20.0	21.4
DIC	32.9	21.5	15.7	19.0	24.5	26.5	17.4
CL	34.1	41.2	39.1	40.7	43.9	45.3	56.5
STAGE			1.39			1.37	1.37
DCH**	8.10	6.65	5.69	5.38	5.10	5.10	4.81

*=UMHOS/CM **=L/SEC

CONTINUED

Table A1.1 (Continued)

SITE= EM8
YEAR= 1976

DATE	08/26	09/08	09/21	10/05	10/25	11/11
PH	7.40	7.40	7.65	7.50	7.35	6.50
ALK	130.	150.	145.	142.	151.	178.
SP COND*	186.	2632.	2736.	2750.	2600.	2800.
T CENT	8.5	8.0	3.0	2.1	.1	.3
SO4	1564.	1685.	1523.	1420.	1380.	1550.
CU T	.018	.017	.020	.012	.012	.010
NI T	2.360	2.420	2.420	2.110	2.090	2.180
CO T			.029	.018	.016	
ZN T	.038	.037	.040			
FE T	.10	.14	.21	.10	.08	.11
CU F	.016	.016	.016	.011		
NI F	2.400	2.400	2.560	2.210		
FE F	.06	.07	.13	.04		
CA	230.	241.	248.	291.	284.	301.
MG				177.	168.	190.
DOC	26.5	36.3	11.5	14.1	15.3	15.9
DIC	19.5	10.3	37.5	33.4	37.9	37.5
CL	29.2		38.0	40.7	42.7	44.7
STAGE	1.33	1.34	1.35	1.34	1.21	1.20
DCH**	3.77	3.77	3.77	3.96	1.42	1.42

*=UMHOS/CM **=L/SEC

Table A1.1 (Continued)

SITE= EM8
YEAR= 1977

DATE	03/18	03/29	04/12	04/13	04/14	04/15	04/20	04/21	04/25	05/05	05/13
PH	7.64	7.25	7.20	7.30	7.50	7.29	7.20	7.20	7.30	7.70	7.40
ALK	286.	83.	296.	257.	150.	197.	99.	53.	335.	157.	123.
SP COND*	3220.	750.	2300.	1950.	1550.	1420.	1210.	625.	1900.	1180.	950.
T CENT			4.0		8.5	3.5	5.0	15.0	3.0	12.8	
SO4	2130.	329.	1380.						846.		
CU T	.031	.020	.034	.027	.026	.024	.019	.020	.041	.013	.015
NI T	3.730	1.120	1.830	1.290	.870	.840	1.180	1.310	.820	.490	.457
CO T										.013	
ZN T										.007	
FE T	.62	1.64	.71	.66	.87	1.09	1.87	.68	1.10	.67	.38
MN T	7.33	4.66	4.01	2.99	2.46	2.30	2.26	.98	3.35	.60	.57
CU F	.021	.012				.021		.019	.027	.009	
NI F	3.510	1.170				.820		1.330	.880	.390	
FE F	.15	1.04				.76		.55	.38	.04	
MN F	7.16	4.56				2.01		.94	3.26		
CA	506.	63.								128.	114.
MG	320.									55.	56.
DOC			11.2		12.5		18.6	22.7	21.7	14.8	40.4
DIC			54.0		41.7		20.8	13.9	94.3	33.8	27.7
CL	53.9	16.3	33.9	30.3			24.1	18.0	28.8	21.2	21.9
NO2-NO3	10.00									.62	
TOTAL P	.10									.04	
STAGE	1.09	1.10	1.62	1.48	1.32	1.22	1.14	1.25	1.26	1.24	1.14
DCH**	.28	.57	16.71	8.78	3.68	1.70	.85	2.27	2.55	2.27	.85

*=UMHOS/CM **=L/SEC

CONTINUED

Table A1.1 (Continued)

SITE= EM8
YEAR= 1977

DATE	05/23	05/31	06/06	06/20	07/05	07/11	07/19	07/25	08/01	08/16	08/17
PH	7.27	7.45	7.16	7.22	7.28		7.41	7.20	7.25	7.10	7.30
ALK	123.	95.	233.	167.	129.		136.		154.	162.	161.
SP COND*	950.	750.	1820.	1710.	1500.	1590.	2020.	1836.	2425.	2600.	2433.
T CENT	9.0		4.0		6.1	5.0	7.7		6.0	7.7	6.3
SO4		353.	892.	674.	281.		1070.			1428.	1605.
CU T	.021	.021	.039	.026	.019		.017		.019	.016	.016
NI T	.566	.386	1.140	.630	.641		.807		1.070	1.190	1.150
CO T		.013		.023	.015						.010
ZN T		.014		.020							.019
FE T	.65	.60	.81	.44	.32		.13		.14	.08	.10
MN T	.66	.43	2.85	2.05	1.01		.68		.93	.76	.85
CU F	.017		.022								
NI F	.528		1.240								
FE F	.35		.24								
MN F	.69		2.77								
CA	110.	90.	210.	179.	160.						328.
MG	56.	47.	126.	107.	82.						178.
DOC		31.6	26.5								
DIC		7.1	22.7								
CL	21.9	17.4	32.4								
NO2-NO3											
TOTAL P											
STAGE	1.34	1.44	1.83	1.82	1.79	1.54	1.46		1.59	1.51	1.50
DCH**	4.53	7.65	32.28	31.43	29.73	13.59	9.63		8.49	5.66	5.38

*=UMHOS/CM **=L/SEC

Table A1.1 (Continued)

SITE= EM8
YEAR= 1978
CONC= MG/L

DATE	07/24	07/31	08/07	08/21	08/24	09/05	09/18
PH	6.80	6.80	7.60	7.30		6.90	7.00
ALK	104.	96.	102.	116.	122.	142.	132.
SP COND*	1800.	2000.	2200.	2200.		2425.	2400.
T CENT	10.0	10.0	11.1	11.1		6.7	5.6
SO4	1100.	1175.	1350.	1150.	1166.	1450.	1150.
CU T	.061	.096	.106	.110	.105	.140	.120
NI T	5.100	7.100	6.700	5.000	3.940	6.500	4.570
CO T	.200	.300	.150	.190		.280	.220
ZN T	.100	.160	.100	.100		.170	.120
CA	167.	200.	225.	275.	201.	225.	187.
MG	130.	150.	175.	130.	123.	130.	100.
NA	63.	63.	93.	86.		122.	72.
DOC				12.0		10.0	9.8
CL	29.0	24.0	29.0	28.0	43.0	29.0	21.0
NO2-NO3	9.60	11.20	14.50	9.20		22.50	11.70
DCM**	18.12	45.02	15.86		44.74	15.86	

*=UMHOS/CM **=L/SEC

CONTINUED

Table A1.1 (Cont.)

SITE= EM8
YEAR= 1978
CONC= MG/L

DATE	10/02	10/16	10/30	11/17	11/27
PH	6.70	6.80	6.80	6.40	6.90
ALK	112.	112.	140.	152.	164.
SP COND*	2300.	2200.	2200.	2200.	2450.
T CENT	10.0	1.1	5.0	1.1	.6
SO4	1500.	1350.	1300.	1280.	1520.
CU T	.180	.180	.170	.150	.150
NI T	7.500	6.650	5.600	3.550	3.550
CO T	.250	.200	.200	.150	.120
ZN T	.150	.130	.110	.100	.100
CA	255.	270.	255.	290.	320.
MG	163.	160.	153.	138.	145.
NA	88.	91.	87.	108.	118.
DOC	8.1	11.0	14.0		
CL	25.0	24.0	27.0	28.0	26.0
NO2-NO3	16.70	16.70	13.90	14.80	22.30
DCH**	15.86	11.89	13.59	5.95	

*=UMHOS/CM **=L/SEC

Table A1.1 (Cont.)

SITE= EM8
YEAR= 1979

DATE	04/03	04/16	05/09	05/16	05/24	06/06	06/22	07/05	07/27	08/09
PH	6.70	6.80	6.70	6.70	6.70	7.00	6.70	6.60	6.90	6.90
ALK			94.	100.	110.	120.	120.	110.	116.	126.
SP COND*			1200.	1200.	1350.	1650.	1450.	1700.	2000.	2100.
T CENT			2.0	7.0		6.0	7.0	9.0	11.0	9.0
SO4			800.	700.	800.	900.	1000.	1100.	1300.	1300.
CU T	.030	.300	.070	.070	.050	.100	.100	.100	.100	.100
NI T	1.200	.330	3.200	2.800	1.900	2.800	3.000	3.000	3.000	5.900
ZN T	.040	.320	.060	.060	.050	.070	.070	.080	.070	.120
FE T	1.00	.30	.50	.50	.30	.30	.30	.30	.30	.30
CA			112.	61.	70.	82.	70.	80.	99.	105.
MG			35.	35.	38.	50.	55.	55.	71.	66.
AL T	.10	.40	.20	.20	.08	.08	.08	.20	.08	.08
DCH**			13.51	15.83	19.65	15.35	23.47	11.07		8.52

*=UMHOS/CM **=L/SEC

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Table A1.1 (Cont.)

SITE= EM8
YEAR= 1979

DATE	08/28	09/13	09/27	10/10	10/19	10/29	11/08	11/29	12/04	12/26
PH	6.90	7.20	7.20	7.20	6.90	7.00	7.20	7.10	7.00	7.20
ALK	134.	126.	110.	94.	92.	100.	102.	104.	112.	124.
SP COND*	2300.	2000.	2700.	2500.	2300.	2650.	2500.	2500.	2500.	2500.
T CENT	3.0	4.0	9.0	8.0	5.0	4.0	1.0	1.0	1.0	1.0
SO4	1200.	1100.	1200.	1400.	1300.	1600.	1200.	1500.	1500.	530.
CU T	.100	.100	.100	.100	.080	.100	.100	.110	.100	.040
NI T	5.300	4.200	6.000	7.500	6.800	7.600	4.000	6.000	6.600	3.000
ZN T	.100	.070	.100	.110	.110	.120	.070	.110	.130	.070
FE T	.30	.30	.30	.20	.30	.30	.20	.20	.30	.50
CA	103.	92.	111.	117.	114.	120.	97.	108.	530.	200.
MG	74.	53.	60.	69.	59.	77.	56.	76.	190.	80.
AL T	.08	.08	.08	.08	.20	.08	.08	.08	.08	.08
DCH**	9.03	22.11	12.66				9.68		6.31	

*=UMHOS/CM **=L/SEC

Table A1.2 Seep 1 raw data, 1976-1979

SITE= SP1
YEAR= 1976

DATE	07/15	07/27	08/12	08/26	09/08	09/21	10/05	10/25	12/07
PH	7.50	7.00	7.02	7.34	7.50	7.30	7.35	7.42	7.20
ALK	161.	184.	190.	188.	227.	220.	213.	229.	205.
SP COND*	3027.	3328.	2324.	3818.	3709.	3809.	3800.	3490.	4600.
T CENT	.5		3.5	3.0	2.0	2.4	1.8	.1	
SO4	2487.	2555.	1839.	2190.	2305.	2004.	2460.	2800.	3000.
CU T	.050	.019	.029	.023	.022	.091	.005	.004	.017
NI T	1.920	1.240	1.400	1.100	.980	.884	.790	.670	1.300
CO T						.132	.129	.123	.110
ZN T		.258	.250	.250	.245	.125	.100	.100	.690
FE T	5.79	.71	3.15	3.80	3.65	7.07	5.44	5.78	7.20
MN T									16.00
CU F					.019	.009	.002		
NI F					.900	.845	.710		
FE F					1.07	5.70	2.84		
CA		194.	233.		225.	226.	246.	249.	396.
MG							464.	451.	528.
DOC	34.5	28.0	33.9	42.8	54.1	23.5	14.9	27.2	
DIC	20.7	35.5	27.6	25.2	23.4	56.0	51.3	61.2	
CL	48.6	49.8	84.3	29.3	40.7	36.3	39.3	39.8	50.0
STAGE			3.21	3.21	3.15	3.13	3.17	3.15	
DCH**	1.70	1.98	1.70	1.42	1.42	1.42	1.42	1.13	.14

*=UMHOS/CM **=L/SEC

Table A1.2 (Cont.)

SITE= SP1
YEAR= 1977

DATE	03/18	03/29	04/12	04/15	04/20	04/21	05/05	05/13	05/23
PH	7.02	7.38	6.79	6.95	6.60	6.71	7.07	7.00	6.75
ALK	441.	83.	50.	100.	72.	61.	124.	164.	98.
SP COND*	3100.	660.	500.	850.	940.	850.	1450.	1500.	1210.
T CENT	0		-.2		-.5	-1.0	1.0		4.5
SO4	1638.	265.	149.						
CU T	.329	.022	.003	.004	.007	.005	.005	.004	.004
NI T	2.580	.135	.053	.088	.136	.100	.320	.168	.213
CO T							.130		
ZN T							.037		
FE T	1.98	.84	.92	2.73	3.00	3.45	8.70		
MN T	7.05	1.94	2.31	4.31	7.28	6.38	19.00	11.65	8.05
CU F	.181	.007		.002		.005	.002		
NI F	2.320	.150		.082		.128	.290		
FE F	.44	.40		2.19		2.95	6.84		
MN F	7.11	1.64		3.81		6.33			
CA	346.	46.						111.	95.
MG	477.							156.	119.
DOC			24.3	26.5	55.9	37.1	36.8		25.2
DIC			13.0	28.2	8.8	20.5	28.6		21.2
CL	121.4	18.0	10.2	16.0	19.0	15.3	23.4	21.5	17.8
NO2-NO3	17.00	1.00					.65		
TOTAL P	.29	.15					.14		
STAGE						2.92		3.22	
DCH**		.14	.14	.57	.14	.28	.96	.08	.42

*=UMHOS/CM **=L/SEC

CONTINUED

Table A1.2 (Cont.)

SITE= SP1
YEAR= 1977

DATE	05/31	06/06	06/20	06/28	07/05	07/19	08/01	08/16	08/17
PH	6.65	6.45	6.64	6.69	6.69	6.60	6.79	6.70	6.75
ALK	74.	46.	52.	79.	62.	62.	99.	92.	82.
SP COND*	1150.	1420.	4450.	4253.	4410.	6900.	7700.	6800.	5508.
T CENT				6.0	5.0	5.0	5.0	6.1	5.5
SO4	677.	801.	2723.	3857.	2677.	4439.		5210.	5636.
CU T	.005	.007	.041	.038	.029	.025	.023	.016	.018
NI T	.370	1.570	12.000	7.800	7.370	8.190	6.340	5.770	5.910
CO T	.110		.870			.640			.640
ZN T	.110		1.500			2.400			2.400
FE T	7.54	2.66	1.45	1.28	.72	.91	.87	.63	.62
MN T	8.60	7.14	13.90	11.10	8.65	13.10	12.10	12.80	13.60
CU F	.004	.007							
NI F	.358	1.610							
FE F	4.83	1.48							
MN F	8.55	7.11							
CA	94.	122.	290.	301.					
MG	122.	142.	486.	652.					
DOC	18.7		34.0						
DIC	17.2								
CL	13.8	15.1							
NO2-NO3									
TOTAL P									
STAGE	3.27		3.17	3.12	3.10	3.18	3.18	3.22	3.15
DCH**	.85	1.42	2.27	2.41	4.19	1.59	1.27	.45	.45

*=UMHOS/CM **=L/SEC

Table A1.2 (Cont.)

SITE= SP1
YEAR= 1978
CONC= MG/L

DATE	07/24	07/31	08/07	08/21	09/05	09/18	10/02	10/16	10/30	11/17
PH	6.80	6.60	7.50	6.50	6.60	6.70	6.40	6.60	6.60	6.30
ALK	80.	96.	120.	116.	176.	124.	124.	116.	132.	136.
SP COND*	5000.	5000.	5000.	5000.	5000.	5000.	5000.	5000.	5000.	5000.
T CENT	8.9	10.0	10.0	6.1	5.6	4.4	6.7	7.8	4.4	1.1
SO4	3275.	4625.	4600.	4600.	5000.	3650.	3750.	4200.	4450.	5000.
CU T	.098	.092	.119	.065	.052	.042	.045	.043	.038	.034
NI T	12.500	11.800	7.000	8.900	8.200	8.200	9.000	7.500	6.800	2.800
CO T	1.000	1.000	.750	.870	.950	.650	.700	.700	.600	.300
ZN T	2.300	2.200	1.400	1.450	1.650	1.570	1.260	1.170	1.020	.180
CA	290.	275.	305.	350.	275.	260.	280.	290.	295.	38.
MG	900.	920.	1100.	780.	920.	400.	590.	600.	620.	450.
NA	135.	115.	150.	140.	152.	95.	103.	97.	105.	145.
DOC				10.0	12.5	8.5	9.5	11.0	13.0	
CL	32.0	30.0	33.0	38.0	43.0	22.0	26.0	28.0	37.0	35.0
NO2-NO3	12.00	18.40	6.70	10.40	8.00	6.00	6.90	10.00	8.40	8.60

*=UMHOS/CM

Table A1.2 (Cont.)

SITE= SP1
YEAR= 1979

DATE	05/09	05/24	06/06	06/22	07/05	07/27	08/09	08/28
PH	6.10	6.40	4.49	4.50	5.40	5.30	6.00	6.30
ALK	28.	4.	2.	2.	18.	8.	14.	50.
SP COND*	1500.		5000.	5000.	5000.	5000.	5000.	5000.
T CENT	0		4.0	5.0	7.0	5.0	4.0	6.0
SO4	1100.	4700.	11000.	3800.	5400.	5100.	6500.	3900.
CU T	.020	.100	.300	.200	.200	.100	.100	.070
NI T	1.500	21.000	32.000	17.000	6.800	5.200	21.000	13.000
ZN T	.250	6.900	17.000	6.600	3.900	3.000	4.100	15.000
FE T	.80	8.50	3.00	2.20	2.10	4.60	3.60	.60
CA	123.	201.	0.	0.	17.	0.	0.	0.
MG	20.	0.	243.	43.	262.	151.	450.	364.
AL T	.30	18.00	54.00	14.00	10.00	5.50	10.00	.70

*=UMHOS/CM

CONTINUED

Table A1.2 (Cont.)

SITE= SP1
YEAR= 1979

DATE	09/13	09/27	10/10	10/19	10/29	11/08	11/29
PH	6.50	6.70	6.90	6.60	6.50	6.00	6.80
ALK	44.	70.	76.	54.	60.	50.	64.
SP COND*	4400.	4900.	5000.	5000.	5000.	5000.	5000.
T CENT	4.0	4.0	6.0	3.0	3.0	2.0	0
SO4	3500.	3600.	3500.	3200.	3300.	3500.	3600.
CU T	.080	.090	.090	.070	.080	.060	.060
NI T	10.000	9.000	8.800	8.700	7.500	6.000	5.900
ZN T	1.800	1.500	1.000	1.100	.920	1.000	1.000
FE T	.80	1.50	.90	.90	1.30	2.80	.70
CA	0.	0.	0.	0.	0.	141.	140.
MG	323.	355.	360.	321.	331.	262.	262.
AL T	.50	.40	.20	.50	.70	.80	.30

*=UMHOS/CM

Table A1.3 Seep 2 raw data

SITE= SP2
YEAR= 1976

DATE	07/15	07/27
PH	6.99	
ALK	69.	
SP COND*	383.	
T CENT	16.0	
SO4	2661.	
CU T	.020	1.900
NI T	.104	20.000
CO T		
ZN T		.383
FE T	.67	.26
CA		226.
DOC	36.5	
DIC	3.6	
CL	16.0	

*=UMHOS/CM

SITE= SP2
YEAR= 1977

DATE	03/18
PH	7.00
ALK	29.
SP COND*	620.
NO2-NO3	3.20
TOTAL P	.07

*=UMHOS/CM

Table A1.4 Seep 3 raw data, 1976-1979

SITE= SP3
YEAR= 1976

DATE	07/15	07/27	08/12	08/26	09/08	09/21	10/05	10/25
PH	6.91	6.80	7.10	7.50	7.55	7.25	7.30	7.60
ALK	68.	77.	87.	100.	127.	119.	126.	129.
SP COND*	2399.	2732.	2614.	3234.	2807.	2899.	3000.	2700.
T CENT	1.0		2.5	1.5	1.2	3.5	1.5	1.0
SO4	1036.	2001.	2603.	1539.	1378.	1628.		1420.
CU T	1.140		.753	.617	.637	.736	.516	.481
NI T	24.700		19.000	19.200	20.600	19.500	16.710	15.770
CO T						.857	.972	.896
ZN T		.403	.350	.330	.338	.318	.320	.310
FE T	.46		.61	.73	1.07	1.20	.77	1.14
CU F		1.880	.624	.588		.504	.345	
NI F		20.000	19.000	19.300		20.000	15.420	
FE F		.24	.14	.57		.35	.12	
CA		226.	260.		242.	253.	320.	329.
MG							247.	233.
DOC	15.2	17.5	23.2	23.8	27.1	15.0	11.6	16.8
DIC	9.0	10.0	27.0	13.7	12.1	31.0	28.7	32.6
CL	62.0	58.9	70.4	38.5	57.5	50.1	57.5	58.9
STAGE	4.53			4.50	4.47		4.48	4.44
DCH**	4.25	3.40	2.55	2.27	1.70	1.70	2.10	.82

*=UMHOS/CM **=L/SEC

Table A1.4 (Cont.)

SITE= SP3
YEAR= 1977

DATE	03/18	03/29	04/04	04/12	04/21	04/27	05/05	05/23	05/31
PH	7.79	7.25	7.10	7.10	7.45	7.18	7.32	7.29	7.38
ALK	97.	144.	141.	206.	156.	201.	162.	111.	109.
SP COND*	890.	1000.	1100.	1550.	1375.	1650.	2650.	2470.	2500.
T CENT		2.0		12.0	7.0		11.0		
SO4	297.	456.	746.	857.			372.		564.
CU T	.037	.084	.270	.105	.125	.146	.104	.198	.237
NI T	.420	1.570	3.200	3.380	1.190	1.390	8.000	13.800	17.450
CO T							.440		.790
ZN T							.073		.250
FE T	.43	1.29	5.45	4.56	1.99	3:43	1.91	1.12	1.15
MN T	.80	1.98	2.74	3.60	1.77		4.51	4.60	5.62
CU F	.025	.081	.052		.080	.101	.068	.069	.178
NI F	.380	1.340	.930		1.180	1.150	10.000	13.800	18.200
FE F	.04	.92	.22		.39	.17	.55		.11
MN F	.44	1.54	.84		1.47			4.50	5.78
CA	93.	105.					368.	249.	323.
MG	52.						123.	200.	234.
DOC				26.3	28.0	59.3	20.9	10.8	
DIC				13.4	40.9	53.6	36.4	29.5	
CL	12.8	19.6	22.3	24.7	23.4	33.9	44.7	38.9	33.5
NO2-NO3	9.90	8.80					9.70		
TOTAL P	.07	.04					.04		
STAGE	4.30	4.32	4.31	4.22	4.14	4.07	4.02	4.82	4.81
DCH**	.28	.28	.28	.14	.28	.14	.14	1.02	.79

*=UMHOS/CM **=L/SEC

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Table A1.4 (Cont.)

SITE= SP3
YEAR= 1977

DATE	06/06	06/13	06/20	07/05	07/19	08/01	08/16	08/17
PH	7.15	7.10	6.99	6.68		6.98	6.95	6.99
ALK	114.	90.	88.	70.	47.	66.		81.
SP COND*	2910.	3100.	3080.	3110.	3370.	3550.	3500.	3400.
T CENT	.5	2.5	1.5	2.6		1.5	2.2	
SO4		1864.	1677.	1622.	2048.			
CU T	.826	.803	.854	1.480	1.710	1.220	.952	.889
NI T	35.900	39.800	36.200	28.900	28.500	26.700	24.600	24.400
CO T			1.900				2.400	1.000
ZN T			.650				.580	.580
FE T	2.10	1.08	1.10	.74	.45	.48	.55	.66
MN T	11.10	11.20	10.40	9.07	8.41	8.99	9.35	9.36
CU F	.612	.722	.685					
NI F	33.500	38.400	35.000					
FE F	.22	.23	.17					
MN F	9.82	10.90	10.10					
CA	342.	353.	336.	284.			388.	376.
MG	274.	286.	271.	215.			288.	276.
DOC	18.9							
DIC	28.1							
CL	56.2	46.0		39.0				
NO2-NO3								
TOTAL P								
STAGE		5.01	5.16	5.02		5.03	5.02	5.02
DCH**	3.11	3.40	9.63	16.14	4.81	4.53	4.53	4.53

*=UMHOS/CM **=L/SEC

Table A1.4 (Cont.)

SITE= SP3
YEAR= 1978
CONC= MG/L

DATE	07/24	07/31	08/07	08/21	09/05	09/18	10/02	10/16	10/30	11/17	11/27
PH	6.60	6.60	7.90	6.40	6.80		6.60	6.80	6.80	6.50	7.70
ALK	100.	80.	96.	82.	116.	128.	108.	96.	100.	116.	120.
SP COND*	3500.	3300.	3250.	2600.	2850.	2300.	2500.	2500.	2500.	2250.	1500.
T CENT	4.4	4.4	4.4	4.4	3.9	3.3	4.4	1.1	5.0	1.1	.6
SO4	2750.	2525.	2200.	1825.	1900.	1600.	1800.	1550.	1800.	1350.	1000.
CU T	1.340	.690	.700	.540	.540	.640	.350	.280	.270	.280	.053
NI T	21.500	17.000	13.300	15.200	15.200	13.500	12.200	10.500	10.500	2.900	1.550
CO T	1.600	1.000	.800	.790	.720	.555	.600	.400	.400	.120	.170
ZN T	.580	.350	.300	.230	.230	.240	.160	.140	.130	.070	.040
CA	250.	265.	300.	310.	255.	240.	272.	295.	285.	285.	170.
MG	405.	335.	333.	240.	210.	162.	180.	190.	190.	145.	100.
NA	115.	107.	130.	100.	88.	66.	76.	75.	71.	60.	43.
DOC				8.2	8.5	9.5	8.4	9.9	13.0		
CL	31.0	20.0	23.0	17.0	29.0	10.0	14.0	15.0	19.0	21.0	21.0
NO2-NO3	9.40	11.20	7.80	6.40	5.20	3.20	5.00	6.90	5.00	7.00	7.00

*=UMHOS/CM

Table A1.4 (Cont.)

SITE= SP3
YEAR= 1979

DATE	05/09	05/16	05/24	06/06	06/22	07/05	07/27	08/09
PH	6.90	7.00		6.91	6.80	7.30	6.70	7.20
ALK	108.	116.	126.	370.	128.	118.	90.	88.
SP COND*	1700.	700.	650.	750.	600.	1000.	1600.	1500.
T CENT	4.0	4.0		9.0	4.0	8.0	10.0	12.0
SO4	300.	400.	400.	370.	270.	490.	800.	1300.
CU T	.100	.070	.060	.060	.060	.080	.070	.080
NI T	.460	.290	.270	.330	.270	.400	1.400	6.700
ZN T	.020	.020	.020	.010	.010	.030	.030	.080
FE T	.40	.40	.60	.30	.30	.50	.30	.50
CA	40.	36.	34.	30.	36.	43.	69.	71.
MG	18.	18.	18.	36.	17.	29.	8.	74.
AL T	.10	.10	.10	.08	.08	.08	.08	.08

*=UMHOS/CM

CONTINUED

Table A1.4 (Cont.)

SITE= SP3
YEAR= 1979

DATE	08/28	09/13	09/27	10/10	10/19	10/29	11/08	11/29
PH	7.30	7.00	6.80	7.20	7.10	7.20	7.40	7.30
ALK	84.	94.	78.	84.	104.	116.	112.	152.
SP COND*	2100.	1900.	2300.	2300.	1800.	1600.	1500.	1600.
T CENT	12.0	5.0	9.0	8.0	7.0	7.0	4.0	2.0
SO4	1200.	1000.	1800.	1500.	1000.	1300.	1100.	900.
CU T	.070	.200	.200	.110	.080	.100	.080	.070
NI T	7.800	10.000	20.000	13.000	8.000	6.900	5.400	1.800
ZN T	.080	.180	.320	.130	.080	.070	.060	.030
FE T	.30	.60	.60	.50	.60	1.20	.60	.80
CA	72.	65.	116.	93.	77.	87.	81.	58.
MG	81.	71.	107.	91.	61.	71.	70.	48.
AL T	.08	.08	.08	.08	.20	.08	.08	.08

*=UMHOS/CM

Table A1.5 - Em-1 raw data, 1976-1979

SITE= EM1
YEAR= 1976

DATE	07/01	07/15	07/27	08/12	08/26	09/08	09/21	10/05	10/25
PH	7.50	7.50	7.59	7.55	7.95	7.90	8.00	7.90	8.17
ALK	76.	92.	113.	97.	105.	117.	109.	98.	95.
SP COND*	393.	905.	787.		690.	818.	606.	675.	695.
T CENT	18.0	20.0		17.0	19.1	12.2	8.0	7.3	1.0
SO4	249.	323.	455.	180.	243.	242.	277.		215.
CU T	.004	.006	.007	.004	.003	.004	.002	.002	.001
NI T	.106	.161	.171	.087	.105	.130	.100	.082	.099
CO T							.001		
ZN T									
FE T	.26	.16	.25	.17	.17	.16	.15	.14	.13
MN T									
CU F	.004	.005	.006	.003	.003	.004	.001	.005	
NI F	.108	.158	.170	.082	.095	.105	.110	.069	
FE F	.24	.12	.11	.13		.08	.10	.14	
CA	41.	48.	70.	41.	42.	51.	46.	58.	61.
MG								37.	40.
DOC	12.7	17.0	18.5	27.4	21.0	28.1	10.0	7.7	10.8
DIC	19.2	13.4	18.0	13.7	14.2	9.4	27.0	21.7	23.6
CL	31.9	52.3	43.2	32.3	20.9	29.5	27.5	22.4	20.9
STAGE		6.29	6.02	7.67	6.81	6.75	6.23	6.79	5.98
DCH**		49.27	31.71	233.61	79.00	68.24	30.58	76.45	24.92

*=UMHOS/CM **=L/SEC

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Table A1.5 (Cont.)

SITE= EM1
YEAR= 1976

DATE	10/28	10/29	11/10	11/11	12/07	12/10
PH	7.74	7.85			7.18	7.04
ALK	99.	93.			255.	255.
SP COND*	600.	482.		720.	700.	850.
T CENT	.8	.7		.0		
SO4	161.	131.	176.	174.	140.	159.
CU T	.002	.001	.002	.001	.005	.004
NI T	.092	.067	.098	.078	.220	.225
CO T					.008	
ZN T					.008	
FE T	.07	.05	.09	.07	1.60	.88
MN T					.36	
CU F						
NI F	.076					
FE F	.04					
CA	52.	45.	51.	54.	58.	62.
MG	35.	27.	38.	36.	47.	48.
DOC	12.8	11.1		11.0		
DIC	22.4	21.2		24.1		
CL	19.0	17.5	23.4	45.7	20.2	25.1
STAGE	6.79	7.72	6.64	6.92	5.60	5.98
DCH**	61.52	144.98	50.69	69.37	11.33	11.33

*=UMHOS/CM **=L/SEC

Table A1.5 (Cont.)

SITE= EM1
YEAR= 1977

DATE	01/31	02/22	02/23	02/24	03/15	03/18	03/29
PH	7.30	7.33	7.29	7.50	7.42		7.13
ALK	95.	99.	96.	95.	79.		
SP COND*	389.	369.	290.	315.	314.	530.	580.
T CENT					.5	1.5	
SO4	53.	19.	25.	23.	25.		
CU T	.007	.003	.002	.002			
NI T	.056	.056	.081	.054			
CO T	.000	.002	.003				
ZN T	.012						
FE T	.14	.38	.68	.33			
MN T	.05	.36	.63	.19			
CU F	.003			.002	.003		
NI F	.060			.033	.048		
FE F				.11	.10		
MN F				.01	.17		
CA	27.	28.	31.	27.			
MG	20.	14.	18.	15.			
DOC							
DIC							
CL	13.0	14.8	15.6	13.5	16.9		
NO2-NO3	5.00						.55
TOTAL P	.08						.12
STAGE	7.62		7.79	7.79		7.10	
DCH**			82.12	50.12		94.58	

*=UMHOS/CM **=L/SEC

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Table A1.5 (Cont.)

SITE= EM1
YEAR= 1977

DATE	04/08	04/11	04/19	04/22	04/25	04/27	04/29
PH	7.57	7.48	7.45	7.12	7.41	7.47	7.30
ALK	86.	88.	68.	54.	70.	65.	68.
SP COND*	480.	380.	510.	416.	475.	520.	625.
T CENT	3.0		4.0	4.0	6.0		
SO4	89.	75.	114.		150.	85.	145.
CU T	.001	.002	.001	.003	.002	.002	.002
NI T	.033	.043	.047	.067	.059		
CO T							
ZN T							
FE T	.11	.18	.08	.24	.13	.11	
MN T	.11	.21	.00	.17	.10		
CU F				.004			.002
NI F				.065			.042
FE F				.14			.09
MN F				.15			.04
CA							
MG							
DOC		13.9	18.7	16.4			7.9
DIC		8.8	9.7	13.3			18.5
CL	30.3	20.4	35.2	23.6		43.7	52.5
NO2-NO3							
TOTAL P							
STAGE	6.20	7.63	7.60	7.48	7.72	7.21	7.16
DCH**	24.07	184.90	178.39	163.38	222.85	129.69	126.57

*=UMHOS/CM **=L/SEC

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Table A1.5 (Cont.)

SITE= EM1
YEAR= 1977

DATE	05/02	05/05	05/13	05/31	06/01	06/02	06/13
PH	7.62	7.61	7.45	7.41			7.40
ALK	86.	82.	85.	81.			71.
SP COND*	580.	510.	462.	490.	392.		672.
T CENT			6.0	14.1	12.4		15.0
SO4	137.	125.	114.	145.			175.
CU T	.002	.002	.003	.003			.005
NI T	.038	.038	.063	.072			.087
FE T	.06	.09	.10	.13			.07
MN T	.05	.01		.04			.03
CU F		.002		.003		.004	
NI F		.031		.068		.086	
FE F		.04		.07		.09	
MN F		.18	.04	.04		.04	
CA			32.	38.			49.
MG			26.	31.			36.
DOC	7.6	9.4		12.3			
DIC	18.3	18.8		19.4			
CL	52.5	43.7	26.9	25.7			
TOTAL P		.02					
STAGE	7.01	7.48	6.70	7.18	8.32	8.20	7.36
DCH**	109.87	203.59	90.04	144.98	376.32	360.75	174.99

*=UMHOS/CM **=L/SEC

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Table A1.5 (Cont.)

SITE= EM1
YEAR= 1977

DATE	06/20	07/05	07/19	07/25	08/10	08/16	08/17
PH	7.70	7.22	7.56	7.55	7.62	7.62	7.65
ALK	54.	56.	79.	88.	106.	98.	
SP COND*	620.	640.	950.	960.		807.	725.
T CENT				18.0	15.0	15.5	14.5
SO4		255.	360.		245.	303.	208.
CU T	.003	.004	.002		.002	.002	.002
NI T	.103	.163	.189		.166	.169	.126
FE T	.10	.20	.09		.07	.08	.04
MN T		.04	.04		.04	.04	.14
CU F							
NI F							
FE F							
MN F	.01		.04				
CA							
MG							
DOC							
DIC							
CL							
TOTAL P							
STAGE		8.33	7.34	7.30	6.24	6.88	7.10
DCH**		381.13	171.31	180.94	57.20	127.99	167.35

*=UMHOS/CM **=L/SEC

Table A1.6 (Cont.)

SITE= EM2
YEAR= 1977

DATE	04/12	05/05	05/13	08/16	08/17
PH	7.40	7.30	7.49	7.60	7.50
ALK	96.	70.	81.	79.	102.
SP COND*	800.	900.	1000.	1450.	1374.
T CENT	4.5	10.8			13.3
SO4	229.	273.	311.	492.	555.
CU T	.004	.005	.006	.005	.005
NI T	.027	.022	.064	.033	.031
FE T	.05	.09	.08	.02	.05
MN T	.39		.01	.00	.02
CU F		.004			
NI F		.018			
FE F		.07			
CA			85.		
MG			53.		
DOC		10.9			
DIC		16.3			
CL	58.6	43.7	50.1		
STAGE	6.00	5.95	5.85	5.94	5.84
DCH**	9.34	6.09	1.70	5.52	1.42

*=UMHOS/CM **=L/SEC

Table A1.7 Em-3 raw data, 1976-1977

SITE= EM3
YEAR= 1976

DATE	07/01	07/15	07/27	08/12	08/26	09/08	09/21	10/05	10/25
PH	7.50	7.50	7.70	7.71	7.82	8.30	8.10	8.00	8.30
ALK	84.	93.	97.	88.	104.	102.	106.	96.	90.
SP COND*	410.	910.	847.	499.	725.	383.	617.	850.	800.
T CENT	16.5	16.0		19.5	17.5	16.0	9.8	6.0	.1
SO4	331.	473.	317.	122.	215.	157.	63.	293.	225.
CU T	.005	.006	.006	.003	.003	.003	.002	.001	.002
NI T	.194	.360	.422	.099	.194	.110	.127	.310	.320
CO T							.002		
ZN T									
FE T	.12	.12	.27	.08	.10	.07	.10		.08
MN T									
CU F	.004	.007		.003	.003	.005	.003	.003	
NI F	.081	.352		.095		.098	.154	.242	
FE F	.08	.06		.03	.08	.04	.03	.16	
CA	47.	65.	55.	35.	46.	31.	39.		84.
MG									49.
DOC	10.5	20.3	16.5	17.4	21.0	24.6	7.5	7.3	10.5
DIC	21.1	11.0	15.5	13.0	14.4	9.1	18.0	22.3	21.0
CL		56.9	35.1	33.9	22.5	25.7	24.0	21.8	20.0
STAGE				7.85	6.88		7.78	6.88	6.50
DCH**		33.70	46.72	178.96	38.23	73.62	126.57	27.75	9.34

*=UMHOS/CM **=L/SEC

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Table A1.7 (Cont.)

SITE= EM3
YEAR= 1976

DATE	10/26	10/27	11/10	11/11	12/07	12/10
PH	8.13	7.87		7.10	7.51	7.45
ALK	98.	97.		112.	183.	144.
SP COND*	647.	493.	550.	620.	600.	600.
T CENT	.5		.1	.1		
SO4	166.	120.	173.	155.	160.	104.
CU T	.003	.002	.002	.002	.007	.003
NI T	.244	.103	.130	.092	.220	.126
CO T					.005	
ZN T					.015	
FE T	.17	.09	.09	.16	.80	.05
MN T					.23	
CU F						
NI F						
FE F						
CA	65.	43.	52.	50.	55.	44.
MG	39.	28.	33.	30.	39.	30.
DOC	9.8	11.9		12.0	11.0	
DIC	21.9	22.2		23.6		
CL	19.0	18.1	29.5		16.5	25.2
STAGE	7.26	8.68	7.36	8.21		
DCH**	46.06	134.03	52.38	177.54	5.66	5.66

*=UMHOS/CM **=L/SEC

Table A1.7 (Cont.)

SITE= EM3
YEAR= 1977

DATE	02/22	02/23	02/24	03/14	03/18	04/22	04/25
PH	7.57	7.61	7.72	7.45	7.54	7.22	7.63
ALK	102.	99.	96.	52.	98.	74.	81.
SP COND*	345.	345.	325.	235.	500.	452.	475.
T CENT	1.0	1.0	1.1	1.0	1.5		
SO4	37.	33.	23.	30.		134.	
CU T	.002	.003	.004	.004	.002	.005	.003
NI T	.060	.038	.038	.034	.035	.055	.059
CO T							
ZN T							
FE T	.07	.25	.27	.26	.20	.40	.25
MN T	.05	.07	.19	.07	.11	.25	.20
CU F			.002	.003	.002		.003
NI F			.011	.041	.032		.054
FE F			.12	.10	.07		.03
MN F			.01	.07	.09		.25
CA	32.	30.	30.	23.	44.		
MG	18.	17.	16.	12.	26.		
DOC							7.4
DIC							19.7
CL	19.7	19.2	18.0	12.4		34.8	39.0
NO2-NO3					10.00		
TOTAL P							
STAGE	6.38	7.49	7.58	7.40	7.32		7.64
DCH**	6.23	98.54	111.85	93.16	83.82		135.63

*=UMHOS/CM **=L/SEC

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Table A1.7 (Cont.)

SITE= EM3
YEAR= 1977

DATE	04/29	05/02	05/05	05/13	08/16	08/17
PH	7.60	7.69	7.58	7.69	7.75	7.65
ALK	79.	96.	87.	94.	100.	86.
SP COND*	650.	530.	455.	380.	650.	596.
T CENT						12.7
SO4		122.	127.	143.	205.	173.
CU T	.002	.002	.003	.002	.003	.002
NI T		.044	.056	.059	.188	.174
CO T						.001
ZN T						.003
FE T	.18	.14	.27	.23	.10	.07
MN T		.13	.13	.08	.03	.01
CU F	.002		.002			
NI F	.040		.043			
FE F	.05		.10			
MN F	.13		.10			
CA				27.		
MG				22.		
DOC	7.9	6.8	8.2			
DIC	20.1	19.9	19.4			
CL	66.1	46.8	37.2	26.0		
NO2-NO3			7.20			
TOTAL P			.03			
STAGE	7.56	7.61	7.76	7.35	7.69	7.76
DCH**	123.46	131.10	155.45	94.58	129.69	140.16

*=UMHOS/CM **=L/SEC

SITE= EM4
YEAR= 1976

Table A1.8 EM-4 raw data, 1976-1977

DATE	07/01	07/15	07/27
PH	6.90	6.40	6.80
ALK	27.	32.	36.
SP COND*	56.	85.	83.
T CENT	16.0	17.0	
SO4	11.	77.	78.
CU T	.005	.001	.001
FE T	1.12	1.26	2.36
CU F	.003	.001	.001
FE F	.75	1.13	1.99
CA	3.	4.	5.
DOC	27.7	33.1	30.0
DIC	6.5	4.3	4.5
CL	1.3	3.5	1.4
STAGE		4.62	
DCH**	18.41	10.19	7.36

*=UMHOS/CM **=L/SEC

Table A1.8 (Cont.)

SITE= EM4
YEAR= 1977

DATE	04/12	04/15	04/27	05/06	05/13
PH	6.70	6.41	6.45	6.83	6.22
ALK	17.	14.	7.	7.	11.
SP COND*	85.	110.	95.	122.	170.
T CENT	4.0	2.0		2.0	
CU T	.002	.002	.002	.002	.002
NI T	.002	.002		.003	.004
FE T	.29	.16	.19	.19	.24
MN T	.20	.02		.03	.06
CU F		.003	.003	.002	
NI F			.003		
FE F		.17	.13	.14	
MN F		.02	.03		
CA					6.
MG					6.
DOC	19.3	20.3	18.1	17.9	
DIC	3.1	4.2	2.4	5.4	
CL	4.3	9.7	3.7	3.3	
NO2-NO3				.66	
TOTAL P				.03	
STAGE	5.40	5.12	5.09	5.33	5.00
DCH**	.14	28.32	14.16	28.32	14.16

*=UMHOS/CM **=L/SEC

Table A1.9 EM-4 raw data, 1976-1977

SITE= EM5
YEAR= 1976

DATE	07/01	07/15	07/27	08/12	08/26	09/08	09/21
PH	7.35	7.41	7.50	7.89	7.80	8.10	7.55
ALK	103.	101.	97.	92.	108.	105.	107.
SP COND*	496.	1023.	492.	396.	1280.	529.	756.
T CENT	14.0	14.0	16.0	17.0	14.1	15.2	8.0
SO4	339.	401.	132.	86.		38.	236.
CU T	.011	.012	.010	.006	.008	.006	.005
NI T	.425	.789	.036	.053	.791	.051	.346
CO T							.005
ZN T			.010				
FE T	.19	.08	.20	.29	.07	.16	.10
CU F	.010	.010	.005	.004	.008	.004	.005
NI F	.420	.663	.023	.046	.666	.049	.356
FE F	.10	.03	.09	.03	.02	.03	.03
CA	59.	78.	10.	30.	92.	28.	60.
MG							
DOC	9.7	18.3	15.5		17.3	24.1	8.5
DIC	25.8	14.4	15.5		14.4	8.2	25.0
CL	38.2	34.1	49.9	32.3	20.6	24.0	20.9
STAGE				6.92	5.80	6.84	
DCH**	19.25	14.16	191.70	224.83	11.04	200.76	29.45

*=UMHOS/CM **=L/SEC

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Table A1.9 (Cont.)

SITE= EM5
YEAR= 1976

DATE	10/05	10/25	11/08	11/11	12/07	12/10
PH	7.70	7.85	7.40	7.21	7.45	7.40
ALK	113.	106.	99.	124.	108.	92.
SP COND*	1300.	1130.	525.	675.	240.	195.
T CENT	3.1	.1	.6	1.2		
SO4	616.	422.	167.	161.	17.	5.
CU T	.005	.004	.002	.003	.004	.002
NI T	.890	.770	.115	.054	.011	.005
CO T	.008	.007			.001	
ZN T					.009	
FE T	.06	.07	.06	.24	.12	.18
CU F	.005					
NI F	.722					
FE F						
CA	125.	114.	52.	56.	18.	19.
MG	77.	64.	28.	33.	19.	13.
DOC	7.3	12.1	9.1	15.6	5.2	
DIC	26.7	24.4	20.1	18.1		
CL	22.9	18.6	10.2	40.7	1.5	2.6
STAGE	5.70	5.66	5.62	6.30		
DCH**	6.23	3.96	1.70	87.21	1.70	1.70

*=UMHOS/CM **=L/SEC

Table A1.9 (Cont.)

SITE= EM5
YEAR= 1977

DATE	02/22	02/23	02/24	05/05	05/13	06/28	08/16	08/17
PH	7.56	7.75	7.79	7.72	7.80	7.60	7.60	7.80
ALK	93.	104.	99.	98.	103.	89.	95.	96.
SP COND*	245.	380.	345.	450.	400.	905.	480.	461.
T CENT	7.5	1.5	2.0	9.0		11.0	12.0	12.2
SO4	2.	31.	30.	111.	96.		122.	129.
CU T	.001	.003	.003	.006	.006	.010	.003	.003
NI T	.024	.015	.013	.010	.023	.220	.029	.025
CO T								.001
ZN T								.001
FE T	.08	.28	.29	.20	.35	.31	.16	.16
MN T				.06	.05	.38	.03	.04
CU F				.002				
NI F				.010				
FE F				.05				
MN F				.04				
CA	23.	32.	32.		31.	87.		
MG	12.	18.	18.		23.	50.		
DOC				13.9				
DIC				20.8				
CL	8.3	18.0	18.2	22.5	26.9			
NO2-NO3				7.90				
TOTAL P				.03				
STAGE	5.50	6.42	6.21	6.44	6.42	5.91	6.69	6.70
DCH**	3.26	46.44	55.78	111.28	106.75	31.43	187.17	191.13

*=UMHOS/CM **=L/SEC

Table A1.10 EM-6 raw data, 1976-1977

SITE= EM6
YEAR= 1976

DATE	07/01	07/15	07/27	08/12	08/26	09/08	09/21
PH	7.50	7.50	7.55	7.81	8.01	8.20	8.10
ALK	87.	86.	95.	92.	88.	104.	99.
SP COND*	276.	521.	500.	347.	329.	367.	346.
T CENT	12.0	15.0	17.0	18.0	17.0	15.5	8.8
SO4	146.	119.	123.	74.	78.	32.	
CU T	.006	.006	.016	.009	.007	.006	.003
NI T		.024	.016	.009	.006	.011	.004
CO T							
ZN T							
FE T	.08	.03	.59	.29	.12	.21	.14
MN T							
CU F	.006	.006		.006	.005	.006	.001
NI F		.021		.016	.008	.011	.003
FE F	.07	.03		.03	.06	.03	.03
CA	25.	31.	11.	25.	22.	25.	23.
MG							
DOC	7.0	14.9	17.0	15.8	16.7	24.4	8.0
DIC	21.9	12.0	15.5	12.9	12.4	7.2	23.5
CL	43.9	32.0	49.9	31.4	15.5	23.4	17.4
DCH**	27.18	9.06	172.44	201.04	5.10	174.99	19.25

*=UMHOS/CM **=L/SEC

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Table A1.10 (Cont.)

SITE= EM6
YEAR= 1976

DATE	10/05	10/25	11/08	11/11	12/07
PH	7.90	8.29	7.60	7.21	7.63
ALK	92.	80.	91.	123.	
SP COND*	350.	218.	243.	600.	330.
T CENT	4.8	.1	.9	1.1	
SO4	25.	6.	101.	107.	
CU T	.002	.001	.003	.004	.004
NI T			.005	.005	.002
CO T					.002
ZN T					.003
FE T	.04	.10	.16	.19	.13
MN T					.02
CU F	.002				
NI F					
FE F	.05				
CA	28.	24.	23.	49.	
MG	15.	13.	15.	28.	
DOC	5.5	9.4	8.2	12.6	9.3
DIC	21.2	18.2	17.9	9.2	
CL	11.2	5.9	7.2	41.7	
DCH**	2.27	2.55	.28	85.80	1.42

*=UMHOS/CM **=L/SEC

Table A1.10 (Cont.)

SITE= EM6
YEAR= 1977

DATE	04/04	04/12	05/05	05/13	06/28	08/16	08/17
PH	7.70	7.79	7.71	7.70	7.55	7.60	7.90
ALK	98.	115.	94.	102.	74.	97.	94.
SP COND*	700.	430.	450.	400.	550.	395.	389.
T CENT	3.1	7.0	10.2		15.0	13.3	12.2
SO4	106.	82.	110.	96.	162.	106.	110.
CU T	.003	.009	.008	.004	.004	.003	.002
NI T	.004	.004	.003	.017	.021		
FE T	.21	.45	.38	.27	.17	.16	.15
MN T	.10	.08	.04	.02	.03	.03	.01
CU F	.003		.002				
NI F	.003		.002				
FE F	.04		.04				
MN F	.09		.02				
CA				29.	43.		
MG				23.	29.		
DOC		6.9	7.0				
DIC		22.3	20.8				
CL	63.7	29.0	39.8	26.9			
NO2-NO3			8.70				
TOTAL P			.05				
STAGE							
DCH**	90.04	59.46	109.02	105.90	18.97	177.54	185.75

*=UMHOS/CM **=L/SEC

Table A1.11 Em-9 raw data, 1976-1977 SITE= EM9
YEAR= 1976

DATE	07/06	07/15	07/19	07/26	07/27	08/12	08/26	09/08	09/21	10/18
PH	6.95	6.89	7.10	6.83	7.00	7.00	7.32	7.40	7.35	7.50
ALK	138.	132.	138.	131.	130.	133.	136.	154.	152.	157.
SP COND*		1718.	1930.	1980.	2048.	2305.	2900.	2655.	3018.	2450.
T CENT	1.0	1.0	.5	.5	.5	.5	.9	1.0	1.8	1.1
SO4	796.	973.	1144.	1119.	1095.	1381.	1619.	1529.	1386.	1500.
CU T	.020	.023	.022	.022	.022	.026	.018	.020	.019	
NI T	1.270	1.610	1.670	2.060	1.890	2.330	2.360	2.360	2.520	
CO T										
ZN T						.029	.035	.035	.043	
FE T	.30	.17	.13	.25	.11	.15	.13	.14	.21	
CU F	.017	.019	.020	.020	.021	.023	.016	.018	.018	.035
NI F	.467	1.630	1.600	1.970	1.890	2.360	2.320	2,360	2.490	2.040
FE F	.01	.06	.07	.07	.09	.06	.06	.08	.11	.46
MN F										1.30
CA	152.	62.	163.	168.	24.	228.	241.	248.	244.	284.
MG										158.
DOC	13.2	25.4	26.2	20.0	17.0	28.2	24.9	32.6	12.0	11.0
DIC	34.9	19.5	19.8	28.5	28.0	13.4	19.8	17.3	39.5	
CL	42.0	40.1	42.0	41.4	42.0	55.6	28.8		38.0	31.0
NO2-NO3										12.00

*=UMHOS/CM

SITE= EM9
YEAR= 1977

Table A1.11 (Cont.)

DATE	03/18
PH	7.39
ALK	306.
SP COND*	3490.
SO4	2317.
NI T	3.950
MN T	6.10
NI F	3.860
FE F	.11
MN F	6.15
CA	578.
MG	365.
NO2-NO3	12.00
TOTAL P	.11

*=UMHOS/CM

APPENDIX II

Additional Figures

Figure A2.1

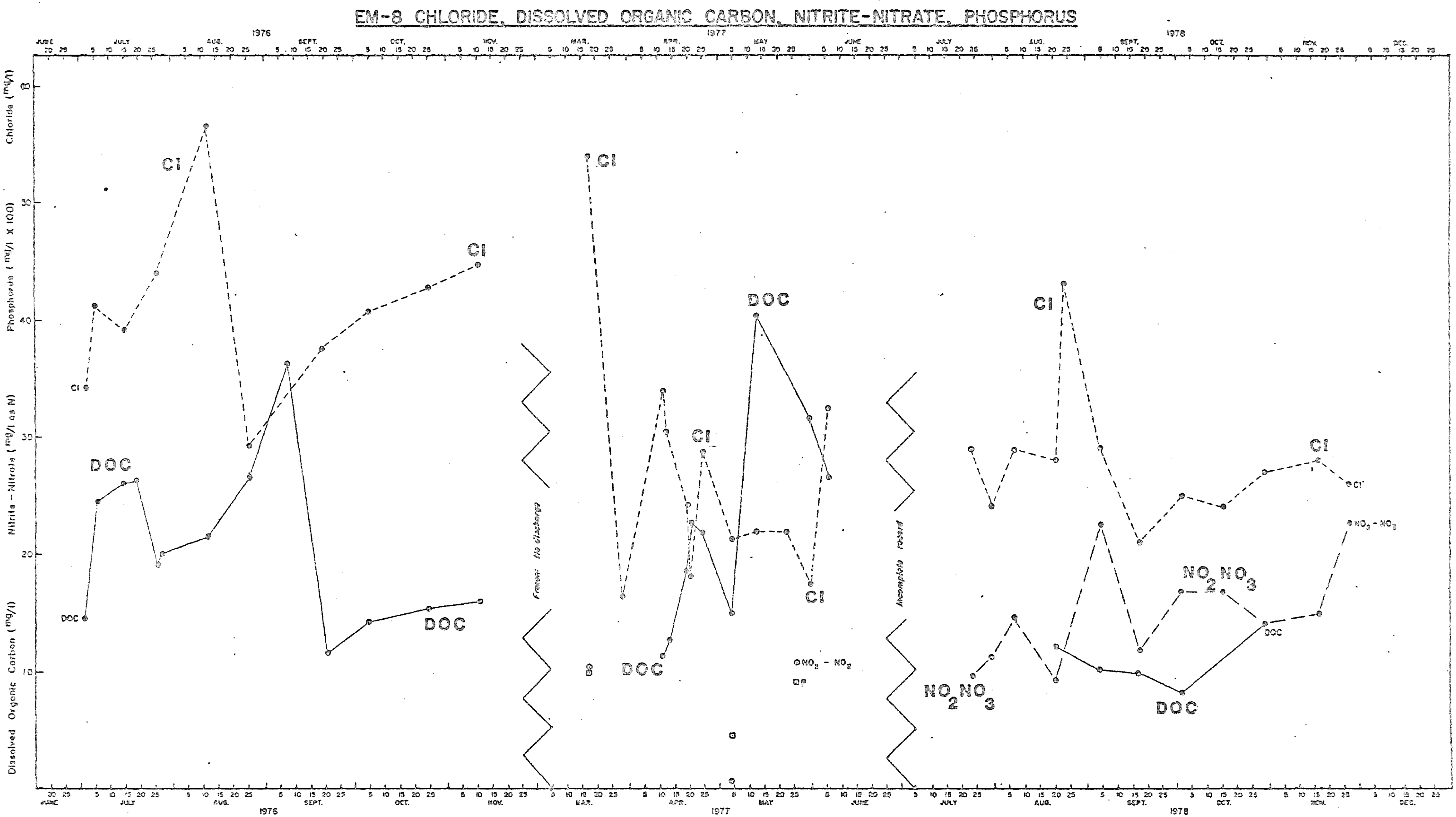
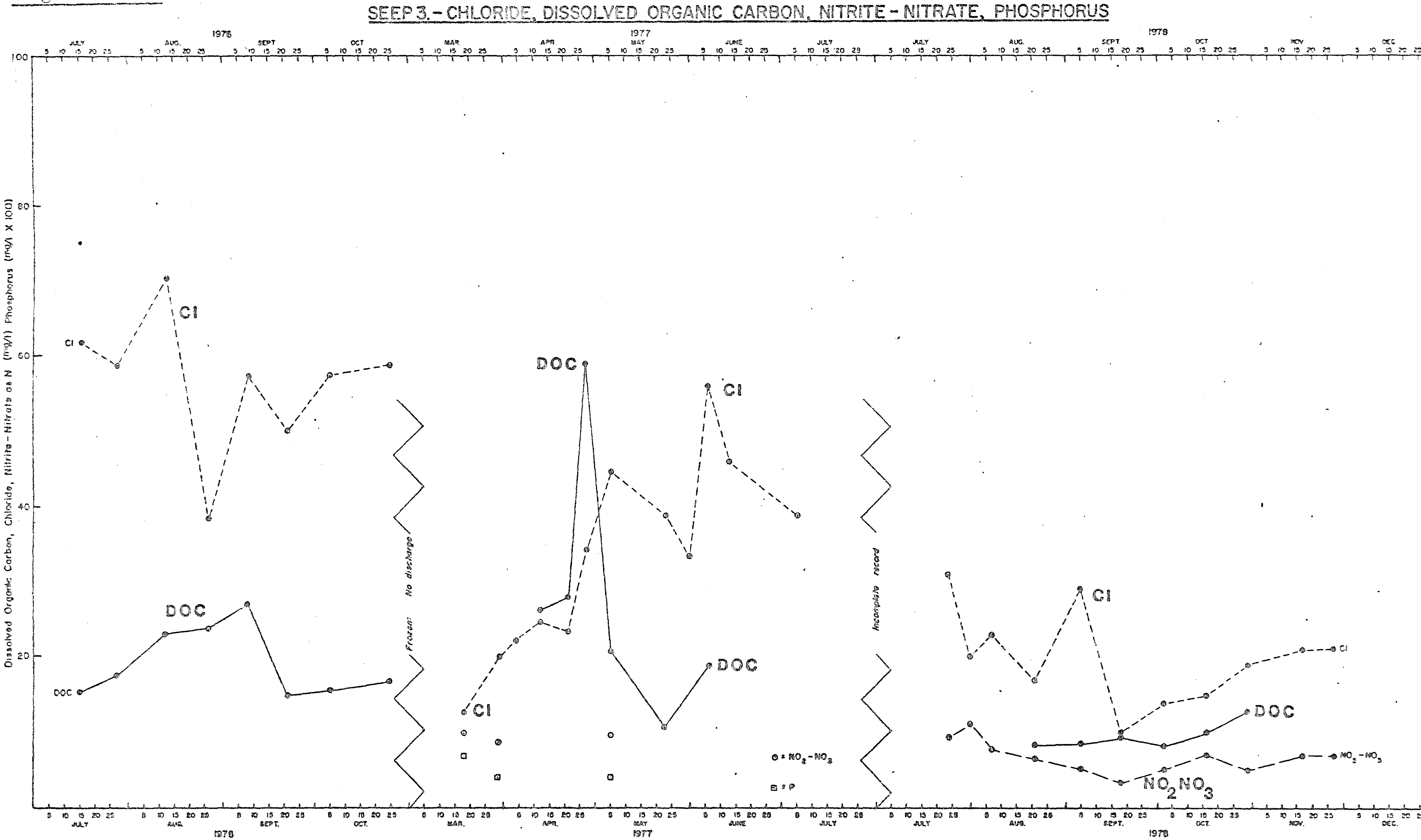

EM-8 CHLORIDE, DISSOLVED ORGANIC CARBON, NITRITE-NITRATE, PHOSPHORUS
1976
1977
1978
Chloride (mg/l)
Phosphorus (mg/l X 100)
Nitrite - Nitrate (mg/l as N)
Dissolved Organic Carbon (mg/l)
Cl
DOC
Frozen - No discharge
Incomplete record
NO_2NO_3
$NO_2 - NO_3$
P

Figure A2.2



SEEP 3.- CHLORIDE, DISSOLVED ORGANIC CARBON, NITRITE - NITRATE, PHOSPHORUS
1976
1977
1978
Dissolved Organic Carbon, Chloride, Nitrite-Nitrate as N (mg/l) Phosphorus (mg/l X 100)
Cl
DOC
Frozen: No discharge
Incomplete record
NO2 NO3
= NO2-NO3
= P
JULY
AUG.
SEPT.
OCT.
MAR.
APR.
MAY
JUNE
NOV.
DEC.

Figure A2.3

EM-1 CHLORIDE, DISSOLVED ORGANIC CARBON, NITRITE-NITRATE, PHOSPHORUS

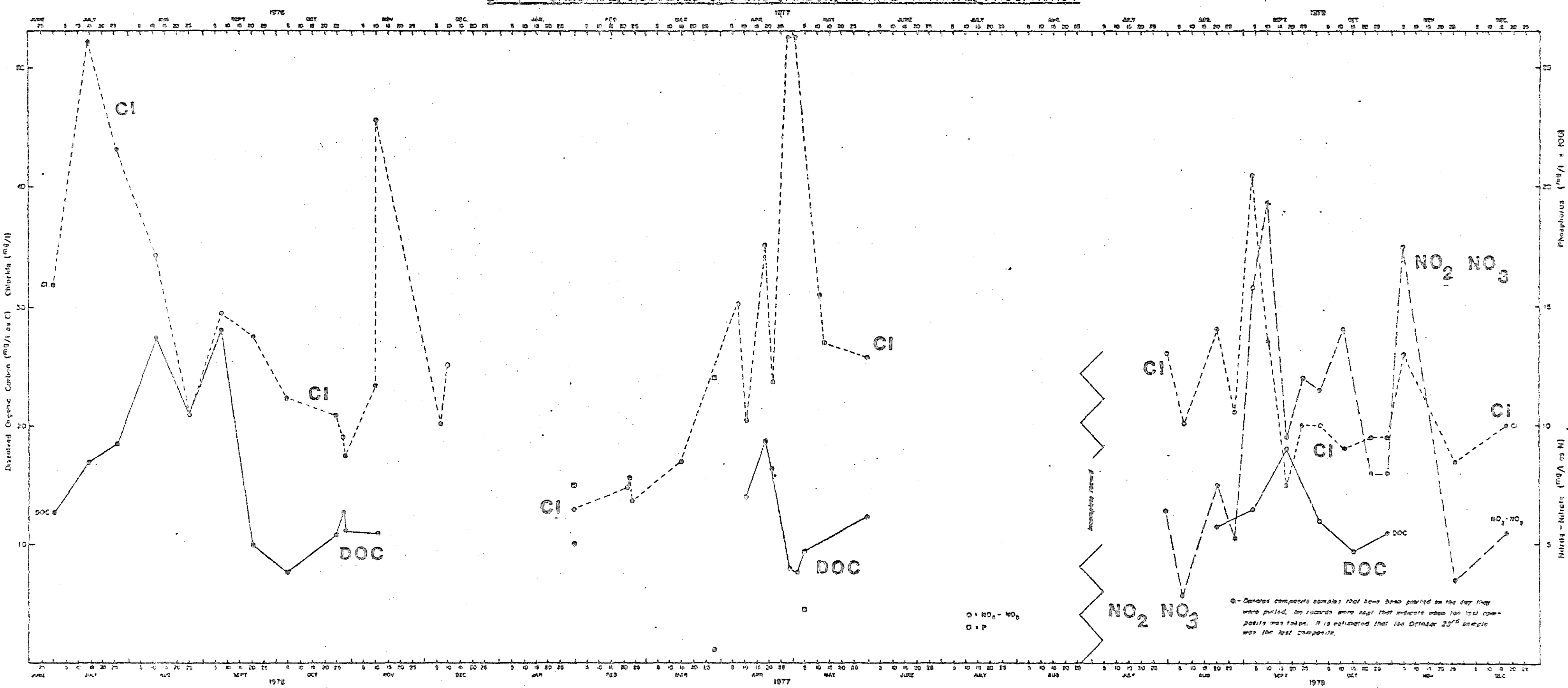


Figure A2.4

EM-I TOTAL COPPER, TOTAL NICKEL, TOTAL IRON, pH

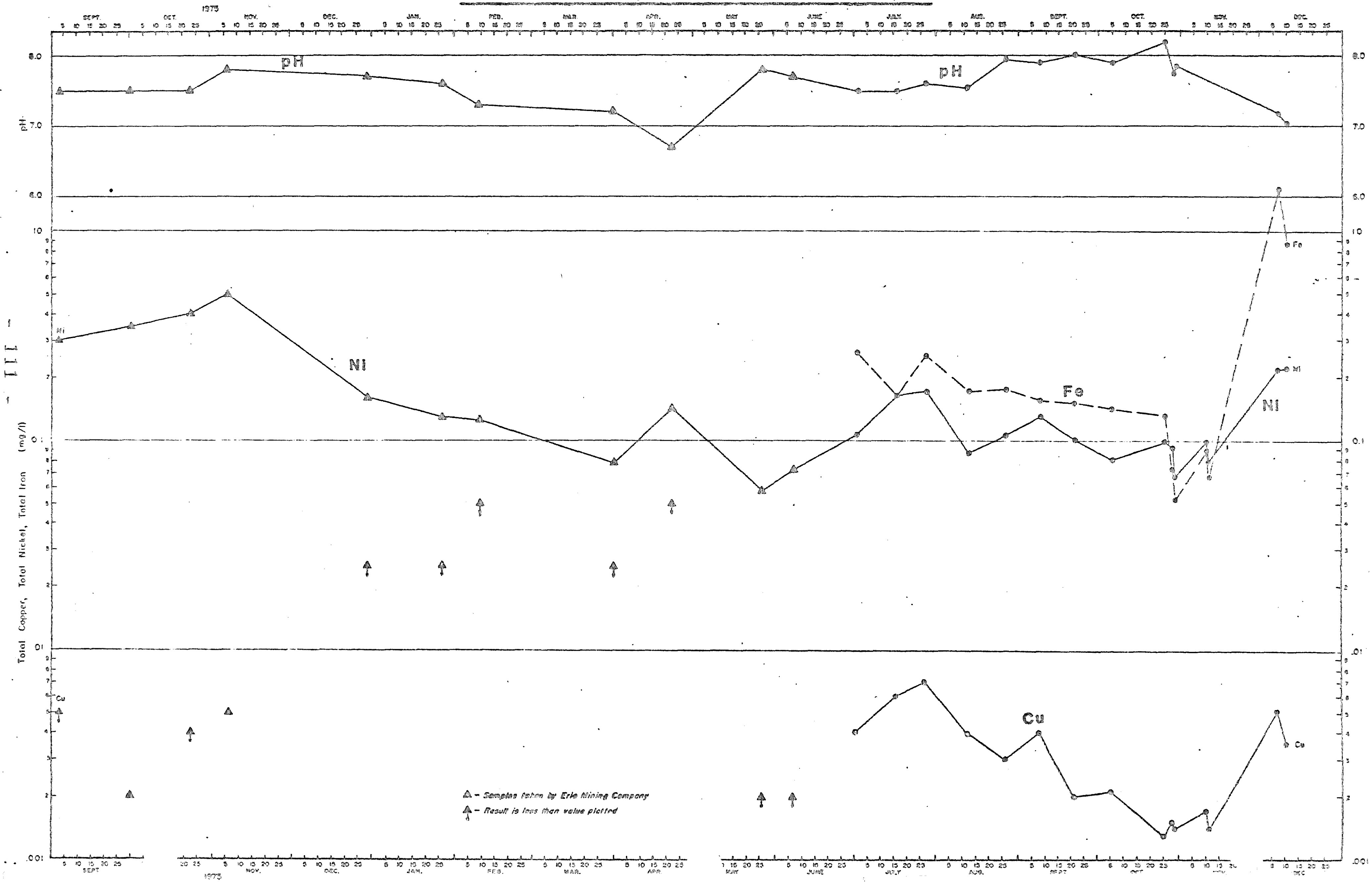


Figure A2.5

EM-1 TOTAL COPPER, TOTAL NICKEL, TOTAL IRON, pH

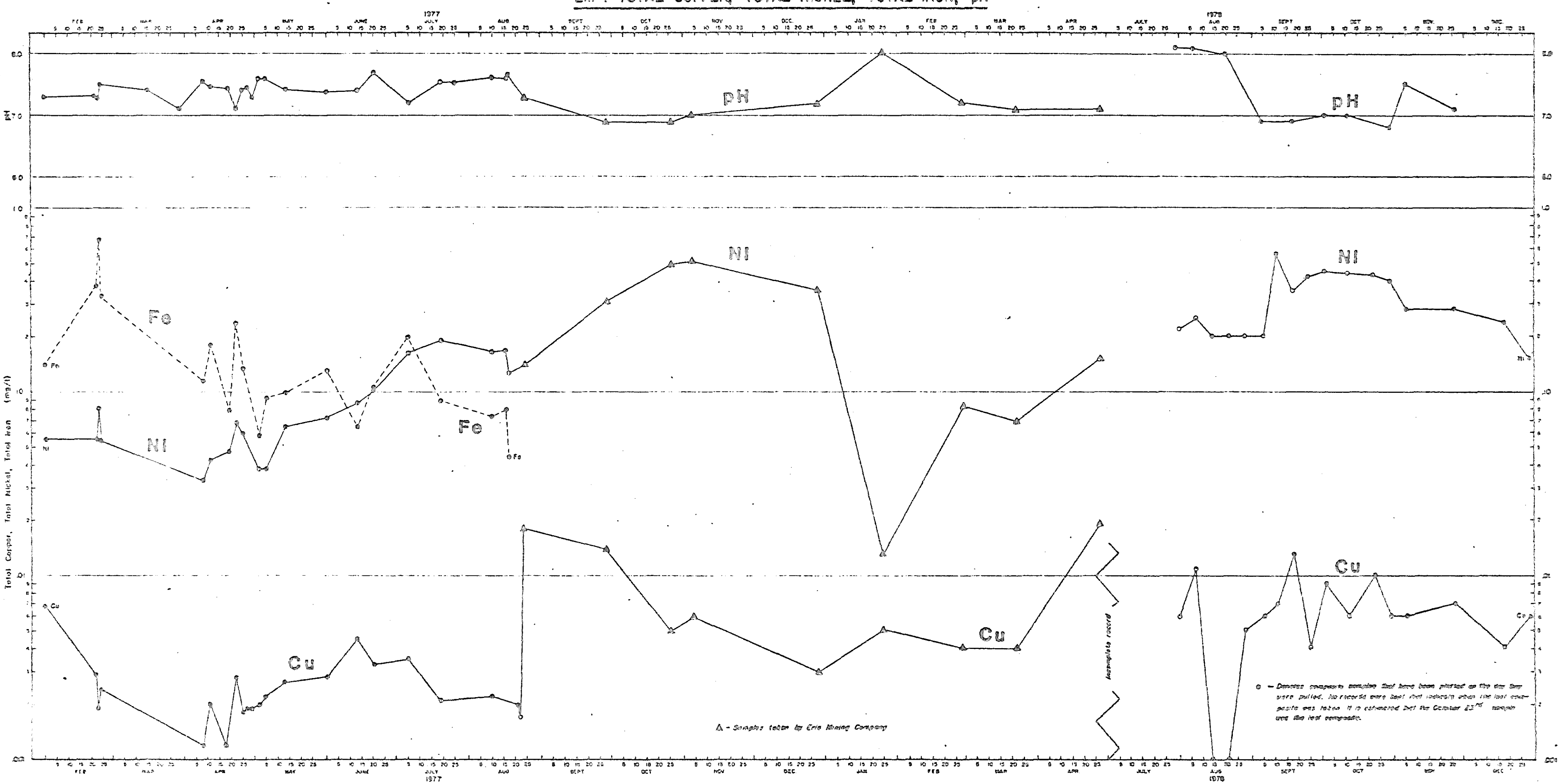


Figure A2.6

EM-I CALCIUM, MAGNESIUM, SULFATE

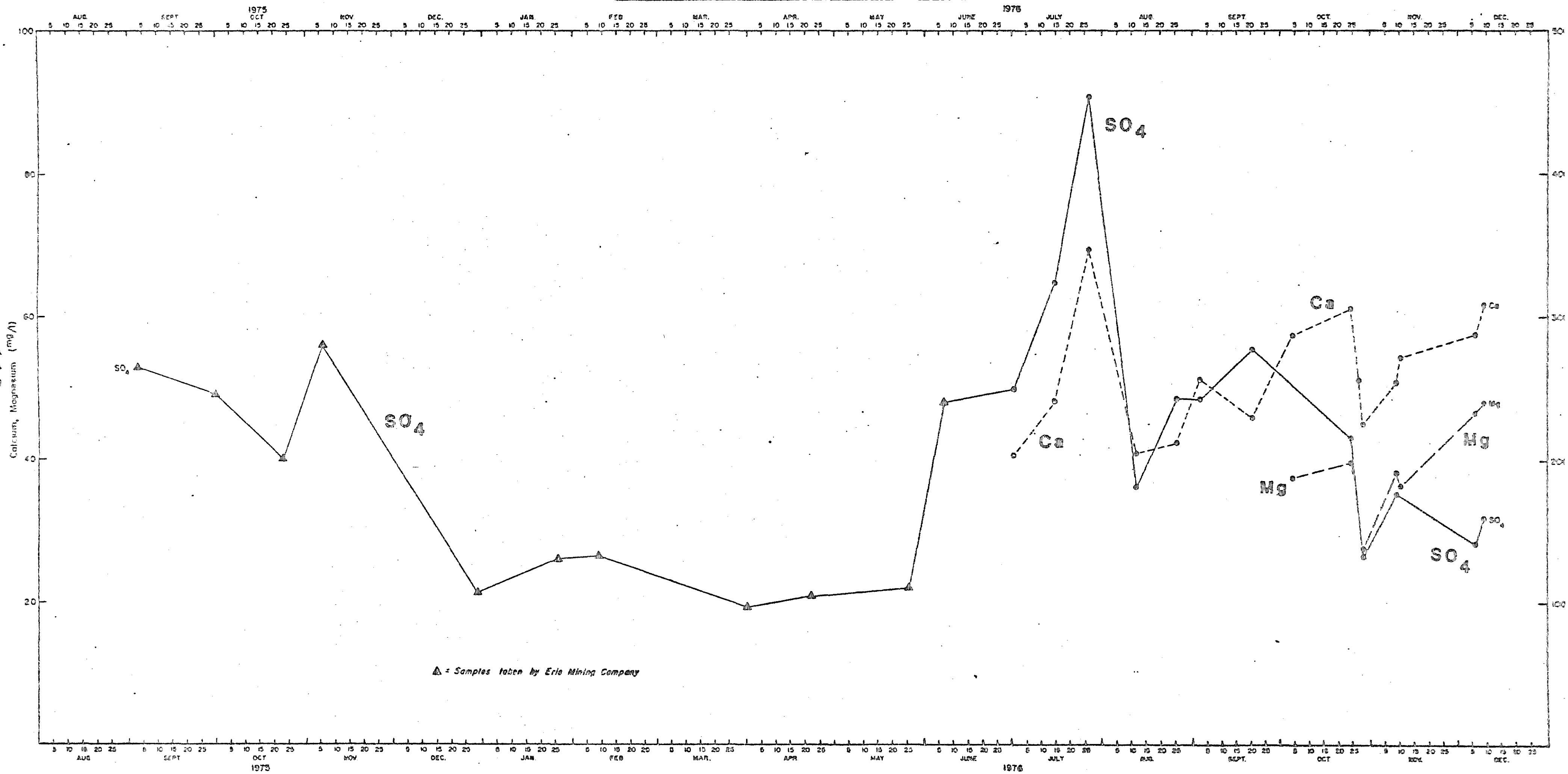


Figure A2.7

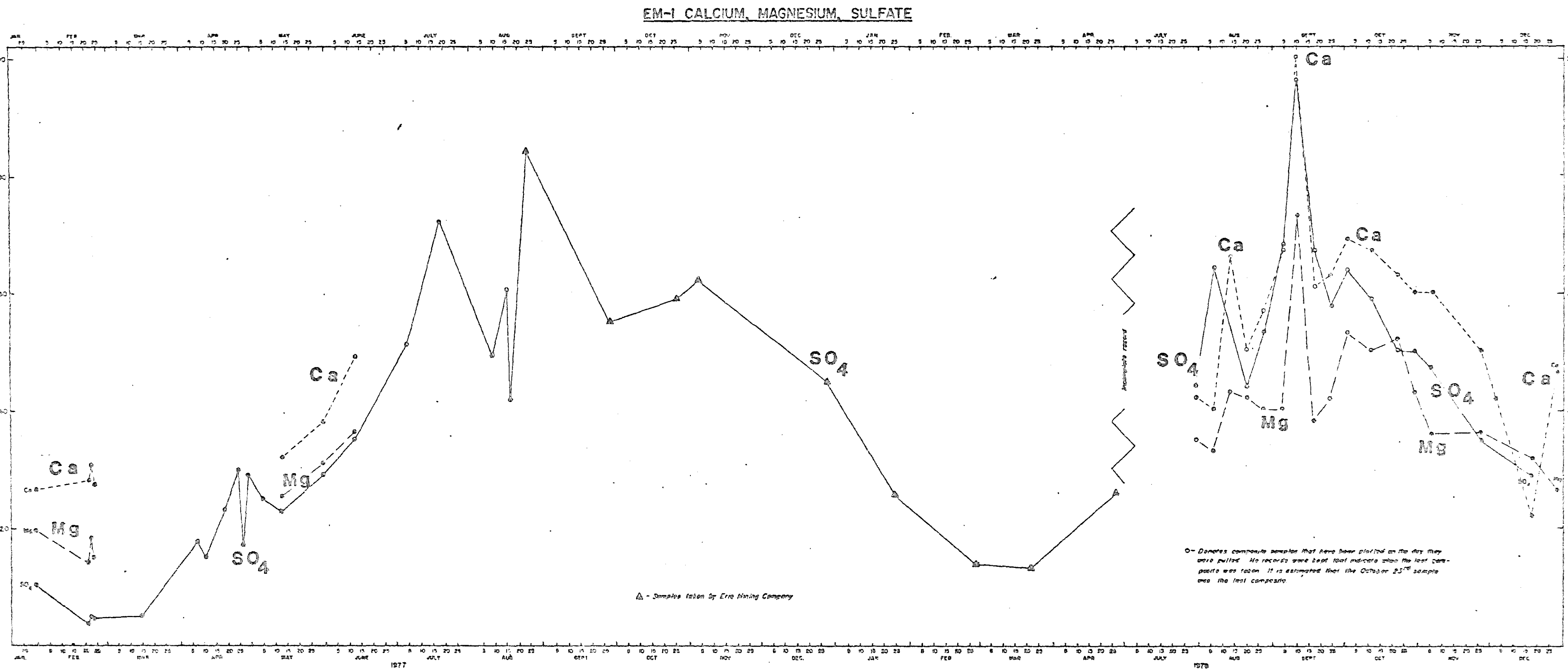
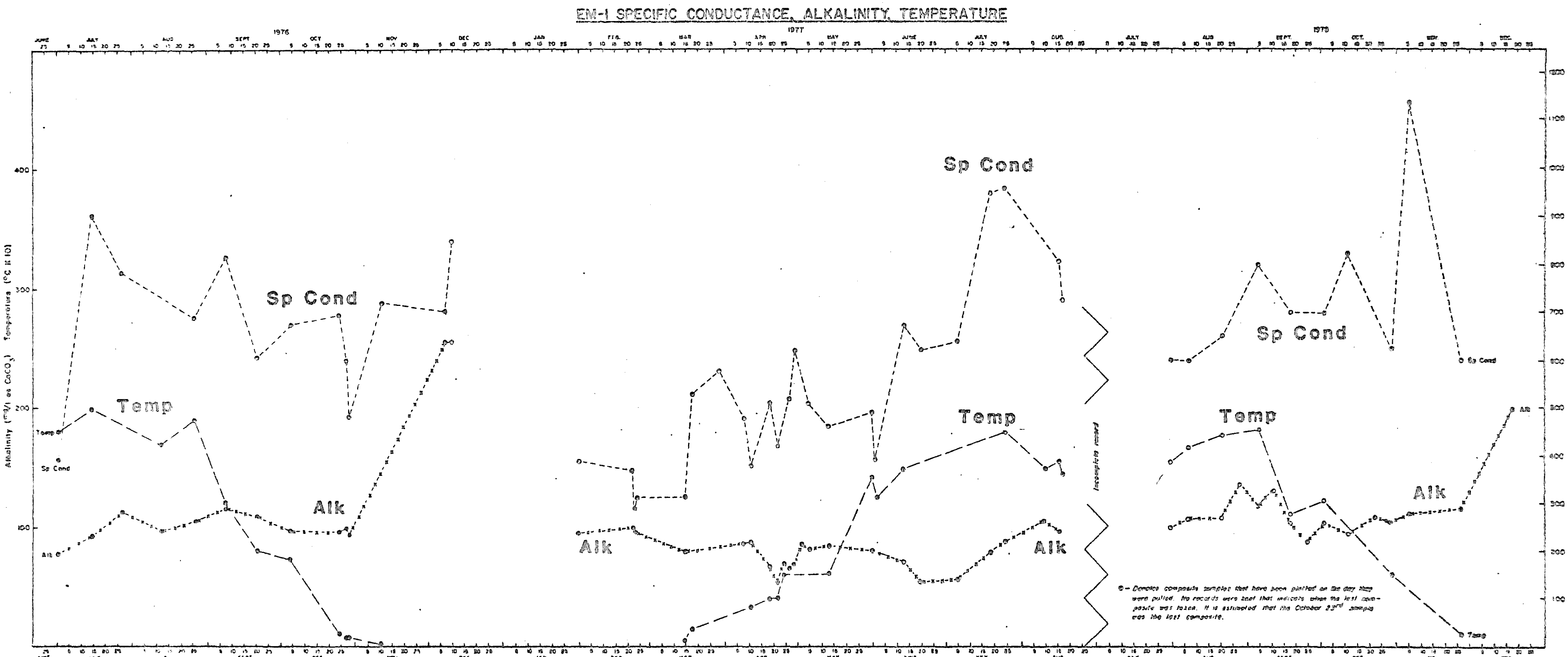

EM-1 CALCIUM, MAGNESIUM, SULFATE
Calcium, Magnesium (mg/l)
Ca
Mg
SO4
Δ - Samples taken by Erie Mining Company
o - Denotes composite samples that have been plotted on the day they were pulled. No records were kept that indicate when the last composite was taken. It is estimated that the October 25th sample was the last composite.
1977
1978

Figure A2.8


EM-1 SPECIFIC CONDUCTANCE, ALKALINITY, TEMPERATURE
1976
1977
1978
Sp Cond
Temp
Alk
Sp Cond
Temp
Alk
Sp Cond
Temp
Alk
Incomplete record

APPENDIX III

ANALYTICAL PROBLEMS

Erie Mining Company

A LIMITED PARTNERSHIP

Pickands Mather & Co., Managing Agent
P. O. Box 847
Hoyt Lakes, Minnesota 55750

Phone 218-225-2171
Telex 29-4456

December 21, 1979

Mr. Kim Lapakko
Division of Minerals
Department of Natural Resources
Centennial Building
St. Paul, Minnesota 55155

Re: Erie Mining Company
NPDES Permit MN0042579

Dear Mr. Lapakko:

This letter is a confirmation of your phone conversation today with J. J. Garmaker and W. H. Boutwell of our staff, and is in reference to your letter dated December 17, 1979. We will analyze the November Seep 1 samples for sodium and include the results in the December report. For November, the calcium and magnesium hardness results in parts per million $CaCO_3$ were calculated from the atomic absorption analysis for calcium and magnesium. All future calcium and magnesium determinations will be done by the atomic absorption spectrophotometer and reported in ppm Ca and ppm Mg. Our laboratory staff discontinued the titration method for total hardness, calcium hardness, and the derived magnesium hardness after discovering an interference with the calcium hardness during analyses of the November samples. If you have questions regarding this matter, please let me know.

Very truly yours,

ERIE MINING COMPANY

J. B. Bowen
Ass't. Manager-Staff Services

JBB:cl-RC

CC: Director, Minnesota Pollution Control Agency
P. D. Brick