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I Wouldn't Drink It: Eph's Pond Recovers from the 1994 Sewage Spill

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Environmental Science 102

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Introduction

Eph's Pond is located near the northeast corner of the Williams College campus. The pond's formation is believed to be a result of the construction of Stetson Road in 1912, which blocked drainage from surrounding marshes.[1]

In February of 1989, an ES 102 class sampled Eph's Pond for various ions and for total and fecal coliform bacteria. Very rarely did fecal coliform show up in these tests. Greg Balco, an individual student testing the pond for his independent research project, found no fecal coliform until his fourth week of testing; he attributed this to repair work done on the sewage pipe beneath Stetson Road the week before.[2]

This year's sewage spill into Eph's Pond was first reported to Buildings and Grounds on Monday 14 March, 1994. By 7:30 p.m. that day the sewage line was temporarily repaired and 40 square yards of sewage were removed from the spillage site. By Tuesday 15 March, 15 feet of clay tile pipe was installed to patch the leak. Straw was laid down in the spill areas as well. Another 8 square yards of sewage was removed from just past the boundary of the straw area on 11 April.[3]

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[1] Osborne, Caitlin "Ion Cycling in Eph's Pond" ES 102 1989

[2] Balco, Greg "A Study of Water Quality in Eph's Pond" ES 102 1989

[3] From a conversation with Donald Clark, Buildings and Grounds

The purpose of this investigation is to chart the recovery (or worsening!) of the contamination, with respect to fecal coliform bacteria and selected anion and sodium concentrations, of Eph's Pond throughout the month of April.

Methods

I began taking samples from four different locations on Eph's Pond on 7 April. I took subsequent samples on April 13, 21, and 29, these times adding four more sample sites, including the outflow and two sites along an inflow stream, which is actually storm drainage. (See Figure One) These I tested for fecal coliform and sodium and anions. In all cases I took the samples from the surface of the pond. It is worth noting here that the shoreline of Eph's Pond has been receding, with increasing temperatures and decreasing precipitation, since I began taking samples, so my sampling sites have become increasingly close to the shore.

My reasons for choosing the sites I chose related to their accessibility and nearby landmarks for finding them again with ease should the length of my "pace" vary from one week to the next. I also wished to track the flow of contaminants - how far away from the spill site they would reach, etc. I sampled the outflow site near B to determine the effect of flowing water on contaminant levels; site B is a control for distance with the outflow. Looking back, I realize that I should have taken samples on the southern shore as well as the northern shore.

The sites I have correspond only to west-east flow, not north-south flow. Also, though I sampled two sites along what is labeled "Inlet 1" on the map in order to find where contamination began; I realize now that samples from the other inlets would have been helpful in determining water quality for the area as it is unaffected by this particular spill.

I chose not to measure total coliform because I thought the values I would arrive at would be too numerous to count. I chose chloride, nitrate, sulfate and sodium as other indicators of sewage contamination; one weakness of chloride or sodium as a sewage indicator is that it can also come from road salt runoff.

I cultured for fecal coliform bacteria by diluting 50mL of sample water, so that all values given were multiplied by two to arrive at #/100mL. Anions were measured by ion chromatography, and sodium by atomic absorption spectrophotometry. Unfortunately, my data for most of these are incomplete because of ion chromatograph breakdowns. Weather data, to give an idea of how precipitation/temperature may have affected coliform levels, came from the Geology Department's weather logs, data taken at Clark Hall.

Data

Figure 2 shows the number of fecal coliform present in 100mL of sample from each of the sites on the four days that I collected samples. Site A is as near to the actual point of spillage as I could reach, so its distance from the spill is considered zero. The area between A and PA and somewhat up hill from them was difficult to reach because of the straw laid in place; consequently, I lack data as to the exact site of the spill. It could be anywhere in that area. All other distance values are given in shortest distance across the pond's surface. No distances were given for the inflows or the outflow because they were under different circumstances with respect to flowing water than the other sites.

Figure 3 gives an idea of how distance affected the amount of contamination that reached a site. It also shows the strong downward trend of contaminant concentration at all sites as time passed.

Figure 4 shows the rate of decline of fecal coliform at each site. Figure 5 looks at individual sites and how fecal coliform had decreased by each sampling date. Figures 3-5 all essentially present similar ideas about fecal coliform dissipation, but in respect to different variables.

Figure 6 can be used to compare pond recovery to temperature and precipitation trends. Also, wind speeds and directions may give some idea as to convection patterns in the pond.

Figure 7 is the map corresponding to Figure 8's data from the 1989 ES 102 class' study of Eph's Pond water quality. Because it was taken in February, when there was still ice on the pond, it is not ideal for comparison with my data, but I will treat it as a basis for comparison with respect to weather, quality and locations of high anion concentration.

Figure 9 shows a weak positive correlation between fecal coliform numbers and chloride concentration - there are probably too few middle-ranged data points to make the graph a strong indicator. Figure 10 shows that salt was probably the source of much of the sodium and chloride ions measured in Eph's Pond. It also allows for extropolation from sodium values where chloride values are not available.

Figures 11 and 12, however, showed surprising results: sodium and sulfate pollution was lower where fecal coliform counts were higher. Finally, Figure 13 shows the most surprising results - concentrations of effluent constituents, when available, actually increased dramatically following the cleanup of Eph's Pond.

Also pertinent are the results of the 1994 Hoosic River flotilla lab by ES 102 - dissolved oxygen was lower and conductivity higher in the outflow from Eph's Pond into the Hoosic than from the other inflow sites.[4]

Conclusions

The graphs referring to fecal coliform presence in Eph's Pond argue for optimism about the pond's assimilative capacity. It is absorbing this spill successfully, as shown by fecal coliform decreases. The graphs referring to sodium, sulfate,

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[4]ES 102 class, Hoosic River Flotilla, May 9-11, 1994

nitrate, and chloride concentrations, however, tell a much different story - this could be due to human or instrumental error, or dredging up of settled contaminants by cleanup efforts, or other, unaccounted-for pollution sources.

According to the Figure 5, sewage reached the inflow as well as the pond itself, seeping in heavily around site PA but causing considerably less contamination at site P0. PA is lower on the slope than P0, so when the spill seeped downhill, more sewage probably settled in the lower areas of the stream, and even more into the western end of the pond. This leads me to believe that, had I sampled from an area between A and PA, possibly right where the inlet reaches the pond, I would have found the highest level of contamination there.

I expected coliform levels at outlet site PB (**P**ipe nearest **B**) to be very similar to those at B given their proximity to each other. They were usually considerably less, however. Similarly, G. Balco's 1989 study showed lower chloride levels near the outlet. Balco suspected, as do I, that the quickly flowing water flushed out contaminants more rapidly than at relatively still sites.[5] At site B there is no discernible difference in water flow from any of the other pond sites.

Sites B-E show an increase in fecal coliform levels for the last sampling date. This could be explained with a number of hypotheses. One possibility is that the increased

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[5]Balco, Greg p.8

temperatures shown in Figure 6 - reaching well into the 70's and 80's - were very favorable to multiplying fecal coliform. The incubation effect would probably not be apparent at site A because of the already-large numbers of fecal coliform there. No similar trends are visible at the flowing-water sites; this could be due to the effect described above. The P0 sample was nearly free of coliform. Another possible explanation could be an increase in animal defecation around the pond's perimeter as they became more active in the warm weather. Though this may be a minor factor, I have more confidence in my first theory.

Why is there such a large decrease in coliform levels from the first week to the second week, but more gradual decreases in subsequent weeks, especially at site A? Recall that on 4/11, between my first and second sample dates, B + G removed a large amount of sewage from near site A. Though the B + G representative I spoke with wondered whether the cleanup effort had only succeeded in stirring up the contaminants that had settled in the pond, it appears that it actually did help with pond recovery. Another possibility is the large amount of precipitation during that week, especially the day of the 13th. This may have diluted the sample somewhat.

One question that I wondered about was exactly how much sewage was initially spilled into the pond. In February of 1989, at least, f.c. levels were very low; those areas with f.c., I suspect, had been visited by animals (see Figure 7). To roughly approximate this amount, I might find out the normal f.c. numbers for sewage (these would be astronomical) and extrapolate from my curve for site A in Figure 4. I would have to take into consideration the removal of 40 square yards of sewage on March 15 - I could also estimate this from the decrease brought about by the April 11 removal.

But how should the erratic cation and anion results be viewed? One factor to keep in mind is the frequent failure of the ion chromatograph, so that perhaps the concentrations it did yield could not be trusted. Another cause could be the stirring up of settled contaminants in the course of the cleanup effort. This effect was not seen in fecal coliform populations, however. Perhaps coliform does not settle as other pollutants do. Another possibility is another, or many other, sources of pollution, such as increased runoff from fertilizer or pesticide applications on Cole Field. I also noted earlier that the shoreline of Eph's Pond had been receding during the entirety of my experiment. With less water, remaining effluents in the pond would become more concentrated. Comparing concentrations of my selected ions given in Figure 2 with those in Figure 8 from 1989, outflow averages were very close for sodium, and high this year for sulfate; inflows of sodium were much higher in 1989, but htis is likely to be due to the time of year - winter, with lots of road salt. Sulfates were lower this year. For the entire pond, chlorides were lower this year, sodium and sulfate very similar, and nitrate considerably higher.

In general, though I would not drink from or swim in Eph's

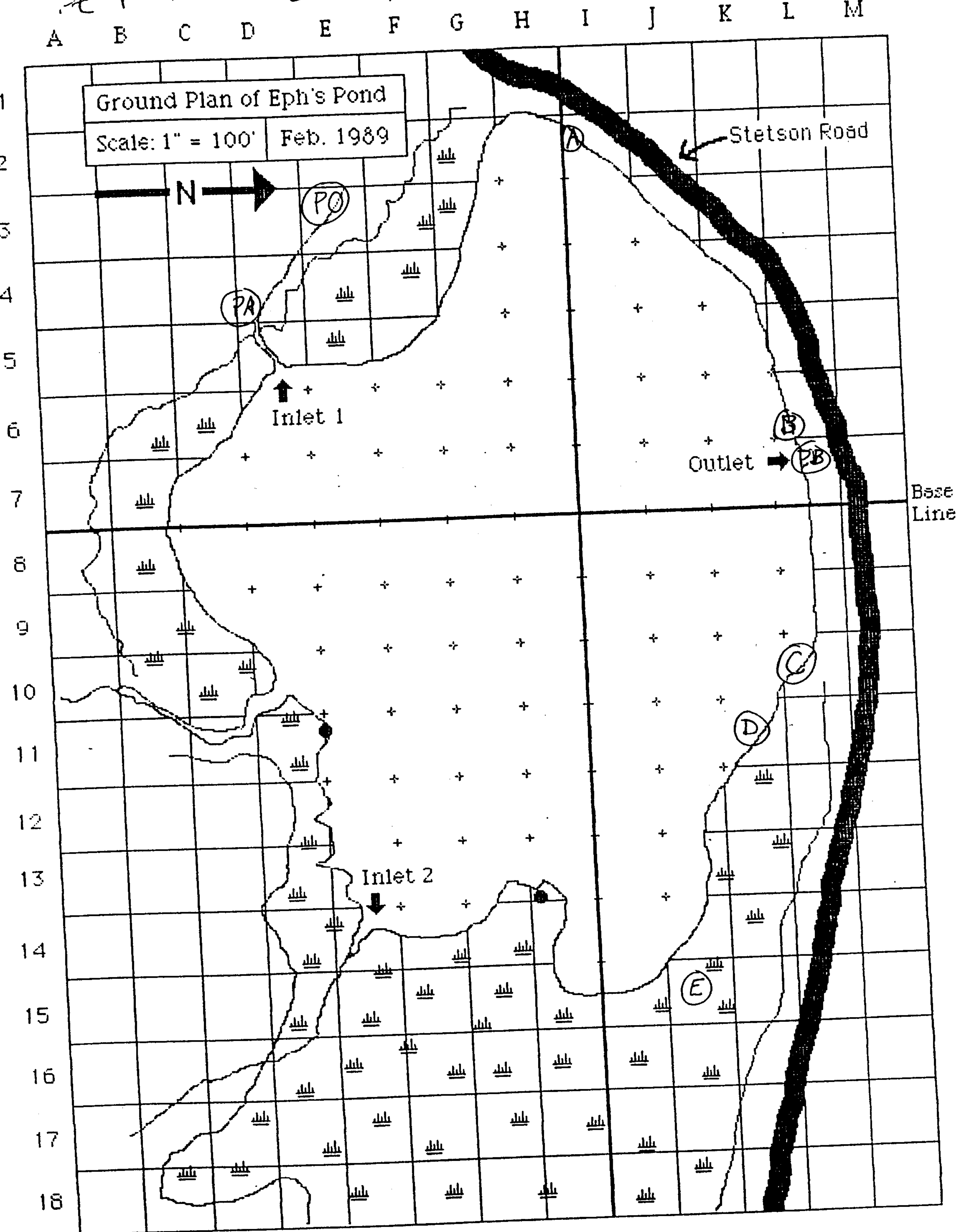
Pond, I do not think that wildlife there is suffering too much due to the spill. I may have no comparison for previous years' life, but vegetation and birds and insects appear healthy. Simple observation of the pond leads me to believe that eutrophication is not accellerating, though this could also be due to my lack of past observations of Eph's Pond. Despite my optimism about the pond's recovery from this spill, I think more caution should be taken in the future so that its assimilative capacity is not breached. The pond is a nice site for bird-watching; it also feeds into the Hoosic River. Though it is not a natural watershed, it does provide benefits to people and animals; it would be a shame if we lost it to sewage.

It's 'natural', just modified by some construction

Bibliography

1. Osborne, Caitlin "Ion Cycling in Eph's Pond" ES 102 1989
2. Balco, Greg "A Study of Water Quality in Eph's Pond" ES 102 1989

* FIGURE 1: EPH'S POND + SAMPLE SITES



* From "A Study of Water Quality in Eph's Pond" Balco, Greg, ES102 May 12 1989
Map based on Spring 1989 ES102 class survey

	Na	no3	so4	Cl	distance	fc/100ml	days	D	
0		4.3500	16.500	127.00	0.0000	TNTC*	17.000	1.0000	
1		2.6000	12.100	71.500	288.00	278.00	17.000	2.0000	→ 4/7
2		1.5800	12.800	76.000	450.00	94.000	17.000	3.0000	
3		0.76000	11.200	79.000	488.00	34.000	17.000	4.0000	
4	11.000		5.8000		0.0000	510.00	23.000	1.0000	
5	22.000		10.000		288.00	100.00	23.000	2.0000	
6	82.500		8.7000		450.00	0.0000	23.000	3.0000	
7	96.500		22.600		488.00	4.0000	23.000	4.0000	→ 4/13
8	7.0000		3.5000		688.00	0.0000	23.000	5.0000	
9	30.000		34.500		PA	404.00	23.000	6.0000	
10	38.000		19.800		PB	50.000	23.000	7.0000	
11	12.500		9.1000		PO	170.00	23.000	8.0000	
12	40.500	0.33000	0.10000		0.0000	492.00	31.000	1.0000	
13	65.000	1.7400	21.300		288.00	6.0000	31.000	2.0000	
14	70.000	1.4000	24.400		450.00	2.0000	31.000	3.0000	
15	36.500	0.020000	14.400		488.00	0.0000	31.000	4.0000	→ 4/21
16	15.500		10.900		688.00	6.0000	31.000	5.0000	
17	67.500		33.600		PA	182.00	31.000	6.0000	
18	73.500		25.600		PB	4.0000	31.000	7.0000	
19	36.000		28.300		PO	4.0000	31.000	8.0000	
20	72.000		18.900	111.00	0.0000	370.00	39.000	1.0000	
21	45.500		23.300	86.000	288.00	24.000	39.000	2.0000	
22	41.000		25.600	81.000	450.00	22.000	39.000	3.0000	
23	50.000		26.800	102.00	488.00	36.000	39.000	4.0000	→ 4/29
24	45.000		57.900	83.500	688.00	10.000	39.000	5.0000	
25	56.500		34.600	113.00	PA	144.00	39.000	6.0000	
26	39.500		25.600	84.000	PB	10.000	39.000	7.0000	
27	30.000		30.900	72.000	PO	6.0000	39.000	8.0000	

*Too numerous to count

FIGURE 3

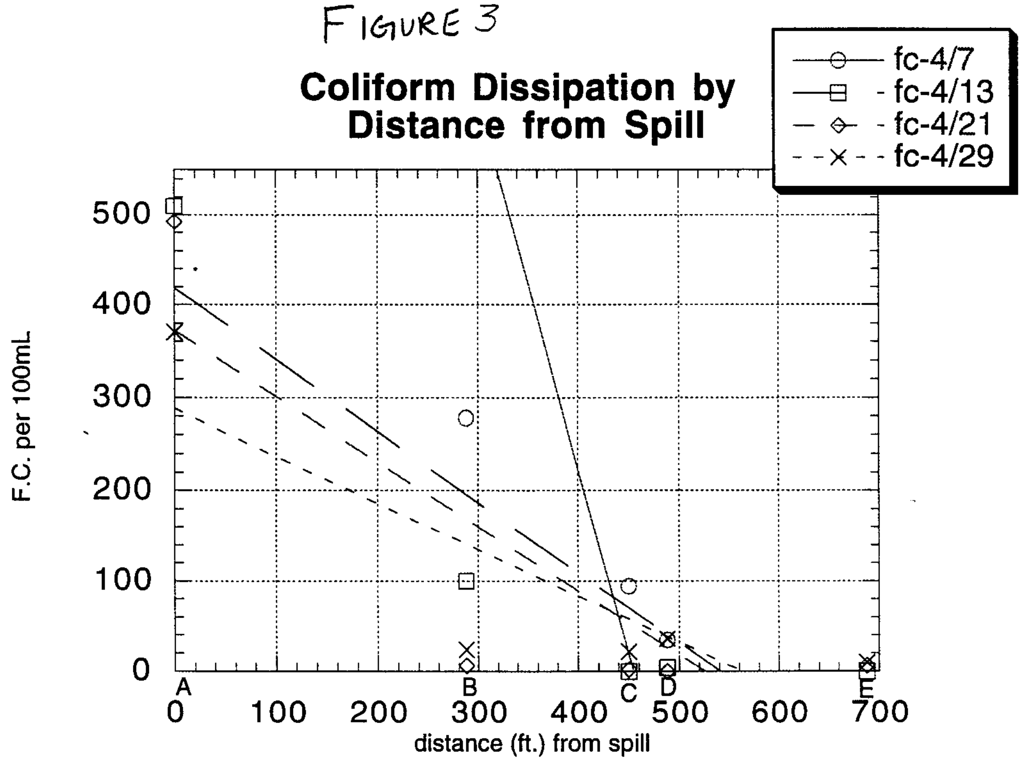

Coliform Dissipation by Distance from Spill
fc-4/7
fc-4/13
fc-4/21
fc-4/29
F.C. per 100mL
500
400
300
200
100
0
A
B
C
D
E
0
100
200
300
400
500
600
700
distance (ft.) from spill

FIGURE 4

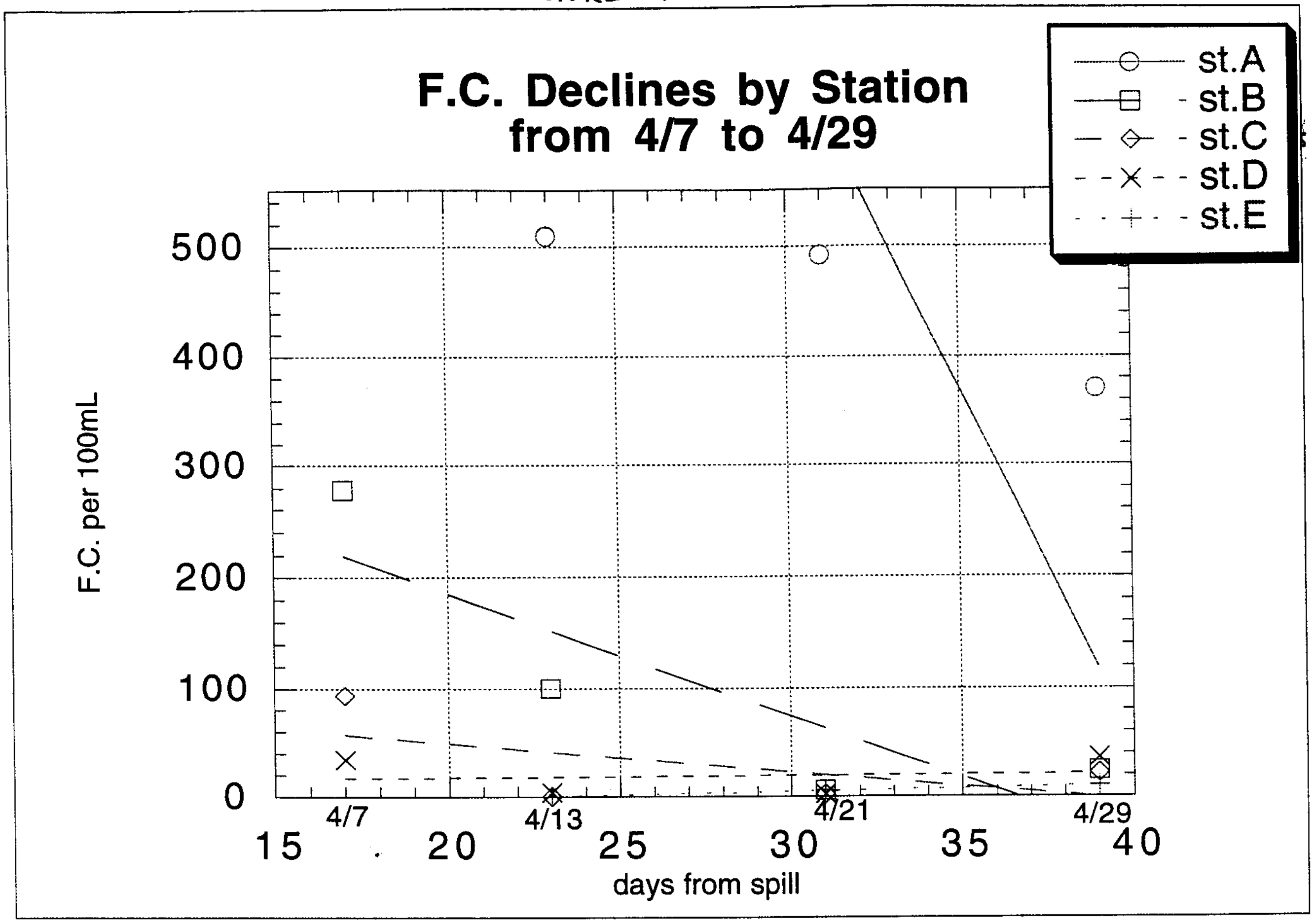


FIGURE 5

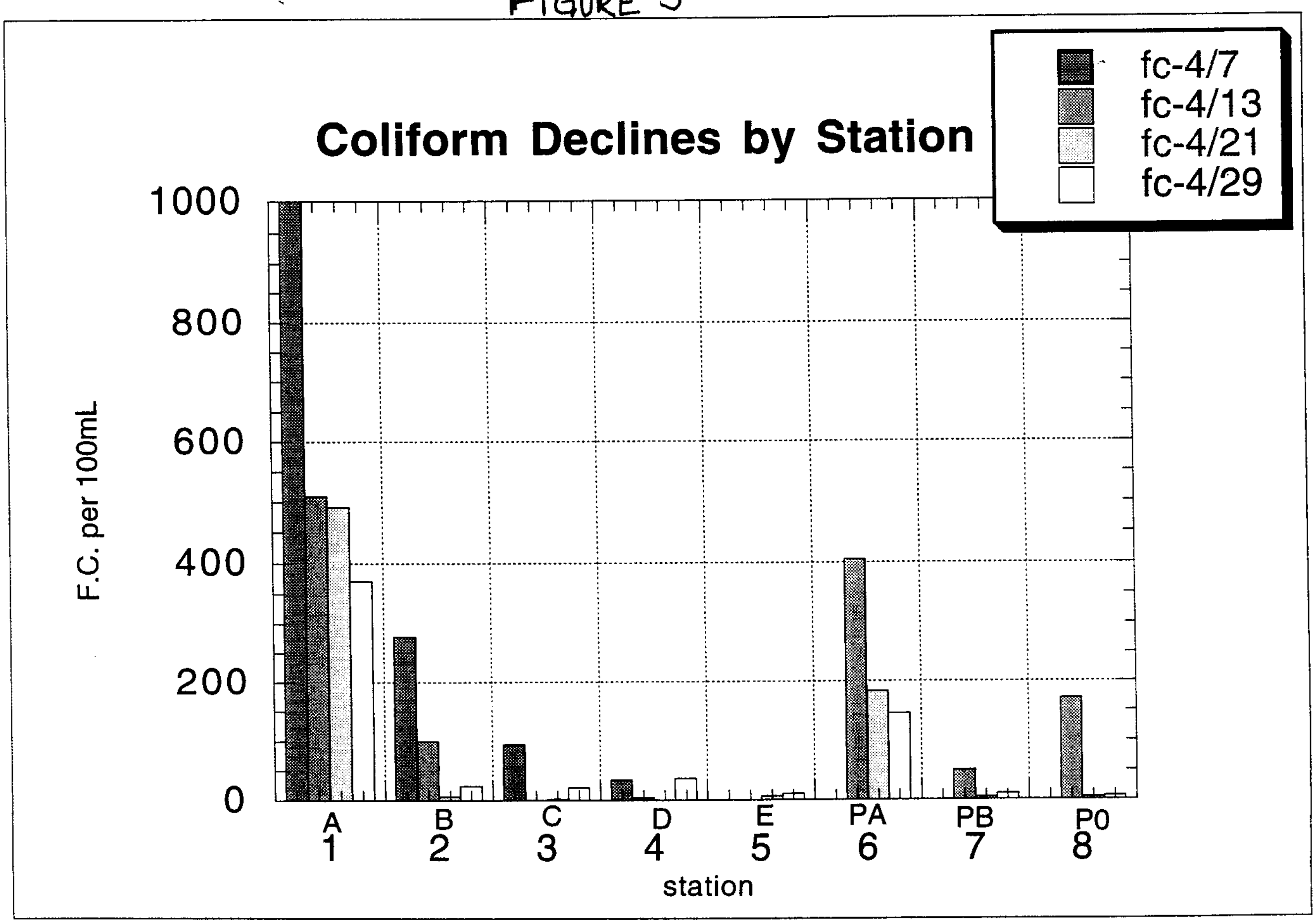


FIGURE 6 - Weather Log

DATE	TEMP	T max	T min	Pressure	P max	P min	↑↓→	Wind Speed	Wind Dir.	Gust	Precip/ S/R	Sky
13 Mar	[illegible]	44	24	30.06	30.43	30.06	↓.03	3.6	SSE	21S	none	cloudy
14 Mar	40°	48°	24°	29.85	30.43	29.83	—	2 mph	WSW	27S	.06	Cloudy
15 Mar	45°	47°	32°	29.50	29.85	29.49	↓.02	5	SW	15 s	.06	OVERCAST
16 Mar	33.4°	47°	32°	29.42	29.85	29.37	—	3	NW	23NW	.1	MOSTLY CLOU
17 Mar	26.9°	29°	11	29.50	29.45	29.5	-.05	11	NW	26 NW	3" S	partly sunny
18 Mar	35.0°	37.0	21.0	29.42	29.62	29.42	-.04	9	S	37 NW	0	CLOUDY
19 Mar	28.0	29.2	23.0	—	—	29.30	↑			41 WNW	0	CLOUDY
20 Mar	—	41.0	—	29.73	29.74	—	↑	12	NE	—	0	PARTLY CLO
21 Mar	—	42	18	—	29.98	—	↓	—	—	36 SSE	—	CLEAR
22 Mar	37	—	—	29.64	—	29.61	↑	8	NNW	—	7" S	CLOUDY
23 Mar						29.62					⊖	
24 Mar											⊖	
25 Mar										~~NW 32~~	⊖	
26 Mar								~~[illegible]~~	~~NW~~	NW 32	⊖	CLOUDY
27 Mar	40	—	26	30.05	30.05	—	↔	6	NW	—	⊖	CLEAR
28 Mar	31	47	24	29.83	30.11	29.83	↓	15	S	34 ESE	0.5" S, R	MIXED S&R
29 Mar												
30 Mar												
31 Mar												
1 Apr	44	48		29.87				6	W			
2 Apr												
3 Apr												
4 Apr	42	58	23	30.00	30.20	29.71	↑	5	NW	32 SW	0.22 R	PARTLY CLO
5 Apr	58	59	25	29.87	30.00	29.87	↓	10	SE	22 S	⊖	CLOUDY
6 Apr	49	50	46	29.83	29.85	29.83	↓	4	SSW	20 SSW	0.08 R	RAIN
7 Apr	36.7	50.0	33.3	29.64	29.80	29.60	↓	4	NW	25 NNW	0.75 R	DRIZZLE
8 Apr	[illegible].8	39	24	30.36	30.37	29.69	[illegible]	6	NNW	27 NNW	-04 [illegible]	clear
9 Apr	51.0	51.0	24.0	30.[illegible]	30.37	29.69	-.02	18	SSW	27 NNW	—	clear
10 Apr												
11 Apr	44.0	57.0	35.0	30.31	30.32	29.85	↑	18	NNE	33 S	none	clear
12 Apr	54.0	56.0	31.0	30.32	30.38	29.85	↓ -.02	10	SSW	25 N	0.63 R	OVERCAST
13 Apr	45	57	42	29.90	30.32	29.90	↓	5	S	25 SE	0.17 R	CLOUDY
14 Apr												

* Weather Data from Geology 166, 1994

IF you missed your DAY, you'll Do it in May!

DATE	TEMP	T max	T min	Pressure	P max	P min	↑↓→	Wind Speed	Wind Dir.	Gust	Precip/ S/R	Sky
15 Apr	48.0	71.0	33.0	29.68	30.05	29.56	-.01	2	NW	WNW 37	rain .26 inch	cloudy
16 Apr	41°c	56	35.9	29.80	29.50	~~29.~~ 29.61	-.01	4	NW	WNW 37	rainfall .25"	Cloudy
→ 17 Apr											0.24 R	
18 Apr	43.9	56	32.0	29.97	29.97	29.61	↑.01	16	NNW	39WNW	~~2.25~~ ~~0.22~~	pt. cloudy
19 Apr												
20 Apr												
21 Apr	44.5	73.0	34.1	30.04	30.04	29.73	.00	7	NW	42WNW	.04R	cloudy
22 Apr	44	55	27	30.02	30.03	29.96	.01	20	NW	35NNW	0	partly cl
23 Apr	59	61	27	29.86	30.10	29.86	.01	7				
24 Apr	75	76.8	48	29.61	29.83	2[illegible]	-.01	6	SW	35NW	0	partly cl
25 Apr	~~[illegible]~~ 63	~~57.5~~ 70.3	~~52.0~~ 45.2	29.81	29.81	29.61	—	2	WNW	30WNW	0	partly cl
26 Apr	56.	57.5	52.0	29.44	30.01	29.44			WNW	39NW	2.29	Cloudy
27 Apr	67.1	73.3	45.8	29.8	29.95	29.8	↓-.01	11	ESE	31 S	0	cloudy
28 Apr		88					↓.04	5	SSE	26(SE)	2.29	clear
29 Apr	52.7	~~82.0~~ ↑	30.2	52.4	88.0	29.7	→	10	SSE	35 NNW		
30 Apr	67	67	42	30.04	30.12	30.03	↓	~~0~~ -1	NW	35 NNW	.01	~~cloudy~~ CLEAR
1 May												
2 May												
3 May												
4 May												
5 May												
6 May												
7 May												
8 May												
9 May												
10 May												
11 May												
12 May												
13 May												

FIGURE 7

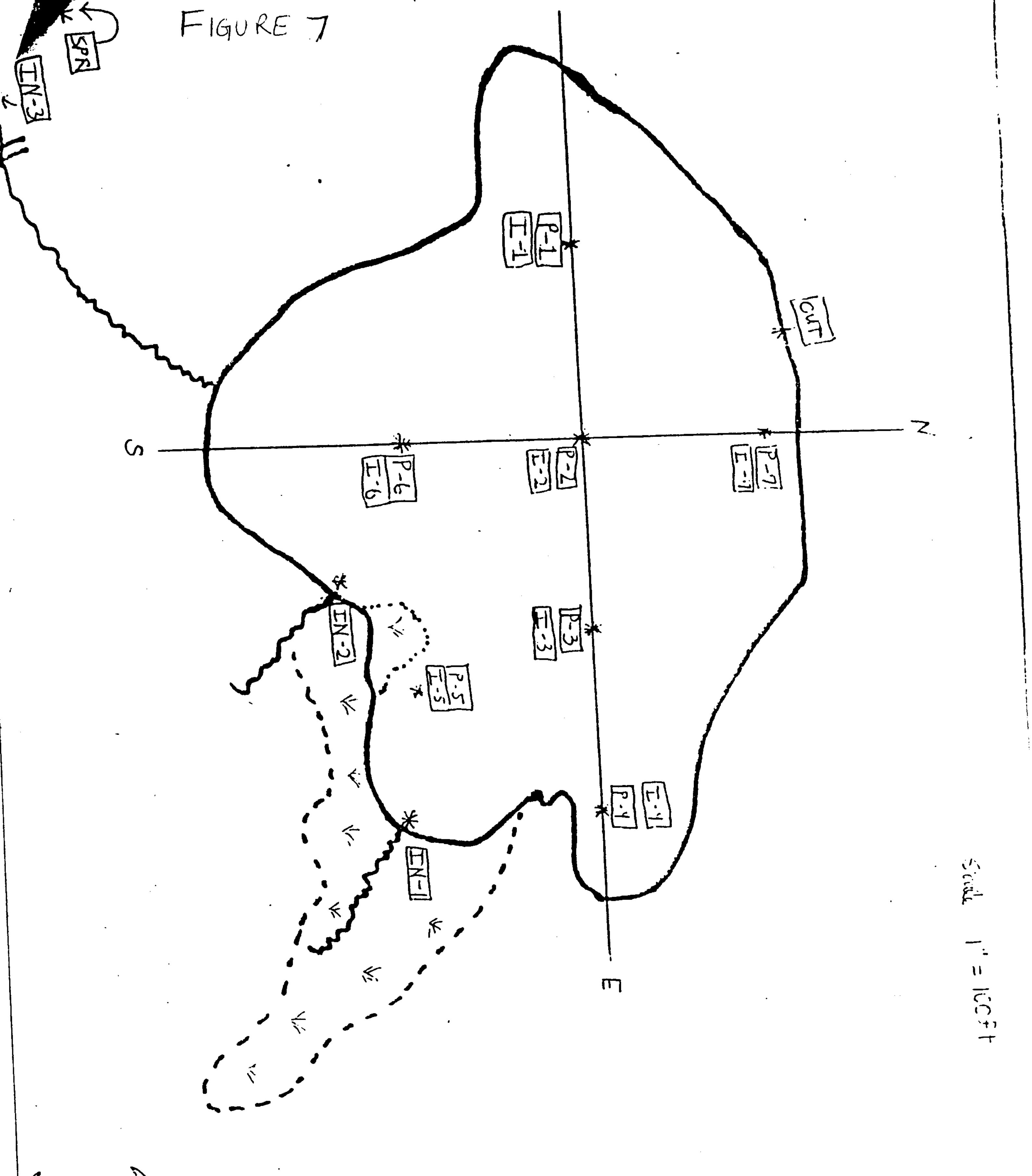


FIGURE 3: LOCATIONS SAMPLED IN POND WATER TESTS TO DETERMINE THE FILTERING EFFECT OF THE POND.

* From "A Study of Water Quality in Eph's Pond" Balco, Greg ES102 1989
Based on Spring 1989 ES 102 class data

~~APPENDIX 3~~ : RESULTS of POND SAMPLING DONE FEB. 07

~~TABLE 4~~
FIGURE 8

[SEE ~~MAPS~~ FIGURE 3 FOR SAMPLING LOCATIONS]

TotColif, FecalColif → # BACTERIA / 100 ml SAMPLE

Name	Lab day	Sample	pH	TotColif	FecalColif
1. SAMPLES TAKEN from INFLOWS TO EPH'S POND					
...ichston	Tues	IN-1-1		0	7
Dye	Wed	IN-1-2	8.06	7	0
		IN-2-1	7.70	17	0
		In-2-2	7.76	33	0
		IN-3-1	8.09		0
		IN-3-2	8.05	[illegible]	0
...flows		Average	7.98	10.83	1.16
2. SAMPLES TAKEN from ICE ON POND					
Nagy	Tues	I-1-1	5.96	0	0
Foster	Tues	I-1-2	6.19	9	22
Christof,	Wed	I-2-1	7.00	0	0
Blaine	Tues	I-2-2	6.25	1	1
		I-3-1	6.65		
Martin	Wed	I-3-2	7.05	[illegible]	0
		I-4-1	6.98	0	0
		I-4-2	6.50		
Kahn	Tues	I-5-1	6.40	1	0
Conley	Wed	I-5-2		40	0
McQuaig	Mon	I-6-1	6.70	[illegible]	0
Kim	Tues	I-6-2	6.82		0
Modesitt	Mon	I-7-1	7.20	0	0
Emerson	Tues	I-7-2	6.69	0	0
Ice		Average	6.67	[illegible]	1.91
3. OUTFLOW SAMPLES					
Rhoda	Mon	Out-1	8.62	1	0
Whitaker	Wed	Out-2	8.72	14	0
Outflow		Average	8.67	[illegible]	0.00
4. SAMPLES TAKEN from OPEN WATER IN THE POND					
A. Session	Wed	P-1-1	8.16	15	0
Roche	Mon	P-1-2	8.47	1	0
M. Hayes	Tues	P-2-1	8.45	1	0
J. Ryden	Tues	P-2-2	8.70	0	0
H. Art	Mon	P-3-1	8.15	0	0
P. Kohn	Wed	P-3-2	8.10	2	1
E. Rogers	Mon	P-4-1	8.48	40	0
Bhagwan	Wed	P-4-2	8.89	36	0
D. Finkelst	Wed	P-5-1	7.68	234	0
A. deGarmo	Wed	P-5-2	7.86	118	0
		P-6-1	8.27	30	0
D. Tweney	Wed	P-6-2	8.20	31	0
Schlesin	Wed	P-7-1	8.22	[illegible]	0
Toder	Wed	P-7-2	8.50	[illegible]	0
Pond		Average	8.16	38.54	0.28
5. SAMPLES TAKEN FROM SPRING					
Bellin	Mon	Spr-1	7.83	1006	497
P. Sedgwic	Tues	SPR-2	7.86	6010	860
Spring		Average	7.85	3508.00	678.50

~~Appendix E~~, p.2.

TABLE 4

ALL CONCENTRATIONS IN PPM

ple	Cond	calcium	magnesium	sodium	chloride	sulfate	nitrate	phosphate
1-1		31.0	13.4	4.10	14	67.6	0	21
1-2	310	41.7	15.0	5.60	13.2	11.8	0	0
2-1	520	61.0	22.6	7.60	22.4	81.4	0	23.4
2-2	510	78.9	25.0		23.0	27.4	0	6.6
3-1	1400	118.6		400.0	200	30.4	0	5.8
3-2	1440	133.8	30.0		544	25.8	0	8.6
lows	836.00	77.50	21.20	104.32	136.10	40.76	0.00	11.26
-1	17.5	2.1	0.18	1.08	2.84	1.90	2.33	0.83
1-2	4.7	4.3		1.05	2.77	2.04	1.72	0.73
2-1	12.0	1.3		0.38	1.38	0.59	0.83	0
2-2		1.1	0.29	0.24	1.17	0.57	0.73	0
3-1		6.4		0.86	2.05	2.28	1.40	1.24
3-2	37.0	6.0		0.85	2.44	7.07	3.39	5.22
4-1	23.0	2.9		0.69	66.2	33.0	29.4	14.2
4-2	32.0	3.6		0.72	3.81	1.62	1.52	0.73
5-1	24.0	3.4	0.75	0.51	1.64	1.65	1.64	1.22
5-2	15.8	3.8	0.92	0.58	30.0	35.6	27.8	1.07
6-1	18.0	4.0		0.58	1.68	1.67	1.36	0.73
6-2	18.0	4.2	0.64	0.56	1.83	1.71	1.50	0.81
7-1	23.0	2.2		1.18	63.4	17.4	14.0	0
7-2	10.5	2.3		1.13	3.21	1.43	1.27	0.70
ce	19.62	3.40	0.59	0.74	14.60	7.76	6.34	1.96
ut-1	490	48.3	12.4	44.0	103.4	13.6	0	0
ut-2	460	41.7	15.0	45.5	107.2	14.4	0	0
utflow	475.00	45.00	13.70	44.75	105.30	14.00	0.00	0.00
P-1-1	535	48.3	10.6	50.0	130.0	14.4	0	0
P-1-2	564	50.0	15.2	54.2	130.2	14.6	0	0
P-2-1	252	27.0		7.50	22	10.4	0	0
P-2-2	255	27.0	11.6	9.1	22	10.4	0	0
P-3-1	245	25.1	12.0	5.8	16.0	9.4	0	0
P-3-2	250	21.0		5.5	17.2	84.0	0	25.8
P-4-1	215	27.0	8.8	5.7	17.2	9.0	0	0
P-4-2	240	35.5	10.2	6.6	16.8	9.4	0	0
P-5-1	300	38.0	11.2	4.20	186	24.8	0	4.8
P-5-2	300	52.1	21.0	5.6	11.6	13.4	0	0
P-6-1	340	50.2	19.8	7.6	20.2	15.2	0	0
P-6-2	375	56.3	18.4	8.1	22.8	68.8	0	21.0
P-7-1	390	35.5		34.2	73	12.2	0	0
P-7-2	395	41.6	12.4	29.4	70.6	11.8	0	0
Pond	332.57	38.18	13.74	16.67	53.97	21.98	0.00	3.63
Spr-1	700	99.3		55.1	130.5	24.0	0	4.6
Spr-2	800	120.5	28.0	57.5	180	25	0	5
Spring	750.00	109.90	26.00	56.30	155.25	24.50	0.00	4.80

FIGURE 9

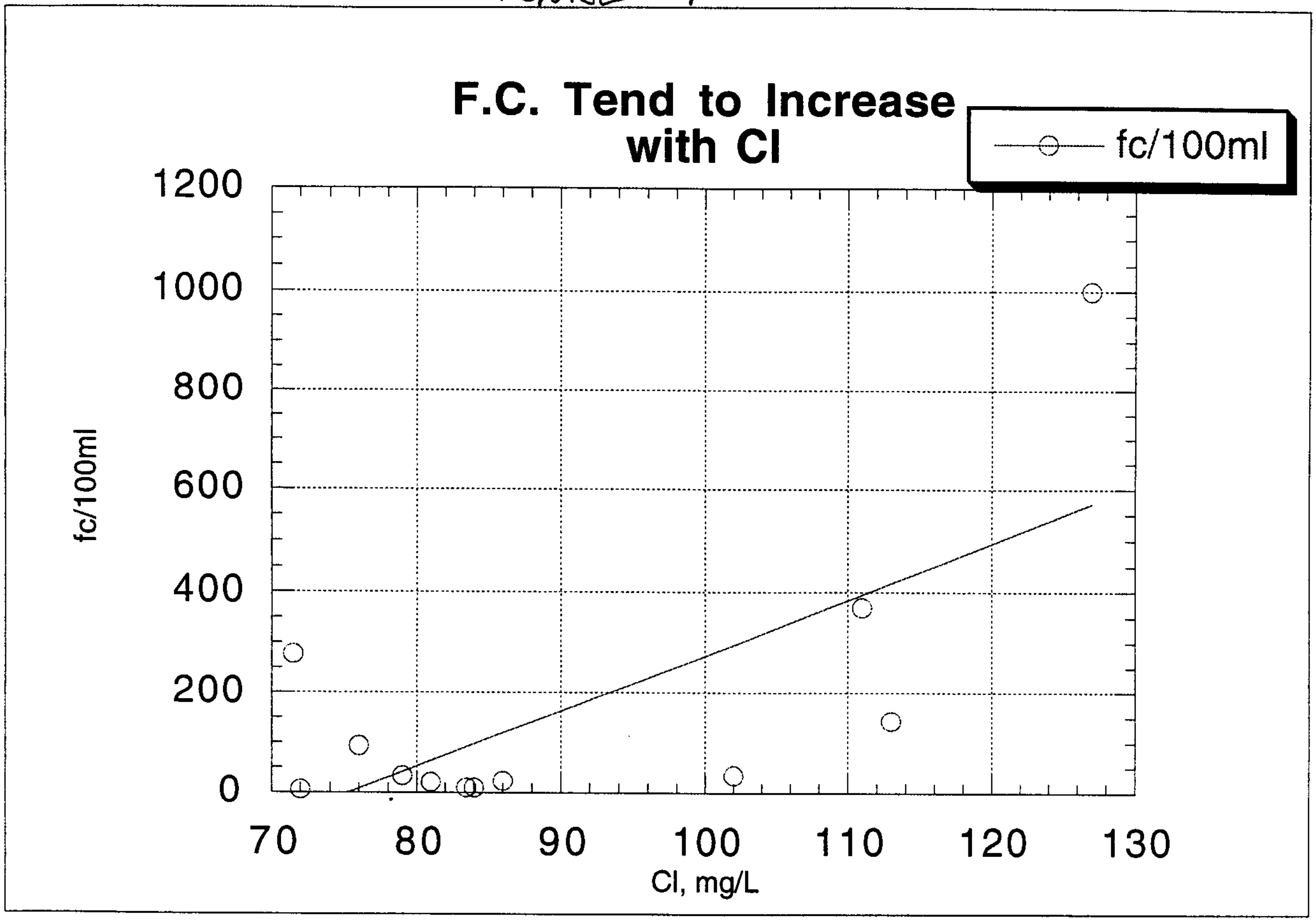


FIGURE 10

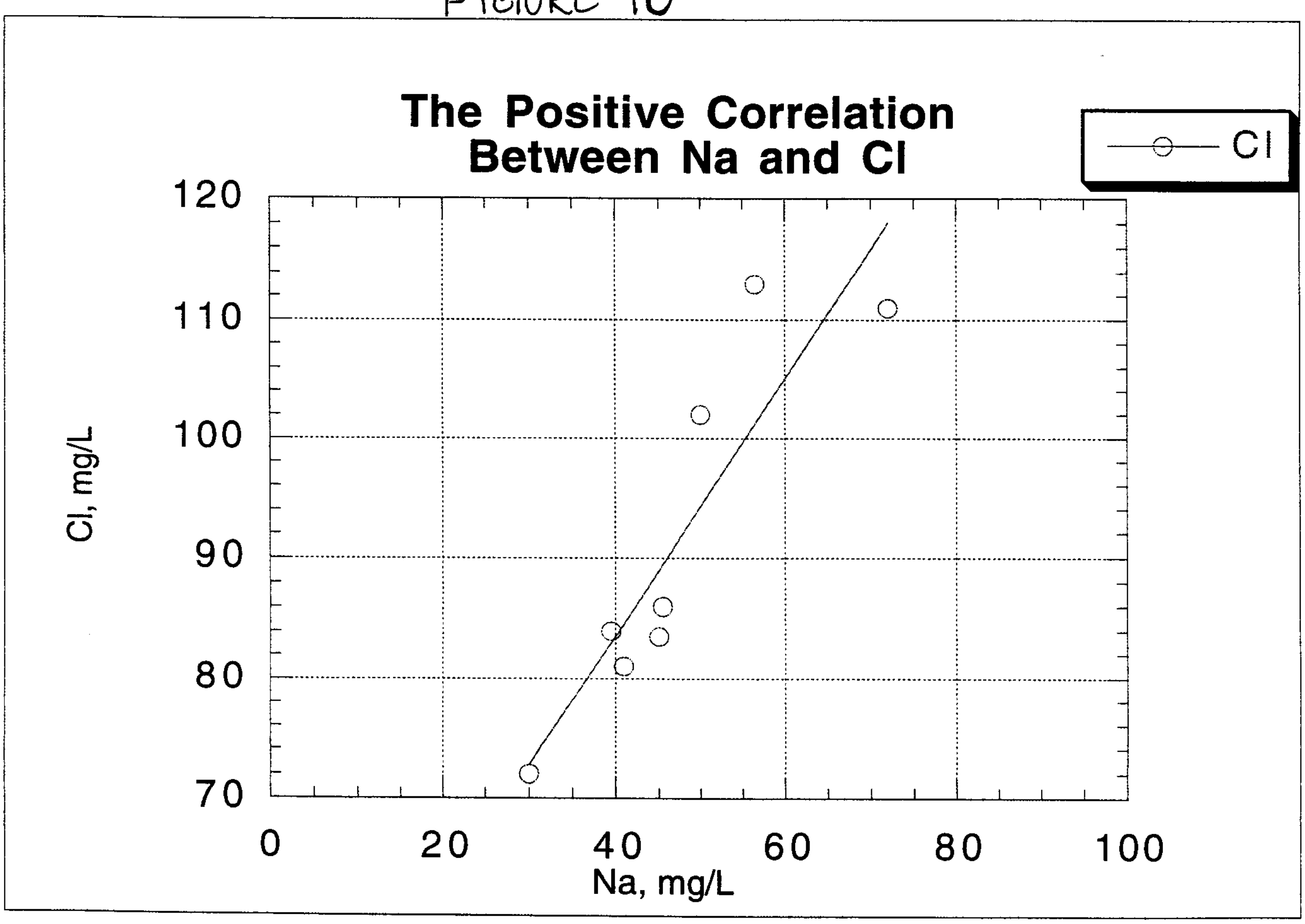


FIGURE 11

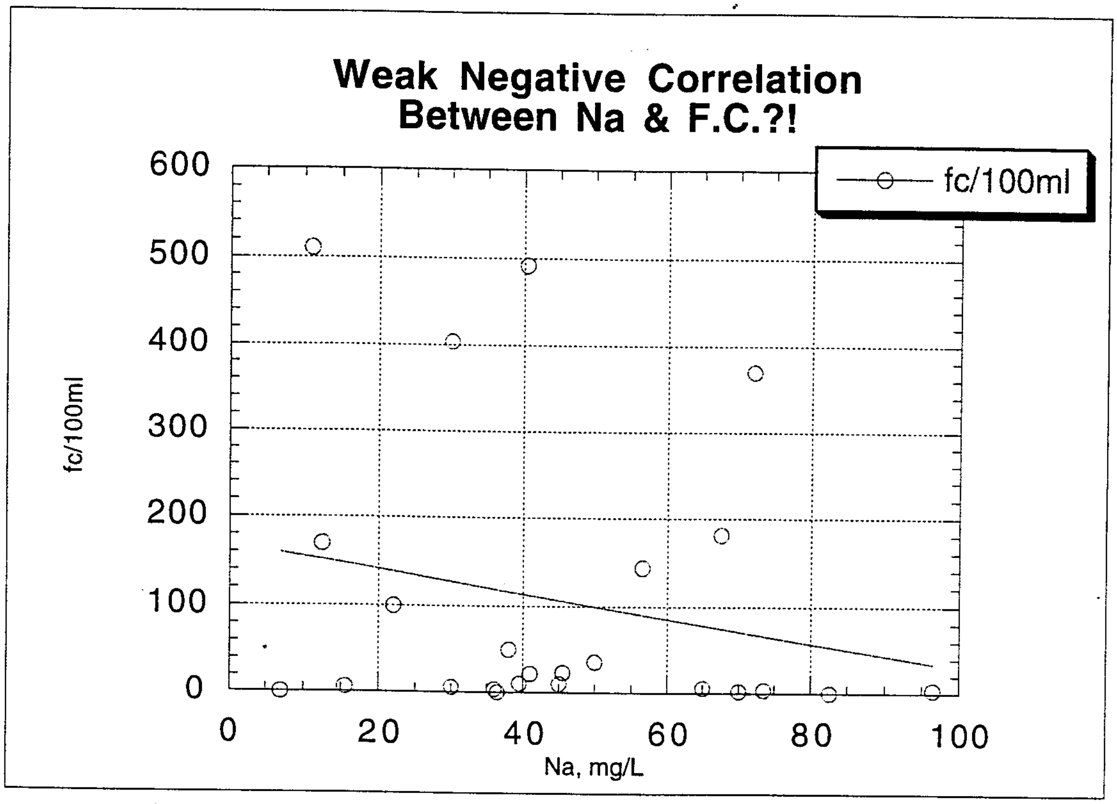


FIGURE 12

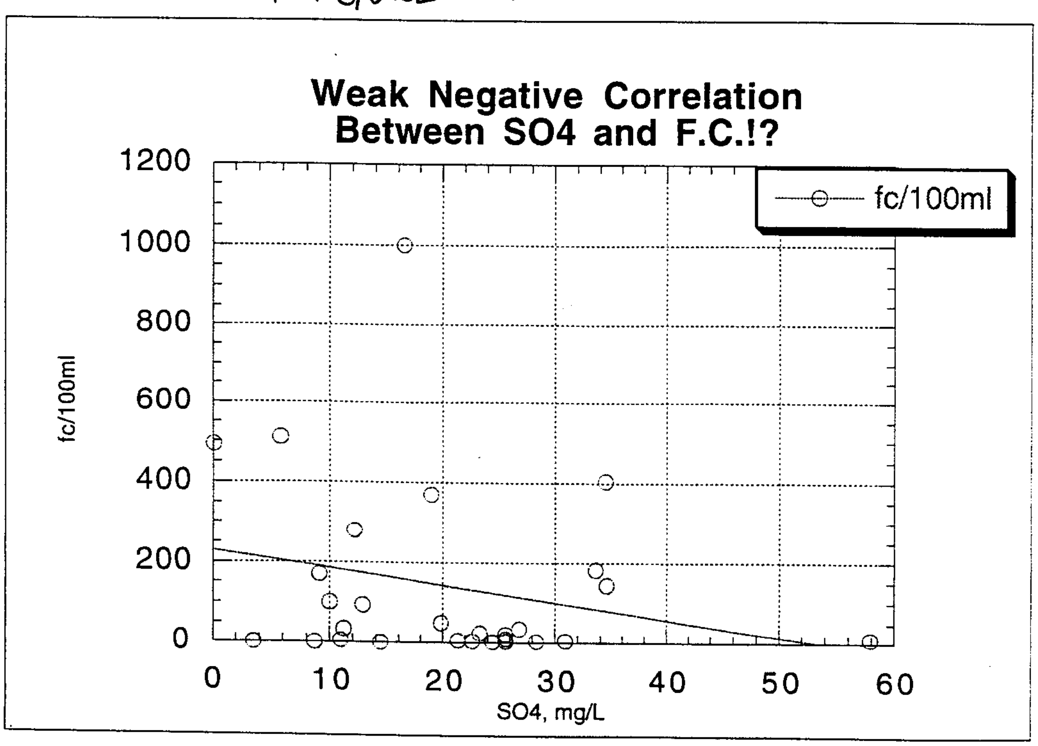


FIGURE 11

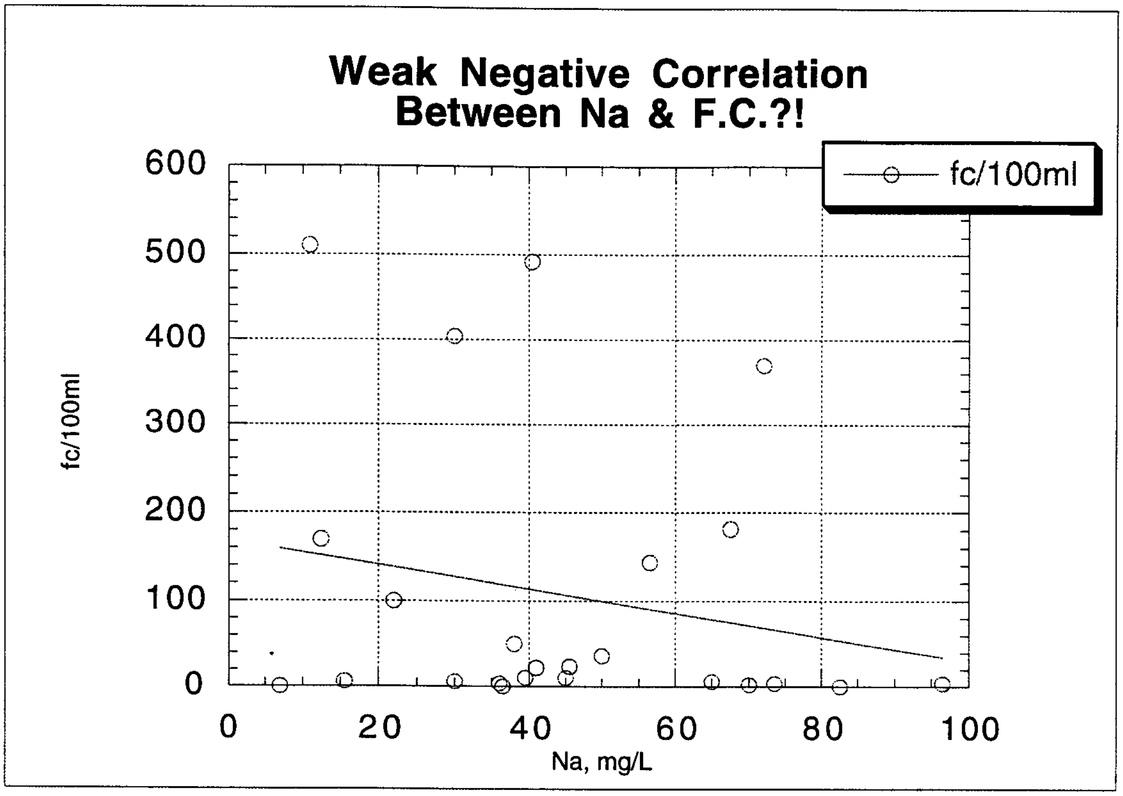


FIGURE 12

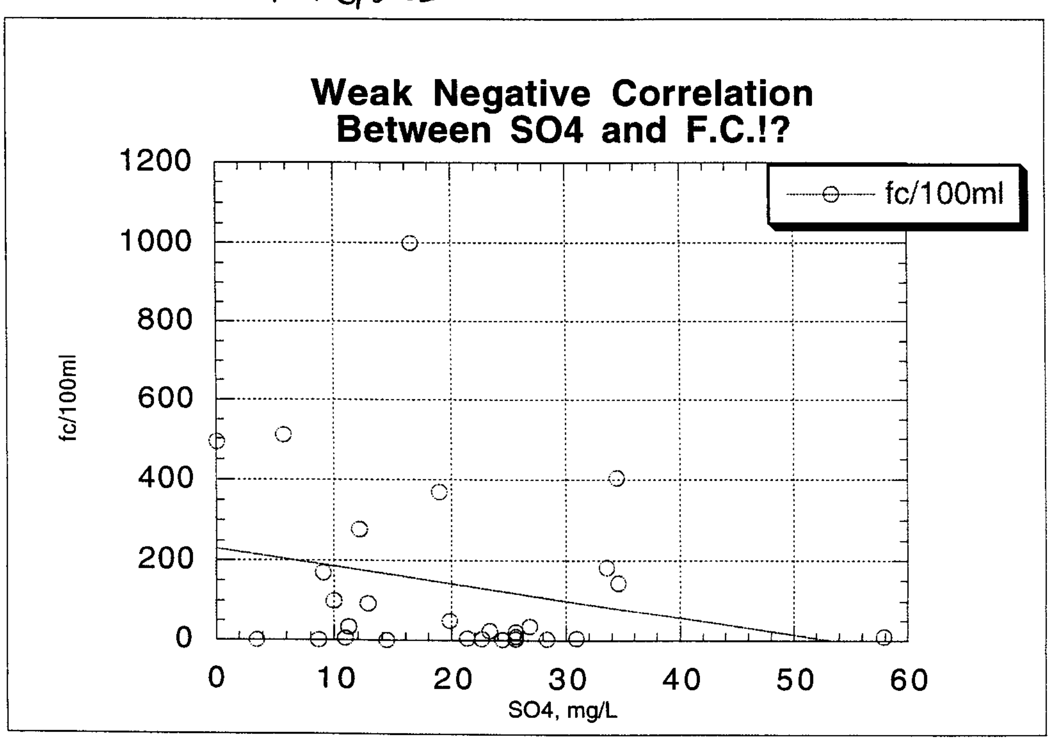
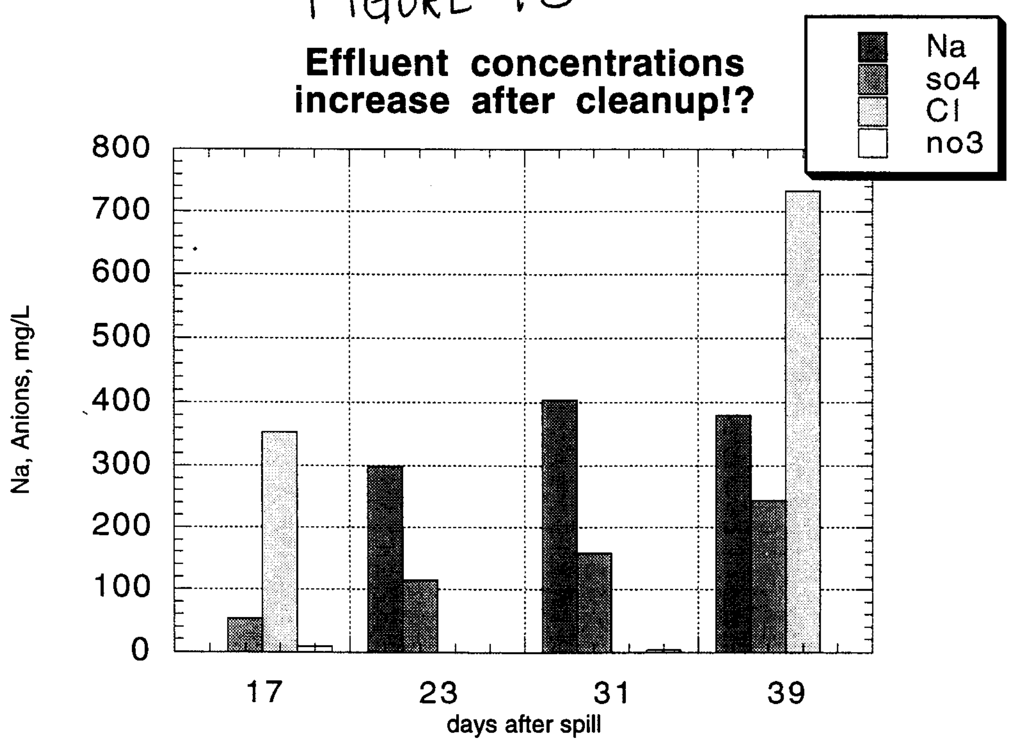


FIGURE 13



Effluent concentrations
increase after cleanup!?
Na
so4
Cl
no3
800
700
600
500
400
300
200
100
0
Na, Anions, mg/L
17
23
31
39
days after spill