

IRISH-DUTCH PEATLAND STUDY

GEOHYDROLOGY AND ECOLOGY

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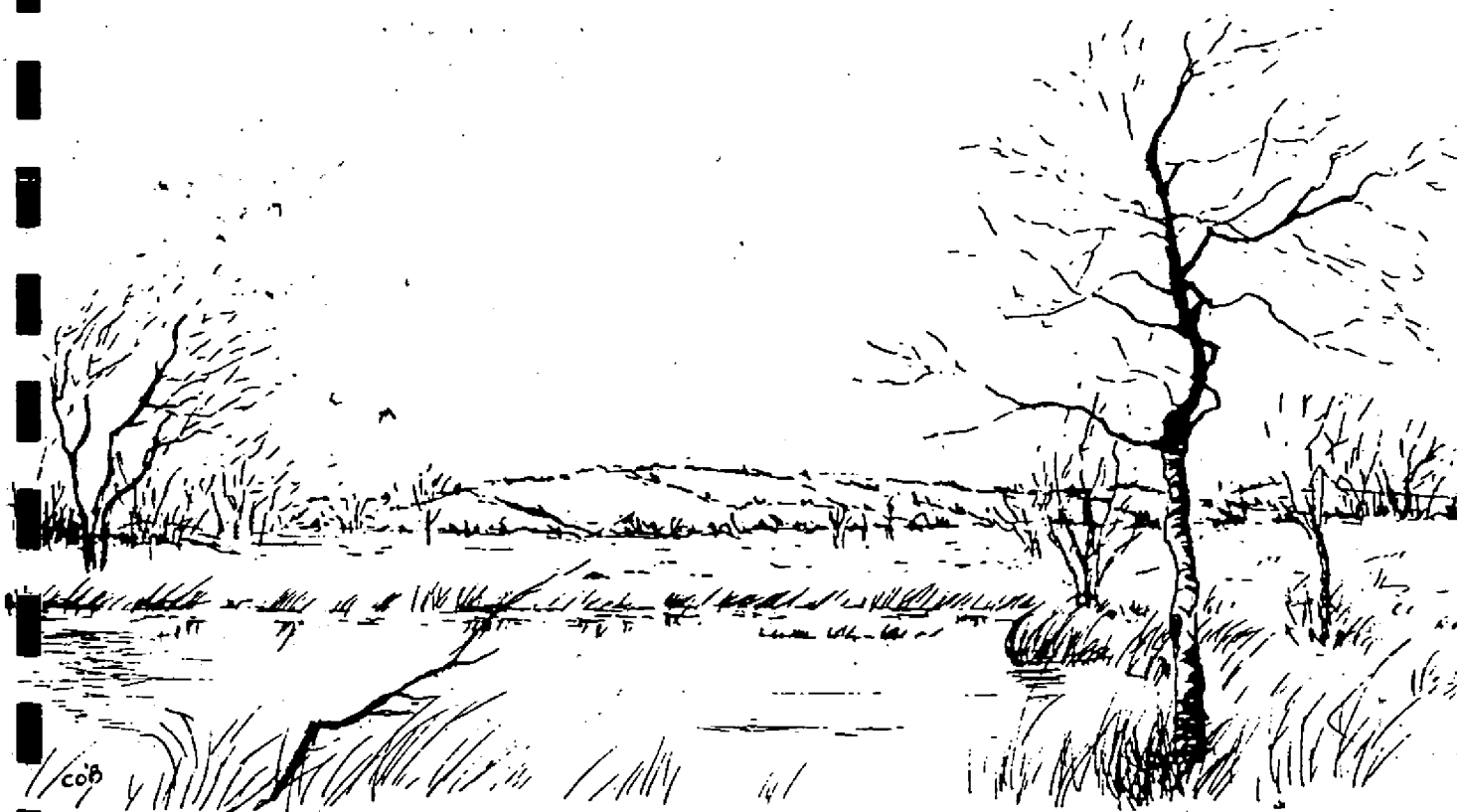
Preliminary Report on the
Hydrochemistry of Clara and Raheenmore
Raised Bogs, Co. Offaly.

By

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1 INTRODUCTION

This report contains an assessment of the usefulness of hydrochemistry as a tool to help describe the hydrological and hydrogeological functioning of both bogs. The report also contains an analysis of preliminary data gathered in 1990.

2 Review.

Various research workers have demonstrated that hydrochemical surveys are useful tools for assessing the hydrogeology of an area. (Lloyd 1969, Marsh 1977). Marsh (1977) demonstrated the usefulness of chloride distribution in showing the influences of geological structural control in the Lincolnshire limestone aquifer. Hydrochemical distribution maps can provide independent checks on piezometry and can reveal hydrogeological conditions which are not necessarily apparent from piezometry. (Lloyd and Heathcote 1985). Collins (1987) has demonstrated the use of hydrochemistry in typing groundwaters as a means of describing the major sources of groundwater to two fens in Norfolk.

In this study it is envisaged that identification of hydrochemical facies will allow a characterisation of water types and consequently permit identification of the lithological sequence(s) from which the water originated. This should help in describing the hydrogeological conditions which pertain to the investigation area.

Analysis of anion evolution and the electrochemical evolution sequence may be used as these sequences, when combined with other hydrochemical analysis and hydrogeological data, can provide considerable information on the flow in aquifer systems. (Daly 1989).

Siegel (1989) investigated the recharge-discharge function of bogs in Alaska by comparing concentrations of solutes and measurements of electrical conductivity in bog groundwater and surface water.

The aims of hydrochemical surveys in this study are as follows:

1. To describe the the general hydrochemistry of the peat and surrounding geological deposits.
2. To describe the hydrological processes operating at the peat-mineral deposit interface. For example, it may allow the identification of upwelling water from concealed springs in drains.
3. The identification of polluted wells in the area may be important as polluted groundwater may have serious impacts on the delicate lagg vegetation zones through eutrophication.
4. The most important use of hydrochemistry may be in the vicinity of the soaks where the minerotrophic vegetation indicate a mineral rich water supply in comparison to bog type water which has a chemistry comparable to rainwater. The vegetation associated with the soak areas is comparable to a fen plant community.

2.1 The Chemistry of Bog Waters.(Raised and Fen Peats)..

As the soaks have been identified as an important hydrological area it is appropriate to review the differences between fen waters and raised bog waters.

Raised peatlands contain water which has a low pH and dissolved constituents. Ombrotrophic peatlands contain abundant dissolved acids from the decomposition of plant materials. These peatlands are generally precipitation fed and since they receive no significant inputs of solid bases from groundwaters, the H^+ ion produced via decomposition is not neutralised (unlike fen peatlands which are primarily groundwater fed). Therefore raised bog waters are acidic and low in ionic strength. (Shotyk 1987).

Gorham (1955) has classified peatlands based on the total concentration of the based cations (K, Mg, Ca, +Na).

Peatland Type	Total concentration of Ca, Mg, Na+K mg/l
Raised Bog	3.3
Extremely Poor Fen	4.4
Poor fen	6.4
Transitional fen	9.7
Rich Fen	10.9
Very Rich Fen	28.8
Extremely Rich Fen	53.4

Tolonen and Seppanen (1976) found that combining Ca+Mg+Na+K and plotting against pH grouped bogs and fens well.

Clausen et al (1980) also showed that fen runoff was higher in pH, conductivity, alkalinity, calcium, magnesium, iron, sodium and manganese than raised bog runoff. However, raised bog waters were higher in colour, mercury and acidity. Shotyk (19--) states that due to the acidic, reducing nature and abundant dissolved organic matter in bog waters they are enriched with iron manganese and aluminium relative to normal freshwaters. Robinson (1930) has shown some bog waters in Virginia to contain up to 2ppm Al, 1-7ppm Mn and 1-40ppm Fe. In typical freshwaters their concentrations are .06ppm Al, .008ppm Mn and .04ppm Fe. (Drever 1982). Verry (1976) has shown that concentrations of organically derived nutrients are highest in the streamflow from watersheds containing ombrotrophic peatlands. Schwintzer and Tomberlin (1982) have shown that total silica is up to 0.3ppm in raised bogs as opposed to 7ppm in fens. Total dissolved boron is generally greater in peat waters than in freshwaters. (Tolonen & Seppanen, 1976).

An important consideration with the interpretation of hydrochemical data are the anthropogenic impacts on systems.

2.2 Anthropogenic Impacts - their importance.

Comparisons of the quality of run off from natural and disturbed (by peat mining) Minnesota peatlands indicate that disturbed peatlands have higher concentrations of colour, suspended sediment, acidity, potassium, iron, aluminium and

sodium. Grootjans et al (1982) point to the importance of recognising polluted groundwater as a possible threat to the delicate lagg zone system. Polluted systems could also confuse interpretation of data.

3 Methods

A number of preliminary hydrochemical surveys have been carried out to date on Clara Bog in April and June 1990. Figure 1 shows the location of sampling sites. Samples of water were taken from piezometers at different depths on the bog, drainage water was sampled and ground water samples were taken from wells and springs situated in the surrounding mineral deposits. pH, conductivity and temperature were measured on site whilst other analytes were determined in the laboratory using standard procedures. All samples were maintained at less than 4°C to prevent chemical decomposition.

4 Results and Discussion

The results of the surveys are shown in the Appendix. The CHEMPROC computer package was used to analyse the data. All concentrations are in ppm. The code refers to the sample number. The ion balance error, ionic ratio is computed and each sample is given a classification code (eg F3-Ca HCO3+) based on its chemistry. The key to this classification system is shown overleaf.

It can be noticed from the results that the bog waters have high ion balance errors indicating an imbalance of cations and anions. These unknowns are probably organic acids (Lamar & Goerlitz 1966 and Puustjarvi 1968). Such ion imbalances are common in coloured, low pH waters (Hem 1970). Malmer (1963) states that other sources of error may include cations measured analytically that were bound to colloids in the undisturbed water.

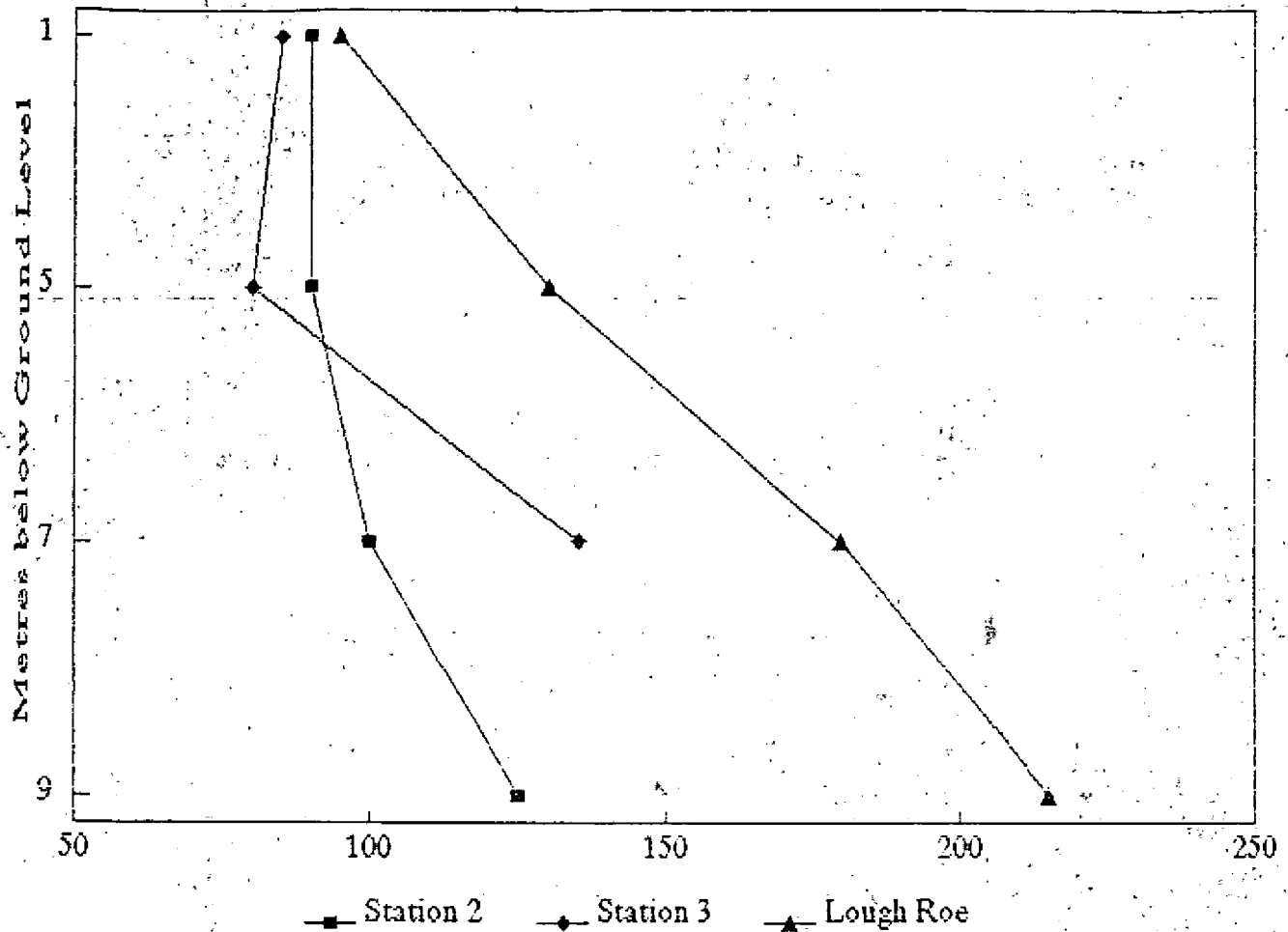
The results show the peat waters to be acidic and low in conductivity. The results agree well with the literature discussed above. The samples from the mineral deposits are of near neutral pH and calcium bicarbonate rich. Samples from drains on the periphery of the bog are also similar to the latter possibly indicating upwelling water to the drain. This will be discussed later.

Hydrochemical profiling was performed at sites on the bog to examine the chemical status of water at different depths in the peat. Figures 2 & 3 allow a comparison of pH and conductivity at three stations on Clara East. They clearly show an increase in conductivity with depth, the greatest at Lough Roe.

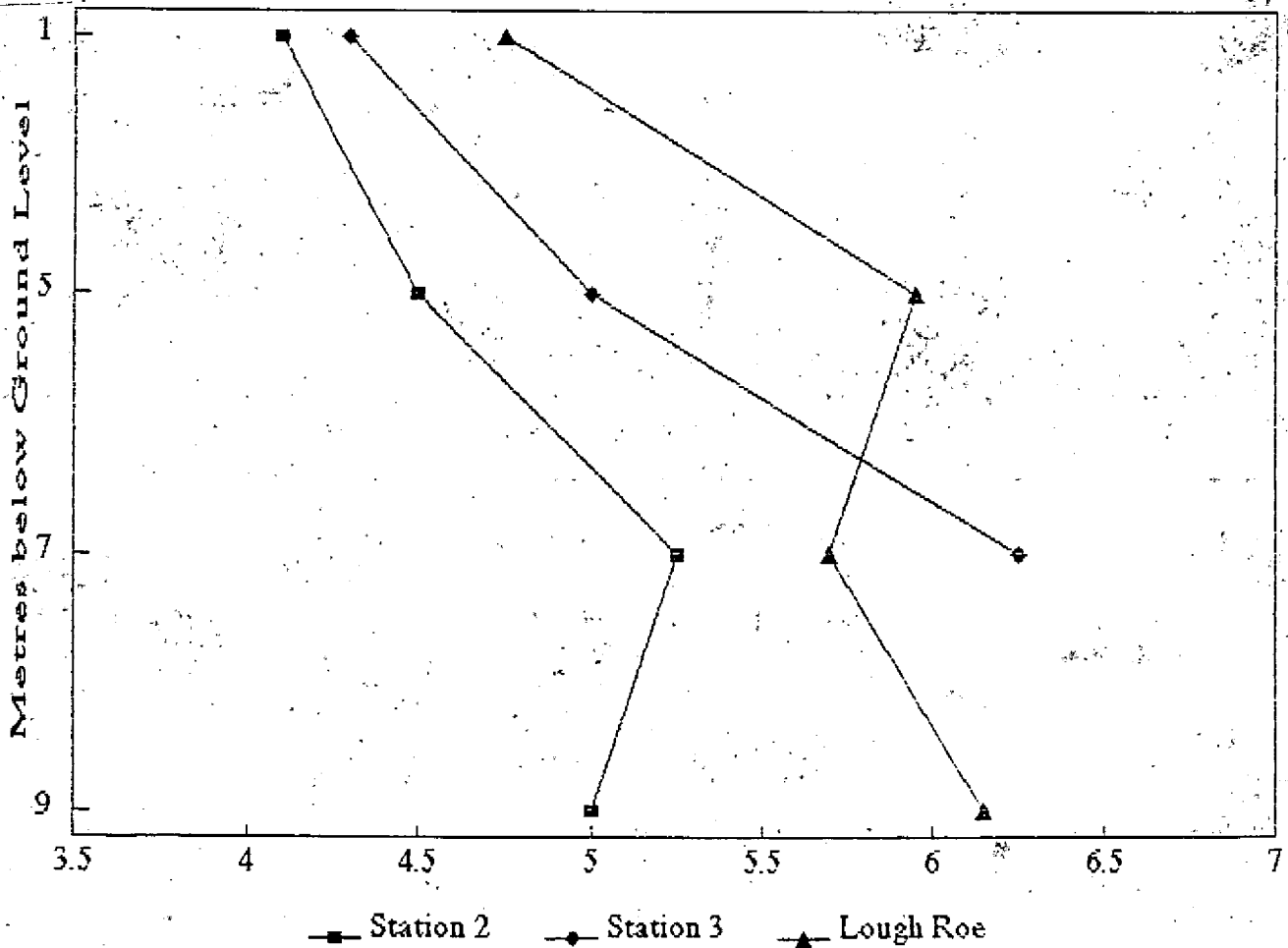
The situation with pH is more complicated but the trend is increasing with depth. These results probably indicate the former fen like situation which occurs prior to the development of a raised bog. This fen peat would have been predominantly fed by mineral groundwater thus the increasing values with depth. An interesting result is that at Lough Roe. Conductivity is greater than at the other sites - a possible upwelling spring may be

Figures 2+3 The diagrams illustrate the results of hydrochemical profiling at Lough Roe and other stations on the bog.

Conductivity (us/cm)



pH



suggested. This of course is speculative and a more rigorous hydrochemical profiling will be necessary.

Groundwater was sampled on a transect across the esker and the bog (fig4). The results of this transect are simplistically illustrated in figure 5. Groundwater samples were taken from the boreholes CLBH2 and CLBH3, the drain and piezometers along the bog transect. One can see there is a large decrease in most parameter concentrations at the bog-esker interface and on the bog. Exceptions to this would be sodium, chlorine and iron which do not change or increase slightly in peat waters. As raised bogs are predominantly rain fed one would expect sodium and chloride to be high. The slightly higher values of iron are in agreement with the literature.

A method developed by van Wirdum(1980) and later used by Grootjans et al (1982) which was employed to explain the sources of groundwater to wetland situations in The Netherlands was used. By plotting ionic ratio against the natural log of corrected conductivity values one can see where the water is situated on the athmocline - lithocline gradient. Ionic ratio is the ratio between calcium and chlorine in waters. It is calculated as follows :

$$\text{Ionic Ratio} = \text{Ca}(\text{meq/l}) / \text{Ca}(\text{meq/l}) + \text{Cl}(\text{meq/l})$$

Low conductivity and mineral poor water (atmocline) is rainwater like. This water would have low calcium. High conductivity, mineral rich water is lithoclinic in nature. This water has high calcium and relatively low chlorine concentrations. Thassoclinic

FIGURE 4

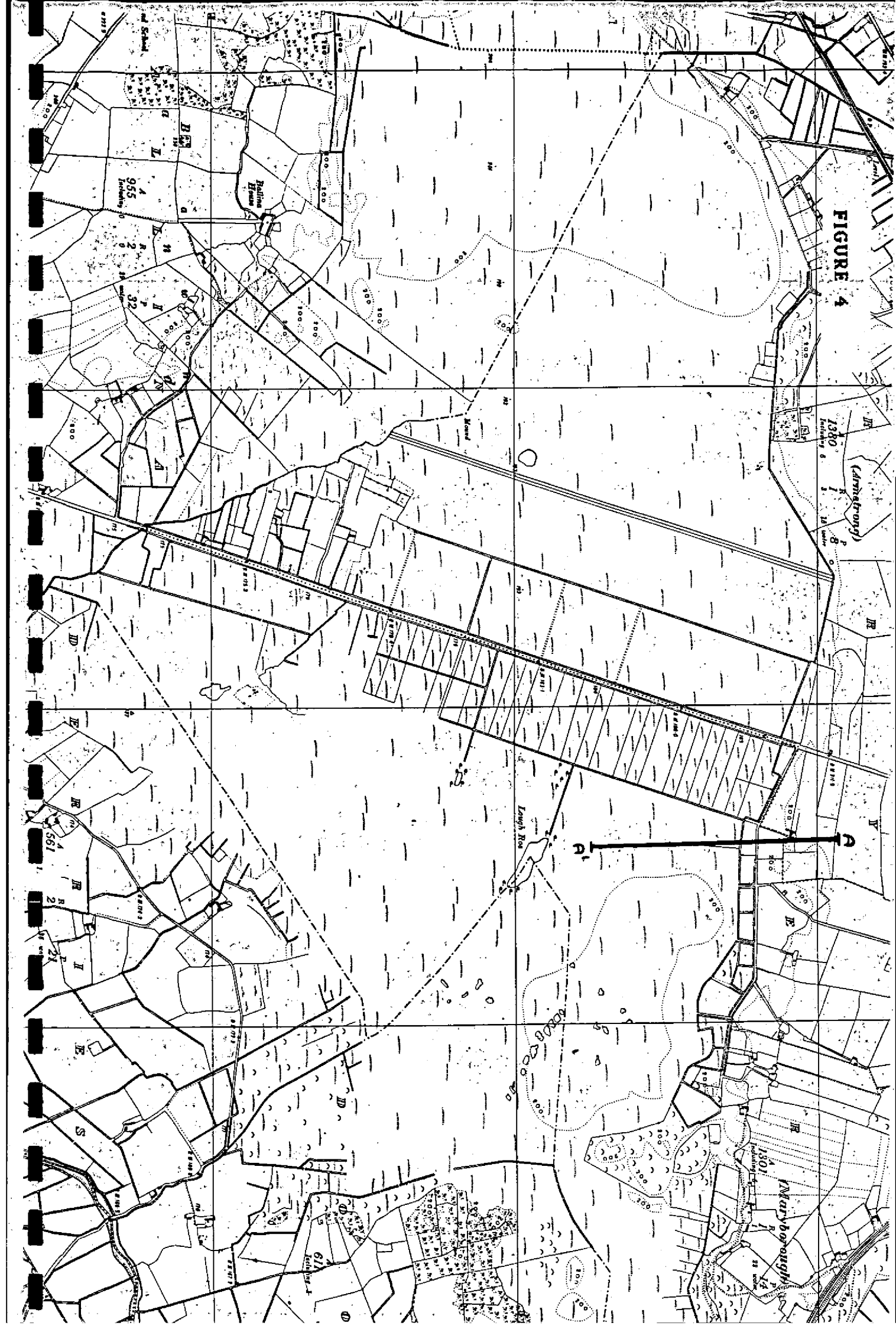
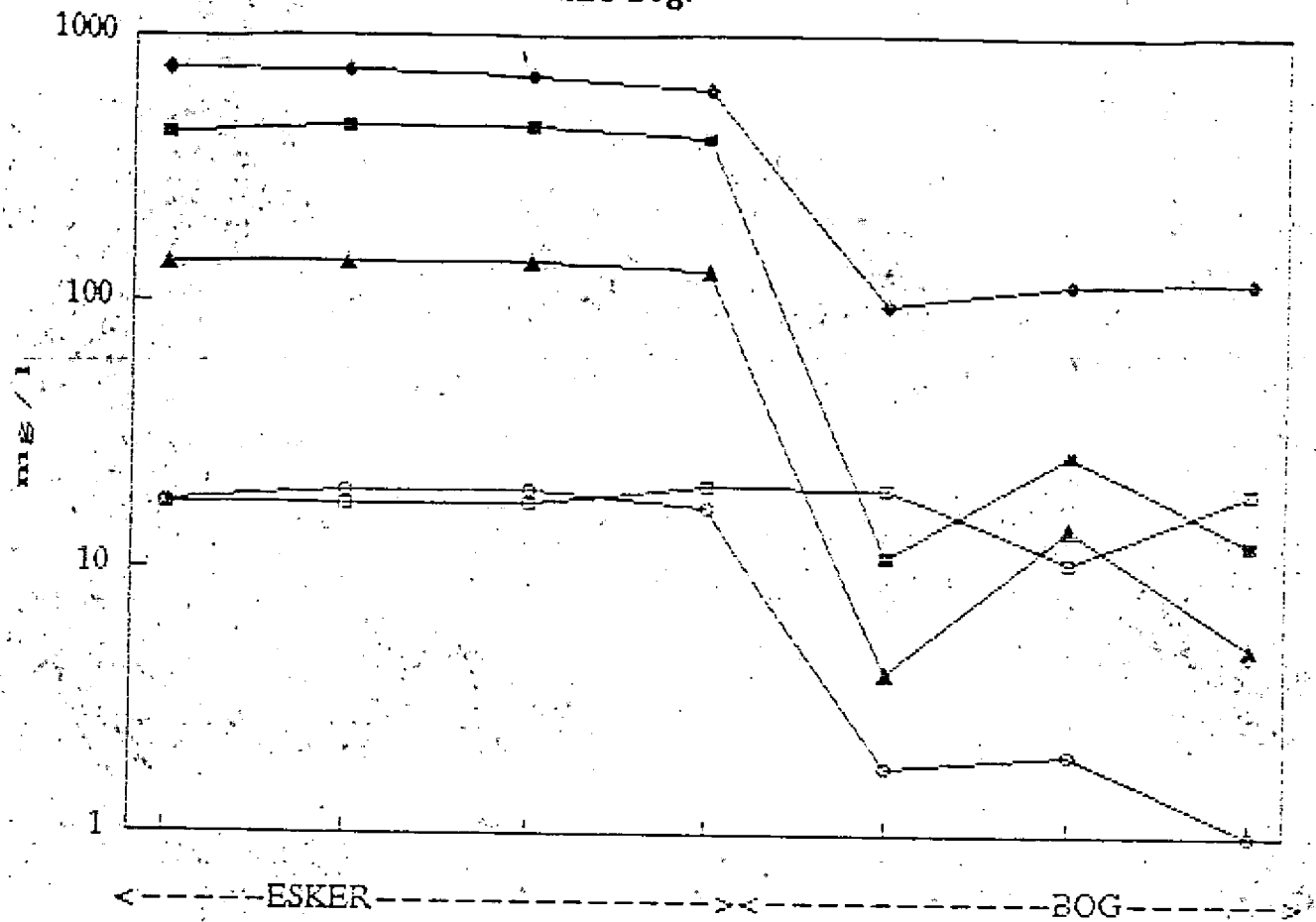
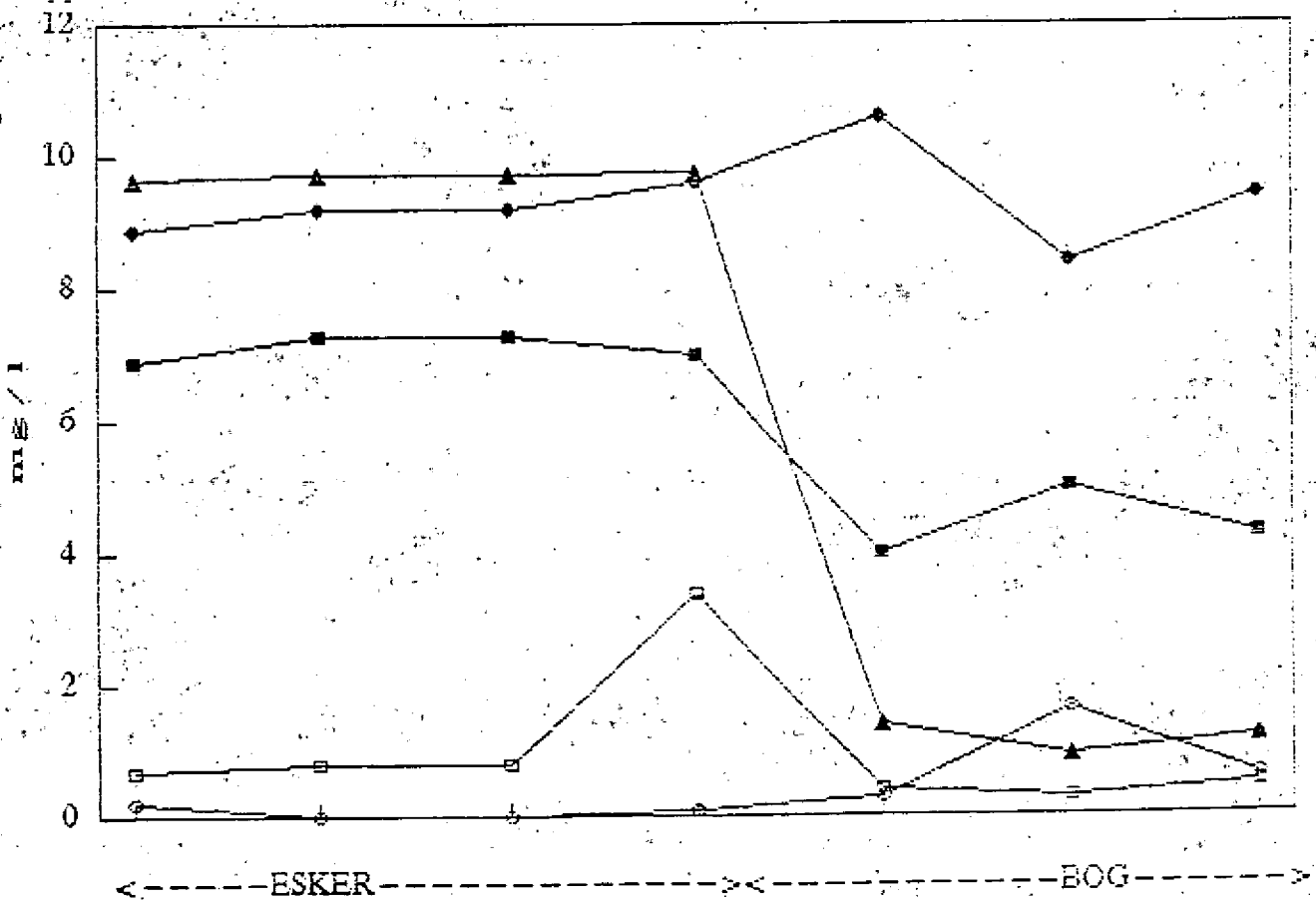


Figure 5 : The results of hydrochemical analysis on waters on a transect across the Esker and Bog.



Note : E.C. is expressed as us/cm.



Note : pH is expressed as pH units.

water is approaching the composition of sea water. This water would be high in chlorine and conductivity. Figure 6 is a plot of the water samples using this technique.

It is clear a number of water types are grouped on the plot. Bog water is situated in the region of the athmocline as would be expected. (Type I) Groundwater from the surrounding eskers are in the lithocline sector. (Type II). Between the athmocline and the lithocline a number of samples are grouped. These are mainly water samples from the drains at the interface between the esker and the bog. (Type III). This probably indicates a situation where mixing is occurring of the bog derived water and upwelling water from the underlying gravels in the drain. Two of the samples were not included because they were polluted.

5. Future Work.

An extensive hydrochemical survey, particularly in the soak areas will be undertaken in March 1991. The analytical techniques applied will be similar to those described above. It is hoped that the results of this survey will lead to a better understanding of the hydrological processes operating around and on the bog.

Ln E.C. -20, v. Ionic Ratio

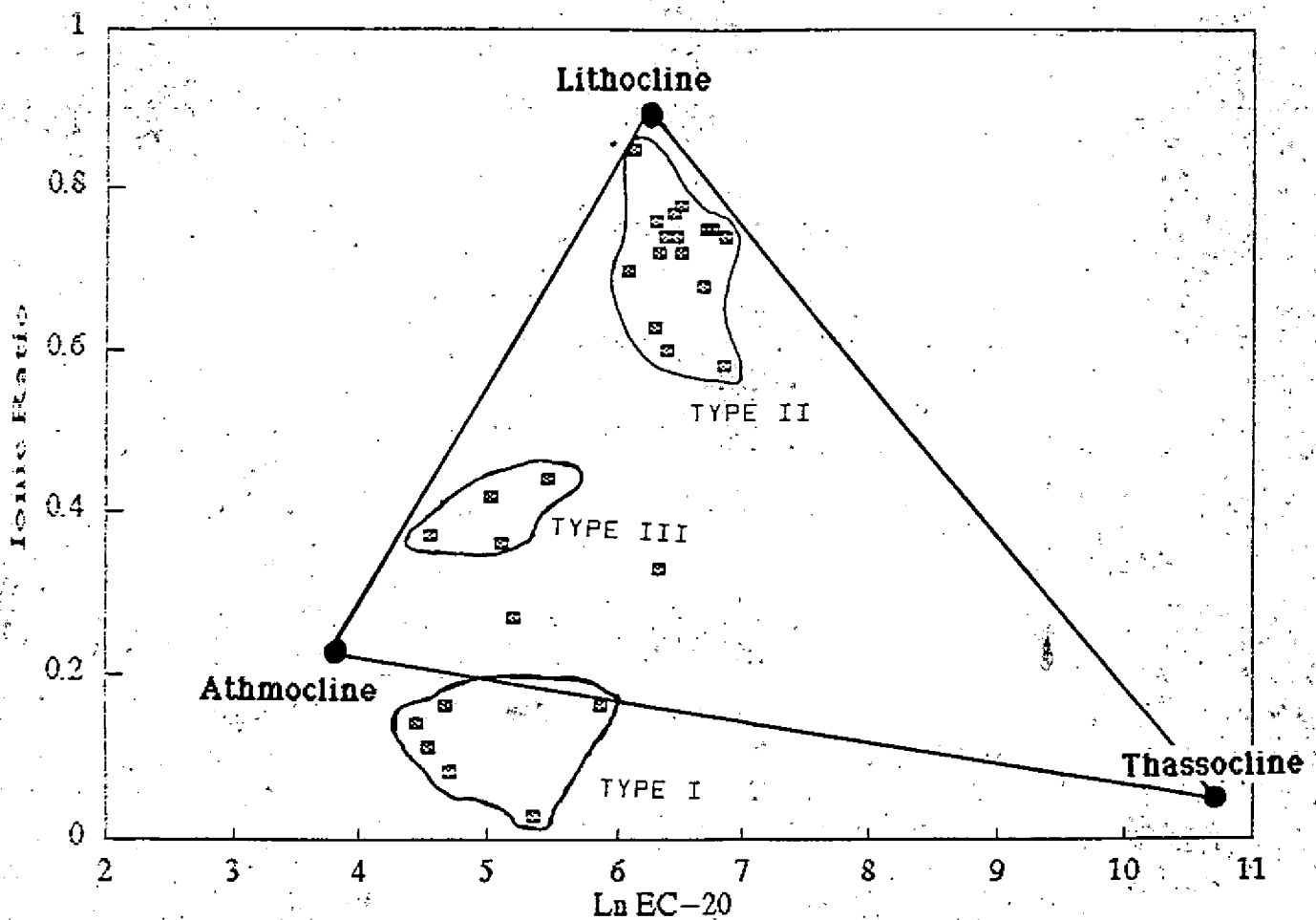


Figure 6: Diagram showing a plot of ionic ratio versus the Ln Electrical Conductivity. The three water types are illustrated.

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APPENDIX

Name	WELL CLARA	Well Clara	Spring Clara	CL BH 1 CLARA	CL BH 3 CLARA	V-NOTCH CLARA
City						
Map	1	1	1	1	1	1
Date	1990.0615	1990.0615	1990.0615	1989.1127	1990.0807	1990.0504
Unit	3	3	3	3	3	3
Code	2	8	9	3	4	15
Depth						
Altitude						
Filter#						
X-Coord.						
Y-Coord.						
Type						
EC	<u>1008</u>	841	743	534	<u>933</u>	<u>99</u>
pH	<u>6.8</u>	6.9	7	7.1	<u>7.5</u>	<u>4.3</u>
Temp.	20	10.001	10.001	10.001	10.001	10.001
Na	25.9	17.8	9.7	8.6	14.1	9
K	42.9	9.7	1.9	.8	1.4	.3
Mg	15.83	17.09	12.58	4.77	10.68	1.12
Ca	162	108.6	99.33	112.9	177.7	7.78
NH4	.17	.02	0	4.6	.09	.02
Cl	<u>52.6</u>	18.4	17.3	15.8	<u>26.1</u>	17.9
HCO3	<u>451.54</u>	375.88	366.12	402.73	478.43	26.3
SO4	42.6	55.7	20.8	1	71	1
NO3	<u>118.5</u>	<u>21.3</u>	9.9	.1	<u>31.8</u>	.3
Fe	.1	0	0	.01	1.2	.15
Mn	.01	.07	0	.171	.142	.004
Al						
SiO2						
o.PDA*			0	0	0	0
Calcite	0.03	-0.24	-0.17	0.03	0.64	-4.92
Dolomit	-0.69	-1.12	-1.07	-1.14	0.22	-10.50
Siderit	-11.26	-14.44	-14.32	-11.18	0.31	-14.98
Rhodoch	-11.38	-11.46	-14.35	-11.21	-10.80	-14.98
Gypsum	-1.47	-1.44	-1.86	-3.13	-1.19	-3.99
OH-Apat	-33.32	-34.31	-42.81	-41.98	-39.55	-65.49
Chalced	-12.20	-12.08	-12.08	-12.08	-12.08	-12.08
Quartz	-11.70	-11.53	-11.53	-11.53	-11.53	-11.53
Gibbsit	-8.62	-9.14	-9.13	-9.13	-9.13	-12.37
Kaolini	-40.25	-41.12	-41.11	-41.10	-41.10	-47.59
pe						
Viviani	-56.64	-65.36	-70.98	-61.68	-27.71	-71.65
P CO2	-1.21	-1.44	-1.55	-1.61	-1.95	0.05
Sum +	11.20	7.53	6.29	6.56	9.91	0.92
Sum -	-11.28	-7.86	-6.91	-6.97	-10.03	-1.01
error %	-0.32	-2.17	-4.68	-3.04	-0.65	-4.41
TIC mg/l	117.77	96.48	89.60	94.55	100.83	769.08
Ion.rat	0.58	0.72	0.72	0.76	0.75	0.16
Na*	-3.33	7.57	0.08	-0.18	-0.41	-0.95
K*	41.86	9.33	1.56	-0.31	0.88	-0.36
Mg*	12.30	15.85	11.42	3.71	8.93	-0.08
SO4*	35.19	53.11	18.36	-1.23	67.32	-1.52
Ca*	160.87	108.20	98.96	112.56	177.14	7.40
Na+K+Mgm	3.53	2.43	1.51	0.77	1.53	0.48
Na+K+Mgc	1.57	0.55	0.52	0.47	0.78	0.54
K-20	937.16	668.84	560.10	547.88	858.95	106.24
EC-20	892.08	744.29	657.55	472.59	825.71	87.61
error %	2.46	-5.34	-8.00	7.38	1.97	9.61
ANC	7.37E0	6.13E0	5.98E0	6.59E0	7.82E0	4.31E-1
Buf.CO2	5.10E-7	4.73E-7	4.61E-7	4.73E-7	8.01E-7	1.15E-4
Buf.tot	5.57E-3	4.33E-3	3.38E-3	2.96E-3	1.38E-3	1.47E-1
HCO3H	F3-CaHCO3+	F3-CaHCO3+	F3-CaHCO3+	F3-CaHCO3	F3-CaHCO3+	F*-CaClO
Tot H	F3-CaHCO3+	F2-CaHCO3+	F2-CaHCO3+	F2-CaHCO3	F3-CaHCO3+	F*-CaClO

Name	West Well	2m Piez NW	4M Piez NW	Drain Edge	Drain Edge	Drain Edge
City	Clara	Clara	Clara	Clara	Clara	Clara
Map	1	1	1	1	1	1
Date	1990.0515	1990.0515	1990.0515	1990.0615	1990.0615	1990.0615
Unit	3	3	3	3	3	3
Code	11	19	20	29	30	33
Depth						
Altitude						
Filter						
X-Coord.						
Y-Coord.						
Type						
EC	793	78	137	485	631	190
pH	6.9	5.4	6.8	6.4	7	6
Temp.	10.001	10.001	10.001	10.001	10.001	10.001
Na	12.7	8.1	8.5	8.6	9.6	9.5
K	11.4	1.4	1.9	1.2	3.4	5
Mg	8.5	1.1	2.4	8.01	9.744	2.33
Ca	194.2	9	18	82.83	132	21.77
NH4				96	0	.2
Cl	41.1	18.6	21.5	15.7	20.7	13.4
HCO3	331.84	7.32	38.27	273.36	414.93	75.66
SO4	30	26.5	35.5	12.6	16.9	2.5
NO3	8.26	1.83	2.67	.1	3.3	2.5
Fe	.05	.24	.36	.9	.1	3.3
Mn				.29	0	.57
Al						
SiO2						
o.P04				0	0	0
Calcite	-0.06		-1.99	-0.95	-0.01	-2.39
Dolomit	-1.31		-4.68	-2.74	-0.98	-5.58
Siderit	-11.51		-12.41	-12.03	-11.29	-1.38
Rhodoch	-11.53		-12.41	-12.05	-14.32	-12.90
Gypsum	-1.52		-2.16	-2.11	-1.87	-3.21
OH-Apat	-33.22		-37.94	-46.57	-42.32	-51.67
Chalced	-12.08		-12.08	-12.08	-12.08	-12.08
Quartz	-11.53		-11.53	-11.53	-11.53	-11.53
Gibbsit	-9.14		-9.15	-9.22	-9.13	-9.37
Kaolini	-41.12		-41.13	-41.28	-41.11	-41.57
pe						
Viviani	-56.49		-56.17	-63.84	-62.05	-30.52
P CO2	-1.50		-2.31	-1.07	-1.50	-1.21
Sum +	10.95		1.47	5.10	7.70	1.80
Sum -	-2.08		-1.97	-5.09	-7.60	-1.70
error %	21.51		14.57	0.12	0.68	2.83
TIC mg/l	84.83		10.62	106.89	101.34	53.49
Ion.rat	0.68		0.27	0.70	0.74	0.42
Na*	-10.14		-3.45	-0.13	-1.90	2.05
K*	10.58		1.47	0.89	2.99	-0.27
Mg*	5.74		0.96	6.96	8.35	1.43
SO4*	24.21		32.47	10.39	13.98	0.61
Ca*	193.32		17.54	82.49	131.56	21.48
Na+K+Mgm	1.54		0.62	1.06	1.31	0.60
Na+K+Mgc	1.23		0.64	0.47	0.62	0.40
K-20	796.46		179.45	437.32	645.44	150.89
EC-20	701.80		121.24	429.23	558.43	168.15
error %	6.32		19.36	0.93	7.23	-5.41
ANC	5.43E0		6.27E-1	4.47E0	6.78E0	1.24E0
Buf.CO2	4.73E-7		5.10E-7	9.75E-7	4.61E-7	2.33E-6
Buf.tot	3.76E-3		5.93E-4	1.02E-2	3.80E-3	7.40E-3
HCO3H	F3-CaHCO3		F0-CaMIS	F3-CaHCO3+	F3-CaHCO3+	F1-CaHCO3o
Tot H	F3-CaHCO3		F0-CaMIS	F2-CaHCO3+	F2-CaHCO3+	F0-CaHCO3o

Name	LA DeePiez	Road Drain	Borehole NE	Drain CPark	Drain NEast	DUG WELL NW
City	Clara	Clara	Clara	Clara	Clara	CLARA
Map	1	1	1	1	1	1
Date	1990.0615	1990.0615	1990.0515	1990.0515	1990.0615	1990.0515
Unit	3	3	3	3	3	3
Code	21	32	6	31	34	1
Depth						
Altitude						
Filterl						
X-Coord.						
Y-Coord.						
Type						
EC	120	151	844	262	640	1029
pH	4.3	3	6.3	6.5	6.7	6.9
Temp.	10.001	10.001	10.001	10.001	10.001	10.001
Na	9.4	15.4	10	11.2	9.4	40.3
K	.5	.8	1	1.4	2.7	41
Mg	1.218	2.96	22.4	3.1	9.14	1.766
Ca	5.2	3.166	203.4	52.4	121	66
NH4	.2	.16			0	
Cl	19.6	36.1	32.4	29.4	19	58.7
HCO3	12.59	2.01	540.8	87.84	373.44	156.16
SO4	1	1.8	82.7	22	15.8	62
NO3	.1	.1	43	1.87	2.7	8.4
Fe	.6	.5	76	.92	21.1	.03
Mn	.17	.36	08	.08	0	
Al						
SiO2						
o.PO4	.63	0				
Calcite	-5.36		-0.47	-1.50	-0.39	-0.80
Dolomit	-11.17		-1.73	-4.05	-1.73	-3.00
Siderit	-15.24		-11.93	-12.38	0.70	-11.78
Rhodoch	-15.24		-11.97	-12.39	-14.66	-11.80
Gypsum	-4.15		-1.11	-1.98	-1.93	-1.52
DH-Apat	-57.33		-36.87	-37.69	-35.41	-35.09
Chalced	-12.08		-12.08	-12.08	-12.08	-12.08
Quartz	-11.53		-11.53	-11.53	-11.53	-11.53
Gibbsit	-12.36		-9.26	-9.20	-9.16	-9.14
Kaolini	-47.56		-41.35	-41.23	-41.17	-41.12
pe						
Viviani	-65.67		-58.55	-57.35	-20.16	-56.17
P.CO2	-0.19		-0.70	-1.65	-1.24	-1.81
Sum +	0.82		11.80	3.33	7.86	6.06
Sum -	-0.83		-10.85	-2.69	-6.87	-5.46
error %	-0.69		4.22	10.57	6.76	5.20
TIC mg/l	411.34		232.05	31.14	109.07	40.31
Ion.rat	0.11		0.74	0.44	0.74	0.33
Na*	-1.49		-8.01	-5.14	-1.16	7.68
K*	-0.39		0.36	0.82	2.32	39.83
Mg*	-0.10		20.22	1.13	7.86	-2.18
SO4*	-1.76		78.13	17.86	13.12	53.73
Ca*	4.78		202.70	51.77	120.59	64.74
Na+K+Mgm	0.51	0.91	2.30	0.78	1.23	2.95
Na+K+Mgc	0.59	1.08	0.97	0.88	0.57	1.76
K-20	94.20	421.21	957.23	290.22	587.28	560.03
EC-20	106.20	133.64	746.94	231.87	566.40	909.78
error %	-5.99	51.83	12.34	11.18	1.81	-23.80
ANC	2.06E-1	-9.67E-1	8.81E0	1.44E0	6.10E0	2.56E0
Buf.CO2	1.15E-4	2.30E-3	1.20E-6	8.01E-7	5.75E-7	4.73E-7
Buf.tot	7.85E-2	2.01E-1	2.41E-2	2.66E-3	6.83E-3	1.84E-3
HCO3H	F*-CaCl0	F*-HC1	F4-CaHCO3	F1-CaHCO3	F3-CaHCO3	F2-CaMIC+
Tot H	F*-CaCl0	F*-HC1	F3-CaHCO3	F1-CaHCO3	F2-CaHCO3	F1-CaMIC+

Name	CL BH2 G	CL BH2 L	4M Piez W	Bog Drain	CL BH2 G3	Spring SW
City	Clara	Clara	Clara	Clara	Clara	Clara
Map	1	1	1	1	1	1
Date	1990.0807	1990.0807	1990.0515	1990.0515	1990.0807	1990.0515
Unit	3	3	3	3	3	3
Code	14	13	24	17	12	5
Depth						
Altitude						
Filter				?		?
X-Coord						
Y-Coord						
Type						
EC	248	211	160	512	760	731
pH	7.3	7.6	5.9	6.7	6.9	6.7
Temp.	10.001	10.001	10.001	10.001	10.001	10.001
Na	9.2	9.8	6.8	9.2	8.9	10.7
K	.8	1	1.1	1.3	.7	4.2
Mg	9.73	9.44	1.1	5.5	9.64	7.1
Ca	140	128.5	14.8	128.3	141.77	209.1
NH4	1	0			.58	
Cl	17.5	16.5	17.6	33.3	17.3	31.3
HCO3	456.5	417.41		204.96	439.37	366
SO4	19.6	18.5	20.7	30.5	18	40
NO3	.8	9.4	2.27	7.44	3.5	7.76
Fe	.025	.116	1.03	.38	.189	.052
Mn	.221	.017			0	
Al						
SiO2						
α.P04	0	0			0	
Calcite	-0.35	0.58		-0.61	-0.06	-0.19
Dolomit	-0.29	0.20		-2.41	-1.11	-1.69
Siderit	-10.95	-10.68		-11.88	-11.37	-11.67
Rhodoch	-10.98	-10.71		-11.89	-14.40	-11.70
Gypsum	-1.79	-1.84		-1.60	-1.82	-1.37
OH-Apat	-40.72	-39.46		-34.95	-42.74	-34.23
Chalced	-12.08	-12.08		-12.08	-12.08	-12.08
Quartz	-11.53	-11.53		-11.53	-11.53	-11.53
Gibbsit	-9.12	-9.13		-9.16	-9.14	-9.16
Kaolini	-41.09	-41.11		-41.16	-41.12	-41.17
pe						
Viviani	-61.27	-60.51		-56.92	-62.37	-57.12
P CO2	-1.76	-2.10		-1.50	-1.38	-1.26
Sum +	8.01	7.42		7.10	8.05	11.24
Sum -	-8.15	-7.62		-4.87	-7.91	-7.49
error %	-0.87	-1.34		18.67	0.85	20.04
TIC mg/l	100.48	86.76		59.99	112.68	106.75
Ion.rat	0.78	0.77		0.63	0.78	0.75
Na*	-0.53	0.63		-9.31	-0.72	-6.70
K*	-0.35	0.67		0.64	-0.34	3.58
Mg*	8.55	8.33		3.26	8.48	5.00
SO4*	17.13	16.18		25.81	15.56	35.59
Ca*	139.62	128.15		127.58	141.40	200.43
Na+K+Mgm	1.20	1.23		0.89	1.18	1.16
Na+K+Mgc	0.52	0.49		1.00	0.52	0.94
K-20	671.83	635.61		542.30	667.62	817.41
EC-20	661.98	629.24		453.12	672.60	646.93
error %	0.74	0.50		8.96	-0.37	11.64
ANC	7.46E0	6.82E0		3.35E0	7.18E0	5.99E0
Buf.CO2	5.75E-7	9.75E-7		5.75E-7	4.73E-7	5.75E-7
Buf.tot	2.10E-3	9.82E-4		3.78E-3	5.05E-3	6.56E-3
HCO3H	F3-CaHCO3+	F3-CaHCO3+		F2-CaHCO3	F3-CaHCO3+	F3-CaHCO3
Tot H	F2-CaHCO3+	F2-CaHCO3+		F2-CaHCO3	F2-CaHCO3+	F3-CaHCO3

Name	LR 2.6mPiez	Pools	E Bog	Rahan	Bridge	Spring	SW M	ST2	DeePiez	V. Notch
City	Clara		Clara		Clara		Clara		Clara	Raheenmon
Lap	1		1		1		1		1	
Date	1990.0515		1990.0615		1990.0515		1990.0515		1990.0615	1990.050
Unit	3		3		3		3		3	
Code	25		18		23		7		26	2
Depth										
Altitude										
Filter										
Coord.	?					?			?	?
Type										
TC	110		97		581		731		119	18
PH	5.2		4		7.1		6.7		5	6
Temp.	10.001		10.001		10.001		10.001		10.001	10.00
Na			10.6		13		10.4		8.4	8
Mg			.4		5.6		3.2		.3	
Ca			1.42		5.6		5.7		.913	1.4
HA			4.066		138.2		10.4		14.5	22.4
Cl			.1						2.21	.0
HCO3	21.5		20.2		40.1		24.5		10.7	17
SO4	39.04		11.13		165.9		317.2		26.85	43.9
NO3			1.8		106		40		2	3
Fe			.1		8.5		8.36		2	
Mn	.06		.3		.27		.17		1.64	.1
Al	.02		.02						.09	.05
SiO2										
Calcite	-3.97		-5.72		-0.30		-1.46		-3.98	-1.7
Dolomit	-19.47		-11.73		-1.81		-3.01		-19.95	-4.4
Siderit	-13.94		-15.50		-11.60		-11.63		-3.10	-12.2
Rhodoch	-13.94		-15.50		-11.61		-11.66		-14.31	-12.2
Gypsum	-14.96		-4.00		-1.06		-2.41		-3.43	-3.0
HK-Apat	-50.11		-68.98		-32.74		-39.99		-59.30	-45.7
Chalced	-12.08		-12.08		-12.08		-12.08		-12.08	-12.0
Quartz	-11.53		-11.53		-11.53		-11.53		-11.53	-11.5
Gibbsitt	-10.14		-13.25		-9.13		-9.16		-10.54	-9.4
Kaolinit	-43.12		-49.33		-41.10		-41.16		-43.91	-41.2
Miviani	-62.08		-72.87		-55.80		-56.64		-35.28	-61.7
BO2	-0.68		0.16		-2.00		-1.30		-0.64	-2.3
Sum +	0.40		0.88		7.56		1.47		1.28	14.6
Sum -	-1.25		-0.89		-5.69		-6.81		-0.82	-1.2
Error %	-51.13		-0.50		14.11		-64.45		21.65	10.6
TIC mg/l	137.23		899.47		381.90		94.02		147.26	11.4
on.rat	0.14		0.08		0.60		0.16		0.37	0.3
Na*	-11.95		-0.63		-9.29		-3.22		2.45	-1.4
K*	-0.43		-0.40		4.80		2.71		-0.21	-0.3
Mg*	-1.44		0.06		2.91		4.05		-0.72	0.2
SO4*	-3.03		-1.05		100.35		36.55		0.49	1.0
Ca*	7.54		3.63		137.34		9.87		14.27	22.0
Na+K+Mgm	0.00		0.58		1.17		1.00		0.37	0.4
Na+K+Mgc	0.64		0.60		1.20		0.73		0.32	0.5
-20	85.50		110.87		598.70		352.76		95.30	139.9
ED-20	97.35		85.84		514.18		646.93		105.31	164.6
Error %	-6.48		12.72		7.59		-29.43		-4.99	-8.1
ANC	6.40E-1		1.82E-1		2.71E0		5.19E0		4.40E-1	7.19E-
Buf.CO2	1.45E-5		2.30E-4		4.73E-7		5.75E-7		2.30E-5	4.73E-
Buf.tot	2.48E-2		1.72E-1		1.21E-3		6.06E-3		2.72E-2	5.43E-
HCO3H	FO-CaHCO3		F*-NaClO		F2-CaMIC		F3-CaHCO3		F*-CaHCO3	FO-CaHCC
tot H	F*-CaHCO3		F*-NaClO		F2-CaMIC		F*-CaHCO3		F*-CaHCO3	FO-CaHCC

Name	Tinker Weir	TinkerSprin
City	Raheenmore	Raheenmore
Map	1	1
Date	1990.0504	1990.0504
Unit	3	3
Code	28	10
Depth		
Altitude		
Filterl		
X-Coord.		
Y-Coord.		
Type		
EC	500	519
pH	7.5	7.4
Temp.	10.001	10.001
Na	9.6	10.6
K	4.4	1.3
Mg	5.48	13.19
Ca	95	107.13
NH4	2.3	2.3
Cl	18.2	8.4
HCO3	293	422.26
SO4	21.7	1
NO3	21.7	.3
Fe	3.8	2.9
Mn	.099	.101
Al		
SiO2		
o.P04	0	0
Calcite	0.23	-0.32
Dolomit	-0.62	-0.10
Siderit	0.67	0.60
Rhodoch	-10.93	-10.90
Gypsum	-1.84	-3.16
OH-Apat	-40.40	-40.73
Chalced	-12.08	-12.08
Quartz	-11.53	-11.53
Gibbsit	-9.13	-9.12
Kaolini	-41.09	-41.09
pe		
Viviani	-25.91	-26.58
P CO2	-2.15	-1.89
Sum +	5.84	7.03
Sum -	-5.97	-7.05
error %	-1.12	-0.15
TIC mg/l	61.96	90.92
Ion.rat.	0.70	0.85
Na*	-0.52	5.93
K*	4.04	1.13
Mg*	4.26	12.63
SO4*	19.14	-0.18
Ca*	94.61	106.95
Na+K+Mgm	0.98	1.58
Na+K+Mgc	0.54	0.25
K-20	505.15	565.71
EC-20	442.50	459.31
error %	6.61	10.38
ANC	4.79E0	6.89E0
Buf.CO2	8.01E-7	6.70E-7
Buf.tot	8.75E-4	1.56E-3
HCO3H	F3-CaHCO3	F3-CaHCO3+
Tot.H	F2-CaHCO3	F2-CaHCO3+

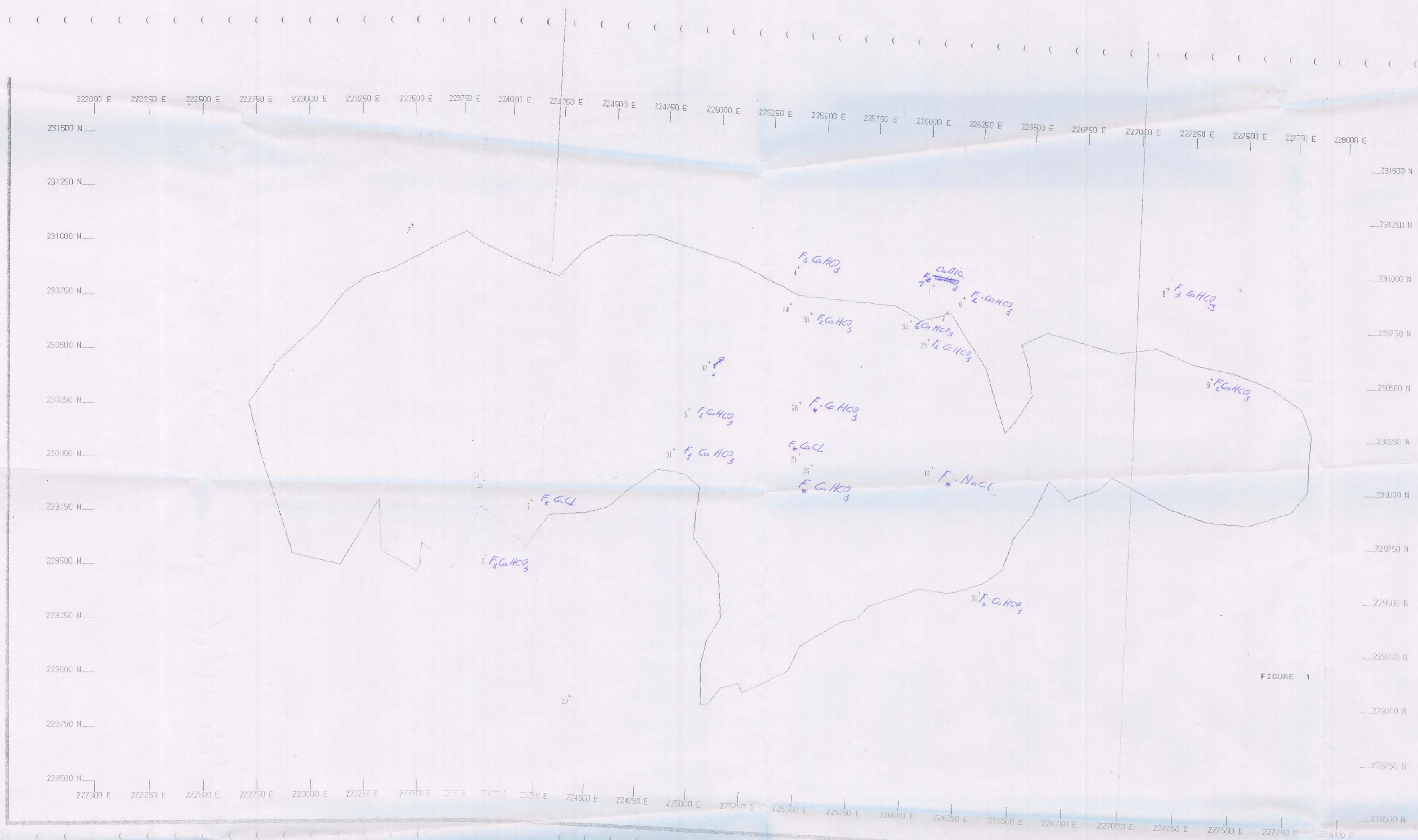


FIGURE 1

Scale 1:10000
 100 0 100 200 300 400 500
 (metres)

Dutch-Irish Peatland Project
Hydrochemical sampling locations
.b2.
.c1.
.c2.
.c3.
Richard Anderson