IRISH - DUTCH

GEOHYDROLOGY AND ECOLOGY STUDY

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An Additional Study in the

Quaternary Geology of Clara Bog.

County Offaly

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Sketch of Clara Bog by Catherine O' Brien, Clara, County Offaly.

Contents.

page.

Introduction 2

Chapter 1.

1.1 The Lough Roe Soak 4
1.2 The vegetation 6
1.3 The Electric Conductivity measurements 8
1.3.1 The nutrient enrichment 9
1.3.2 Methods 9
1.3.3 Results of the E.C. measurements 10
1.3.4 Results of the Temperature measurements 13
1.4. Conclusions 14

Chapter 2.

2.1 The Electric Resistivity soundings 15
2.2 The methods 15
2.3 The Results of the Electric Resistivity soundings 16

Chapter 3.

3.1 The Quaternary geology field mapping program 19
3.2 The Quaternary geology of the Clara Bog area 20
3.2.1 Till deposits 20
3.2.2 Esker deposits 21
3.2.3 Lacustrine deposits 22
3.3 Conclusions 22

Acknowledgements 23

References 24

Appendix 1. E.C. and Temperature diagrams 25

Appendix 2. Electric Resitivty measurements 37

Appendix 3. The Quaternary field mapping positions and augering data . 39

Introduction.

The following report is an account of a three month study carried out as part of the Irish-Dutch project on the geohydrology and ecology of two partially intact raised bogs. These are located in the center of Ireland: Clara Bog and Raheenmore Bog, both in County Offaly (see fig. 1).

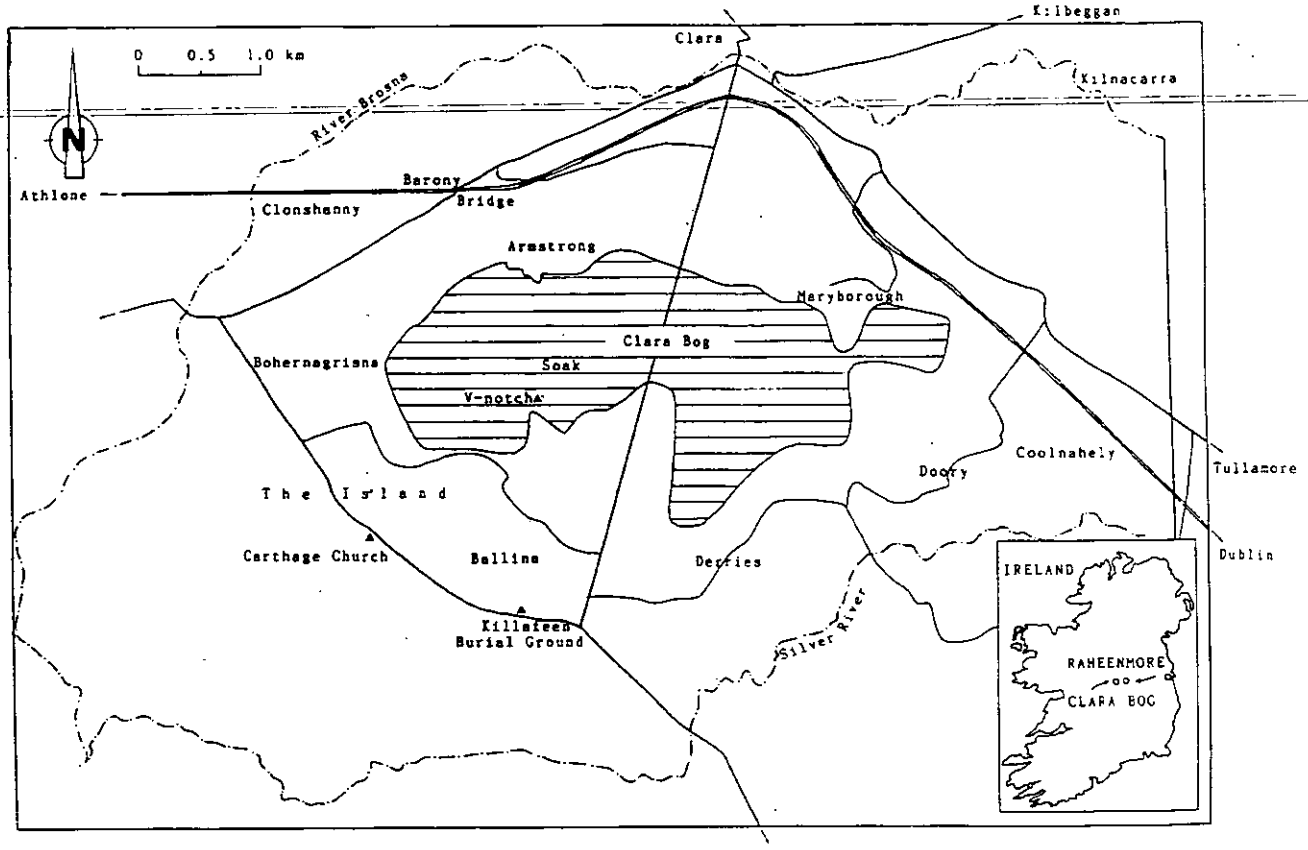

Figure 1. Clara Bog and the surrounding study area.

This project is a co-operative study between the Dutch Forestry Commission (Staatsbosbeheer) and the Irish Office of Public Works, and is supported by several Dutch universities like the Agricultural University of Wageningen and the University of Amsterdam. On the Irish side the project is supported by Trinity College in Dublin, the Geophysics and Geology Department of the University of Galway and the Geological Survey of Ireland.

The aim of the project is to acquire more knowledge about raised bog systems. This knowledge will be used in The Netherlands and in Ireland for the management of the remains of raised bogs in both countries.

In this report only Clara Bog will be discussed. Clara Bog is situated in a depression in glacial deposits, South of an esker ridge, South of the town of Clara. The bog is roughly 5 kilometres long and 1.5 kilometres wide.Through the bog runs a bogroad which splits the bog in two halves, the Eastern and the Western part.

My stay in Ireland was a continuation of the participation in the project by students from the Fysisch geografisch en Bodemkundig laboratorium of the University of Amsterdam. Our part in the project is to gain information about the Quaternary geology and the geomorphology underlying and surrounding Clara and Raheenmore Bog. This is done in co-operation with the Geological Survey of Ireland and the Geophysics and Geology Department in Galway.
A Quaternary geology map and a geomorphological map was produced in 1990 (van Tatenhove & van der Meer, 1990). Later on several geophysical surveys were carried out (Farenhorst & Biewinga, 1990). More detailed studies were done on the distribution and the sedimentological and hydrological characteristics of the lacustrine clay underlying the bog (Rijsdijk & van der Meer, 1991; Lenting & van der Meer, 1992; Bloetjes & van der Meer, 1992). These deposits cause an impermeable layer necessary for the initial stages of raised bog formation. This year the till sediments which underlie the whole area are studied by Mary Smyth.
My stay in Clara involved participation in a number of different study projects. These projects included:

- Quaternary fieldmapping, involving augering to define boundaries between several Quaternary deposits in the area of Clara Bog and Raheenmore Bog,
- assisting with a geophysical survey using Resistivity Vertical Electric Soundings, on and around Clara Bog,
- a separate project on the soak systems, concerned with the Electrical Conductivity of the water in and around these soaks.

Chapter 1.

1.1 The Lough Roe Soak.

On Clara Bog a few open water areas and very wet spots, called soaks, occur on the Eastern part as well as on the Western part. These wet places are characterized by the occurrence of minerotrophic plant communities that differ from the ombrotrophic plant communities which are generally found on the surface of the bog.
Because Lough Roe on the East side of Clara Bog, is the most extreme example of these wet areas it was decided to take this soak as the object of separate study (see fig. 2).

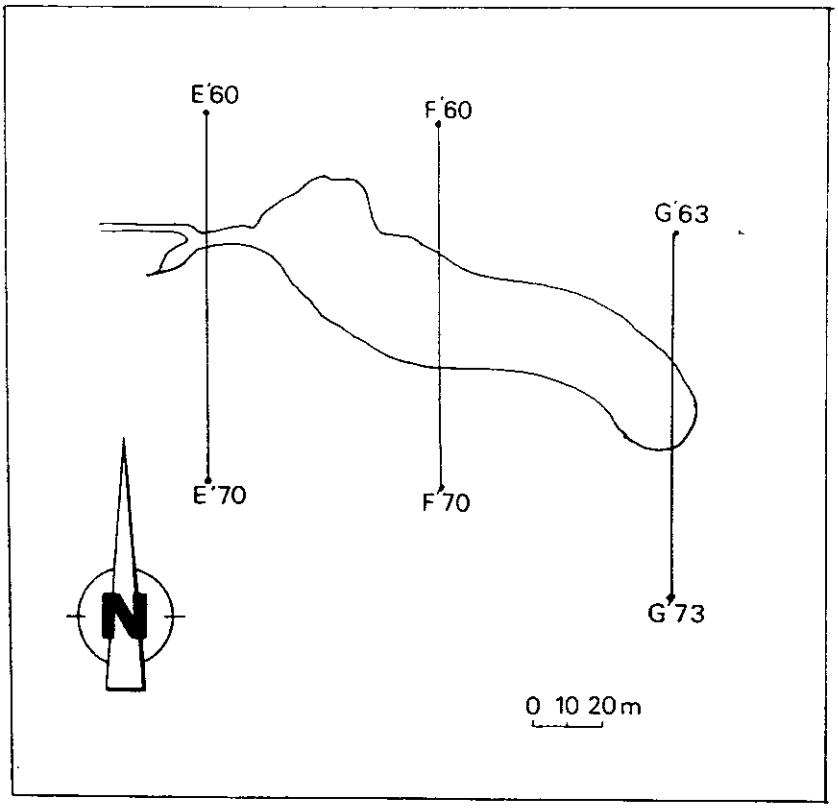

Figure 2. The Lough Roe soak on the Eastern part of Clara Bog, and the lines of the sampling grid.

One of the reasons why this project is paying so much attention to the Lough Roe soak on Clara East, is because soaks are a very rare phenomena on raised bogs. The soak on Clara West is the largest and one of the few left in Ireland.

Another reason why the soak system plays a major role in this research project is the fact that there is no theory that fully explains the origin and working of the soak system.
These two reasons make Clara Bog one of the most valuable areas for both scientists and nature conservationists.

There are several theories for the origin of the soak systems.One theory suggests that the soak could be caused by up-welling of mineral rich water coming from the esker. But for the up-welling of water to occur under hydrostatic pressure, the clay should be permeable at this spot which is not likely. Also hydrological measurements have not indicated up-welling of water in this area.

From historical sources we know that in the last century farmers blew holes in the bog to create attraction spots for ducks which were very easy to hunt in this way. The lakes NE of Lough Roe almost certainly originated from this.

What is certain, is that the lakes are at least a hundred years old, as they are indicated on the topographical maps which date from the end of the last century.

Another theory is that due to the cutting of turf on the edges of the bog, the surface has subsided. At certain spots the water ran into a newly formed catchment area on the surface of the bog. So the soaks would be a sort of drainage point.

Another thing that we know about the Lough Roe soak is that it was open water until about ten years ago, until the outlet of this soak was blocked. In time, over the ten years a thick mat of mineral loving water plant species has covered the open water with an approximately 1.5 metre thick mattress of organic matter.

A study was carried out in order to get more information about the main aspect of this soak system, namely the mineral rich water. We decided to use the Electric Conductivity properties of the water as an instrument to indicate the mineral richness of the water.
But before discussing the E.C. study in detail a picture of the occurring plant communities will follow.

1.2 The vegetation.

The vegetation of the soak system differs from the vegetation on the main part of the bog. Going from the bog vegetation to the soak, one will find a transition from an ombrotrophic environment to a minerotrophic environment. The influence of this minerotrophic environment spreads in a radius of more than 100 metres around the edges of the actual soak.
As vegetation is a very good indicator of this nutrient rich environment around the soak, a rough indication along the transect of the E.C. and temperature measurements of the different plant communities may help to complete the picture (Kelly, 1992).
In order to prevent too much overlap the plant species on and around the soak are divided into six groups describing the transitional environment along the transects (see figs. 2 and 3).

A A A' B C B A' A A A A
E'60—1—2—3—4—5—6—7—8—9—E'70.

A A A A' A' B D E E D D
F'60—1—2—3—4—5—6—7—8—9—F'70.

A A A A A' A' B D D B A' A
G'63—4—5—6—7—8—9—0—1—2—3—G'74.

Figure 3. Showing the grid transects and the different vegetation groups.

Group A.

This is the group of the ordinary bog vegetation with very little influence of the soak and therefore an almost complete ombrotrophic environment. The main plant community of this
group is the *Oxycoccus-Sphagnetia*. Characteristic species are *Calluna vulgaris, Erica tetralix, Carex panicea* and *Narthecium ossifragum*.

Group A'.

This group is closely related to group A, but the influence of the mineral rich environment and of better aeration is already obvious. Characteristic species of this group are *Calluna vulgaris* (which tends to be greener and higher than in the ordinary bog vegetation due to better aerated soil conditions), *Cladonia portentosa* (a lichen) and *Eriophorum angustifolium*.

Group B.

This group is to be found on what used to be the bank of the former soak lake and on the banks of the former drain. The latter was an outlet for the soak water on the Western side until it was blocked approximately ten years ago. The *Calluna vulgaris* in this group reaches extreme heights and is very green.
This can occur due to the good aeration and also because this environment is very well drained. Its also the right place for *Betula pubescens* to appear. The *Calluna* has an undergrowth of *Hypnum jutlanticum*, a moss species.
Note that further down the drain *Salix repens* and *Carex curta* occur. This is the only place on Clara Bog where these species are to be found.

Group C.

This group is found in the former drain which is still quite wet. Characteristic species are *Mollinia caerulea*, *Potentilla palustris* and *Juncus effusus* which indicates a disturbed environment.

Group D.

This group is fairly well influenced by the nutrient source of the soak. It is the best example of the transition between ombrotrophic and minerotrophic conditions. Still *Calluna vulgaris* occurs and also *Mollinia caerulea* and *Eriophorum angustifolium*. *Drosera rotundifolia* indicates a more open environment. A few small birch trees are also to be found.
Other species indicating nutrient enrichment and more wet conditions are *Sphagnum majulanicum*, *Menyantis trifoliata*, *Luzula multiflora* and *Empetrum nigrum*.

Group E.

The last group to be distinguished is found on the wettest parts of the soak. Plant species like *Galium palustre*, *Vaccinium oxycoccus*, *Sphagnum recurvum*, *Potentilla palustris*, *Anthoxanthem oderatum*, *Carex rostrata*, *Sphagnum squarrosum*, and *Lychnis flos-cuculi* indicate the nutrient rich and wet area.

1.3 The E.C. measurements.

The Electric Conductivity of a solution is a measure of its ability to carry an electrical current, and varies both with the number and type of free ions the solution contains. In practice we do not measure the conductance of a solution but its reciprocal value, the specific resistance expressed in Ohm per metre. The specific conductance in the diagrams of appendix 1 is expressed in micro Siemens.

The aim of this study was to find a core of mineral rich water by laying a grid on the Lough Roe soak and measuring E.C. and temperature at various depths, at intervals along the grid.
It was expected that the displayed data would show a so called 'bell' of high E.C. values at the place were the source of mineral rich water would be.
Together with the temperature data, it was hoped that conclusions could be made about possible water and mineral transportation patterns due to temperature differences.
But before discussing the methods and results of these measurements, it is important to first take a look at previous results on water quality tests first from this soak system.

1.3.1 The nutrient enrichment.

The nutrient enrichment of the soak has been proven by several previous tests of the water quality. These tests have shown that the Electric Conductivity (E.C.) on Lough Roe is much higher than its surroundings.

The main elements that are indicative for this minerotrophic environment are **Ca2+**, **HCO3-** and **Mg2+**. **Ca2+** concentrations of 12.3 to 18.2 ppm have been found in the centre of the soak. The average concentration on the surrounding bog is about
4.0 ppm.

HCO3- concentrations in the centre of the soak reach values of 50 ppm, while on the surrounding bog concentrations of less than 3 ppm have been found.
Likewise **Mg2+** concentrations in the centre of the soak have been found at values of 1.2 to 2.0 ppm, while on the surrounding bog they do not reach values higher then 0.4 ppm.

Also the pH of the soak differs from the average pH on the bog. On the bog the average pH varies from 3.2 to 4.5, this is a bit lower then the average pH of rain water which is about
pH 5. The average pH of the soak is about pH 6.0 at a depth of 40 cm (Kelly, 1992).

The average E.C. on the soak at a depth of 40 cm is about 100 micro Siemens a year (pH corrected). This value lies close to the E.C. of rain water which is also about 100 micro Siemens.

1.3.2. Methods.

To collect the data a 184 cm long metal stick containing a temperature and E.C. probe at about 12 cm from the bottom of the stick was used. The stick was connected to a PW9525/10 Conductivity and Temperature Meter. In order to obtain a regular gridded data-set a transect was lain over Lough Roe based on the already existing O.P.W. grid
(see fig. 2). At each site the temperature and E.C. was measured at a depth of 32, 52, 72, 92, 112, 132, 152 and 172 cm To get a good picture of how the E.C. and temperature would change in time the measurement was carried out once a month in May (15-5-'92), June (14-6-'92) and July (12-7-'92).
The results of the measurements were processed by the graphical mapping program SURFER.

1.3.3. Results of E.C. measurements.

If we look at the diagrams produced from the measurements along transect E' (see appendix 1) we can see that, at a distance between approximately 30 and 50 metres and at a depth of 32 to 72 cm, a reoccurring pattern appears. The pattern of the measurements on 15-5-'92 (fig. 4a) has its mode around approximately 30 metres while on 14-6-'92 (fig. 4b) and on 12-7-'92 (fig. 4c) the centre of the pattern is around 50 metres. This pattern corresponds more or less with the position of the former drain. There is a slight shift of the 100 uS-line towards the surface during these three months.
Another feature is the "circular" spot at a depth of approximately 92 to 112 cm. In this respect the picture of 12-7-'92 is almost the mirror image of the picture representing 15-5-'92. The E.C.-values of this pattern show a decrease in time (figs. 4a,b,c).

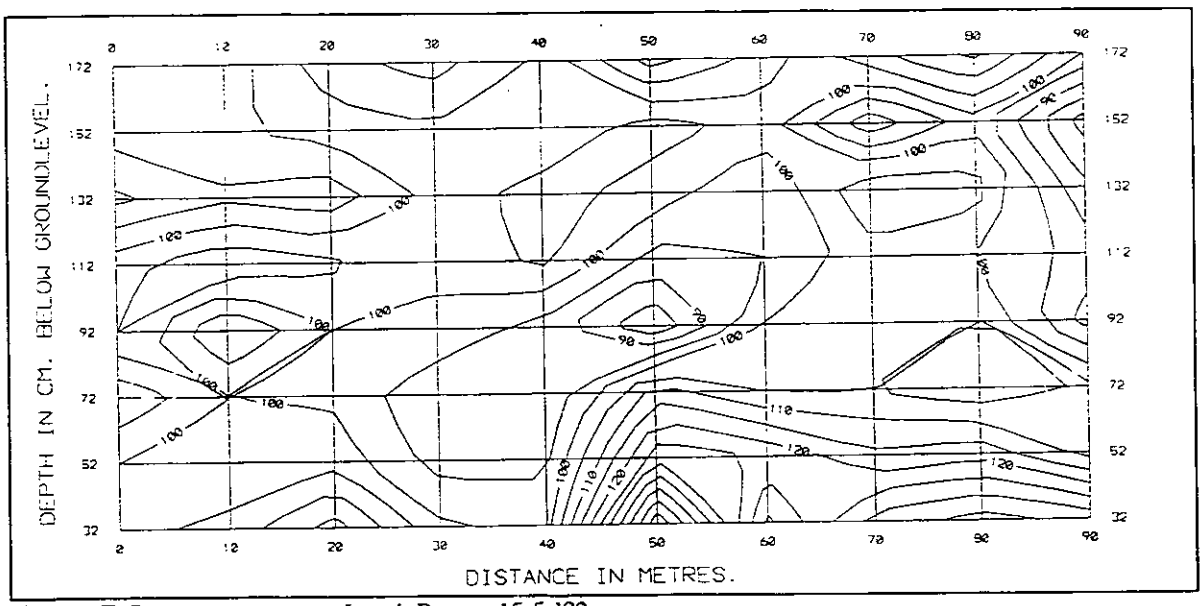

Fig. 4a. E.C. measurements on Lough Roe on 15-5-'92
along transect E'60 - E'69.

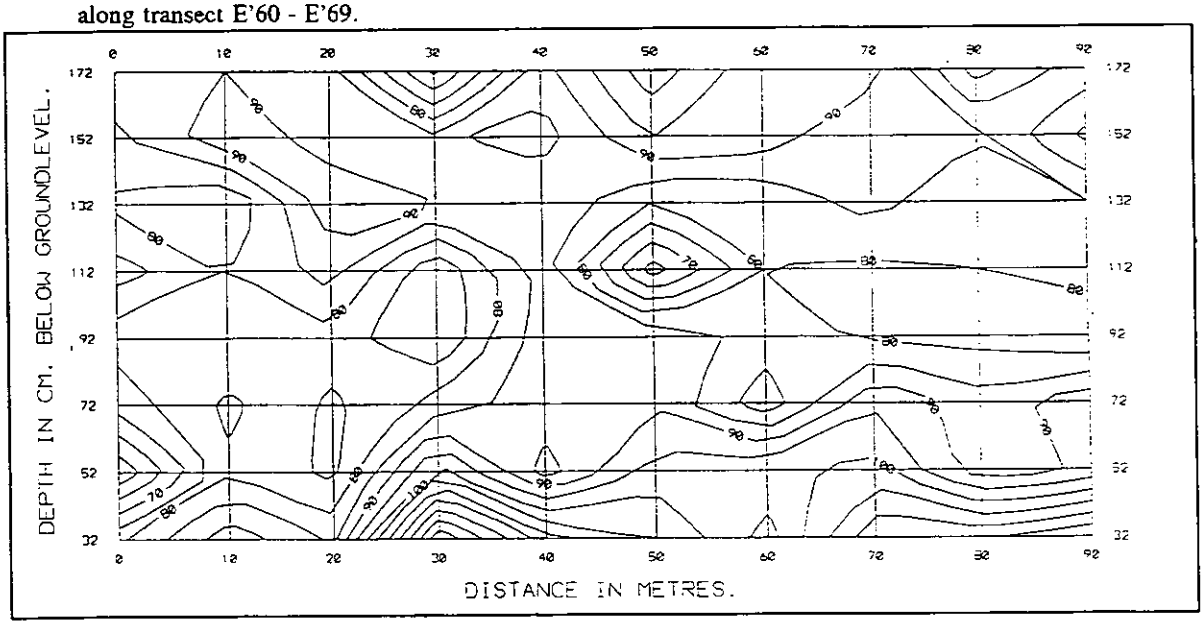

Fig. 4b. E.C. measurements on Lough Roe on 14-6-'92
along transect E'60 - E'69.

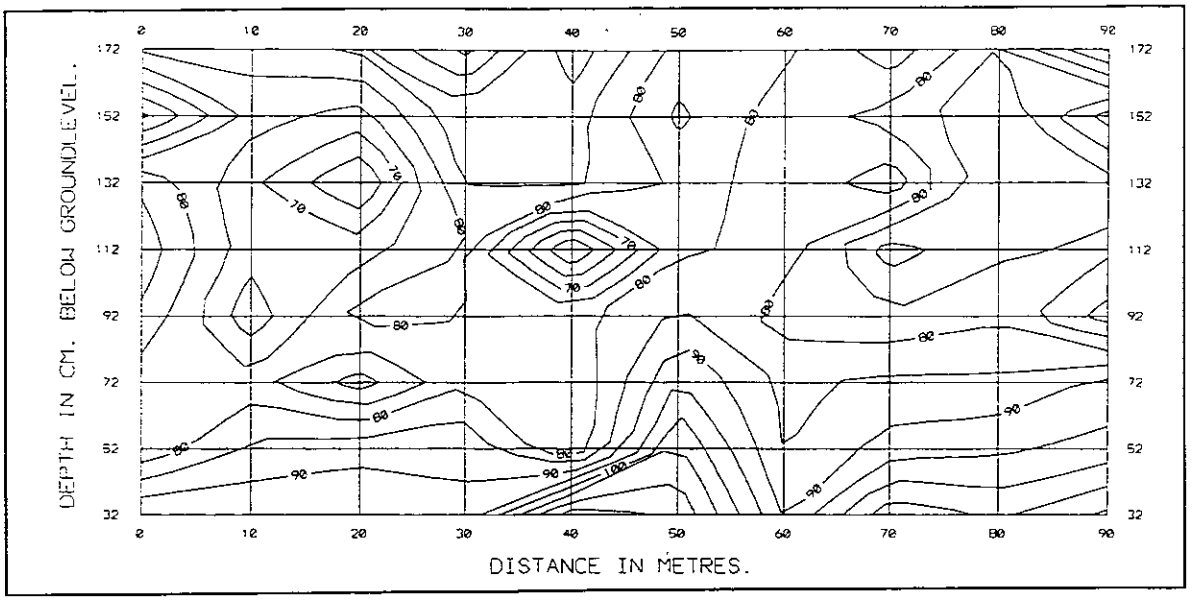

Fig. 4c. E.C. measurements on Lough Roe on 12-7-'92
along transect E'60 - E'69.

The diagrams of transect F' show clearly the expected "E.C.-bell" (fig. 5). The pattern of the bell shows a slight change in time but this could be due to erratic measurements. If we take a look at the vegetation diagram of fig. 3, we see that the pattern fits with the vegetation pattern, with its centre shifted slightly to the 80 metre line.

There is no clear sign of decreasing E.C.-values in the bell, although the E.C. of the surface does decline.The diagrams along transect G' (fig. 6) show the same pattern as that shown in the diagram of transect F'.

This pattern also matches with the vegetation recordings. The core of the bell has slightly higher E.C.-values than the bell of transect F'. In transect F' these values are about 180 to 190 uS, while in transect G' E.C.-values reach 230 uS, except for the measurements on 12-7-'92. Thus the E.C. is decreasing in time during the summer.

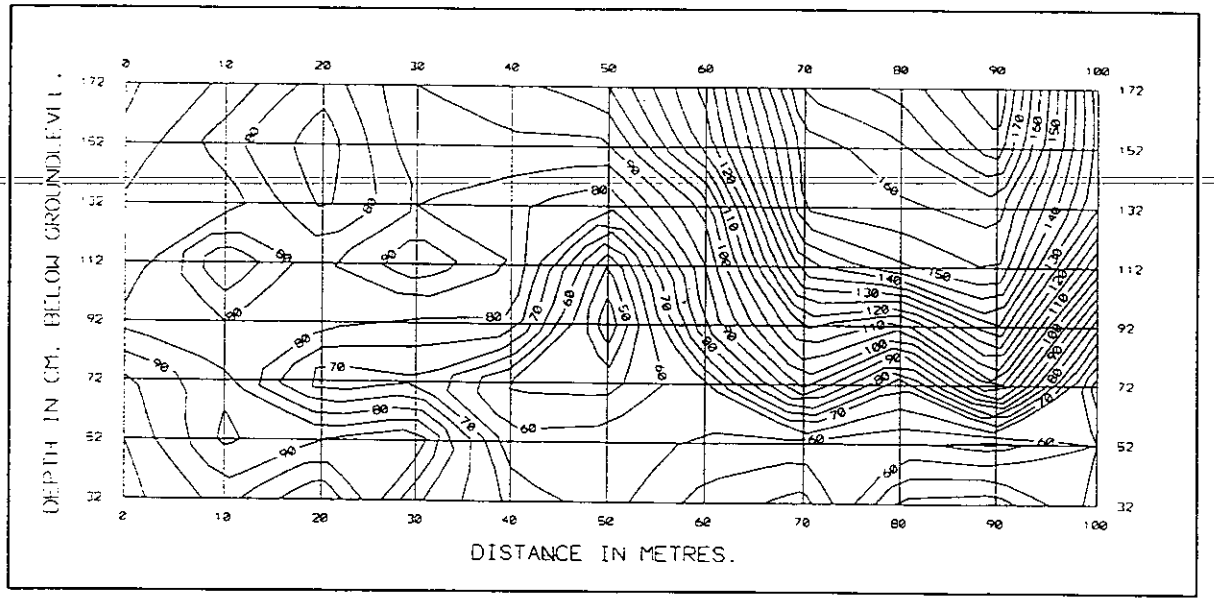

Fig. 5. E.C. measurements on Lough Roe on 15-5-'92 along transect F'60 - F'70.

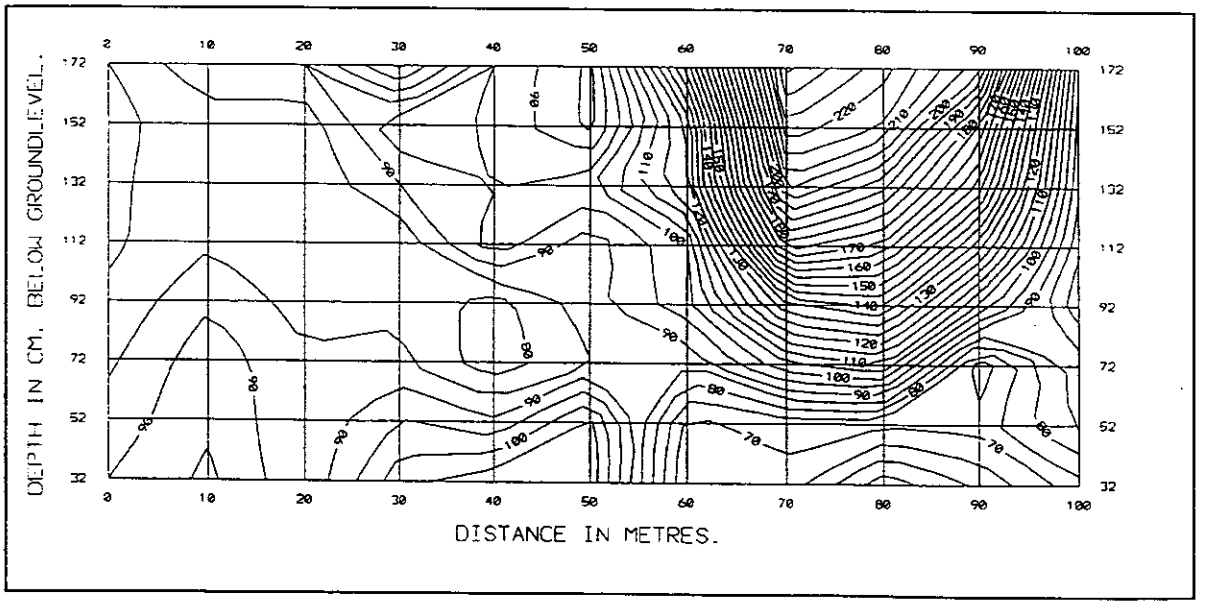

Fig. 6. E.C. measurements on Lough Roe on 15-5-'92 along transect G'63 - G'73.

1.3.4. Results of temperature measurements.

The temperature data diagrams do not show as clear a picture as that shown in the diagrams of the E.C. measurements. If we compare the diagrams of 14-6-'92 (fig. 7a) and of 12-7-'92 (fig. 7b) along transect E', we can see that the temperatures are increasing during the summer months. And we can also see a very vague dome-like pattern with its centre more or less in the blocked drain.

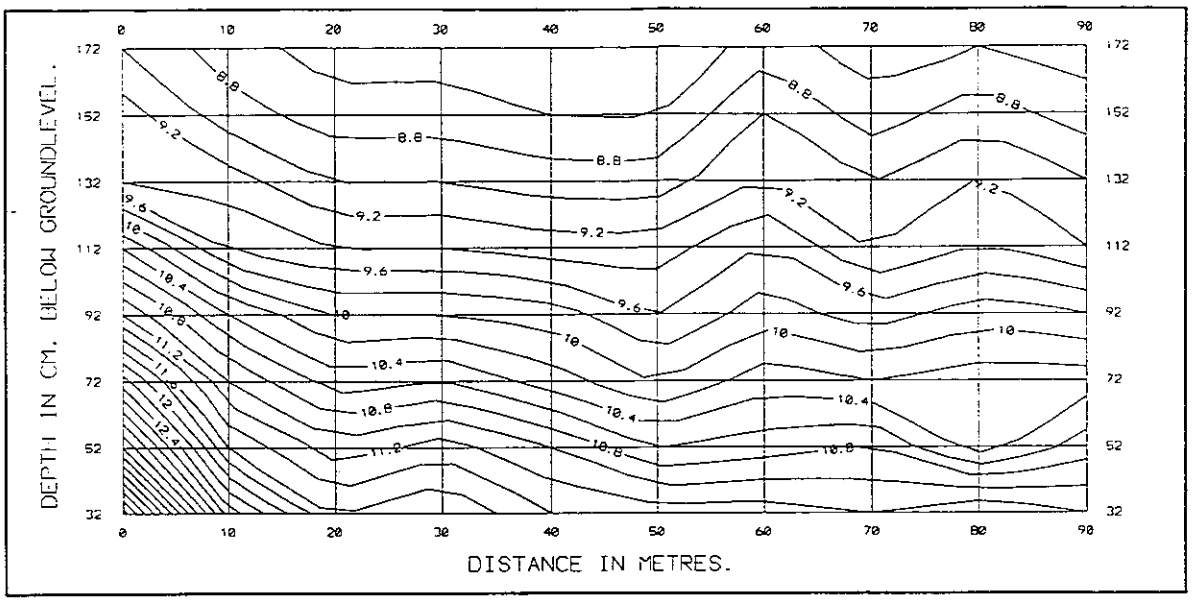

Fig. 7a. Temperature measurements on Lough Roe on 14-6-'92
along transect E'60 - E'69.

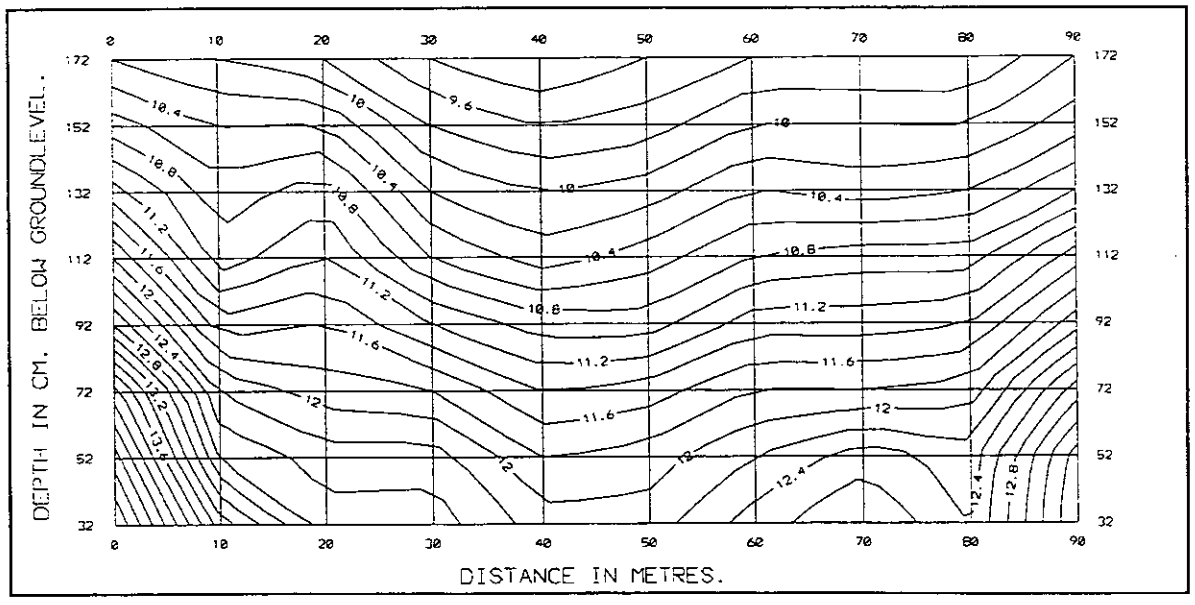

Fig. 7b. Temperature measurements on Lough Roe on 12-7-'92
along transect E'60 - E'69.

The diagrams along transect F' do not give enough resolution to give the impression of a clear pattern. There may be some matching of higher temperatures and the occurring of open water around the 60 metre line.

There is also a slight increase in the temperature during the summer. The erratic appearance of the diagram of 15-5-'92 may be due to malfunctioning of the equipment.

In the diagrams of transect G' we can see a dome shaped pattern, with its centre switching between 50 and 70 metre.
Except for the measurements on 15-5-'92. Along this transect the temperature is also increasing during the summer.

1.4. Conclusions.

It is possible to distinguish clear patterns in the E.C., as shown in the diagrams. However less clear patterns are shown in the temperature data diagrams.
The general trend in the E.C. diagrams, as well as in the temperature diagrams are the decreasing E.C. values and the increasing temperatures during the months of measuring. Therefore the conclusion to be made is that mineral rich water is not transported to the surface by convectional circulation of the water.
E.C. values close to the surface are similar to the average E.C. values of rain water.
The core of mineral rich water, which expresses itself in the E.C. diagrams, must be around the F'67-68 part of transect F' and G'70-71 part of transect G'.
If we want to get a better picture of changing E.C. values and temperature in time, it will be necessary to have a more detailed data set, which includes measurements at greater depths and over a longer period of time.
Therefore it must be stated that we cannot draw too many conclusions from these data sets. It is however very useful to combine this information with information from previous and future studies, in order to gain a more complete understanding of the processes involved.

Chapter 2.

2.1 The Electric Resistivity Soundings.

During my stay in Clara a two week intensive geophysical program was carried out in June. Approximately 60 Vertical Electric Resistivity Soundings (VES) were carried out on Clara Bog, some of which were carried out in the surrounding area of the bog.
The aim of the VES survey was to fill in the gaps in the sounding coverage on the bog and thus produce more detailed maps than the existing VES map produced by Smyth in 1991. A repeat of four soundings was also carried out in the survey, as the former data collected were not reliable due to instrument problems.

2.2 The methods.

The VES technique is based on the principle of specific resistance difference of the materials to be measured below a given point on the ground surface. The VES technique is used to measure the resistivity of the subsurface geological layers.
As the electrode spacings are increased, the apparent resistivity at increasing depths is measured. This technique assumes a horizontally layered earth, where resistivity only
varies vertically downwards. In practice, the resistivity of the earth also varies horizontally, and therefore influences the results. For this reason the technique is not suitable in areas of horizontally varying resistivity or varying topography.
The VES carried out in this survey involved the use of the Offset-Wenner array (see Fig. 8). The VES Schlumberger array had been used in a previous survey, but the Offset-Wenner array is a much faster technique to operate in the field. The measurements were carried out with the ABEM Signal Averiging System 300 Terrameter (SAS 300). The SAS 300 is built up by a transmitter and a receiver. The transmitter sends a current (I) into the ground via the current electrodes, a receiver measures the resulting potential difference (delta V) between the current electrodes, then a microprocessor calculates the resistance (delta V/I) from the values measured in the field. The electrodes are attached to a Barker cable witch has 10 electrode connectors with a spacings of 0.5, 1, 2, 4, 8, 16, 32, 64, 128 and 256 metres on both sides of the instrument. With the switch board on the SAS 300 it is possible to switch to the different spacings.

At each single distance five different resistivities are measured (see fig. 8). Two of the resistivities, RD1 and RD2, are actually measuring the Offset-Wenner resistivity. The remaining resistance measurements are used to average the data and also as a control check in the field.

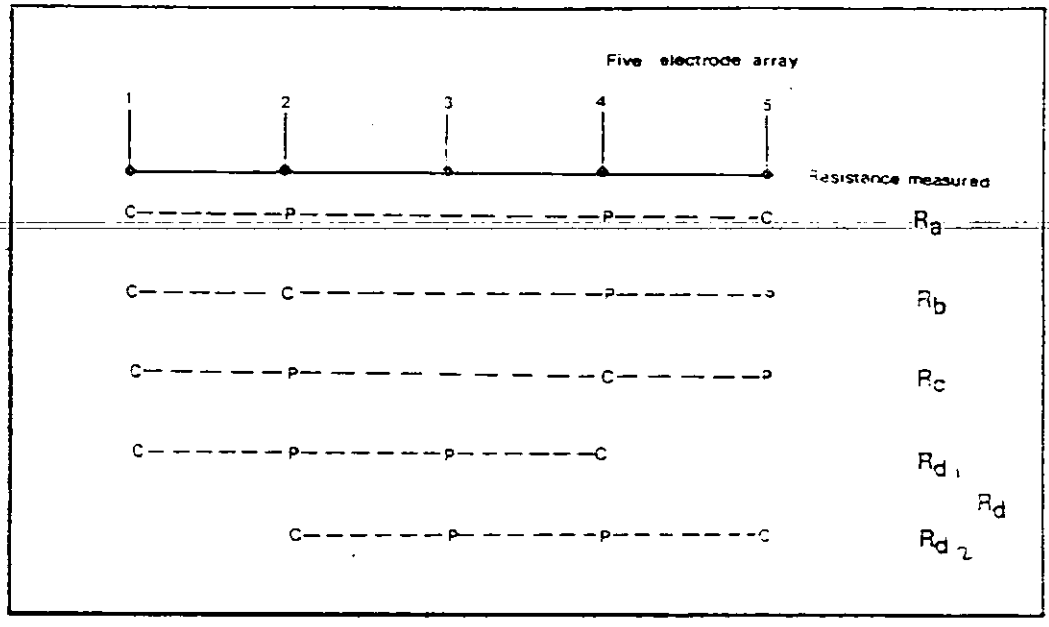

Figure 8. The set of five resistances measured for each elektrode spacing during an Offset-Wenner sounding.

2.3 The results of the Electric Resistivity soundings.

In this survey a complete coverage of soundings was carried out on the East side of Clara Bog, which had little coverage in the previous survey. Additional soundings were also carried out on Clara West, to obtain more detailed information. Two soundings were carried out on the esker sediments and a total of four VES on the margin of the bog (see appendix 2).
The soundings on the esker proved to be inconclusive due to the varying topography of the esker.
At present the VES are being interpreted in the Applied Geophysics Unit, University College, Galway and the completed work will not be ready for this report.
However, to give an impression of the interpretation of the soundings, some soundings of the previous survey will be discussed here (Smyth, 1992).

In figure 9 one can see a diagram of an interpreted resistivity sounding curve produced by the "Restint" resistivity sounding interpretation program, used by the Geophysics Department in Galway. This is a typical example of an apparent resistivity sounding curve on the bog.

Along the Y-axis the logarithmic scale of the apparent resistivity in Ohm-metre is shown. Along the X-axis the logarithmic scale of the electrode spacing is given.

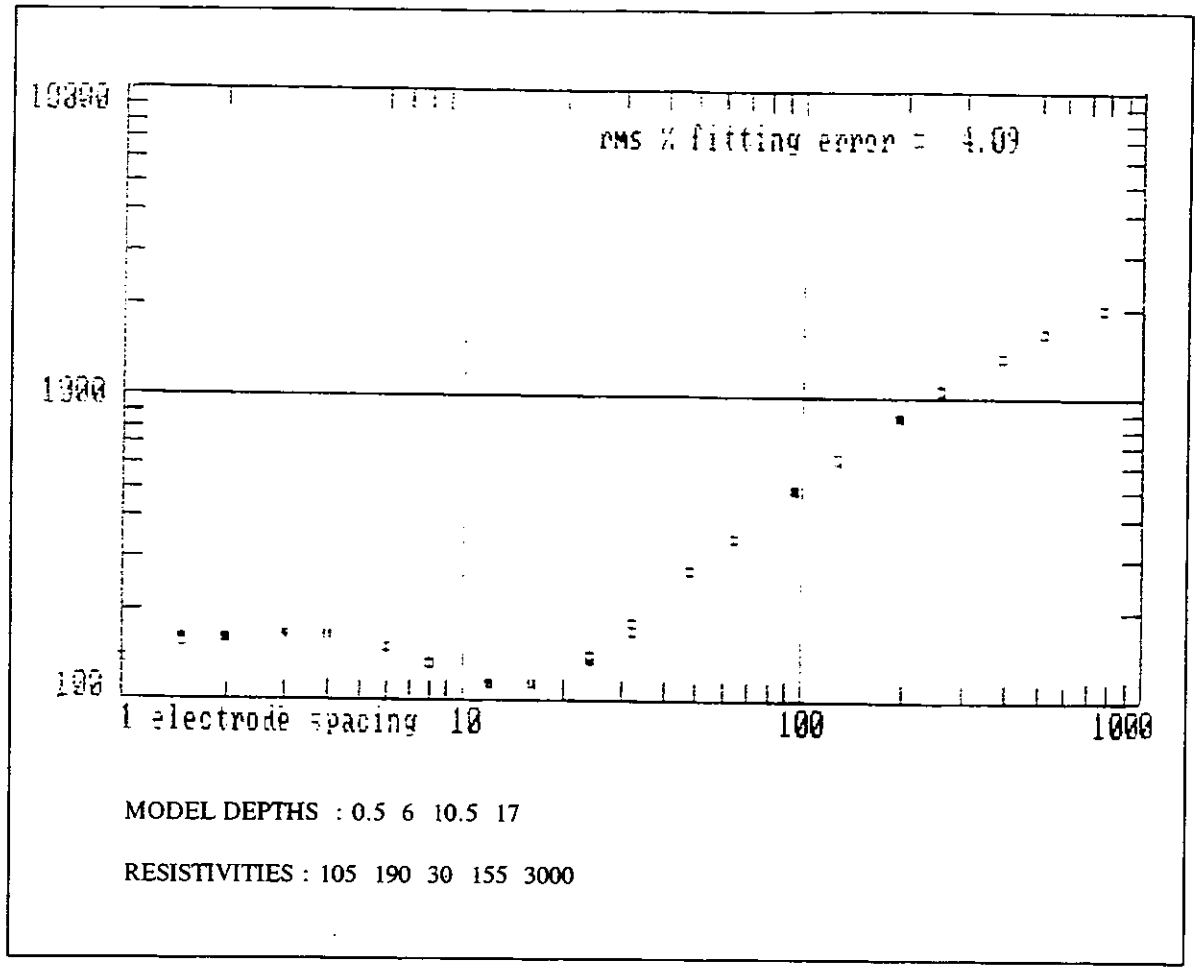

Figure 9. An example of an interpreted sounding on Clara Bog produced by "Restint".

Based on the knowledge that at this locality a peat layer is overlying a clay layer, followed by a till layer and finally limestone bedrock, we can now interpret this curve. In figure 10 the mean resistivities of the lithologies occurring on Clara Bog are given in histograms. Using these mean resistivities we can try to fit a curve on the data that were collected in the field. These data are represented by the curve of open blocks. When a curve has been fitted the program calculates the relative depth of the material in this case, the relative depths of peat, lacustrine clay, till and bedrock.

From this picture we can conclude that the peat is 5.5 m thick, the clay layer is at a depth of 6 m to 10.5 m so its calculated thickness is 4.5 m The till layer extends from a

depth of 10.5 to 17 m so that its thickness is 6.5 m Finally bedrock is shown to be at a relative depth of 17 m below the surface of the bog.

In appendix 2. we can see the results of most of the soundings that were carried out during the summer of 1992. The soundings which did not give reasonable results, due to erratic measurements, have been excluded. On the map we can see the relative depth to bedrock.
If these data are combined with the data of previous soundings they should give, together with information of the drillings, a good picture of the relative (and absolute) depth of the bedrock underlying Clara Bog.

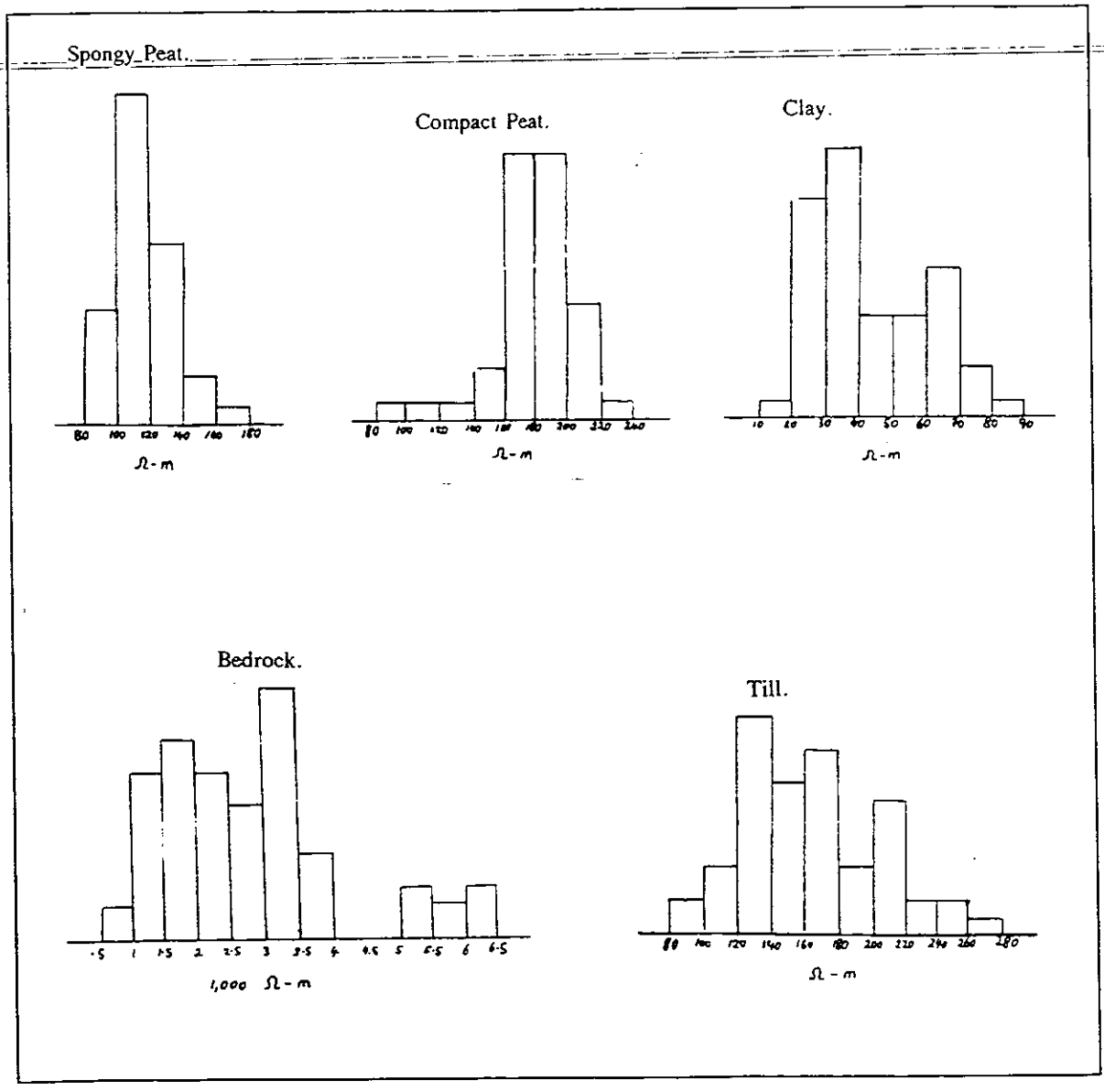

Figure 10. Histograms of VES Apparent Resistivities in Ohm per metre of the Lithologies occuring at Clara Bog.

Chapter 3.

3.1 The Quaternary geology field mapping program.

During the summer months of this year a Quaternary field mapping program was carried out around Clara Bog and also around Raheenmore Bog.
The aim of this mapping program was to refine the boundaries of the existing Quaternary geology map and check for new exposures (van Tatenhove & van der Meer, 1990; see also appendix 3).
Special attention was paid to the boundaries between:

- alluvial deposits and lacustrine deposits
- alluvial deposits and till deposits
- lacustrine deposits and till deposits.

Another aim of the mapping exercise was to get familiar with the deposits in context with the landscape forms.
In the field we used man-made exposures like drains or pits and an Edelman (hand-)auger to check on places where no exposures were available.
The Edelman auger proved to be a good instrument to take a quick look at the top sediments in the alluvial and lacustrine deposits but when the lacustrine clay got to dense
it was sometimes a little bit difficult to get through. In the till the Edelman auger was not of much use, due to boulders which made the augering almost impossible.
In describing the sites the standard FAO soil classification terms were used together with some terms that were more fitting at the site.

3.2 The Quaternary geology of the Clara Bog area.

The geology of the area around Clara Bog mainly consists of Pleistocene and Holocene deposits. The whole area is underlain by Carboniferous limestone bedrock (290 - 345 million years old). The most abundant type is the "reef" limestone, stretching across the County of Offaly, in a NE/SW direction. Light to medium grey colour, fine-grained, poorly bedded and containing many fossils are the main characteristics of this type of limestone.
The other type of limestone in the study area that overlies the reef limestone is a dark grey to black, well bedded, muddy limestone called the Calp Limestone.

The surface landscape is mainly determined by landform features which were formed by deposits of the last glaciation, the Fenitian. These glacial and fluvioglacial deposits can be roughly classified into three groups:

- **till deposits.**
- **esker deposits.**
- **lacustrine deposits.**

3.2.1 Till deposits.

Till deposits were formed during the Fenitian glaciation (75.000 to 10.000 years B.P.) when all of Ireland was covered by ice.
The till in the study area is mainly derived from the limestone discussed above. Recent studies of the till resulted in recognizing two types of till (van Tatenhove & van der Meer, 1990). The first type is a typical till for Clara Bog area. It is characterized by a sandy-loamy and pebbly texture with a high content of big boulders. This type of till was mainly found under the SW part of Clara Bog.
A high amount of angular light-grey limestone boulders should indicate a very shallow bedrock. This was also found at the sites MB18 and MB19 (see Appendix 3) in the SE part of the study area. At borehole CL8 (N 226019 - E 229410), on the SE side of the bog bedrock was hit at approximately 7.5 metres below the surface.
At borehole CL9 (N 222753 - E 229581), on the SW part of Clara Bog, bedrock occurred at 5.85 metres below the surface. Also sites MB11, MB12a and MB12b can be recognized as sandy-loamy till close to bedrock.
The other till was described as a gravelly till (van Tatenhove & van der Meer, 1990). This type of till can be found on the South and SW side of the bog.
It consists of a sandy matrix with a high gravel content.

A last type, an "undefined" till has been distinguished, occuring at the SsE side of the bog (G4, G5).
This has been called undifined because it is not possible to define a regular texture of its contents. These tills are gravelly and stony. The matrix varies from sandy to sandy loam.
It could be that this type is much more wide spread than suggested in the report of van Tatenhove & van der Meer.

3.2.2 Esker deposits.

The Northern boundary of Clara Bog is formed by esker ridges, running in a NW to SE direction.
Typical for the eskers is the presence of material of all sizes. Sand, gravel and boulder layers are common but also silt and clay layers do occur.

The esker topography varies from steep ridges, conical hills to gently sloping shapes. The Northern side of the esker at the Clara town is steeper than at the side where the esker meets the margin of the bog. At this side the sediments are derived from the steeper parts of the esker and contain much washed out clay.

Another interesting feature of the steeper parts of the esker is that in the depressions between the steep ridges water stagnation takes place as we saw at Lough Cuith (site MB8, appendix 3).
In this watery environment it seems that Peat development took place indicated by 80 centimetres of peaty soil.
The reason why water stagnation occurs is obvious. The depression is bowl shaped so it functions as a catchment for all the water coming from the surrounding slopes. The washed out fine clay which was found at a depth of approximately 1 metre prevents the water from percolating quickly. The reason that peat development stagnated could be due to agricultural use of this terrain involving the nutrification of the area.
At other depressions we found no stagnating water. The subsoil contained gravels and sand so that water could easily percolate.

In the toplayer of the esker deposits soil development has taken place ever since the deglaciation.
Most of the toplayers show oxidation and reduction features (sites H4, H5, H6 and H8). At site H9 possibly an illuviated clay layer was found with a very high content of iron oxide which coloured the clay bright orange.
So another process occuring on the esker slopes is the illuviation of clay often forming a Bt-horizon.

Another feature of the esker material is the solution of calciumcarbonate. The CaCO3 tends to precipitate in vein-like structures in the material, for example at site MB3.
At the bottom of the esker slope, on the South side where the esker meets the margin of Clara Bog the mineral soil is often covered by a layer of mineralized peat (H1, H2 and H3).

3.2.3 Lacustrine deposits.

Lacustrine deposits consist of washed out, fine material from esker and till deposits, deposited in the lower part of the landscape. Usually the material has a clayey texture, but sometimes the clay layers alternate with layers of a more sandy nature. When the material is dry it is very firm, when it is wet the material has a more plastic feeling. Due to the fine clay in the material stagnation of percolated water may occur, creating a perched water table.

The boundary between lacustrine and Holocene alluvial deposits was very difficult to distinguish in the field because of the similarity between these two sediments. Most of the time the difference was based on textural criteria and colour. The lacustrine clay was more firm and plastic than the alluvial clay.

3.3 Conclusions.

The Quaternary geology map produced by previous research (van Tatenhove & van der Meer, 1990), proved to be most adequate during the field check. Sometimes some boundaries
and map units could be adjusted. But one can ask himself if this will be of any further significance in the context of the project.
But on the other hand with respect to different types of till as distinguished in the Quaternary geology map, it proved that during the field work it was very hard to maintain the different types of till.
The texture of the till is so variable over short distances, that classifying according to the previous types of till does not give a reliable picture of the actual conditions in the field.
As far as the bounderies between the several sediments concerned the system proves to be much more complex as suggested on the previous Quaternary geology map. But again we must ask our selves if it necessary and important for the project.

Acknowledgements.

My three-month stay in Clara was meant to get experience with different kinds of research techniques used in this fieldwork.
Besides the experience with these fieldwork techniques I also learned a bit about the organization and problems concerning this project and science in general. I also got to taste a little bit of Irish landscape and culture. If the aim of my stay was to learn a few things from practice, well I think I certainly did. And therefore I would like to thank all people who helped me to make these three months an unforgettable experience.

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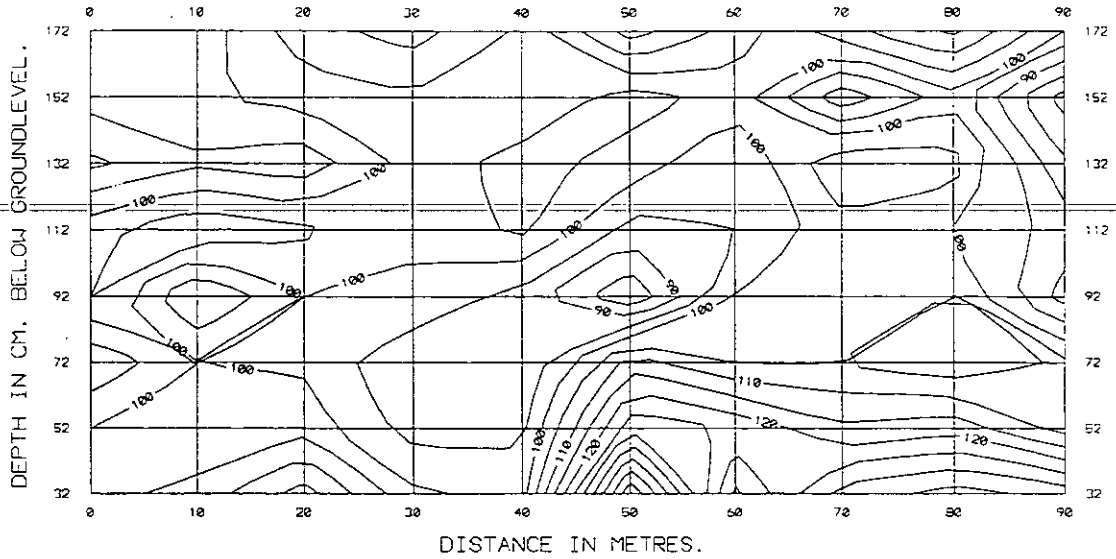
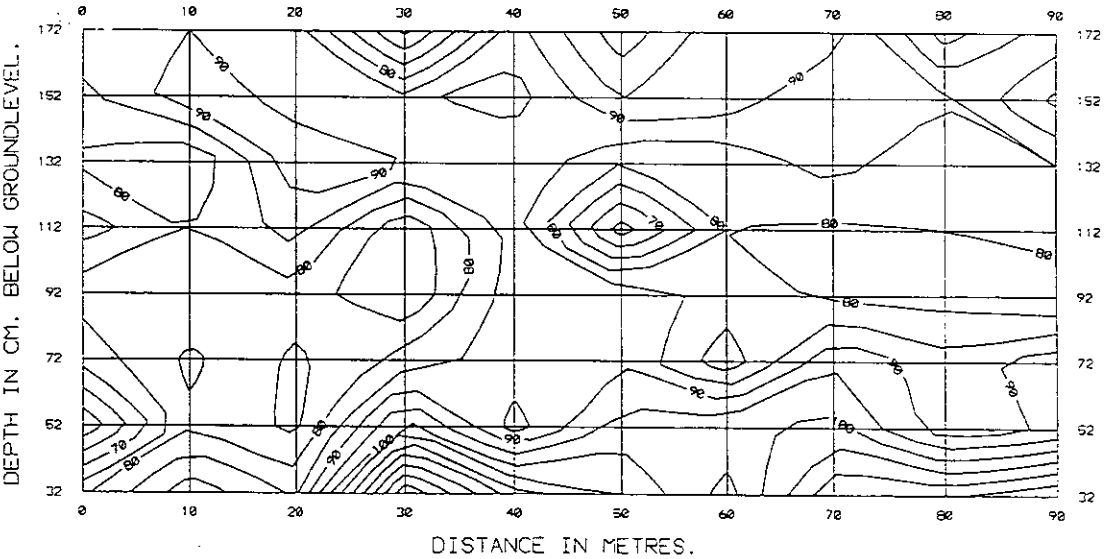
Appendix 1.

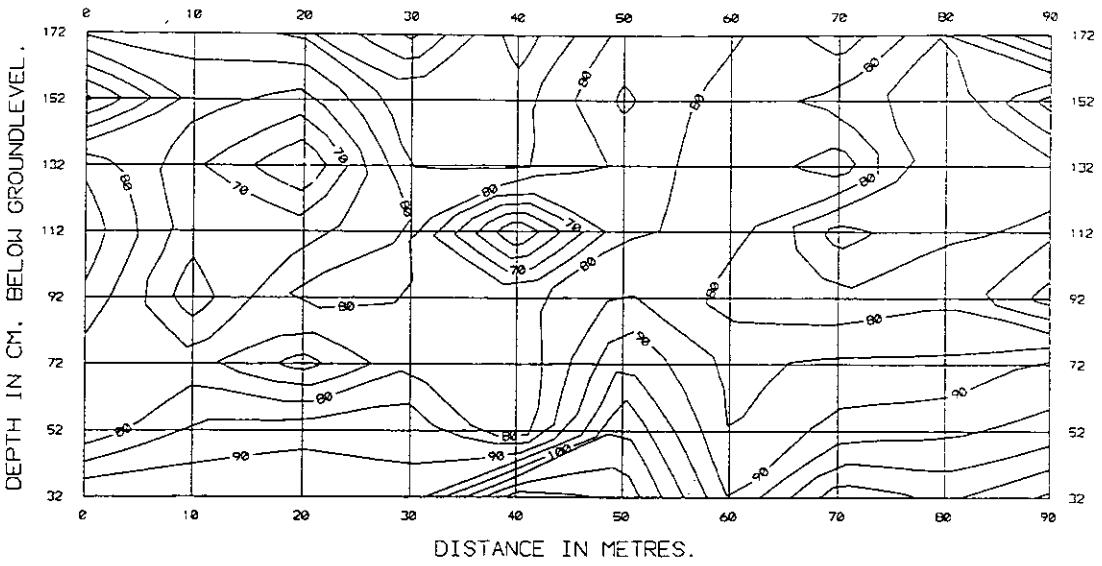
E.C. and Temperature diagrams.

E.C. measurements on Lough Roe on 15-5-'92
along transect E'60 - E'69.



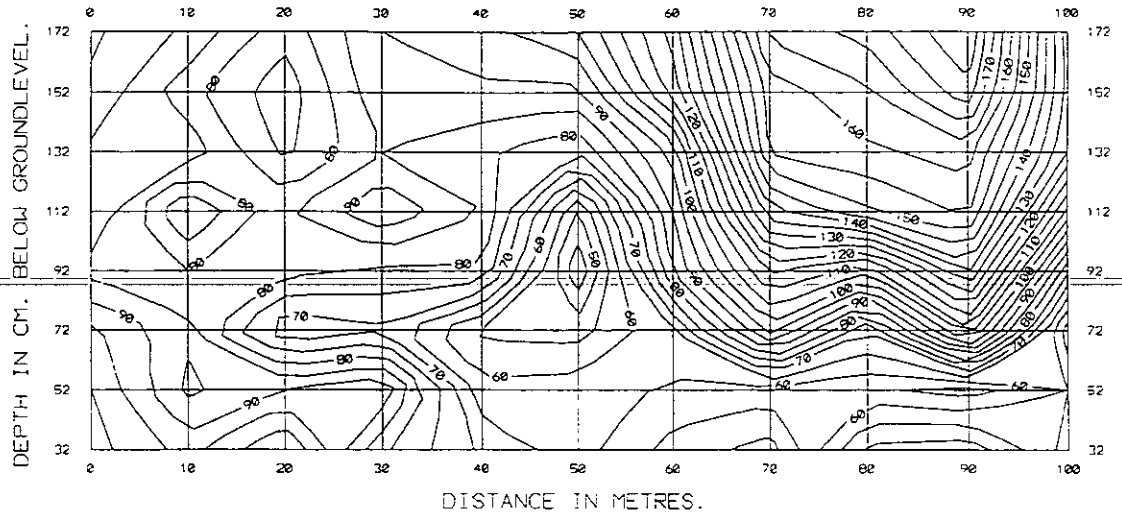
E.C. measurements on Lough Roe on 14-6-'92
along transect E'60 - E'69.



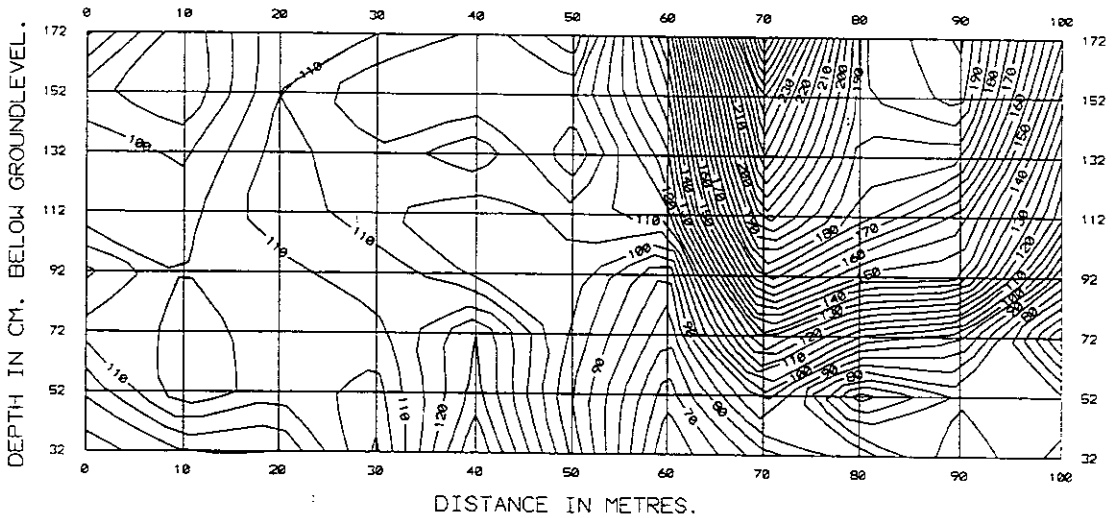


E.C. measurements on Lough Roe on 12-7-'92
along transect E'60 - E'69.

E.C. measurements on Lough Roe on 15-5-'92
along transect F'60 - F'70.



E.C. measurements on Lough Roe on 14-6-'92
along transect F'60 - F'70.



E.C. measurements on Lough Roe on 12-7-'92
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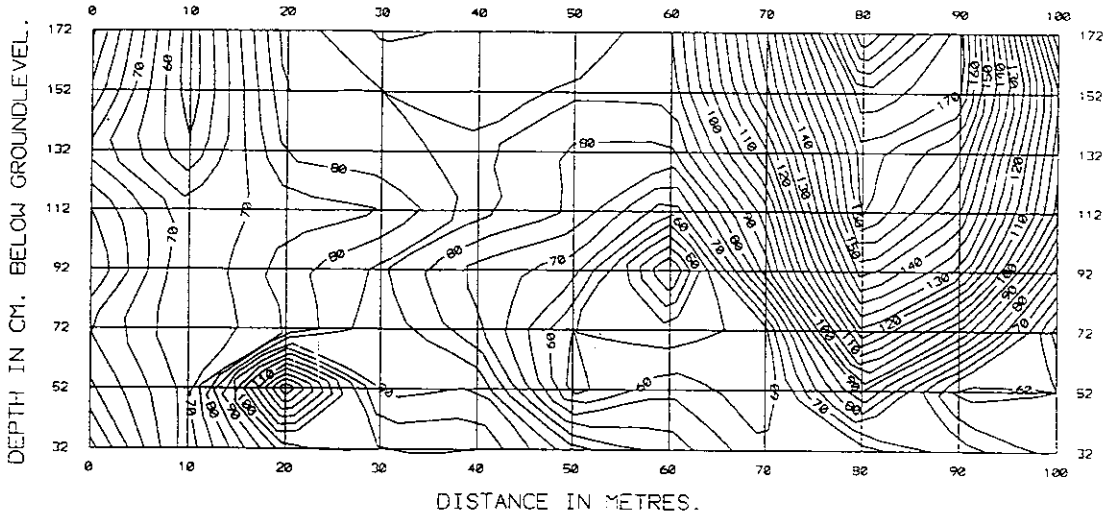
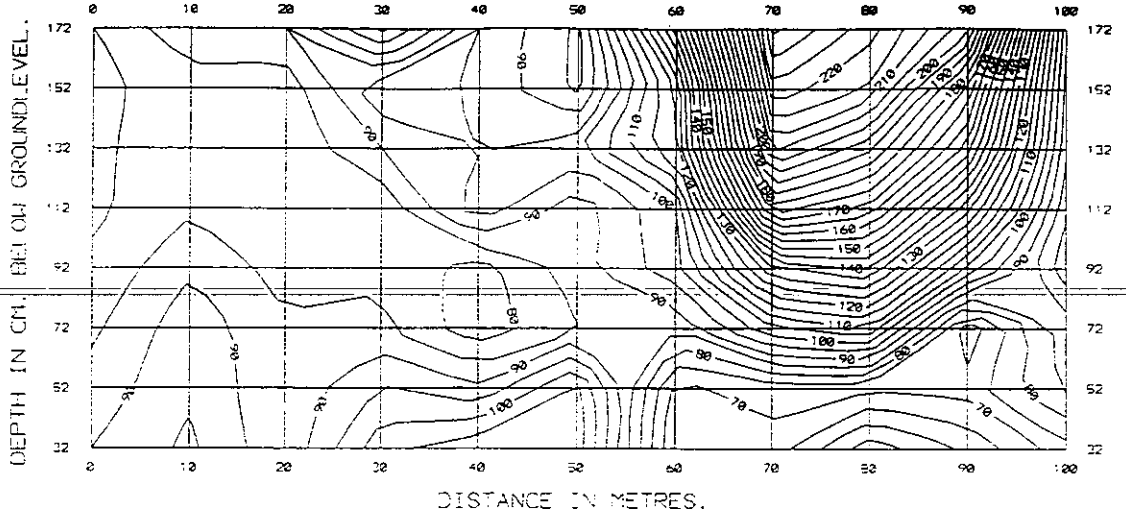
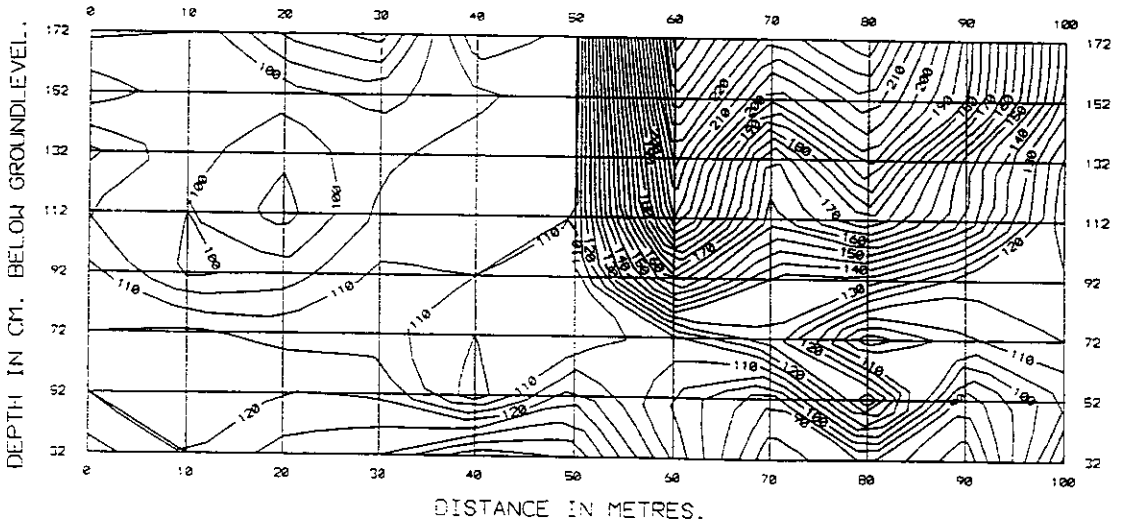


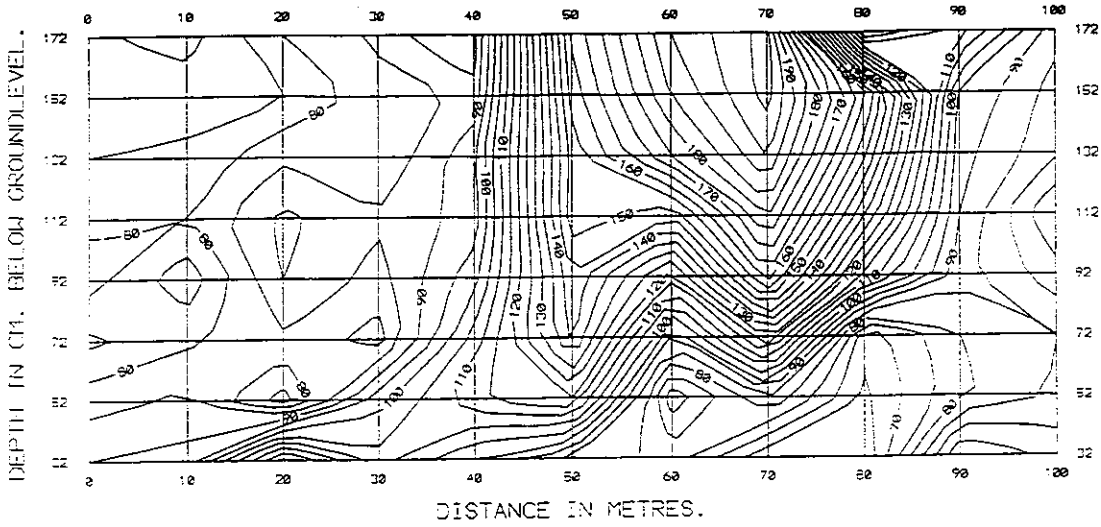
E.C. measurements on Lough Roe on 15-5-'92
along transect G'63 - G'73.



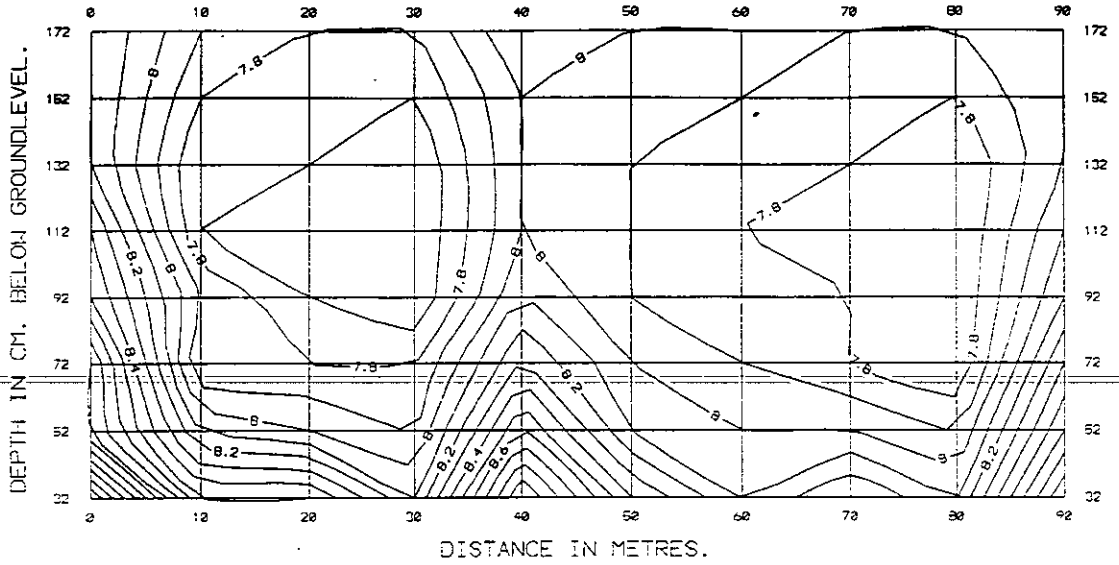
E.C. measurements on Lough Roe on 14-6-'92
along transect G'64 - G'74.



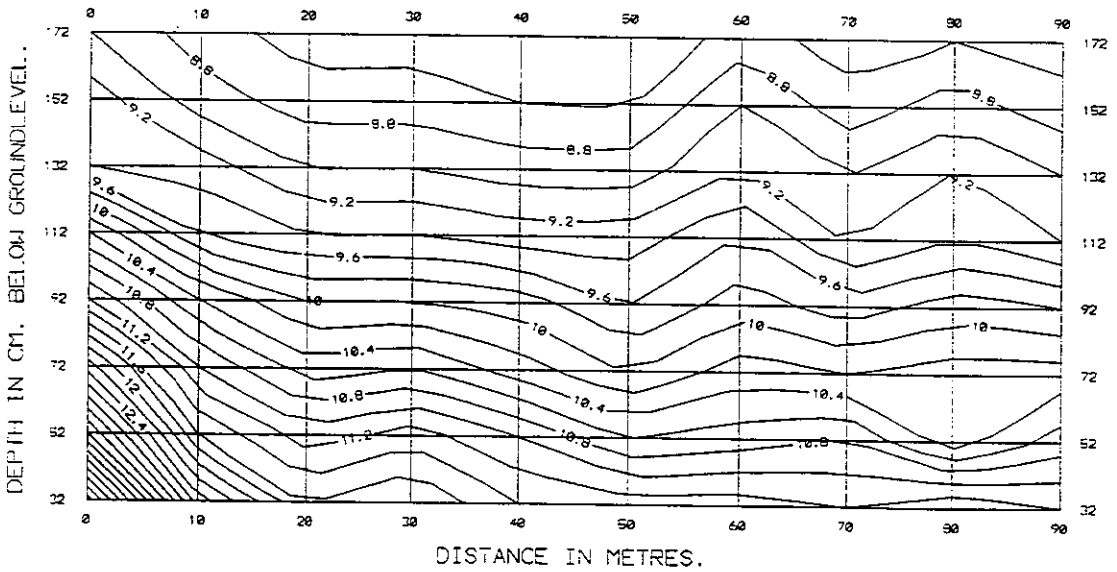
E.C. measurements on Lough Roe on 12-7-'92
along transect G'64 - G'74.



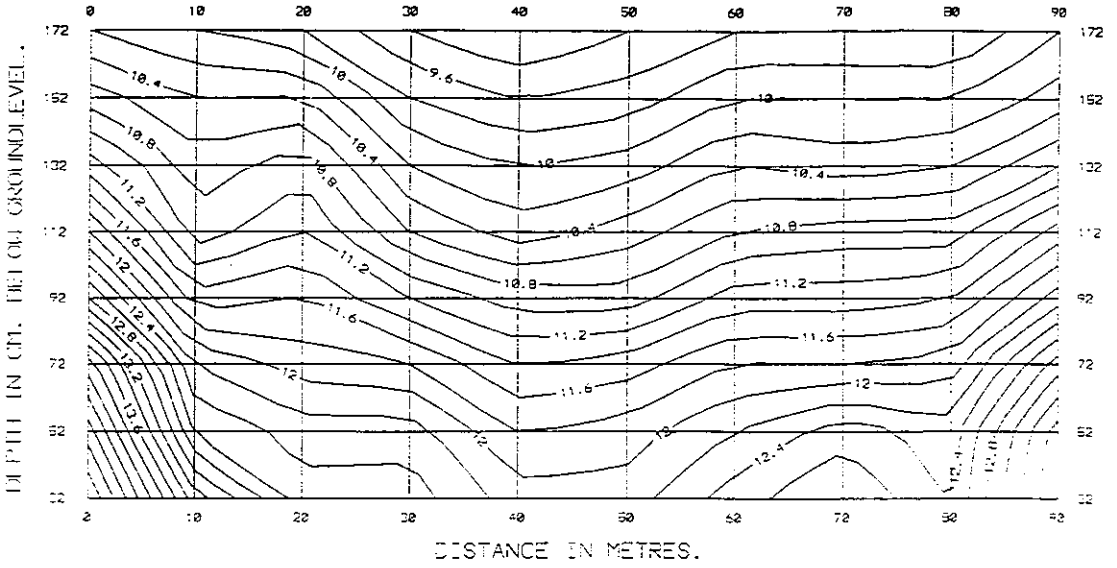
Temperature measurements on Lough Roe on 15-5-'92
along transect E'60 - E'69.



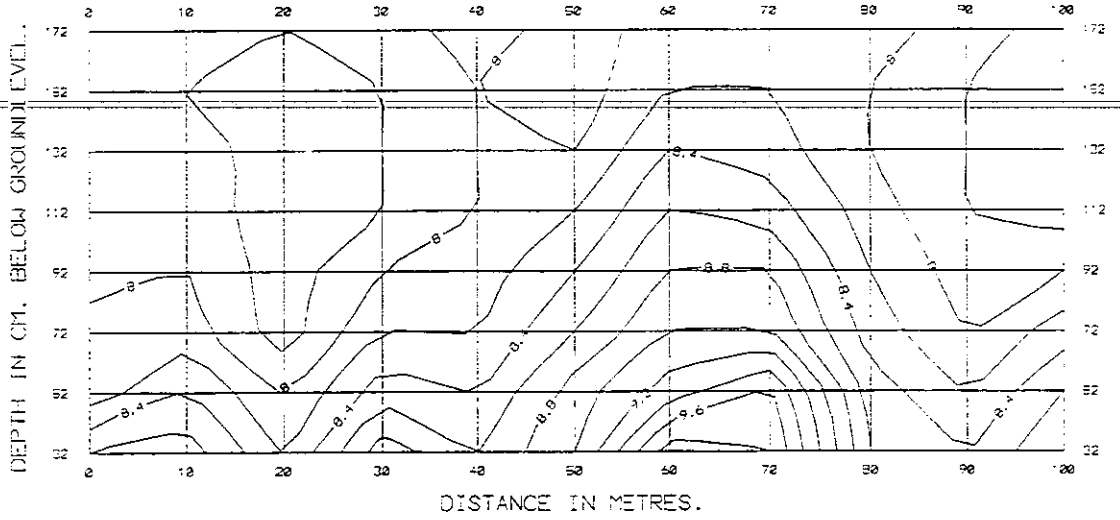
Temperature measurements on Lough Roe on 14-6-'92
along transect E'60 - E'69.



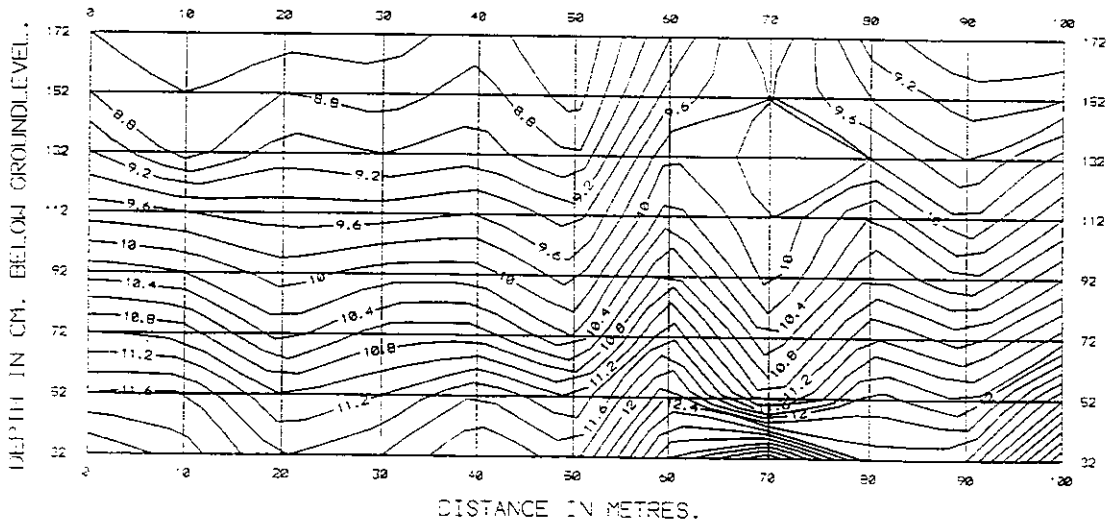
Temperature measurements on Lough Roe on 12-7-'92
along transect E'60 - E'69.



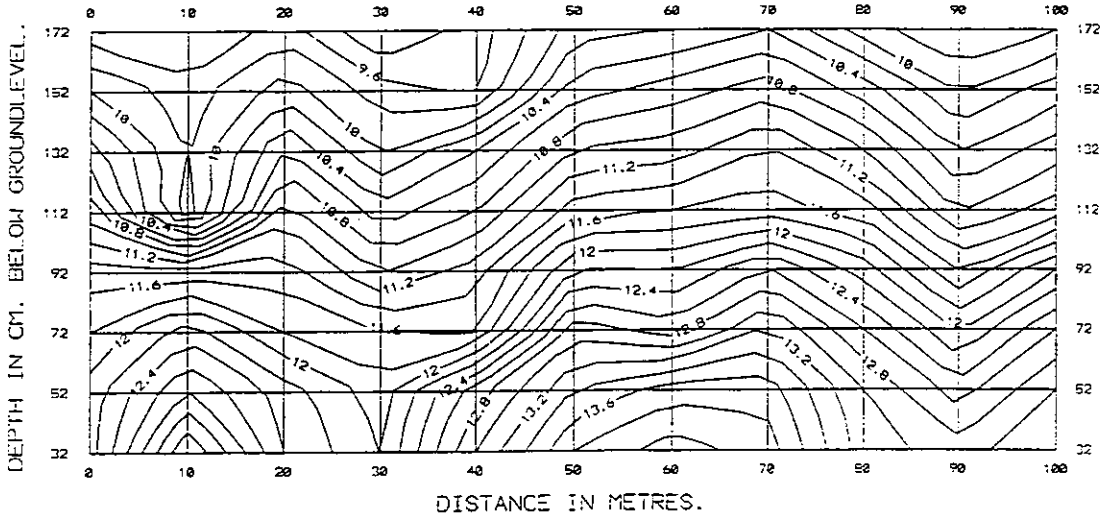
Temperature measurements on Lough Roe on 15-5-'92
along transect F'60 - F'70.



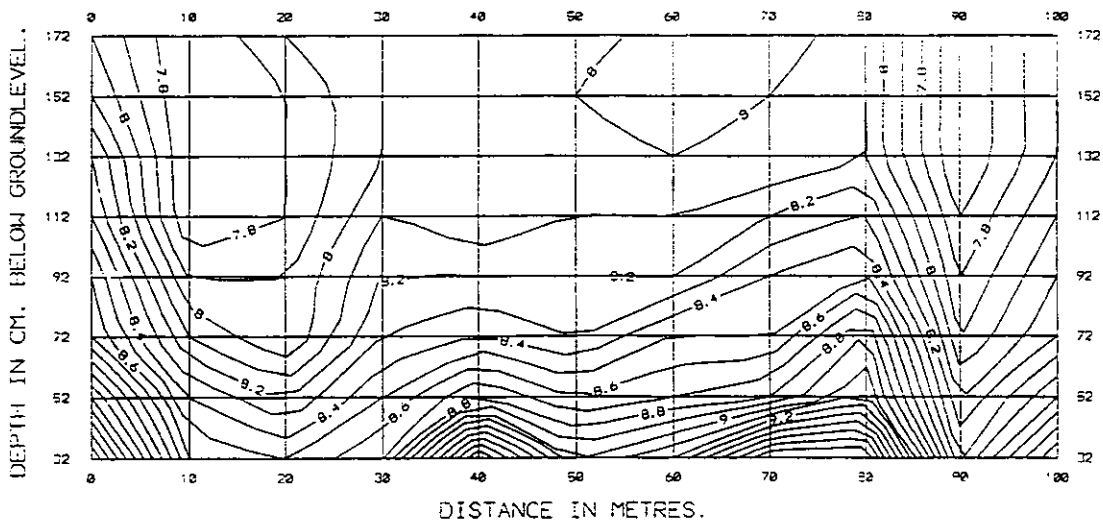
Temperature measurements on Lough Roe on 14-6-'92
along transect F'60 - F'70.



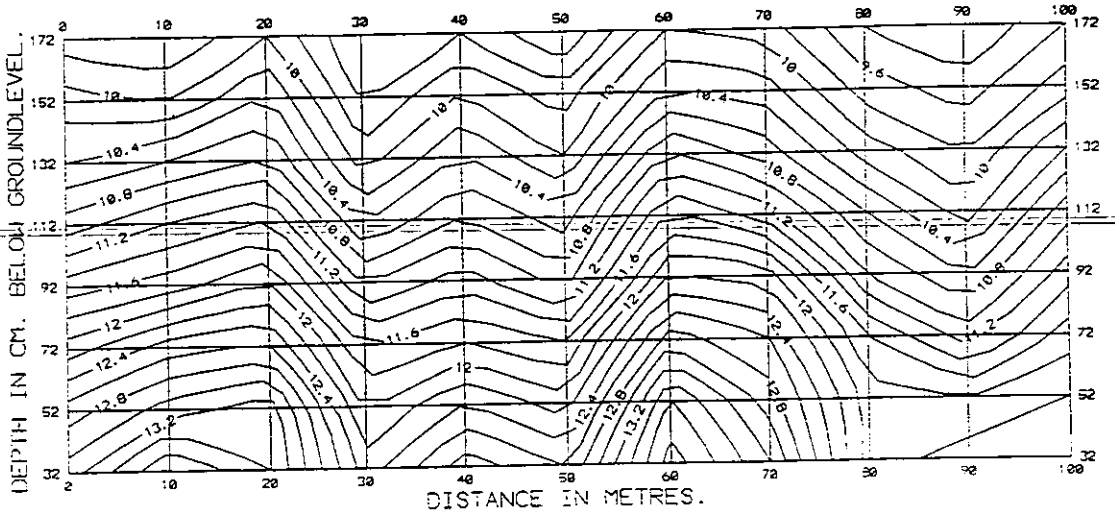
Temperature measurements on Lough Roe on 12-7-'92
along transect F'60 - F'70.



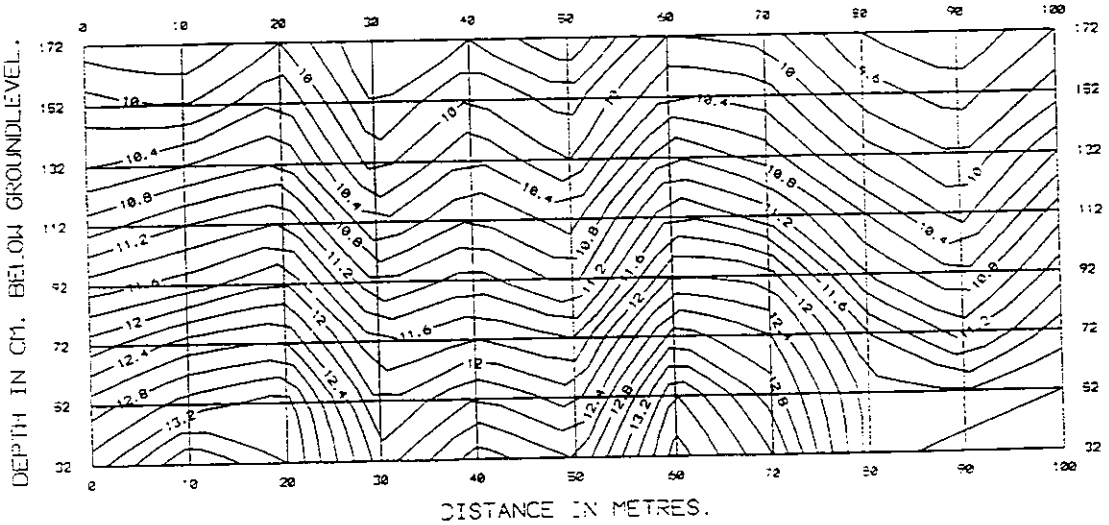
Temperature measurements on Lough Roe on 15-5-'92
along transect G'63 - G'73.



Temperature measurements on Lough Roe on 14-6-'92
along transect G'64 - G'74.

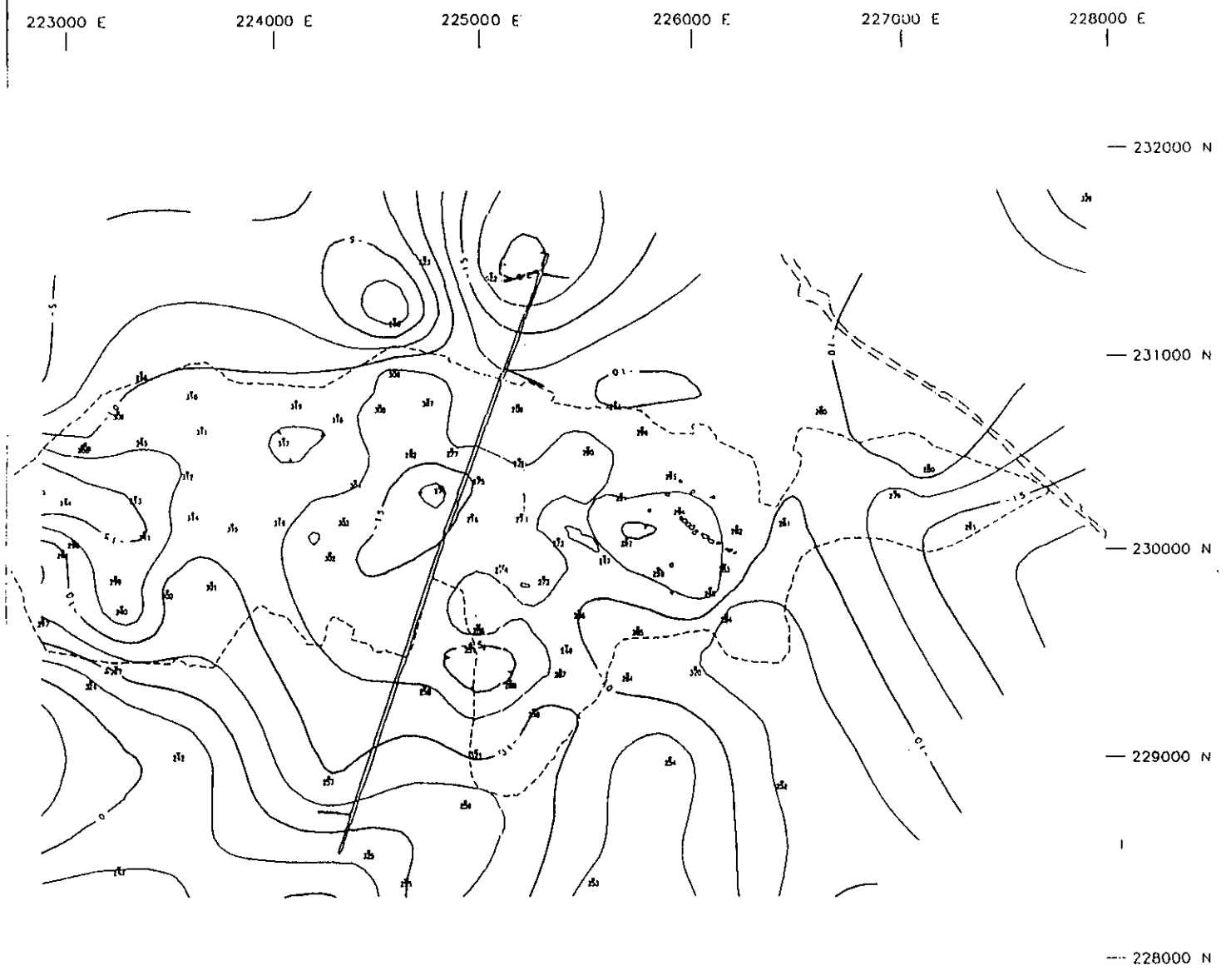


Temperature measurements on Lough Roe on 12-7-'92
along transect G'64 - G'74.



Appendix 2.

Resistivity Soundings.



38

Scale 1:20000

250 0 250 500 750 1000 1250 1500

(metres)

Dutch–Irish Project

Contoured depth to bedrock ma

Data from Nov 1991 and June 1992.

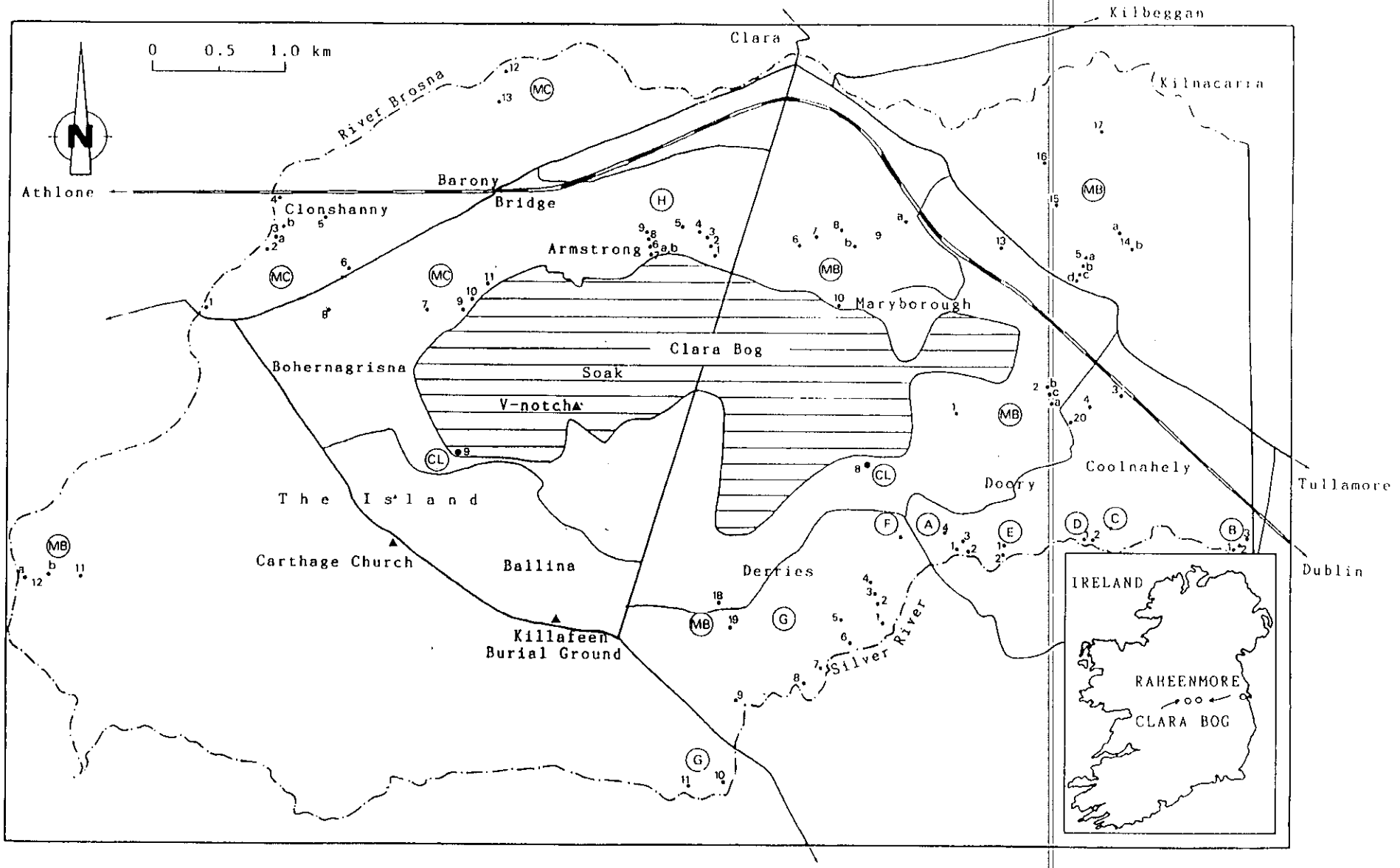
1991 -- 240/268. 1992 -- 269/321

depth in metres below surface

contour interval 5 metres

Appendix 3.

Quaternary field mapping positions and augering data.


0 0.5 1.0 km
N
Athlone
Clonshanny
Barony Bridge
River Brosna
Clara
Kilbeggan
Kilnacarra
Armstrong
Maryborough
Clara Bog
Soak
V-notch
Bohernagrisna
The Island
Carthage Church
Ballina
Killafeen Burial Ground
Derries
Silver River
Doory
Coolnahely
Tullamore
Dublin
IRELAND
RAHEENMORE
CLARA BOG
MC
MB
CL
G
H
A
B
C
D
E
F

Augerings around Clara Bog.

Site: **A1.**
Position: N 226724 - E 228743
10 m from the Silver River, flat area:
0 - 30 cm : Humic topsoil.
30 - 35 cm : Sandy silty clay,Blue-grey.
35 + cm : Cobble.
Interpretation: *alluvial deposit.*

Site: **A2.**
Position: N 226762 - E 228744
about 10 m from the riverside and about 25 m
East of A1, flat topography, meadow:
0 - 30 cm : Very humic topsoil.
45 - 55 cm : Silty medium sand.
Grey.
Slightly moist.
55 - 70 cm : More silty, finer sand.
Oxidation among roots.
70 - 100 cm : Fine silty sand.
Cohesive.
Slightly moist.
100 - 115 cm : Very fine silty sand.
Pebbles, rounded, up to 1 cm.
115 + cm : Large cobbles.
Note: Groundwater level at ca. 1 metre.
Interpretation: *transition between till and alluvial material.*

Site: **A3.**
Position: N 226742 - E 228762
25 m NE of A1, undulating topography, meadow:
0 - 8 cm : humic topsoil.
8 + cm : dry white powdery material, probably weathered boulder clay.
Interpretation : *till.*

Site: **B1.**
Position: N 228772 - E 228753
30 m NE of the Silver River, 8 m NW from hedge:
0 - 90 cm : humic topsoil.
90 + cm : dark grey fine silty sand.
Interpretation: *alluvial deposit.*

Site: **B2.**
Position: N 228781- E 228762
15 m NE of SW boundary of the field:
0 - 10 cm : black humic topsoil, peaty.
10 - 90 cm : firm clay, a bit silty, medium grey, traces of oxidation.

Note: ground water at 90 cm, clay more plastic and very firm at 80 cm.
Interpretation: *lacustrine clay.*

Site: **B3.**
Position: N 228715 - E 228782
20 m NE of B1, at NE boundary of the field next to the Silver river, 30 m SW of location B2, flat black humic tilled field:
0 - 40 cm : black humic topsoil.
40 - 65 cm : sandy silty clay, cohesive, dark grey, roots present.
65 - 110 cm : coarse sand, no clay, dark grey, wet, very loose.
110 - 130 cm : very firm silty clay, small pieces of grit up to 0.5 mm.
130 - 160 cm : very coarse sandy clay, very dark grey, less cohesive.
170 - 180 cm : coarse sandy clay, not very cohesive, dark grey.
180 - 220 cm : getting more clayey to very firm clay, angular pebble of 1 cm, end of augering due to a stone.
Interpretation: *lacustrine deposit.*

Site: **C.**
Position: N 227906 - E 228896
peaty flat grassland, 25 m West of boundary drain,
approximately 50 m East of high till mound:
0 - 30 cm : peat.
30 + cm : dark grey clay, cohesive, firm, damp, slightly sticky.
Interpretation: *lacustrine deposit.*

Site: **D1.**
Position: N 227734 - E 228801
25 m of the Silver River, 20 m East of hedge:
0 - 20 cm : peat.
20 + cm : very dark grey clay, very stiff, firm, plastic, silty.
Interpretation: *lacustrine deposit.*

Site: **D2.**
Position: N 227763 - E 228800
30 m SE of D1.
Exposure:
lacustrine deposits below ca. 20 cm.
Interpretation: *lacustrine deposit.*

Site: **E1.**
Position: N 227133 - E 288743
SW of farmhouse, 30 m of the Silver River, slight till rise to the West, peaty flat area with some till boulders present:
0 - 30 cm : peat.
30 - 50 cm : dark grey sticky clay, silty, slightly fluid.
50 + cm : soft textured clay, slightly fluid, dark grey.
Interpretation: *alluvial/lacustrine* deposit ?.

Site: **E2.**
Position: N 227124 - E 228715
15 m of Silver River:
0 - 35 cm : black humic topsoil.
35 - 45 cm : soft, medium grey clay, cohesive, slightly fluid, silty clay.
45 - 60 cm : coarse sand material, wet, no clay present.
60 - 65 cm : silty, fine sand.
65 - 80 cm : coarse sand, no clay.
80 - 110 cm : firm silty clay, brown staining (oxidation), damp wet, many roots and humic material present throughout the clay.
110 - 120 cm : very sticky firm clay.
Interpretation: *alluvial/lacustrine deposit.*

Site: **F.**
Position: N 226315 - E 228819
50 m South of field boundary, 100 m West of the road. Central depression of the till mound (elevation of 1 m), Southern part of field is a rise in till, ern part is a peaty field, extending :
0 - 40 cm : black brown humic topsoil.
40 - 55 cm : grey, very dense, very firm clay, oxidation mottles, silty.
55 + cm : dry sandy clay, brown grey, angular pebbles of 1 cm and gritty.
Interpretation: *contact zone between lacustrine clay and till surface.*

Site: **G1.**
Position: N 226286 - E 228267
25 m of Silver River, peaty flat area:
0 - 30 cm : dark brown topsoil, humic.
30 - 50 cm : light grey, silty sand.
50 - 60 cm : sand becomes fine.
60 - 65 cm : slightly silty again, oxidation mottles.
65 - 70 cm : fine sandy deposit, no silt or clay, oxidation mottles.
70 - 90 cm : silty fine sand.
90 - 150 cm : fine sandy silt, groundwater at 110 cm.
Interpretation: *alluvial deposit.*

Site: **G2.**
Position: N 226210 - E 228400
very flat area, 30 m South of hedge:
0 - 35 cm : topsoil, dark-brown humic.
35 - 50 cm : silty smooth material, silt.
50 - 70 cm : fine sandy silt.
70 - 90 cm : medium grey clayey silty fine sand.
Interpretation: alluvial deposit ?.
90 - 150 cm : extremely dense, firm plastic, blue-grey clay,
oxidation patches, some vegetation matter present.
Interpretation: *lacustrine deposit.*

Site: **G3.**
Position: N 226190 - E 228457
6 m South of hedge, 40 m of G2:
0 - 30 cm : topsoil.
30 - 55 cm : grey fine silty sand, damp.
55 - 90 cm : fine silty, vegetation matter present, groundwater present at 75 cm.
90 - 100 cm : very dense, very firm plastic clay, oxidation mottles, blue-grey.
Interpretation: *lacustrine deposit.*

Site: **G4.**
Position: N 226181 - E 228495
10 m of drain at field boundary, field
has a very gentle rise:
0 - 20 cm : topsoil.
20 - 30 cm : dry silty clay.
30 + cm : dry, weathered, gritty pieces, limestone.
Interpretation: *till surface.*

Site: **G5.**
Position: N 225934 - E 228219
long NS depression in till landscape, 4 m to 3 m high undulating hills, field is full of these broad circular hills extending to the Silver River; rolling hills.
0 - 20 cm : topsoil, humic brown.
20 - 30 cm : dense clay, grey.
30 + cm : dry, coarse gritty material mixed with clay.
Interpretation: *thin lacustrine clay layer on till surface.*

Site: **G6.**
Position: N 226019 - E 228095
40 m N of the Silver River, same depression as G5.
0 - 15 cm : topsoil.
15 - 20 cm : blue grey clay, very firm.
Interpretation: *lacustrine clay.*
Note: till extends to the Silver River, the river is flowing through relatively undulating till area, therefore the till is exposed on both sides of the river bank.

Site: **G7.**
Position: N 225762 - E 227877
8 m from the Silver River, broad depression in till:
0 - 75 cm : brown loamy topsoil.
75 + cm : firm clay, silty, organic matter, vegetation matter, oxidation mottles, typical lacustrine deposit colour.
Interpretation: *lacustrine clay.*

Site: **G8.**
Position: N 225429 - E 227734
10 m of the Silver River, slight depression in till area:
0 - 120 cm : loamy topsoil.
120 + cm : typical blue gray firm lacustrine clay.
Note: close to the river, topsoil maybe disturbed.
Interpretation: *lacustrine clay.*

Site: **G9.**
Position: N 225172 - E 227630
drain perpendicular to the Silver River.
Exposure:
25 cm of topsoil than firm clay, light grey, with large cobbles in places on the NE side bank,gravelly till, clay matrix, cobbles up to 10 cm on the SW side bank, gravels and boulders on the bottom of the ditch.
Interpretation: *Transition zone between till and lacustrine clay.*

Site: **G10.**
Position: N 225029 - E 227095
depression at the bottom of a very gentle till rise towards the NW:
0 - 30 cm : brown loamy topsoil.
30 - 80 cm : black peaty soil.
80 - 90 cm : very fine sandy clay, moist, slightly fluid.
90 - 110 cm : clay is getting more plastic and wet, not very dense, groundwater at 1 m.
Interpretation: *lacustrine clay.*
Note: river side at G10, lacustrine deposits on till with big boulders up to 50 cm, lacustrine clay is very firm, grey.

Site: **G11.**
Position: N 224724 - E 227048
Bollybeg Callows, 10 m from Silver River side:
0 - 50 cm : loamy topsoil.
50 - 210 cm : mineralized peat, black soft peat, wet,
woody fragments at 95 cm, water table at 1 m.
210 + cm : blue grey, plastic soft clay.
Interpretation: *lacustrine clay.*
Note: river bank at this location contains no boulders, although exposure is not very good.

Site: **H1.**
Position: N 225057 - E 230925
removed peat area rising towards the esker gravels, 5 m N of hedge:
0 - 230 cm : *Peat.*

Site: **H2.**
Position: N 225038 - E 231019
15 m of hedge, centre of field,
very slight rise in undulating topography:
0 - 200 cm : strongly mineralized peat.
200 - 230 cm : clayey material with gravels.
Interpretation: *esker or till deposit.*

Site: **H3.**
Position: N 225029 - E 231067
5 m South of hedge, base of rising esker gravel slope:
0 - 20 cm : peaty topsoil.
20 - 30 cm : weathered quartzite grains, dirty white material,
dried damp crystals like coarse salt.
30 - 40 cm : sandy material with pebbles, subrounded to subangular, light-brown to butterscotch, probably due to leaching of humic material, silty weathered stone fragments up to 1.5 cm.
40 - 65 cm : grey clay, soft putty texture, no pebbles and no grit, silty.
65 - 70 cm : clay gets a bit darker, sandy clay, less firm.
Interpretation: *till or esker slope material.*

Site: **H4.**
Position: N 225010 - E 231076
6 m of hedge, NW of location G3.

0 - 60 cm	: topsoil, heavy clayey loam, butterscotch brown.
60 - 80 cm	: clayey coarse sand to fine gravel, average size is smaller then 2 cm, grayish with brown traces.
80 - 90 cm	: brownish weathered material, angular black limestone pieces up to 2 cm, matrix is brown clayey coarse sand.
90 - 110 cm	: again brown coarse sand, pebbles up to 1.5 cm, subrounded.
110 - 130 cm	: grayish-brown clayey sand, damp and sticky.
130 - 140 cm	: brownish-grey silty sand, sticky, subrounded pebble.
140 - 190 cm	: very weathered clayey dry sand, normal colour seems dark grey, large humic brown mottles mixed into the material, angular pebbles up to 5 mm.
195 + cm	: angular pebbles, high humic content, gritty clayey sand.

Interpretation: *Colluvial material from the esker.*

Site: **H5.**
Position: N 224896 - E 231105
flattish area on a steep slope, threshold on the main slope:

0 - 60 cm	: topsoil, brown heavy loamy material with pieces of grit, at 30 cm colour changes to ash brown.
60 - 65 cm	: yellow brown gritty sand.
65 - 70 cm	: dry fine gravelly, very brown, subrounded to subangular, pieces of grit up to 5 mm.

Interpretation: *esker slope material.*

Site: **H6.**
Position: N 224640 - E 231067
Fleming's field, 30 m West of the Hedge,
transition zone between the base of the esker
and the Peat, no clear boundary as field goes
out into the bog, approximately 20 m into field,
on the edge of the peaty area.

0 - 20 cm	: Peat, black.
20 - 30 cm	: whitish grey, coarse sand, dry.
30 - 40 cm	: a bit clayey but denser.
40 - 50 cm	: light grey, clayey coarse sand, gritty, more firm consolidated.
60 - 90 cm	: grey plastic, soft, putty like clay, very sticky.
90 +	: dry rotten rock material, hard lumps which are very brittle and grind up into grains f coarse sand.

Interpretation: *esker material.*

Site: **H7a.**
Position: N 224640 - E 231038
10 m South of H6., small depression before peat rise (see Fig. A3a).

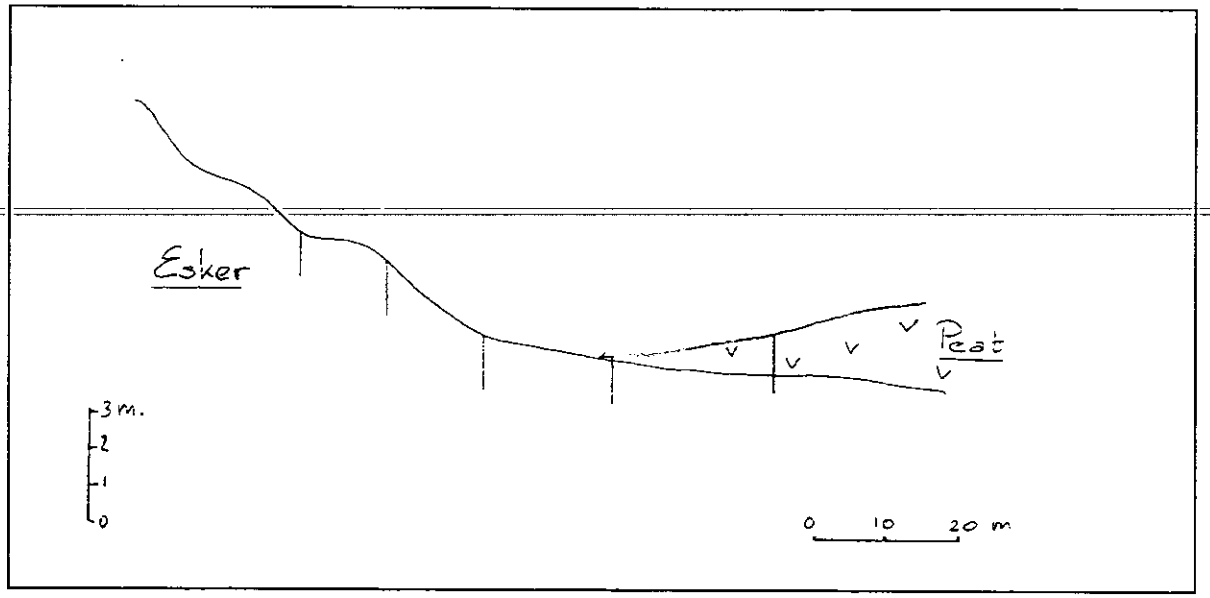


Figure A3a.

0 - 170 cm : black humified peat, wood tissue at 90 cm
170 - 190 cm : light brown wet medium coarse sand.
190 - 200 cm : wet grey medium coarse sand, a bit silty.
Interpretation: *lacustrine deposit.*

Site: **H7b.**
Position: N 224640 - E 231038
southern edge of Clara-West, contact zone between the bog and the esker, Flemings field.
0 - 200 cm : black peat with woody fragments.
200 - 210 cm : peat, fluid clay, sandy.
210 - 220 cm : fine silty sand, fluid, light grey.
220 - 250 cm : very dense, dry clay, firm, light grey.
250 - 300 cm : very stiff dense clay, sticky, slightly moist, grayish with a touch of brown, small amount of silt present.
Interpretation: *lacustrine clay.*

Site: **H8.**
Position: N 224640 - E 231086
10 m of location H6., main rising slope, near the base of the esker.
0 - 10 cm : peaty topsoil.
10 - 70 cm : dry fine gravelly material, common size < 2 cm, subangular.
70 - 110 cm : silty sandy clay, pieces of grit, mottles of due to humic impurities, subangular stones up to 2 cm on a depth of 110 cm.
110 - 150 cm : rubbish mix of humic peaty grey, clayey sand.
150 - 190 cm : sand, with a bit of silty material, wet, grey.
Interpretation: *esker slope material.*

Site: **H9.**
Position: N 224640 - E 231115
10 m of location H8., ground level 1.2 m above location H8.
0 - 35 cm : top soil, brown loamy, heavy sand.
35 - 40 cm : gravelly material, subrounded to subangular, pebble size up to 1 cm, clayey gravel, white grey.
40 - 60 cm : lose sand, damp, light brown grey, a bit clayey.
60 - 70 cm : ash brown, bright orange due to high amount of Iron oxide, very firm, dry, cohesive clay.
70 - 100 cm : very light grey silt material with a bit of clay, soft putty like.
100 - 105 cm : grey damp clayey silt, a bit sticky, at 115 cm very dark brown-grey silty sand, at 125 cm becomes more greyer, at 180 cm grey firm clay, at 190 cm grey fine sand, at 210 cm brown humic mottles.
Note: remarkable much Iron oxide at 60 to 70 cm, ma bey due to an iron object in the ground ?.
Interpretation: *esker slope material.*

Site: **MB1.**
Position: N 226896 - E 229639
flat field SE of the deciduous forest on the SE side of Clara East.
Exposure:
clayey till, large boulders, dull brown colour, rounded gravels, common calcarnitic blocks, limy sandstone with cemented quartzite grains and brown-red weathering spots,
inside is dark grey, subangular tabular.
Interpretation: *clayey till, with large boulders.*

Site: **MB2a.**
Position: N 277515 - E 229848
slightly undulating field, on the East side of Clara bog (see Fig. A3b.).

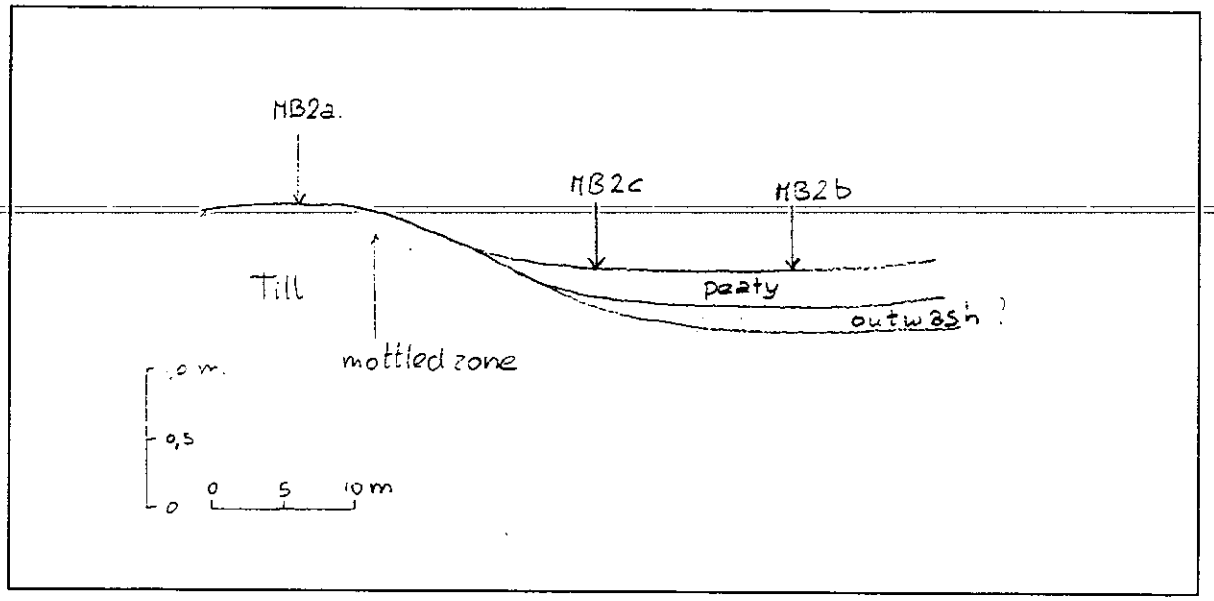


Figure A3b.

0 - 8 cm : topsoil.
8 - 40 cm : weathered stone fragments, matrix of clayey sand, grey colour.
Interpretation: *till.*

Site: **MB2b.**
Position: N 227524 - E 229905
depression in undulating field, 40 m from MB2a.
0 - 55 cm : black humified peat.
55 - 80 cm : very wet fine light grey sand, getting a bit more silty towards 80 cm.
80 - 90 cm : same as above but a bit more clayey.
90 + : sandy clay with small gritty pieces of limestone, size up to 0.5 cm.
Interpretation: *washed out material, till/lacustrine.*

Site: **MB2c.**
Position: N 227518 - E 229886
between MB2a. and MB2b., a bit sloping.
0 - 5 cm : topsoil.
5 - deeper : grey pieces of rotten rock, fine sand, silty matrix, white pieces of weathered material.
Interpretation: *till.*

Site: **MB3.**
Position: N 228010 - E 230010
NE esker ridge near the Tullamore road.
exposure: dug out material.
1.Bouldery layer : subrounded to rounded boulders, size up to 20 cm, light grey limestone, fine sandy silty matrix.
2.Silty layer : very fine silt, well stratified, CaCO3 veins.
3.Gravelly layer : gravels, common size up to 2 cm, occasionally up to 10 cm, fine sandy matrix.
Note: peaty area up to exposure in the esker.
Interpretation: *esker gravels.*

Site: **MB4.**
Position: N 227754 - E 229867
across the road of the field of MB2.
Exposure: dug out ditch material.
large boulders, size 0.5 to 1 m, subrounded to subangular,
occasional boulder bigger then 1 m, limestone and occasional
calcarnite., clayey sand matrix.
Interpretation: *till.*

Site: **MB5.**
Position: transect perpendicular to the Tullamore road, where it cuts the esker, very flat area at the base of the esker.

A:
N 227781 - E 230772
0 - 5 cm : humic peaty top soil, field with rushes.
5 - 20 cm : stiff weathered clay with root fragments, brown grey colour.
20 - 50 cm : blue grey clay, putty like, very dense.
Interpretation: *lacustrine clay.*

B:
N 227762 - E 230743
0 - 20 cm : peaty topsoil.
20 - 70 cm : grayish brown clay, firm, a bit silty, root fragments, very weathered, getting moist at 70 cm.
70 - 80 cm : soft plastic clay, grey with orange brown oxidation mottles.
Interpretation: *lacustrine clay.*

C:
N 227754 - E 230714
0 - 40 cm : peaty top soil.
40 - 50 cm : plastic sticky soft clay, blue grey colour, slightly weathered.
50 - 90 cm : very soft clay, getting wet at 90 cm.
90 + : very fluid clay, a bit silty.
Interpretation: *lacustrine clay.*

D:
N 227743 - E 230705
0 - 40 cm : black peaty topsoil.
40 - 45 cm : weathered clay with small weathered rock fragments, gravelly.
45 - 60 cm : weathered gravelly clay.
60 - 70 cm : very gritty, less gravelly, weathered rock fragments, a little bit sandy.
Interpretation: *slope material.*
Note: also exposure at the roadside, gravelly till with boulders up to 15 cm, brownish colour, weathered.

Site: **MB6.**
Position: N 225801 - E 231429
Northern esker ridge near Lough Cuith.
Exposure: road cut through the top of the esker ridge.
bottom of exposure consists of big rounded to subrounded boulders up to 1 m with a coarse to fine silty sand matrix, subrounded gravels and subangular grit pieces.
middle part of exposure very slumped and disordered.
top part consists of gravelly material with small boulders up to 10 cm and brownish weathered.
Note: no clear layering, limestone and some calcarnite.

Site: **MB7.**
Position: N 225896 - E 231448
between two esker ridges in a bowl shaped depression.
0 - 15 cm : heavy, loamy top soil, brown.
15 - 40 cm : brown grey weathered sandy clay.
40 - 60 cm : damp wet, grey clayey sand.
60 - 110 cm : sandy grayish, unweathered material.
110 - 190 cm : silty weathered sand.
190 - 240 cm : clayey sand, grey and brownish.
Interpretation: *washed out slope material, or lacustrine deposit?.*

Site: **MB8.**
Position: N 226076 - E 231467
bowl shaped depression surrounded by esker ridges.
mapped as Lough Cuith, wet area with rush, marsh penny wort and other species indicating a wet area probably under water most time of the year.

0 - 80 cm	: black peaty top soil.
80 - 90 cm	: gravels, few up to 1 cm in soft sticky clay, light grey colour.
90 - 110 cm	: silty sticky sand with angular gravels.
110 - 120 cm	: very soft sandy sticky clay, occasional pieces of angular grit up to 0.5 cm.

Interpretation: *lacustrine deposit.*

Site: **MB9a.**
Position: N 226314 - E 231381
on the western esker ridge, along the roadside.
Exposure: road cut away through the esker ridge.
rounded boulders up to 1 m, subrounded gravels up to 3 cm, no silty layers, matrix consists of clayey sand, limestone.
at the bottom of the exposure the material has slumped.

Site: **MB9b.**
Position: N 226200 - E 231353
50 m further down the road, to the West.
Exposure: road cut away through the esker ridge.
coarse gravel deposit, matrix consists of very coarse sand,
few rounded boulders up to 60 cm, no clear layering, massive.

Site: **MB10.**
Position: N 226067 - E 230629
western esker ridge, contact zone between the Peat and the esker at the side of Clara East, flat peaty area.
Exposure: freshly dug out ditch.
sandy or clayey lacustrine deposit underlying the Peat.
Interpretation: *contact zone lacustrine deposit and Peat.*

Site: **MB11.**
Position: N 220114 - E 228667
far West side of the study area, 200 m from the river Brosna.
Exposure: dug out ditch, flat area.
angular big boulders, size 0.5 to 1.5 m., grey Limestone,
some calcarnite boulders, sandy loamy matrix with few gravels,tabular boulders, size up to 2 m
Interpretation: *flat till area, non undulating.*

Site: **MB12a.**
Position: N 219753 - E 228620
at the Brosna riverside, West of MB11.
Exposure: river bank.
big boulders up to 1 m, subangular, shaly black limestone, matrix consists of sandy loamy material with occasional subrounded to subangular gravels up to 3 cm, a few cobbles up to 10 cm.
Interpretation: *flat till.*

Site: **MB12b.**
Position: N 219867 - E 228658
75 m East of MB12a.
0 - 8 cm : loamy topsoil, butterscotch brown.
8 - 50 cm : heavy grey brown weathered clay with a few gravels.
50 + : to gravelly to drill.
Interpretation: *flat till.*

Site: **MB13.**
Position: N 227067 - E 231305
flat field East of the Tullamore road, 5 m East of the ditch, peaty area.
0 - 30 cm : black peaty top soil.
30 + : grey sticky clay, moist but not fluid, soft putty type, very easy to deform, possibly because of high silt content.
Interpretation: *lacustrine clay.*

Site: **MB14a.**
Position: N 228019 - E 230949
flat field, peaty ,drain on West side of field.
Exposure: dug out ditch.
topsoil consists of 50 cm black peat, dark clayey material underneath with boulders up to 10 cm, few calcarnite boulders the rest is limestone, heavy clay dug out of drain with out boulders.
Interpretation: *contact zone Peat/lacustrine/till* ?

Site: **MB14b.**
Position: N 227887 - E 230934
field to the side of the road.
Exposure: dug out ditch, not very fresh.
brown loamy topsoil about 50 cm thick, underneath clayey sandy material, feels very silty.
Interpretation: *washed out slope material* ?

Site: **MB15a.**
Position: N 227696 - E 231143
flat grass field.
0 - 15 cm : black peaty topsoil.
15 + : dark grey clay, soft and putty like, silty to taste, sticky.
Note : all along the ditch freshly dug out clayey material.
Interpretation: *lacustrine clay.*

Site: **MB15b.**
Position: N 227710 - E 231175
6 m West of the ditch.
0 - 8 cm : peaty topsoil.
8 + : dark grey, soft and putty like clay.
Note: in the ditch on the East side clay deposits with an occasional boulder up to 10 cm.
Interpretation: *lacustrine clay.*

Site: **MB16.**
Position: N 277610 - E 231620
South of the road.
Exposure: drain parallel to the road.
loose fine cobble gravel in drain, dug out material consists of normal clast size 2 to 5 cm, subrounded light grey limestone.
Interpretation: *gravelly till.*

Site: **MB17.**
Position: N 228000 - E 2312810
second field SW of the T-junction, of the Tullamore road.
Exposure: drain.
dark grey clay with few subrounded pebbles up to 1 cm, tiny dark grey angular limestone pieces, clay overlies a clayey till.
Interpretation: *gravelly clay till.*

Site: **MB18.**
Position: N 225076 - E 228362
Clara SE, corner of the field, flat till fields South of the wood on Clara East, to the high till mounds, occasional boulder visible at the surface.
Exposure: massive boulders some bigger than 3 m, weathered, dirty brown grey colour, tabular angular, lots of small boulders up to 50 cm, possibly indicative of shallow bedrock. dark grey, smooth grained limestone, occasional fossils.
Interpretation: *till close to bedrock.*

Site: **MB19.**
Position: N 225133 - E 228276
South of Clara East, the Derries, SW of the Mushroom stone (van Tatenhove & v.d. Meer), flat field.
Exposure: dug out drain.
all weathered dirty dull brown large angular boulders up to 1.5 m, medium grey limestone, fine grained, abundant fossils.
Interpretation: *bouldery till.*

Site: **MB20.**
Position: N 227591 - E 229724
East of the road to the Derries.
Exposure: dug out ditch.
gravels, large boulders up to 1 m, small pebbles up to 5 cm matrix consists of very consolidated, firm dry clay, not very sandy, fine gravel pieces form 2 to 3 mm.
Interpretation: *gravelly till.*

Site: **MC1.**
Position: N 221143 - E 230600
70 m of the Ballycumber Bridge, along the river Brosna.
Exposure: tabular, large blocks along the river bank.
dark grey shaly limestone, very fossiliferous, apparent bedding, possibly just shaly constituent that gives a bedding impression.
Interpretation: *till, close to bedrock.*

Site: **MC2.**
Position: N 221486 - E 230934
field 50 m East of the river, very steep rising ground.
0 - 40 cm : loamy brown top soil.
40 - 60 cm : clayey loam, very firm, humic material, black, in brown clay, seemed very disturbed.
60 - 70 cm : grey, very firm dense clay, silty to taste.
70 + : boulder.
Interpretation: *till.*

Site: **MC3a.**
Position: N 221562 - E 231076
Inchaloan Island, area immediately East is very high undulating till topography.
Exposure:
very large boulders, 2.5 to 1 m, very weathered, tabular shaped, dark limestone.
Interpretation: *till, very close to bedrock.*

Site: **MC3b.**
Position: N 221667 - E 231190
very flat meadow field, part of Inchaloan Island, 30 m East of the river.
0 - 30 cm : brown loamy topsoil, dry.
30 - 35 cm : becomes more clayey, brown grey clay with black stains.
35 - 60 cm : loose dry clay, very silty, becomes a little more sandy after 60 cm, still very dry.
Interpretation: *dried out alluvial deposit or else Colluvial material ?.*

Site: **MC4.**
Position: N 221667 - E 231448
South side of the rail track, drain along the rail embankment, 40 m East of Brosna river.
Exposure: dug out ditch.
medium gravel boulders, subrounded, size from 10 to 20 cm in dry clayey, coarse sand to fine gravel matrix.
Interpretation: *till.*

Site: **MC5.**
Position: N 222019 - E 231448
200 m South of the railway, few 100 m East of the river Brosna, flat peaty area with rushy wet grass.
Exposure: dug out ditch.
lacustrine clay, dark grey fluidly, very dense, 2.5 m large boulder, dark limestone.
Interpretation: *lacustrine clay.*

Site: **MC6.**
Position: N 222324 - E 231286
West of Clara Bog.
Exposure:
Gravelly clay,very gritty,large striated boulders.
Interpretation: *grey till.*

Site: **MC7.**
Position: N 222705 - E 230429
100 m from Western bog edge.
Exposure: dug out material
very fine clay,dried out,light grey,no boulders or gravels.
Interpretation: *lacustrine clay.*

Site: **MC8.**
Position: N 222105 - E 230410
200 m South of road Clara-Ballycumber,near Brosna.
Exposure: extremely deep ploughed field.
very large boulders sandy and clayey material in matrix.
Interpretation: *grey till.*

Site: **MC9.**
Position: N 222848 - E 230477
20 m from the Western bog edge end of esker complex on the Northern side of the bog.
Exposure: situation in field.
Peat cover on the esker ridge.

Site: **MC10.**
Position: N 222886 - E 230514
20 m from MC9,on the esker ridge.
Exposure: dug out ditch.
coarse sand to fine gravel,subrounded pebbles.
Interpretation: *esker material.*

Site: **MC11.**
Position: N 223019 - E 230629
esker ridge, NW bog edge.
Exposure:
sandy gravelly material,rounded boulders up to 5 cm,angular gravels,weathered rock fragments.
Interpretation: *esker material going over into peaty area.*

Site: **MC12.**
Position: N 223438 - E 232410
10 m south of the Brosna,50 m of till mount.
0 - 30 cm : topsoil.
30 - 45 cm : weathered material,with oxidation mottles.
45 + : fine sandy homogeneous material,moist,dark grey.
Interpretation: *alluvial deposit.*

Site: **MC13.**
Position: N 223353 - E 232219
100 m South of Brosna.
0 - 10 cm : topsoil.
10 + : clayey dark grey material,moist.
Interpretation: *alluvial deposit or lacustrine clay.*