IRISH - DUTCH RAISED BOG STUDY
GEOHYDROLOGY AND ECOLOGY

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ACROTELM SURVEY OF CLARA BOG

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

Acrotelm survey of Clara Bog

Part one:

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Appendices:

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Erratum

The map scales on appendices V.1, V.2, VI.1 and VI.2 show 2.5 cm to 1 km. This should be 2.5 cm to 200 m

PART ONE

PREFACE

This report is the result of a close cooperation between the authors. But we never could have done this without some very good help and assistance. Therefore we would like to thank everyone who has given us a helping hand. Especially we would like to thank Sake van der Schaaf, our supervisor, for giving us directions and keeping us in touch with the Netherlands, Mr. F. Dolezal for the supply of the evaporation figures and last but not least our Irish colleagues: Ray, Lara and Mary.

For this research we spent five months in Ireland. Although we were staying in Clara during one of the wettest winters in years, we enjoyed almost every minute of it. The sport- and publife was a welcome diversion after working on a cold and wet bog all day. We thank the people of Clara for their hospitality and friendship which we enjoyed during our stay.

Wageningen, April 1993.

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SUMMARY

In the north-western part of Europe raised bogs have become rare. The Irish government tries to preserve the raised bog remnants now as good as possible. Sound hydrological management is therefore needed. The Irish-Dutch bog project is set up to find solutions concerning this management. The project is a cooperation between the Irish Wildlife Service and the Dutch National Forest Service.

This report consists mainly of an inventory of the health of Clara Bog, especially of the toplayer, the acrotelm. To understand the importance of the acrotelm first a reconstruction and a general description of Clara Bog is given.

The acrotelm is the toplayer of the bog. It is defined here as the top layer that consists of fresh to almost unhumified plant remains with a humification degree of 1 or 2. It is important for the bog because of its hydrological characteristics, like its relatively high permeability and its periodically fluctuating phreatic level.. The main discharge of excess rainwater is through this layer. A thick acrotelm normally means that the bog is healthy.

To gain information about the spatial variability of the acrotelm layer, an acrotelm thickness map was made for both Clara-East and Clara-West. This was done with the "foot-spade" method. Also some augerings were made to give some information about the state of health the bog is in. From the acrotelm thickness map and the map with the augerings it is found that Clara-West is much healthier than Clara-East.

It would be very convenient to look at the vegetation map of the bog and find the hydrological conditions of the bog as well. Therefore it is tried to find a relation between the acrotelm thickness and the vegetation. By comparing the acrotelm thickness map and the vegetation map made by Larissa Kelly, an attempt was made to find some relations. This resulted in a division of three classes of vegetation types. A first class with disturbance indicators with no acrotelm at all, a second class with transition types with a strongly changing acrotelm thickness and a third class with vegetation types which are confined to very wet areas with a thick acrotelm.

The relation acrotelm thickness and slope is important because a steeper slope will cause a higher surface runoff and thus a lower phreatic level and thus a thinner acrotelm. By looking at cross-sections along the grid-lines it was found that there is no healthy acrotelm on slopes steeper than 0,4%. Except for the situation where a steep slope occurs at the end of a catchment area. So there is another relationship between acrotelm depth and water supply.

By looking at the standard deviation around the mean of the phreatic levels in tubes placed on the bog, a relation was found between the acrotelm thickness and the fluctuation of the phreatic level in time. In areas with an acrotelm present there is less fluctuation of the phreatic level than in areas with no acrotelm at all.

It was said before that the relatively high transmissivity is an important hydrological feature of the acrotelm. To measure the transmissivity of the acrotelm two methods

were used: the Guinness method and the Pitbailing method. Both seem to underestimate the transmissivity. The transmissivity depends on the following factors: humification degree of the peat, thickness of the acrotelm, groundwater level or depth below surface and the vegetation cover.

A clear relation between the transmissivity and the humification degree has not been found. It is a fact that for the humification degrees 1 and 2 relatively high transmissivities are found, that was to be expected.

The relation between acrotelm thickness and transmissivity is rather clear. The thicker the acrotelm, the higher the transmissivity.

The relation between the transmissivity and depth of the phreatic level is given by means of an empirical formula that contains two important parameters. This estimated relation is very much dependent on the amount of the available data and on the depth for which the transmissivities are measured.

The relation between transmissivity and vegetation cover is found in the structure of the vegetation. Coarse plant species with big roots cause a very loose acrotelm with high transmissivities. More slender and fine constructed plant species cause a more compact acrotelm with lower transmissivities.

A task in the fieldwork was the measurement of the evapotranspiration with lysimeters. The results are compared with the evaporation derived with the Penman and the Thom & Oliver equations.

To give some help in the process of making management plans for Clara Bog it was tried in a synthesis to give some directives. The main conclusion of this is that Clara-West still is a rather healthy bog and bog growth could be regenerated here again.

1 INTRODUCTION

1.1 The project

Raised bogs once covered large parts of Europe and in Russia undisturbed raised bogs still occur. In the past centuries serious damage has been done to the ecosystems by turf cutting and other anthropogenic influences. The few surviving bogs are important from an ecological point of view, mainly because of their particular vegetation and their remarkable nutrient supply: the ombrotrophy, this is the sole manner of feeding by precipitation [Streefkerk and Casparie, 1989].

Ireland, which once was covered with bogs for more than 17% of its area, is one of the few countries in northwestern Europe which still has some larger remnants of raised bogs. Especially in the Irish Midlands they occur. But they are also threatened because Ireland is the only country apart from Russia and some parts of Scandinavia which still uses peat as an energy source.

It is only 50 years ago that raised bogs were the dominant feature of the Irish Midlands. They covered an area of about 310,000 ha. As a result of cutting, drainage and afforestation, today only 22,000 ha. is in a suitable state for possible conservation. No fully undisturbed bogs remain, but remnants contain considerable areas of living bog land [Cross, 1989].

Figure 1.1: Location of Clara and Raheenmore bogs

In recent years, bogs have been acquired for conservation by the Irish Wildlife Service. Two of them, Clara Bog and Raheenmore Bog (figure 1.1), are studied geohydrologically and ecologically as a joint research project by the Irish and Dutch governments, since the end of 1989. The information gathered will enable the Irish Wildlife Service to draw up appropriate management programmes for raised bogs and will help the Dutch government or, to be more specific, the Dutch Forestry Service in their attempts to regenerate bog growth in The Netherlands. Sound hydrological management is needed because the hydrological systems and thus the ecological systems of a bog are easily disturbed by drainage and turf cutting at the bog edges. So it is very valuable to obtain information as to the minimum requirements a bog remnant should meet to make purchasing worthwhile.

1.2 The report

This research deals mainly with an inventory of the health of Clara Bog, especially of the top layer, the acrotelm. This because the acrotelm is the main hydrological system on a living raised bog. But first, in chapter 2, there is a reconstruction of the development of raised bogs and a general description of Clara Bog in particular.

Then, in chapter 3 (the emphasis of this research), the top layer of the bog, the acrotelm, is described. To be more specific: its thickness, its degree of humification, its vegetation cover and the lateral flow through the acrotelm. The thickness of the acrotelm has been investigated in relation with the vegetation, the slope and the fluctuation of the phreatic level. The lateral water flow has been related with the degree of humification, the phreatic level, the thickness of the acrotelm and the vegetation cover. There is also a description of the sensitivity test of the transmissivity measuring methods.

For the relation between acrotelm thickness and vegetation, Larissa Kelly's most recent version of her vegetation map is used. And for the relation between transmissivity and vegetation, her previous map.

In chapter 4 the evapotranspiration is calculated with the data from the lysimeters. The evapotranspiration will also be calculated with some formulas which use data from the weather station on Clara-West.

In chapter 5 there are some hypotheses about the chances of surviving of Clara Bog (especially of Clara-West) and some possible steps that should be taken to save the acrotelm.

Chapter 6, the last chapter, contains the conclusions and some recommendations.

2 RECONSTRUCTION AND GENERAL DESCRIPTION

2.1 Reconstruction of the development of raised bogs

Peat is the accumulated remains of several species of partly decomposed dead plants. Climatic change is of prime importance for the changes in vegetation, but it is not the only factor the development of mires is dependent on. Many internal and external factors (like local conditions, the topography, mineral status and hydrology) determine the evolution of a mire.

In Ireland especially blanket bogs and raised bogs are found. In the Irish Midlands raised bogs are much more common than blanket bogs. Water is very important for bogs because their water content is about 95% by volume. According to Streefkerk and Casparie (1989), for a raised bog, as well as for a blanket bog, the precipitation (and not the temperature) is almost certainly the limiting factor. But in this research it is thought that the evapotranspiration, and therefore the temperature in relation to the precipitation is important.

Raised bogs are marked by a somewhat domed topography (lens shaped). The centre of the dome approaches a flat surface. Well developed raised bogs occur in temperate and cool climatic areas with a high relative humidity and with a relatively high frequency of precipitation in particular, to a measure of 700 to 1150 mm. per year [Schouten, 1984; Overbeck and Happach, 1956]. The plant materials do not really decompose because of the anaerobic circumstances and the low pH-value.

After the disappearance of the permafrost in the Late Dryas, some 10,000 years ago (table 2.1), in many areas in central Ireland free drainage was impeded. The water was trapped in between esker ridges and cut-off valleys of brooks and rivers. There was a lot of clay deposition in the melt water lakes, which created an impermeable layer.

In the Preboreal, some 9000 years ago (table 2.1), the raised bogs of nowadays started developing in these lakes as the climate was wet enough to facilitate the development of fen peat (figures 2.1A+B and 2.2). Usually fen peat is mainly composed of layers of reed, various sedge species and (birch) trees. This type of peat can in general start developing from the beginning of the improvement in climate after a glacial period. Because it is at the bottom of the bog, it becomes very compact after a long time because of the weight of the layers above. Once a lake is overgrown, the influence of eutrophic water gradually declines because the roots of the plants can not get in contact with the mineral-rich ground water anymore and a mesotrophic environment, the transitional stage (figures 2.1C+D and 2.2), develops. As a result, plants invade which are able to grow in the mineral-poor habitat, such as *Sphagnum*, which makes the ground even more acid by its ion replacement activity. *Sphagnum* is very important for sustaining the bog, drawing up water and keeping the surface wet and water logged, in all but the driest periods.

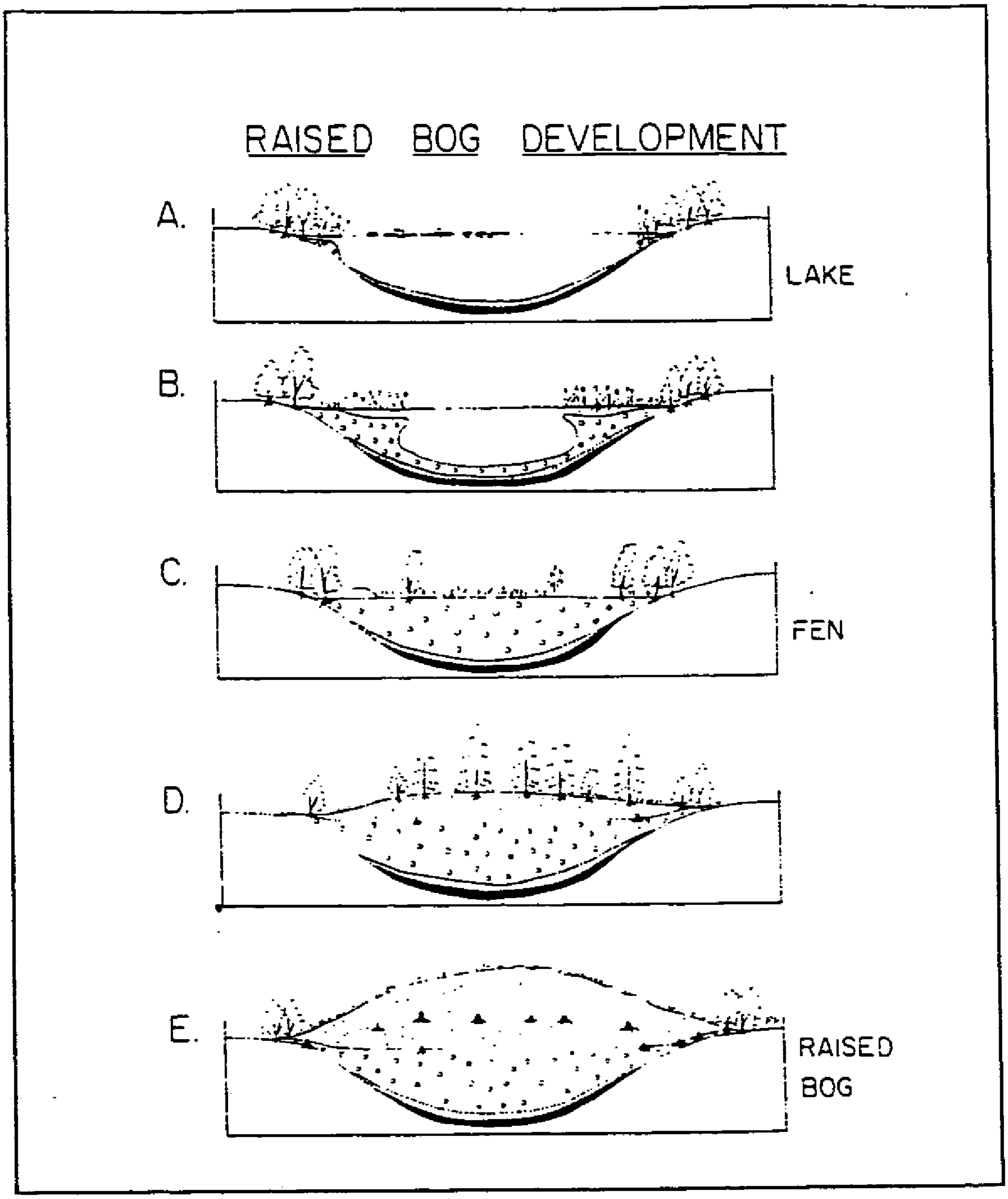

Figure 2.1: Stages in the development of a raised bog
A: a lake with open water and marginal reed beds
B: the lake infilled with fen reed peat;
C: the fen stage;
D: the raised bog woodland phase;
E: a profile through a present raised bog [Hobbs, 1986].

Table 2.1: Time table for the bio-geological periods after the Weichsel-Pleniglacial [Streefkerk and Casparie, 1989]

HOLOCENE	Subatlantic	800 B.C.
	Subboreal	3000
	Atlantic	5500
	Boreal	6800
	Preboreal	8300
LATE-GLACIAL	Late Dryas	8900
	Allerød	9800
	Older Dryas	10200
	Bølling	11200 B.C.
PLENIGLACIAL		

In time the plants become solely dependent on the nutrient-poor rain water, the ombrotrophic stage (figures 2.1E and 2.2), and plants typical of raised bogs, such as heather, invade the tops of the *Sphagnum* hummocks, completing the invasion of bog species. From about the beginning of the Atlantic, some 7000 years ago (table 2.1), up to present, the climate in Ireland was suitable for ombrogenous peat growth [Streefkerk and Casparie, 1989].

As people started draining the bogs and cutting the turf, probably some 500 years ago, the bogs started shrinking. Drainage and turf cutting cause subsidence and forming of cracks in the peat along the bog edges in the first place. Because of the subsidence, the slope increases and drainage effects gradually extend towards the centre of the bog. Thus the remnants of the bogs which are left, may also have been affected in their central parts.

2.2 Clara Bog

For the general description of Clara Bog in this paragraph, appendix I can be used.

Clara Bog is located 2 km. south of Clara town on either side of the road from Clara to Rahan in County Offaly. On the northern side the bog is bounded by the esker Riada and to the south by cut-away bog. The total area of Clara Bog nowadays is about 500 ha. The western part (Clara-West) is the largest one with an estimated area of about 280 ha. The rest (Clara-East),about 220 ha, is situated on the eastern side of

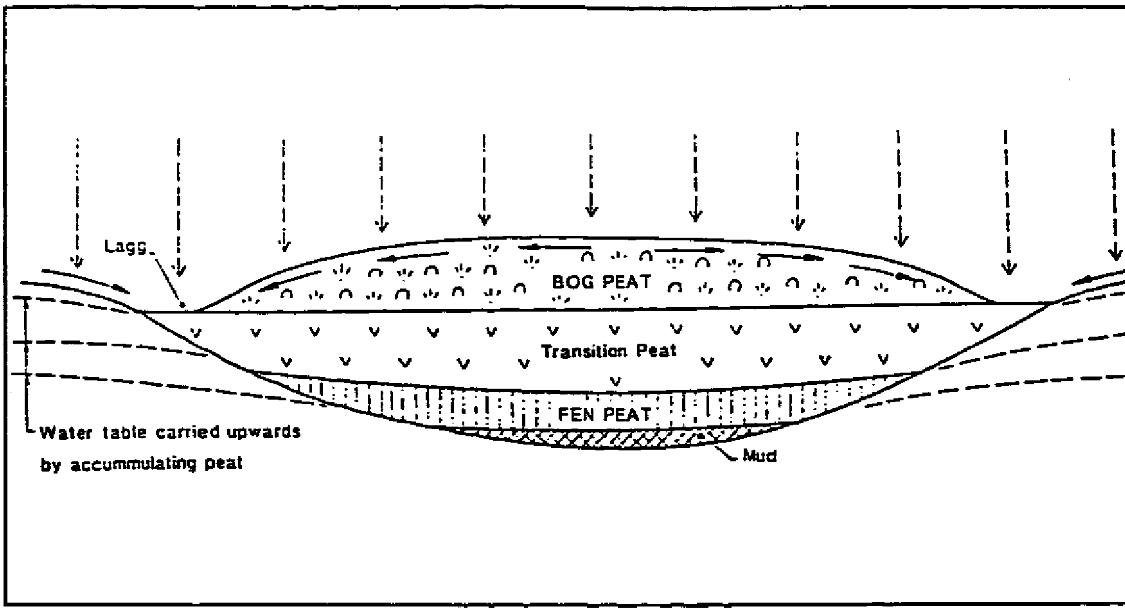

Figure 2.2: Raised bog confined in a deep basin

the road from Clara to Rahan.

Clara Bog started developing some 8000 years ago. Its first start probably was in a lake, situated in the central part of the present bog. In this lake the fen peat started developing [Bloetjes and Van der Meer, 1992]. The growing of the bog probably continued till about 500 years ago. By this time Clara Bog was part of a huge bog that was much bigger, especially to the south and the east. This can be seen from the contour map of the surroundings and from the fact that there is peat found everywhere in the top soil in this area.

Then the turf cutting started near the Silver River. The turf was cut systematically from the river, perpendicular on the water course. Also from the eskers that surround Clara Bog on the northern and the southwestern side, turf was cut [Moore, 1992].

It is said that the drainage of the bog was intensified when three drains were dug in a north-south direction on one of the highest parts of the bog, maybe some 300 years ago. This was done to build a road over the bog, but the spot that was chosen, proved to be too wet. The common belief is that then new drains were dug, some 500 metres to the east, where the road from Clara to Rahan is nowadays. During the big famine in the early 1850's, some famine roads were built on Clara Bog. This was done just to labour the people [Moore, 1992]. The big lakes in a row with the steep edges on Clara-East are probably from the same time. It is said that the English soldiers made these lakes by using explosives. Doing so, they tried to attract geese and ducks [Bloetjes, 1992].

Later on, Bord na Móna came to exploit Clara Bog. In 1983 they dug a network of drains (every 12 to 15 metres) with a north-south and east-west direction on Clara-East. But it was only in 1987 when the Irish government committed itself to conserve

Clara Bog because of the importance of the nature values of one of the last and largest remnants of the raised bogs which once covered the Irish Midlands. Nowadays two-thirds of Clara Bog is nature reserve. The southern and very western part of the bog are still under private ownership and is being cut intensively for use as fuel.

Probably because of the drains dug by Bord na Móna and also because of the influence of the road from Clara to Rahan, Lough Roe on Clara-East has dried out; although the area can still be very wet. Alltogether Clara-East is much drier than Clara-West. It is drained more intensively and the peat in the top layer is less saturated with water. But it is not clear whether Clara-East is drier than Clara-West because of the drains or the drains were dug on Clara-East because it already was drier and more humified and thus more suitable for exploitation.

On Clara-West there still is a so-called soak system with a lake: Shanley's Lough. The vegetation there is more fen-like than the rest of the bog and there are birch groves and individual trees surrounding this soak. There are two possible hypotheses for the existence of these trees. The first one is that mineral rich ground water is welling up over here. This water can come from the mound (an elevation of the bog surface), but it is also possible that it is the more mineral rich ground water from the deeper bog layers. This water is pressed out of the pores because of the subsidence. The subsiding bog causes smaller pores and the water that is in the pores has to escape and takes the route with the least resistance. Thus the water will go up as the deeper bog layers are almost impermeable [Van Lanen, 1993]. The second hypothesis is that because of the existence of three 300 year old drains in this area, the humification of the peat body has gone that far that the soil is strong and mineral rich enough to make tree growth possible. Of course is a combination of the two hypotheses also possible. Other soak systems on Clara-West do not have a real lake anymore, but they can still be very wet, especially during winter time.

On Clara-West there are many widespread hummock and hollow systems. A more specified explanation of hummocks and hollows will be given in paragraph 3.2.2.3. In the hollows all different species of *Sphagna* occur; dependent on the average depth of the phreatic level below the bog surface and the pH (table 2.2). Fewer *Sphagnum* species occur on top of a hummock, although some *Sphagnum* species are hummock formers. But *Eriophorum vaginatum, Erica tetralix* and *Calluna vulgaris* are more abundant over here [Streefkerk and Casparie, 1989].

On top of the mound, which is about 3 metres higher than its surroundings, the maximum subsidence (if there is a maximum subsidence for peat) has probably already been reached at this moment. The peat surface can hardly subside here anymore, but the peat layer that surrounds this mound can because the mineral subsoil is much deeper below the bog surface over here [Bloetjes and Van der Meer, 1992]. Because of the fact that the bog surface in the central part of a bog originally probably used to be more or less flat, it can be concluded carefully that the bog surface used to be at least as high as the unsubsided top of the mound.

Table 2.2: Preference of Sphagna for range of pH and the phreatic level [Streefkerk and Casparie, 1989]

Sphagnum species	Growing spot	Depth of ave-rage phreatic level below surface in m.	Range of pH
- *fuscum*	adapted to hummocks	0.25 - 0.37	3 - 4
- *magellani-cum*	hummocks/ adapted to hollows	0.05 - 0.25	3 - 6
- *acutifolium*	adapted to hollows	0.03 - 0.05	3 - 6.5
- *cuspidatum*	adapted to hollows	0.00 - 0.01	3 - 6

The same situation (a higher mineral subsoil) is found in the very southern part of the bog. The mineral subsoil is much higher over here [Bloetjes and Van der Meer, 1992]. The subsidence is probably at or near its maximum. This can also be concluded from the many cracks that occur over here. The hypothesis is that the higher mineral subsoil also caused the concave shaped bog instead of a dome shaped one, which is natural. This because the peat body in the central part of the bog could continue subsiding as the peat body on top of the higher mineral subsoil already reached its maximum subsidence or is near to it.

2.3 The main discharge systems on Clara-West

Clara-West is mainly drained by three drains. Two drains are well known for some longer time already. These are situated in the lowest part of the bog. Analogue recorders are measuring the discharge through a Rossum and a Thomson V-notch (appendix I). These notches are situated in the lower part of the two drains.

The third drain has just been noticed by the members of the project, but it already exists for a much longer time. It is not far away from the other two drains, but this "drain" is a tunnel. It is found at a depth of about two and a half metres below the bog surface and has a southeast-northwest direction. Maybe the tunnel even splits up after some distance, but this is just a hypothesis. This tunnel is also discussed in paragraph 3.2.1.3.

The fact that a third discharge point has been found, means that the catchment area of the Rossum and Thomson drains as calculated by Lensen (1991), may be smaller. Looking at table 2.3, it is even possible that it is only two-thirds of the area which has been calculated. It has to be said that the higher discharges as measured with the bucket and stop-watch method, are not that good because only a small bucket was used.

Table 2.3: The discharge of the Rossum, Thomson and Tunnel drains and their mutual ratio's, measured with a bucket and a stop-watch

	Discharge					
	14-01-1993		27-01-1993		01-02-1993	
Drain	l/s	%	l/s	%	l/s	%
Rossum	8.3	24	10.0	21	2.6	15
Thomson	16.7	48	25.0	53	9.1	53
Tunnel	10.0	28	12.5	26	5.6	32

	Discharge					
	03-02-1993		05-02-1993		23-02-1993	
Drain	l/s	%	l/s	%	l/s	%
Rossum	2.1	17	1.6	14	0.6	15
Thomson	5.9	48	5.9	53	2.2	57
Tunnel	4.3	35	3.6	33	1.1	28

*) the measured discharges are possibly not correct, but the mutual ratio's probably are.

From the information given, it can be carefully concluded that the Tunnel drain has a discharge that is in between that of the Rossum and Thomson drains. The discharges measured in the Rossum and Thomson drains, fluctuate a little more; they react quicker to precipitation than the Tunnel drain. This is because of the fact that surface runoff and lateral flow can react more or less immediately to precipitation. The Tunnel drain is small and can not discharge all the water immediately, so it keeps on giving a relatively higher discharge for a longer time. But as a whole, the three drains react more or less the same. So they also have more or less the same catchment characteristics. This is because both catchments have soak systems and thick acrotelm layers.

The hypothesis is that the creation of the Tunnel drain is caused by a local source that is fed by water from the mineral subsoil. The water from this source found its way through the bog and created a tunnel. This tunnel drained the catotelm and caused some subsidence. Later on, as draining caused by turf cutting took place as well, at a certain moment the subsidence of the bog had gone that far that contact was made with the surface water. At this stage the tunnel really started draining the bog. The only question which remains, is how it is possible that the tunnel follows such a straight line. This points at anthropogenic influences.

According to Larissa Kelly (1993), the theory of a local source from the mineral subsoil is very well possible because some plant species on top of where the drain is situated, definitely need mineral fertilization. A source from the mineral underground could explain the existence of these plant species. But it is also possible that the mineral fertilization is caused by mineralisation of humified peat or by water movement.

3 ACROTELM

3.1 The diplotelmic bog

In a vertical cross-section of a living raised bog from the top downward, two main zones can be distinguished: respectively the acrotelm and the catotelm. The catotelm is the deeper, well humified peat body. The degree of humification is determined with the help of the Von Post and Granlund humification scale (appendix II). The acrotelm is the overlying layer of diagenesis in which the organic matter undergoes conversion to peat. The layer consists of fresh to almost unhumified plant remains. The degree of humification is 1 or 2 (appendix II).

The acrotelm can be defined as the system of living *Sphagna* and other bog plants, including their water supply, which retains the phreatic level close to the surface. In practice the acrotelm is the top layer of the living raised bog with a thickness to an estimated maximum for Clara Bog of about 0.70 m. The hydrological characteristics of this layer are its relatively high transmissivity and its periodically fluctuating phreatic level, which is mainly regulated by the amount of precipitation, evapotranspiration and discharge. Furthermore a change in height of the bog surface occurs during the year, caused by the capacity of the acrotelm to swell and shrink, depending on the seasonal conditions.

The catotelm is defined as the peat body between the acrotelm and the mineral subsoil. The organic material in it, is usually more humified. Because oxygen is lacking, the decay of the peaty material is very slow. Because of the considerable change in the nature of the plant material, the volume and hence the transmissivity is small. The catotelm does not show changes of moisture content, so that the capacity to hold a certain amount of water is fairly constant. The capacity for shrinkage or swelling is smaller for the catotelm than for the acrotelm [Streefkerk and Casparie, 1989].

Thus hydrologically the acrotelm and catotelm mainly differ in two hydrophysical properties: transmissivity and storage coefficient. The transmissivity sometimes differs from some thousands of m^2/day at the top of the acrotelm, to less than a m^2/day in the catotelm. So for the discharge of water the acrotelm is much more important than the catotelm.

Here the storage coefficients in the acrotelm have been roughly estimated from 30% to sometimes even more than 50%. Where no acrotelm is present, they are considerably lower. They have been estimated to less than 10% and sometimes maybe even less than 5%. For a short description of the differences between the acrotelm and the catotelm: see table 3.1.

The structure of the acrotelm changes a lot on short and long distance. There is a big difference in acrotelm thickness and in vegetation types at short distance and thus also in transmissivity at short distance. These have all their own structure which causes a very heterogenic pattern in the hydrological system. On the other hand the

Table 3.1: Characteristic differences between the properties of acrotelm and catotelm [Streefkerk and Casparie, 1989]

Properties	Characteristic differences	
	Acrotelm	Catotelm
- degree of humification	zero/low	high
- hydraulic conductivity	large/variable	very small
- capacity to store water	large	small
- capacity to swell and shrink	large	small
- process of decomposition	rel. aerobic	rel. anaerobic
- peat forming capacity	present	absent

transmissivity and the phreatic level, in turn, influence the vegetation by affecting physical conditions in the root zone. At long distance the difference is also big; on the edge of the bog there is a poorly developed acrotelm with a low transmissivity and in the middle there is a well developed acrotelm with a high transmissivity.

When the acrotelm is getting wetter, its volume increases, thus it is much easier for the water to flow through. When it is getting drier, the acrotelm decreases in volume (caused by shrinkage) and the water is kept in the bog. The transmissivity decreases with increased depth of the phreatic level. So acrotelm conditions are part of the factors which determine the discharge of water from the bog and, doing so, regulate the fluctuation of the phreatic level in between a certain range. This conditions the hydrological conditions in a bog and thus facilitates the growth of specific bog species.

A good acrotelm can only survive if the conditions are not too dry. A phreatic level that is too low would cause the death of the living *Sphagna* by desiccation and therefore cessation of peat forming. Also the humification is stimulated by an increased aeration. The plant materials start humifying from the top. In this case the degree of humification at the top is higher than just under this top. The same situation can also be found on the steeper sloping parts of the bog. As a result of gravity, the water runs off very quickly and the acrotelm is rudimentary or not present at all anymore.

On the other hand, prolonged (quick) raising of the phreatic level would lead to a prolonged reduction or cessation of aeration of the acrotelm. This would produce a decrease in the growth of plants and a decrease in the annual increment of mass of vegetable matter, as a result of which the plant cover would begin to decay and peat accumulation would cease. [Ivanov, 1981; Ingram and Bragg, 1984; Ingram, 1987].

As said before, the drainage of a bog mainly occurs via the acrotelm (high transmissivity) and the surface slope. In this research only the transmissivity of the acrotelm will be investigated to obtain a better insight in the discharge of Clara Bog and, in this research, especially in that of Clara-West.

3.2 Acrotelm mapping

3.2.1 The acrotelm map

3.2.1.1 Introduction

To gain information about the spatial variability of the acrotelm layer of the bog, an acrotelm thickness map was made. Furthermore this map can, in combination with a surface contour map, give information about the drainage patterns on the bog and the health of the bog. In this paragraph the method of mapping is explained. Detailed examination includes discussion of irregularities found. In some cases a comparison between the map of Clara-East and Clara-West is made.

3.2.1.2 Methods

In order to map the acrotelm thickness on both Clara-East and West as detailed as possible, the "foot-spade" method was used. It is very easy to notice the difference in acrotelm thickness just by walking over the surface of the bog. The movement and the softness of the surface is less noticeable in areas with a thin layer of acrotelm or no acrotelm at all. This gives a very rough idea about the thickness of the acrotelm. To gain more detailed information and to verify the estimated thickness the spade was used. Sometimes the boundaries between the areas with a different acrotelm thickness were noticeable just by looking at the difference in colour of the vegetation in each area. The mapping of the acrotelm thickness has been done by three persons. Two people walked from peg to peg and the third one walked in between them, holding the map. The pegs have been placed in a 100 * 100 meters grid on the bog. In this way it was possible to do the mapping in reasonable detail and within a reasonable period of time. The different thicknesses of the acrotelm are divided in classes of 0, 0-5, 5-10, 10-20, 20-30, 30-40, and >40 cm. The reason why the 0/5 cm. area is used, is because it was very hard to make a distinction between areas with 5 cm. of acrotelm and areas with no acrotelm at all.

There is a pronounced difference between the mapping results of Clara-East and Clara-West. Clara-West has a much wetter surface and a much thicker acrotelm than Clara-East. On both Clara-East and Clara-West, the thickness was measured in comparison to the average thickness of the acrotelm, especially in the areas with an acrotelm thickness of 0/5 cm.

3.2.1.3 Results

The results of the acrotelm thickness mapping are found in appendix III. The map has to be seen as an average situation because on a large part of the bog the acrotelm thickness can differ within one or two metres, for example in between 0 and 30 cm. So it is very difficult to represent the actual acrotelm thickness on every part of the bog. These situations where the acrotelm differs so much occur more frequently on Clara-East than on Clara-West. Also the boundaries between the areas with a different acrotelm thickness look very pronounced. In reality they are not that clear, so the map has to be seen as an indication rather than a real representation of the bog surface.

By comparing the acrotelm thickness maps of Clara-East and Clara-West, some differences are found. It is very obvious that Clara-East has less acrotelm then Clara-West and that the acrotelm on Clara-East is much thinner than the acrotelm on Clara-West. Only in filled up pools and lakes a thick acrotelm is found on Clara-East. An explanation for the difference in acrotelm thickness on Clara-East and West may be found in the fact that the surface of Clara-East has a spherical shape and Clara-West has a bowl-shaped form. The water on Clara-East therefore can easily discharge. On the contrary on Clara-West the water escapes only on the very lowest spots of the facebank. Also the large amount of drains on Clara-East can be an explanation for the lack of acrotelm. The question is whether an acrotelm can be destroyed by drainage in ten years time. Looking at the spatial pattern of acrotelm on Clara-East, one can see that the main discharge of excess rain water is almost never by way of the acrotelm but probably by way of the drains. On the other hand, on Clara-West the discharge of water from the bog is mainly via the acrotelm. The drainage patterns are noticeable on the map, by looking at the way the areas with a thick acrotelm are connected to each other via acrotelm. Almost all of these patterns lead via the soak area to the drains with the Rossum and Thomson V-notches (appendix I). It is true that the main natural discharge is in that part of the bog. Striking are the two large areas with an acrotelm of more than 40 cm. thick. The biggest of these two, which contains Shanley's Lough, discharges on the two drains with the recorders. But the other one, in the south-western corner of Clara-West, may have its discharge by way of an underground drainage system that leads to a hole in the facebank between pegs H14 and I15. This underground drain or tunnel can be seen on the map (appendix I). In between peg K13 and L14 and around peg J14, two areas are found where there is no acrotelm at all. In these areas very deep holes are found where the water runs through. The hole in the facebank lies exactly there where a straight line through the two areas with no acrotelm crosses the facebank. An explanation for this tunnel is given in paragraph 2.3.

The relation between the slope of the bog surface and the presence of an acrotelm can also be found on the map. Near the sides of the bog most of the time the acrotelm has gone because of the slope of the surface. This is caused by subsidence due to turf cutting and drainage. Of course this drainage itself is also a reason for the lack of acrotelm near the sides. Striking are the two open spots without any acrotelm on the map of Clara-West. One around peg I13 and one around peg K8. The first one was mentioned before as the mound. Both occurrences can be explained by the fact that the slope of the surface up there is too steep to make the existence of acrotelm possible. As said before, the higher surface slope of these areas is due to the topography of the mineral underground below the bog.

3.2.2 The augerholes and hummock/hollow map

3.2.2.1 Introduction

This paragraph concerns the drillings done with the Eykelkamp-auger during the fieldwork. These drillings were made to verify the acrotelm thickness map and to find an indication about the decline of the bog. The map made from the augerings is discussed. Also the location of the hummock/hollow areas which are presented on the map, are discussed.

3.2.2.2 Methods

To verify the acrotelm thickness mapping, done by the "foot-spade" method, some drillings in the upper 50 cm of the bog were done. The drillings done in every acrotelm hole (see paragraph 3.6) were used as well. The drillings give the degree of humification in every 10 cm over the profile. This humification degree is determined with the "Von Post and Granlund scale" (appendix II). The Eykelkamp-auger has a sampling body consisting of half a cylinder with a length of 50 cm and a diameter of 4.5 cm. Another reason for these drillings is to give some indication about the state of health the bog is in as derived from the acrotelm depth. An indication about the declining of the bog is given where the degree of humification shows a decrease from the surface downwards.

To give some information about the decline of the bog, the humification profiles of the augerholes are divided into 5 classes. The different classes are presented in table 3.2.

A distinction, between the profile with a decreasing humification degree from the surface downwards and a profile with an increasing humification degree, is made. The reason for this distinction is due to the fact that a decreasing humification degree in the profile indicates that the bog on that particular spot is dying from above. The top layer gets humified at a faster speed than the underlying peat. A reason for this process is aeration, due to for example the presence of drains or other anthropogenic influences. Normally the humification degree increases downwards in the profile. The humification process is quickened by changes in the bog environment. Class 1 contains the augerholes with an undisturbed acrotelm. The top layer in table 3.2 is defined as the first 20 cm. of the profile from the surface downwards. The augerholes in class 2 and 3 contain hardly any or no acrotelm at all. Class 3 is a normal situation of a declining bog and class 2 may indicate some irregularity in the humification process. The reason for the distinction between the top layer with a humification degree of 3 to 5 and the ones with 6 to 10 is found in future planning to regenerate the bog. The maximum degree of humification where regeneration is still possible lies around 5 [Streefkerk and Casparie, 1989]. So for the areas with class 2 or 3 regeneration is probably possible. The augerholes with a toplayer with a humification degree of 6 to 10 are divided in two classes (4 and 5) for the same reason as the dividing of the augerholes with humification 3 to 5 in the top layer.

Table 3.2: Augerhole classification

Class	Degree of humification	
	Toplayer (0-20cm)	Profile from toplayer downwards
1	1 - 2	-
2	3 - 5	decreasing
3	3 - 5	increasing
4	6 - 10	decreasing
5	6 - 10	increasing

3.2.2.3 Results

The results of the augerings can be found in appendix IV. The results of the procedures described in paragraph 3.2.2.2 are found on the augerholes and hummock/hollow map in appendix V.

To verify the acrotelm thickness map, it was compared with the augerholes map. From this comparison can be concluded that, as expected, in most cases the augerholes with class 1 lie in areas with a good acrotelm. This is very obvious for Clara-West as well as for Clara-East. Clara-East and Clara-West show some differences in the height of the classes. Like on the acrotelm map Clara-West looks much healthier on the augerholes map compared to Clara-East. Furthermore Clara-East has a lot more augerholes in the classes 2 and 4. Probably the drains on Clara-East are responsible for this increase in humification degree from the top downwards. This is not really certain because the speed of humification is not exactly known. It is possible that the decline of Clara-East started before the drains were cut.

The information about the areas where hummocks and hollows are common, shown on the map, are taken from the vegetation map made by Larissa Kelly. These areas are very characteristic for a raised bog. Hummocks are mounds on the bog surface, which can range in heights from a few centimetres to a metre. Hollows are shallow depressions in the bog surface where the water collects or where the phreatic level reaches surface level or just above it. Marginal hollows tend to be linear as they are focus points for surface water runoff. On the bog they take many forms but are often elliptic. The areas with hummocks and hollows are important for the hydrology of the bog. They influence the discharge and the storage of water.

The hummock/hollow areas are divided into three classes. These are the hummock/hollow areas with frequent pools, with scattered pools and with tear or orientated pools. Pools are depressions in the bog surface where the phreatic level normally remains above surface level during most of the year. So areas with frequent pools are much wetter than the hummock/hollow areas with scattered pools. The areas with orientated pools are the driest of the three.

The hummock/hollow areas on Clara-East are concentrated on the part of the bog where still some acrotelm is left. Unlike Clara-East, the hummock/hollow areas on Clara-West are scattered over the bog. Commonly they are confined to the wetter areas with a good acrotelm. The orientated pool zone around G6 is an exception. Although this is a wet area, it is possible that the existence of a reasonable acrotelm is limited due to the steep slope of the surface which causes quick runoff in that area. The influence of the slope on the acrotelm is reviewed in paragraph 3.4.

3.3 Relation acrotelm thickness and vegetation

3.3.1 Introduction

In order to obtain some information about the thickness of the acrotelm on a bog, it would be very easy to look at the vegetation rather than trying to map the thickness very precisely. A lot of time and money has to be invested before a good acrotelm thickness map is made. Vegetation mapping has the advantage that it can be done by looking at aerial photographs. Naturally a ground survey is necessary as well. So the vegetation map will give direct information about the hydrological condition of a bog and this could for instance be used to make decisions about the management plans of a bog.

3.3.2 Methods

By comparing the acrotelm thickness map (appendix III) and the vegetation map (appendix VI) done by Larissa Kelly, an attempt was made to find some relations between both maps. Difficulties arise when comparing them because of problems concerning the grid. Probably the grid has changed slightly over the years because of constant copying, and that is why the grid on the acrotelm thickness map has some differences compared to the grid on the vegetation map. Also the borders of the different vegetation units hardly ever seem to match the borders on the acrotelm thickness map exactly. There are several reasons for this. One is that both the mappings are on a reasonably small scale, so for instance if a border is drawn one millimetre to the left or to the right, makes a lot of difference. Another reason is that the borders between the different units are hardly ever as clear in the field as they are on the map. Most of the time there is a transition zone between the vegetation units, which is not shown on the map. But on the acrotelm thickness map, the transition zones are shown. The differences in vegetation are not only due to natural circumstances, but can also be influenced by burning. Some irregularities in the comparison of the maps can be explained by this.

First the maps are put over each other, and for each vegetation complex zone is checked in which acrotelm zone they are common. Later it is tried to specify the relation with the acrotelm thickness for every vegetation from the vegetation map by looking at their specified habitat.

3.3.3 Results

Table 3.3 gives the result of the comparison between the acrotelm thickness map (appendix III) and the vegetation map compiled by Larissa Kelly (appendix VI). In this table it is tried to give the possibility in percentage that a certain acrotelm thickness is present in a complex zone. Also the vegetation zones and the hydrological environment in which they are common are given. This is all done in relation to the acrotelm thickness. To give some kind of key to the relation between acrotelm and vegetation, a summary follows about disturbance indicators, transition vegetation and wet environment types.

The characteristics of the habitat of the vegetation complex zones are very important because they are directly related to the acrotelm thickness and thus to hydrology. The following is a short description of the vegetation types found on the map compiled by Larissa Kelly.

The facebank zone (appendix VI) is characterised by a very low phreatic level with a restricted number of plant species and is considered depauperate. Obviously there is no acrotelm in this zone.

The *Scirpus* zone is situated on the marginal areas of the bog. *Scirpus caespitosa* indicates past disturbances, for example drainage, burning, etc. The acrotelm in this zone is limited to some spots with a thickness of 0/5 cm.

Also the zone in which *Narthecium ossifragum* is dominant, is found in the marginal vegetation complexes. *Narthecium* is connected to the drier peat vegetation. *Narthecium* grows best in areas where the phreatic level is low. But *Nartecium* needs a certain wetness. *Narthecium* indicates an acrotelm with a thickness of 0/5 to 10 cm. or no acrotelm at all.

Carex panicea indicates a contact zone where the phreatic level fluctuates and nutrient levels are increased. It is found on the bog as well as on the esker. It indicates drier areas. Therefore the acrotelm is limited to a thickness of 10 to 20 cm. in some parts of this complex zone. But most of the time there is hardly any or no acrotelm at all.

In the *Rhynchospora alba* zone the phreatic level fluctuates and drying out occurs frequently. *Rhynchospora alba* also occurs in the hollows of a raised bog in the phase immediately succeeding *Sphagnum cuspidatum* [Tansley, 1953]. In this zone, the acrotelm is limited to a thickness of 5 to 10 cm. or is not present at all.

Rhynchospora fusca is found in communities of hollows close to the marginal areas of the bog. In these areas the water level tends to be below the surface throughout the year. The zone where *Rhyncospora fusca* hollows occur is drier than the

Table 3.3: Relation vegetation complex zone and acrotelm thickness

Complex type	Acrotelm (cm)			
	70%	20%	10%	5%
Facebank	0			
Scirpus	0		0/5	
Narthecium	0	0/5	10	20
Carex panicea	0		0/5	10
Carex panicea/Nartecium	0	0/5	10	20
Carex panicea/Rhynchospora fusca	0/5		10	
Carex panicea/Dactylorhiza	0			
Rhynchospora alba	0	0/5		
Rhynchospora fusca	0	0/5		
Calluna	0		0/5	
Calluna/Eriophorum	0	0/5	10	
Hummock/hollow frequent pools	30	>40, 40	30	20, 10, 0/5
Hummock/hollow scattered pools	20	30	10	0/5
Hummock/hollow orientated pools	0/5	10		20
Sph. magellanicum/Eriophorum ang.	10, 20	0, 30 ,0/5		40
Transition *Sphagnum magellanicum*	0/5, 10	20	30	
Calliergon cuspidatum	0/5	20, 0		
Eriophorum vaginatum	20	10, 30		0/5
Enriched Sphagnum magellanicum	40	30	20, 10	0/5
Enriched *Sp. magel./Sp. cuspidatum*	>40	40		
Myrica	0	0/5, 10	20	
Myrica/Narthicium	0			

Myrica/Sphagnum magellanicum	40	30	20, 10	0/5
Molinia	0	10, 20	30	
Molinia/Myrica	30	40	20, 10	
Eriophorum vag./Sphagnum rec. lawn	>40			
Juncus effusus	>40			
Typha latifolia	>40			
Lough Roe central	>40		40	
Lough Roe edge	10			
Betula scrub/*Molinia*	>40 20		10	0/5
Betula tree	>40	20, 30		
Betula/Juncus effusus	>40			
Sphagnum imbricatum	0			
Sp. recurvum/Sp. cuspidatum lawn	>40			
Enriched West Soak	>40	40, 30, 20	10	
West Soak	40	30, 20	10	

Rhynchospora alba zone. Therefore the acrotelm is not present or limited to a thickness of 5 cm.

Calluna is very common all over the bog; its habitat can be in rather wet and in dry areas. *Calluna* grows best where there is a low watertable. *Calluna* prefers dry spots and in wetter areas it is found mainly on the higher parts like hummocks. Areas where *Sphagnum* species have a low cover, where a number of species occur at low abundances, are specified as *Calluna* zone. Normally there is no acrotelm in this zone. This certainly does not mean that in areas where *Calluna* is present, an acrotelm is absent. On the contrary *Calluna* in combination with species of wet areas indicates of course the presence of an acrotelm.

Eriophorum is found in parts of the bog which are usually saturated and frequently oversaturated with water, though the surface layer may become quite dry during a drought. Of the two common species *Eriophorum angustifolium* and *Eriophorum vaginatum*, the latter occupies drier peat than the former. *Eriophorum angustifolium* rapidly colonises very wet peat [Tansley, 1953]. So with the *Eriophorum angustifolium* present the presence of a relatively thick acrotelm is very likely, depending on the species with which it is combined. If it is found with *Calluna*, the plants are scattered. This indicates a very thin acrotelm. But if *Eriophorum angustifolium* is dominant, like in the soak areas, a very thick acrotelm is present.

Paragraph 3.2.2.3 also discusses the hummock/hollow areas. In general the hummock/hollow areas are confined to zones with an acrotelm. Going from wet to drier conditions is like going from hummock/hollow with frequent pools to areas with scattered pools to areas with orientated pools. This is immediately related to acrotelm conditions. The pools are related to the acrotelm, so in general, areas with lots of pools have a good acrotelm, depending on the height of the phreatic level in these pools. But due to the effect of drainage the acrotelm thickness in these zones varies in between 0 to 40 cm.

The transition *Sphagnum magellanicum* zone is a transitional zone where wet conditions (with hummock/hollow) are as common as dry conditions (with *Narthecium*). The acrotelm thickness varies between 0 and >40 cm. Because of the presence of the many different vegetation types in the *Sphagnum magellanicum* zone, it is very difficult to give an explicit acrotelm thickness which is the most common one. It is not even possible to say whether there is an acrotelm or not in this zone. The same can be said for the enriched *Sphagnum magellanicum* zone. But in this zone there is always an acrotelm present. This variability can be accounted for due to effect of the soak system. The *Sphagnum magellanicum* zone with *Eriophorum angustifolium* is also such a transition zone where the acrotelm varies in between 0 and 40 cm. It mostly covers areas with a reasonable thick acrotelm, but due to the effect of drainage it also occurs in areas with no acrotelm. A specification concerning the acrotelm thickness for these three transition zones could be given by using a mean value of 10 to 20 cm. acrotelm.

Myrica gale is an indicator of lateral water movement. It is common to be found in areas with *Betula* and *Molinia*. In the *Myrica gale* zone itself the acrotelm thickness varies between 0 to 10 cm.

Molinia caerulea has a wide range of habitats, particulary in regard to the pH value. It requires a larger supply of mineral salts than the most bog vegetation. So it is almost always found on spots where there is a supply of mineral water or on spots where there is water flowing. *Molinia* is probably always to be regarded as a transitional or marginal community [Tansley, 1953]. That is why *Molinia* is found in areas with an acrotelm thickness that can be more than 40 cm. and in areas with no acrotelm at all, as it occurs as a transitional type to the soak systems.

Betula pubescens trees occur on spots that function like some kind of reservoir with most of the time a larger concentration of mineral salts compared to the rest of the bog. *Betula* indicates enriched circumstances and is often found near soaks and other irregularities. It is difficult to say what the exact acrotelm thickness under *Betula* trees is because they are found on dry as well as on wet spots. But in general there is an acrotelm present in the areas containing *Betula* trees on Clara Bog. *Betula pubescens* normally occurs in lagg zones.

The extensive *Sphagnum recurvum* and *Sphagnum cuspidatum* lawns are situated in areas with very wet conditions, usually around a soak or other wet spots like drains. It is understandable that the acrotelm thickness in this zone normally is more than 40 cm.

Juncus effusus is confined to the very wet areas of the bog. Its habitat is often situated in or near soaks or other areas with open water. It possibly indicates a higher concentration of nutrients. Therefore the acrotelm thickness in this complex zone is always 30 to 40 cm. Also in combination with *Betula* it is connected to areas where an acrotelm is present.

Typha latifolia has its habitat in areas which are flooded throughout the year. So, like *Juncus effusus*, always in soaks or other areas containing open water. It indicates mesotrophic conditions. It is obvious that around *Typha* zones the acrotelm is always more than 40 cm. thick.

3.3.4 Conclusions

The group of bog vegetation types can be split up in three classes. This is done by looking at their habitat features in connection with the acrotelm. The splitting up results in a division in a group of disturbance indicators, a group of the transitional kind and a group that contains vegetation types which are confined to the wettest areas of the bog and thus connected to a very thick acrotelm.

The disturbance indicators are the vegetation types which are found in the areas of the bog where there is some kind of disturbance that has lead to the drying out of the peat. These vegetation types flourish in these dry areas. It is obvious that in the areas where these disturbance indicators are common, the acrotelm is only present in a very thin form but most of the time there is no acrotelm at all. *Molinia* and *Betula* are exceptions. Although they are components of some kind of disturbance vegetation they do not belong to this particular group. They show another form of disturbance like the presence of more mineral water or water movement than the surroundings. Also in the *Molinia* and *Betula* zones a thick acrotelm can be present.

For some vegetation types it is very difficult to say whether there is an acrotelm present in the particular area they flourish. This is because the spatial variability in acrotelm thickness in these areas is very large. These complex zones are gathered under the name transition zone.

The last group of vegetation types are confined to the very wet spots on the bog. It is certain that where these types are found, a thick acrotelm is present.

Table 3.4 gives a very rough impression of the relation acrotelm and the vegetation and should be used very carefully. The relations are not so clear, but by using this table, a reasonable indication can be obtained.

Table 3.4: Vegetation and presence of acrotelm

1	2	3
Scirpus	*Calluna*	*Sp. recurvum*
Narthecium	*Calluna/Eriophorum*	*Sp. cuspidatum*
Carex panicea	*Transition Sp. mag.*	*Eriophorum*
Rhynchospora alba	*Enriched Sp. mag.*	*Hummock/hollow*
Rhynchospora fusca	*Betula*	
Myrica gale	*Molinia*	

1: disturbance indicators
2: transition vegetation
3: wet environment types

It is clearly impossible to give an exact acrotelm thickness for every vegetation type. Therefore it is tried to answer the question whether there is an acrotelm present or not. Even the outcome of this should be used with great care because of the enormous spatial variation on a bog of acrotelm thickness as well as vegetation.

3.4 Relation acrotelm thickness and slope

3.4.1 Introduction

A steeper slope causes a faster surface runoff and thus a lower phreatic level and thus a thinner acrotelm layer because oxidation and humification are stimulated by frequent aeration. If the slope is steep enough, there is no acrotelm at all, apart from situations where old soak systems occur.

3.4.2 Methods

Some north-south and east-west cross-sections along the grid lines have been made on Clara-West and Clara-East. These have been made as much as possible in the direction of the slope.

The cross-sections were chosen with the help of the acrotelm thickness map (appendix III). It has been tried to obtain at representive cross-sections, including all different thicknesses of the acrotelm. Then the surface level (in m+O.D.) at the pegs (see 3.2.1.2) is used and the acrotelm thickness according to the acrotelm maps. Table 3.5 shows the cross-sections which are chosen.

Table 3.5: The chosen cross-sections (see also appendix III for the grid lines)

Spot	Cross-section grid lines	
	south - north	west - east
Clara-West	F, H, K, N, Q	5, 7, 9, 11, 13, 15
Clara-East	I, L	4, 6, 8

The figures are graphed in appendices VII (for Clara-West) and VIII (for Clara-East). Small irregularities in the figures may be caused by the large working scale. So the cross-sections do not give very detailed information. From left to right in the figures is from south to north and from west to east in reality.

3.4.3 Results

3.4.3.1 Clara-West

It can be seen from all the figures that when there is hardly any slope, there is a certain acrotelm layer. Its thickness varies. There does not seem to be any relation between the thickness of the acrotelm and the slope. It is also clear that when there is a real slope, there is no or hardly any acrotelm present. In general this occurs when the slope is steeper than about 0.4%.

It is striking that there is a thick acrotelm layer and a steep slope in the graphs in appendix VII.7 and VII.8. This occurs in the soak area around Shanley's Lough. The slope does not have much influence on this low and wet area because all the water of a big catchment area collects here. This catchment is obviously able to keep the area around the soak wet and delivers enough water to prevent the acrotelm layer from humification.

Another small irregularity is that the rather flat surface in appendix VII.1 has hardly any acrotelm layer. This is caused by the fact that the main slope is perpendicular to the shown cross-section.

3.4.3.2 Clara-East

The cross-sections on Clara-East have been made over the parts of the bog with a thick acrotelm. Only areas where the acrotelm layer is still present, are chosen. Still the figures hardly show any acrotelm layer. And when an acrotelm occurs, it is on the sloping parts. Only appendix VIII.2 shows some acrotelm on the flat parts. However the area where this acrotelm layer occurs, has a slight slope perpendicular to the cross-section. So this area may not be as flat as it seems from the cross-sections. Also in appendix VIII.3 there is only an acrotelm on a rather steep slope. The same counts for the acrotelm layer in appendix VIII.5. Possible explanations are given in paragraph 3.4.4.

3.4.4 Conclusions

There is a difference in the occurrence of an acrotelm layer for Clara-West and Clara-East. On Clara-West there is only an acrotelm on the flat parts and no or hardly any acrotelm occurs on slopes steeper than 0.4%. However the acrotelm on the flat parts is healthy. On Clara-East there are not so many flat parts and they do not have much acrotelm. However on the steep slopes (steeper than 0.4%) there is some acrotelm present. Probably this layer is still from the period before the slope became as steep as it is now. If this is the case, then the acrotelm will probably disappear in the future.

The main conclusion can be that there is no well developed acrotelm layer present when the slope is steeper than 0.4%. Van 't Hullenaar and Ten Kate (1991) found for Raheenmore Bog that there is no or hardly any acrotelm at slopes steeper than 0.3%. There can be different circumstances which make it possible for an acrotelm to grow on steeper slopes, but the main condition is that there has to be an inflow of water. This can be caused by more precipitation and a higher intensity of precipitation.

An hypothesis is that the size of a bog may be important as well in the relation between the acrotelm thickness and the slope. The rain water that falls on a larger bog stays in the bog for a longer time than when it falls on a smaller bog. This because it takes more time for the water from the more inward part of a large bog to reach the edge. So areas at the end of the different catchments will hardly dry out, not even when the slope is rather steep.

The shape of the bog can be important as well. Raheenmore Bog is dome shaped with a flat central part and Clara-West is slightly concave shaped in the centre. This means that, except for the central part, all the rain water that falls on Raheenmore Bog runs off to the edges immediately and the rain water that falls on Clara-West is first sampled in the central part. Again it counts that the area at the end of the catchment will hardly dry out.

3.5 Relation acrotelm thickness and the fluctuation of the phreatic level

3.5.1 Introduction

There could be a relation between the range in which the phreatic level fluctuates and the thickness of the acrotelm. It is thought that the thickness of the acrotelm has a quenching influence on the variation of the phreatic level because of the high storage coefficient of the acrotelm (paragraph 3.1).

3.5.2 Methods

3.5.2.1 Clara-West

First the standard deviations around the mean of the phreatic levels in most of the tubes (piezometers) (appendix I), which were monitored once a forthnight from February 6, 1992 till January 21, 1993, are calculated. The standard deviation is used because it gives the rate of the fluctuation of the phreatic level in one number. In this way it is possible to compare the tubes. Also the mean phreatic level in the tubes above surface is calculated. This is to check wether the mean phreatic level in areas with no acrotelm is on average lower than in areas with a thick acrotelm.

Table 3.6: The acrotelm thickness at the different tubes

Acrotelm thickness (cm)	Tube number
0	48, 49, 50, 57, 85, 86, 87, 88, 92, 98, 99
10	58, 89, 93, 94, 97
20	59, 61[1], 62[1], 63[1], 90, 95
30	47, 91, 96
40	46, 51, 52, 53, 54, 55, 56, 70

[1] tubes which are standing near a facebank

Tubes which are standing near a facebank have not been considered because the water levels in these tubes fluctuate much more than in the other tubes due to recent anthropogenic draining of the bog. An exception is made for the tubes 61, 62 and 63 as they never dried out. These tubes are used to prove the statement that has just been made. Furthermore each tube is selected on acrotelm thickness. The selection is shown in table 3.6.

3.5.2.2 Clara-East

For Clara-East the standard deviations of the phreatic levels in the vegetation plots A1, A2, B2, B3, C2 and C3 (appendix X) are calculated. The tubes where monitored once in every 2 weeks from October 23, 1990 till October 10, 1991. The tubes are not selected on acrotelm thickness, but the average standard deviations have been calculated per plot. Nevertheless the acrotelm thicknesses are mentioned as well. The mean phreatic level of every tube is calculated as well for Clara-East.

The figures which are mentioned in the following text, are graphed in appendices X (for Clara-West) and XI (for Clara-East).

3.5.3 Results

3.5.3.1 Clara-West

If the tubes are classified on acrotelm thickness, it can be seen from appendix X.1, where the tubes with an acrotelm thickness of 0 cm. are shown, that tube 49, which is situated on the mound, has as expected a larger standard deviation than the other tubes. This is because over here the phreatic level can fall much in dry periods. This is also noticeable in the very low mean phreatic level of tube 49.

For the rest it is striking that the tubes 98 and 99 have standard deviations with a value that is below 5 cm. Such a value is more expected for areas with a certain acrotelm layer. An explanation can be that these tubes are situated near the edge of a catchment area, which restrains the phreatic level from increasing too much. This because all the water is immediately discharged to the lower parts of the bog.

From the rest of the graphs (appendix X.2, X.3, X.4, X.5 and X.6) can be said that the values for the standard deviations are lower and very homogeneous in a certain acrotelm layer. Except for the tubes 61, 62 and 63. The values of these standard deviations are clearly higher (figure X.3). As expected, the water levels differ much more over here because of the higher discharges, which are caused by the draining via the facebank and the "natural" slope. Here the fluctuation patterns in relation to the precipitation should be examined. So in appendix X.4 the standard deviations for an acrotelm thickness of 20 cm. are shown again, but this time without concerning the tubes 61, 62 and 63. This gives a better idea of the fluctuation of the phreatic level in areas with an acrotelm thickness of 20 cm. The average value of this graph is used in appendix X.7.

From appendix X.7, where the standard deviation of all values around their means for the different acrotelm thicknesses are shown, it can be concluded that the standard deviation of the phreatic level is higher when the acrotelm is absent than for situations where an acrotelm layer occurs. The standard deviation of all values of one acrotelm thickness gives an average for that particular acrotelm thickness. For the rest it does not seem to matter for the value of the standard deviation if the acrotelm is 10 cm. or 40 cm. thick, as long as it is there. The mean phreatic level in areas with no acrotelm is very low. In areas where there is an acrotelm present, the mean phreatic level is varies around the bog surface.

Obviously the occurrence of an acrotelm layer depends on a constant phreatic level rather than on a high one. The phreatic level will probably be lower when the acrotelm is only 10 cm. thick, but the fluctuation of it is more or less the same as when the acrotelm has a thickness of 40 cm. It can be carefully concluded from above that not only the acrotelm has a quenching influence on the phreatic level, but also that the occurrence of an acrotelm is dependent on a constant phreatic level. The higher this constant phreatic level is, the thicker the acrotelm layer.

3.5.3.2 Clara-East

There does not seem to be any relation between the acrotelm thickness and the standard deviation of the phreatic levels. In appendix XI.1 the standard deviation of all values around their means is shown. It is obvious from appendix XI.1 that the plots A2, C2 and C3, where no acrotelm occurs, have a standard deviation that is, as expected, rather large. This can also be expected for the plots A1 and B2, where an acrotelm is absent as well, but this is not the case. It is not clear why these plots do not react the same and have lower values for the standard deviation. These low values are only expected when there is a certain acrotelm layer present; like on plot B3, where an acrotelm occurs. The average value of 4 cm. for the standard deviation that is found over here, was to be expected. A reason for the low fluctuation of the phreatic level in plots A1 and B2 can be found in the fact that the drains around these plots are blocked very well.

If looking at the values of the standard deviations of each plot separately (appendix XI.2), it is obvious that in general the standard deviations per plot do not differ much. Except for the standard deviations of some drains, which are lower sometimes. The differences between the plots are better noticeable by looking at appendix XI.3, XI.4 and XI.5. In these graphs also the mean height of the phreatic level is shown. In plots A1 and A2 the mean phreatic level in the tubes is around surface level, this is an explanation for the rather low standard deviation in these plots. The difference in standard deviation of plot A1 and A2 can be explained by the presence of acrotelm. This is also the explanation for the difference in standard deviation of plots B2 and B3. On plots C2 and C3 is hardly any acrotelm present and so the mean phreatic level is very low too (probably the drains are not blocked very well). This explains the high standard deviation of the fluctuation of the phreatic level on these plots.

3.5.4 Conclusions

More value should be given to the results found on Clara-West because this bog is not as disturbed as Clara-East and it is more healthy. Clara-East is more difficult because factors like blocking of drains can be important.

Only one real conclusion concerning the relation between the thickness of the acrotelm and the value of the standard deviation of the phreatic level can be made. This relation is found on Clara-West and says that there is a reciprocal relation between the existence of an acrotelm layer and the standard deviation of the fluctuation of the phreatic level. The thickness of the acrotelm does not matter for the value of the standard deviation, as long as it is there. If there is an acrotelm present, then the value of the standard deviation of the fluctuation of the phreatic level is lower than when there is no acrotelm at all.

3.6 The methods for measuring the transmissivity

3.6.1 Introduction

Two methods are used for measuring the transmissivity of the acrotelm layer: the Guinness method and the Pitbailing method. The measurements have been done in square holes of approximately 20x20 cm. in horizontal cross-section and a depth of about 40 cm.

3.6.2 The two methods

3.6.2.1 The Guinness method

Using the Guinness method, water is pumped out of the hole with a constant discharge until semi steady state is reached. Here semi steady state is defined as the situation that the water level in the hole is not changing visibly while water is pumped outof the hole. The final drawdown, the pumping time, the length of the side of the hole and the pump discharge have to be measured.

The Guinness method is based on steady state radial flow of water to a well in phreatic water, enclosed by an impermeable layer. The equation describing this flow is the Thiem equation:

$$H_2^2 - H_1^2 = \frac{Q}{\pi * k} * \ln\left(\frac{r_2}{r_1}\right) \quad (3.1)$$

H_2	:	phreatic head at distance r_2 (m);
H_1	:	phreatic head at steady state (m);
r_2	:	radius of area influenced by pumping (m);
r_1	:	well radius (m);
Q	:	pumping discharge (m^3/day);
k	:	hydraulic conductivity (m/day).

Assuming D is large compared to the final drawdown, it is allowed to say D is constant. The average thickness can be approximated by $0.5*(H_2+H_1)$. Combining this with eqaution 3.1 gives:

$$H_2 - H_1 = \frac{Q}{2*\pi*kD}*\ln(\frac{r_2}{r_1}) \quad (3.2)$$

When $r_1 = r_w$ (effective radius of the hole), $r_2/r_w = n$, and H_2-$H_1 = s_w$ then:

$$kD = \frac{Q*\ln(n)}{2*\pi*s_w} \quad (3.3)$$

The effective radius is approximated by the following equation [Van der Schaaf, 1990]:

$$r_1 = 0.6*a \quad (3.4)$$

a : length of a side of the square borehole (m).

r_2 is unknown. Since it is also the radius of the depression cone, it can be approximated from the volume of water removed using the following implicit relationship [Van der Schaaf, 1992]:

$$t = \frac{\pi*r_1^2*s_w}{Q}*(1+\frac{\mu(n^2-1-2*\ln(n))}{2*\ln(n)}) \quad (3.5)$$

t : pumping time (day);
μ : storage coefficient (-);
n : ratio r_2/r_1 (-);
s_w : drawdown in well (m).

3.6.2.2 The Pitbailing method

When semi steady state is not reached and the drawdown becomes too large the Pitbailing method is used. The method is also used after the Guinness method, the Pitbailing recovery test. The rise of the water level is measured after the pumping has been stopped. The water level is read in intervals of 5 or 15 seconds, depending on how fast the water level rises. This is continued until the equilibrium level is reached or when 4 minutes were elapsed. For every time interval the transmissivity is calculated and at the end the average value is calculated.

The equation for calculating the transmissivity is derived from the Depuit equation and is the Thiem equation with $A*dh/dt$ instead of Q. The equation is:

$$kD(t) = A*\frac{dh}{dt}*\frac{\ln(n)}{2*\pi*(H-h(t))} \tag{3.6}$$

where:

H	:	the phreatic level at equilibrium (m).
h(t)	:	the phreatic level at time t (m)

n is calculated according equation 3.5.

3.6.3 The conditions for the two methods and the accuracy of the measurements

Using the two methods a few conditions have to be met [Van der Schaaf, 1990]:

- a the extent of the acrotelm aquifer is much larger then the distance to which the phreatic level is noticeably affected by the drawdown in the well;
- b the aquifer is homogeneous;
- c the phreatic level was approximately horizontal before the test;
- d the discharge rate has been constant;
- e the well fully penetrates the acrotelm aquifer;
- f the flow is horizontal;
- g thc thickness of the acrotelm aquifer is constant in the area of influence;
- h the drawdown in the hole should be in between 0.8 and 2.5 cm [Van der Schaaf, 1992].
- i the measured layer has to be enclosed by an impermeable layer.
- k there should be a steady state situation

The requirements a, c and d are met during the research. As the underlying catotelm shows small permeabilities related to the permeability of the acrotelm, it is assumed that condition i is also met. Condition f is doubtfull. This because the area of influence is very small compared to the thickness of the aquifer and probably the flow is not horizontal. The fact that the aquifer, here the acrotelm, is not homogeneous is another problem. It is known that the permeability decreases with depth [Ingram, 1984]

It is very important that the bottom of the hole equals or is in the impermeable layer, here the catotelm. Otherwise the transmissivity can be miscalculated seriously [Bouwer and Rice, 1983]. For this condition the acrotelm should not be thicker than 40 cm, because the depht of the hole is more or less 40 cm. There were the thickness of the acrotelm exceeds 40 cm, the well does not fully penetrate the aquifer. The thickness of the acrotelm is not everywhere the same, it varies even within a small distance. Therefor at many locations the thickness in the area of influence will not be the same.

The drawdown should not be lower then 0.8 cm, because then it is difficult to read the water level at different times during the pitbailing test. Sometimes the preatic level is rising very fast and it is difficult to read the level with an accuracy of 1 millimetre. In most cases this causes an error of 10% in the measured transmissivity. For almost all measurements this requirement was met. for locations with very high transmissivities the drawdown was less than 0.8 cm., because the pomp capacity was not large enough. This is no problem because in this situation the water level was rising too fast and the Pitbailing recovery method was not used. Equation 3.2 is based on the assumption that Sw is small compared to D, therefore the drawdown should not be large. Here it is said it should not be larger than 2.5 cm. At many locations the thickness of the acrotelm layer is not more than 10 cm. The question is if it is still right to assume D being constant, because the final drawdown (in between 0.8 and 2.5 cm) is not very small compared to D.

As well the Guinness method as the Pitbailing method are based on the assumption of a steady state situation, which does not exist during the tests. Using the Guinness method, only semi steady state is reached. At semi steady state the water level in the hole is not changing visibly while water is pumped out, but the area of influence is still increasing. Therefore r_2 and also n (n is defined in equation 3.3) is underestimated. A high accuracy of n is not that important because the transmissivity depends on the logarithm of n, but it should be noticed that the transmissivity is probably underestimated. During the Pitbailing method the water level in the hole, the ground water level in the surrounding and the area of influence are changing in time. Steady state will never be reached, the depression cone expands during the Pitbailing recovery test. Calculating the transmissivity at different times this is not taken into account. Therefore the calculated transmissivities using the Pitbailing method are also underestimated.

For location E2 the transmissivity has been calculated in two different ways: using a constant n-value and using a time dependent n-value, the results are given in table 3.7. The constant value is calculated by using the Guinness method. In the other case the n-value is calculated per time interval, using equation 3.5, Sw per time interval and assuming the volume of the depression cone is constant (Q*t). Using a constant n-value, the average transmissivity calculated for a depth of the phreatic layer in between 7.0 cm and 9.3 cm, is 6 m^2/day. Using a time dependent n-value the average transmissivity is 34.2 m^2/day, so a large difference using the different methods is found. The second Pitbailing method is the best because it is certain that the depression cone expands during the Pitbailing recovery test. The Guinness method gives a value of 12 m^2/day, which is lower than the value estimated with the Pitbailing method using a time dependent n-value. The latter method is also used for calculating the transmissivity at location B2, also these results are given in table 3.9. Again the time dependent Pitbailing test gives higher values. In this case the Guinness method gives the highest value.

Table 3.7: Transmissivities calculated by using different methods

Location	Pitbailing, n time dependent (m^2/day)	Pitbailing, n constant (m^2/day)	Guinness (m^2/day)	Depht (cm - surface)
E2	34	6	12	8.15
B2	333	206	617	3.80
B2	805	286	1108	2.00

During this survey the values obtained by using the Guinness method will be used, because this approximated the assumption of steady state the best. Sometimes it was not possible to reach semi steady state due to low transmissivities and only the Pitbailing method was used. When only the Pit bailing method was used, the pumping time was not measured and therefore it is not possible to calculated *n* according equation 3.5. Healy and Laak [Bouwer and Rice, 1983] assumed a value of 4 for *n* and here this value is used. The expection is that this value is too high because the Pitbailing method is used for locations with low transmissivities. Using the Guinness method it is clear that the *n*-value is lower than 4 at low transmissivities. In this case the calculated transmissivities are too high.

For calculating *n*, the pumping time (t) has to be measured. It is very hard to find accuracte values for it, because it is very diffficult to see when semi steady state is reached. Sometimes *t* will be underestimated, more often *t* will be overestimated because semi steady state was already reached before the pump was turned off. Van der Schaaf (1992) writes that the pump can be switched off after the water level in the hole has not changed visibly during some 15 seconds. Sometimes the pump discharge was measured after semi steady state had been reached. During this measurement the water level in the pit sometimes was 1 millimetre lower after 30 or 45 seconds.

Also the storage coefficient has to be known for calculating *n*. The storage coefficient can be defined as the ratio of change in specific water storage or moisture content of the substrata and the change in height of rise, in this case of the phreatic level in the peat. Specific storage is defined as the storage above a particular level of reference per unit of horizontal surface [Streefkerk and Casparie, 1989]. The storage coefficient depends on the porosity of the soil. In a peat soil the porosity decreases with depth due to humification and the weight of the upperlaying peat. Many researchers investigated the relationship between the humification degree and the storage coefficient. Streefkerk and Casparie (1989) graphed the data from these surveys and found a correlation between the storage coefficient and the humification degree (figure 3.1). The acrotelm has a humification degree of 1 or 2. Figure 3.1 shows that the storage coefficient should be in between 0.5 and 0.8. Sijtsma and Veldhuizen (1992) determined the storage coefficient of the upper 10 cm. of the bog with the use of lysimeters. On Raheenmore Bog an average value of 0.3 was found. This value is much lower than those given by Streefkerk and Casparie (1989). Calculating the transmissivity, a value of 0.3 has been used.

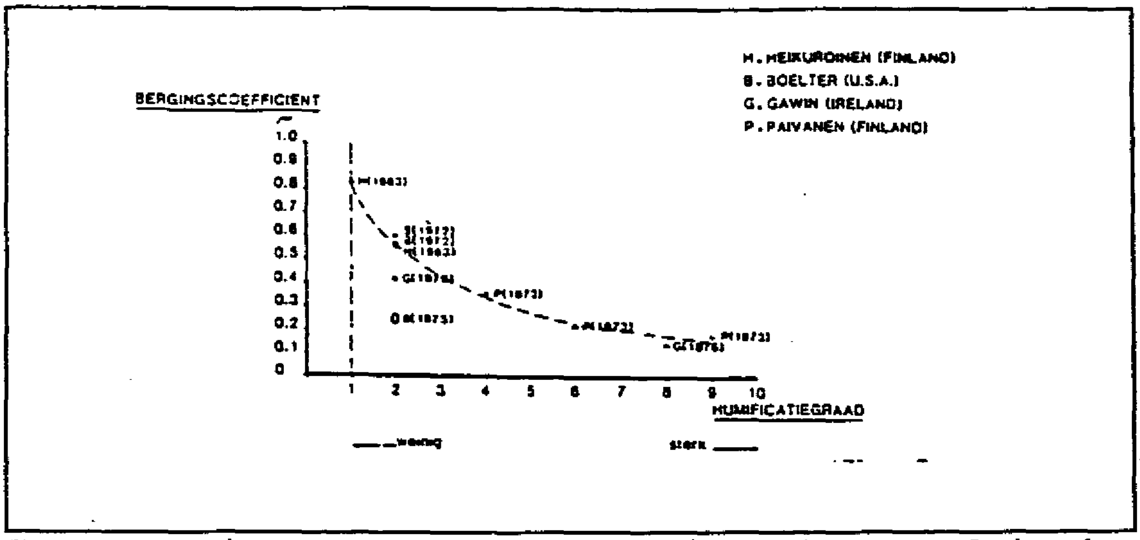

Figure 3.1: Relation storage coefficient and humification degree [Streefkerk and Caspari, 1989]

Table 3.8: Transmissivity calculated according the Guinness method, using assumed μ and t values

Location	t (sec)	μ (-)	Sw (cm)	kD (m2/day)
F5 m	30	0.3	0.7	28
F5 a	30 + 15	0.3	0.7	41
F5 a	30	0.3 + 0.2	0.7	21
F5 a	30 + 10	0.3	0.7 + 0.1	29
D4 m	20	0.3	0.2	2324
D4 a	30 + 15	0.3	0.2	2538
D4 a	30	0.3 + 0.2	0.2	2093
D4 a	30 + 10	0.3	0.3	1549
D5 m	23	0.3	0.9	352
D5 a	23 + 15	0.3	0.9	412
D5 a	23	0.3 + 0.2	0.9	300
D5 a	23 + 10	0.3	0.9 + 0.1	345

a: transmissivity calculated with assumed values for *t* and μ
m: transmissivity calculated with measured values for *t* and μ

To show the effect of differences in μ and t upon the calculated transmissivity, some calculations are done with assumed μ and t values. The results are presented in table 3.8, here the changes in t and μ are printed bold. The transmissivity is calculated using the Guinness method. The deviations between the measured and the assumed transmissivity are presented in figure 3.2. From the figure it seems that sometimes the deviation is large (in between 30% and 40%). In other cases it is neglegible. Concerning the pmping time, the measured transmissivity is more sensitive at locations where the transmissivity is low. In all cases the measured transmissivity is lower for higher storage coefficients. Larger drawdowns combined with larger pumping times give for location F5 a lower transmissivity and for the other two locations higher transmissivities. The deviation depends strongly upon the height of the drawdown. An increase in drawdown of 0.1 cm, when it was 0.2 cm, shows of coarse a large differenc. The drawdown is always small at locations with a high transmissivity and therefore it can be concluded that the error for high transmissivities is the largest. It should be better to use a pump with higher capacity.

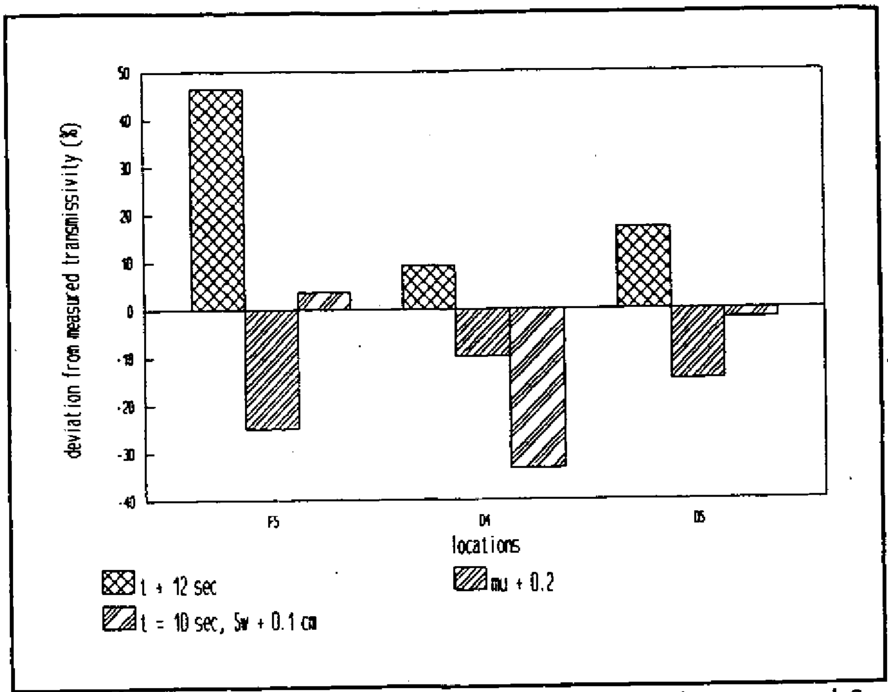

Figure 3.2: The effect upon the transmissivity, when μ, t and Sw differ

At location D3 the transmissivity was measured for the same phreatic level (2.8 cm - suface), using different pump discharges. The results are given in table 3.9

Table 3.9: Transmissivity depending on drawdown, pumping time and discharge, measured at location D3 at a water level of 2.8 cm below surface; using the Guinness method

Discharge (l/s)	pumping time (s)	draw down (cm)	Transmissivity (m^2/day)
0.11	60	3.0	89
0.11	60	2.7	103
0.10	30	1.9	103
0.02	25	0.5	49
0.02	60	0.5	99
0.009	30	0.2	80

The lowest value measured is 49 m^2/day and the highest 103 m^2/day. Five of the six values are in between 80 and 103 m^2/day. The average of those values is 95 m^2/day and the standard deviation ($n=7$) is 9 m^2/day. This is not alarming. The lowest value seems to be wrong due to a faulty measurement. The same can happen at other locations without being noticed because most of the times the tests were only done once. This should be taken into account looking at the measured transmissivities. Furthermore the drawdown is higher using higher discharges. That the transmissivity depends on the drawdown can not be concluded.

3.6.4 The accuracy of the measured transmissivity in general

It is clear that it is very hard to measure the transmissivity. The two methods used are the best available, but they have some disadvantages. Doing the measurements, on some locations different values are found at the same depth of the phreatic level. It is hard to say which value is correct. It is not possible to measure the transmissivity exactly, it will fluctuate around a certain value. In this survey the relation between the transmissivity and the depth of the phreatic level will be investigated by estimating the parameters of a certain equation (equation 3.7). The question is if the inaccuracy of the measurements is not bigger than the decrease of the transmissivity per cm depth of the phreatic level, calculated with the equation.

3.7 Transmissivity

3.7.1 Introduction

In the period november 1992 until februari 1993, the transmissivity was measaured at different water levels at 62 locations on Clara West. The locations are given in appendix XII. The descriptions of the locations are presented in appendix IV. Here the relation between the transmissivity and the following factors will be investigated:

- humification degree of the peat;
- thickness of the acrotelm;
- the ground water level or depth below the surface;
- vegetation cover;

Estimating the relation depth of the phreatic level and transmissivity, the average value of the highest and lowest water level during the measurement are taken.

3.7.2 Humification degree

Van 't Hullenaar and Ten Kate (1991) and also Sijtsma and Veldhuizen (1992) investigated the relation between the humification degree and the permeability on Raheenmore Bog. The result is shown in figure 3.3.

From the figure a clear relation can not be shown, the variation is very large. Probably because the permeability depends on many more factors as mentioned before. An important factor is the phreatic level, so this factor should also be taken into account. In the figures 3.4a, 3.4b, 3.4c, and 3.4d values of the transmissivity are plotted against the depth of the phreatic level for the humification degrees 4, 5, 6 and 7.

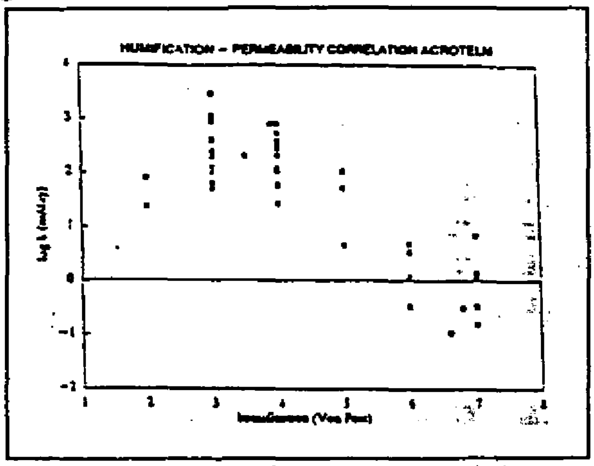

Figure 3.3: Humification-Permeability correlation in toplayer [van 't Hullenaar and ten Kate, 1991]

All figures show an increasing transmissivity with a decreasing depth, but comparing the four figures it is hard to find a relation with the humification degree. In general the transmissivity is very low and varies in between 0 m^2/day and 10 m^2/day. At some locations higher values are found in the upper layer. Maybe because the roots of the plants have caused a loose structure. Also the values measured at location B4, where the humification degree of the upper layer is equal to 3 are low. The highest value, measured at a depth of 1.05 cm, is 21 m^2/day. At a depth of 3.2 cm the transmissivity is 11 m^2/day and at a depth of 6.1 cm it is 2 m^2/day. In general a humification degree of 2 gives much higher values. Most of them are in between 50 m^2/day and 1000 m^2/day, the highest value found is 3414 m^2/day (location D4). Concerning the transmissivity in the upper layer there should be made a distinction between a humification degree lower or equal to 2 and higher than 2. Therefore in this research the acrotelm is defined as the upper layer of the bog with a humification degree of 1 or 2.

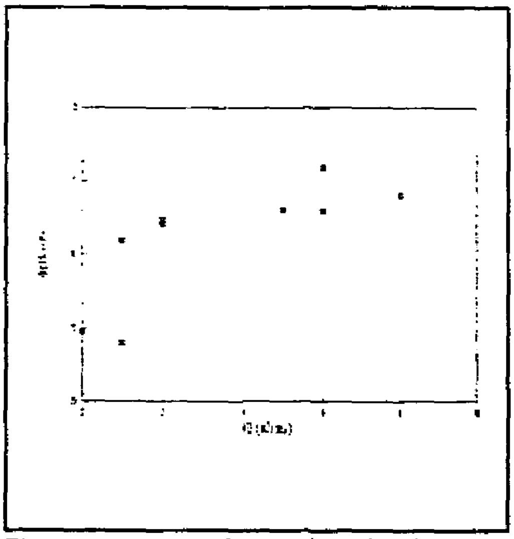

Figure 3.4a: Relation kD-depth humification degree 4

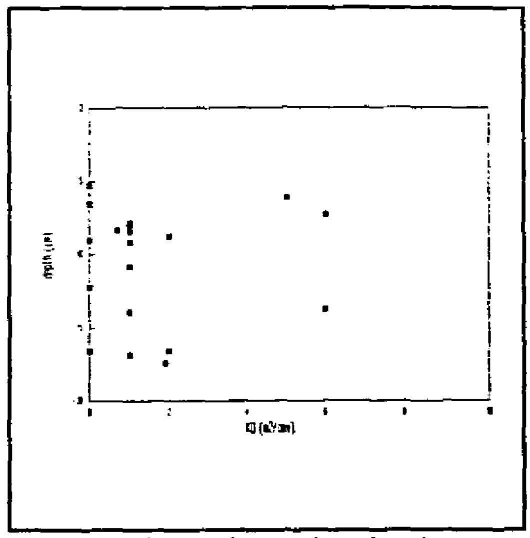

Figure 3.4b: Relation kD-depth humification degree 5

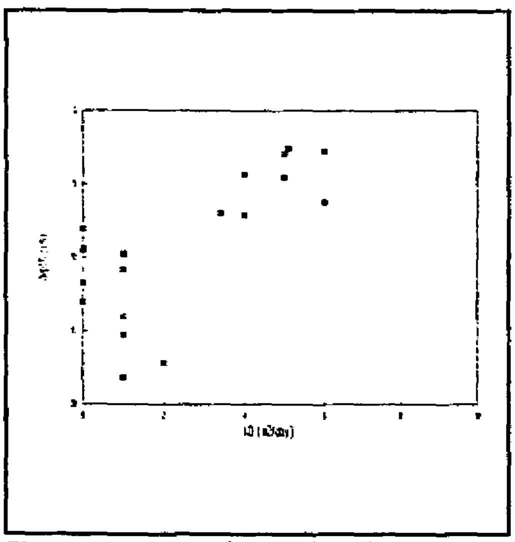

Figure 3.4c: Relation kD-depth humification degree 6

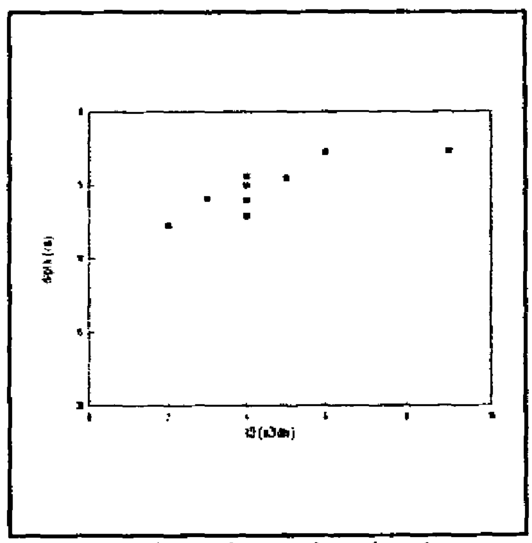

Figure 3.4d: Relation kD-depth humification degree 7

3.7.3 Depth of the phreatic level

The transmissivity increases with a higher phreatic level. Not only because the aquifer is thicker, but also the hydraulic conductivity increases with the depth. Ivanov (1957) and Romanov (1961) suggest the following relation between the hydraulic conductivity and the depth [from Ingram and Bragg, 1984]:

$$k(z) = \frac{A}{(z+1)^m} \qquad (3.7)$$

A, m	:	empirical factor (-);
k	:	hydraulic conductivity (cm/s);
z	:	depth from surface (cm).

As long as the empirical factor m is not smaller than or equal to one, the transmissivity at every depth of the phreatic level below the surface can be calculated according to:

$$kD = \frac{A}{(m-1)*(z+1)^{m-1}} \qquad (3.8)$$

kD	:	transmissivity (cm^2/s).

By multiplying the right handside of equation 3.8 by 8.64 the transmissivity is calculated in m^2/day [Sijtsma and Veldhuizen, 1992]. This is done because the transmissivity is measured in m^2/day.

From equation 3.8 it can be concluded that the decrease of *kD* per cm. depth of the phreatic level depends on both the value of the A- and m- factor. The height of the transmissivity in the upper layer is most related to the factor A. This because the depth of the phreatic level is small and therefore the influence of the denominator is small.

3.7.4 Transmissivity related to acrotelm thickness

As mentioned before the transmissivity depends on the thickness of the acrotelm. The expection is that the thicker the acrotelm the higher the transmissivity which means a higher A-value. The relation acrotelm thickness and m-value is not clear yet.

Sijtsma and Veldhuizen (1992) made a computer programm which determines the optimum m and A value for acrotelm holes within the same vegetation type. They estimated the two factors for different vegetation types, without taking any account of the thickness of the acrotelm. For the transmissivity they imposed a value of 2 m^2/day at a depth of 40 cm. In this survey not only a distinction is made on basis of vegetation complexes, but also on the principle that the course of the transmissivity with the depth of the phreatic level, differs with the acrotelm thickness. Here it is assumed that the transmissivity directly underneath the acrotelm is less than 20 m^2/day. This is based on the fact that a value of about 20 m^2/day is found, when there is no acrotelm at all in the top layer. This has a large influence upon the estimated relation. For some vegetation complexes the optimum m- and A-values are estimated without any imposed value. In some cases the standard deviation was lower, but the calculated transmissivity directly underneath the acrotelm was more than 250 m^2/day. This seems to be impossible. First the m- and A-values for locations without an acrotelm were determined without any imposed value for the transmissivity at a certain depth. Using these values, sometimes the calculated transmissivity at a depth of 0.1 cm was very high. Even much higher than for locations with a thick acrotelm, which is not possible. The high values are not reasonable. Therefore a value of less than 100 m^2/day at a depth of 0.1 cm is assumed for locations with no acrotelm at all.

The optimum A- and m-values for the different vegetation complexes and acrotelm thicknesses are mentioned in appendix XIV. Per acrotelm thickness the average of the estimasted A- and m- values are presented in table 3.10.

From the figures in table 3.10 it seems that the average A-values increase with an increasing acrotelm thickness. Those for 10, 20 and 30 cm acrotelm are more ar less the same. Furthermore the standard deviation for each thickness is very large. A clear relation between the acrotelm thickness and the m-value is not found. For both 10 cm. and 40 cm. acrotelm a value of 2.7 is found. Here also the deviation is very large. The large deviations show that the height of the transmissivity and its decline with the depth of the phreatic level differ for locations with the same acrotelm thickness. The expection is that this is caused by differences in the vegetation cover. Therefore the relation transmissivity-depth of the phreatic level will be investigated for different acrotelm thicknesses within the same vegetation complex.

Table 3.10: Average values for the A and m factors and the standard deviations per acrotelm thickness

Acrotelm	avg A	$\hat{s}$(A)	avg m	$\hat{s}$(m)	n
0 cm	74	161	2.3	0.3	8
10 cm	577	878	2.7	0.5	13
20 cm	558	369	2.3	0.7	4
30 cm	539	-	2.5	-	1
40 cm	2353	3620	2.7	0.3	9

avg : average
s : standard deviation of the average
- : standard deviation can not be estimated due to the fact that there is only one value available
n : number of values

In the *Sphagnum magellanicum* zone all the different acrotelm thicknesses are represented. Therefore this zone is very well suitable to investigate the relation transmissivity and acrotelm thickness for a certain zone. In table 3.11 the A- and m-values are given and in figure 3.5 the estimated relations transmissivity-depth of the phreatic level are graphed.

Table 3.11: The m- and A-values for areas with different acrotelm thicknesses within the *Sphagnum magellanicum* zone.

Acrotelm	A	m	s	n	AVG(T)
0 cm	15	2.2	6	7	8
10 cm	126	2.5	95	21	113
20 cm	483	2.6	615	9	529
30 cm	539	2.5	113	5	301
40 cm	679	2.6	318	24	392

s : standard deviation of the estimated relation
n : number of measured transmissivities
AVG(T): average of the measured transmissivity

The deviation of the estimated relation is large. Despite this, the relation between the acrotelm thickness and the factors A and m will be examined. From figure 3.5 it is clear that the height of the transmissivity in the toplayer depends on the thickness of the acrotelm. The thicker the acrotelm the higher the transmissivity. This was expected because the thicker the acrotelm the deeper the aquifer. Lineair regression analyses show a rather clear relation between the A-factor and the acrotelm thickness (A=17.41*(acrotelm thickness)+20.2). The correlation coefficient is equal to 0.94. It is also clear that the difference in thickness mainly causes different transmissivities in the upper layer. At a large depth of the phreatic level, there is hardly any difference noticeable anymore. It seems that the transmissivity at larger depths depends just a little bit on the thickness of the acrotelm. Probably the lower values are due to compaction caused by the weight of the upper layer and perhaps gradually increases degree of humification within a scale unit.

The values for m are for acrotelms of 10 cm and more, more or less the same. This means that here the decrease of the transmissivity per cm. depth of the prheatic level is determined by the factor A.

3.7.5 Transmissivity related to vegetation cover

As mentioned before it is assumed that the relation transmissivity and phreatic level differs with the vegetation cover.

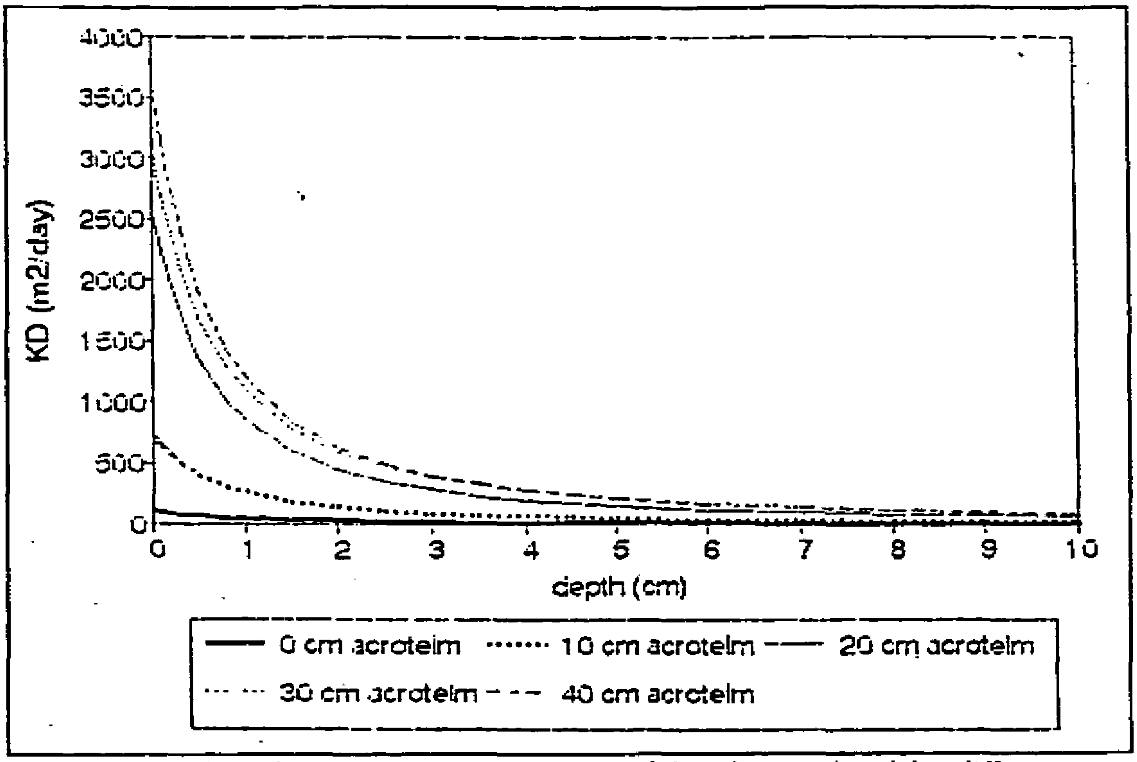

Figure 3.5: The relation transmissivity-depth of the phreatic level for different acrotelm thicknesses within the *Sphagnum magellanicum* zone

Ingram and Bragg [Bragg, 1982] estimated the A and m factor according to equation 3.8 at Dunn Moss for a part of the bog dominated by *Sphagnum magellanicum* and for a part dominated by *Sphagnum capillifolium*. Different values for the two factors were found. The relations for the two *Sphagnum* types are plotted in figure 3.6. It is clear that *Sphagnum capillifolium* has a lower permeability in the upper layer. *Sphagnum capillifolium* is a more slender and finely constructed species. The structure of the acrotelm is more compact. So it is reasonable to conclude that the structure of the acrotelm, and also the course of transmissivity with depth, differs with the vegetation cover.

The main subject of this research is to investigate the relation transmissivity and depth of the phreatic level for the different vegetation complexes. Values for the transmissivity all over the bog can be estimated, using the relationship and the map. Therefore the values for A and m have been estimated for each vegetation community complex.

The different vegetation community complexes, the acrotelm holes situated in it and the thickness of the acrotelm are given in table 3.12. Also the optimum m- and A-values are given.

In general vegetation complexes with *Betula*, *Molinia* or *Myrica gale* in it show the highest A-values, except in case of the *Sphagnum magellanicum* with *Myrica gale* complex and an acrotelm of 20 cm. thick. Also the m-values for these zones are high.

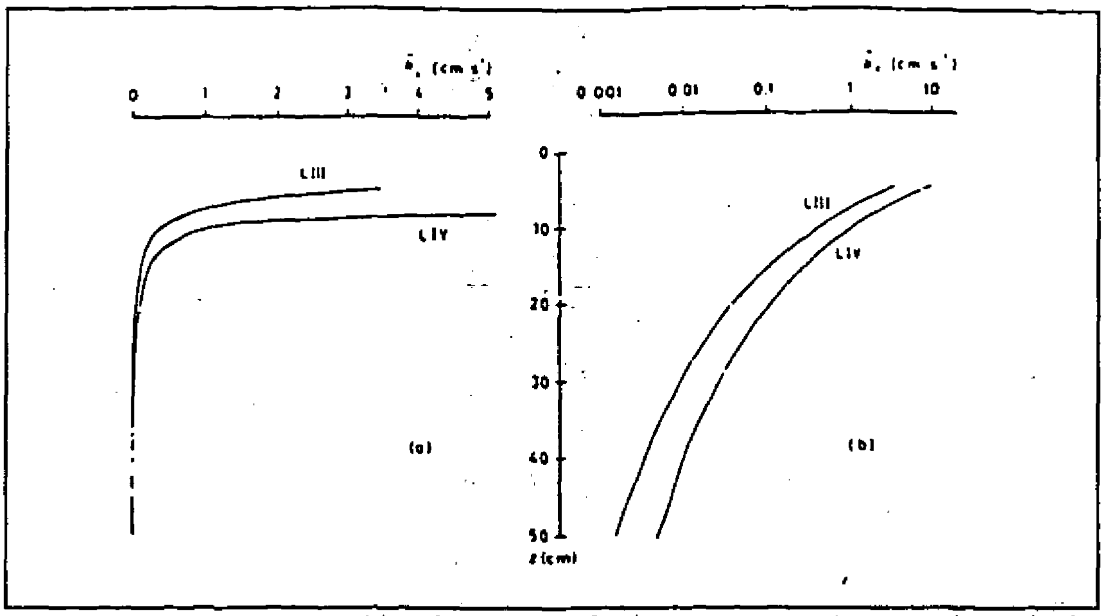

Figure 3.6: Variation with depth z of the mean estimate of hydaulic conductivity,LIII: *Sphagnum capillifolium*, LIV: *Sphagnum magellanicum* [Bragg, 1982]

These zones are in common situated in the wettest parts of the bog, therefore it is possible that the high values for the transmissivity are caused by the presence of surface water. In this case the transmissivity measured at low depths of the phreatic level is very high because the flow resistance in the surrrounding is very low. During lower phreatic levels there is no surface water and the transmissivity, measured at higher depths, is much lower. On the other hand the roots of these plant species are very thick and cause a toplayer with a very loose structure. In general it can be concluded that the transmissivity for these zones is high and that it increases quickly with an increasing depth of the phreatic level. Thus at high phreatic levels water will be discharged very fast and when it is getting drier the resistance for water flow becomes higher.

An acrotelm thickness of 10 cm is present in many vegetation complex zones. So comparing the transmissivity of the different vegetation zones with each other can best be done for this acrotelm thickness. The following zones, ranged from high to low based on the determined A-values, are presented in this category (d = the depth of the phreatic level):

- *Betula* woodlands (A=3456, m=3.4, d > 17.6 cm);
- *Sphagnum magellanicum/Eriophorum vaginatum* (995, d > 5.6 cm);
- *Myrica gale/Calluna* (A=747, m=3.1, d > 4.2 cm);
- *Sphagnum magellanicum* orientated pool (A=418, m=2.9, d > 8.0 cm);
- Hummock/hollow (A=418, m=2.4, d > 2.1 cm);
- Transitional *Narthecium* (A=418, m=2.9, d > 5.9 cm);
- *Carex panicea* (A=396, m=3.1, d > 7.8 cm);
- *Sphagnum magellanicum* with *Myrica* (A=268, m=2.8, d > 2.9 cm);

- *Eriophorum/Narthecium* (A=130, m=2.7, d > 3.0 cm);
- *Sphagnum magellanicum* (A=126, m=2.5, d > 1.3);
- *Eriophorum* (A=92, m=2.4, d > 0.9 cm);
- *Sphagnum magellanicum* with scattered pools (A=25, m=2.4, d > 2.7 cm);
- Transitional *Sphagnum magellanicum* (A=4, m=1.7, d > 4.1 cm).

The highest A-value has been found for the *Betula* Woodlands zone. This zone is located in one of the wettest parts of the bog. There is also a lot of surface water during periods with high phreatic levels. Partly this has caused the high transmissivity at low depths of the phreatic level. *Myrica* gale is an indicator for lateral water movement so it is not strange that a high A-value in the upper layer is found.

In general the complexes with *Sphagnum magellanicum* show relatively low A-values. Compared to all the other species, *Sphagnum* is a more slender and finely constructed species. Therefore lower transmissivities could be expected. For the m-factor different values were found.

The A-value for the *Carex panicea* zone is relatively high. It is generally known that this species indicate a disturbance and low transmissivities are expected. Two explanations for this high value can be found. On one hand the scale of the vegetation map is large and therefore it is impossible to reproduce all the details. So it is possible that the only hole in this complex is located in a small area where other vegetation species florish. Larissa Kelly made a detailed description fo the vegetation type araound the holes. In case of the *Carex panicea* complex, the community type description around the hole is *Sphagnum capillifolium*, so a relatively high A-value can be expected, which is the case.

On the other hand it is also possible that the high A-value is estimated due to the fact that there are only a few values measured. In this case all of them are measured at a large depth of the phreatic level. After some experiments with the computer programme it seemed that this can influence the determination of the A- and m-values. For the *Sphagnum magellanicum* zone with an acrotelm of 10 cm the A- and m-values have been estimated in two ways. First all the available data were used. A value of 126 was estimated for A and m was 2.5. This has been repeated, only using the data measured at a depth of the phreatic level of 4 cm and larger. In this case the values for A and m are respectively 418 and 2.9. Probably because the most curves show a rather straight line below a depth of 4 cm. At a depth of about 4 cm the curve shows a bend and most of the times the line becomes straight again above a depth of 1 cm. When there are only values measured at a depth larger than 4 cm., the curve is fitted by using this low and hardly varying values, compared to the values calculated in between a depth of 1 cm. and 4 cm. Most times the result is a high A-value. When also transmissivities have been measured in the bend of the curve, in general a lower A-value has been found. Therefore, to draw conclusions about the relation vegetation and the A-value, this has to be done very carefully because the estimated values seem to depend on the amount of available data and the range of depths of the phreatic level. It is very suspicious that in most of the cases, high A-values have been estimated when there were only transmissivities measured at a depth of the phreatic level larger than 4 cm. Additional measurements at high phreatic levels are needed. Unfortunately those levels will never be reached.

Table 3.12: Acrotelm holes, vegetation zone, acrotelm thickness, m- and A-values

Vegetation complex	acrotelm thickness	location	A	m
Sphagnum magellanicum	0 cm	H2,J2	15	2.2
Sphagnum magellanicum	10 cm	C11,H1, H4,H5,H8	126	2.5
Sphagnum magellanicum	20 cm	H3,C7	483	2.6
Sphagnum magellanicum	30 cm	B3	539	2.5
Sphagnum magellanicum	> =40 cm	B2,B2s, B2sw,D3	679	2.6
Transition *Sphagnum magellanicum*	10 cm	G2	4	1.7
Transition *Sphagnum magellanicum*	0 cm	B4,I2	5	2.2
Sphagnum magellanicum orientated pool	10 cm	F5	418	2.9
Sphagnum magellanicum with scattered pools	10 cm	I3	25	2.0
Sphagnum magellanicum/ Eriophorum vaginatum	10 cm	J1	995	3.2
Sphagnum magellanicum/ Eriophorum vaginatum	> =40 cm	F1	537	2.8
Betula scrub/*Myrica*	0 cm	F2	469	2.6
Betula scrub	20 cm	E1	749	2.7
Molinia/Betula scrub	40 cm	D2,C3	11846	3.1
Molinia/Betula scrub/ tree/*Myrica*	> =40 cm	D4,D5	4953	3.0
Betula woodlands	10 cm	C8	3456	3.4
Soak vegetation *Betula* scrub woodland understorey vegetation	> =40 cm	C9	749	2.7

Vegetation complex	acrotelm thickness	location	A	m
Sphagnum recurvum	> = 40 cm	G1,D1	911	2.5
Burnt *Calluna*	0 cm	C4	15	2.3
Hummock/Hollow	> = 40 cm	C5se,C5sF 3,F4, G3,H9	586	2.4
Hummock/Hollow	10 cm	C5	418	2.9
Transition soak to *Eriophorum*	> = 40 cm	C1	425	2.2
Eriophorum	10 cm	C10,G4	92	2.4
Eriophorum	40 cm	C2,C2n, C2e	498	2.6
Narthecium	0 cm	H6,J3	9	2.4
Transitional *Narthecium*	10 cm	H7	418	2.9
Carex panicea	0 cm	E4	1	2.1
Carex panicea	10 cm	E3	396	3.1
Carex panicea/Narthecium	0 cm	I1	1	1.7
Myrica gale/Calluna	10 cm	A3s	747	3.1
Myrica gale/Calluna	20 cm	A3n	999	2.8
Sphagnum magellanicum with *Myrica gale*	10 cm	A3	268	2.8
Sphagnum magellanicum with *Myrica gale*	20 cm	A1,A2	2	1.1
Eriophorum/ Narthecium	0 cm	F6,F7,F8	20	2.2
Eriophorum/ Narthecium	10 cm	E2	130	2.7

In appendix XIV the m- and A-values, the standard deviation, the average transmissivity, the calculated transmissivity at a depth of 0.1 cm for the different vegetation complex zones and acrotelm thicknesses are presented. In most of the cases the standard deviation is very high. On one hand this indicates that the measured transmissivities do not follow the used exponential relationship exactly, which is normal. On the other hand that there is a large spread in transmissivities within a certain vegetation complex. Three explanations can be given. First, as mentioned before a vegetation complex is never uniform. There are a lot of different vegetation community types within it and these will cause different transmissivities.

Also the influence of the underlying peat is not exactly known. The humification degree of this layer will differ. Probably locations with a layer with low humification degrees will give higher values than locations with high humification degrees. Here, determining the A- and m-values a transmissivity of 20 m^2/day directly underneath the acrotelm is assumed, independent of the humification degree. In a continuing survey this has to be investigated. Last but not least it can be due to failures in the measurements on the bog and the used methods.

It has to be considered that the estimated relationship does not give the exact transmissivity at every depth. It gives more or less an indication of the value.

3.8 A and m as indicators of the condition of the bog

For bog growth the phreatic level should not become to high for long periods (3.1). Therefore at high phreatic levels the water has to be discharged quickly and high transmissivities are needed. At small depths of the phreatic level, the transmissivity is mainly determined by the A-factor. As high A-values indicate high transmissivity, high A-values indicate good conditions for bog growth. Of coarse depends the discharge also on the gradient of the phreatic level. Therefore it is very difficult to give a height for the A-values which are neccasary for bog growth. At steeper gradients the A-value can be lower. Very low A-values ($A<20$) are found at locations were there is no acrotelm at all or just a thin layer.

Also should the prheatic level not become too low (3.1). Therefore the transmissivity should decrease with increasing depths of the phreatic level. Because the decrease is determined by as well the m-factor as the A-factor, it is hard to indicate the decrease of the transmissivity by the two factors. When the values for both factors are high the decrease of the transmissivity with the depth of the phreatic level is large. This is very important when high transmissivites are measured fot high phreatic levels. For lower transmissivities at high phreatic levels the decrease of the transmissivity per cm. depth of the phreatic level does not have to be very large and one or both of the two factors can be smaller.

4 EVAPOTRANSPIRATION

4.1 Introduction

One of the targets of the project is to make a waterbalance of Clara West. For this, the amount of evaporating water has to be known. Evapotranspiration can be estimated in a few different ways. It can be calculated with the Penman equation or the equation of Thom&Oliver. The evapotranspiration can also be estimated in the field by using lysimeters.

4.2 The different methods

4.2.1 The Penman and the Thom & Oliver equations

The potential evapotranspiration can be calculated with the Penman equation:

$$\lambda E = \frac{s(Q^{*}-G)+\gamma\lambda E_a}{s+\gamma} \tag{4.1}$$

E	:	evapotranspiration (mm/s);
Q_*	:	net radiation (W/m^2);
G	:	soil heat flux density (W/m^2);
γ	:	psychometric constant (mbar/K);
s	:	slope of the saturation water vapour pressure curve = de_s/dT (mbar/k);
λ	:	specific latent heat of vaporisation (J/kg);
E_a	:	isotermic evaporation (kg/m^2.s).

The Penman equation has two components: a radiation component and an aerodynamic component. The equation emphasizes the radiation component too much. For this reason the calculated evapotranspiration for the summer is too high and for the winter it is too low. Thom and Oliver adjusted the equation:

$$\lambda E_{pot} = \frac{s(Q^{*}-G)}{s+\gamma(1+n)} + \frac{\rho c_p}{r_a(s+\gamma(1+n))}\Delta e \tag{4.2}$$

with

$$n = \frac{r_c}{r_a} \qquad (4.3)$$

$$r_a = 4.72 \frac{(\ln(\frac{z}{z_o}))^2}{(1+0.54U_2)} \qquad (4.4)$$

ρ	:	specific weight: 1.204 kg/m3;
c_p	:	specific warmth of air 1010 J/kg.K);
r_c	:	canopy resistance (s/m);
r_a	:	aerodynamic resistance to water vapour (s/m);
z	:	measure hight of windspeed, 2 m;
z_o	:	roughness length: 0.041 m;
U_2	:	average windspeed at a hight of 2 metres (m/s);
Δe	:	mean water pressure deficit (mbar).

The yearly amount of evapotranspiration calculated with the two equations is more or less the same, only the distribution over the year differs [Thom and Oliver, 1977].

4.2.2 Lysimeters

A lysimeter is a bucket filled with a column of soil, covered by vegetation. The buckets are placed in holes in such a way that the edge of it is at the same level as the surface of the surrounding peat; this to create natural conditions as good as possible. The buckets are 0.50 m. deep and have a diameter of 0.40 m. The buckets are weighed once a week.

For an accurate measurement of the evapotranspiration, the water level inside the lysimeters should be the same as the one outside the lysimeter, the natural water level. This is not be the case because the buckets are sealed and lateral and vertical flow can not occur. This has to be imitated by pumping out or adding water, an artificial flow system

When the amount of rainfall is much higher than the evapotranspiration, the water level in the lysimeter will rise and after a while water will flow out. This has to be prevented by pumping out water when the water level becomes too high.

The evapotranspiration for a week is calculated as follows:

$$E = P + \frac{V_s - \Delta V}{A} \tag{4.5}$$

E	:	evapotranspiration (mm);
P	:	rainfall (mm);
A	:	surface area of lysimeter (m^2);
Vs	:	volume added water (l);
dV	:	change volume of stored water (l).

On Clara West there are 15 lysimeters. These lysimeters are filled with 5 different plant species, three of each. The different plant species are: *Calluna*, burnt *Calluna*, *Sphagnum*, *Eriophorum* and *Molinia*. This to measure the evapotranspiration for the different species. On the locations where the soil columns were dug piezometers have been placed to measure the water level. The intention was to keep the water level in the lysimeters at the same level to create as much as possible natural conditions in the lysimeters. During the survey it did not seem to be possible to do this. The water level in the lysimeters had to be kept at a lower level, otherwise water had to be pumped out after a rainfall of a few millimetres. Which means more times a day during winter time and too much time should be spent by pumping out water.

Much rain is fallen in the winter of 1992-1993. During some weeks the rainfall was that high that, in spite of the fact that water was pumped out several times, water still flew out of the lysimeters. When this happened it was not possible to measure the weekly evapotranspiration. Many times the lysimeters were surrounded by surface water. Because the edge of the buckets are equal to the surface, water flew into some lysimeters. Also in this case the evapotranspiration could not be estimated. During those wet periods the buckets were placed higher and it was not possible anymore for surface water to flow in. In some lysimeters the surface of the soil inside the lysimeter, is lower than the edge of the bucket. In this case the storage in the lysimeter is very high and water will never flow out of it. When this happens, also the evapotranspiration of surface water is measured. This is no problem because there is a lot of surface water on the bog during a very wet period and in this case this component of the evapotranspiration is also measured.

During very strong winds, the buckets were swinging during the measurement and it was not possible to measure the weight with a very high accuracy. Sometimes there was a difference of 0.08 kg between the lowest and highest value. This is equal to 0.6 mm evapotranspiration, which is not such a big inaccuracy. To measure the evapotranspiration with lysimeters, it is very important to place them in such a way that the conditions in and around the lysimeters are the same. During the winter the conditions of the lysimeter station changed. The surface of it became a mud puddle. It was not only very hard to do the measurements, but probably also the radiation balance was influenced. Therefore the question is what the accuracy is of the measurements done this winter.

4.3 Results

4.3.1 The Penman and the Thom & Oliver equations

A weather station is placed near the lysimeters. Mr. F. Dolezal, calculated with data contained from it, the potential evapotranspiration per day with both the Penman equation and the Thom & Oliver equation. For the year 1992 an evapotranspiration of 475.8 mm. has been found using Penman and 412.4 mm. using Thom & Oliver. The conclusion is that the evapotranspiration, calculated with the equation of Thom & Oliver is larger in winter and smaller in summer, in comparison with the Penman equation. This was to be expected (4.2.1). The yearly evapotranspiration is smaller from Thom & Oliver. This can be changed by a different choice of parameters [Dolezal, 1992].

In table 4.1 the evapotranspiration calculated with the two equations is presented. The periods used, are the same of those for the lysimeters.

Table 4.1: Weekly evapotranspiration in mm/day according to the Penman and Thom & Oliver equation, for the period 02/10/92-24/02/93.

Period	Penman	T & O	Period	Penman	T & O
02/10-08/10	0.76	0.81	03/12-09/12	0.01	0.11
09/10-15/10	0.70	0.79	10/12-16/12	0.17	0.24
16/10-22/10	0.51	0.50	17/01-07/01	0.10	0.23
23/10-29/10	0.36	0.36	08/01-20/01	0.30	0.45
30/10-05/11	0.46	0.49	21/01-27/01	0.40	0.63
06/11-12/11	0.21	0.27	28/01-03/02	0.24	0.27
13/11-18/11	0.23	0.32	14/02-11/02	-	-
19/11-26/11	0.06	0.30	12/02-17/02	-	-
27/11-02/12	0.00	0.17	17/02-24-02	-	-

The evapotranspiration for the last three periods is not available yet. From tabel 4.1, It is clear that the Thom & Oliver equation gives higher values for the winter.

4.3.2 Lysimeters

The weekly evapotranspiration of the different plant species, measured with lysimeters, is presented in appendix XV. From the values it is clear that some of them are strange. Sometimes a negative value was measured because water had flown into the lysimeters. As mentioned before, some of the lysimeters were sometimes flooded. This causes very high values for the evapotranspiration. In appendix XVI the remarks about this are presented. Appendix XVII gives the values which seem to be alright, but it is not certain that some of these values are not effected by flooding or inflowing water. Some of the values cover more than one week because it was not always possible to weigh the lysimeters.

It is hard to draw conclusions from the results because a lot of values are missing and many things went wrong. But a first attempt will be made.

In order to make a waterbalance, average values for the weekly evapotranspiration are important. Sijtsma and Veldhuizen (1992) found a significant difference in evapotranspiration between the different plant species. As mentioned before, some values are missing. Often these are values for the same lysimeters and also the same plant species. It is not right to calculate the average of the available data because this value will be too much influenced by the plant species for which always evapotranspiration has been measured, because these lysimeters were never flooded. Therefore distinction is made for the different species. First, the average evapotranspiration is calculated for the different plant species (appendix XVIII). Using these values the average daily evapotranspiration for the bog has been calculated, pretending each species covers one-fifth of the bog, which is not true. The values are presented in table 4.2.

Table 4.2: Daily average evapotranspiration in mm/day measured with lysimeters, for the periode 02/10/1992-24/02/1993.

Period	E	Period	E	Period	E
02/10-08/10	1.08	13/11-18/11	0.31	08/01-20/01	0.79
09/10-15/10	1.05	19/11-26/11	*0.68	21/01-27/01	-
16/10-22/10	0.53	27/11-02/12	*0.59	28/01-03/02	0.63
23/10-29/10	0.85	03/12-09/12	0.45	04/02-11/02	0.40
30/10-05/11	0.94	10/12-16/12	0.72	12/02-17/02	0.93
06/11-12/11	0.49	17/12-07/01	0.49	18/02-24/02	1.07

Two values are marked by a star. Here the average has been calculated not using the average evapotranspiration of all the different plant species because they are not available. The evapotranspiration of period 19/11-26/11 is the average of the *Molinia* and *Eriophorum* lysimeters, the value of period 27/11-02/12 is the average of the *Molinia* and *Sphagnum* lysimeters. For the period 21/01-27/01 no value is available because no rainfall was measured during this period.

For one period the evapotranspiration, measured with lysimeters, is missing. A value can be estimated in two different ways. The average of the evapotranspiration of the foregoing period and the following period can be taken. In this case the evapotranspiration for this period is 0.71 mm/day. A better method is to do it by linear regression analyses. Plotting the evapotranspiration measured with lysimeters against the Thom&Oliver evapotranspiration (figure 4.1) a relation can be shown, although it is not that clear. Regression analyses gives the following result:

$$E_{lys} = 0.92 * E_T + 0.32 \qquad (4.6)$$

E_{lys} : calculated evapotranspiration according to lysimeters (mm/day);
E_T : evapotranspiration according to Thom & Oliver (mm/day).

The standard deviation of the calculated evapotranspiration compared to the measured evapotranspiration is 0.16. This is very high it is 23% of the average value. Calculating the evapotranspiration for period 21/01-27/01 using equation 4.6 the evapotranspiration is 0.90 mm/day. Calculating the monthly evapotranspiration the last value is used.

The monthly evapotranspiration is calculated by using the data of the two different equations and the lysimeters. The results are presented in table 4.3.

Table 4.3: Monthly evapotranspiration (mm)

Month	lysimeters	Thom & Oliver	Penman
October, 1992	27.5	19.0	18.0
November, 1992	17.8	9.3	5.6
December, 1992	16.7	6.2	3.4
January, 1993	22.5	13.8	9.1

The monthly evapotranspiration is also projected in figure 4.2

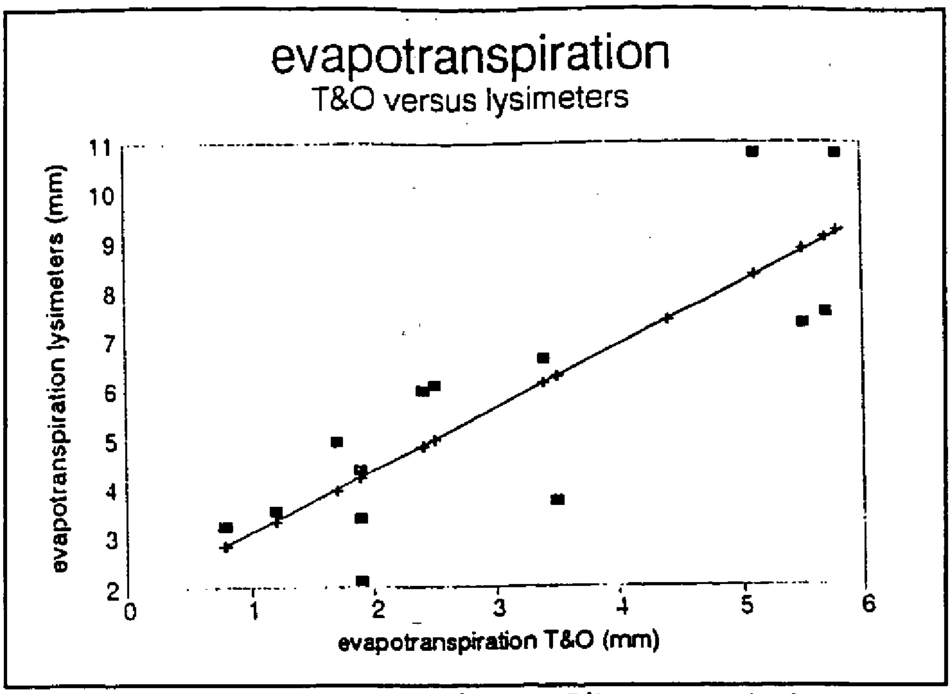

Figure 4.1: Evapotranspiration Thom & Oliver versus Lysimeters

It is clear that the monthly evapotranspiration calculated by using the data obtained from the lysimeters is higher compared to the values calculated by using the Penman or the Thom & Oliver equation. The lysimeters give an evapotranspiration of 84.5 mm. during the four months. Penman and Thom & Oliver give respectively 36.1 mm. and 48.3 mm. The differences are respectively 48.4 mm. and 36.2 mm. which is very much. Assuming the yearly evapotranspiration of bogs in Western Europe is 450-500 mm, the differences are 10.2% and 7.6% of the yearly evapotranspiration.

At the end the conclusion is that the evapotranspiration estimated with lysimeters is higher compared to the evapotranspiration calculated with the Penman or Thom&Oliver equation. But it has to be taken into account that there were many problems during the lysimeter survey and that it is not sure that all the values are right. It is possible that some of them are too high due to flooding of the lysimeters.

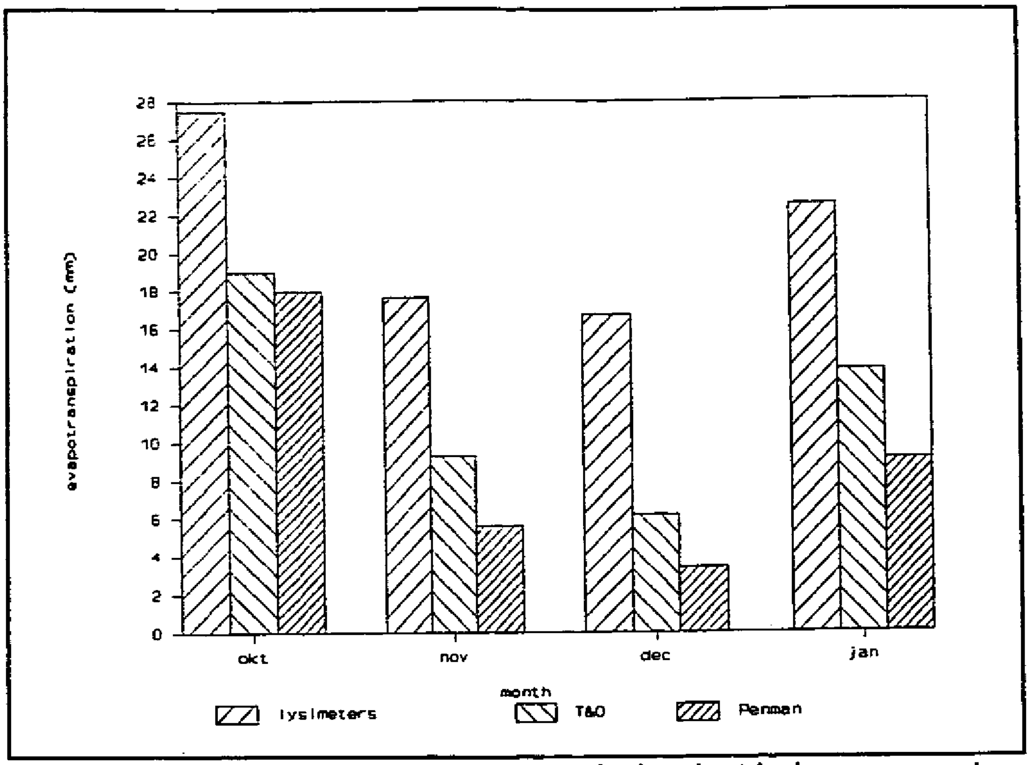

Figure 4.2: Monthly evapotranspiration calculated with the two equations and measured with the lysimeters

5 SYNTHESIS

5.1 Introduction

Some of the plans unfolded in the following paragraph have been formed during the field work period. Other plans are inspired by the people working on the project. They are just global plans and hypotheses. The plans just try to conserve the present bog and to prevent the bog from becoming a complete anthropogenic made raised bog.

5.2 Synthesis

Clara-East is in a rather bad state; hardly any acrotelm is left, except for the former soaks. The Bord na Móna drains and the rather big slope of the surface drain the bog too well. It maybe be difficult to make this part of the bog valuable for nature again.

Probably the only solution to save Clara-East is to close the road from Clara to Rahan and to make a lake of it by building some dams at the northern and southern side of it, to stop the "good" drainage system of this part of the bog to the west side. This extremity will be seen as impossible. Especially the people who live in this area will for probably this measure as too drastic. The politicians will probably agree with them because otherwise an enormous amount of money will have to be spent on compensation for the people who own land just south of the bog because the way of travelling from Clara to Rahan will then be via Ballycumber.

On the contrary Clara-West has some large areas where the acrotelm is very healthy and there are extensive hummock and hollow systems. This part of Clara Bog is rather well suited for chances of surviving.

At the very southern side the mineral subsoil is rather high and mound shaped at the place where the facebank is. The bog surface, that was probably much higher once [Bloetjes and Van der Meer, 1992], probably already reached its maximum subsidence over here some time ago, while a little bit more to the centre the subsidence went on for a while. This caused a natural barrier for the water in the more central part of the bog. The bog is more or less closed and the water can not escape quickly to the drains at the southern facebank, but it has to go a longer and slower route. Thus the water is kept in the bog for a longer time and it can cause more and longer lasting anaerobic conditions. This means that the *Sphagnum* cover and thus the acrotelm can easier survive or even grow.

The western part of Clara-West causes a problem. At the place where the facebank is nowadays the mineral subsoil lies rather deep. This means that the subsidence can go on further and cause an even steeper slope than there is now. This will cause more surface runoff and maybe, if subsidence can go on for some longer time, draining of the central part of the bog. But the steep slope is still some hundreds of metres away from the wet central part. If this part of the bog is really threatened, the process of subsidence can probably be stopped by building a dam around the western facebank and, doing so, creating a small lake at this side of the bog.

The northern part does not cause real troubles. It can be seen in the field that the turf cutting in the past did not go very far from the esker at this side of the bog. Thus the mineral subsoil, or the soil under the esker, is rather close to the bog surface and subsidence can not go very much further on. The bog hardly drains over here. Only the small hummock and hollow area with the rather thick and healthy acrotelm in the mid-northern part may need some protection. If necessary, a small dam will already do.

The eastern side of Clara-West causes a real problem. The road from Clara to Rahan drains, as already mentioned before, a big part of the bog. Subsidence caused a slope, that is rather steep especially near the road, and a ruined acrotelm. Nowadays the surface gradient from the soak system of Shanley's Lough southwards is larger than in the direction of the road (appendix XIX). When in the future the process of subsidence on the eastern side continues, this may change and then water from some parts of the soak system may be discharged very quickly in the direction of the road. Maybe this can be prevented by building a barrier on the bog itself if this occurs.

The southwestern side of the bog causes the main problem at the moment, but there are some solutions. It is the lowest part of the bog and much water is collected over here and is then carried off. The soak is really threatened because it lies only a couple of hundreds of metres from the facebank and much bog over here is still privately owned. This bog should be bought or exchanged and a dam should be built around this low part. Doing so a small lake will be created. This lake will cause a higher water level than there is now in the drains and a much higher water level in front of the facebank.

Because many irreversible damages threaten Clara-West immediate action is needed. Private ownership has to disappear from this part of the bog. People should be bought out or bog should be exchanged. Exchanging parts of Clara-East for parts of Clara-West with private owners should be considered. Of course the best situation is not giving away any bog and buying the private owners out, but this will probably cost too much money and then the question will still be if everybody will sell. Because immediate action is needed to save Clara-West and the fact that it will be difficult to restore Clara-East because of the high humification degrees of the top layer, this plan should be considered. Maybe later on the exchanged bog can be bought back again if plans are made to restore even Clara-East.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The conclusions in this chapter are just an enumeration of the conclusions of the foregoing chapters; it is also tried to describe some relations. At last some recommendations for further investigation are given.

6.2 Conclusions

The reason for the fact that Clara-East is more humified than Clara-West could be the presence of the drains. Another option is that the drains were dug on Clara-East because it already was drier and more humified and thus more suitable for exploitation. Undoubtedly the drains advantaged some extra drying out and humification.

It can be concluded that Clara Bog probably subsided a lot. The concave shape instead of a dome shape of Clara-West may have been caused by this subsidence and the relief in the mineral subsoil.

The Tunnel drain is probably caused by a local source that is fed by water from the mineral subsoil.

The catchment area of the Rossum and Thomson drains is smaller than the 100 ha. calculated by Lensen (1991). This due to the Tunnel drain and it can also be concluded from the acrotelm thickness map (appendix III). Maybe it is only two-thirds of its original area.

Looking at the acrotelm thickness map (appendix III), it is found that Clara-West is much healthier than Clara-East. Also the results following from the augerholes (appendix V) give this impression.

To give a relation between acrotelm and vegetation, the vegetation types can, in connection with the acrotelm thickness, be divided into a first class with disturbance indicators, a second class with transition types and a third class with types which are confined to very wet areas. The acrotelm thickness in the areas with types of the first class is negligible. The acrotelm thickness in the areas with types of the second class varies in between 0 and 40 cm. An average of 20 cm. is reasonable for these areas. In the areas containing vegetation of the third class, an acrotelm thickness of even more than 40 cm. can be found.

No healthy acrotelm is found on slopes steeper than 0.4%, except for situations where a steep slope occurs at the end of a catchment area.

A reciprocal relation between the existence of an acrotelm and the standard deviation of the fluctuation of the phreatic level exists.

The Guinness method and the Pitbailing method both underestimate the transmissivity. At the other hand the methodes both overestimate the transmissivity, because of the assumption that is made in the Thiem equation. In reality the slope of the water table in the depression cone is steeper than Thiem assumes. When the Pitbailing method is used, it is better to make the n-value time depend.

It is not possible to measure the transmissivity exactly because for some locations different transmissivities are measured for the same depth of the phreatic level.

A clear relation between the transmissivity and the humification degree has not been found. Only a distinction between on one hand the humification degrees 1 and 2 and on the other hand 3, 4, 5, 6 and 7 can be made. For the humification degrees 1 and 2, relatively high transmissivities have been found. Spots with a humification degree higher than 2 show transmissivities lower than 20 m^2/day. Concerning the transmissivity of the upper layer, the acrotelm has been defined as the upper layer of the bog with a humification degree of 1 or 2.

The relation between the acrotelm thickness and the transmissivity is rather clear. The thicker the acrotelm, the higher the transmissivity. The transmissivity in the upper layer for an acrotelm of 40 cm. thick is not twice as big as in case of 20 cm. acrotelm. For the different acrotelm thicknesses, there is hardly any difference in transmissivity noticeable at higher depths. Probably this will prevent the phreatic level from falling to deep.

The relation between the transmissivity and depth of the phreatic level is very much influenced by the fact, whether there is a value for the transmissivity directly underneath the acrotelm inflicted or not. Also the estimated relationship idepends very much on the amount of the available data and on the depth of the phreatic level for which the transmissivities are measured. When transmissivities only have been measured at low phreatic levels, most of the times the estimated transmissivities, using the relation transmissivity-depth of the phreatic level, for the most upper layer will be overrated.

From the estimated relationships, it seems that in case high transmissivities are measured in the most upper layer, it will decrease very quickly with a decreasing phreatic level. This is partly caused by the existence of surface water around the holes at high phreatic levels. The quick decrease of the transmissivity will cause a smaller fluctuation of the phreatic level.

Plant species with big roots which are coarse constructed, like *Molinia, Myrica gale* and *Betula* cause a very loose acrotelm with high transmissivities. *Sphagnum* is more slender and finely constructed and causes a more compact acrotelm layer with lower transmissivities.

The scale of the vegetation map is large and it is not possible to reproduce all the details. So within a zone there can be small spots with different plant species. This causes a big spread in transmissivities within a certain vegetation zone. The estimated relationship will only give an indication of the transmissivity at a certain depth.

It is difficult to use the emperical A and m factors as indicators for the conditions of the bog.

Clara-West still is a rather healthy bog. It is not lost yet. Sound management can keep the bog from further humification and subsiding. Maybe bog growth can be regenerated again.

6.3 Recommendations

Further research should be done to answer the question about what is the reason for the decline of Clara-East. The question is if the drains are responsible or if there are other circumstances.

Water samples should be taken from the Tunnel drain to see if this drain only drains the bog or if there is also a water component from the mineral subsoil.

It has to be investigated if the inaccuracy of the measurements is not larger than the decrease of the calculated transmissivity per cm. depth by using the estimated relationship.

It has to be investigated if the spread in transmissivities within a certain vegetation community complex can be explained by differences within the community complexes themselves, by determining the relation between the transmissivity and the depth of the phreatic level per vegetation community type, which is a detailed description of the vegetation around the holes.

Underneath the acrotelm, layers with different humification degrees are found. Maybe higher values have been measured for lower humification degrees in these layers. This has to be investigated.

The *Sphagnum magellanicum* zone is very large. Research has to be done to see if the relation transmissivity-depth of the phreatic layer depends on the location of the holes. It can be expected that the relation differs per locations, depends on the slope of the surface and the height of the phreatic level. When there are low phreatic levels all over the year, low A- and m-values can be expected because here the humification process is going fast.

The areas with high transmissivities have to be located. This is very important considering the conservation of the bog. Not all the bog is owned by the Wildlife Service. Along the edges the cutting of peat still goes on. If a drains is dug in parts of the bog where the transmissivity is very high, the bog will be drained very quickly. This can be prevented by buying these parts before it is too late.

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PART TWO

PREFACE

This report contains a continuining research of the survey I have done before in close cooporation with Joost van der Cruijsen and Arjen Grent. For 5 months we have been in Ireland, doing research on Clara Bog in the county Offaly. This period has been very important for me. Living in another country with another culture has effected and changed me in a certain way. In the beginning I had to get used to the Irish lifestyle. A sentence I saw at a postcard will probably reflect the Irish life the best, it sais: "Takin' it easy in Ireland".

The research could not have been brought to a good end without the support of the following people and that is why I want to thank them: my supervisor Sake van der schaaf, my Irish colleagues Ray and Lara, Matthijs Schouten and of course Joost and Arjen. Also do I have to thank the people in Clara who made me feel at home with their hospitality and friendship.

Further I thank my family, friends and girlfriend for sending me letters and postcards to keep in touch. It was always a great pleasure to hear the postman coming.

Wageningen, July 1993

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SUMMARY

In a diplotelmic bog two layers can be distinguished; the acrotelm and the catotelm. This report deals with the acrotelm. Many definitions are found for it, here the acrotelm is defined as the toplayer of a bog with humification degree 1 or 2 in the scale of von Post and Granlund. The catotelm is the well humified underlying peat body.

The transmissivity of the acrotelm depends upon the phreatic level. On one hand because of the difference in aquifer thickness, on the other hand because of the decrease of the permeability with the depth. The relation transmissivity-phreatic level is not everywhere the same, but depends on many factors. In general the transmissivity is lower where the bog has dried out. As vegetation will indicate wet or dry areas, different relations between the transmissivity and the phreatic level for different vegetation types might be present. During the research the relation transmissivity-phreatic level for different vegetation types has been examined and it has been proven that the relation differs with vegetation type. For vegetation types which indicate dry areas low transmissivities declining relatively slowly with decreasing phreatic levels have been found and for vegetation types florishing in wet areas, high transmissivities declining quickly with decreasing phreatic levels. The relations per type are not very clear. The deviation of the estimated relation derived from Ivanov and Romanov, is very large. It has been proven that the used Ivanov-Romanov equation to reflect the relation is not in all cases the right one. For instance in some cases the relation is linear.

The runoff of water is through the acrotelm and thus depends upon the characteristics of it. Because the transmissivity decreases with an increasing depth of the phreatic level, the resistance for waterflow is increasing with the depth of the phreatic level. By analysing the hydrographs the non-linearity of the acrotelm has been proven.

Compared to 1991, in the year 1992 the runoff of water in the months April and May is faster at lower water levels, maybe this is caused by the digging of the drain at the end of March 1992.

1 INTRODUCTION

In a vertical cross section of a living raised bog from the top downward, two main zones can be distinguished. These are respectively the acrotelm and the catotelm. The catotelm is a well humified peat body with a low permeability. The acrotelm is the overlying layer. This layer consist of fresh to almost unhumified plant remains. Many definitions for the acrotelm are given in literature, here it is defined as the toplayer with a humification degree of 1 or 2 in the scale of Post and Granlund (appendix II]. It is this layer this research is dealing with.

One of the goals of this survey is to determine the condition of the acrotelm, which also gives an impression of the condition of the bog. This can be done by measuring the transmissivity of the acrotelm, because high transmissivities decreasing rapidly with decreasing phreatic levels can be expected at healthy spots. This research is also meant to collect information for modelling the lateral flow through the acrotelm. For this purpose the transmissivity all over the bog has to be known. For the management of the bog it is important to know the transmissivity at locations where cutting still goes on. When a drain is dug in a part with high transmissivities, the bog will dry out very quickly.

During five months the transmissivity has been measured at different phreatic levels in square holes at 60 locations at Clara-Bog, Ireland. A detailed description of the used methods, the Pitbailing and the Guinness method, is given in part one. In that report the relation between the transmissivity and the depth of the phreatic level for different vegetation community complexes was examined. The results were not satisfactory. The deviations from the estimated curves were very large and it was thought that this was caused by the non-uniformity of the complexes. In this research the same relation will be examined but now per community type, which is a detailed description of the vegetation around the holes where the measurements were done.

The lateral flow of the surplus water is through the acrotelm. The question is: how does the specific characteristics of the acrotelm infuence the discharge at the two weirs at the edge of the bog? To answer this question, hydrograph analyses of the discharge for different periods and phreatic levels are made.

2 CORRELATION BETWEEN THE TRANSMISSIVITY AND THE PHREATIC LEVEL

2.1 Introduction

Dealing with the targets, the transmissivity all over the bog has to be known. Measuring the transmissivity everywhere is too much work. Therefore is looked for something which is related to the transmissivity and which is easier to measure.

Sijtsma and Veldhuizen (1992) investigated the relation transmissivity-depth of the phreatic level for different vegetation types on Raheenmore bog. They found different relations for different vegetation types. In this research the same relation for different vegetation types will be examined. If there is a relation, the transmissivity all over the bog can be determined by using the relation transmissivity-phreatic level and a description of the vegetation cover.

For this survey, more than 250 measurements at square holes at 60 locations has been done on Clara bog in Ireland, the results are presented in appendix XIV. The holes are numbered and the locations are shown on the map of appendix XII. Plotting the depth of the phreatic level from the surface and the transmissivity for each location separately in a graph, in most cases a more or less clear relation is shown. However because of the targets, estimating the relation per location is no use. The locations have to be grouped, based on the vegetation that is florishing at the spot.

In part one the relation between the transmissivity and the depth of the phreatic level for Clara-Bog was already examined. Because the vegetation map is based on vegetation community complexes, the locations were selected based on these complexes. For each different vegetation community complex the relation transmissivity-depth of the phreatic level was estimated using equation 2.1. The standard deviation from these estimated curves was very large. The reason for the large deviation is most likely the non-uniformity of the complex zones. In this work an attemption is made to find the relation transmissivity-depth of the phreatic level for more uniform and smaller unities. This time the locations are selected based on the detailed description at the location, the community type. This description is made by Larissa Kelly and probably at the end of 1993 there will be a report with a more detailed description of the types.

2.2 Relation transmissivity-phreatic level

Ivanov [1957] and Romanov [1961] (from Ingram and Bragg, 1984) give an equation for the relation permeability-depth. Sijtsma and Veldhuizen [1992] derived from this equation the following equation which is used for estimating the relation transmissivity-depth of the phreatic level:

$$T = kD = 8.64 * \frac{A}{(m-1)*(d-1)^{m-1}} \tag{2.1}$$

T	:	transmissivity (m^2/day);
A,m	:	emperical factor (-);
d	:	depth of prheatic level from surface (cm).

In this report the transmissivity is kwantified in m^2/day. In other reports, for instance Romanov [1961], it is given in cm^2/sec. To keep the abillity of comparing the A-values of the different reports, the factor 8.64 is added to the emperical equation.

A computer programm to estimate the optimum values of the parameters has been developed [Sijtsma and Veldhuizen, 1992]. In this programm the range of A and m values for which the curve has to be estimated has to be given. By using the model it seemed that the optimum curve strongly depends on the ranges of A and m. That is why rather large ranges are used to optimize the values.

The holes at different locations are not only selected on the principle of the community type, but also of the acrotelm thickness. This is done because the transmissivity is the ability of an aquifer, here the acrotelm, to conduct the water. For thicker acrotelm layers, higher transmissivities could be expected. The different locations and the category they are in, are presented in table 2.1. The descriptions of the different community types are given in appendix XX.

To examine if locations within a certain community type show the same relation transmissivity-depth of the phreatic level, the relations are only estimated for the vegetation types in which more than one hole is located.

Compared to the preceeding work in part one, additional data are available. During the months March and April complementary tests have been done at deeper phreatic levels. Now the measured data includes in most cases as well the horizontal and vertical part of the curve, as the bend of the curve. This is very important for a good estimation of the curve [van der Part one].

The estimated optimum values of m and A for the different community types are given in table 2.2. The standard deviation, the average and the number of measurements are also presented in table 2.2. The range of phreatic levels is given because the estimated optimal curve depends upon it.

In most cases the deviation of the curve is high compared to the average measured values. Thus selecting the locations on basis of vegetation community type does not give a better result. In Appendix XXI the tansmissivity and the phreatic level for each category are plotted in a graph. From the figures it is clear that there is a big spread in the measured transmissivities and the deviation of the estimated curve is rather large. The only conclusion that can be drawn, is that at higher depths lower transmissivities are found. That the Ivanov-Romanov-equation found for a certain type is valid for that type can not be concluded. For this the variation is far to large. The A and m value,

Table 2.1: Classification of the acrotelm holes

type/acro	0 cm	10 cm	20 cm	30 cm	40 cm
3A	B4,H2, H6,J2 J3				
3Ba		A3,H4		B3	B2,F1
3Bb	C4	C5,E2, F5,G2, G4,H8	A2,H3		B2e, B2w, C2e,D3, F4,G3, H9
3C		C6,C11, H5,J1		C7	C5s,
3D	F6				
4A	F7,F8	H7			
4B	I1,I2				
4E	E4,F2	C10,E3, H1	E1		C2n,C3 F3
4F		I3			
9A					C1,D1, D4,G1, D2
11			C9		
12Ac		C8			
14B					D5

or the estimated relation, gives a very rough indication of the transmissivity and its decline with a decreasing phreatic level. But the exact value can not be estimated by using the relation.

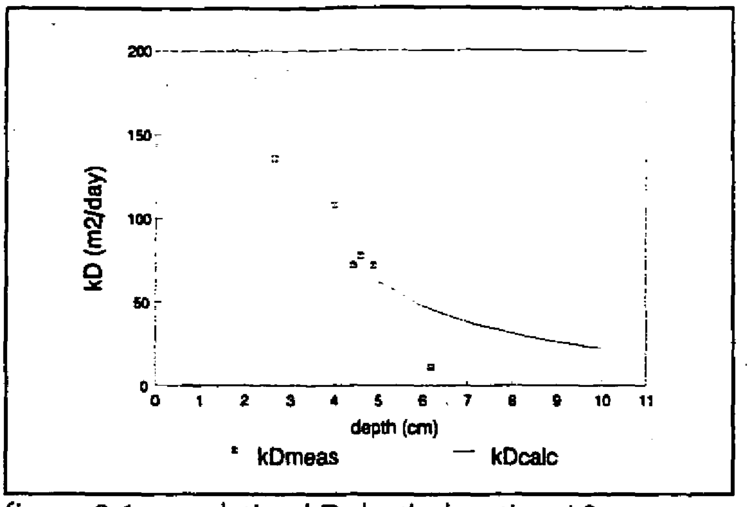
Vegetation community type 3Bb is present at the locations A2 and H3 and at both locations the acrotelm is 20 cm. thick. From figure 2 in appendix XXI, it shows that 5 points are located above the curve. These values are measured at location H3. The six values below the curve are measured at location A2. Although thye are located in the same community type, a large difference between the two locations is present. The relation transmissivity-depth of the phreatic level is estimated for the two locations separately using equation 2.1. The results are given in figure 2.1 and figure 2.2.

Table 2.2: A, m, s and avg per type and acrotelm thickness

type, acro	A	m	s (m2/ day)	avg (m2/ day)	range (cm-surface)	n
3A, 0 cm	3	1.8	5	6	1.05-7.65	19
3Ba, 10 cm	780	3.2	90	160	1.30-9.10	9
3Ba, 40 cm	2628	3.1	193	531	1.60-9.70	14
3Bb, 10 cm	126	2.5	111	105	0.50-15.10	29
3Bb, 20 cm	999	2.8	330	261	2.65-15.70	12
3Bb, 40 cm	120	1.9	110	253	1.90-20.10	37
3C, 10 cm	995	3.2	245	200	2.65-16.10	20
4A, 0 cm	20	2.5	3	4	4.10-16.70	8
4B, 0 cm	2	1.9	1	4	2.75-7.25	7
4E, 0 cm	6	1.5	94	47	4.30-10.90	7
4E, 10 cm	93	2.4	35	40	2.85-12.10	12
4E, 40 cm	748	3.0	483	636	2.70-13.00	14
9A, 40 cm	5099	2.9	849	970	1.70-13.10	24

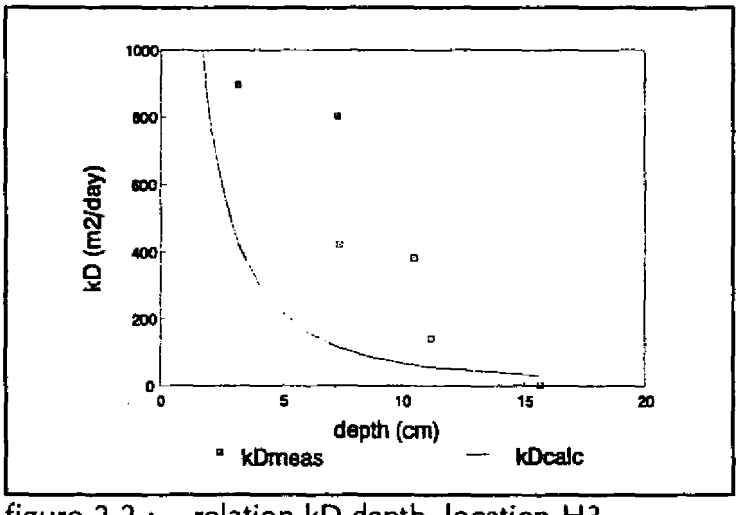
s : standard deviation from estimated curve
avg : average of the measured transmissivities
range : range between lowest and highest depht of phreatic level form the surface
n : number of measurements

As can be seen the relations are very different. The transmissivity at location H3 is much higher and the decline per cm. phreatic level is much larger than in case of location A2. The conclusion is that the relation differs per location and that it is impossible to estimate a clear relation per community type, probably more factors are influencing the transmissivity and its decline per cm. depth of the phreatic level. First, both holes are situated in different complexes. Around hole A2 there is *Myrica gale* which indicates lateral water movement. In turn this indicates a relatively steep



A = 258
m = 2.7
s = 20 m^2/day
n = 6

figure 2.1 : relation kD-depth, location A2



A = 1430
m = 2.9
s = 424 m^2/day
n = 6

figure 2.2 : relation kD-depth, location H3

slope. More important is the fact that hole A2 is situated near the edge of the bog. Probably the proces of subsidence is already started and the acrotelm is more compact than in case of location H3. In all probability the vegetation does not react immediately on changing conditions of the nearest surrounding.

From figure 2.2, it is clear that the wrong relation has been chosen, the figure shows a lineair relation. For locations C1, D1 and F1 at the edge of the soak a lineair relation is found. Because of this and the large deviations of the estimated curves, it is proven that the Ivanov-Romanovcurve does not reflect the relation transmissivity-depth of the phreatic level in all cases. This does not mean there is no relation at all, only a specific relation to describe the relation between the transmissivity and the phreatic level is not found.

It is was very difficult to measure the transmissivity at a certain depth [part one]. By repeating the test at the same depth different values have been found. Although these values where not differing very much, the differences are very important in this survey. From the differences and the estimated Ivanov-Romanov-relations it is very clear that the differences in the measured values, at a certain depth of the phreatic level, are most of the time larger than the decrease per cm. depth, calculated by the estimated curve.

2.3 Relation community type and estimated A and m

In the preceeding chapter the relation transmissivity-depth of the phreatic level per different vegetation type is expressed by means of two emperical factors A and m. Although it is concluded that the Ivanov-Romanov curve does not reflect the relation perfectly and in all cases, an attempt will be made to see if there is a relation between the community type and the estimated values for m and A. For this the types are devided in three groups:

* disturbance or dry area indicators:

  4A: the typical variant of the community *Calluna vulgaris, Sphagnum Capillifolium, Cladonia Potentosa.*
  3A: the typical variant of the community of *Narthecium ossifragum, Sphagnum magellanicum and Sphagnum tenellum.*
  4B: the variant with *Campylopus introflexus* and *Cladonia floerkeana.*

* transition vegetation

  3Bb: the typical subvariant of the phase with *Sphagnum magellanicum.*
  3C: the phase with *Sphagnum papillosum*
  4E: the phase with *Sphagnum Capillifolium.*

* wet environment types

  3Ba: the subvariant with *Sphagnum cuspidatum* of the phase with *Sphagnum magellanicum*
  9A: the typical variant of the community of *Sphagnum recurvum* and *Polytrichum alpestre.*

The community type classification is made based on the different plant species within the type. The characteristics of the different types are given in part one. The disturbance types show A-values in between 2 and 20 and m is in between 1.9 and 2.8. The low A-values were to be expected because the plant species indicate some kind of disturbance that has lead to the drying out of the peat. A-values in between 6 and 999 are found for types within the transition vegetation, m is in between 1.5 and 3.2. This group comprehences types that flourish in no particular area. A large spread in A-values is found. These values are partly dependent on acrotelm thickness. The last group, wet enironment types, show A-values in between 780 and 5099 and m-values in between 2.9 and 3.2. The high A-values are not surprising because this group includes types with plant species confined to very wet spots, so high permeabilties can be expected. The m-values are higher for the wet environment types. This means a quickly declining transmissivity with decreasing prheatic levels. The same was found in part one.

A relation between the vegetation community type and the height of the transmissivity and its decline with depth is found, but within the different types a large spread in the measured transmissivities is found. The reason for this spread is that at no location the conditions are the same.

2.4 General conclusion

When plotting the transmissivity and the depth of the phreatic level in a graph, a more or less clear relation per location is found, but alos a big difference between the different locations is found. This occurs although the selection was based on community type. Probably more factors are involved determining the relation. One of the factors could be the gradient of the surface, another one could be the distance to the edge of the bog.

The Ivanon-Romanov curve in relation to the vegetation cover does not seem to be a clear indicator of the health of the bog. On one hand because it is not clear wether or not the vegetation reacts immediately when one of the conditions of the environment changes, on the other hand because it is proven that Ivanov-Romanov-equation does not reflect always the relation transmissivity-phreatic level.

The results of an earlier research, using the approche based on vegetation community complexes, were not satisfactory. After this, it was recommended to select the locations on basis of community type. This study shows that this also causes problems. The relations for different community types and community complexes, both show large deviations. Knowing this, selecting the holes based on complexes is to be preferred because there is a vegetation community complex map available. By using this map and the estimated relation something can be said about the height of the transmissivity and its course with depth. Keep aware of the fact that there is a large deviation of the estimated relation. In all cases the deviation is larger than the increase in transmissivity per cm. depth. A continuing research has to be done, to find a equation which reflects the realtion transmissivity-depth of the phreatic level.

3 NON-LINEAR RUNOFF

3.1 Introduction

The runoff of the water surplus at raised bogs is mainly through the acrotelm. The distribution of the acrotelm is not the same all over the bog. At some spots no acrotelm at all has been found. In general the thickness of the acrotelm layer is in between 0 cm. and 40 cm. or more. This variation in acrotelm thickness means that the aquifer is not everywhere the same. From the acrotelm map (appendix VII), a concatenation of areas with an acrotelm can be seen. From the surface level map (appendix XIX), it can be shown that this concatenation functions like drains and can be called a drainage pattern. All the water is flowing through this patern to the areas with more than 40 cm. acrotelm. These areas are the soaks and their nearest surroundings. The water that is discharged at the Rossum weir and the Thomson weir comes from Shanley's Lough, this is the soak at the righthand side of the map.

Concerning the runoff, an important feature of the acrotelm is the relation transmissivity-depth of the phreatic level. In this layer the transmissivity decreases with an increasing depth of the phreatic level, which means that the resistance of water flow increases with the depth of the phreatic level. Thus the resistance for water flow differs with the phreatic level and the height of the preatic level should have influence upon the discharge and the course of it with time. To determine the infuence, hydrograph analyses are made and the reservoir coefficient (eq. 3.1) at different phreatic levels is estimated.

As mentioned before the water is collected at the soak and from here it is flowing to the two weirs. Searching for the relation reservoir coefficient and the phreatic level it is very important to know the level in the area between the soak and the weirs because this influences the discharge the most. In this area there are some tubes and the waterlevel has been measured once a forth night. The problem is that this is not a continuous observation. The hydrographs and also the estimated coefficients cover small periods, most of the time less than two or three days. To study the relation reservoir coefficient and the phreatic level, the fluctuation of the level in this period has to be known. This information can only be obtained from ground water recorders. In this case ground water recorder CWG1 is chosen. This one stands near tube 70 (appendix I) and is the closest to the weirs. Investigating the relation reservoir coefficient and the phreatic level, it has to be taken into account that the phreatic level and its fluctuation differs per location, this has also its influence upon the discharge.

3.2 Hydrograph analyses.

The course of discharge in time after rainfall is approximated by the equation [Warmerdam, 1987]:

$$q = q_0 * e^{-t/\alpha} \tag{3.1}$$

q : discharge (l/s);
q_0 : discharge at the instant at which the recession begins (l/s);
t : time (d);
α : reservoircoefficient (d).

Alpha can be shown equal to the time elapsed between the occurrence of any discharge q and q/e in the graph of recession. It is rather clear that alpha is smaller for catchments with a dense network of drains. This because in that case the resistence of flow is very small and the water will be discharged very fast. Alpha can be approximated using the following equation:

$$\alpha = \frac{(t_2 - t_1)}{\ln(\frac{q_1}{q_2})} \tag{3.2}$$

q_1 : discharge at t_1;
q_2 : discharge at t_2.

The discharge is continously measured at two weirs, the Thomson and the Rossum V-notch. The measured data are translated into discharges per hour. Using this data, the reservoir coefficient can be estimated in two ways:

1) plotting ln(q) and the time in a graph, the recession limb should produce a straight line, with lineair regression analyses the reservoir coefficient can be estimated;
2) using equation 2, the reservoir coefficient per time interval can be calculated.

The reservoir coefficient for the sum of the discharges of the Thomson and Rossum weirs has been calculated using the two methods. The calculated coefficients did not show large differences.

As mentioned before the transmissivity of the acrotelm decreases with an increasing depth of the phreatic level. Because the lateral discharge of water is through the

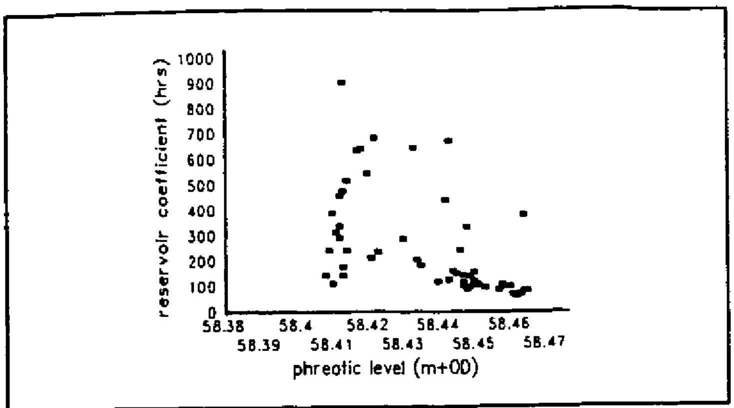


figure 3.1a: reservoir coefficient vs. phreatic level at CWG1, jan.-may 1991

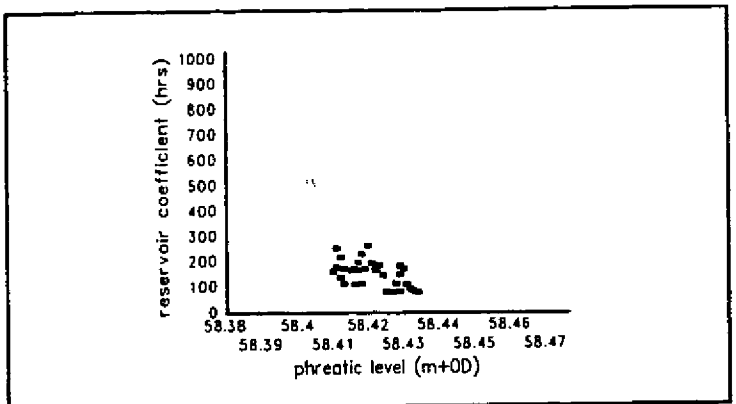


figure 3.1b: reservoir coefficient vs. phreatic level at CWG1, Dec. 1991-March 1992

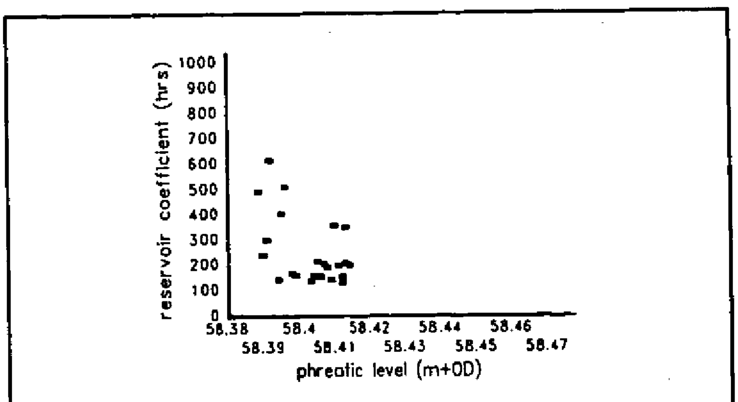


figure 3.1c: reservoir coefficient vs. phreatic level at CWG1, April and May 1992

acrotelm, the discharge and its recession will be related to the phreatic level. Therefore the reservoir coefficient are calculated at different phreatic levels for the years 1991 and 1992. The results are given in figure 3.1. The phreatic level is measured at ground water recorder CWG1. The estimated reservoir coefficients and the periods they are estimated for are presented in appendix XXII.

It is clear that the reservoir coefficients differ with the depth of the phreatic level and thus also the non-linearity of the acrotelm as a system for runoff is proven.

For the two years a difference can be seen. The reservoir coefficients of the year 1992 show lower values at low phreatic levels compared to the year 1991. Maybe the difference is caused by the digging of the drain to mark the property of the Wildlife Service. This drain was dug at the end of March 1992. In April and May 1992, relatively low reservoir coefficients have been found for low phreatic levels (58.39-58.41 m+OD). This means that the resistence of water flow has become lower, maybe this is effected by the drain. It is expected that the drain causes a quicker drying out of the upperlayer of the bog. However this is not certain. On one hand because of the precense of surface water at CWG1, the fluctuation of the phreatic level is rather small. The fluctuation in other areas will be larger. On the other hand because the discharge of water depends on the characteristics of the acrotelm and the height of the prheatic level on the whole bog. Here the analyses is connected to only one feature which is only measursed at one spot.

A certain correlation between the reservoir coefficient and the phreatic level measured at ground water recorder CWG1 is found. At low levels the coefficient is very high. The transmissivity at this depths is relatively low and thus the resistence for water flow is high. At higher levels the coefficient is low and decreasing smoothly with an increasing phreatic level. At the highest levels the curve seems to become steeper. This is probably caused by the occurence of surface runoff.

It is tried to find an equation that represents the relation between the reservoir coefficient and the phreatic level. The function that reflects the relation the best is a linear function, although this does not give an optimal result. In appendix XXIII, figures with the measured data and the estimated lines are presented. The values of the parameters of the equation and the statistical quantities are also given in this Appendix. In all cases the values for a and b are very high. The last because of the steep gradient of the line. a Is the value of the reservoir coefficient at level 0 m+O.D. and is very high due to the steep gradient within the range 58.38 m+O.D. and 58.42 m+O.D. However, this level is unrealistic because it never will be reached.

As can be seen the variation in estimated coefficients is rather large. This can be due to faulty measurements, but in all probability due to the variation in the fluctuation of the phreatic level on the whole bog, which means everchanging conditions for waterflow. It has also to be taken into account that the range in which the phreatic level fluctuates is very small, as the coefficients are estimated per millimetre difference in the phreatic level. The recorder can give deviations of this kind, registrating the levels.

3.3 The hydrological functioning of the bog.

A bog can only survive if the conditions are not too dry. On the other hand a prolonged (quick) raising of the phreatic level would lead to a prolonged reduction or cessation of aeration of the acrotelm. For this it is very important that the phreatic level does not become too high or too low. To require this the acrotelm has two important features [Ivanov, 1981; Ingram and Bragg, 1984; Ingram 1987]:

- it shrinks at droughts and swells at wet periods;
- the transmissivity decreases with depth, to require high discharges at high phreatic levels and low discharges at low levels.

From the estimated the reservoir coefficients, the condition of Clara bog seems to be good. They are very low at low depths (high phreatic levels), this means that the water will be discharged very quickly. At low phreatic levels the coefficients are high and the water is discharged slower.

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Plotting the measured transmissivity and the depth for each location seperately, shows more or less a clear relation. Searching for the same relation for a few holes within the same community type, there is no clear relation anymore. The variation in measured transmissivity is very large and also the deviation of the estimated curve is very large. In all probability there are more factors determining the relation, for instance the distance to the edge of the bog and the gradient of the surface. Probably does the vegetation not react immediately when the conditions change.

First the locations were selected at the principle of community complexes. The results were not satisfactory and it was thought that this was due to the non-uniformity of the complexes. Selecting the locations based on community types gives the same result. Because a vegetation map based on complexes is avalable, selecting the location on basis of complexes is preferred.

To approximate the relation transmissivity-depth of the phreatic level the adjusted Ivanov-Romanov equation is used. It seems that this equation does not reflect the relation in all cases. In some cases linear relations were found.

The non-linearity of the acrotelm as a system for runoff is clear. The reservoir coefficient and also the resistance for water flow is not constant and dependent on the depth of the phreatic level. This indicates a rather healthy raised bog with a quick discharge of water at high phreatic levels and a slow discharge at low levels

Compared to 1992, lower values for the reservoir coefficients for the same phreatic level at CWG1, were found in April and May 1993. It is not certain if this is the effect of the digging of a drain or high phreatic levels in the area between the soak and the weirs

4.2 Recommendations

Further research has to be done, to find a equations which reflect the relation transmissivity-depth of the phreatic level better.

In the summer of 1992 the drain has been blocked by dams. It will be very interesting to see what is the influence of this measure. Maybe this can be shown by analysing the hydrographs for the winter 1992-1993.

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APPENDICES

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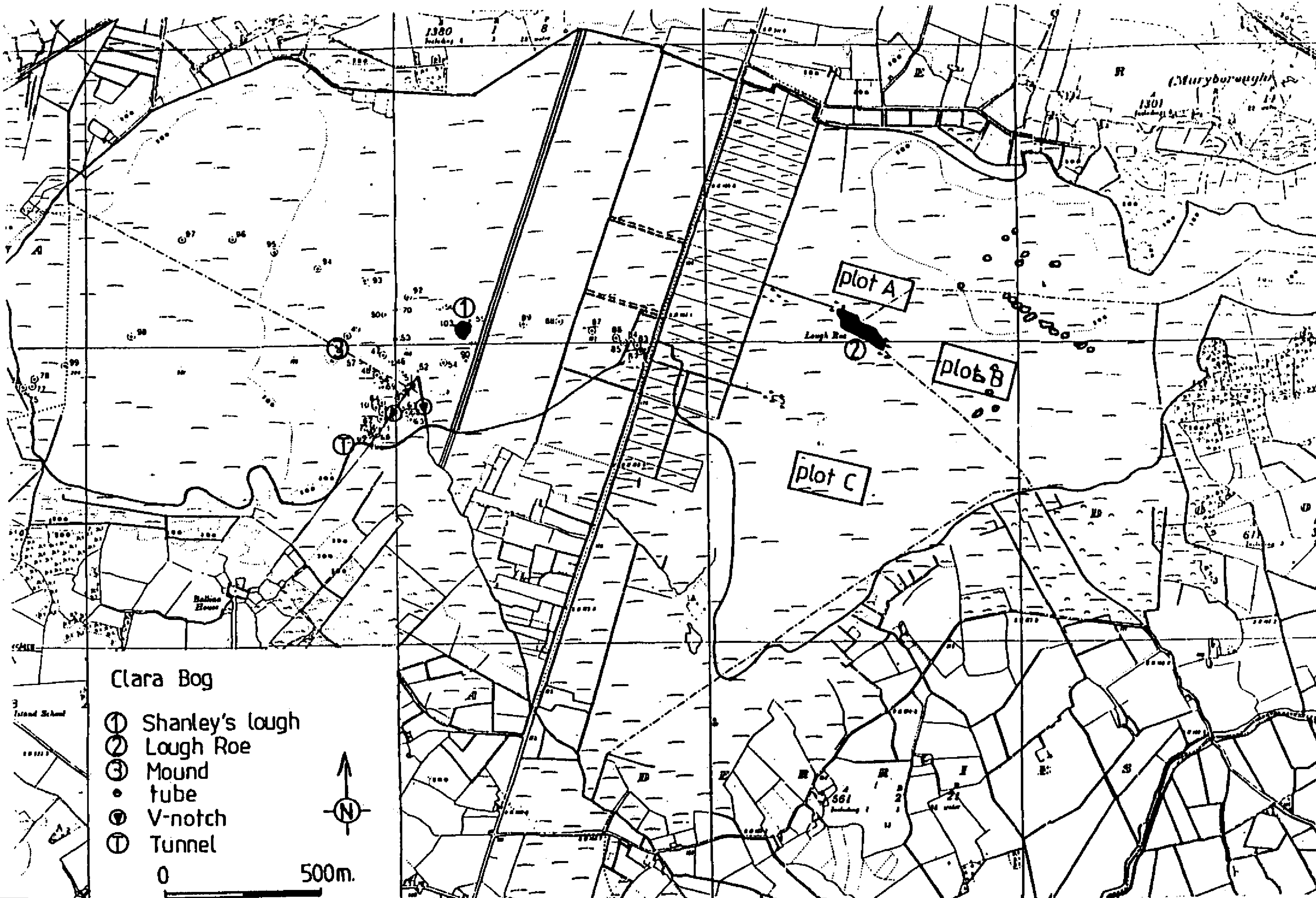
APPENDIX 1


plot A
plot B
plot C
Lough Roe
Balline House
Island School
Clara Bog
① Shanley's lough
② Lough Roe
③ Mound
• tube
V-notch
Ⓣ Tunnel
0
500m.
N

APPENDIX II

The Von Post and Granlund humification scale

H1 Completely unhumified plant remains, from which by hand only almost colourless water can be squeezed.

H2 Almost unhumified plant remains; the squeeze water is light brown and almost clear.

H3 Very poorly humified plant remains; the squeeze water is cloudy and brown.

H4 Poorly humified plant remains; peaty substance does not escape from between the fingers by squeezing.

H5 Moderately humified plant remains; the structure is however still clearly visible; the squeeze water is dark brown and very cloudy, while some peat escapes between the fingers.

H6 Fairly highly humified plant remains; the structure (texture) is unclear. About a third part of the peat escapes through the fingers. The part remaining in the hand has a more clear plant structure than the part that was squeezed out.

H7 Highly humified plant remains; about half of the material escapes when squeezed. The water which may escape is dark brown in colour.

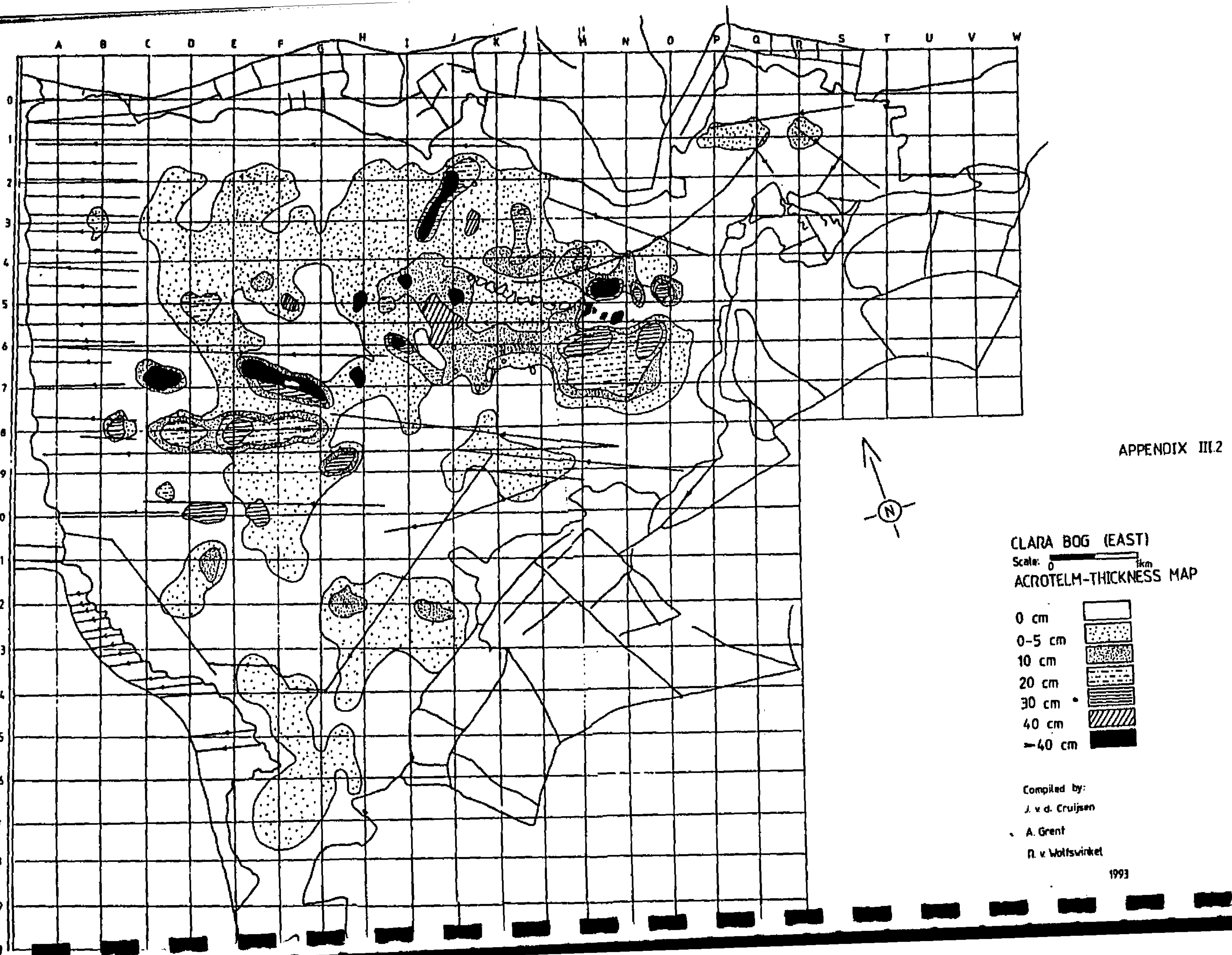
H8 Very highly humified plant remains; two-thirths escape through the fingers. The remainder consists mainly of resistant bits of roots, wood, etc.

H9 Almost completely humified plant remains; almost all the peat escapes through the fingers. Structure is almost absent.

H10 Totally humified plant remains; amorphous peat; all the peat escapes between the fingers without any water being squeezed out.

APPENDIX III 1

APPENDIX III.2



APPENDIX IV

Description of the acrotelm holes and drillings

Description of the acrotelm holes

CLARA EAST

A1.4s humification: 6.7.7.6.6
A1.4b humification: 2/6.7.7.6.3

A1.3s hollow, *Scirpus, Calluna, Narthecium, Eriophorum*, no acrotelm, depth 40 cm

0-10 cm	roots, H6
10-20 cm	old *Sphagnum*, bog cotton, roots, H5
20-30 cm	old *Sphagnum*, bog cotton, fibres, H5
30-40 cm	old *Sphagnum*, bog cotton, fibres, H5
40-50 cm	fresh/old *Sphagnum*, fibres, H3

A1.3b hummock, *Scirpus, Calluna, Narthecium, Eriophorum*, no acrotelm, depth 38 cm

0-10 cm	roots, H4
10-20 cm	roots, H4
20-30 cm	roots, bog cotton, H3-4
30-40 cm	bog cotton, H3
40-50 cm	bog cotton, fibres, H3

A1.2s humification: 6.6.6.5.4
A1.2b humification: 2.3/4.6.6.4

A2.9s humification degree: 3.6.5.6.5
A2.9b humification degree: unknown
A2.8s humification degree: 5.6.6.6.6

A2.8b hummock, strongly disturbed, *Scirpus, Eriophorum, Sphagnum, Calluna*, depth 37 cm

0-10 cm	roots, H5
10-20 cm	roots, H5
20-30 cm	roots, old *Sphagnum*, bog cotton, H5
30-40 cm	old *Sphagnum*, fibres, calluna, H6
40-50 cm	old *Sphagnum*, bog cotton, fibres, H5

A2.7s hollow, strongly disturbed, *Scirpus, Eriophorum, Sphagnum, Calluna*, depth 38 cm

0-10 cm	old *Sphagnum*, roots, H4
10-20 cm	old *Sphagnum*, roots, H3
20-30 cm	old *Sphagnum*, fresh *Sphagnum*, roots, H3

	30-40 cm	old *Sphagnum*, fresh *Sphagnum*, roots, H3
	40-50 cm	old *Sphagnum*, fresh *Sphagnum*, roots, H3

A2.7b humification degree: 2.6.6.7.7

B2.24s humification degree: 2.2/6.6.6.5
B2.24b humification degree: 2.2/5.6.6.6
B2.23s humification degree: 6.6.5.6.5
B2.23b humification degree: 3.6.8.7.6
B2.22s humification degree: 8.7.6.4.4
B2.22b humification degree: 6.5.5.3.3

B3.29s humification degree: 6.6.6.6.6
B3.29b humification degree: 6.6.4.5.3
B3.28s humification degree: 2.2.2.2.7

B3.28b hummock, *Calluna, Eriophorum*, no acrotelm, depth 38.5 cm

0-10 cm	dead organic material, BA, H3, 5YR.4/4
10-20 cm	roots, A, H6, 5YR.2/3
20-30 cm	roots, fibres, bog cotton, *Calluna*, A, H5. 5YR.2/3
30-40 cm	fibres, old *Sphagnum*, roots, young *Sphagnum*, A, H4, 5YR.2/3
40-50 cm	fibres, *Calluna*, old/young *Sphagnum*, H4-5, 5YR.2/4

B3.27s humification degree: 2/5.2/5.2/5.2/5.3
B3.27b humification degree: 3.4.6.6.6

C2.36s hollow, *Calluna*, no acrotelm, depth 35 cm

0-10 cm	fibres, *Calluna*, BA, H5-6, 5YR.3/2
10-20 cm	young *Sphagnum*, fibres, A, H3, 5YR.4/3
20-30 cm	young *Sphagnum*, fibres, bog cotton, A, H3, 5YR.4/3
30-40 cm	young *Sphagnum*, fibres, A, H3, 5YR.4/2
40-50 cm	young *Sphagnum*, fibres, bog cotton, *Calluna*, A, H2, 5YR.6/4

C2.36b hummock, *Calluna*, no acrotelm, depth 37 cm

0-10 cm	roots, BA, H5-6, 5YR.3/2
10-20 cm	roots, *Calluna*, BA, H5, 5YR.3/2
20-30 cm	many fine fibres, roots, *Calluna*, BA, H5, 5YR.3/2
30-40 cm	fibres. old *Sphagnum*, H6, 5YR.3/3
40-50 cm	young/old *Sphagnum*, fibres, bog cotton, *Calluna*, A, H5, 5YR.3/4

C2.38b humification degree: 6.7.6.5.4
C2.39b humification degree: 3.5.4.6.6
C2.39s humification degree: 7.8.7.4.5

C3.42s hollow, *Calluna, Erica, Eriophorum*, acrotelm 5 cm, depth 38 cm

0- 5 cm	fresh *Sphagnum*

5-10 cm	roots, BA, H6, 5YR.2/1
10-25 cm	roots, fibres, BA, H5, 5YR.2/1
25-30 cm	young *Sphagnum*, fibres, A, H4, 5YR.4/3
30-40 cm	young *Sphagnum*, fibres, A, H3, 5YR.5/3
40-50 cm	young *Sphagnum*, fibres, bog cotton, *Calluna*, A, H3, 5YR.5/3

C3.42b	humification degree: 2.5.4.5.4
C3.43s	humification degree: 6.5.4.3.3
C3.43b	humification degree: 4.4.6.6.6
C3.44s	humification degree: 6.6.7.4.6
C3.44b	humification degree: 5.5.5.4.3

CLARA WEST

A1	location	:	10 m W tube 63
	acrotelm	:	20 cm
	depth	:	35 cm
	wide	:	27 cm
	vegetation	:	*Sphagnum cuspidatum/S. capillifolium/ Narthecium* hollow
	zone	:	*Sphagnum magellanicum* with *Myrica gale*
	slope	:	flat, uneven surface
	0-10 cm	:	fresh *Sphagnum*, H2
	10-20 cm	:	fresh *Sphagnum*, H2
	20-30 cm	:	old *Sphagnum*, fibres roots, *Calluna*, H3, 5YR.3/2
	30-40 cm	:	old *Sphagnum*, fibres, roots, H3, 5YR.3/4
	40-50 cm	:	old *Sphagnum*, fibres, roots, H3, 5YR.3/4
A2	location	:	north tube 59
	acrotelm	:	20 cm
	depth	:	35 cm
	wide	:	23 cm
	vegetation	:	*S. magellanicum/S. papillosum* hollow
	zone	:	*Sphagnum magellanicum* with *Myrica gale*
	slope	:	gentle, in direction of facebank
	0-10 cm	:	fresh *Sphagnum*, H2
	10-20 cm	:	fresh *Sphagnum*, H2
	20-30 cm	:	old *Sphagnum*, bog cotton, fibres, roots, *Calluna*, H5, 5YR.2/3
	30-40 cm	:	old *Sphagnum*, fibres, bog cotton, roots, H3, 5YR.3/3
	40-50 cm	:	bog cotton, fibres, H3, 5YR.2/3
A3	location	:	near tube 58
	acrotelm	:	10 cm

	depth	:	35 cm
	wide	:	22 cm
	vegetation	:	*S. magellanicum/S. tenellum/ S. cuspidatum* hollow
	zone	:	*Sphagnum magellanicum* with *Myrica gale*
	slope	:	flat, uneven
	0-10 cm	:	fresh *Sphagnum*
	10-20 cm	:	old *Sphagnum*, fibres, roots, *Calluna*, H3, 5YR.3/3
	20-30 cm	:	old *Sphagnum*, fibres, bog cotton, roots, H3, 5YR.4/4
	30-40 cm	:	old/fresh *Sphagnum*, bog cotton, fibres, roots, H3, 5YR.4/4
	40-50 cm	:	bog cotton, fresh *Sphagnum*, fibres, *Calluna*, H3, 5YR.3/4
A3s	location	:	4 m N tube 58
	acrotelm	:	10 cm
	depth	:	35 cm
	wide	:	24 cm
	vegetation	:	*Sphagnum capillifolium* hummock
	zone	:	*Myrica gale/Calluna*
A3n	location	:	3 m E tube 58
	acrotelm	:	20 cm
	depth	:	40 cm
	wide	:	20 cm
	vegetation	:	*Sphagnum capillifolium/ Eriophorum vaginatum* tussock
	zone	:	*Myrica gale/Calluna*
B1	location	:	near Thomson and Rossum, in end of drain
	acrotelm	:	60 cm
	depth	:	55 cm
	wide	:	21 cm
	vegetation	:	*Sphagnum cuspidatum* infilled drain
	zone	:	*Sphagnum cuspidatum*
	slope	:	flat
	0-10 cm	:	fresh *Sphagnum*, H2
	10-20 cm	:	fresh *Sphagnum*, H2
	20-30 cm	:	fresh *Sphagnum*, H2
	30-40 cm	:	fresh *Sphagnum*, H2
	40-50 cm	:	fresh *Sphagnum*, H2
B2	location	:	10 m SE tube 46
	acrotelm	:	70 cm
	depth	:	45 cm
	wide	:	22 cm
	vegetation	:	*Sphagnum magellanicum/S. cuspidatum* hollow
	zone	:	*Sphagnum magellanicum*
	slope	:	flat

0-10 cm	:	fresh *Sphagnum*, H2
10-20 cm	:	fresh *Sphagnum*, H2
20-30 cm	:	fresh *Sphagnum*, H2
30-40 cm	:	fresh *Sphagnum*, H2
40-50 cm	:	fresh *Sphagnum*, H2

B2s	location	:	5 m S tube 46
	acrotelm	:	40 cm
	depth	:	40 cm
	wide	:	20 cm
	vegetation	:	Low *S. magellanicum* hummock
	zone	:	*S. magellanicum*

B2sw	location	:	10 m S tube 46
	acrotelm	:	40 cm
	depth	:	40 cm
	wide	:	21 cm
	vegetation	:	*S. magellanicum/Calluna* hummock
	zone	:	*S. magellanicum*

B3	location	:	near tube 48, 5 m in the direction of peg
	acrotelm	:	30 cm
	depth	:	35 cm
	wide	:	27 cm
	vegetation	:	*Sphagnum magellanicum/S. cuspidatum* hollow
	zone	:	*Sphagnum magellanicum*
	slope	:	gentle, internal in direction of mound
	water on surface		

0-10 cm	:	fresh *Sphagnum*, H1-H2
10-20 cm	:	fresh *Sphagnum*, H1-H2
20-30 cm	:	fresh *Sphagnum*, H1-H2
30-40 cm	:	old *Sphagnum*, roots, H3, 5YR.4/6
40-50 cm	:	fibres, bog cotton, roots, H3, 5YR.3/3

B4	location	:	10 m NE tube 49
	acrotelm	:	0 cm
	depth	:	45 cm
	wide	:	20 cm
	vegetation	:	*Narthecium/S. tenellum/S. cuspidatum* hollow
	zone	:	Transition *Sphagnum magellanicum* to *Narthecium*
	slope	:	gentle, internal, uneven surface

0-10 cm	:	old *Sphagnum*, roots, fibres, bog cotton, H3, 5YR.3/1
10-20 cm	:	old *Sphagnum*, roots, fibres, bog cotton, H3, 5YR.3/1
20-30 cm	:	roots, bog cotton, H3, 5YR.3/2
30-40 cm	:	old *Sphagnum*, fibres, roots, *Calluna*, H3, 5YR.3/2
40-50 cm	:	old *Sphagnum*, bog cotton, fibres, roots, H3, 5YR.3/2

C1	location	near soak, 20 m N tube 55, path 55/56
	acrotelm	> = 50 cm
	depth	40 cm
	wide	20 cm
	vegetation	*Sphagnum recurvum/S. capillifolium* low hummock
	zone	Transition from soak to *Eriophorum*
	slope	flat, hummock/hollow, surface water
	0-10 cm	fresh *Sphagnum*, bog cotton, H2, 7,5YR.4/5
	10-20 cm	fresh *Sphagnum*, bog cotton, H2, 7,5YR.4/5
	20-30 cm	fresh *Sphagnum*, bog cotton, H2, 7,5YR.4/5
	30-40 cm	fresh *Sphagnum*, bog cotton, H2, 7,5YR.4/5
	40-50 cm	fresh *Sphagnum*, bog cotton, H2, 7,5YR.4/4
C2	location	5 m NE tube 56
	acrotelm	> = 50 cm
	depth	38 cm
	wide	18 cm
	vegetation	*Sphagnum capillifolium/S. tenellum*/some *Aulacomium palustre* hummock
	zone	*Eriophorum*
	slope	flat, hummock/hollow
	0-10 cm	fresh *Sphagnum*, H2
	10-20 cm	fresh *Sphagnum*, H2
	20-30 cm	fresh *Sphagnum*, bog cotton, roots, H3, 5YR.3/4
	30-40 cm	fresh *Sphagnum*, bog cotton, roots, fibres, H3, 5YR.3/4
	40-50 cm	fresh *Sphagnum*, bog cotton, roots, fibres, H2, 5Yr.4/6
C2e	location	10 m W tube 56
	acrotelm	40 cm
	depth	40 cm
	wide	22 cm
	vegetation	*S. magellanicum* lawn
	zone	*Eriophorum*
C2n	location	10 m NW tube 56
	acrotelm	40 cm
	depth	40 cm
	wide	23 cm
	vegetation	*S. capillifolium/ Polytrichum/Hypnum jutlandicum* hummock
	zone	*Eriophorum*
C3	location	5 m NE peg G10
	acrotelm	40 cm
	depth	40
	wide	20 cm
	vegetation	*Sphagnum capillifolium/Eriophorum vaginatum* hummock

	zone	:	Fringing scrub *Betula/Molinia*
	slope	:	flat, hummock/hollow
	0-10 cm	:	fresh *Sphagnum*, bog cotton, roots, H2, 5YR.5/3
	10-20 cm	:	fresh *Sphagnum*, bog cotton, roots, H2, 5YR.5/3
	20-30 cm	:	fresh *Sphagnum*, bog cotton, roots, H2, 5YR.5/3
	30-40 cm	:	fresh *Sphagnum*, bog cotton, roots, H2, 5YR.5/3
	40-50 cm	:	old/fresh *Sphagnum*, bog cotton, roots, H3, 5YR.4/4
C4	location	:	5 m SW tube 92
	acrotelm	:	0 cm
	depth	:	40 cm
	wide	:	18 cm
	vegetation	:	Small lawn of *Sphagnum magellanicum*
	zone	:	Burnt *Calluna* dominated
	slope	:	strong, internal
	0-10 cm	:	old *Sphagnum*, roots, H5, 5YR.2/3
	10-20 cm	:	old *Sphagnum*, bog cotton, roots, H5, 5YR.3/3
	20-30 cm	:	old *Sphagnum*, bog cotton, roots, fibres, H6, 5YR.3/3
	30-40 cm	:	old *Sphagnum*, fibres, H5, 5YR.2/3
	40-50 cm	:	old *Sphagnum*, fibres, H5, 5YR.2/3
C4s	location	:	10 m SE tube 92
	acrotelm	:	0-5 cm
	depth	:	40 cm
	wide	:	21 cm
C4w	location	:	W C4.2
	acrotelm	:	0 cm
	depth	:	40 cm
	wide	:	20 cm
C5	location	:	10 m SW tube 93
	acrotelm	:	10 cm
	depth	:	40 cm
	wide	:	20 cm
	vegetation	:	Low *Sphagnum magellanicum/S. capillifolium* hummock
	zone	:	Hummock/hollow
	slope	:	gentle internal, hummock/hollow, surface water
	0-10 cm	:	fresh *Sphagnum*, H2, 5YR.4/5
	10-20 cm	:	fresh/old *Sphagnum*, roots, fibres, H5, 5YR.3/3
	20-30 cm	:	old *Sphagnum*, roots, fibres, H5, 5YR.3/3
	30-40 cm	:	old *Sphagnum*, bog cotton, roots, fibres, *Calluna*, H5, 5YR.3/3
	40-50 cm	:	old/fresh *Sphagnum*, fibres, H5. 5YR.3/2

C5s	location	:	10 m SW tube 93
	acrotelm	:	40 cm
	depth	:	40 cm
	wide	:	26 cm
	vegetation	:	*S. papillosum/S. capillifolium* hummock
	zone	:	Hummock/hollow
C5se	location	:	10 m S tube 93
	acrotelm	:	40 cm
	depth	:	40 cm
	wide	:	20 cm
	vegetation	:	*S. papillosum/ Odontoschisma sphagni* low hummock/ lawn
C6	location	:	5 m E tube 94, peg K10, CWG2
	acrotelm	:	10 cm
	depth	:	45 cm
	wide	:	20 cm
	vegetation	:	Low *S. papillosum* hummock
	zone	:	*Sphagnum magellanicum*
	slope	:	gentle internal, hummock/hollow
	0-10 cm	:	fresh *Sphagnum*, H2
	10-20 cm	:	old *Sphagnum*, roots, H6, 5Yr.3/2
	20-30 cm	:	old *Sphagnum*, roots, H5, 5Yr.3/2
	30-40 cm	:	old *Sphagnum*, roots, fibres, *Calluna*, H5, 5YR.3/2
	40-50 cm	:	old *Sphagnum*, roots, fibres, H5, 5YR.3/2
C7	location	:	4 m N peg N10, tube 96
	acrotelm	:	30 cm
	depth	:	40 cm
	wide	:	19 cm
	vegetation	:	Low *S. papillosum/S. capillifolium* hummock
	zone	:	*Sphagnum magellanicum*
	slope	:	flat, hummock/hollow
	0-10 cm	:	fresh *Sphagnum*, bog cotton, H2, 5YR.4/4
	10-20 cm	:	fresh *Sphagnum*, bog cotton, H2, 5YR.4/4
	20-30 cm	:	fresh *Sphagnum*, bog cotton, H2, 5YR.4/4
C8	location	:	50 m WSW peg M10, near broken tree
	acrotelm	:	10 cm
	depth	:	35 cm
	wide	:	22 cm
	vegetation	:	*Polytrichum formosum/Eriophorum vaginatum* hummock
	zone	:	*Betula* woodland
	slope	:	gentle, internal
	0-10 cm	:	fresh *Sphagnum*, H2, 2.5YR.3/4

	10-20 cm	:	fresh/old *Sphagnum*, bog cotton, H3, 5YR.3/2
	20-30 cm	:	old *Sphagnum*, H5, 5YR,3/2
	30-40 cm	:	old/fresh *Sphagnum*, bog cotton, roots, H5, 5YR.2/3
	40-50 cm	:	old *Sphagnum*, bog cotton, roots, fibres, *Calluna*, H5, 5YR.3/3
C9	location	:	5 m N tube 95
	acrotelm	:	20 cm
	depth	:	40 cm
	wide	:	20 cm
	vegetation	:	*Aulacomium palustre/Empetrum nigrum/S. capillifolium*
	zone	:	Soak vegetation *Betula* scrub woodland understorey vegetation
	slope	:	gentle, internal
	0-10 cm	:	fresh *Sphagnum*, roots, H2, 5YR.3/3
	10-20 cm	:	fresh *Sphagnum*, roots, H2, 5YR.3/3
	20-30 cm	:	fresh/old *Sphagnum*, roots, H3, 5YR.3/3
	30-40 cm	:	old *Sphagnum*, roots, H4, 5YR.3/2
	40-50 cm	:	old/fresh *Sphagnum*, roots, *Calluna*, H5, 5YR.3.3
C10	location	:	peg O10
	acrotelm	:	0 cm
	depth	:	40 cm
	wide	:	20 cm
	vegetation	:	*S. capillifolium/Eriophorum vaginatum* hummock
	zone	:	*Eriophorum vaginatum*
	slope	:	hummock/hollow
	0-10 cm	:	roots, bog cotton, H7
	10-20 cm	:	roots, bog cotton, H5
	20-30 cm	:	roots, bog cotton, *Calluna*, H7
	30-40 cm	:	roots, *Calluna*, H7
	40-50 cm	:	old *Sphagnum*, roots, H6
C11	location	:	peg P10
	acrotelm	:	0 cm
	depth	:	40 cm
	wide	:	19 cm
	vegetation	:	*S. magellanicum/S. papillosum/S. capillifolium* hummock
	zone	:	*Sphagnum magellanicum*
	slope	:	hummock/hollow
	0-10 cm	:	roots, H7
	10-20 cm	:	roots, H7
	20-30 cm	:	roots, H6
	30-40 cm	:	roots, old *Sphagnum*, H6
	40-50 cm	:	old *Sphagnum*, roots, H5

D1	location	:	near edge of soak, SE
	acrotelm	:	> = 50 cm
	depth	:	45 cm
	wide	:	24 cm
	vegetation	:	*Sphagnum recurvum/ Aulacomium palustre* lawn
	zone	:	*Sphagnum recurvum*
	slope	:	flat
	0-10 cm	:	fresh *Sphagnum*, H2
	10-20 cm	:	fresh *Sphagnum*, H2
	20-30 cm	:	fresh *Sphagnum*, H2
	30-40 cm	:	fresh *Sphagnum*, H2
	40-50 cm	:	fresh *Sphagnum*, H2
D2	location	:	35 m SE of soak, near birch tree
	acrotelm	:	10 cm
	depth	:	45 cm
	wide	:	23 cm
	vegetation	:	*S. capillifolium/S. recurvum* flat
	zone	:	*Molinia/Betula* scrub
	slope	:	gentle, internal
	0-10 cm	:	fresh *Sphagnum*
	10-20 cm	:	fresh/old *Sphagnum*, fibres, roots, birch, H3, 5YR.3/3
	20-30 cm	:	fresh/old *Sphagnum*, fibres, roots, birch, H3, 5YR.3/3
	30-40 cm	:	old *Sphagnum*, fibres, roots, *Calluna*, H3, 5YR.3/4
	40-50 cm	:	old *Sphagnum*, fibres, roots, *Calluna*, H3, 5YR.3/4
D3	location	:	10 m NW tube F12
	acrotelm	:	60 cm
	depth	:	55 cm
	wide	:	24 cm
	vegetation	:	*Sphagnum magellanicum* lawn
	zone	:	*S. magellanicum*
	slope	:	gentle, internal
	0-10 cm	:	*Sphagnum*, bog cotton, H2
	10-20 cm	:	*Sphagnum*, bog cotton, H2
	20-30 cm	:	*Sphagnum*, bog cotton, H2
	30-40 cm	:	*Sphagnum*, bog cotton, H2
	40-50 cm	:	*Sphagnum*, bog cotton, H2
D4	location	:	40 m E tube G12
	acrotelm	:	50 cm
	depth	:	50 cm
	wide	:	21 cm
	vegetation	:	*Sphagnum recurvum/Aulacomium palustre/ Eriophorum vaginatum*
	zone	:	*Molinia/ Betula* tree/ *Myrica*

	slope	:	flat
	0-10 cm	:	fresh *Sphagnum*, H2
	10-20 cm	:	fresh *Sphagnum*, H2
	20-30 cm	:	fresh *Sphagnum*, H2
	30-40 cm	:	fresh *Sphagnum*, H2
	40-50 cm	:	fresh *Sphagnum*, H2
D5	location	:	between tube 52 and 54, 20 m NE tube 52
	acrotelm	:	30 cm
	depth	:	40 cm
	wide	:	22 cm
	vegetation	:	*Sphagnum magellanicum/ Molinia* area
	zone	:	*Molinia/ Betula* scrub/ *Myrica*
	slope	:	flat
	0-10 cm	:	fresh *Sphagnum*, H2
	10-20 cm	:	fresh *Sphagnum*, H2
	20-30 cm	:	fresh *Sphagnum*, H2
	30-40 cm	:	fresh *Sphagnum*, roots, H3, 5YR.4/5
	40-50 cm	:	fresh/old *Sphagnum*, bog cotton, fibres, roots, *Calluna*, H3, 5YR.3/3
CWG1	location	:	10 m W groundwater recorder CWG1
	acrotelm	:	30 cm
	depth	:	30 cm
	wide	:	20 cm
	vegetation	:	Extensive *Sphagnum magellanicum* lawn
	zone	:	Fringing *Sphagnum cuspidatum/S. recurvum*
	slope	:	flat, surface water
	0-10 cm	:	fresh *Sphagnum*, H1-H2
	10-20 cm	:	fresh *Sphagnum*, H1-H2
	20-30 cm	:	fresh *Sphagnum*, H1-H2
	30-40 cm	:	old *Sphagnum*, roots, H4, 5YR.3/3
	40-50 cm	:	old *Sphagnum*, bog cotton, roots, fibres, H5, 5YR.3/3
E1	location	:	3 m SE tube 90
	acrotelm	:	20 cm
	depth	:	35 cm
	wide	:	20 cm
	vegetation	:	*Eriophorum vaginatum/S. capillifolium* tussock
	zone	:	*Betula* scrub
	slope	:	flat, uneven surface
	0-10 cm	:	fresh *Sphagnum*, H2, 5Yr.5/6
	10-20 cm	:	fresh *Sphagnum*, H2, 5Yr.5/6
	20-30 cm	:	old *Sphagnum*, bog cotton, fibres, H3, 5YR.3/3
	30-40 cm	:	old *Sphagnum*, fibres, H5, 5Yr.3/3

	40-50 cm	:	old *Sphagnum*, fibres, H5, 5YR.3/2
E2	location	:	between E10 and E11
	acrotelm	:	10 cm
	depth	:	40 cm
	wide	:	20 cm
	vegetation	:	*Sphagnum magellanicum/Odontoschisma sphagni* hummock
	zone	:	*Eriophorum/Narthecium*
	slope	:	flat
	0-10 cm	:	fresh *Sphagnum*, *Calluna*, roots, H2, 5YR.3/4
	10-20 cm	:	old *Sphagnum*, fibres, H4, 5YR.3/3
	20-30 cm	:	old *Sphagnum*, fibres, H5, 5YR.2/3
	30-40 cm	:	fibres, H7, 5YR.2/2
	40-50 cm	:	old *Sphagnum*, fibres, *Calluna*, H6, 5YR.2/3
E3	location	:	between tube 89 and peg D10
	acrotelm	:	10 cm
	depth	:	38 cm
	wide	:	16 cm
	vegetation	:	*Sphagnum capillifolium* hummock
	zone	:	*Carex panicea*
	slope	:	gentle, internal in direction of bog road
	0-10 cm	:	fresh *Sphagnum*, H2, 5YR.4/4
	10-20 cm	:	old *Sphagnum*, bog cotton, roots, H5, 5YR.3/3
	20-30 cm	:	old *Sphagnum*, roots, H5, 5YR.3/3
	30-40 cm	:	old/fresh *Sphagnum*, fibres, H4, 5YR.3/3
	40-50 cm	:	old/fresh *Sphagnum*, fibres, H5, 5YR.3/3
E4	location	:	tube 881
	acrotelm	:	0 cm
	depth	:	38 cm
	wide	:	18 cm
	vegetation	:	*S. capillifolium* hummock
	zone	:	*Carex panicea* burnt
	slope	:	gentle, internal
	0-10 cm	:	old *Sphagnum*, fibres, H5, 5Yr.3/2
	10-20 cm	:	old *Sphagnum*, fibres, *Calluna*, H5, 5YR.2.2
	20-30 cm	:	bog cotton, old *Sphagnum*, fibres, *Calluna*, H5, 5YR.2/2
	30-40 cm	:	bog cotton, *Calluna*, fibres, H4, 5YR.3/3
	40-50 cm	:	bog cotton, fibres, roots, H4, 5YR.3/3
F1	location	:	near soak, 20 m SE tube 55
	acrotelm	:	> - 40 cm
	depth	:	40 cm
	wide	:	18 cm

	vegetation	:	*Sphagnum magellanicum* lawn
	zone	:	*Sphagnum magellanicum/ Eriophorum vaginatum*
	slope	:	flat
	0-10 cm	:	fresh *Sphagnum*, bog cotton, H2, 5YR.4/5
	10-20 cm	:	fresh *Sphagnum*, bog cotton, H2, 5YR.4/5
	20-30 cm	:	fresh *Sphagnum*, bog cotton, H2, 5YR.4/5
	30-40 cm	:	fresh *Sphagnum*, bog cotton, H2, 5YR.4/5
F2	location	:	peg F10
	acrotelm	:	0 cm
	depth	:	35 cm
	wide	:	20 cm
	vegetation	:	*S. capillifolium/ Vaccimium oxyoccus* hummock
	zone	:	*Betula* scrub/ *Myrica*
	slope	:	flat
	0-10 cm	:	old *Sphagnum*, bog cotton, H6, 5YR.2/3
	10-20 cm	:	old/fresh *Sphagnum*, bog cotton, fibres, H5, 5YR.3/4
	20-30 cm	:	fresh/old *Sphagnum*, fibres, H3, 5YR.3/4
	30-40 cm	:	old *Sphagnum*, fibres, H5, 5YR.2/3
	40-50 cm	:	old/fresh *Sphagnum*, fibres, H3, 5YR.2/4
F3	location	:	peg F9
	acrotelm	:	40 cm
	depth	:	40 cm
	wide	:	20 cm
	vegetation	:	*S. capillifolium* hummock
	zone	:	Hummock/hollow
	slope	:	flat, hummock/hollow
	0-10 cm	:	fresh *Sphagnum*, bog cotton, H2, 5YR.3/3
	10-20 cm	:	fresh *Sphagnum*, bog cotton, H2, 5YR.3/3
	20-30 cm	:	fresh *Sphagnum*, bog cotton, H2, 5YR.3/3
	30-40 cm	:	fresh *Sphagnum*, bog cotton, H2, 5YR.3/3
	40-50 cm	:	old/fresh *Sphagnum*, H5, 5YR.3/4
F4	location	:	30 m N peg F8
	acrotelm	:	>= 50 cm
	depth	:	42 cm
	wide	:	18 cm
	vegetation	:	Low *S. magellanicum* hummock
	zone	:	*S. magellanicum* orientated pool
	slope	:	flat, hummock/hollow, surface water
	0-10 cm	:	fresh *Sphagnum*, bog cotton, H1-H2, 5YR.4/4 => 5YR.4/6
	10-20 cm	:	fresh *Sphagnum*, bog cotton, H1-H2, 5YR.4/4 => 5YR.4/6

	20-30 cm	:	fresh *Sphagnum*, bog cotton, H1-H2, 5YR.4/4 => 5YR.4/6
	30-40 cm	:	fresh *Sphagnum*, bog cotton, H1-H2, 5YR.4/4 => 5YR.4/6
	40-50 cm	:	fresh *Sphagnum*, bog cotton, H1-H2, 5YR.4/4 => 5YR.4/6
F5	location	:	15 m NNE CGW3
	acrotelm	:	10 cm
	depth	:	35 cm
	wide	:	18 cm
	vegetation	:	*S. magellanicum* hummock
	zone	:	Hummock/hollow
	slope	:	gentle, internal, hummock/hollow
	0-10 cm	:	fresh *Sphagnum*, H1, 5YR.5/5
	10-20 cm	:	old *Sphagnum*, roots, H7, 5YR.2/2
	20-30 cm	:	fresh *Sphagnum*, roots, H2, 5YR.3/4
	30-40 cm	:	old/fresh *Sphagnum*, bog cotton, roots, fibres, *Calluna*, H3, 5YR.3/3
	40-50 cm	:	fresh/old *Sphagnum*, roots, fibres, H3, 5YR.3/3
F6.	location	:	peg F7
	acrotelm	:	0 cm
	depth	:	40 cm
	wide	:	19 cm
	vegetation	:	*Carex panicea* burnt flat area
	zone	:	*Eriophorum/Narthecium*
	slope	:	gentle, internal, hummock/hollow
	0-10 cm	:	old/fresh *Sphagnum*, bog cotton, H5, 5Yr.2/3
	10-20 cm	:	old *Sphagnum*, fibres, bog cotton, H6, 5YR.2/3
	20-30 cm	:	old *Sphagnum*, fibres, H5, 5Yr.2/3
	30-40 cm	:	old *Sphagnum*, fibres, bog cotton, H6, 5YR.2/3
	40-50 cm	:	old *Sphagnum*, fibres, bog cotton, H5, 5YR.2/3
F7	location	:	peg F6
	acrotelm	:	0 cm
	depth	:	50 cm
	wide	:	18 cm
	vegetation	:	Low burnt hummock
	zone	:	*Eriophorum/Narthecium*
	slope	:	gentle, internal, hummock/hollow
	0-10 cm	:	roots, H6-H10, 5YR.2/2
	10-20 cm	:	roots, H6-H10, 5YR.3/1
	20-30 cm	:	old/fresh *Sphagnum*, fibres, H6, 5YR.2/3
	30-40 cm	:	fresh/old *Sphagnum*, fibres, H3, 5YR.3/5
	40-50 cm	:	fresh/old *Sphagnum*, fibres, H4, 5YR.3/3

F8	location	:	peg F5
	acrotelm	:	0 cm
	depth	:	40 cm
	wide	:	18 cm
	vegetation	:	Low burnt hummock
	zone	:	*Eriophorum/Narthecium*
	slope	:	gentle, internal
	0-10 cm	:	old/fresh *Sphagnum*, roots, H4, 5YR.2/3
	10-20 cm	:	old *Sphagnum*, roots, H6, 5Yr.2/3
	20-30 cm	:	old *Sphagnum*, roots, H6, 5YR.2/2
	30-40 cm	:	fresh/old *Sphagnum*, roots, fibres, H4, 5YR.3/4
	40-50 cm	:	fresh *Sphagnum*, bog cotton, roots, fibres, *Calluna*, H3, 5YR.2/3
G1	location	:	peg G9
	acrotelm	:	> = 50 cm
	depth	:	44 cm
	wide	:	22 cm
	vegetation	:	*Aulacomium palustre/S. magellanicum* hummock
	zone	:	*S. recurvum*
	slope	:	flat, hummock/hollow, surface water
	0-10 cm	:	fresh *Sphagnum*, H2, 5YR.5/5
	10-20 cm	:	fresh *Sphagnum*, H2, 5YR.5/5
	20-30 cm	:	fresh *Sphagnum*, H2, 5YR.5/5
	30-40 cm	:	fresh *Sphagnum*, H2, 5YR.5/5
	40-50 cm	:	fresh *Sphagnum*, H2, 5YR.5/5
G2	location	:	peg H8
	acrotelm	:	10 cm
	depth	:	40 cm
	wide	:	18 cm
	vegetation	:	*S. magellanicum/S. papillosum* low hummock
	zone	:	Transition *Sphagnum magellanicum*
	slope	:	gentle, internal
	0-10 cm	:	fresh *Sphagnum*, H2, 5YR.5/5
	10-20 cm	:	old *Sphagnum*, roots, H6, 7,5Yr.4/3
	20-30 cm	:	old *Sphagnum*, bog cotton, roots, H6, 7,5Yr.4/4
	30-40 cm	:	fresh/old *Sphagnum*, bog cotton, fibres, H5, 7,5YR.3/4
	40-50 cm	:	fresh/old *Sphagnum*, bog cotton, fibres, H6, 7,5YR.3/4
G3	location	:	peg I7
	acrotelm	:	40 cm
	depth	:	40 cm
	wide	:	20 cm
	vegetation	:	*Sphagnum papillosum/S. magellanicum* lawn
	zone	:	Hummock/hollow

	slope	:	gentle, internal, hummock/hollow, surface water
	0-10 cm	:	fresh *Sphagnum*, bog cotton, H2, 5YR.4/5
	10-20 cm	:	fresh *Sphagnum*, bog cotton, H2, 5YR.4/5
	20-30 cm	:	fresh *Sphagnum*, bog cotton, old Sphagnum, H2, 5YR.4/3
	30-40 cm	:	fresh *Sphagnum*, bog cotton, old Sphagnum, H2, 5YR.4/3
	40-50 cm	:	old/fresh *Sphagnum*, fibres, H6, 5YR.3/2
G4	location	:	peg J6
	acrotelm	:	10 cm
	depth	:	43 cm
	wide	:	18 cm
	vegetation	:	*S. magellanicum/ Odontoschisma sphagni* lawn
	zone	:	*Eriophorum*
	slope	:	gentle, internal
	0-10 cm	:	fresh *Sphagnum*, H2, 5YR.4/5
	10-20 cm	:	old *Sphagnum*, roots, *Calluna*, bog cotton, H5, 5YR.3/1
	20-30 cm	:	bog cotton, old/fresh *Sphagnum*, *Calluna*, roots, fibres, H4, 5YR.3/3
	30-40 cm	:	old/fresh *Sphagnum*, fibres, roots, H6, 5YR.3/4
	40-50 cm	:	old/fresh *Sphagnum*, fibres, H8, 5YR.4/3
H1	location	:	peg K13
	acrotelm	:	10 cm
	depth	:	48 cm
	wide	:	189 cm
	vegetation	:	*Sphagnum capillifolium* hummock
	zone	:	*Sphagnum magellanicum*
	slope	:	gentle, internal, hummock/hollow
	0-10 cm	:	fresh *Sphagnum*, H2, 2,5YR.5/5
	10-20 cm	:	old *Sphagnum*, roots, H5, 5YR.3/4
	20-30 cm	:	old *Sphagnum*, roots, *Calluna*, H6, 5YR.2/4
	30-40 cm	:	fresh/old *Sphagnum*, bog cotton, roots, *Calluna*, H4, 5YR.3/4
	40-50 cm	:	fresh/old *Sphagnum*, roots, fibres, *Calluna*, H3, 5YR.4/5
H2	location	:	peg K12
	acrotelm	:	0 cm
	depth	:	38 cm
	wide	:	18 cm
	vegetation	:	*Narthecium ossifragum* hollow
	zone	:	*Sphagnum magellanicum*
	slope	:	gentle, internal, highest point
	0-10 cm	:	roots, H6-H10, 5YR.2/1
	10-20 cm	:	old *Sphagnum*, roots, *Calluna*, H7, 5YR.2/3
	20-30 cm	:	old *Sphagnum*, fibres, roots, H5, 5YR.3/2

	30-40 cm	:	old *Sphagnum*, fibres, H6, 5YR.2/4
	40-50 cm	:	old *Sphagnum*, fibres, H7, 5YR.2/3
H3	location	:	between peg K11 en K12
	acrotelm	:	20 cm
	depth	:	38 cm
	wide	:	22 cm
	vegetation	:	*Sphagnum magellanicum/S. papillosum* hummock
	zone	:	*Sphagnum magellanicum*
	slope	:	gentle, internal, hummock/hollow
	0-10 cm	:	fresh *Sphagnum*, H2, 5YR.4/6
	10-20 cm	:	fresh *Sphagnum*, H2, 5YR.4/6
	20-30 cm	:	fresh/old *Sphagnum*, roots, fibres, *Calluna*, H5, 5YR.3/4
	30-40 cm	:	fresh/old *Sphagnum*, roots, fibres, *Calluna*, H5, 5YR.3/4
	40-50 cm	:	fresh/old *Sphagnum*, roots, fibres, *Calluna*, H5, 5YR.3/4
H4	location	:	peg K11
	acrotelm	:	10 cm
	depth	:	40 cm
	wide	:	23 cm
	vegetation	:	*Sphagnum magellanicum/S. cuspidatum* hollow
	zone	:	*Sphagnum magellanicum*
	slope	:	gentle, internal
	0-10 cm	:	fresh *Sphagnum*, H2
	10-20 cm	:	fresh/old *Sphagnum*, roots, H3, 5YR.3/3
	20-30 cm	:	fresh/old *Sphagnum*, roots, fibres, H6, 5YR.4/3
	30-40 cm	:	fresh/old *Sphagnum*, fibres, roots, H6, 5YR.2/3
	40-50 cm	:	old *Sphagnum*, fibres, *Calluna*, H7, 5YR.3/2
H5	location	:	peg K9
	acrotelm	:	10 cm
	depth	:	38 cm
	wide	:	18 cm
	vegetation	:	Low hummock of *Sphagnum papillosum*
	zone	:	*Sphagnum magellanicum*
	slope	:	gentle, internal
	0-10 cm	:	fresh *Sphagnum*, H2, 5YR.4/4
	10-20 cm	:	old/fresh *Sphagnum*, roots, fibres, H6, 5YR.3/2
	20-30 cm	:	fresh/old *Sphagnum*, bog cotton, roots, fibres, *Calluna*, H5, 5YR.3/2
	30-40 cm	:	fresh/old *Sphagnum*, fibres, H4, 5YR.3/4
	40-50 cm	:	fresh/old *Sphagnum*, bog cotton, fibres, *Calluna*, H6, 5YR.3/2

H6	location	:	peg K8
	acrotelm	:	0 cm
	depth	:	38 cm
	wide	:	19 cm
	vegetation	:	Hollow of *Carex panicea/Calluna/Sphagnum papillosum* & *S. tenellum*
	zone	:	*Narthecium*
	slope	:	gentle, internal
	0-10 cm	:	roots, H5-H10, 5YR.2/1
	10-20 cm	:	old *Sphagnum*, roots, H6, 5YR.2/3
	20-30 cm	:	old *Sphagnum*, roots, H6, 5YR.2/4
	30-40 cm	:	fresh/old *Sphagnum*, roots, H4, 5YR.3/3
	40-50 cm	:	fresh/old *Sphagnum*, roots, fibres, *Calluna*, H6, 5YR.3/3
H7	location	:	peg K7
	acrotelm	:	10 cm
	depth	:	38 cm
	wide	:	18 cm
	vegetation	:	Typical low hummock, no species dominating
	zone	:	Transitional *Narthecium*
	slope	:	gentle, internal
	0-10 cm	:	fresh *Sphagnum*, H2, 5YR.6/5
	10-20 cm	:	old *Sphagnum*, bog cotton, roots, H5, 5YR.3/2
	20-30 cm	:	old *Sphagnum*, roots, H6, 5YR.3/3
	30-40 cm	:	old *Sphagnum*, bog cotton, fibres, roots, *Calluna*, H5, 5YR.3/2
	40-50 cm	:	old *Sphagnum*, bog cotton, fibres, H5, 5YR.3/2
H8	location	:	peg K6
	acrotelm	:	10 cm
	depth	:	38 cm
	wide	:	20 cm
	vegetation	:	Low hummock of *S. magellanicum* and *Hypnum jutlandicum*
	zone	:	*Sphagnum magellanicum*
	slope	:	gentle, internal
	0-10 cm	:	fresh *Sphagnum*, roots, H2, 5YR.3/3
	10-20 cm	:	fresh/old *Sphagnum*, roots, *Calluna*, H7, 5YR.3/4
	20-30 cm	:	fresh/old *Sphagnum*, roots, fibres, H6, 5YR.3/4
	30-40 cm	:	fresh/old *Sphagnum*, roots, fibres, *Calluna*, H5, 5YR.3/3
	40-50 cm	:	old *Sphagnum*, bog cotton, fibres, *Calluna*, H7, 5YR.3/5
H9	location	:	20 m S K5
	acrotelm	:	>= 50 cm
	depth	:	40 cm
	wide	:	20 cm

	10-20 cm	:	old *Sphagnum*, bog cotton, roots, H5
	20-30 cm	:	old *Sphagnum*, roots, bog cotton, H6
	30-40 cm	:	old *Sphagnum*, roots, bog cotton, H8
	40-50 cm	:	old *Sphagnum*, fibres, H8
J1	location	:	peg N9
	acrotelm	:	10 cm
	depth	:	40 cm
	wide	:	18 cm
	vegetation	:	*Sphagnum papillosum/S. capillifolium* hummock
	zone	:	*Sphagnum magellanicum* and *Eriophorum vaginatum*
	slope	:	flat
	0-10 cm	:	fresh *Sphagnum*, H3
	10-20 cm	:	roots, H6
	20-30 cm	:	roots, bog cotton, H7
	30-40 cm	:	bog cotton, fibres, H7
	40-50 cm	:	bog cotton, fibres, H7
J2	location	:	peg N8
	acrotelm	:	0 cm
	depth	:	40 cm
	wide	:	17 cm
	vegetation	:	*Narthecium/S. tenellum* hollow
	zone	:	*Sphagnum magellanicum*
	slope	:	hummock/hollow
	0-10 cm	:	roots, H7
	10-20 cm	:	roots, *Calluna*, H7
	20-30 cm	:	roots, fibres, H7
	30-40 cm	:	fresh/old *Sphagnum*, fibres, *Calluna*, H6
	40-50 cm	:	fresh/old *Sphagnum*, fibres, H7
J3	location	:	peg N7
	acrotelm	:	0 cm
	depth	:	38 cm
	wide	:	17 cm
	acrotelm	:	0 cm
	vegetation	:	*Narthecium* hollow with *Calluna*
	zone	:	*Narthecium*
	slope	:	flat
	0-10 cm	:	roots, H7
	10-20 cm	:	bog cotton, roots, H6
	20-30 cm	:	roots, H8
	30-40 cm	:	old/fresh *Sphagnum*, roots, H8
	40-50 cm	:	bog cotton, old/fresh *Sphagnum*, roots, H6

	vegetation	:	*S. magellanicum* hummock
	zone	:	Hummock/hollow
	slope	:	flat, hummock/hollow, surface water
	0-10 cm	:	fresh *Sphagnum*, bog cotton, roots, H2, 5YR.5/6
	10-20 cm	:	fresh *Sphagnum*, bog cotton, roots, H2, 5YR.5/6
	20-30 cm	:	fresh *Sphagnum*, bog cotton, roots, H2, 5YR.5/6
	30-40 cm	:	fresh *Sphagnum*, bog cotton, roots, H2, 5YR.5/6
	40-50 cm	:	fresh *Sphagnum*, bog cotton, roots, H2, 5YR.5/6
I1	location	:	tube 99
	acrotelm	:	0 cm
	depth	:	38 cm
	wide	:	18 cm
	vegetation	:	Low burnt hummock with *S. capillifolium/Hypnum jutlandicum/Campylopus paradoxus*
	zone	:	*Carex panicea/Narthecium*
	slope	:	gentle marginal
	0-10 cm	:	roots, H7
	10-20 cm	:	old/fresh *Sphagnum*, roots, H7
	20-30 cm	:	old/fresh *Sphagnum*, roots, H5
	30-40 cm	:	old/fresh *Sphagnum*, roots, fibres, H5
	40-50 cm	:	old/fresh *Sphagnum*, fibres, roots, H5
I2	location	:	tube 98
	acrotelm	:	0 cm
	depth	:	40 cm
	wide	:	17 cm
	vegetation	:	Low burnt hummock with *S. capillifolium/Campylopus paradoxus*
	zone	:	Transitional *S. magellanicum* to *Narthecium*
	slope	:	gentle internal
	0-10 cm	:	roots, H6
	10-20 cm	:	roots, H6
	20-30 cm	:	fresh *Sphagnum*, fibres, H3
	30-40 cm	:	fresh *Sphagnum*, bog cotton, fibres, H3
	40-50 cm	:	bog cotton, H4
I3	location	:	tube 97
	acrotelm	:	10 cm
	depth	:	38 cm
	wide	:	18 cm
	vegetation	:	*S. imbricatum/ S. papillosum* hummock
	zone	:	*S. magellanicum* zone with scattered pools
	slope	:	hummock/hollow
	0-10 cm	:	fresh/old *Sphagnum*, bog cotton, roots, H2

Description of the drillings

CLARA EAST, humification degree at certain depth

location	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-50 cm
peg A3	6	5	3	2	2
peg B3	6	5	5	5	5
peg C3	2-5	5	5	6	3-4
peg D3	6	6	3	3	3
peg E3	6	8	6	8	5
peg F3	6	8	5	5	3-5
peg G3	9	6	5	6	6
peg H3	2	2	2	3	5
peg I3	5	7	6	5	5
peg J3	6	6	5	5	5
peg K3	3	5	4	3	3
peg L3	2-3	3	3	2	2
peg M3	8	8	6	6	3-5
peg N3	8	8	7	5	5
peg A9	6	5	5	5	3
peg B9	5	4	4	3	4
peg C9	7	5	3	3	3
peg D9.hol	8	5	6	3	5
peg D9.hum	8	7	5	4	3
peg E9.hol	2-8	7	6	4	3
peg E9.hum	6	7	8	8	6
peg F9	3-4	3	3	3	3
peg G9	8	8	5	3	2-3
peg H9	5	6	7	5	5
peg I9	5	5	6	7	5
peg J9	6	5	3	3	5

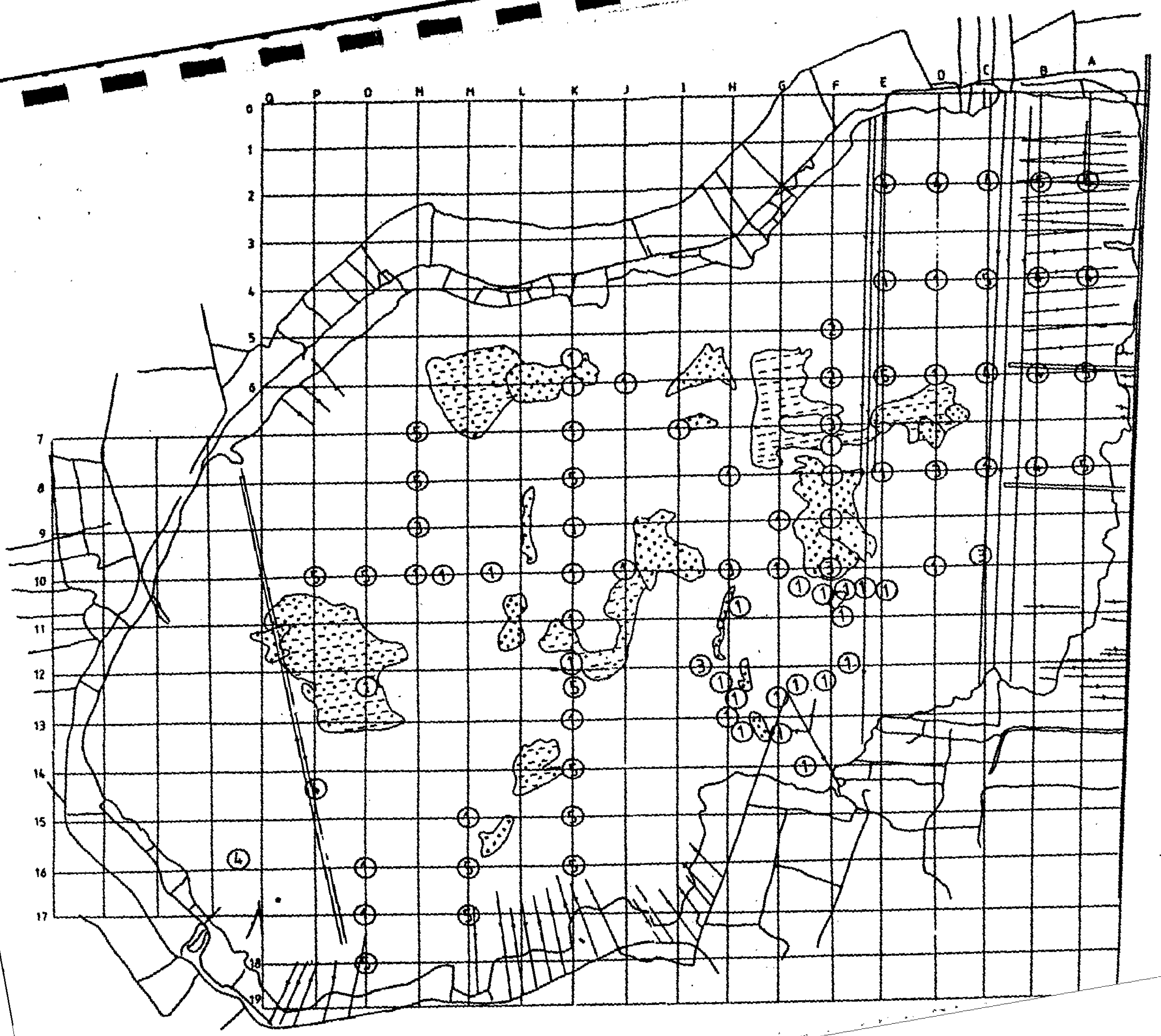
location	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-50 cm
peg B6	2	2-6	9	9	9
peg C6	9	9	8	8	8
peg D6	8	8	7	7	4
peg E6	6	7	3	3	8
peg F6	6	6	5	5	4
peg G6	2-6	3-6	7	6	8
peg H6.hol	2-8	6	5	5	5
peg H6.hum	8	7	5	5	5
peg I6	2	6	6	4	5
peg J6	2	4	4	4	3
peg K6	8	8	5	6	6
peg K6	2	2	8	6	8
peg L6.hol	2	2	3	8	3
peg L6.hum	2	2	8	5	4
peg M6	2	2	5	6	3
peg N6.hum	2	2	2-6	5	5
peg N6.hol	2-6	8	8	8	4
peg D12	8	5	5	6	5
peg E12	7	8	9	9	9
peg F12	8	9	9	9	4
peg G12.hol	2-6	8	9	9	4-3
peg G12.hum	2	7	9	9	3
peg H12	2	9	9	9	6
peg I12	2	8	8	7	7
peg J12	7	8	8	3	3

hum = hummock
hol = hollow

CLARA WEST, humification degree at certain depth

location	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-50 cm
peg A2	8	8	6	5	4
peg B2	8	8	6	7	7
peg C2	8	8	7	3	3
peg D2	8	8	7	3	4
peg E2	8	8	6	5	4
peg A4	8	8	7	5	6
peg B4	8	8	7	5	3
peg C4	8	8	6	7	8
peg D4	2	6	8	8	8
peg E4	2-8	8	8	7	5
peg A6	7	7	5	5	7
peg B6	8	6	6	5	5
peg C6	8	8	8	5	5
peg D6	2	2	2	2	3
peg E6	2	8	8	5-6	3-5
peg E6	7	8	8	8	6
peg A8	7	7	5	5	7
peg B8	6	5	3	3	3
peg C8	2	2	3	3	3
peg D8	2-6	8	6	8	3
peg E8	2	2	2	2	2
peg K14	2-8	8	8	8	8
peg K15	8	7	6	8	8
peg K16	8	5-6	6	7	7
peg M15	2	2	2	2	2
peg M16	2-6	8	8	8	8
peg M17	7	8	8	9	9
peg O16	2	2	2	2	2
peg O17	2	2	2	2	2

APPENDIX V1



CLARA BOG (WEST)

Scale: 0 1km

Augerholes and Hummock/Hollow Map

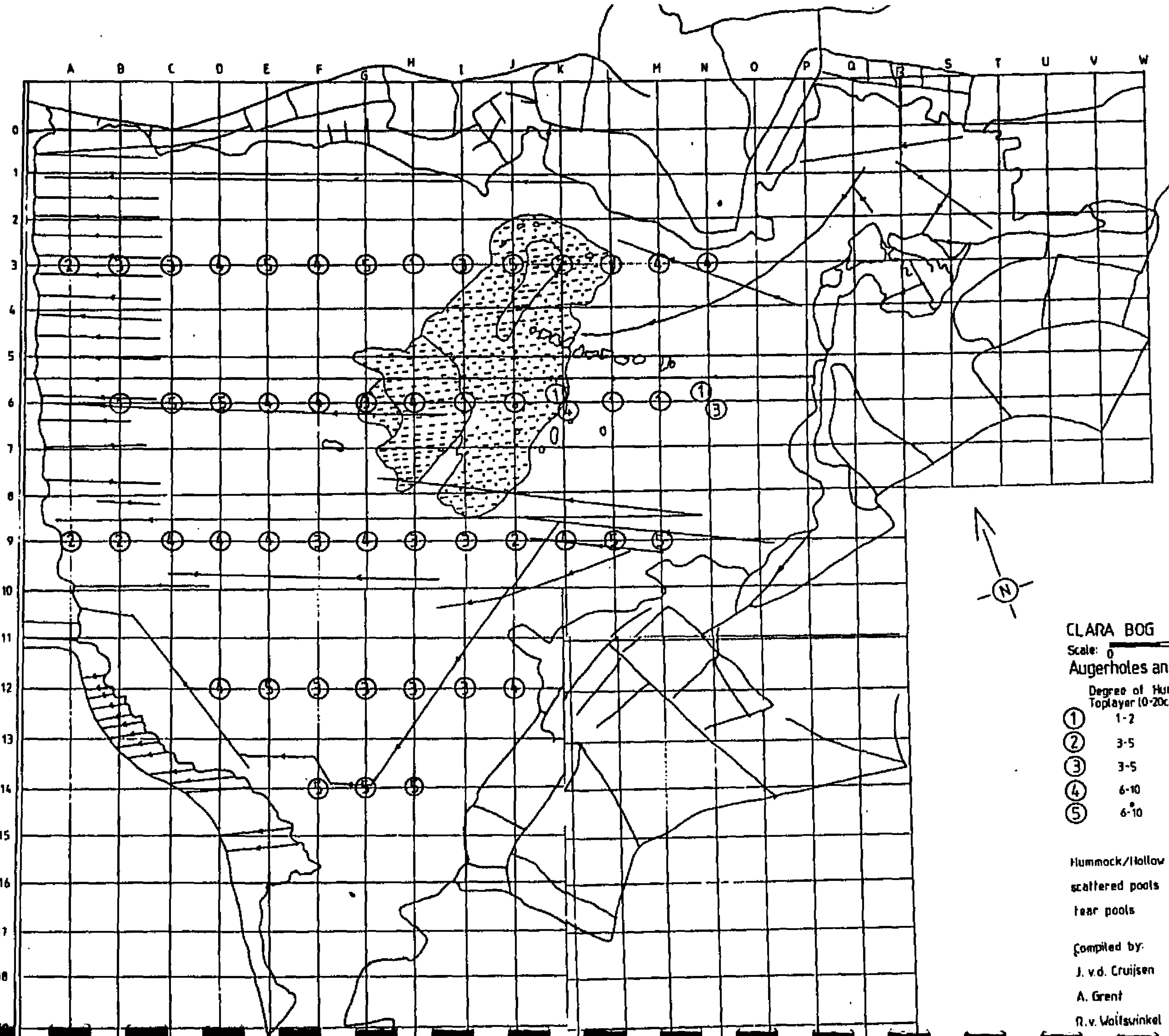
Degree of Humification
Toplayer (0-20cm) | Profile (0-50cm) from the top do

(1) 1-2 | decreasing
(2) 3-5 | increasing
(3) 3-5 | decreasing
(4) 6-10 | increasing
(5) 6-10

Hummock/Hollow
frequent pools
scattered pools
fear pools

Compiled by:
J. v. d. Cruijsen
A. Grent
R. v. Wolfsvinkel
1993

APPENDIX V.2



CLARA BOG (EAST)

Scale: 0 1km

Augerholes and Hummock/Hollow Map

Degree of Humification

	Toplayer (0-20cm)	Profile (0-50cm) from the top
①	1-2	
②	3-5	decreasing
③	3-5	increasing
④	6-10	decreasing
⑤	6-10	increasing

Hummock/Hollow

scattered pools

tear pools

Compiled by:

J. v.d. Cruijsen

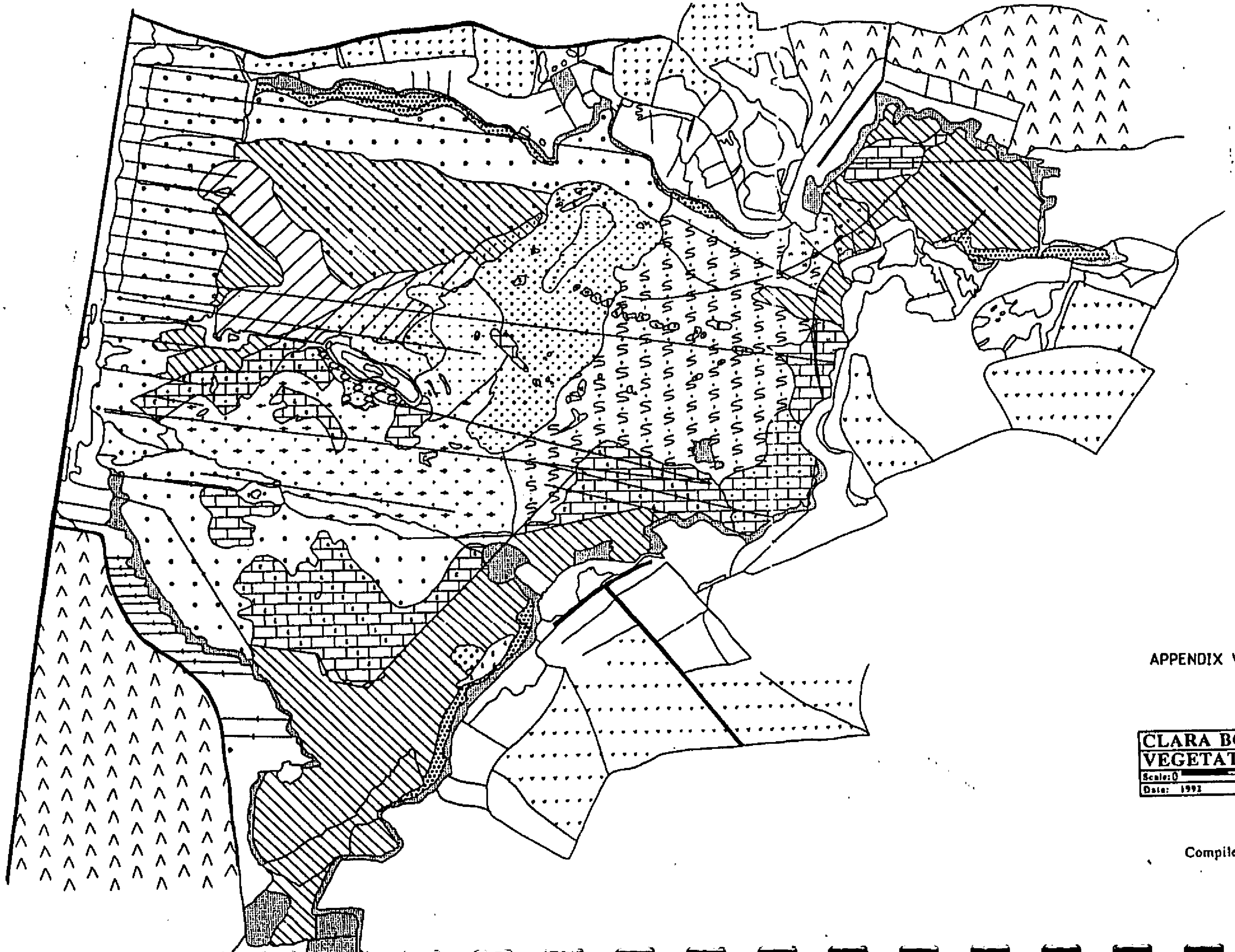
A. Grent

R. v. Wolfsvinkel

APPENDIX VI.1

CLARA BOG (WEST)
VEGETATION MAP
Scale: 0 — 1km
Date : 1992

Compiled by Larissa Kelly



APPENDIX VI.2

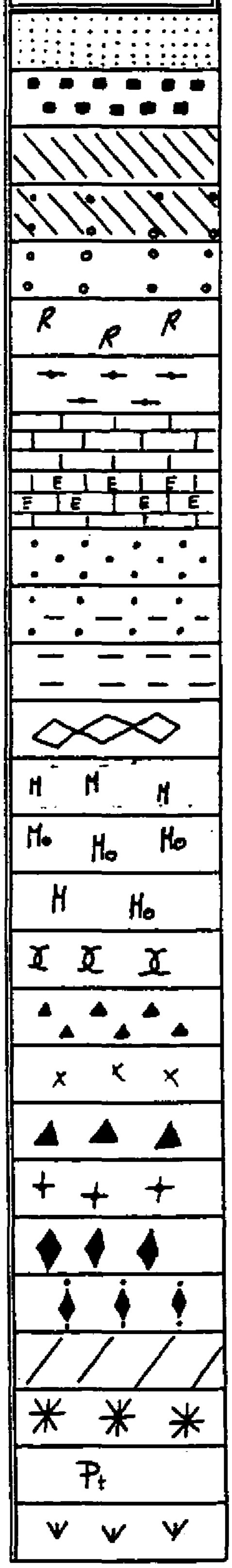
CLARA BOG (EAST)
VEGETATION MAP
Scale: 0 — 1km
Date: 1992

Compiled by Larissa Kelly

APPENDIX VI.3

Vegetation map

Design



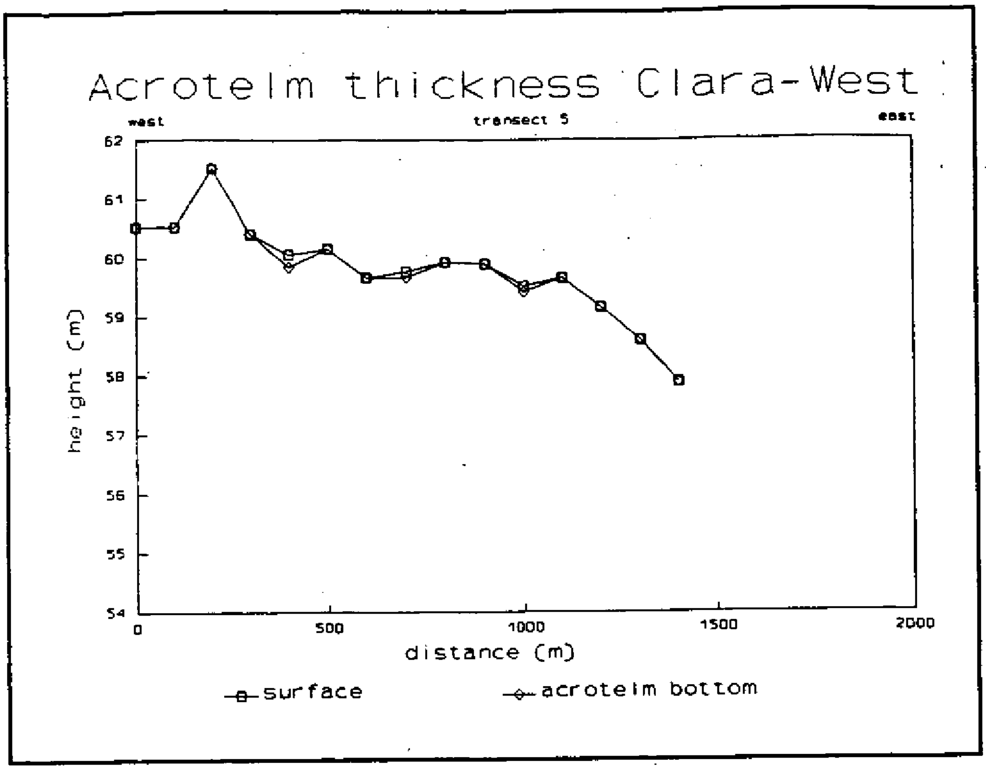
Complex Zone
Face bank zone
Scirpus zone
Narthecium zone
Narthecium & *Carex panicea*/burnt zone
Carex panicea/burnt zone
Rhyncospora alba
Rhyncospora fusca
Calluna burnt
Calluna / *Eriophorum angustifolium*
Hummock/hollow frequent pool zone
Hummock/hollow scattered pool zone
Hummock/hollow orientated pool zone
Transition *Sphagnum magellanicum* zone
Myrica gale zone
Molinia zone
Molinia & *Myrica* zone
Betula scrub / *Molinia* zone
Betula tree stands
Betula trees & *Juncus effusus*
Sphagnum imbricatum zone
Sphagnum recurvum & *S.cuspidatum* lawn zone
Enriched west soak zone
Less enriched west soak zone
Banded zone
Eriophorum vaginatum zone
Pteridium
Grassland

^ ^ ^ ^	Coniferous forestry
J J J	*Juncus effusus* stand
T T T	*Typha*
D D D	*Dactylorhiza maculata*
H H H	*Huperzia selago*
+ + + + +	*Cladonia portentosa* an important element

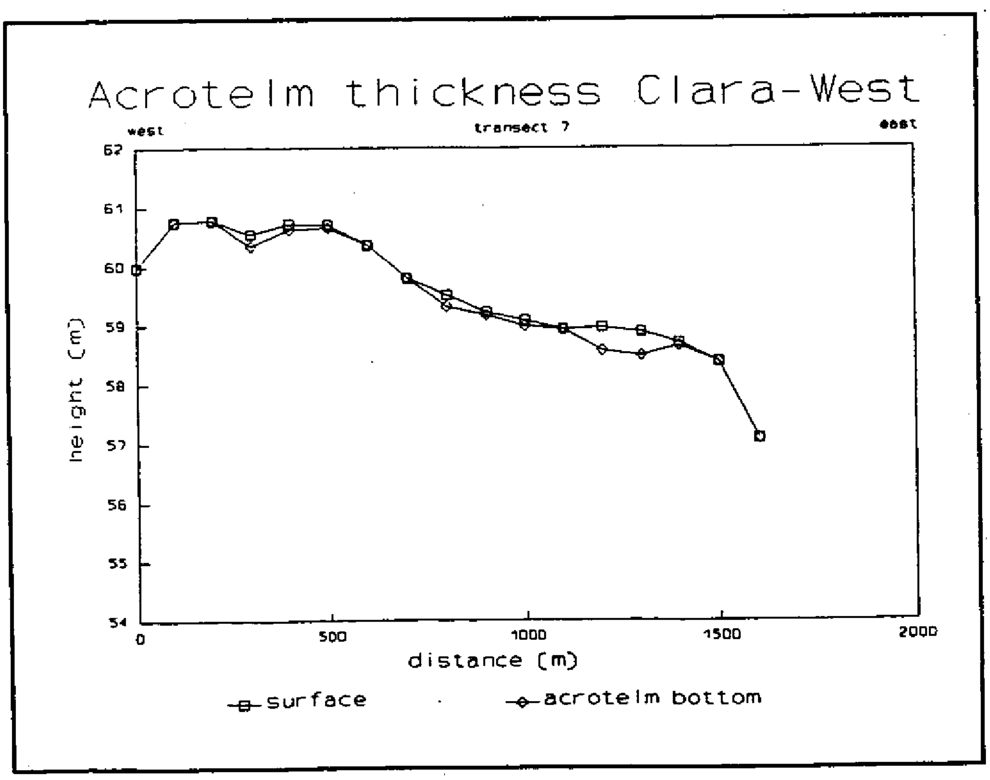
APPENDIX VII

Acrotelm thickness cross sections of Clara-West

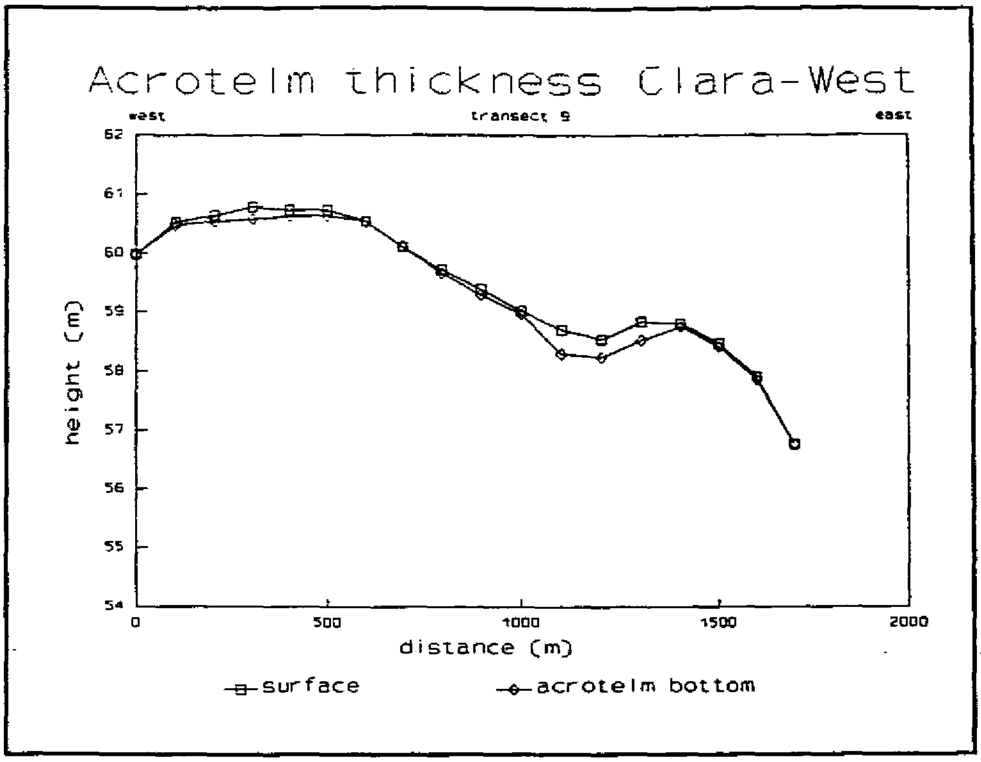
VII.1



VII.2

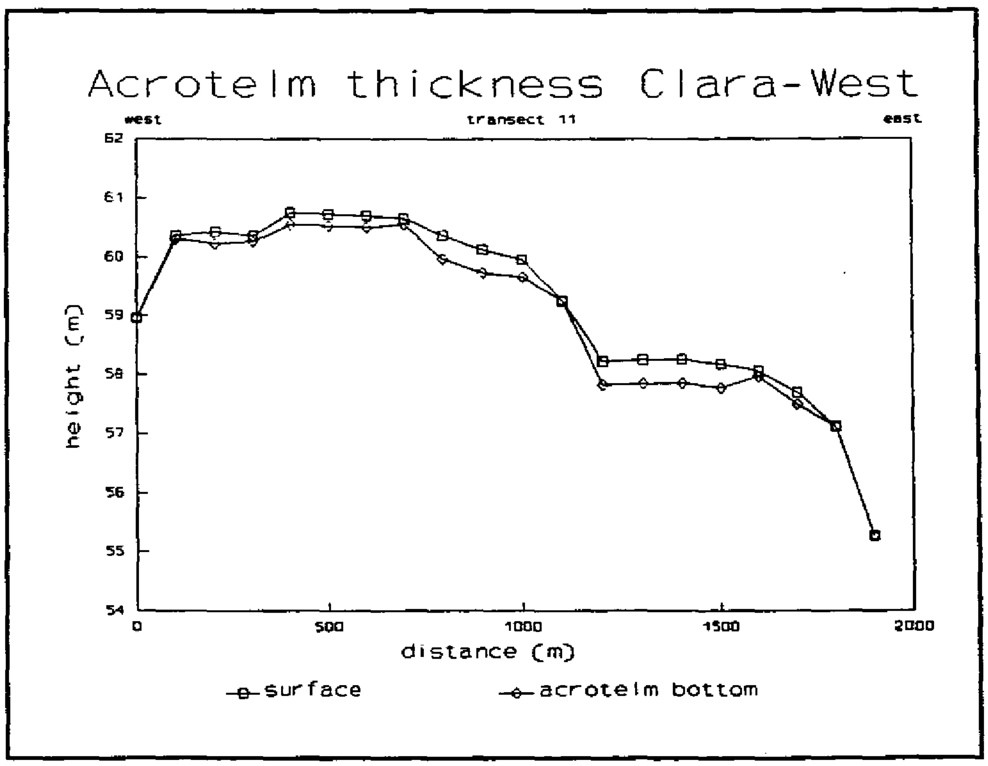


VII.3



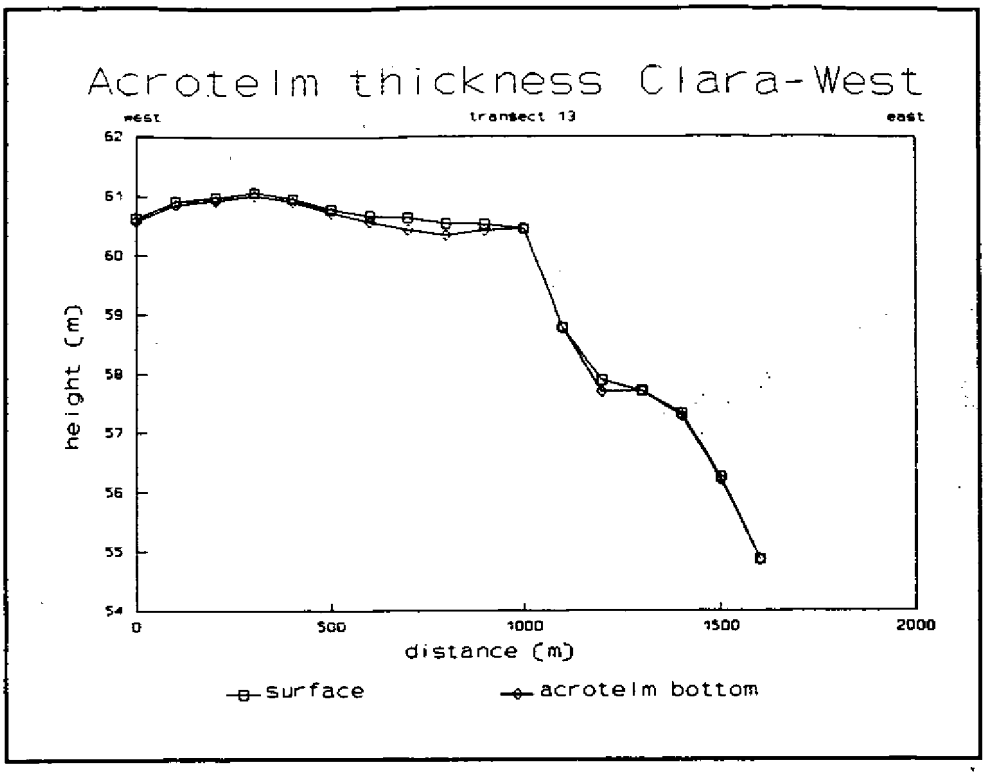
Acrotelm thickness Clara-West
west
transect 9
east
62
61
60
59
58
57
56
55
54
height (m)
0
500
1000
1500
2000
distance (m)
surface
acrotelm bottom

VII.4

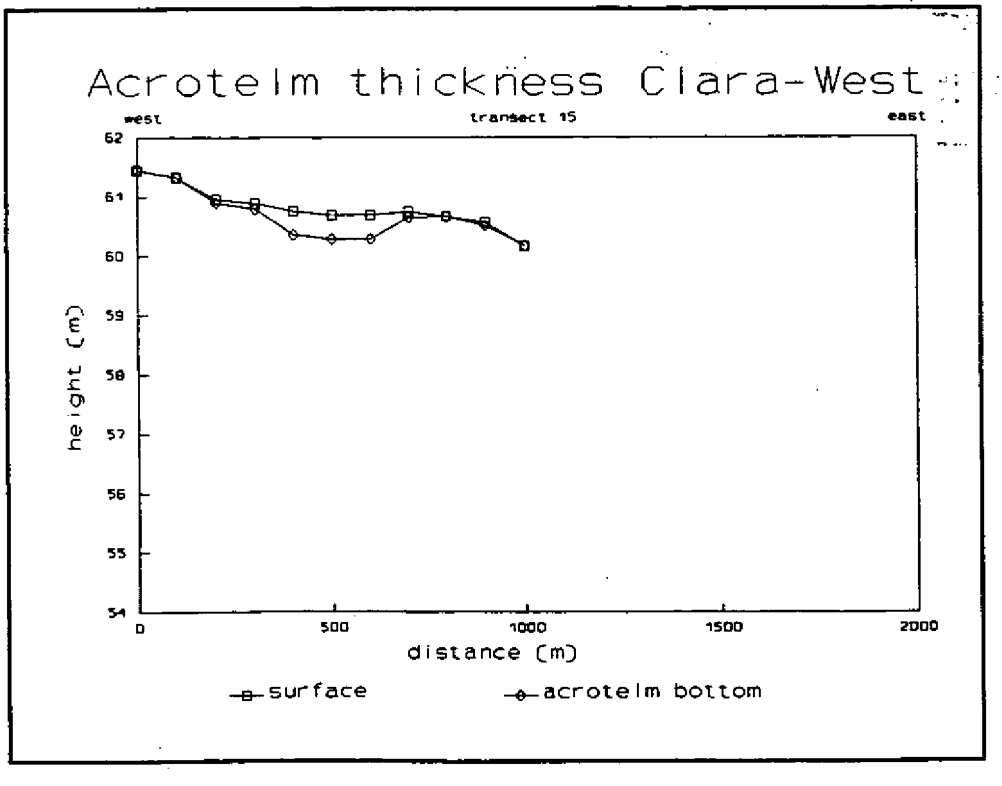


Acrotelm thickness Clara-West
west
transect 11
east
62
61
60
59
58
57
56
55
54
height (m)
0
500
1000
1500
2000
distance (m)
surface
acrotelm bottom

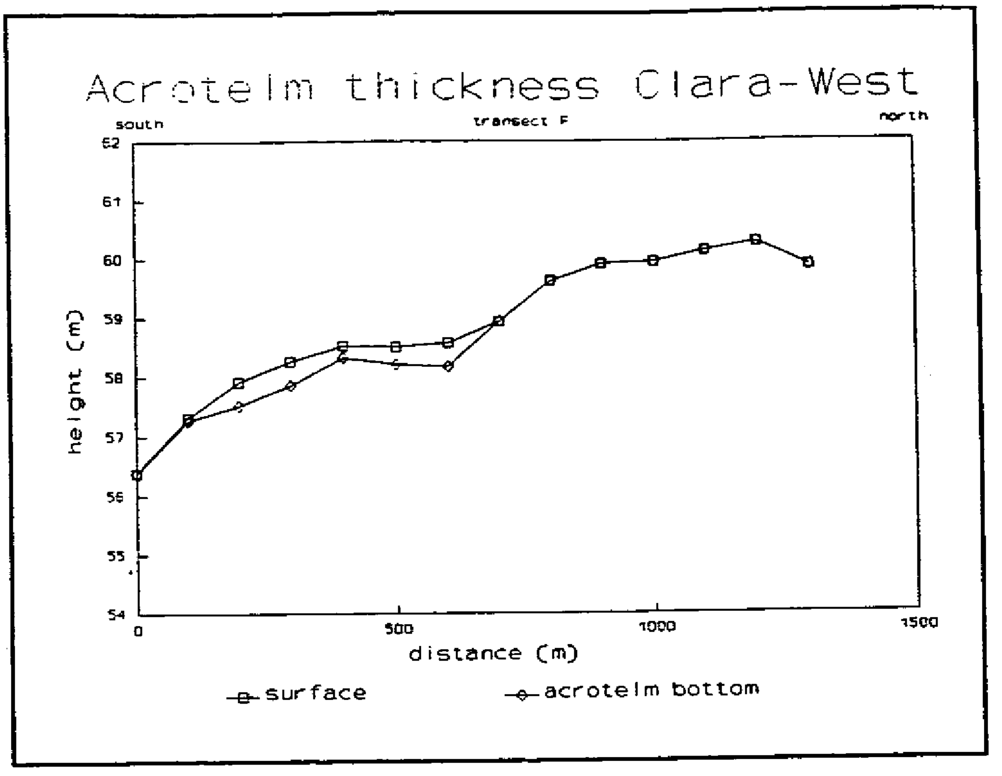
VII.5


Acrotelm thickness Clara-West
west
transect 13
east
height (m)
62
61
60
59
58
57
56
55
54
0
500
1000
1500
2000
distance (m)
surface
acrotelm bottom

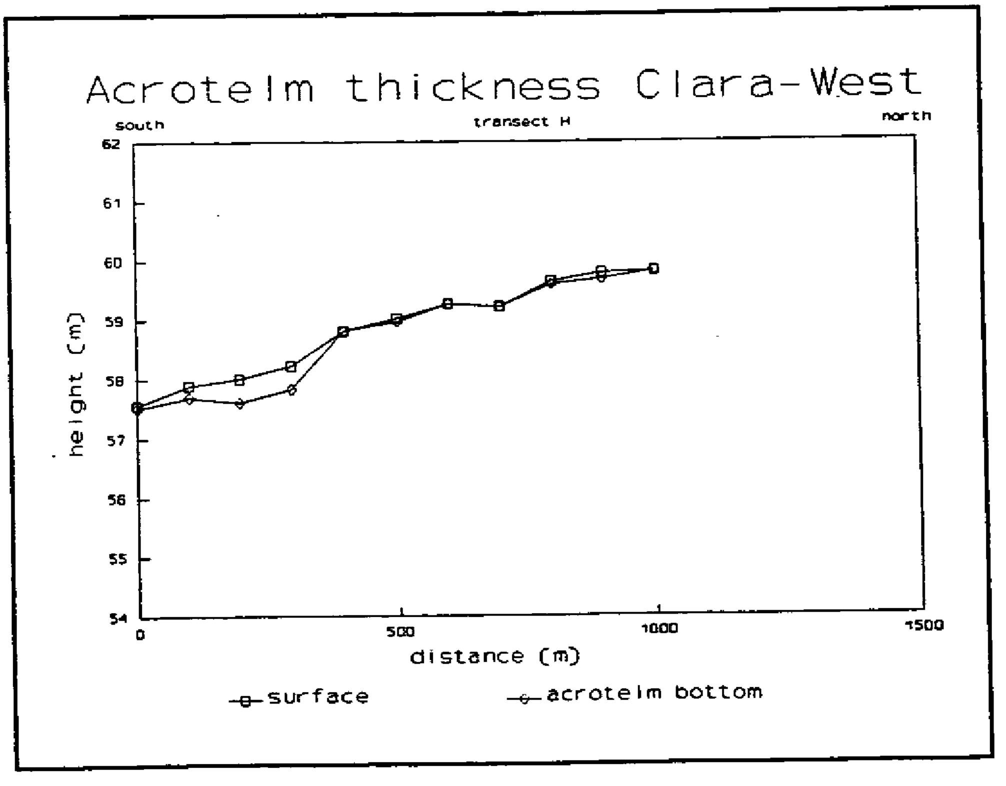
VII.6


Acrotelm thickness Clara-West
west
transect 15
east
height (m)
62
61
60
59
58
57
56
55
54
0
500
1000
1500
2000
distance (m)
surface
acrotelm bottom

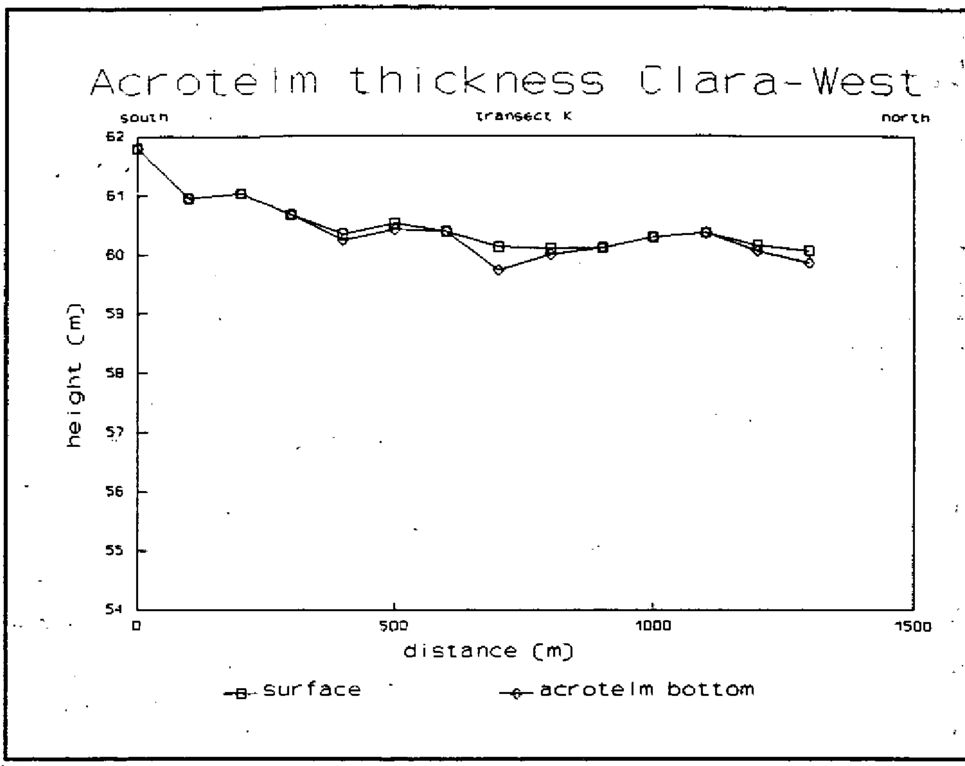
VII.7


Acrotelm thickness Clara-West
south
transect F
north
height (m)
distance (m)
surface
acrotelm bottom

VII.8

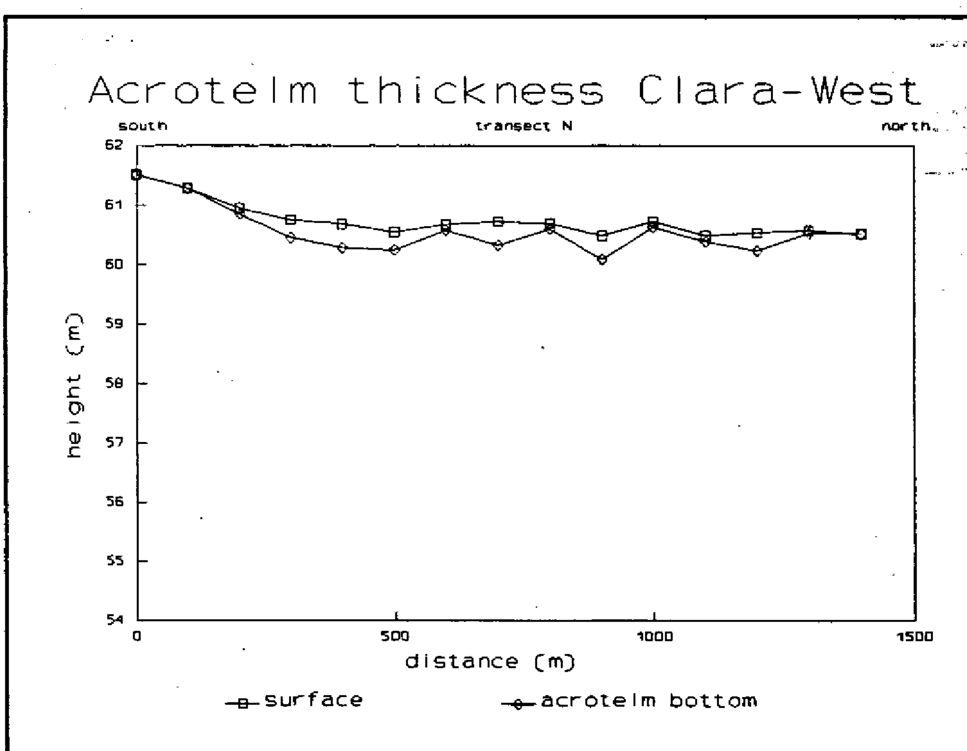

Acrotelm thickness Clara-West
south
transect H
north
height (m)
distance (m)
surface
acrotelm bottom

VII.9



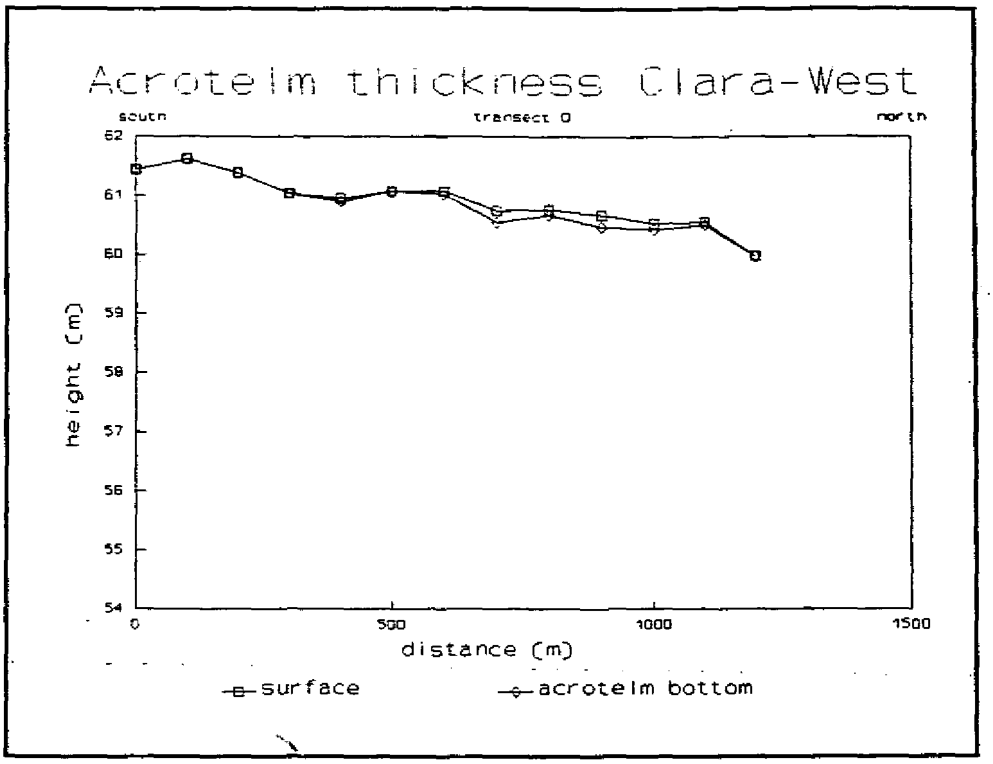
Acrotelm thickness Clara-West
south
transect K
north
height (m)
distance (m)
surface
acrotelm bottom

VII.10



Acrotelm thickness Clara-West
south
transect N
north
height (m)
distance (m)
surface
acrotelm bottom

VII.11

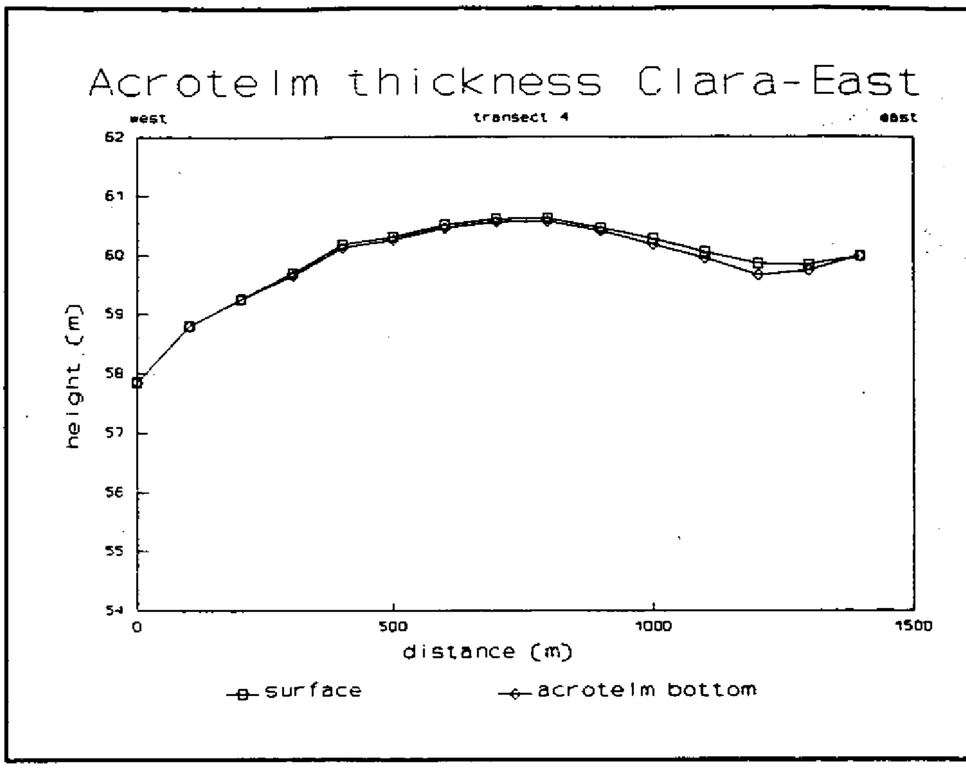


Acrotelm thickness Clara-West
south
transect 0
north
62
61
60
59
58
57
56
55
54
height (m)
0
500
1000
1500
distance (m)
surface
acrotelm bottom

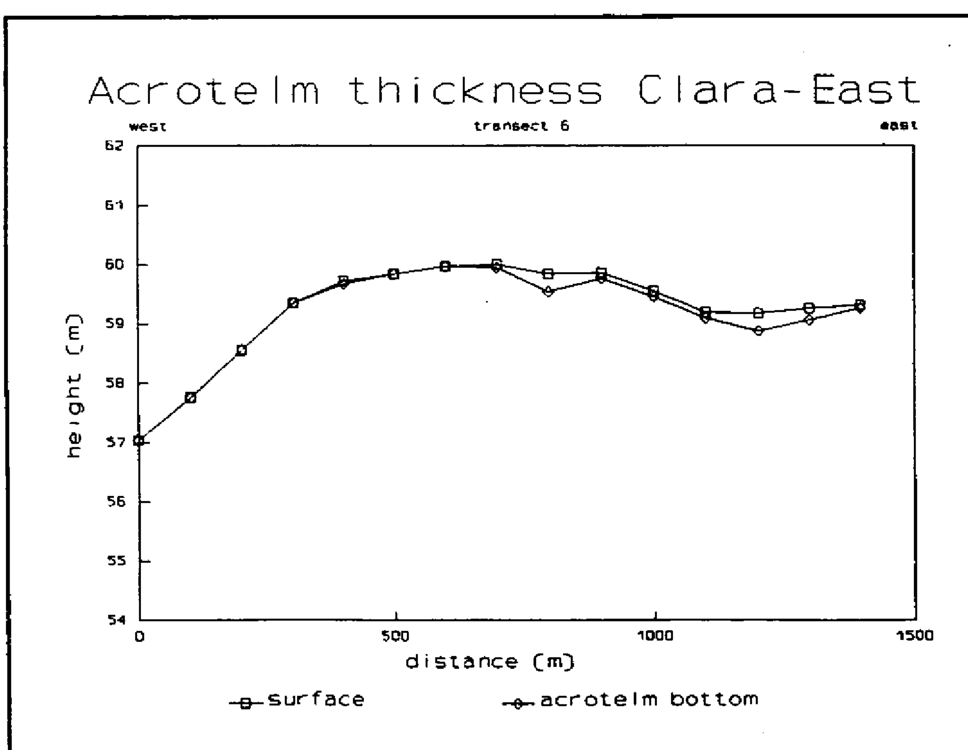
APPENDIX VIII

Acrotelm thickness cross sections of Clara-East

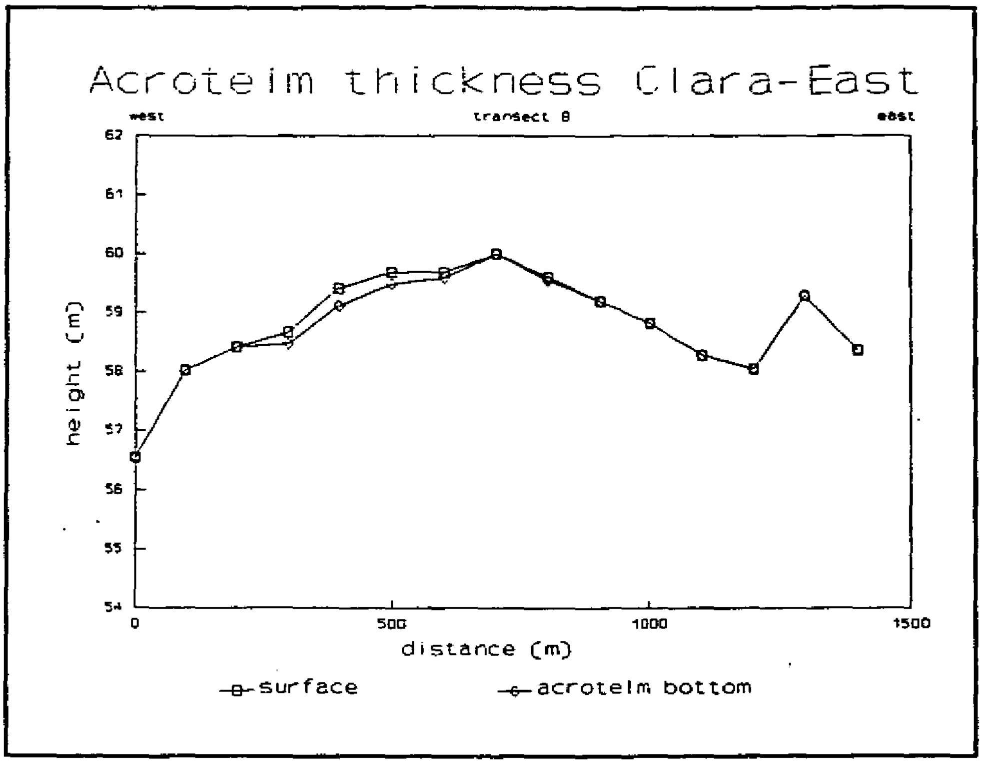
VIII.1



VIII.2

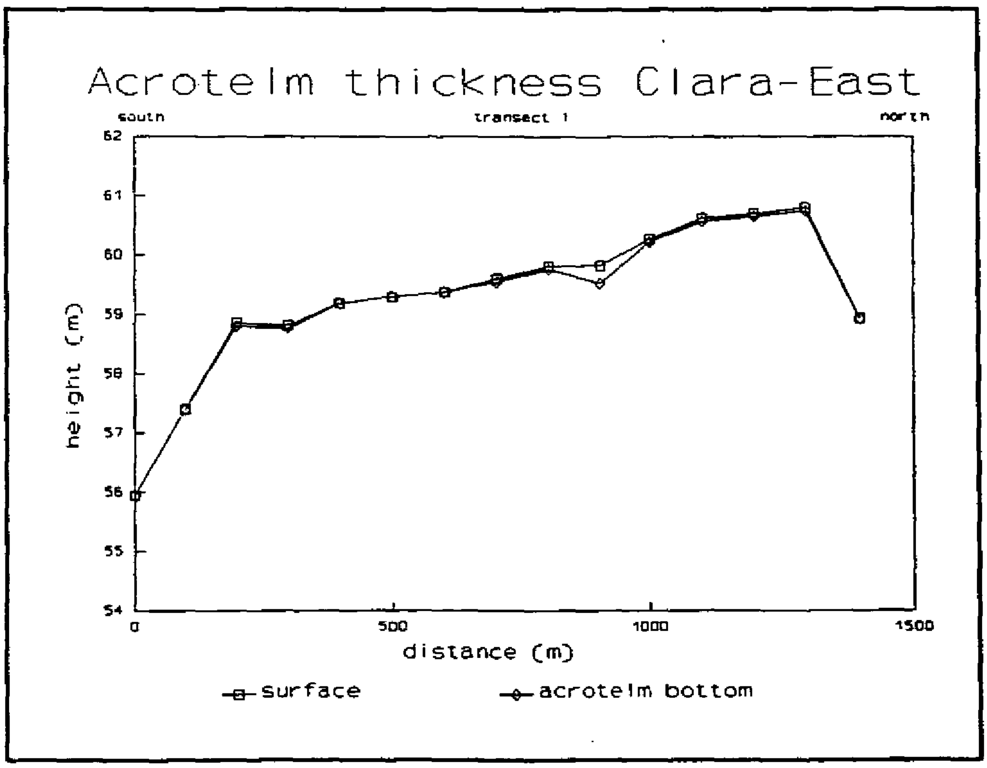


VIII.3



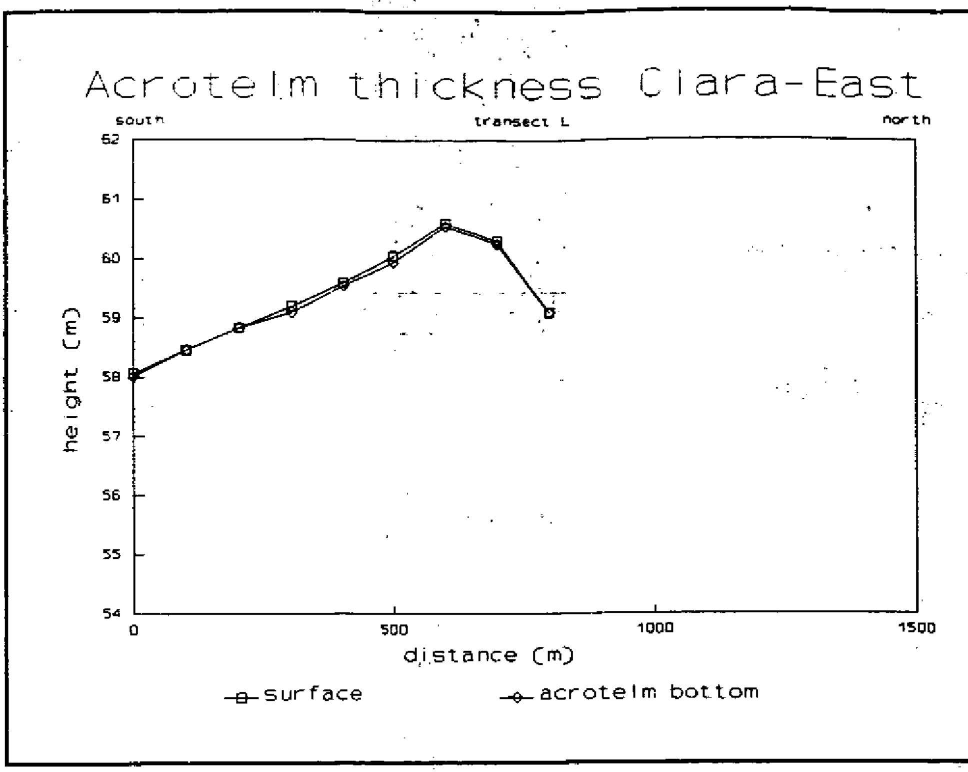
Acrotelm thickness Clara-East
west
transect 8
east
62
61
60
59
58
57
56
55
54
height (m)
0
500
1000
1500
distance (m)
surface
acrotelm bottom

VIII.4



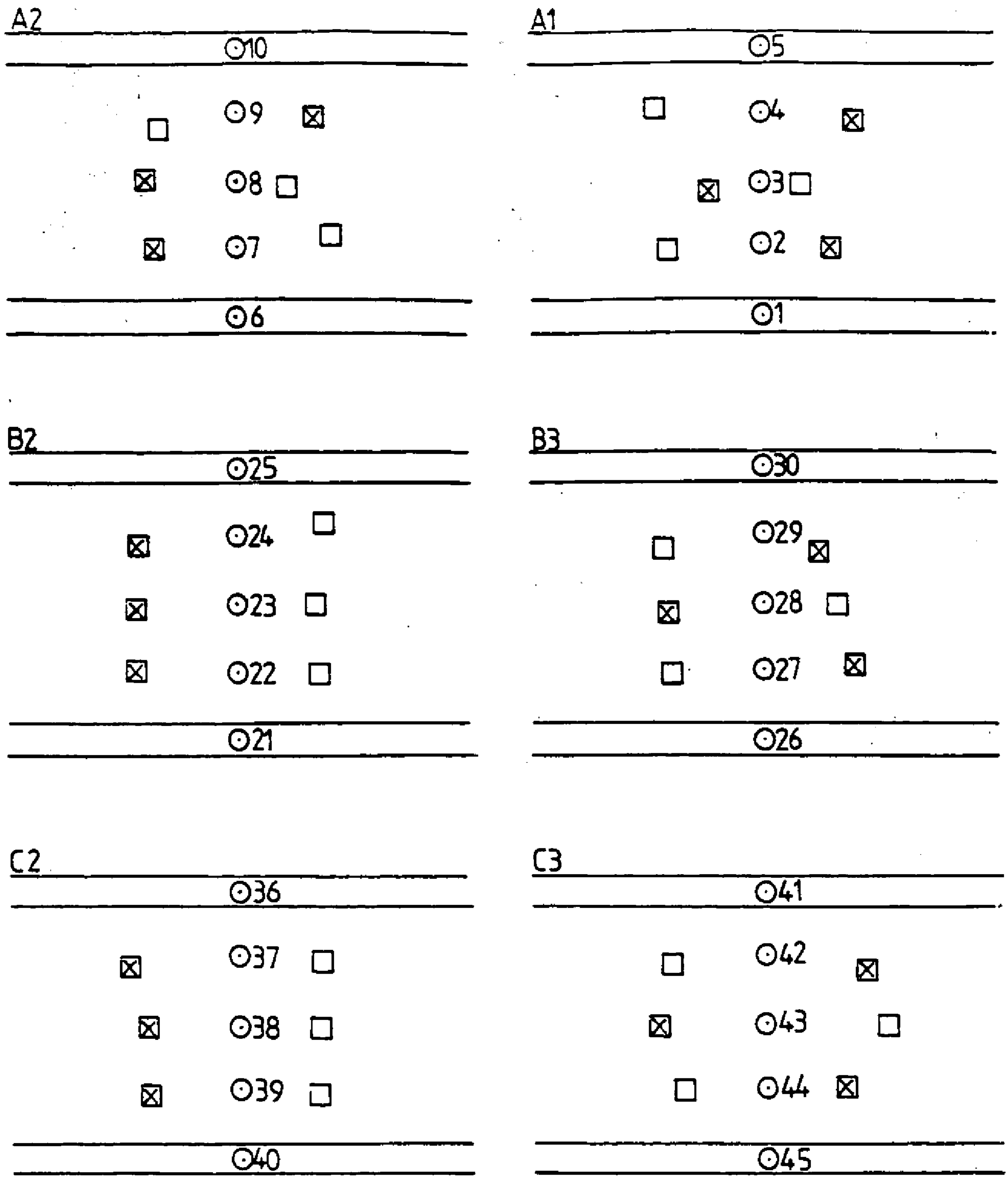
Acrotelm thickness Clara-East
south
transect 1
north
62
61
60
59
58
57
56
55
54
height (m)
0
500
1000
1500
distance (m)
surface
acrotelm bottom

VIII.5



Acrotelm thickness Clara-East
south
transect L
north
height (m)
distance (m)
surface
acrotelm bottom

APPENDIX IX



Acrotelm holes on plots Clara-East

⊙ tube

☐ acrotelm hole in a hollow

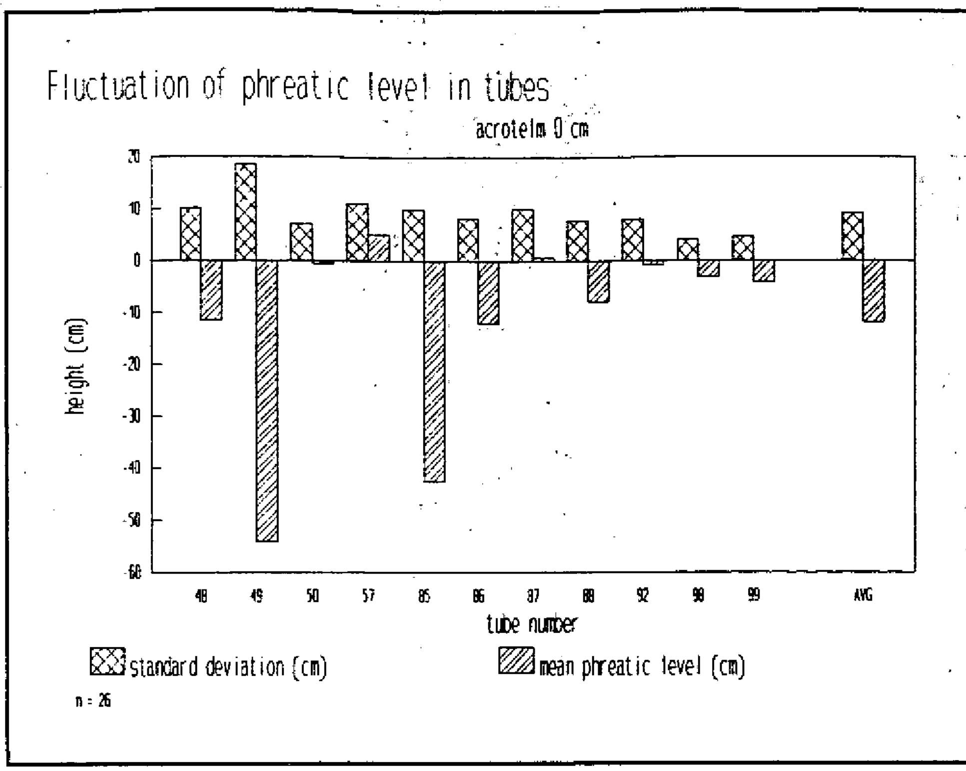
☒ acrotelm hole in a hummock

═ drain

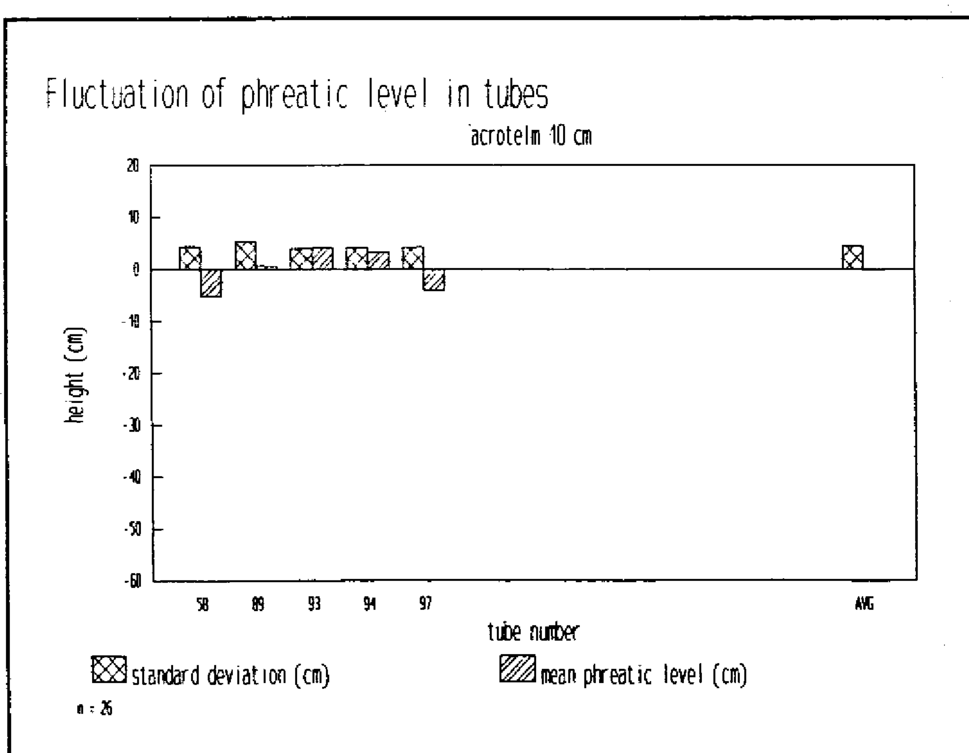
APPENDIX X

Fluctuation of phreatic level in tubes (Clara-West)

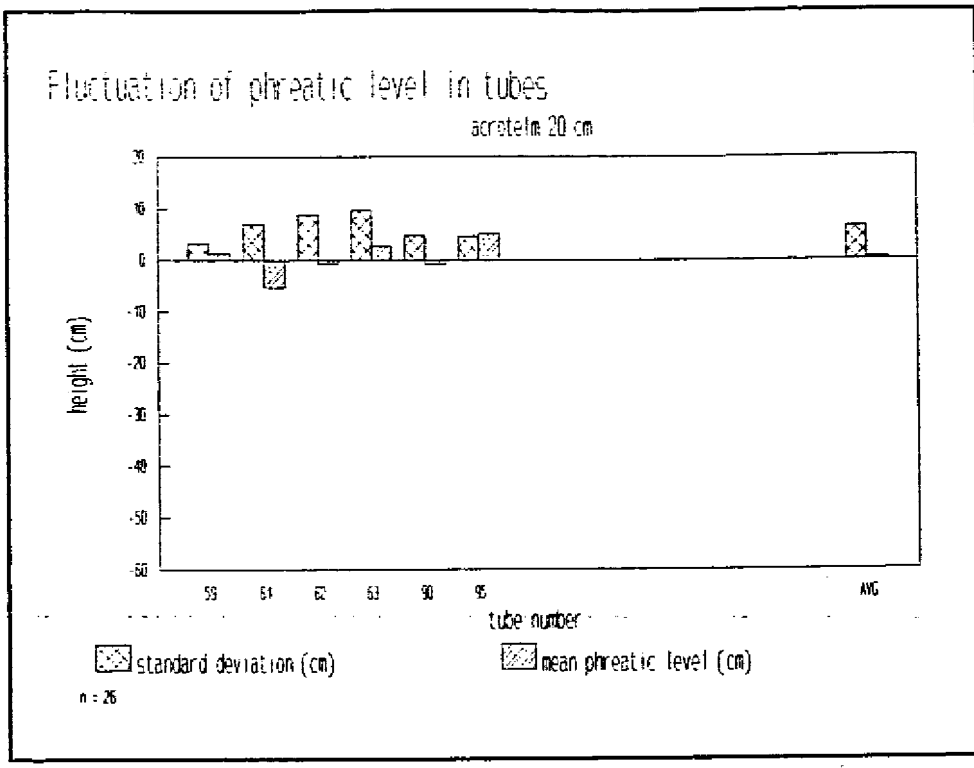
X.1



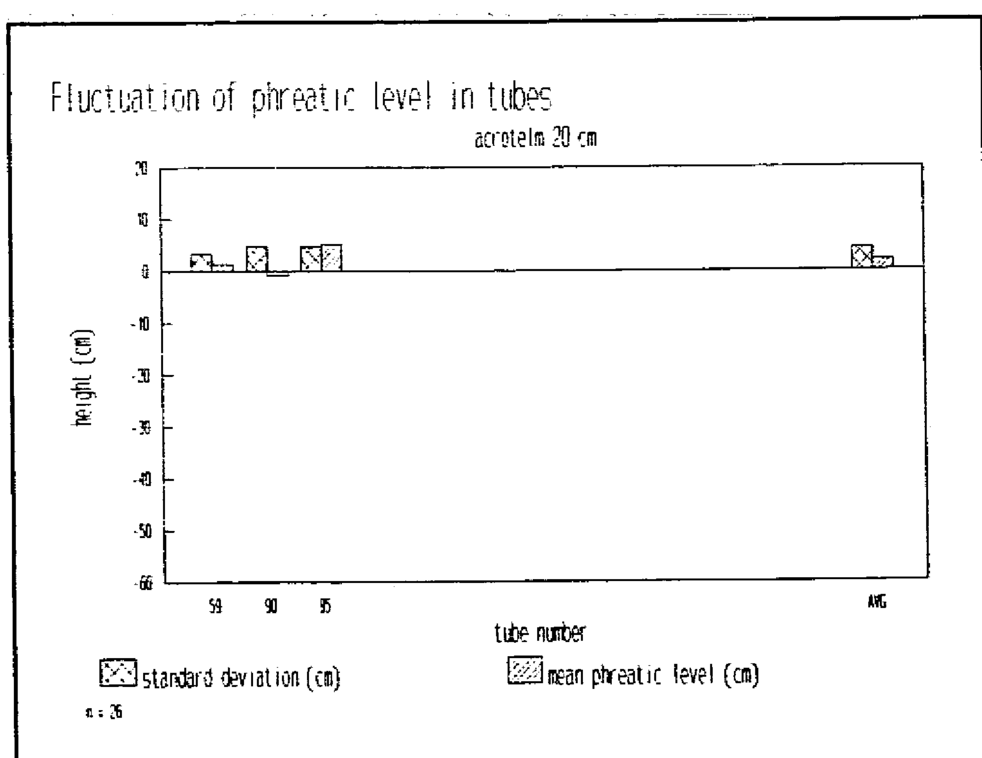
X.2



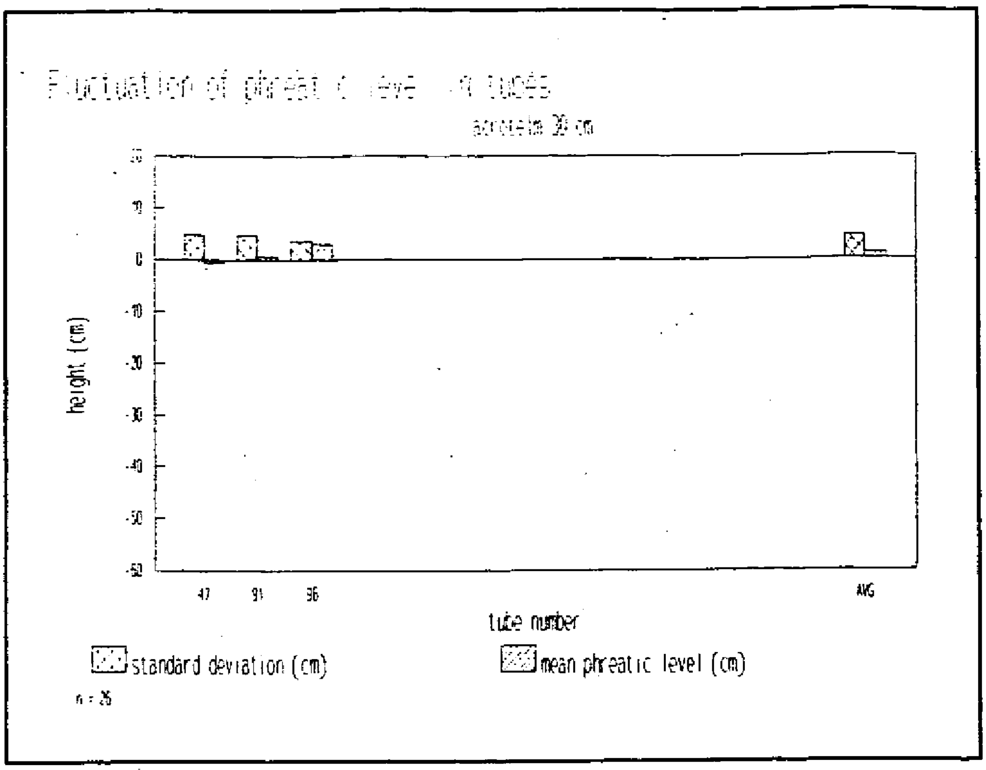
X.3


Fluctuation of phreatic level in tubes
acrotelm 20 cm
height (cm)
tube number
59
61
62
63
90
95
AVG
standard deviation (cm)
mean phreatic level (cm)
n = 26

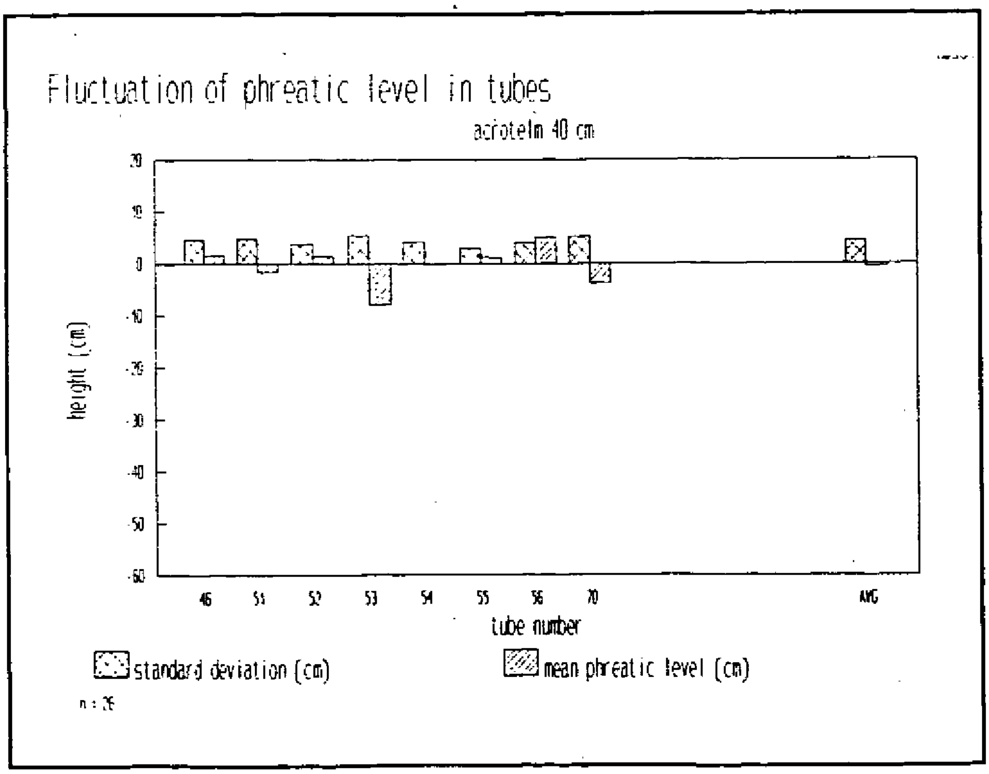
X.4


Fluctuation of phreatic level in tubes
acrotelm 20 cm
height (cm)
tube number
59
90
95
AVG
standard deviation (cm)
mean phreatic level (cm)
n = 26

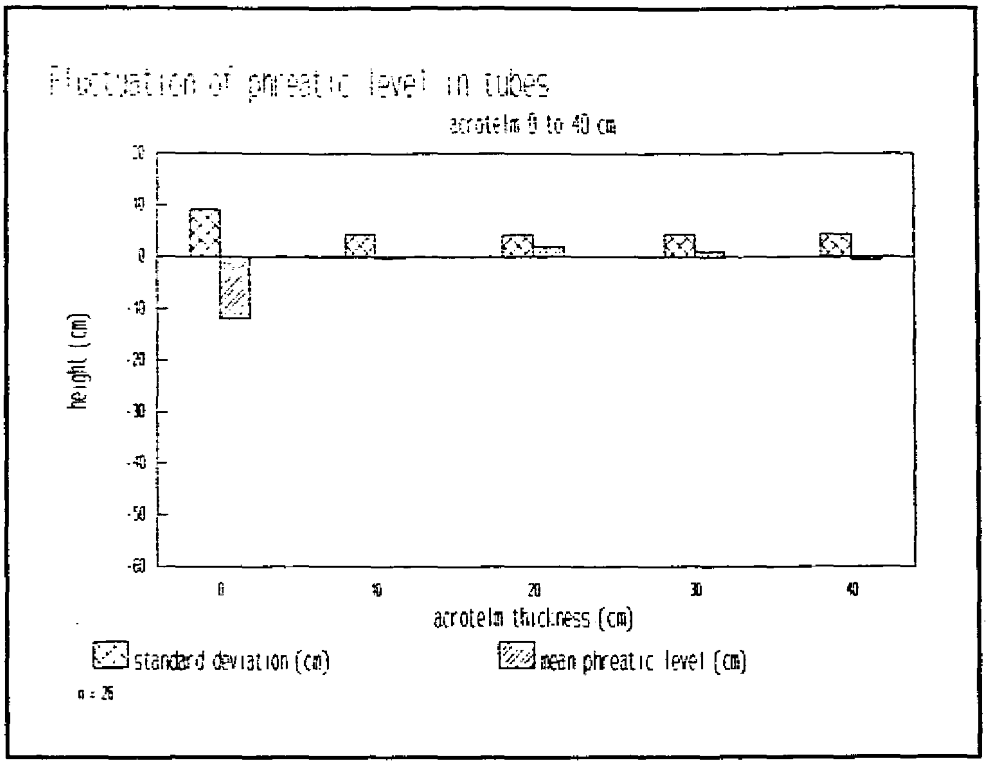
X.5


Fluctuation of phreatic level in tubes
acrotelm 30 cm
height (cm)
tube number
47
51
56
AVG
standard deviation (cm)
mean phreatic level (cm)
n = 26

X.6


Fluctuation of phreatic level in tubes
acrotelm 40 cm
20
10
0
-10
-20
-30
-40
-50
-60
height (cm)
46
51
52
53
54
55
56
70
AVG
tube number
standard deviation (cm)
mean phreatic level (cm)
n = 26

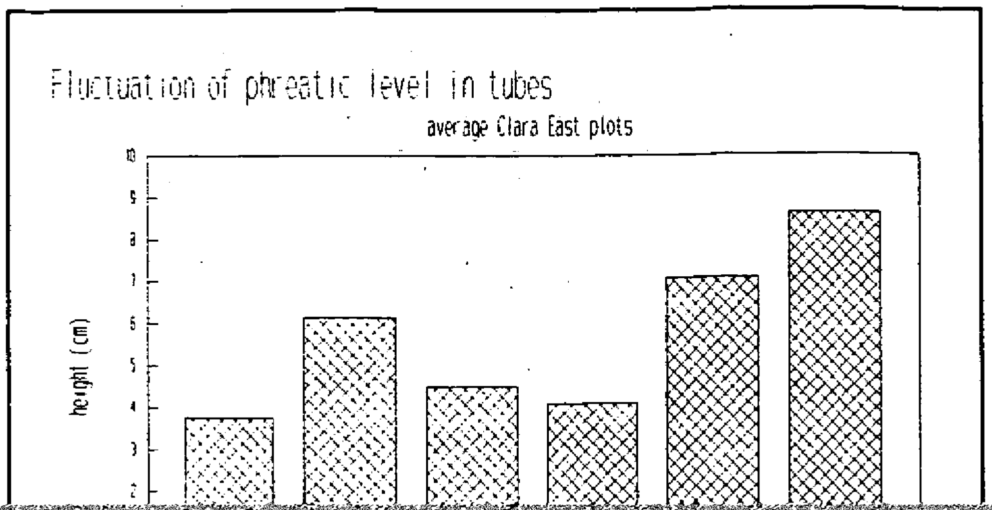
X.7


Fluctuation of phreatic level in tubes
acrotelm 0 to 40 cm
20
10
0
-10
-20
-30
-40
-50
-60
height (cm)
0
10
20
30
40
acrotelm thickness (cm)
standard deviation (cm)
mean phreatic level (cm)
n = 26

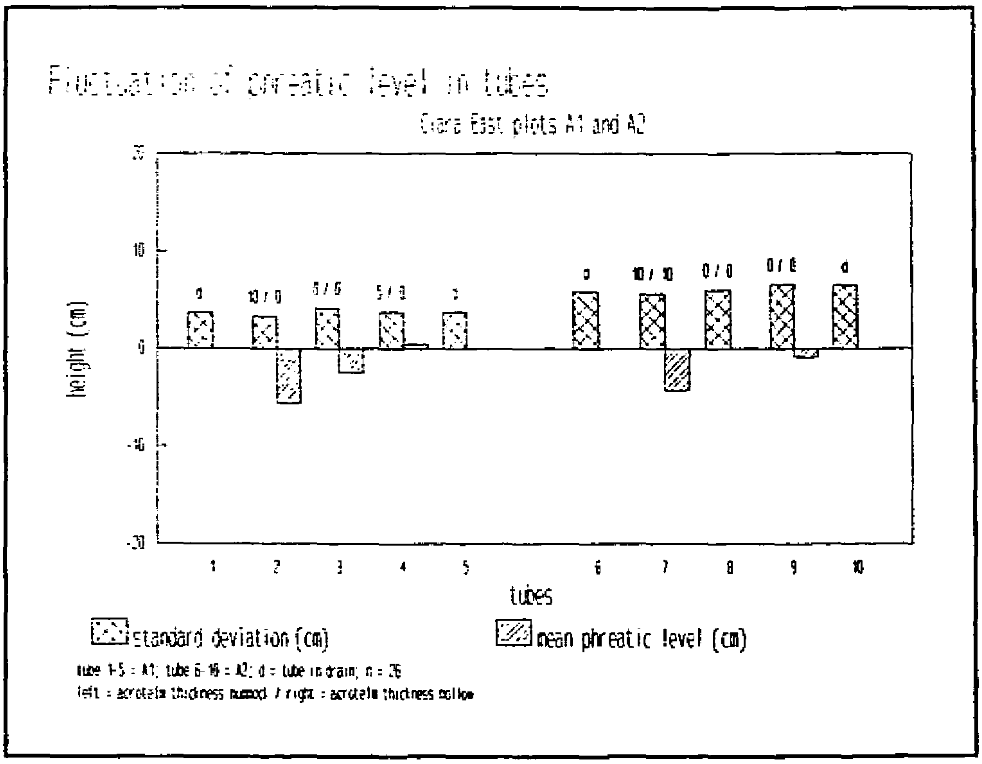
APPENDIX XI

Fluctuation of phreatic level in tubes (Clara-East)

XI.1

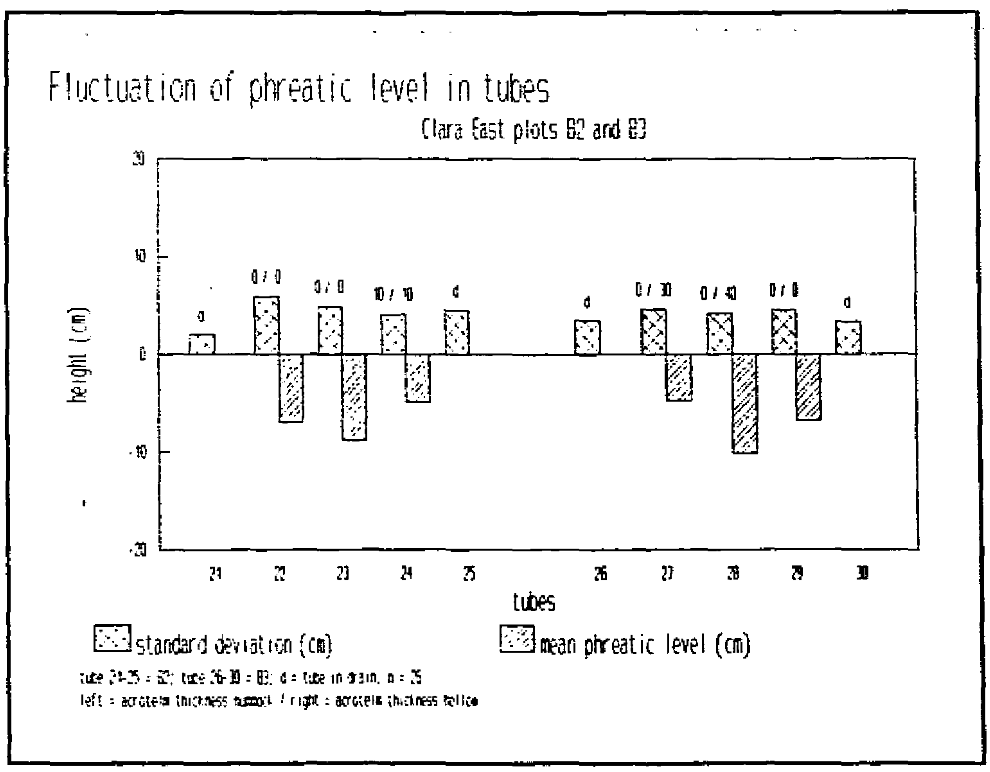


XI.3



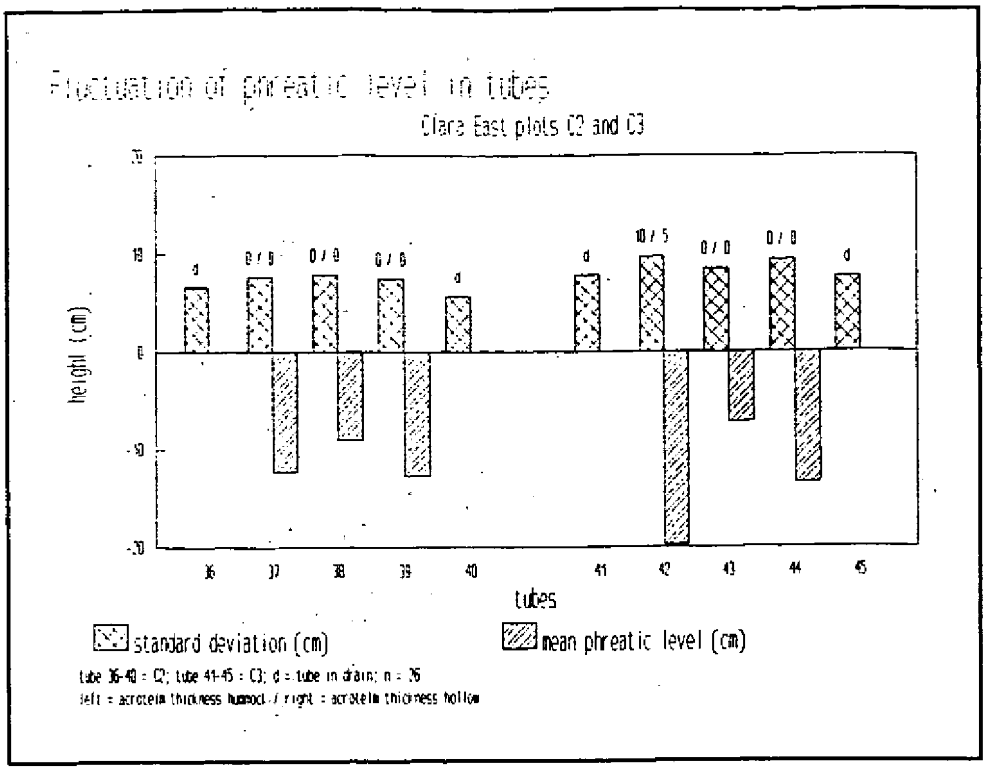
Fluctuation of phreatic level in tubes
Clara East plots A1 and A2
height (cm)
tubes
standard deviation (cm)
mean phreatic level (cm)

XI.4



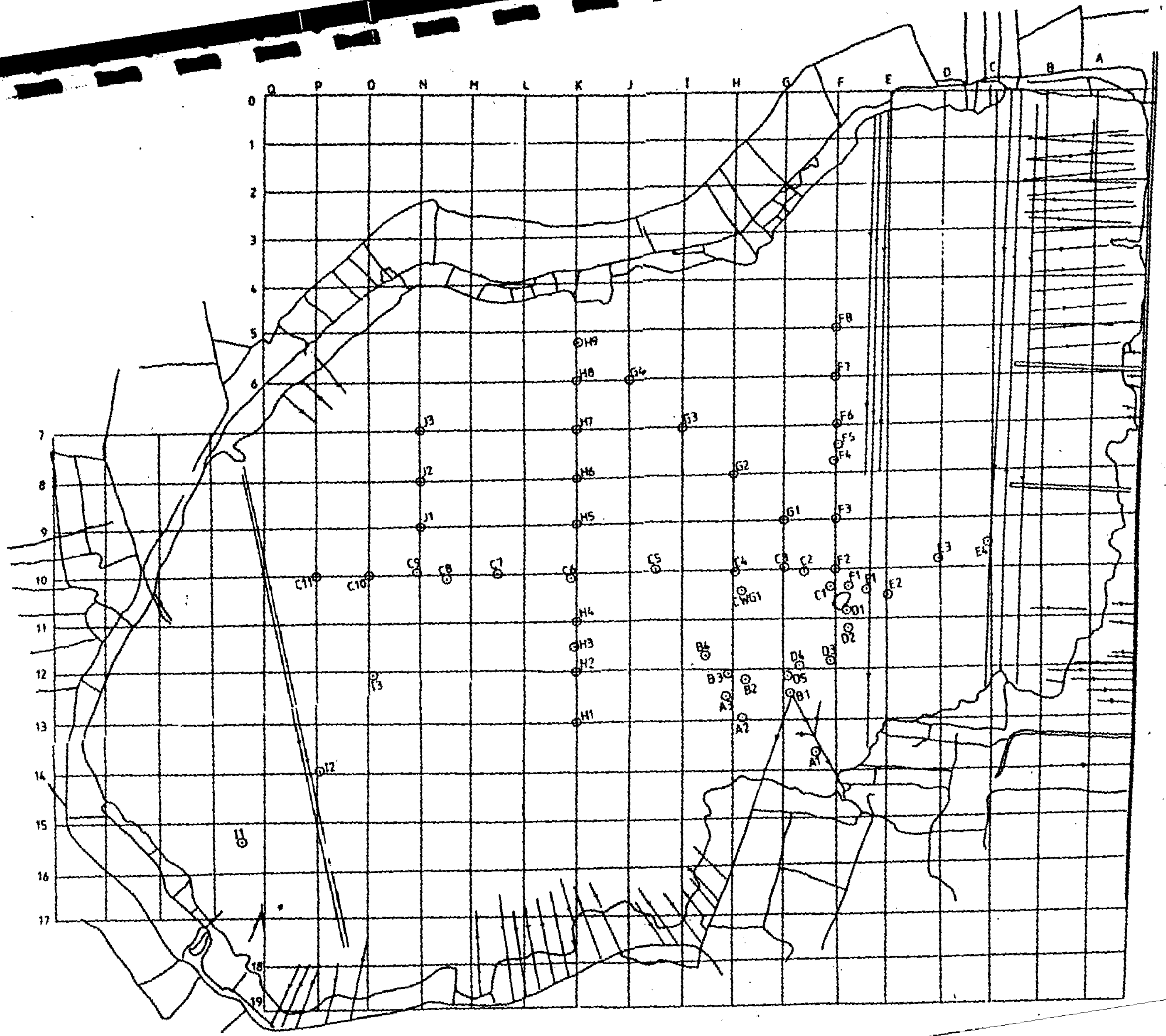
Fluctuation of phreatic level in tubes
Clara East plots B2 and B3
height (cm)
tubes
standard deviation (cm)
mean phreatic level (cm)

XI.5



Fluctuation of phreatic level in tubes
Clara East plots C2 and C3
height (cm)
tubes
36 37 38 39 40 41 42 43 44 45
d
10 / 5
standard deviation (cm)
mean phreatic level (cm)
tube 36-40 = C2; tube 41-45 = C3; d = tube in drain; n = 26
left = acrotelm thickness hummock / right = acrotelm thickness hollow

APPENDIX XII



CLARA BOG (WEST)
Scale. 0 1km
Position Acroteim holes

APPENDIX XIII

The A- and m-values for the different vegetation zones, also the standard deviation, the average transmissivity (m^2/day) and the calculated transmissivity (m^2/day) at a depth of 0.1 cm are given.

vegetation zone	Acro	A	m	s	AVG	0.1	n
Sphagnum magellanicum	0	15	2.2	6	8	96	7
Sphagnum magellanicum	10	126	2.5	95	113	629	21
Sphagnum magellanicum	20	483	2.6	615	529	2239	9
Spahgnum magellanicum	30	539	2.5	113	301	2691	5
Sphagnum magellanicum	40	679	2.6	318	392	3148	24
Transition *Sphagnum magellanicum*	10	4	1.7	0.7	14	46	4
Transition *Sphagnum magellanicum*	0	5	2.2	2	6	32	9
Sphagnum magellanicum orientated pool	10	418	2.9	41	42	1586	6
Sphagnum magellanicum with scattered pools	10	25	2.0	45	53	125	3
Sphagnum magellanicum/ eriophorum vaginatum	10	995	3.2	413	355	3168	4
Sphagnum magellanicum/ Eriophorum vaginatum	40	537	2.8	53	144	2171	4
Betula scrub/*Myrica*	0	469	2.6	99	108	2174	3
Betula scrub	20	749	2.7	33	92	3237	6
Molinia/Betula scrub	40	11846	3.1	1163	1447	4.10^4	8
Molinia/Betula scrub/ tree/*Myrica*	40	4953	3.0	860	1601	2.10^4	7
Betula woodlands	10	3456	3.4	781	502	9898	7
Soak vegetation *Betula* scrub woodland understorey vegetation	20	749	2.7	33	92	22	6

vegetation zone	acro	A	m	s	AVG	0.1	n
Sphagnum recurvum	40	911	2.5	350	470	4548	8
Burnt *Calluna*	0	15	2.3	14	16	88	8
Hummock/hollow	40	586	2.4	221	400	3165	20
Hummock/hollow	10	418	2.9	247	295	1586	5
Transition soak to *Eriophorum*	40	425	2.2	33	168	2729	4
Eriophorum	10	92	2.4	36		497	8
Eriophorum	40	498	2.6	40	389	2309	13
Narthecium	0	9	2.4	1	4	49	7
Transitional *Narthecium*	10	418	2.9	35	50	1586	4
Carex panicea	0	1	2.1	0.6	1	7	4
Carex panicea	10	396	3.1	0.5	11	1334	4
Carex panicea/Narthesium	0	1	1.7	1	3	12	3
Myrica gale/Calluna	10	747	3.1	4	68	2516	[illegible]
Myrica gale/Calluna	20	999	2.8	122	197	4039	[illegible]
Sphagnum magellanicum with *Myrica gale*	10	268	2.8	29	78	1084	5
Sphagnum magellanicum with *Myrica gale*	20	2	1.1	127	158	171	7
Eriophorum/ Narthecium	0	20	2.5	3	3	100	12
Eriophorum/ Narthecium	10	130	2.7	4	26	562	4

AVG : average of the measured transmissivity
s : standard deviation
0.1 : calculated transmissivity at a depth of 0.1 cm.
n : number of measured values

APPENDIX XIV

Measured transmissivities at the different locations

wl = water level (cm-surface)
T = Transmissivity (m²/day)
G = Guinness
P = Pitbailing
* = measured after februari 1993

location	High wl	Low wl	avg wl	T	method
A1	4.3	5.8	5.05	227	G
A1	4.2	5.9	5.05	414	G
A1	10.6	13.0	11.80	3	P*
A2	4.0	4.9	4.45	72	G
A2	4.0	5.2	4.60	78	G
A2	2.6	5.4	4.00	108	G
A2	1.6	3.7	2.65	136	G
A2	3.0	6.8	4.90	72	G
A2	5.0	7.4	6.20	11	P*
A3	4.0	4.8	4.40	40	G
A3	4.5	5.7	5.10	68	G
A3	1.8	4.0	2.90	118	G
A3	3.1	3.8	3.45	49	G
A3	2.1	5.0	3.55	117	G
A3S	2.8	5.6	4.20	98	G
A3S	6.8	8.2	7.50	38	G
A3N	4.6	5.2	4.90	316	G
A3N	7.1	7.7	7.40	78	G
B1	6.5	7.5	7.00	402	G
B1	6.6	7.5	7.05	436	G
B1	4.9	5.4	5.15	831	G
B1	4.8	5.3	5.05	598	G
B1	6.4	7.3	6.85	346	G
B1	8.9	9.5	9.20	18	P*
B2	3.4	4.2	3.80	617	G
B2	1.6	2.0	1.80	1029	G
B2	1.6	2.4	2.00	1108	G
B2	1.5	1.7	1.60	1623	G
B2	3.2	3.8	3.50	593	G
B2	2.6	3.0	2.80	921	G
B2	3.4	4.1	3.75	379	G
B2	5.4	6.1	5.75	400	G
B2	9.3	10.1	9.70	125	G*
B2W	1.6	2.3	1.95	435	G
B2W	4.5	5.8	5.15	275	G
B2W	5.4	6.8	6.10	197	G
B2E	1.4	2.4	1.90	268	G
B2E	3.8	5.3	4.55	237	G

location	High wl	Low wl	avg wl	T	method
B2E	4.8	6.3	5.55	189	G
B3	2.6	3.5	3.05	497	G
B3	2.6	3.4	3.00	535	G
B3	1.5	2.0	1.75	642	G
B3	2.0	2.6	2.30	344	G
B3	3.3	4.1	3.70	432	G
B3	5.3	6.5	5.90	288	G*
B4	3.5	8.7	6.10	2	P
B4	1.4	5.0	3.20	11	P
B4	0.0	2.1	1.05	15	P
B4	4.1	7.8	5.95	4	P
B4	6.4	8.9	7.65	4	P
C1	10.4	12.2	11.30	160	G
C1	9.3	11.1	10.20	182	G
C1	7.7	9.1	8.40	227	G
C1	9.8	12.6	11.20	101	G
C1	12.3	13.3	12.80	91	G*
C2	4.9	6.1	5.50	121	G
C2	3.4	4.6	4.00	304	G
C2	1.8	2.7	2.25	348	G
C2	4.4	7.5	5.95	96	G
C2	1.0	1.4	1.20	780	G
C2	3.0	4.9	3.95	197	G
C2	4.1	7.0	5.55	111	G
C2	6.9	8.5	7.70	122	G*
C2E	1.8	2.5	2.15	408	G
C2E	4.0	5.5	4.75	156	G
C2E	5.6	7.6	6.60	106	G
C2N	5.5	5.7	5.60	1657	G
C2N	7.5	7.8	7.65	1392	G
C2N	8.9	9.2	9.05	974	G
C3	8.5	9.3	8.90	378	G
C3	8.5	9.3	8.90	378	G
C3	5.7	6.2	5.95	815	G
C3	2.6	2.8	2.70	2037	G
C3	6.8	7.5	7.15	454	G
C3	10.3	11.1	10.70	169	G*
C4	4.6	7.2	5.90	5	P
C4	2.9	6.1	4.50	19	P
C4	2.9	3.5	3.20	12	P
C4	1.6	2.6	2.10	53	G
C4	2.5	5.9	4.20	14	P
C4	1.0	2.2	1.60	12	P
C4	2.1	5.1	3.60	5	P
C4	2.8	5.8	4.30	4	P
C4E	1.4	2.1	1.75	29	G
C4E	5.0	7.5	6.25	6	P
C4E	6.5	8.8	7.65	7	P
C4W	1.4	2.2	1.80	35	G

location	High wl	Low wl	avg wl	T	method
C4W	3.3	6.3	4.80	5	P
C4W	4.6	6.4	5.50	4	P
C5	4.4	5.8	5.10	301	G
C5	2.5	3.9	3.20	240	G
C5	1.3	2.8	2.05	207	G
C5	3.0	4.8	3.90	454	G
C5	4.2	5.3	4.75	272	G
C5E	2.8	4.3	3.55	536	G
C5E	4.8	5.4	5.10	481	G
C5E	6.0	6.4	6.20	471	G
C5S	2.5	2.9	2.70	698	G
C5S	4.2	4.6	4.40	564	G
C5S	5.9	6.4	6.15	536	G
C6	5.8	6.7	6.25	425	G
C6	5.6	6.5	6.05	335	G
C6	4.2	5.0	4.60	524	G
C6	3.0	3.7	3.35	454	G
C6	4.2	5.3	4.75	272	G
C7	8.0	13.1	10.60	56	G
C7	6.5	7.0	6.75	69	G
C7	4.3	8.0	6.15	77	G
C7	4.3	8.2	6.25	78	G
C7	14.2	17.4	15.80	3	P*
C8	24.5	30.5	27.50	2	P
C8	21.5	23.6	22.60	126	P
C8	21.5	21.9	21.70	309	G
C8	21.5	22.0	21.80	349	G
C8	21.5	23.1	22.30	209	G
C8	17.3	17.8	17.60	1626	G
C8	19.2	19.6	19.40	896	G
C9	9.2	10.0	9.60	70	G
C9	9.2	13.6	11.40	67	G
C9	8.0	8.7	8.35	63	G
C9	8.1	11.4	9.75	103	G
C9	4.5	5.1	4.80	577	G
C9	6.0	7.5	6.75	201	G
C9	11.7	12.3	12.00	96	P*
C10	4.2	5.7	4.95	128	P
C10	2.5	3.2	2.85	63	G
C10	3.8	4.6	4.20	62	G
C10	9.5	11.5	10.50	5	P
C11	4.1	4.6	4.35	63	G
C11	4.1	8.0	6.05	83	G
C11	2.3	2.8	2.55	136	G
C11	3.6	4.2	3.90	87	G
C11	8.1	10.7	9.40	5	P
D1	5.5	8.6	7.05	84	G
D1	5.9	7.5	6.70	133	G
D1	5.4	7.0	6.20	161	G

location	High wl	Low wl	avg wl	T	method
D1	6.5	7.7	7.10	51	G
D1	8.5	10.1	9.30	57	G*
D2	9.0	9.5	9.25	795	G
D2	6.3	6.7	6.50	2428	G
D2	4.3	4.4	4.35	3792	G
D2	7.6	8.0	7.80	873	G
D2	11.1	13.3	12.20	5	P*
D3	4.5	7.7	6.10	92	G
D3	0.5	2.6	1.55	104	G
D3	2.0	5.2	3.60	80	G
D3	5.3	6.8	6.05	81	G
D3	2.8	3.3	3.05	49	G
D3	2.8	3.0	2.90	80	G
D3	2.8	4.7	3.75	103	G
D3	2.8	5.8	4.30	89	G
D3	2.8	5.5	4.15	103	G
D3	2.8	3.3	3.05	99	G
D3	8.0	8.4	8.20	36	G*
D4	4.0	4.2	4.10	1988	G
D4	1.6	1.8	1.70	2324	G
D4	1.6	1.9	1.75	3414	G
D4	2.5	2.8	2.65	2372	G
D4	6.3	6.7	6.50	1549	G*
D5	3.8	4.6	4.20	448	G
D5	3.2	3.1	3.15	352	G
D5	2.8	3.7	3.25	307	G
D5	5.7	6.3	6.00	221	G*
E1	8.8	9.7	9.25	47	G
E1	9.0	14.2	11.60	46	G
E1	6.5	9.2	7.85	126	G
E1	4.1	5.8	4.95	193	G
E1	7.4	8.0	7.70	89	G
E1	9.8	12.4	11.10	5	P
E2	10.0	11.5	10.80	16	G
E2	7.7	9.7	8.70	11	G
E2	2.6	3.3	2.95	63	G
E2	7.0	9.3	8.15	12	G
E3	10.5	13.6	12.10	8	G
E3	8.5	11.6	10.10	10	G
E3	6.3	9.2	7.75	17	G
E3	9.4	13.4	11.40	8	P
E4	7.5	14.2	10.90	1	P
E4	5.7	10.3	8.00	1	P
E4	6.5	8.2	7.35	1	P
E4	6.9	11.2	9.05	0	P
F1	5.3	7.4	6.35	141	G
F1	3.4	6.1	4.75	136	G
F1	2.0	3.7	2.85	176	G
F1	3.8	6.6	5.20	122	G

location	High wl	Low wl	avg wl	T	method
F1	7.4	9.6	6.35	59	G*
F2	6.0	8.0	7.00	18	G
F2	3.6	5.0	4.30	266	G
F2	5.1	6.4	5.75	40	G
F3	8.0	11.4	9.70	87	G
F3	4.5	6.7	5.60	167	G
F3	7.5	11.3	9.40	74	G
F3	9.3	11.6	10.50	61	G
F3	11.9	14.1	13.00	5	P*
F4	6.0	6.6	6.30	684	G
F4	3.7	4.4	4.05	653	G
F4	1.3	1.9	1.60	522	G
F4	5.4	6.1	5.75	590	G
F4	8.7	9.1	8.90	372	G
F4	8.7	9.7	9.20	390	G
F4	17.7	20.1	18.90	2	P*
F5	10.8	11.6	11.20	39	G
F5	10.8	12.4	11.60	21	G
F5	8.4	9.1	8.75	28	G
F5	6.5	9.4	7.95	116	G
F5	10.6	12.5	11.60	35	G
F5	14.3	15.8	15.10	10	P
F6	13.2	17.4	15.30	1	P
F6	10.3	13.2	11.80	0	P
F6	10.5	12.9	11.70	0	P
F6	11.4	14.7	13.10	0	P
F7	15.3	18.1	16.70	2	P
F7	7.7	10.4	9.05	0	P
F7	7.0	9.1	8.05	0	P
F7	7.8	11.0	9.40	0	P
F8	7.5	10.6	9.05	6	P
F8	4.5	7.4	5.95	8	P
F8	3.1	5.1	4.10	13	G
F8	5.4	8.7	7.05	6	P
G1	7.7	8.4	8.05	408	G
G1	5.1	5.8	5.45	618	G
G1	3.0	3.3	3.15	1153	G
G1	3.5	3.8	3.65	1153	G
G1	12.7	13.5	13.10	136	G*
G2	6.8	8.6	7.70	11	G
G2	4.8	6.9	5.85	12	G
G2	2.8	5.4	4.10	15	G
G2	2.5	5.1	3.80	17	G
G3	7.6	9.3	8.45	201	G
G3	4.1	5.1	4.60	460	G
G3	3.0	3.7	3.35	500	G
G3	11.3	13.1	12.20	3	P*
G4	7.6	8.7	8.15	39	G
G4	2.9	3.6	3.25	99	G

location	High wl	Low wl	avg wl	T	method
G4	0.0	1.8	0.90	192	G
G4	2.0	2.0	2.00	192	G
G4	11.4	14.4	13.80	3	P*
H1	10.7	12.3	11.50	16	G
H1	9.0	10.8	9.90	28	G
H1	6.6	9.8	8.20	102	G
H1	10.0	12.6	11.30	33	G
H2	9.2	18.1	13.65	0	G
H2	7.6	12.1	9.85	1	G
H2	4.3	10.0	7.15	4	G
H2	8.4	11.0	9.70	1	G
H3	10.0	10.9	10.45	384	G
H3	7.0	7.6	7.30	803	G
H3	3.0	3.4	3.20	896	G
H3	7.0	7.7	7.35	423	G
H3	10.6	11.7	11.15	141	G
H3	14.7	16.7	15.70	2	P*
H4	4.5	5.5	5.00	281	G
H4	0.9	1.6	1.30	508	G
H4	1.5	2.8	2.15	209	G
H4	7.9	10.3	9.10	3	P*
H5	7.0	8.9	7.95	22	G
H5	3.9	5.4	4.65	40	G
H5	2.0	3.3	2.65	34	G
H5	2.5	3.2	2.85	41	G
H5	8.9	13.1	11.50	3	P*
H6	11.3	16.8	14.05	1	P
H6	9.5	12.2	10.85	1	P
H6	6.0	8.6	7.30	6	P
H6	7.9	11.5	9.70	1	P
H7	13.2	14.4	13.80	26	G
H7	9.7	11.4	10.55	17	G
H7	5.5	6.2	5.85	99	G
H7	7.8	8.7	8.25	58	G
H8	8.6	9.7	9.15	21	G
H8	9.0	10.2	9.60	40	G
H8	3.8	4.3	4.05	155	G
H8	0.0	1.0	0.50	276	G
H8	1.5	2.4	1.95	262	G
H9	11.0	12.5	11.75	207	G
H9	7.4	8.6	8.00	385	G
H9	4.5	5.3	4.90	419	G
H9	5.0	6.1	5.55	272	G
H9	12.8	14.2	13.50	66	G
H9	14.5	16.3	15.40	35	G*
I1	6.0	8.2	7.10	4	P
I1	4.5	7.3	5.90	3	P
I1	5.5	9.0	7.25	2	P
I2	3.5	5.6	4.55	5	P

location	High wl	Low wl	avg wl	T	method
I2	1.7	3.8	2.75	6	P
I2	2.8	5.9	4.35	4	P
I2	5.3	9.2	7.25	3	P
I3	4.0	4.8	4.40	11	G
I3	2.3	3.1	2.70	59	G
I3	3.8	7.3	5.55	90	G
J1	7.5	8.5	8.00	377	G
J1	5.2	5.9	5.55	488	G
J1	7.2	7.9	7.55	488	G
J1	12.5	13.5	13.00	68	G
J1	15.5	16.7	16.10	106	G*
J2	5.0	7.2	6.10	10	P
J2	3.0	5.2	4.10	22	G
J2	5.0	7.7	6.35	19	G
J3	4.3	7.8	6.05	4	P
J3	1.8	3.5	2.65	9	P
J3	3.0	7.0	5.00	4	P

APPENDIX XV

Evaporation measured with lysimeters on Clara Bog

begindate	enddate	lysi-1	lysi-2	lysi-3	lysi-4	lysi-5	lysi-6	lysi-7	lysi-8
02-10-92	09-10-92	7.7	8.7	8.4	7.9	4.5	7.8	8.0	7.7
09-10-92	16-10-92	8.2	8.4	8.5	7.3	6.8	6.5	8.1	7.1
16-10-92	23-10-92	4.7	4.0	1.0	4.6	5.8	5.5	3.2	2.8
23-10-92	30-10-92	8.9	13.1	8.9	7.1	2.0	1.5	22.7	17.2
30-10-92	06-11-92	10.6	6.1	15.8	5.6	5.6	-1.7	4.0	5.1
06-11-92	13-11-92	1.6	5.2	4.3	3.8	2.5	1.7	4.1	3.8
13-11-92	19-11-92	1.5	-0.8	0.5	-2.8	-2.5	0.8	3.7	0.2
19-11-92	27-11-92	32.5	28.2	18.1	28.2	14.4	19.7	35.5	25.5
27-11-92	03-12-92	-1.9	28.0	28.9	31.7	13.4	29.0	19.8	10.2
03-12-92	10-12-93	6.6	6.4	3.6	1.0	1.9	1.2	6.9	3.5
10-12-93	17-12-93	4.6	6.3	1.2	4.4	-1.1	6.6	4.5	-10.7
17-12-93	08-01-93	9.9	12.7	10.5	10.9	6.6	15.4	11.0	3.7
08-01-93	21-01-93	26.2	30.8	12.9	20.8	29.2	8.3	42.4	41.7
21-01-93	28-01-93	****	****	****	****	****	****	****	****
28-01-93	04-02-93	4.4	5.5	6.3	4.5	4.4	4.4	2.7	3.6
04-02-93	12-02-93	2.8	1.0	3.1	3.0	1.7	5.0	1.8	5.0
12-02-93	18-02-93	5.1	3.1	7.1	4.9	7.2	6.6	4.8	4.6
18-02-93	25-02-93	6.1	8.4	6.1	5.4	7.1	4.6	5.9	7.7

begindate	enddate	lysi-9	lysi-10	lysi-11	lysi-12	lysi-13	lysi-14	lysi-15
02-10-92	09-10-92	8.2	5.7	7.4	6.4	8.7	8.8	7.5
09-10-92	16-10-92	7.3	5.1	6.0	4.5	9.0	10.2	7.0
16-10-92	23-10-92	2.2	1.8	3.3	4.2	5.6	4.3	2.9
23-10-92	30-10-92	8.1	19.7	2.8	18.0	4.5	4.6	5.7
30-10-92	06-11-92	2.1	3.5	4.9	7.4	6.6	8.1	7.6
06-11-92	13-11-92	2.9	5.0	1.8	2.2	4.5	2.9	4.8
13-11-92	19-11-92	-0.6	6.9	2.3	1.1	1.4	****	2.8
19-11-92	27-11-92	17.5	33.0	3.6	24.8	7.9	-2.3	6.5
27-11-92	03-12-92	5.8	15.7	-0.5	15.4	3.7	15.4	1.2
03-12-92	10-12-93	0.1	5.3	-1.3	3.0	1.4	-1.7	1.2
10-12-93	17-12-93	3.9	4.1	2.7	8.2	6.8	-9.0	6.1
17-12-93	08-01-93	4.8	9.1	-3.7	9.8	16.5	16.3	12.2
08-01-93	21-01-93	5.7	34.2	11.5	38.7	16.7	33.7	9.5
21-01-93	28-01-93	****	****	***	****	****	****	****
28-01-93	04-02-93	4.2	6.6	2.7	2.8	2.7	2.7	8.5
04-02-93	12-02-93	3.5	2.9	2.6	4.4	4.0	4.0	3.2
12-02-93	18-02-93	5.9	3.6	4.3	3.9	7.7	7.4	7.7
18-02-93	25-02-93	8.1	8.1	6.4	5.9	11.7	11.7	9.6

APPENDIX XVI

Remarks concerning the Lysimeter survey

30-10-92	All lysimeters were frozen; maybe some of them were flooded.
06-11-92	All lysimeters were frozen; maybe some of them were flooded.
14-11-92	Lysimeter 1,2,4,7,8,9,10,11 and 12 probably flooded.
27-11-92	Lysimeter 1,2,4,7,8,9,10 and 12 probably flooded.
27-11-92	Mistakes could have been made due to the fact that the paper was wet because of the rain. In not all of the lysimeters the water level was back to normal during the last measurement.
03-12-92	Lysimeter 2,3,4,5,6,7,10 and 12 probably overflown.
11-12-92	Water was flowing from the surface into lysimeter 8.
17-12-92	Water was flowing from the surface into lysimeters 8 en 14.
23-12-92	All lysimeters were frozen.
31-12-92	All lysimeters were frozen.
08-01-93	Lysimeter 9 had to be pumped before weighing. From lysimeter 8 water was flowing out during weighing.
15-01-93	Too dangerous to measure; measuring site too wet and extremely muddy. Lysimeter 3,4,9 and 10 were probably flooded.
19-01-93	Lysimeter 8 is overflown; in lysimeters 1,3,5,6,9,10,13 and 15 surface water is present.
28-01-93	Lysimeter 1,7,10 and 12 inflow or outflow of water.
04-02-93	Big difference in water level before and after weighing because of the not upright position of the lysimeters. Lots of sunshine and low water level; it is sure that there was no in- or outflow of water. No adding of water neccesary because rain is expected.
25-02-93	In the *Molinia* lysimeters strange things occur; the waterlevels are higher and the weights are lower than the last time.

APPENDIX XVII

Values of the evapotranspiration measured with lysimeters, which seem to be alright

begindate	enddate	lysi-1	lysi-2	lysi-3	lysi-4	lysi-5	lysi-6	lysi-7	lysi-8
02-10-92	09-10-92	7.7	8.7	8.4	7.9	4.5	7.8	8.0	7.7
09-10-92	16-10-92	8.2	8.4	8.5	7.3	6.8	6.5	8.1	7.1
16-10-92	23-10-92	4.7	4.0	1.0	4.6	5.8	5.5	3.2	2.8
23-10-92	30-10-92	8.9	13.1	8.9	7.1	2.0	1.5		
30-10-92	06-11-92	10.6	6.1	15.8	5.6	5.6		4.0	5.1
06-11-92	13-11-92	1.6	5.2	4.3	3.8	2.5	1.7	4.1	3.8
13-11-92	19-11-92	1.5		0.5			0.8	3.7	0.2
19-11-92	27-11-92								
27-11-92	03-12-92								
03-12-92	10-12-93	6.6	6.4	3.6	1.0	1.9	1.2	6.9	3.5
10-12-93	17-12-93	4.6	6.3	1.2	4.4		6.6	4.5	
17-12-93	08-01-93	9.9	12.7	10.5	10.9	6.6	15.4	11.0	
08-01-93	21-01-93			12.9			8.3		
21-01-93	28-01-93								
28-01-93	04-02-93	4.4	5.5	6.3	4.5	4.4	4.4	2.7	3.6
04-02-93	12-02-93	2.8	1.0	3.1	3.0	1.7	5.0	1.8	5.0
12-02-93	18-02-93	5.1	3.1	7.1	4.9	7.2	6.6	4.8	4.6
18-02-93	25-02-93	6.1	8.4	6.1	5.4	7.1	4.6	5.9	7.7

begindate	enddate	lysi-9	lysi-10	lysi-11	lysi-12	lysi-13	lysi-14	lysi-15
02-10-92	09-10-92	8.2	5.7	7.4	6.4	8.7	8.8	7.5
09-10-92	16-10-92	7.3	5.1	6.0	4.5	9.0	10.2	7
16-10-92	23-10-92	2.2	1.8	3.3	4.2	5.6	4.3	2.9
23-10-92	30-10-92	8.1		2.8		4.5	4.6	5.7
30-10-92	06-11-92	2.1	3.5	4.9	7.4	6.6	8.1	7.6
06-11-92	13-11-92	2.9	5.0	1.8	2.2	4.5	2.9	4.8
13-11-92	19-11-92		6.9	2.3	1.1	1.4		2.8
19-11-92	27-11-92			3.6		7.9		6.5
27-11-92	03-12-92	5.8				3.7		1.2
03-12-92	10-12-93	0.1	5.3		3.0	1.4		1.2
10-12-93	17-12-93	3.9	4.1	2.7	8.2	6.8		6.1
17-12-93	08-01-93	4.8	9.1		9.8	16.5		12.2
08-01-93	21-01-93	5.7		11.5		16.7		9.5
21-01-93	28-01-93							
28-01-93	04-02-93	4.2	6.6	2.7	2.8	2.7	2.7	8.5
04-02-93	12-02-93	3.5	2.9	2.6	4.4	4.0	4.0	3.2
12-02-93	18-02-93	5.9	3.6	4.3	3.9	7.7	7.4	7.7
18-02-93	25-02-93	8.1	8.1	6.4	5.9	11.7	11.7	9.6

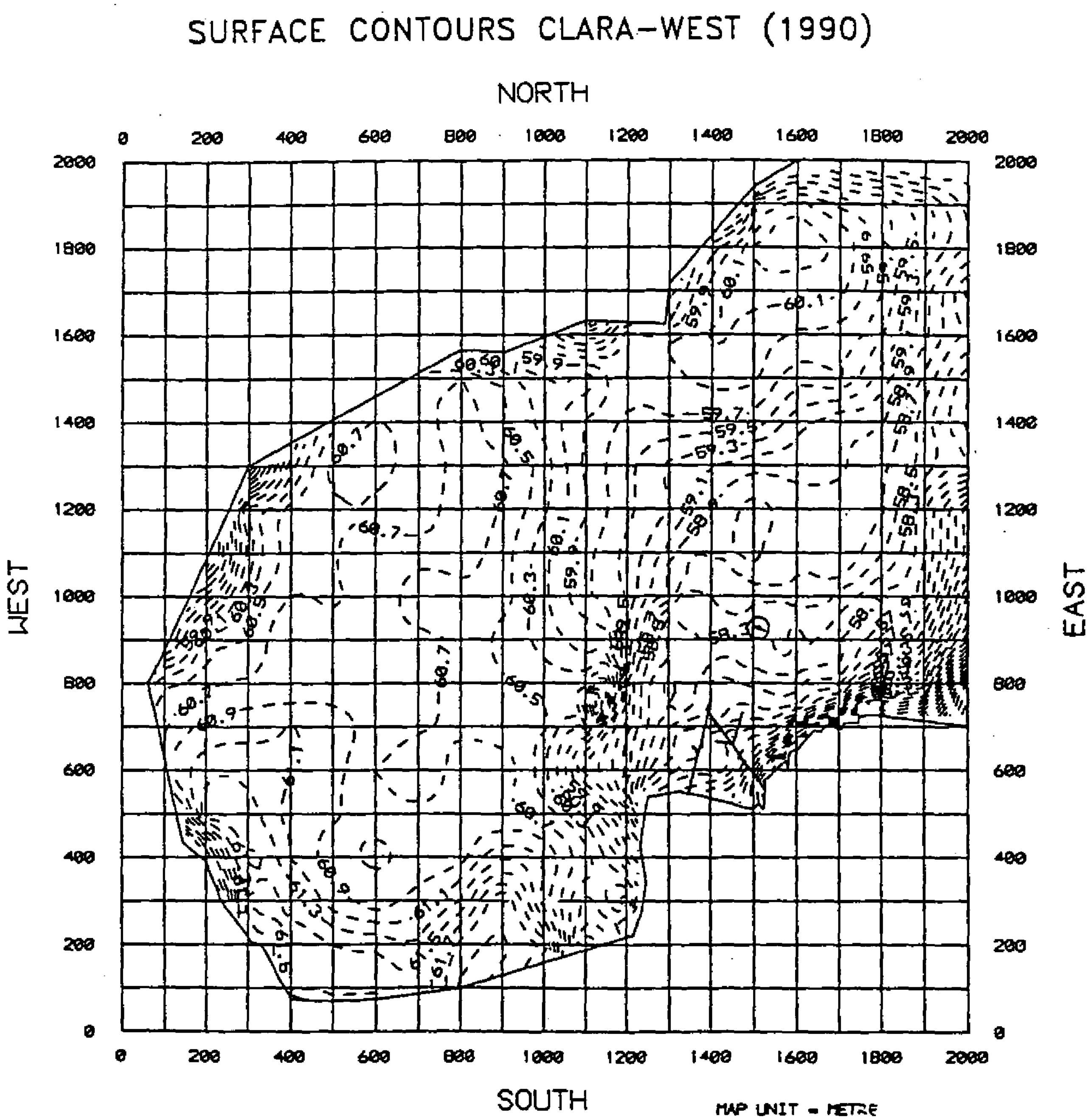
APPENDIX XVIII

Average evapotranspiration for the different plant species

begindate	enddate	Calluna AVG	burnt Calluna AVG	Sphagnum AVG	Eriophorum AVG	Molinia AVG
02-10-92	09-10-92	8.3	6.7	8.0	6.5	8.3
09-10-92	16-10-92	8.4	6.9	7.5	5.2	8.7
16-10-92	23-10-92	3.2	5.3	2.7	3.1	4.3
23-10-92	30-10-92	10.3	3.5	8.1	2.8	4.9
30-10-92	06-11-92	10.8	5.6	3.7	5.3	7.4
06-11-92	13-11-92	3.7	2.7	3.6	3.0	4.1
13-11-92	19-11-92	1.0	0.8	2.0	3.4	2.1
19-11-92	27-11-92				3.6	7.2
27-11-92	03-12-92			5.8		2.5
03-12-92	10-12-93	5.5	1.4	3.5	4.2	1.3
10-12-93	17-12-93	4.0	5.5	4.2	5.0	6.5
17-12-93	08-01-93	11.0	11.0	7.9	9.5	14.4
08-01-93	21-01-93	12.9	8.3	5.7	11.5	13.1
21-01-93	28-01-93					
28-01-93	04-02-93	5.4	4.4	3.5	4.0	4.6
04-02-93	12-02-93	2.3	3.2	3.4	3.3	3.7
12-02-93	18-02-93	5.1	6.2	5.1	3.9	7.6
18-02-93	25-02-93	6.9	5.7	7.2	6.8	11.0

APPENDIX XIX

Surface contour map of Clara-West



APPENDIX XX

Description of the different vegetation community types

3A The typical varioan of the community of *Narthesium ossifragum, Sphagnum magellanicum* and *Sphagnum tenellum*

3Ba The subvariant with *Sphagnum cuspidatum* of the phase with *Sphagnum magellanicum*

3Bb The typical subvariant of the phase with *Sphagnum magellanicum*

3C The phase with *Sphagnum papillosum*

3D The variant with *Campylopus introflexus* and *Zygogonium ericetorum*

4A The typical variant of the community of *Calluna vulgaris, Sphagnum capillifolium* and *Cladonia portentosa*

4B The variant with *Campylopus introflexus* and *Cladonia floerkeana*

4E The phase with *Sphagnum capillifolium*

4F The phase with *Sphagnum imbricatum*

9A The typical variant of the community of *Sphagnum recurvum* and *Polytrichum alpestre*

11 The community of *Sphagnum capillifolium* and *Empetrum nigrum*

12Ac The subvariant with *Polytrichum alpestre* of the community of *Betula pubescens* and *Molinea caerulea*

14B The variant with *Sphagnum recurvum* of the community of *Molinea caerulea, Potentillaerecta* and *Erica tetralix*

APPENDIX XXI

Relation transmissivity and depth of phreatic level form surface for each category

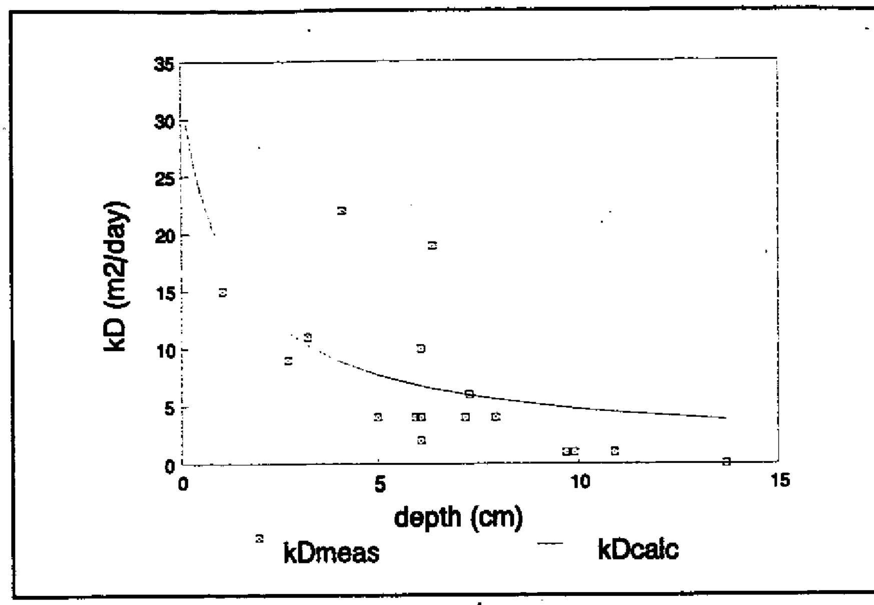


figure 1: type 3a, 0 cm acrotelm

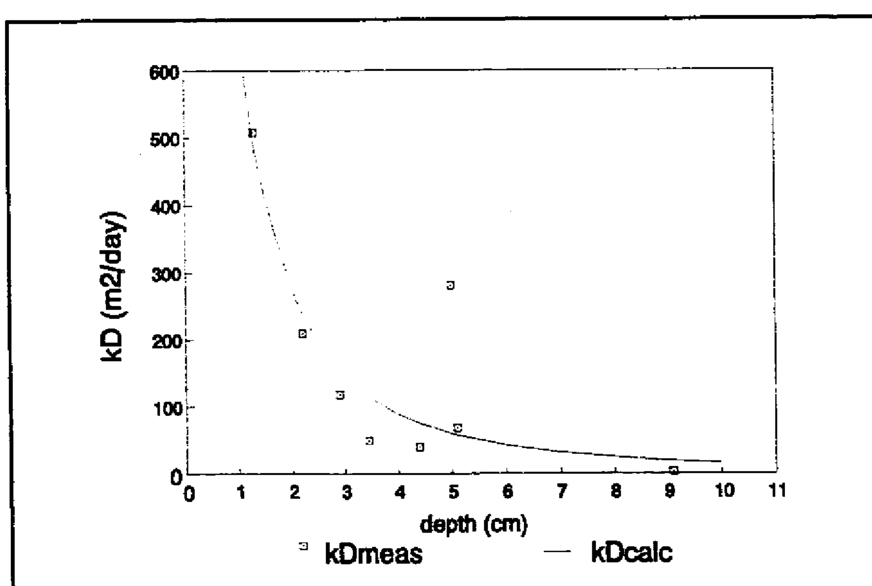


figure 2: type 3Ba, 10 cm acrotelm

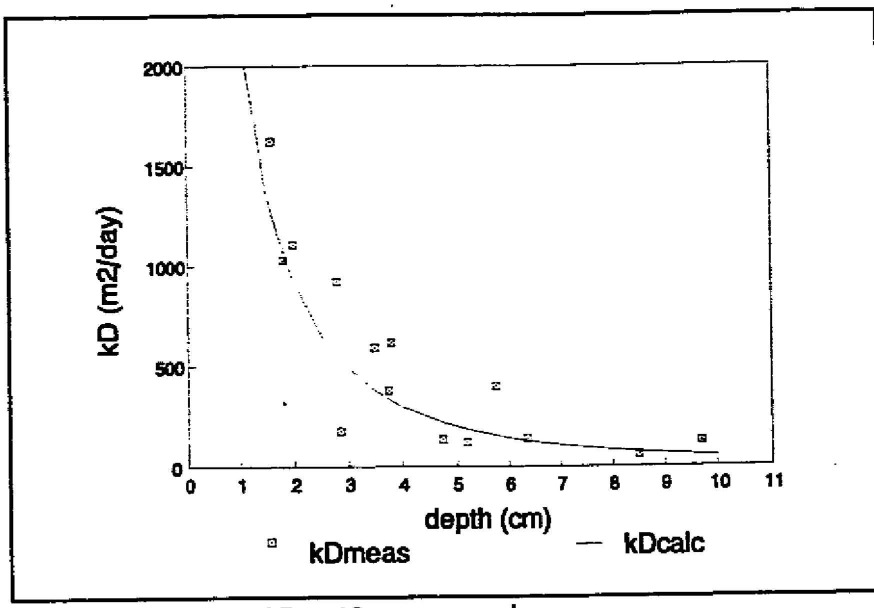


figure 3: type 3Ba, 40 cm acrotelm

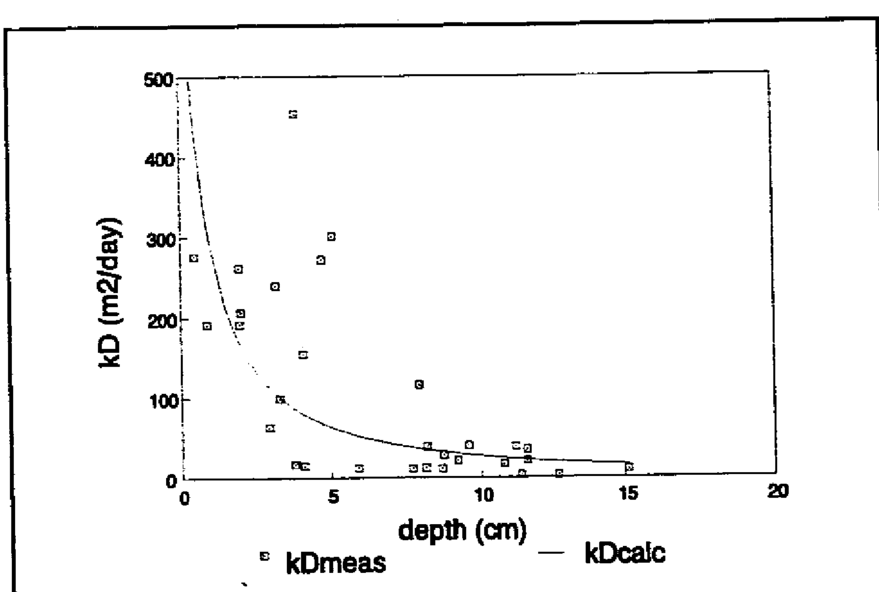


figure 4: type 3Bb, 10 cm acrotelm

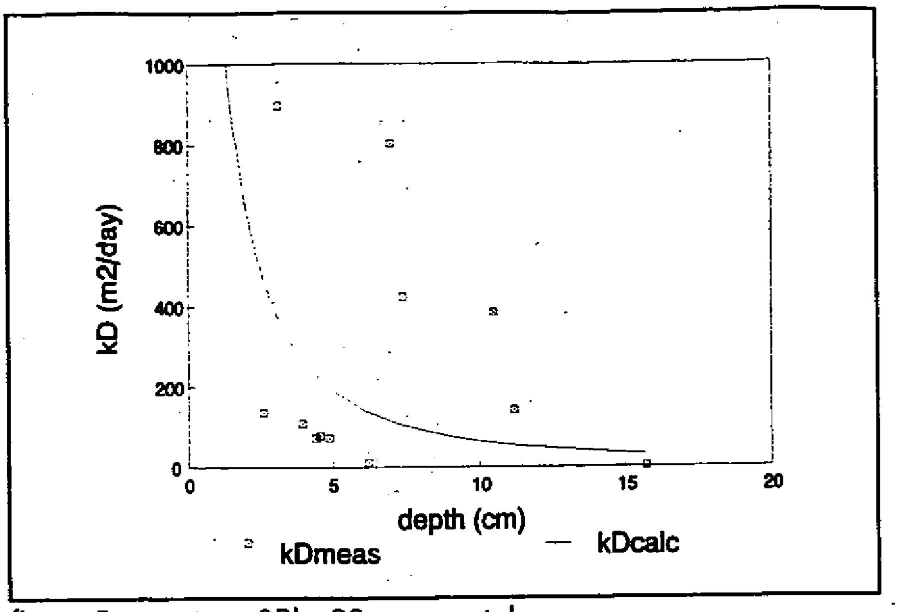


figure 5: type 3Bb, 20 cm acrotelm

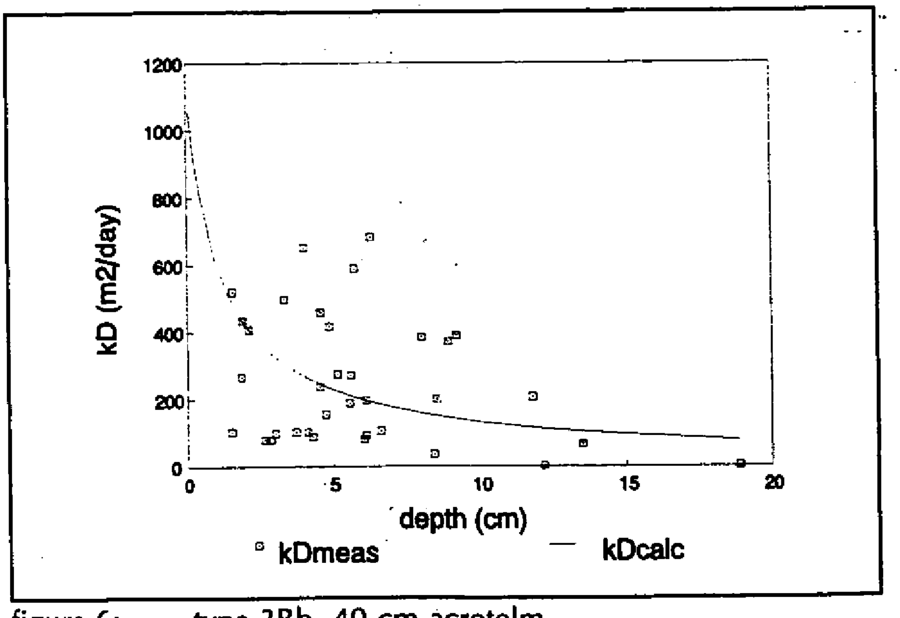


figure 6: type 3Bb, 40 cm acrotelm

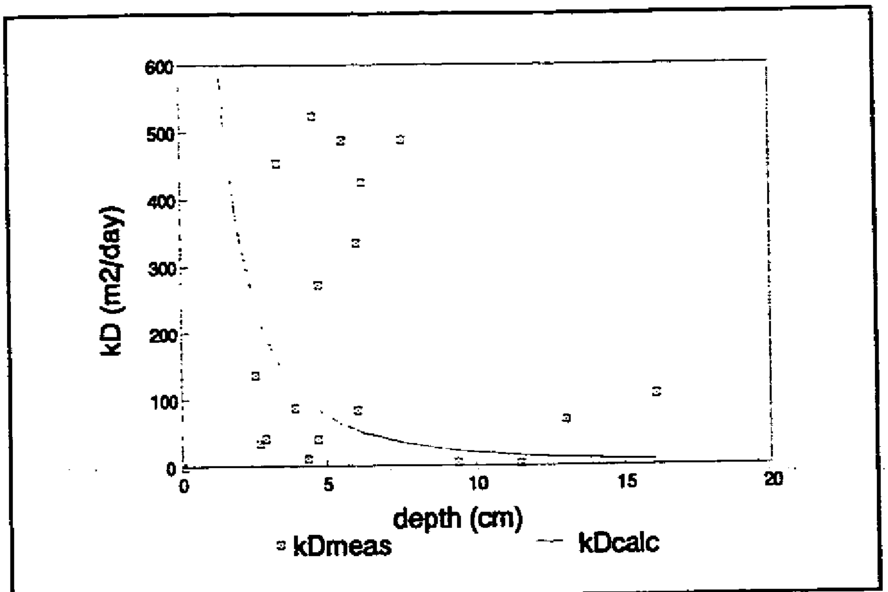


figure 7: type 3C, 10 cm acrotelm

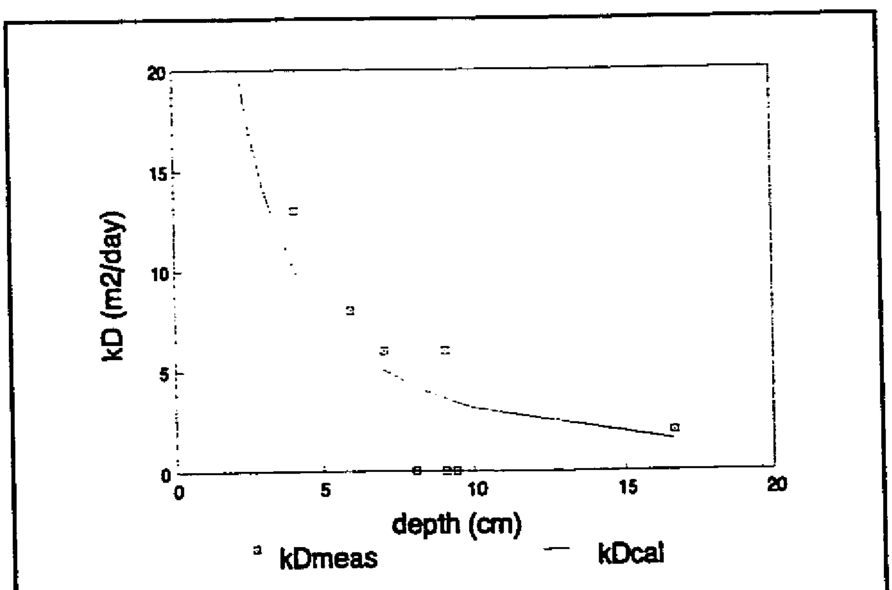


figure 8: type 4A, 0 cm acrotelm

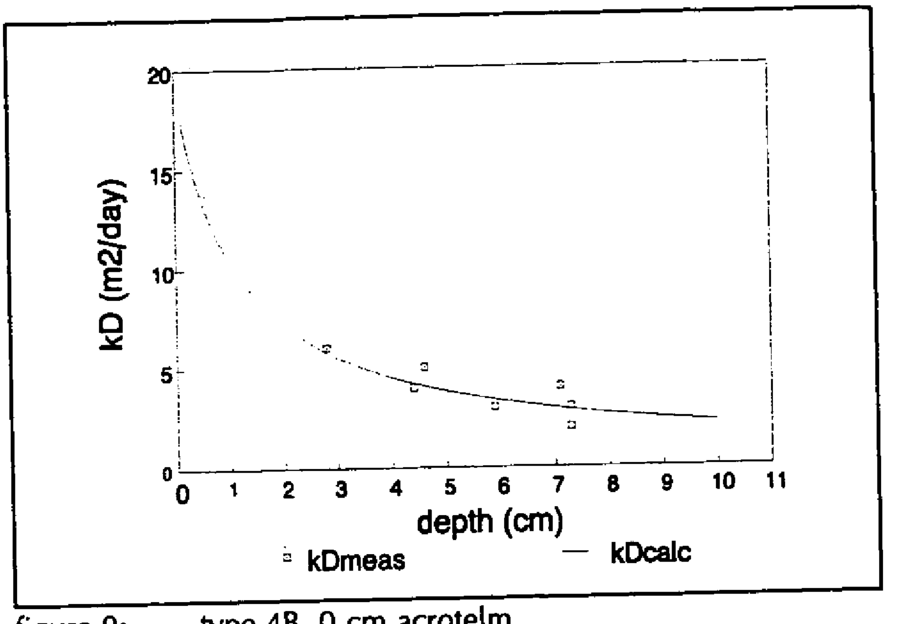


figure 9: type 4B, 0 cm acrotelm

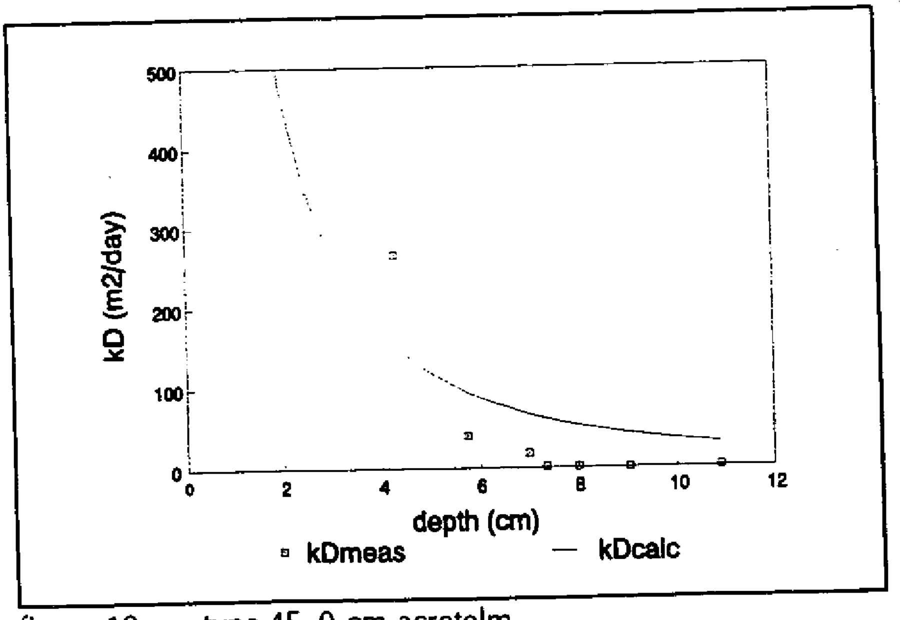


figure 10: type 4E, 0 cm acrotelm

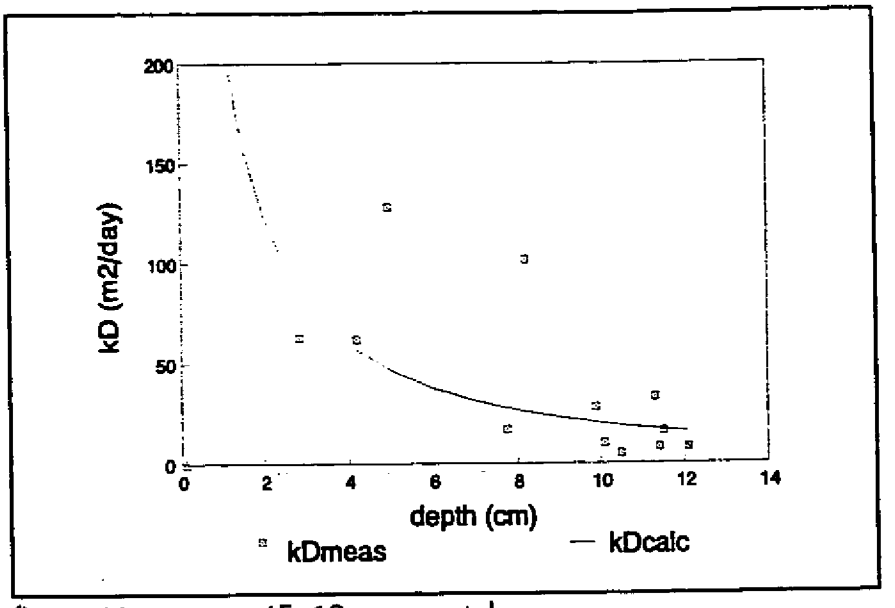


figure 11: type 4E, 10 cm acrotelm

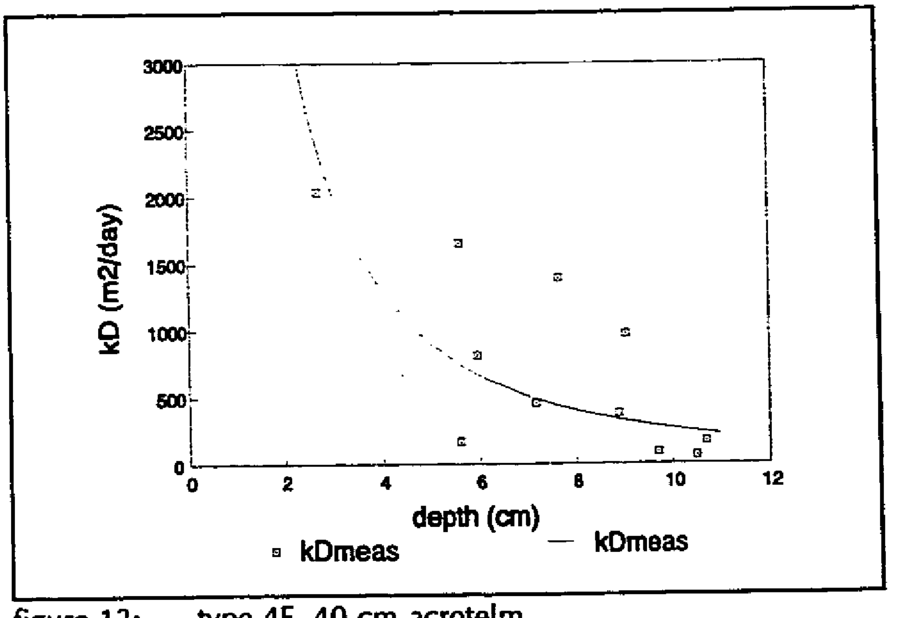


figure 12: type 4E, 40 cm acrotelm

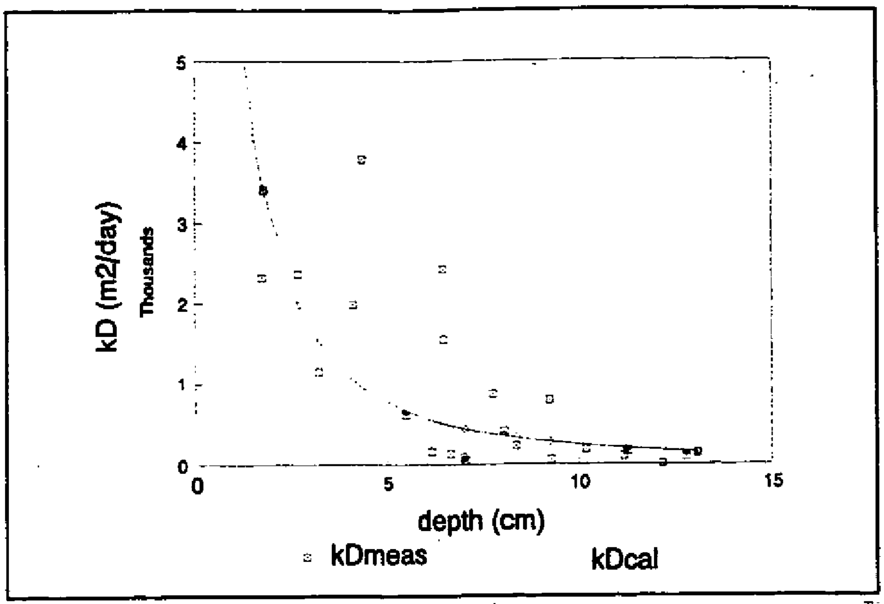


figure 13: type 9A, 40 cm acrotelm

APPENDIX XXII

Reservoir coefficients and the periods they are estimated for

periode : 05/01/91 (22:00) - 09/01/91 (12:00)

phreatic level (m. + O.D.)	reservoir coefficient (hrs)
58.450	150
58.449	93
58.448	84
58.447	110
58.446	238
58.447	136
58.444	155
58.443	667
58.442	437

periode : 29/01/91 (18:00) - 01/02/91 (08:00)

phreatic level (m. + O.D.)	reservoir coefficient (hrs)
58.409	235
58.410	383
58.412	452
58.413	900
58.414	235
58.413	172
58.413	136
58.412	286

periode : **12/04/91 (19:00) - 18/04/91 (11:00)**

phreatic level (m.+O.D.)	reservoirr coefficient (hrs)
58.464	373
58.465	76
58.464	74
58.463	62
58.462	54
58.461	61
58.460	94
58.459	92
58.458	100
58.457	79
58.453	89
58.451	102
58.450	115
58.449	134
58.448	329
58.447	96
58.445	143

periode : **29/04/91 (20:00) - 14/05/91 (11:00)**

phreatic level (m.+O.D.)	reservoir coefficient (hrs)
58.433	118
58.440	112
58.435	178
58.434	201
58.433	640
58.430	282
58.423	230
58.422	678
58.421	206
58.420	540
58.418	636
58.417	630
58.413	470
58.414	511
58.412	332
58.411	308
58.410	105
58.408	137

periode : 23/12/91 (19:00) - 25/12/91 (24:00)

phreatic level (m. + O.D.)	reservoir coefficient (hrs)
58.418	103
58.417	156
58.416	101
58.415	156
58.413	103
58.412	130
58.411	244

periode : 05/01/92 (22:00) - 07/01/92 (07:00)

phreatic level (m. + O.D.)	reservoir coefficient (hrs)
58.434	70
58.433	75
58.432	82
58.431	99
58.430	162
58.429	175

periode : 08/01/92 (18:00) - 14/01/92 (24:00)

phreatic level (m. + O.D.)	reservoir coefficient (hrs)
58.429	140
58.429	74
58.428	106
58.427	70
58.425	72
58.424	136
58.423	176
58.422	158
58.421	185
58.420	253
58.419	162
58.419	220
58.417	189
58.416	160
58.413	164
58.412	207
58.411	169
58.410	153

periode : 01/04/92 (18:00) - 05/04/92 (15:00)

phreatic level (m.+O.D.)	reservoir coefficient (hrs)
58.413	197
58.412	120
58.414	189
58.413	340
58.412	144
58.411	189
58.410	349
58.409	132
58.408	182
58.407	195
58.406	145
58.405	204
58.404	146
58.403	125

periode : 13/04/92 (02:00) - 13/04/92 (19:00)

phreatic level (m.+O.D.)	reservoir coefficient (hrs)
58.396	501
58.395	394
58.394	132

periode : 14/04/92 (20:00) - 16/04/92 (21:00)

phreatic level (m.+O.D.)	reservoir coefficient (hrs)
58.392	606
58.391	290
58.390	230
58.389	482

periode : 17/04/92 (01:00) - 18/04/92 (13:00)

phreatic level (m.+O.D.)	reservoir coefficient (hrs)
58.385	1743

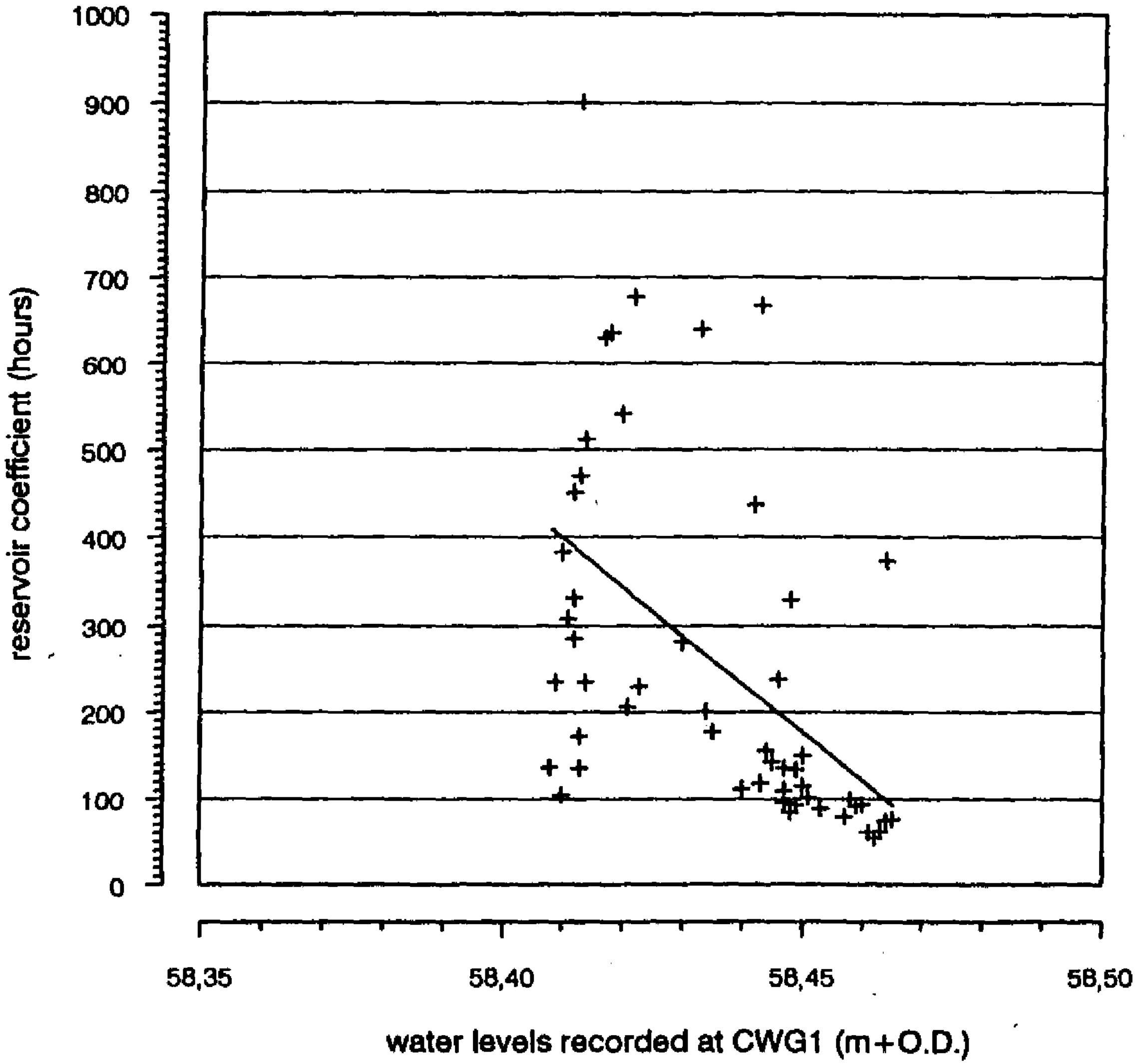
periode : 13/05/92 (13:00) - 14/05/92 (14:00)

phreatic level (m.+O.D.)	reservoir coefficient (hrs)
58.399	149
58.398	156
58.397	2152

APPENDIX XXIII

Reservoir coefficients vs. levels recorded at CWG1

January thru May 1991



Polynomial regression: (N = 52)

$y = a + bx + cx^2 + dx^3 \ldots$

a = 325094.7602188553

b = -5558.899259736

Variance of residuals = 30700.6768807936

Std. dev. of residuals = 175.2160862501

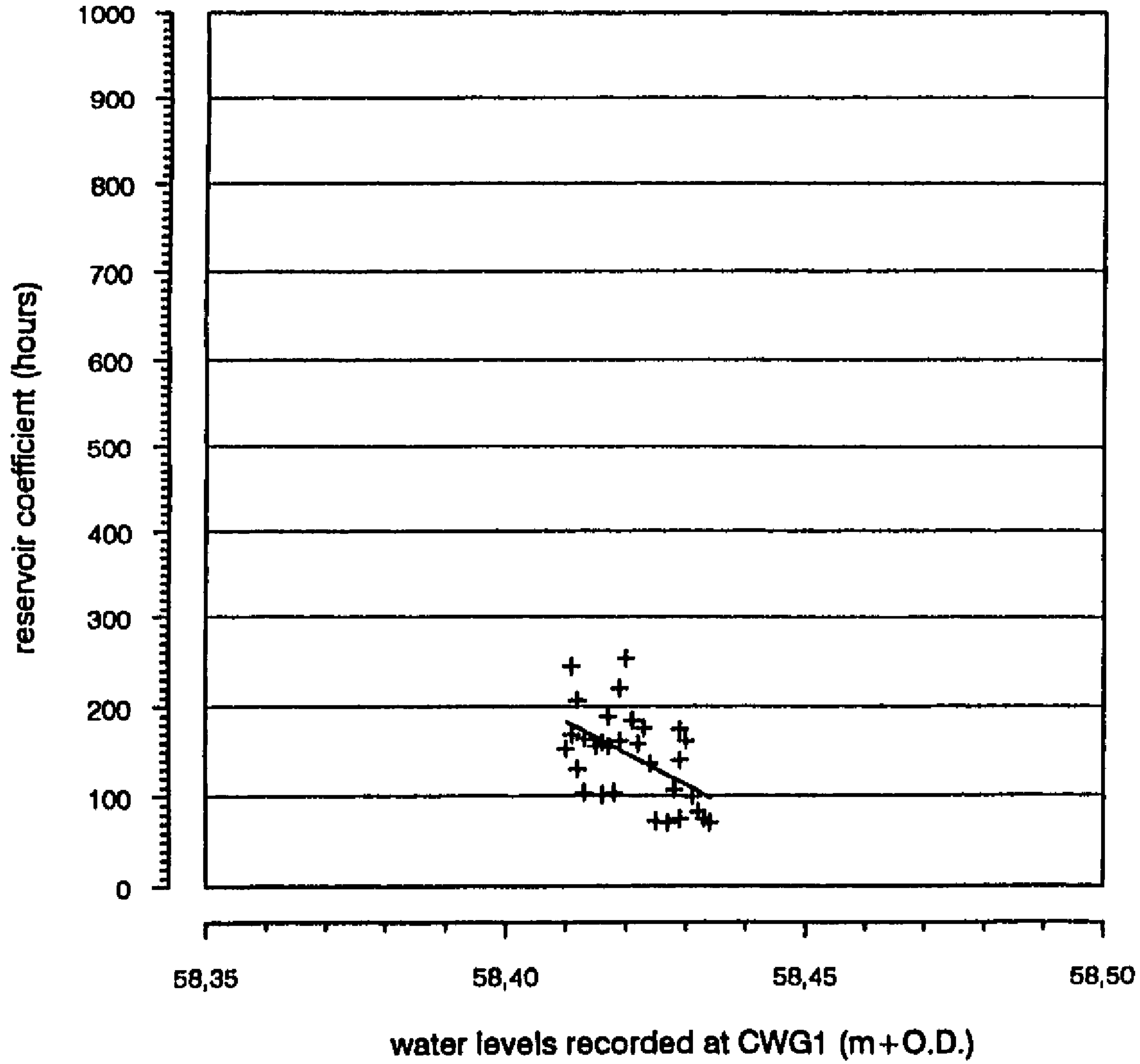
Correlation coefficient = 0.5186159058

df = 50

p = 0.022 %

Reservoir coefficients vs. levels recorded at CWG1

December 1991 thru March 1992



Polynomial regression: (N = 31)

$y = a + bx + cx^2 + dx^3 \ldots$

a = 210503.3353443965

b = -3600.7464129636

Variance of residuals = 1892.4307647188

Std. dev. of residuals = 43.5020777058

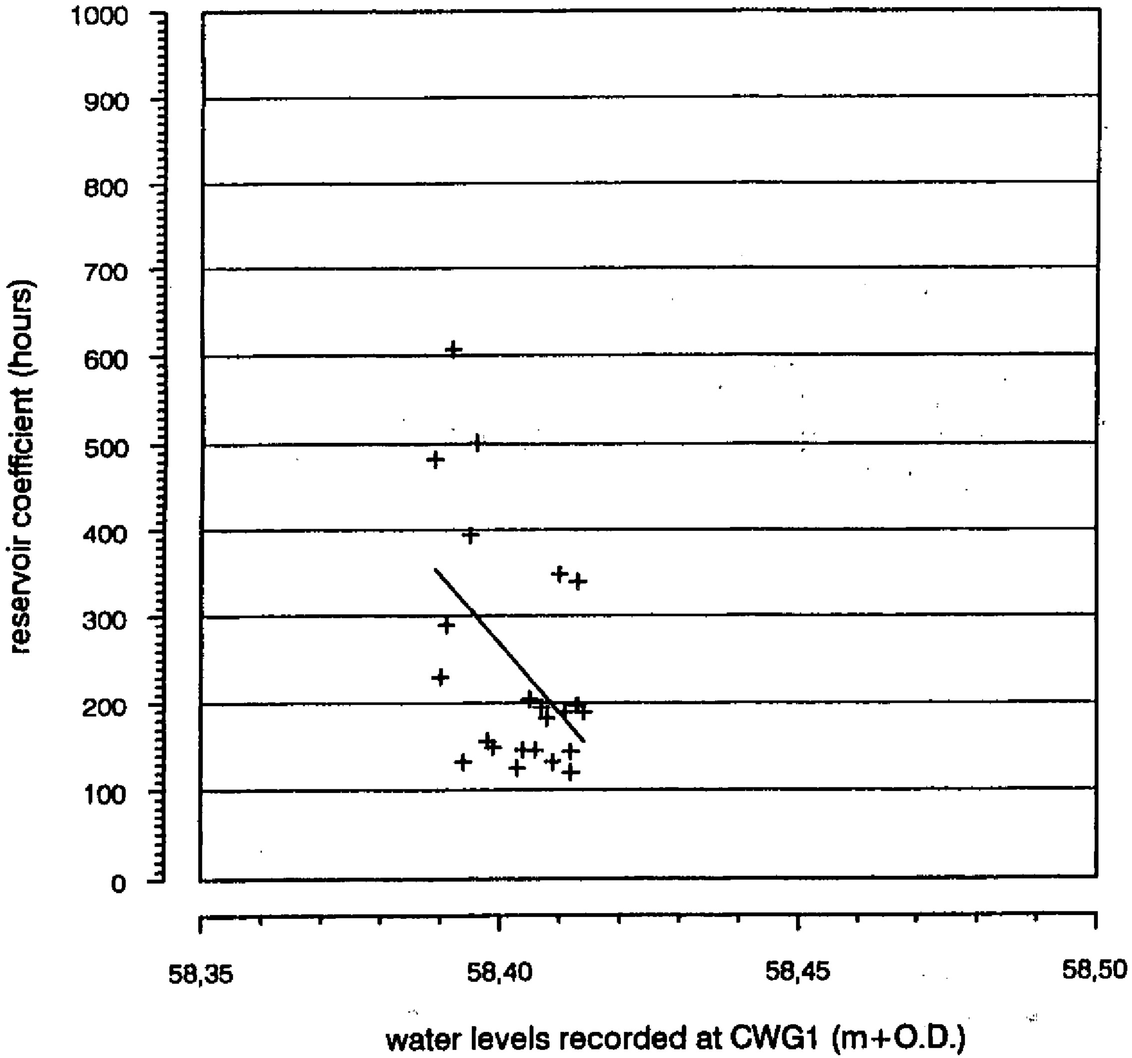
Correlation coefficient = 0.5252342981

df = 29

p = 0.272 %

Reservoir coefficients vs. levels recorded at CWG1

April and May 1992



Polynomial regression: (N = 23)

$y = a + bx + cx^2 + dx^3 ...$

a = 464761.5908887169

b = -7953.659083268

Variance of residuals = 14432.43745479

Std. dev. of residuals = 120.1350800341

Correlation coefficient = 0.4859675276

df = 21

p = 1.780 %