IRISH - DUTCH RAISED BOG STUDY

GEOHYDROLOGY AND ECOLOGY

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- Geological Survey of Ireland, Dublin
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GENERAL PROPOSALS FOR TECHNICAL MEASURES FOR THE CONSERVATION AND RESTORATION OF THE RAISED BOGS CLARA BOG AND RAHEENMORE

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

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June, 1994

CONTENT

1. INTRODUCTION

1.1. Occasion

In the "Irish-Dutch project on bogs" field reseach has yielded data that allow a diagnosis of negative effects occurring on the bog systems in Ireland. This information forms the basis for the formulation of technical measures to be taken in order to restore and conserve these systems. This document is a first attempt to propose such measures. It will focus on the options for restoration.

1.2. Aims of the document

This document provides technical principles and specifications for measures for restoration of acrotelm functions

1.3. Scope of the proposals

The research programme of the 'Irish-Dutch project on bogs' not only includes the high bog but also lagg-zones and soaks. The research on the latter two systems has not been concluded yet and it would be premature to formulate possible management measures for laggs and soaks. That will happen in a later phase of the project. At present management measures can only be proposed for those parts of the bog system of which the hydrological functions are sufficiently understood.

1.4. Problem definition

As a result of past efforts to drain sections of the high bog, of peat extraction at the bog margins and of drainage connected to the road across Clara Bog, the acrotelm, the upper peatlayer in which peatgrowth is largely regulated, is drying out in many parts of the bogs. Consequently, conditions for further peat growth are being affected. In the worst case this might lead to an irreversible damage to the acrotelm.

1.5. Summary

Chapter 2.	The acrotelm: peat growth regulation system, ecological and hydrological functions of the acrotelm are described.
Chapter 3.	Negative effects. Description of negative effects of drainage on the acrotelm.
Chapter 4.	Technical measures. Description of technical measures against the negative effects and a survey of data required in general and in specific cases.

2. THE ACROTELM: PEAT GROWTH REGULATION SYSTEM

A living bog can be defined as an organogenic ecosystem with peat forming plant communities which for their nutrient and water supply are completely dependent on precipitation. Bogs can only develop in areas where organic material can accumulate to levels over the original drainage base.

The acrotelm of a bog system is the upper peat layer in which the peat forming processes are largely regulated. The annual fluctuations of the phreatic water level occur within the reach of the acrotelm and as a result this surface layer is to a greater or lesser extent aerated. The presence of aerobic micro-organisms in the acrotelm induces a relatively quick decomposition of the organic matter. The depth of the acrotelm is dependent on the degree of humification near the bog surface and varies between 0.30 and 0.70 m. In an intact acrotelm the organic material is poorly decomposed (H2 to H4 according to research results of: ten Kate/van 't Hullenaar,1991; Sijtsma/ Veldhuizen, 1992; Kelly, 1992) and as a result the permeability is in general quite high. The vegetation types present on an intact acrotelm are generally dominated by Sphagnum species.
In a dried-out and strongly humified acrotelm (H6 to H8) the permeability decreases considerably. The phreatic water level shows larger fluctuations and is relatively low in the summer period. In such situations the vegetation cover often shows a high abundance of ling heather, whereas Sphagnum species play a less prominent role.

Normally the degree of humification in a bog increases rapidly at a depth of a few dm below the surface. Therefore, an intact acrotelm can be defined as a surface layer through which there is mainly lateral transport of water. Yhe acrotelm includes to a large extent the living biomass. In undisturbed situations Sphagnum species usually play a predominant role in the vegetation cover.

The plants belonging to the genus Sphagnum have a stem which continues to grow at the top while the bottom part of the plant (0.1 to 0.3 m below the capitulum) dies off. Sphagnum plants have no water conducting tissue and water and nutrients are directly absorbed by the weakly cutinized cells of leaves and stem. For non-aquatic species the water supply to the upper part of the plant is by means of capillary water transport. The dense network of intracellular and extracellular spaces in a Sphagnum carpet forms an efficient capillary pathway. Unlike a stand of vascular plants, there is no sustained supply of water to the surface of a Sphagnum cushion under strongly evaporative conditions. Under such conditions the larger spaces in the upper part of the cappilary pathway are emptied of water and further evaporation is temporarily halted (the "mulch-effect', Schouwenaars and Vink, 1989). Growth of Sphagnum mosses is therefore slow in the summer period.
Because of the capillary means of water supply, Sphagnum species are dependent on a high water table. A lowering of the water table of 0.2 m reduced the percentage of capillary water in a Sphagnum cover to less than 5 % (Romanov, 1968) which is at least ten times less then normal. Therefore, lowering of the groundwater table easily leads to the breaking of the capillary water stream which eventually leads to the death of the Sphagnum carpets.

3. NEGATIVE EFFECTS

Human interferences with the hydrology of bog systems usually aim at drainage. Drainage can affect the acrotelm functions as a result of water losses from the acrotelm or desiccation of the top peat layer. In the latter case the peat forming capacity of this layer can be irreversably damaged and no further peat growth takes place.
On Raheenmore and Clara Bog the following activities have resulted in drainage of parts of these bogs:

1. Superficial drainage upon the high bog.
2. Cutting and extracting peat from the bog margins, and digging of ditches in the cut-over areas.

On Clara Bog additional damage has been caused by:

3. Combined drainage effects associated with the road across the bog.

These negative effects will be described here.

3.1. Superficial drainage upon the high bog

Drains on the high bog are usually cut to lower the phreatic water table in the bog. Because of subsidence of the poorly humified peat as a result of drainage, the drains have to be deepened up to six times before the bog surface is dry enough to allow peat exploitation. The water content of the surface peat is lowered in this way from 90-95% to about 75% (Streefkerk and Casparie, 1992). The whole process takes about 18 months (comm. Bord na Mona). Such a drainage procedure damages the acrotelm irreversibly. Water losses result in a better aeration of the surface peat which leads to an increased rate of decomposition. The changes in the physical properties of the surface peat irreversibly affect the water storage capacity and larger fluctuations in the phreatic water level are the result. A continued water supply to the Sphagnum carpet is then endangered. A lowering of the groundwater table of 5-10 cm is often sufficient to break the capilllary water stream.

3.1.1. Superficial drainage on Raheenmore Bog

On the eastern part of the bog and near the southern margin of this reserve there are old drains which were cut a 100 to a 150 years ago. The drains on the eastern section have partly filled in with Sphagnum; the drains near the southern margin are still open.
The effects of the eastern drains can be seen from the fact that in this area the bog surface shows a hollow as a result of peat subsidence. Furthermore, there are no pools or hummocks, but there is a rather uniform vegetation cover. Interestingly enough, the vegetation still indicates to some extent a rather wet environment. This can be explained by the fact that water from the higher parts of the bog is now discharged into the subsided area. Furthermore, after the drains started filling in with Spagnum moss, the water table in the drained area would have risen again as the functioning of the drains became more and more impeded.
The drains near the southern side of the bog have resulted in a strong desiccation of the acrotelm as is shown by the presence of Molinea caerulea.

3.1.2. Superficial drainage on Clara bog

On the eastern half of Clara Bog in 1993/84 drains have been cut approximately every 15 m by Bord na Mona as the first stage in peatland development. When the bog was purchased for conservation purposes, this first phase in the drainage operations had been completed. The effects on the acrotelm and on the bog vegetation are not as severe yet as on part of Raheenmore because of the shorter time span during which drainage took place, but restoration measures are necessary. As there are also other reasons for desicccation on the eastern half of Clara, such as marginal peat extraction and past fires, no overall picture of the necessary measures can be given until all the research data will be available.

3.2. Drainage by marginal cutting

Cutting and peat extraction at the bog margin result in lowering of the phreatic water table in the marginal zone of the bog. This has a number of effects:

- Permanent structural changes of the peat. The porosity decreases which results in a further lowering of the average groundwater table and also in greater fluctuations of the water table.
- When the water table is lowered considerably, desiccation leads to irreversible structural damage to the acrotelm which then loses its peat-forming capacity.
- These processes are reflected by the vegetation which changes from Sphagnum-dominated communities to vegetation types dominated by Erica tetralix, Narthecium ossifragum and Scirpus cespitosus, and finally to Calluna-dominated communities.
- The lowering of the groundwater table results also in subsidence of the peat which increases the inclination of the bog surface towards the margin. The discharge of surface water increases, which then may cause a lowering of the groundwater table at a greater distance from the margin. Peat subsidence will, therefore, extend further into the bog until a new equilibrium has been formed. This equilibrium is probably also dependent on the extent to which the permeability of the peat decreases as a result of water losses. Near the margins the permeability may decrease considerably resulting in a substantial increase in drainage resistance.

These effects are accelerated when fissures are formed in the dessicating peat or when mass movement of the marginal peat takes place (peat sliding, slumping etc.).

3.2.1. Marginal cutting on Raheenmore Bog

The margins of the bog have largely been cut away. The width of the cut-away zone varies between 30 and 300 m (v. Tatenhove 1990). The depth to which the peat has been extracted varies as well and is among other things dependent on the depth of the mineral subsoil. At present the marginal facebank is 1.5 to 4.0 m over the peat surface in the cut-away. The bog margin shows locally extensive fissure formation and peat slippage. In the NW, the N and the SE, cut-aways extend locally over a considerable distance into the original high bog area.

3.2.2. Marginal cutting on Clara Bog

Up to about 1840 the bog had hardly been affected by peat extraction. After that date, peat cutting started, at first alongside the road across the bog but in the last 100 years peat was also cut at the southern, northwestern and eastern edges of the bog. Hundreds of hectares of bog were cut (v. Tatenhove, 1990; v.d. Molen, 1992). The margins of Clara Bog have therefore been much more damaged than those of Raheenmore. Only alongside the northern and southwestern margins is the situation comparable to that of Raheenmore. Peat stratigraphical research (Bloetjes, 1992) shows that the thickness of poorly decomposed moss peat layers decreases considerably over a distance of about 300 m towards the road. The same phenomenon is also found over a distance of about 200 m towards the southern edge of the bog as well as also in the northeastern section of the bog which has been seriously affected by peat cutting. The surface contour lines also give a clear indication of peat subsidence alongside the road and near the southern margin of the bog. Ecological and hydrological data are expected to confirm this picture. At present, the marginal facebanks have a height of 1.5 to 3.0 m. Locally, the bog margins show extensive fissure formation and indications of mass movement.

3.2.3. Drainage effects associated with the Clara Bog road

The road was constructed in 1838 (v.d. Molen, 1992). Since that time drainage has taken place alongside the road in a zone of about 250 - 300 m at each side, and from there some attempts were made to drain the bog at greater distances from the road. Peat extraction problably also started at that

date (Samuels, 1992). Also a 1884 map shows that peat had been cut in the drained zone alongside the road but that only a limited area at the southern side of the bog had been affected by peat cutting. About 90 years later (1973 map) the situation has changed dramatically and a large section of the southern half of the bog has disappeared as a result of peat extraction.
The management problems related to the road are from the hydrological point of view (Bell, 1991; Samuels, 1992) comparable to those of the marginal areas so that more or less the same type of research is being carried out alongside the road.

4. TECHNICAL MEASURES

4.1. General

4.1.1. Management strategies

The hydrological and ecological studies provide a sight into the functioning of the ecosystem and into the extent of damage to the system as result of human interference in the past.

Before a management strategy for the bogsystem can be devoloped, management strategies will have to be formulated in which the Wildlife Service indentifies its aims in maintaining e.g. restoring specific ecological values.

Next; physical and ecological constraints as well as political and financial limitations have to be taken into account in order to determine a practical management strategy which will than have to be translated into concrete technical measures (figure 1).

Figure 1: Overview management strategies and planning

a.	Abiotic information - acrotelm map - acrotelm conditions	Intergration	Biotic information - vegetation map - characteristics different plant communtities
b.	Desiccesion map		Physical and ecological constraints for management
c.		Formulation of management objectives	
d.	Political and financial constraints for management	Formulation of management possibilities	
e.	reseach for planning - detailed levelling - detailed peat-stratigraphy and humification degree - detailed work on watercontent of the peat at different dephts - indication of subsidence	Application of requirements translated into technical management measures	
f.		Management Plan	
g.		Execuution of the plan	

4.1.2. Data required

The ecological and hydrological research has provided insight into the distribution of the different vegetation types in relation to hydrological conditions of the bogs. Special attention has been given to botanical indications of peat desiccation. The data are summarized in:

1. A vegetation map which gives the distribution of the different plant communities.
2. Abiotic characteristics of the different community types:
   - duration lines for phreatic water level
   - characteristics of soil water chemistry
   - classification of acrotelm conditions.

3. A desiccation map based on the evidence just-mentioned, which gives a qualitative and quantitative assessment of the degree of desiccation of the acrotelm.
4. A study of the water balance of the bog system, which will in a general sense provide insight into the water discharge of the bog. Critical factors can then be identified in order to set priorities in reserve management.
5. A study of the relation between phreatic water level and drain water level (in three plots on Clara Bog-East) for different vegetation types indicating different degrees of desiccation. This study will give indications of different types of field situations from which restoration measures will have to proceed.
6. A study of ecological conditions for the restoration of Sphagnum-growth, based on evidence in surface drains which have been blocked earlier.
7. A study of physical, hydrological and ecological conditions in relation to peat subsidence and inclination of the bog surface.
8. A detailed view of the levels (above O.D.) of those stretches of bog where dams are planned.
9. A deatailed view of the peat stratigraphy in the marginal areas of the bog. The report by Bloetjes does not provide sufficient data on the marginal bog sections.
10. A study of the specific conditions alongside the road across Clara Bog, e.g.:

    - the peat stratigraphy alongside the road
    - the degree of peat subsidence alongside the road
    - gradients in transmissivity and water content of the peat, both horizontally and vertically, in a zone alongside the road.
    - gradients in phreatic water level towards the road.
    - inclination of the bog surface, condition of the acrotelm and vegetation types present in a zone alongside the road.
    - plan for raising the drainage level of the ditches alongside the road by installing weirs or partial blocks (see report Samuels).

4.1.3. Specific measures

Plan principles:
Possible measures are directed towards raising the phreatic watertable in those parts of the bogs where the acrotelm function has been damaged. It is expected that the acrotelm function can be restored in many places, provided that the phreatic watertable is adjusted at the correct level. A rise of the watertable in the bogs can be effectuated by various hydrological "management-measures". These measures are finally based on the use of peat as the raw material for construction of the hydrological infrastructure. Depending on the character of the negative effects described in paragraph 3, specific approaches are necesserary.

Technical approach:
- In the case of drainage by superficial drains (see 3.1) the phreatic watertable in the acrotelm should be restored by blocking the drains.
- In the case of drainage by marginal cutting (see 3.2) the phreatic water table in the bog

margins should be restored by building dams or a hydrological bufferzone. In addition hydrological measures should be taken in the cut-away areas such as blocking of ditches in order to restore the groundwater table. The hydrological measures in the cut-aways will also depend on possible restoration objectives of parts of the former lagg-zone.

- In case of drainage effects associated with the Clara Bog road (see 3.3) the same kind of measures are required as in the case of marginal drainage. The possible scope of such measures depends on evidence which is yet required from research.

4.2. Blocking drains on the high-bog

4.2.1. Data required

In order to assess the effectiveness of blocking drains for the restoration of acrotelm functions, general data as mentioned in 4.12. numbers 1, 2, 3 and 6 will be necessary. An operational plan for the drainblocking also requires specific technical data. These are:

- A surface contour map (both for the high bog and for the cut-aways) which provides information on the relief of the bog surface. It forms the basic map from which location and density of drain blocks will be determined.
- A map showing the drain pattern.
- Information on the composition, the degree of humification and the water content of the surface peat layer will be required in order to determine the usefulness of the local peat for the drain blocks. The humidity of the peat will also determine in what way the operation will have to be executed, either by hand or by machine.

4.2.2. Technical principles

Plan principles:

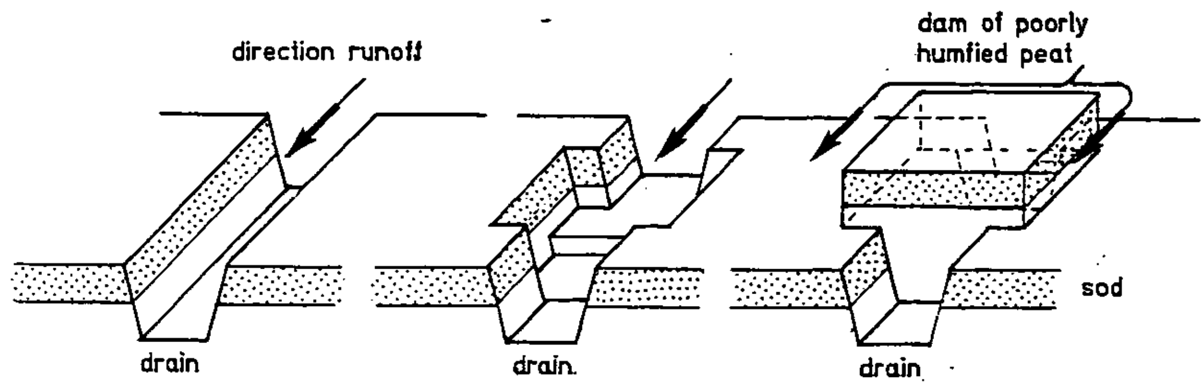
- The number of drain blocks required depends on the relief of the bog surface. In general the number of blocks will increase towards the margin of the bog. The surface contour map will be an essential tool in this respect since on the basis of this map flow directions and water catchments can be indicated which will determine density and location of blocks. Logically the blocking of drains should proceed outwards from the centre of the bog in order to prevent increasingly wet working conditions during the operation.
  By distinguishing different catchments, the work can be separated into different units.
- The difference in water level between the successive blocked compartments should not be more than 0.10 m considering the preconditions which apply to the functioning of the acrotelm.

Technical specifications:

- For blocking drains on the bog, weakly humified Sphagnum peat can be used which can be locally obtained. The top 0.3 m of peat is not suitable because its permeability is too high. If the material is not obtained from the drain itself the holes formed by removal of peat for the drain blocks should be deep enough to contain water all over the year round (otherwise the recolonization by Sphagum species will be slow or absent). A depth of at least 0.4 m would be required possibly even more, depending on the results of the Sphagnum recolonization study; see 4.12., number 6.
- The best results will be obtained when freshly cut peat is put against fresly cut peat. This would mean that the surface layer of peat will have to be removed from the sides of the drain at the site where the block will be inserted (fig.2).
- This procedure prevents leakage of water alongside the block and it also prevents peat erosion.
- The blocks will have to reach to just over the bog surface and will have to be covered with sods.
- It is clear that the drain-blocking operations should take place in the driest part of the year, i.e. the summer period.

- Depending on the humidity of the top peat layer a choice will have to be made between manual or mechanized operations. The decision should be taken by the reserve manager in consultation with an expert from Bord na Mona. The expert will also have to decide on the type of machinery to be used.

Figure 2: Construction of a dam in a drain



Follow-up and maintenance:
After the blocks have been inserted it will be necessary to check in periods with high precipitation whether the blocks are functioning properly. Blocks which are not functioning adequately will have to be repaired or replaced. This follow-up maintenance will take several years; thereafte intermittant maintenance will be sufficient.

4.3. Building dams along the bog margins and closing ditches

4.3.1. Data required

Cut-aways:
- The extent of the cut-aways. Furthermore, depth and composition of the remaining peat has to be known (this will also determine the usefulness of the peat for the construction of peat dams)
- The original location and level of the bog margin. This boundary is of importance when one attempts to restore as far as possible the original hydrology which was based on a domed bog surface.
- The level of the present margin of peat deposits, its distance to the facebank and the height of the facebank, which determine the number of dams which will have to be constructed in the marginal area of the bog. Such information should, therefore, be available.
- The areas and spots where the mineral soil has been laid bare as a result of peat extraction or digging of ditches. These are the sites where downwards seepage may occur and where the hydraulic head in the mineral subsoil may have been lowered.

Bog margins (Facebanks):
- A survey of marginal areas showing fissures and mass movement has to be made.
- As to fissures, two different types should be distinguished:

  . formation of fissures as a result of desiccation processes
  . formation of fissures as a result of mass movement

When such indications of instability occur in connection with high facebanks, additional management measures will be needed to counteract further peat movement.

If facebanks cut through Sphagnum cuspidatum deposits, the extent of such layers will have to be determined in order to assess whether there is a chance of future mass movement.

Ditches in the cut-away areas:

- A map with the ditch pattern in the cut-aways, their size and depth, as well as flow directions (for winter period). Indication of the specific discharge, by visual appraisal (e.g. zero, low, moderate, high). This gives an indication where most of the discharge occurs, which is important for the decision where to block the ditches. Furthermore, a piezometric surface map of the mineral soil will be required to determine the relation with the regional ground water.

4.3.2. Technical principles

Plan principles:

a. Dams

- Depending on the degree of desiccation of the bog margin, the extent of fissures present and the degree of peat subsidence, decisions will have to be made concerning the types of measures necessary to prevent further water losses and peat subsidence. It may be necessary to construct dams of stongly humified peat and in particular cases of weakly humified peat in order to repair the damage to the bog margin. Such dams not only counteract further desiccation and peat subsidence, they can also be used to decrease the slope of the marginal zone in order to restore acrotelm conditions. Eventually peat growth may even be started again. It is important that the construction of dams does not have a negative impact on the more central parts of the bog, for instance by causing stagnation of water or inundation in the undisturbed parts of the bog.

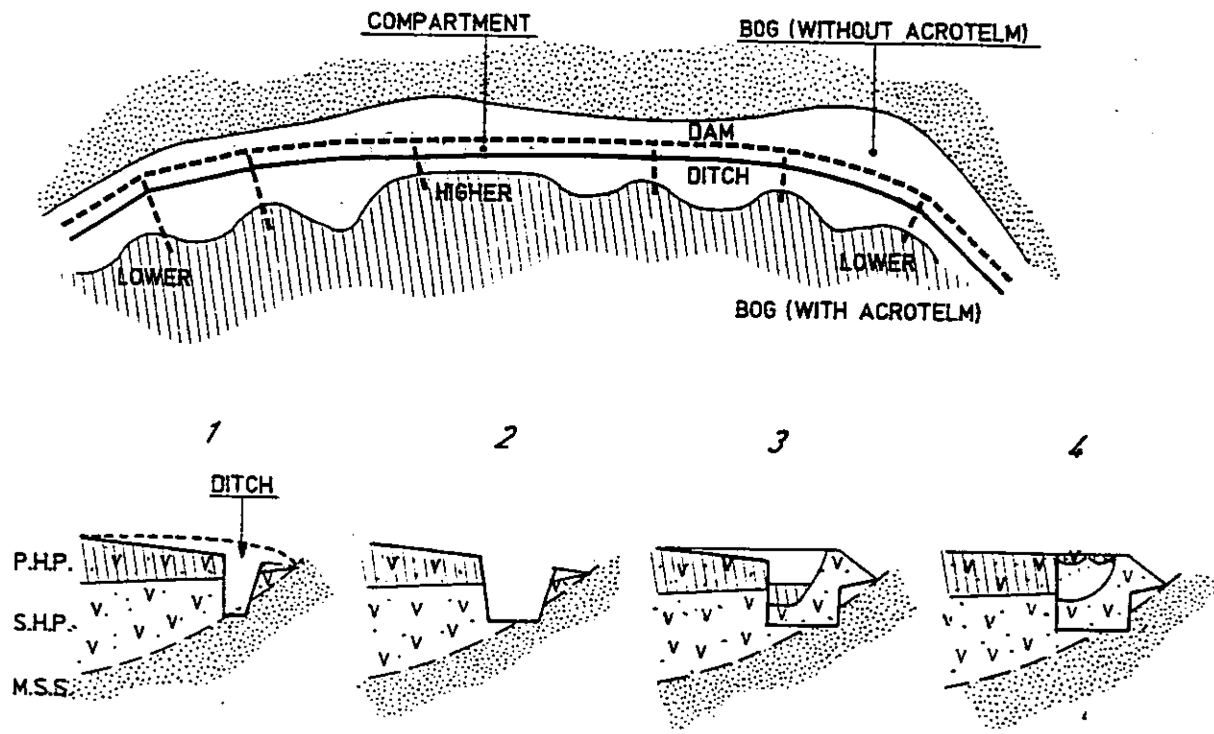
- When there is a high incidence of fissures, a dam of strongly decomposed peat should be put against the facebank to provide counter-pressure and prevent further mass movement. If layers of Sphagnum cuspidatum are present, the extent of such layers determines the size of the dam.

b. Closing ditches

- In the cut-aways and in the extent of the former lagg-zones, ditches will largely have to be filled in or blocked. This would also mean that the reserve should be extended in such a way that it becomes independent of agricultural drainage requirements.
- Within the extent of the peatland, the ditches will have to be filed-in or blocked with strongly decomposed peat. Different measures may be necessary in this respect depending on the field situation:
  - If the marginal ditch cuts through an uncut section of the bog, this will have resulted in peat subsidence. The measure which requires the lowest amount of peat, will be the construction of a dam of strongly decomposed peat alongside the ditch (on the side furthest away from the centre of the bog). The proposed reconstruction of the bog relief will then determine the height of the dam. A deailed levelling of the stretch of bog on which the dam is projected, will be required. At both ends of the dam the ditch will have to be blocked with strongly decomposed peat (see figure 3).
  - If ditches cut through to the mineral subsoil, the local hydrology can be restored by bringing a layer of strongly decomposed peat into the ditch. This will prevent further downward or upward seepage. The top of this layer should be one meter above the local peat base of the bog.
  - If ditches do not cut into the mineral subsoil, they just need to be blocked.
- Location and number of blocks can be determined using the discharge and levelling evidence. The number of blocks wil be highest in non-level areas. In such areas the exact location of blocks should be based on detailed leveling, especially towards the edge of the

cuttings.

Figure 3: Construction of a dam along a marginal ditch



Legend:

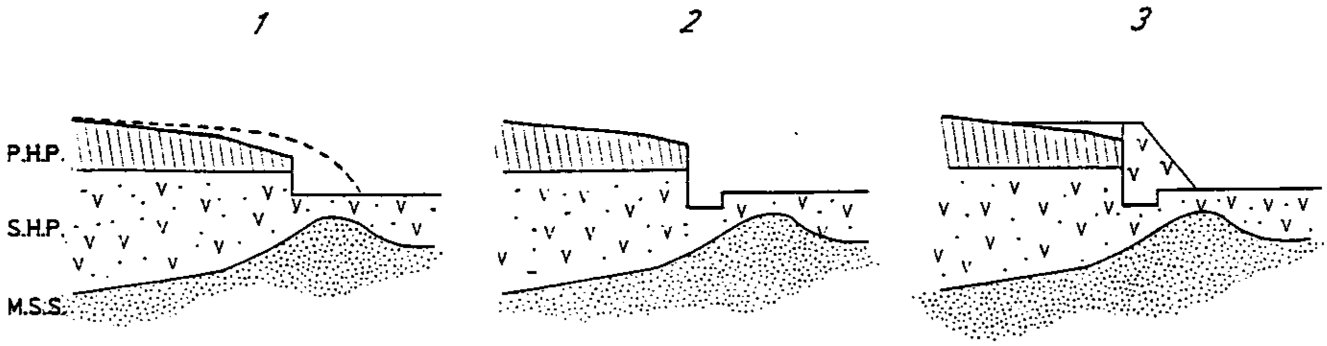
P.H.P. = poorly humified peat
S.H.P. = strongly humified peat
M.S.S. = mineral subsoil

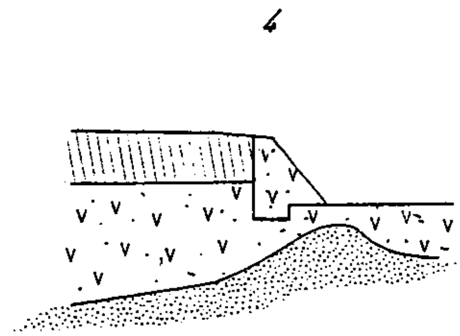
Technical specifications:
There is a difference in the use of dams consisting of poorly or strongly humified peat.

a. Dams of strongly humified peat

Such dams serve a function in retaining water and can only be used in the most marginal sections of the bog. The dams have to be constructed on a base of strongly humified peat in order to guarantee a proper grounding. They show little swelling and shrinkage under different moisture conditions.
After the installation of such a dam, the water level will at first rise to the level of the dam, but later the the top peat layer (if not too strongly decomposed) will start to swell to that level (Fig.4.). Again the excact levels above O.D. of the area where the dam is planned need to be known. Furthermore, the peat stratigraphy should be known as well as the water content of the peat on which the dam is projected. A dam can only be built on a base of peat with a humification degree over 5 (on the van Post-scale and a water content of less than 80 %.. If such a situation does not excist in particular marginal stretches of the bog , the dam will have to be built in the cut-away.
When there is a strong relief in the mineral subsoil and the cut-away is rather narrow, then the base of the dam can be constructed in such a way that it makes contact with the mineral subsoil (Fig.5.).

Figure 4: Construction of a dam of strongly humified peat in the marginal zone of the bog

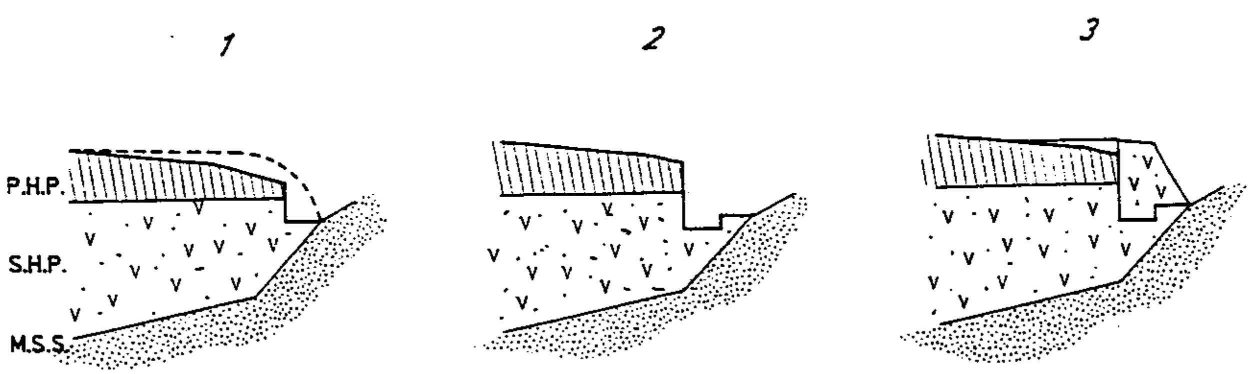


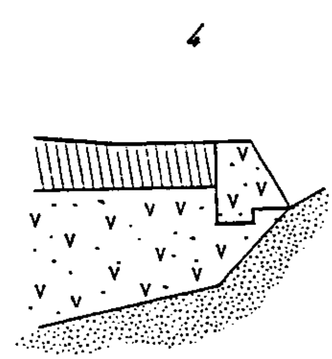


Legend:

P.H.P. = poorly humified peat
S.H.P. = strongly humified peat
M.S.S. = mineral subsoil

Figure 5: Construction of a dam of strongly humified peat over a strong relief in the subsoil





Legend:

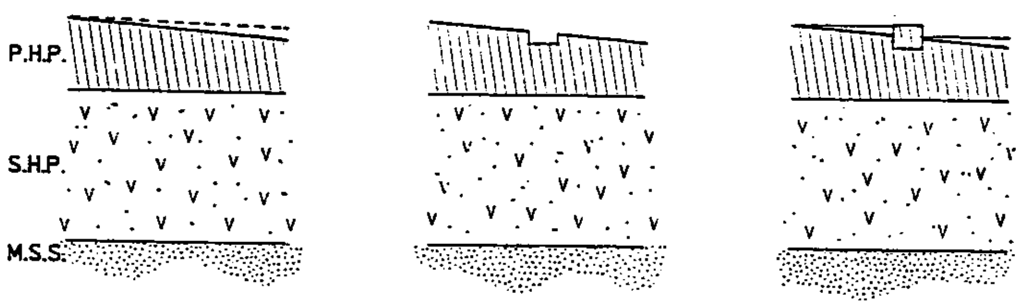
P.H.P. = poorly humified peat
S.H.P. = strongly humified peat
M.S.S. = mineral subsoil

On the basis of economic and of nature conservation considerations it will have to be decided where the peat to be used for this type of dam should be obtained. Possibilities are bog remainders in the vicinity of the reserves. It will be necessary to obtain an indication of the amount of ~~3 m~~ peat needed for the ~~top of~~ dam construction.

b. Dams of poorly humified peat

Dams of poorly humified peat are not suitable for the most peripheral sections of the bog but are to be constructed more to the interior of the reserve. The dams can be used in combination with polythene foil which is inserted into the dam as it is being constructed. Such dams are particularly suited for situations where the level of the bog surface is expected to rise considerably through swelling of the top peat layer after rewetting. A surplus length of foil is inserted and wound around a board which is then placed on top of the dam. With the swelling of the dam, the foil is extended (Fig.6.).

Figure 6: <u>Construction of dam of poorly humified peat</u>



Legend:

P.H.P. = poorly humified peat
S.H.P. = strongly humified peat
M.S.S. = mineral subsoil

4.4. Measures alongside the road across Clara Bog

4.4.1. Data required

The effects of peat subsidence and drainage, both hydrologically and ecologically, will have to be known. Also a fair idea of the orginal level of the bog surface, prior to the construction of the road, should be available.

4.4.2. Technical principles

Basically, the same measures can be used as in the case of the bog margins. The principles for the use of dams of strongly and weakly humified dams do also apply. It is important to note that there is the possibility of a change of direction of the discharge into a more southerly course. This requires additional management measures which should be evaluated in relation to the management measures needed at the southside of the bog. The drainage level of the ditches alongside the road should be raised as far as possible by partial blocks or weirs.

Finally, it should be remarked that before embarking upon technical restoration measures one should be very clear of the conservation objectives and of the technical implications.

5. MONITORING

In order to determine the effects of the technical measures in a management strategy a monitoring program will have to be set up (which in part will be the continuation of already existing monitoring program).
In such a program monitoring is necessary of:

- phreatic groundwatertable
- ratio precipitation/runoff
- level of bogsurface (installation of benchmarks)
- changes in vegetation

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