A Bog Flow at Bellacorrick Forest, Co. Mayo

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Summary

A bog flow occurred in mid-July, 1988 at Sheskin property, Bellacorrick forest which affected an area of 2.4ha of blanket peat planted with lodgepole pine. Over much of the area the bog was completely removed down to a basal, greasy peat layer. The lower, softer layers flowed over this material and carried the upper, firmer layers downslope. This pattern is very similar to other bog flows which have occurred in the same region.

It is suggested that the exceptional weather of May, June and July contributed to the flow together with the lack of collector drains which left the peat soft and saturated. These factors, together with a topography which predisposed the bog to movement, initiated the flow.

Collector drains placed at sufficient depth and intensity should be sufficient to prevent similar occurrences.

Keywords: Bog flow, blanket peat, ploughing, peat strength.

1. BACKGROUND

Bog flows and slides have been recorded on a number of occasions in Britain and Ireland (Carling, 1986; Tomlinson, 1981). Bog flows refer to slides where peat from lower, softer layers becomes semi-liquid and flows out from under the overlying firmer, less humified top layer. Bog slides occur where intact blocks of peat move down slope with no outflowing of softer peat. Both types have been recorded in Ireland (Tomlinson and Gardiner, 1982).

The most widely known bog flow in Ireland occurred on the 29th December 1896 near Killarney, Co. Kerry (Praeger and Sollas, 1897) and resulted in large scale damage.

Bog flows have been recorded in North-West Mayo on a number of occasions. In 1931 a flow occurred at Glencullin near Glenturk (Delap et al., 1932) which resulted in some damage to property and loss of livestock. More recently, in 1985, a flow occurred at a site 8 miles east of Belmullet which caused damage to a county road (Shevlin, 1988). Both flows occurred on unplanted ground. Other flows have very likely occurred

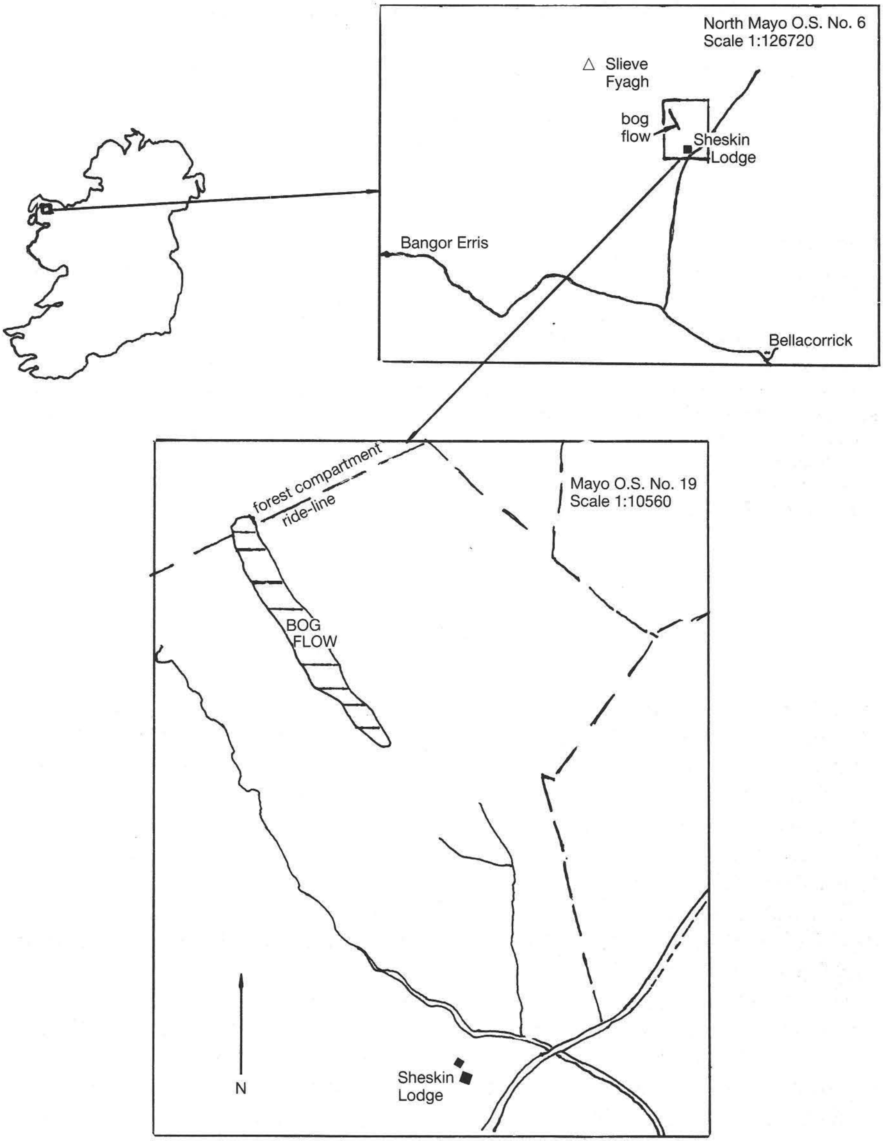

Figure 1: Flow location and extent

in the years between the two recorded. Two further flows have occurred on lands owned by Coillte Teoranta in the same region in recent years. One was at Glenlossera property, Ballycastle forest in December 1986 and the other at Sheskin property, Bellacorrick forest in July 1988. This paper refers to the latter event.

2. SITE

2.1 Location:

The bog flow occurred at Sheskin property, Bellacorrick forest about 1200 m north-east of Sheskin Lodge (national grid reference F 94 27). While it was largely confined to compartment 81617U, a small portion of the head extended into compartment 81614M (Figure 1).

2.2 Extent

The flow extended for 340 and 270 m above and below the forest road as shown in Figure 1. It had an average width of 45 m and altogether an area of about 2.4 ha was affected (Figure 2).

2.3 Topography:

The site slopes to the south-east at an angle of 3°, apart from two discontinuities where the slope increases to 7° (Figure 3). A 1500 to 2000 mm deep layer of blanket peat covered the site before the flow (Figure 4). The basal peat layer is about 100 mm thick and is firm and greasy.

Figure 2: General view of the flow area, looking southeastwards from the head of the flow.

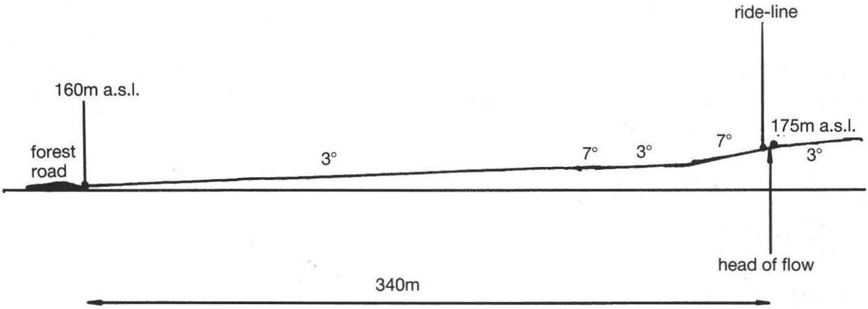

Figure 3: Diagrammatic cross section of area of flow *above* forest road.

2.4 Establishment methods, crop and vegetation:

Tunnel ploughing, running in the direction of maximum slope, was used in compartment 81617U where most of the flow occurred, which was planted in 1980. Double mouldboard ploughing (DMB), running in the same direction, was used in compartment 81614M, which was planted in 1982 (Figure 6). The bottom of the tunnels are from 80-90 cm deep.

Figure 4: Peat depth about 1.7m (near forest road) – rod is 1.5m high and is resting on bog floor.

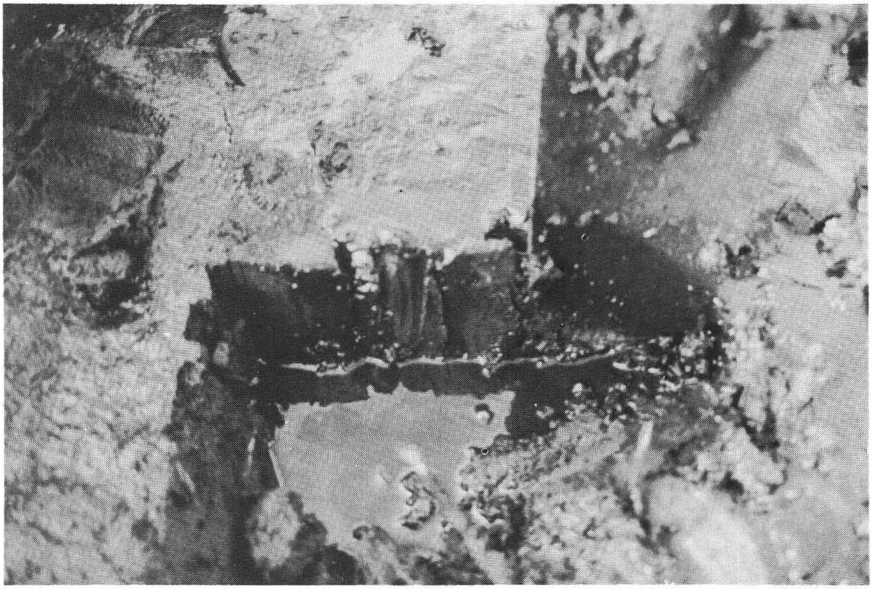

Figure 5: Basal 'greasy' peat layer over which flow moved (about 100mm deep), the object at the top right is a spade.

Both compartments were planted with lodgepole pine which had reached a height of about 2.5 m. The vegetation consisted of a dense sward of *Molinia caerulea.*

3. FLOW DESCRIPTION

The flow occurred sometime between the 15th and 22nd of July 1988. The head of the flow is located in compartment 81614M. As the head of the flow is almost always the point of initiation (Rodgers, 1988), it can be reasonably concluded that the flow began at this point and continued downslope. At the head of the flow lateral and longitudinal tears can be seen in the double mouldboard furrow bottoms (Figure 7). The head of the flow coincides with the 40m long break in slope shown in Figure 3.

As the peat moved down slope the more amorphous, less cohesive peat below a depth of 600-700 mm flowed out from under the fibrous top layer, which broke into large blocks from 500 to 3000mm in diameter. The flow continued downslope to the forest road where its momentum must have been checked as the affected area below the road is depositional only and no peat has been removed. This pattern of movement is very similar to that described by Delap et al. for the 1931 flow at Glencullin.

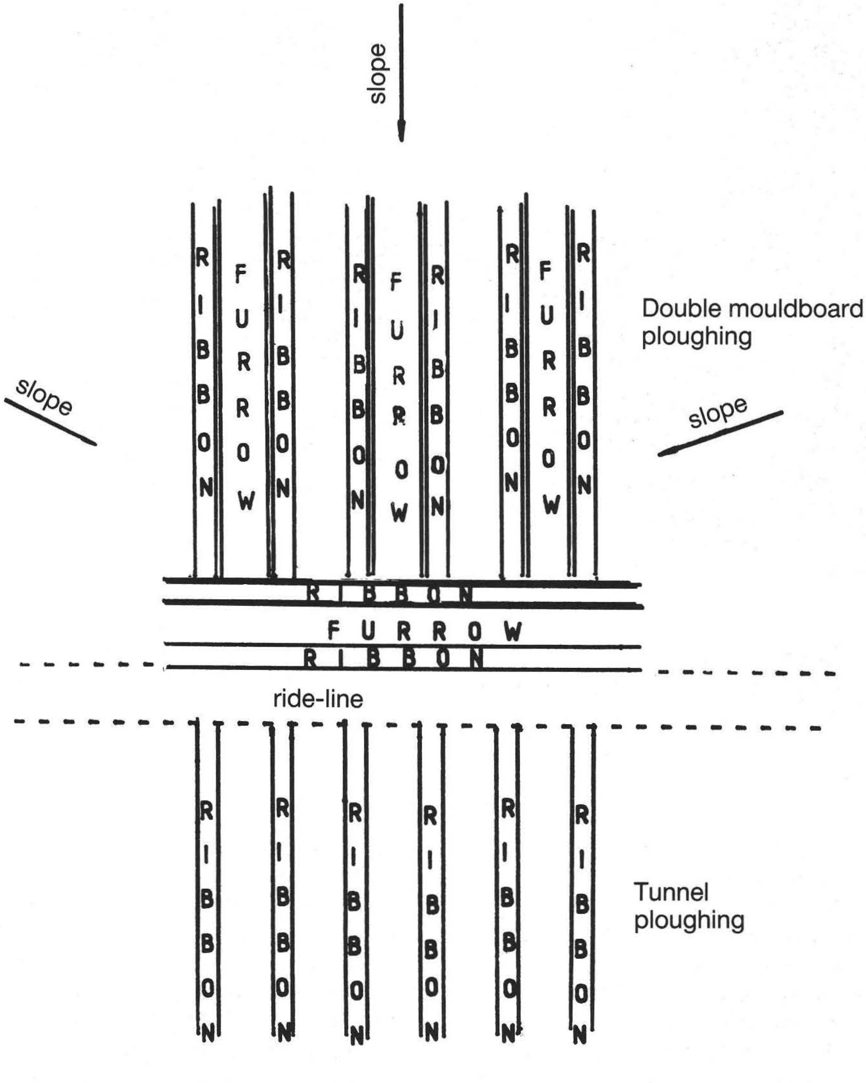

Figure 6: Ploughing layout at head of flow.

Figure 7: Lateral tears in bottom of DMB furrow immediately above head of flow.

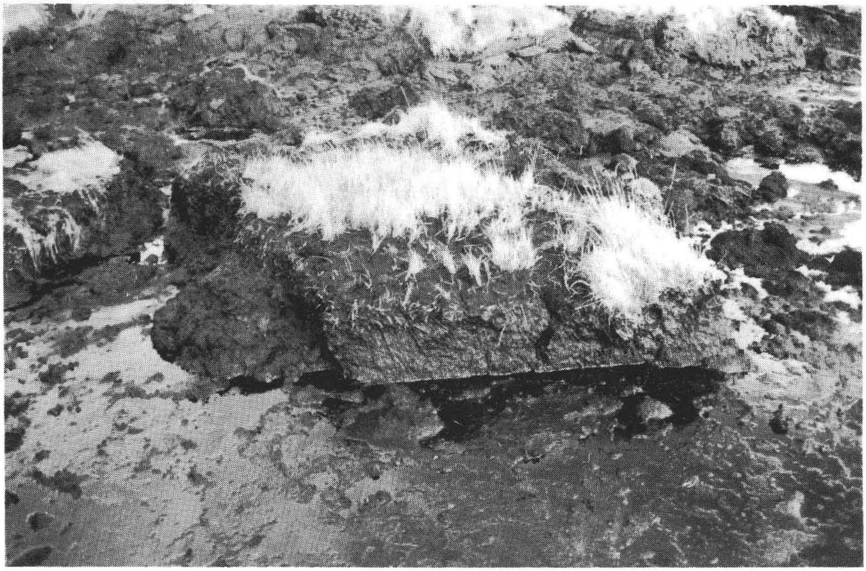
Figure 8: Blocks of solid peat resting on semi-liquid peat.

Above the forest road all of the peat has been removed above the firm greasy basal layer. The latter was very slippery and difficult to traverse. In places the peat was redeposited with solid blocks of peat resting on soft semi-liquid material (Figure 8).

In the tunnel ploughing area 2000mm wide blocks of peat, coinciding with the tunnel runs, were sheared off and moved down-slope. This explains the straight edges of the flow shown in Figure 1. The loose peat material moved downslope with considerable force as blocks of peat were uplifted at several points along the western edge of the flow (Figure 9).

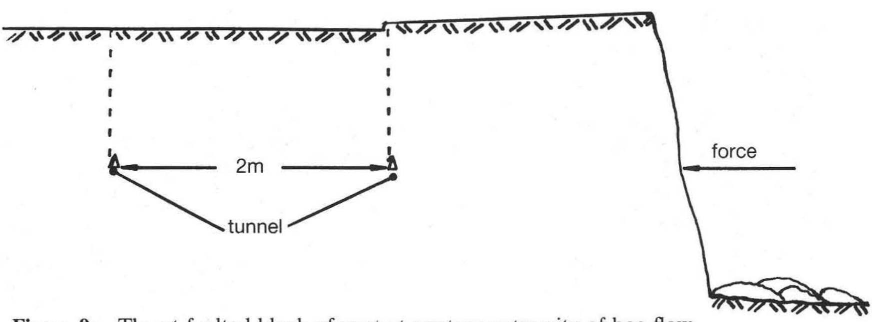

Figure 9: Thrust-faulted block of peat at western extremity of bog flow.

Water was flowing from the head of the flow on the 10th November, 1988 even though a cutoff drain had been installed above the head after the flow had occurred.

An area of 2.5ha was affected but only in the area above the forest road, 1.5ha, was peat removed. Given an average peat depth of 1750mm this represents a volume of 27,000m^3 or about 28,000 tonnes of wet peat. This amount of material could cause considerable damage to structures in its path.

4. CAUSES

4.1 Ploughing and drainage:

As stated above, the flow in all probability began in the double mouldboard ploughing area in compartment 81614M. The plough furrows, which run down-slope, carry considerable volumes of water as they are bare and free of vegetation, particularly near the break in slope which coincides with the rideline (Figure 2). These were not connected to any collector drain and ended at two double mouldboard furrows which ran across them at right angles. This resulted in ponding of water above the rideline and discharge across it following heavy rain.

The tunnel ploughed area was crossed by two collector drains. These were not deep enough to collect water coming downslope in the tunnels. In the area adjacent to the flow they were full of *Sphagnum* and tufts of *Molinia*. In effect these drains collect no water. During heavy rain it is probable that the tunnels became full of water and pore water pressures built up, as a result of the increased head of water. These pressures would increase with depth.

4.2 Weather:

Bog flows and slides are associated with periods of heavy rain or thunderstorms. Prior to flows that occurred in Antrim in 1981, 97 mm (4 inches) of rain fell in threequarters of an hour (Tomlinson and Gardiner, 1982). Carling (1986) reported on bog slides in the Pennines following a rainstorm of similar intensity.

Rainfall data for May, June and July are presented below for the two nearest Meteorological Service stations at Belmullet and Glenamoy (Table 1). May and June were particularly dry months at both stations. At Glenamoy, for instance, during June there was a 26 day period from the 4th to the 29th when only 13.5mm (½ inch) of rain fell. Only 46.5mm fell in the full month (58% of average). Such a long dry spell during May and June would result in considerable drying of the surface peat. This could have opened cracks in the furrows where water could move rapidly to the soft lower peat, particularly at breaks in slope. In relation to the Pennines slides, Carling states that there was a 28 day antecedent period with only 15.8 mm of rain.

Table 1: Rainfall amounts for Belmullet and Glenamoy, May-July 1988.

DATE	MAY B*	MAY G*	JUNE B	JUNE G	JULY B	JULY G
	mm					
1	4.6	1.4	1.2	2.3	7.6	4.5
2	1.0	0.1	1.7	4.5	9.0	8.5
3	–	–	5.6	5.5	–	1.5
4	0.1	0.6	0.1	–	2.8	4.0
5	0.1	–	0.4	–	12.7	14.5
6	–	–	5.1	5.0	2.0	7.3
7	–	–	–	–	7.1	6.6
8	–	0.1	–	–	1.8	0.5
9	2.3	1.7	–	–	10.7	19.7
10	4.8	0.8	–	–	8.1	6.5
11	–	4.1	–	–	1.4	1.4
12	3.2	4.5	–	–	11.6	10.2
13	0.5	0.1	–	–	–	0.9
14	–	–	–	–	0.1	0.2
15	–	–	–	–	0.7	0.2
16	–	–	0.1	–	2.0	3.0
17	–	0.5	–	–	0.2	–
18	1.1	4.5	–	–	3.1	5.5
19	1.6	0.1	–	–	0.3	–
20	0.1	–	2.9	4.0	3.3	6.0
21	–	–	0.5	–	5.3	4.0
22	–	–	–	–	0.4	–
23	7.1	5.2	–	–	7.9	5.0
24	13.2	8.8	0.2	–	14.9	18.0
25	9.4	2.5	1.1	1.2	8.6	13.0
26	2.1	2.8	0.2	–	1.6	3.0
27	5.0	11.0	–	–	0.6	2.1
28	2.9	8.6	–	–	3.0	3.8
29	2.3	–	5.2	3.3	3.8	4.3
30	5.1	5.0	16.9	19.3	2.0	1.0
31	0.5	0.9	–	–	–	–
TOTAL	67.0	63.0	41.2	46.5	132.6	156.3

* B = Belmullet Meteorological Service Station
* G = Glenamoy Meteorological Service Station

From the 30th of June until the 12th of July there was rain on all days at both stations (apart from the 3rd at Belmullet). Over the country as a whole, July 1988 was the wettest for 30 years (T. Keane, 1988). At Belmullet and Glenamoy the July rainfall was 184% and 176% of average respectively (1951 – 1980 average for period). While examination of the July rainfall at Belmullet shows no exceptional rainstorms this constant heavy rain would have brought the water table back to the surface of the peat (Table 2).

Table 2: Simplified water balance for peat at bog flow area assuming Belmullet rainfall, evapotranspiration of 4 mm/day and drainable pore space of 10%.

Date	Water Table Depth mm	Evapotrans-piration (E) mm	Rainfall (R) mm	R - E mm
29/6	–400	4	5	1
30/6	–390	4	17	13
1/7	–260	4	8	4
2/7	–220	4	9	5
3/7	–170	4	0	–4
4/7	–210	4	3	–1
5/7	–220	4	13	9
6/7	–130	4	2	–2
7/7	–150	4	7	3
8/7	–120	4	2	–2
9/7	–140	4	11	7
10/7	– 70	4	8	4
11/7	– 30	4	2	–2
12/7	– 50	4	12	8
13/7	+ 30 (overland flow)			

4.3 Slope:

As shown in Figure 2 above, there are two breaks in slope in the area above the forest road. Flows are almost always associated with breaks in slope (Carling 1986, Tomlinson and Gardiner, 1982). Calculations on the effects of slope can be made (Appendix) but the safety factors are dependent upon the value for soil cohesion.

5. DISCUSSION

5.1 Probable sequence of events prior to and during flow

The exceptionally dry months of May and June initiated drying and cracking of the surface peat. This was followed by prolonged heavy rain in July. Rainfall moved down slope and accumulated at the end of the plough furrows at the head of the flow. The weight of this water and the saturated nature of the peat encouraged the lower peat layers to begin to flow over the basal greasy peat layer at the break in slope, where the peat had the poorest hold. Downslope the peat in the tunnel ploughed area was also saturated owing to the absence of proper collector drains. This allowed the flow to continue down-slope. The flow was further facilitated as the surface peat readily sheared longitudinally along the 2000 mm wide cuts made by the tunnel plough.

When the flow reached the forest road its momentum was checked owing to the damning of the flow by the road formation. Effectively the *in situ* bog ceased to flow at this point. However, the material that had flowed downslope continued over the road and was deposited on the lower side of the road.

5.2 Implication for tunnel ploughing:

Tunnel ploughing, if properly drained, should reduce the probability of bog flows. Tunnel ploughing has been shown to lower the water-table to a greater extent than double mouldboard ploughing (O'Carroll et. al. 1981). This lowering will result in lower pore water pressures, increased peat strength and higher factors of safety (Appendix).

6. RECOMMENDED PRACTICE

1. All ploughing sites on peat should have collector drains installed at a minimum intensity of 100m/ha. These should be sufficiently deep to intercept flow in furrows and tunnels and have a sufficient bottom gradient to remove water rapidly from the site without causing erosion (a 2-3° gradient is sufficient on sloping ground).

2. Drains should be installed above distinct breaks in slope to prevent water seeping to vulnerable slope faces.

3. Planted blanket peat areas which adjoin public roads, dwellings and reservoirs should be critically examined to ensure that they have sufficient collector drains to remove **storm** rainfalls. This would be particularly important in the case of areas which have slopes exceeding 6°.

7. Acknowledgements

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APPENDIX

Calculation of factor of safety for Bellacorrick site.

$$F = \text{factor of safety} = \frac{\text{sum of resisting forces}}{\text{sum of driving forces}}$$

($F>1$ safe slope; $F<1$ unsafe slope).

$$F = \left[1 - \left(\frac{\gamma w}{\gamma s} \times \frac{Dw}{D} \right) \right] \times \frac{\tan \varnothing^1}{\tan \propto} + \frac{2\,C^1}{\gamma s\, D \sin 2\propto}$$

Where:

γw	= unit weight of water	=	$9.81 kN/m^3$
γs	= unit weight of wet peat	=	$10.24 kN/m^3$
Dw	= depth of peat below water table	=	1.5m
D	= depth of peat	=	1.5m
$\varnothing^1$	= angle of internal friction	=	14.45°
$\propto$	= slope	=	7°
C^1	= residual cohesion	=	$1 kNm^{-2}$

Substituting these values gives an F value of 0.6. Lowering the water table to 60cm below the surface increases the factor of safety to 1.4.

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