UR1977-37

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1977/37. Piezometric measurements in Tertiary lacustrine sediments in the Tamar Valley.

C.J. Knights

Abstract

Five sites were investigated during landslip studies of the Tamar Valley. Aquifers containing pressure water were found at all sites. Pressures in these aquifers have subsequently been monitored and related to rainfall patterns.

This report covers the period June 1974 to January 1977. During this time there were two exceptionally wet winters, followed by a very dry summer and winter.

Factors considered by the study are:

(1) Position and composition of the aquifer.
(2) The relationship between piezometric pressure and rainfall.
(3) Time response of piezometric pressure in aquifers of various depths.
(4) Total pressure heads.
(5) Varying response in different parts of the same aquifer.

The maximum head recorded is 9.5 m. The minimum head occurs in part of an aquifer which is not under pressure for much of the year.

In general, shallow aquifers are under peak pressure at the time of, and soon after, prolonged rainfall. Deep aquifers reach their critical period several months after the maximum rainfall.

After an extended period of dry weather, the first rains are taken up in filling the soil moisture deficit, then when this is satisfied, water will percolate downwards. It seeps along the dry part of the aquifer, slowly filling it, in balance with the loss of water from downslope outlets. Pressure develops in the lower part of the aquifer, and as more water is added the pressurised section extends upslope. Consequently, following a dry period there is a delay time between the onset of rainfall and the rise in pressure. For shallow aquifers the delay time may be a few days or weeks; for deep aquifers it is usually several months. After the very dry summer of 1975-1976 the delay period was as long as six months.

Once the aquifer is under pressure then any further addition of water will rapidly transmit the increased pressure throughout the aquifer. When this stage is reached, the delay time between rainfall and a rise in pressure is accounted for in the time it takes for water to travel through the unsaturated section of the drainage path. For shallow aquifers this is less than one day, but for deep aquifers the time lag may still be several months.

With the onset of dry weather there is a delay time before water pressure decreases. This lag depends in part on the amount of water in the unsaturated section of the drainage path, and in part depends on the permeability of the aquifer and its outlets.

1977/37. Piezometric measurements in Tertiary lacustrine sediments in the Tamar Valley, Tasmania.

C.J. Knights

During landslip studies in the Tamar Valley five sites were investigated by auger drilling to depths up to 12 m. Aquifers containing pressure water were found at all sites. Pressures in these aquifers have subsequently been monitored and related to rainfall patterns.

Tertiary sediments in the Tamar Valley consist of overconsolidated, but not lithified, clay and sandy clay, with minor sand, gravel, lignite and siderite horizons. Towards the top of the sequence there are basalt flows which are more resistant to erosion than the sediments, and therefore cap many of the hills and give rise to oversteepened slopes. Cainozoic gravel terraces also form resistant features and cap many of the hills.

The period of study covered by this report is from June 1974 to January 1977. During this period there were two exceptionally wet winters followed in 1976 by a very dry summer and winter.

Factors considered in the study:

(1) Position and composition of aquifer.
(2) The relationship between piezometric pressure and rainfall.
(3) Time response of piezometric pressure in aquifer at various depths.
(4) Total pressure heads.
(5) Varying response in different parts of the same aquifer.

WATER LEVEL MEASUREMENTS IN RELATION TO PIEZOMETRIC PRESSURES

When one or more aquifers were encountered during the augering of a bore hole, a slotted plastic pipe was installed in the hole, and back-filled around with gravel. The measurements which are recorded in Figures 6, 8, 10 and in Appendix 2 are the depths between the standing water levels and the tops of the holes. This is normally equivalent to the depth to the piezometric surface.

Depth to piezometric surface and recorded water levels are taken to be approximately equivalent because a number of the bores have been pumped out, and in each case the water level was restored within one day, thus indicating that the aquifers are sufficiently permeable to allow pressure changes to be manifested as changes in water level. The holes which were pumped out are: St Leonards 1, 7, 14; McEwans Road 4, 6; and Wanstead 5, 6.

In three bores at Deviot the water levels do not represent the piezometric surface: the deep, pressure aquifer is of lower permeability than the shallow aquifer, so that when water enters the hole from near-surface the levels do not adjust themselves. At certain holes, during long dry periods, water levels do not represent pressure, because if a hole extends below the base of an aquifer which becomes dry there will still be water left in the hole, and this may, or may not, drain away depending upon the permeability of the clays. Small water level fluctuations can be caused by changes in atmospheric pressure.

Piezometric pressure, or head is equivalent to the depth between the piezometric surface and the top of the aquifer.

POSITION AND COMPOSITION OF AQUIFERS

Shallow aquifers commonly occur within 3 m of the surface. During seismic surveys on Tertiary sediments this zone is revealed as a low velocity layer, and it is interpreted as a zone of weathering, unloading and expansion of the clay, and of downslope creep, where water can percolate through fissures in the clays. At St Leonards (Knights and Matthews, 1977) four adjacent bores were drilled, each intersecting water at different depths although their piezometric surface was the same. These results are interpreted as indicating the presence of a water-filled, interconnecting fissure system.

Shallow aquifers also occur where clay and rock fragments, derived from the weathering of basalt talus, overlie Tertiary sediments.

Wherever a deep aquifer containing pressure water has been located, it is accompanied by a change in lithology. Sand occurs in some aquifers. An aquifer can be thin, as at St Leonards where it occurs between two compact clay horizons; or it can be extensive, as at McEwans Road, where there is a 3 m layer of very soft clay and lignite.

Chemical analysis of water from deep aquifers shows a salinity range of 4000-8500 ppm. Preliminary work on the exchangeable sodium percentage of the clay indicates that clay close to the aquifer is in chemical equilibrium with the groundwater, whereas that further away is not. Dispersion may occur in some aquifers.

PIEZOMETRIC LEVELS

Profiles of water level fluctuations are shown in Figures 6, 8, 10.

The maximum head which has been found is 9.5 m at Bradys Lookout. The minimum head for a deep aquifer is found in Hole 30 at St Leonards where for much of the year the aquifer does not contain pressure water.

After an extended period of dry weather, the first rains are taken up in filling the soil moisture deficit, then when this is satisfied, water will percolate downwards. It seeps along the dry part of the aquifer, slowly filling it, in balance with the loss of water from downslope outlets. Pressure develops in the lower part of the aquifer, and as more water is added the pressurised section extends upslope. Consequently, following a dry period there is a delay time between the onset of rainfall and the rise in pressure. For shallow aquifers the delay time may be a few days or weeks; for deep aquifers it is usually several months. After the very dry summer of 1975-1976 the delay period was as long as six months.

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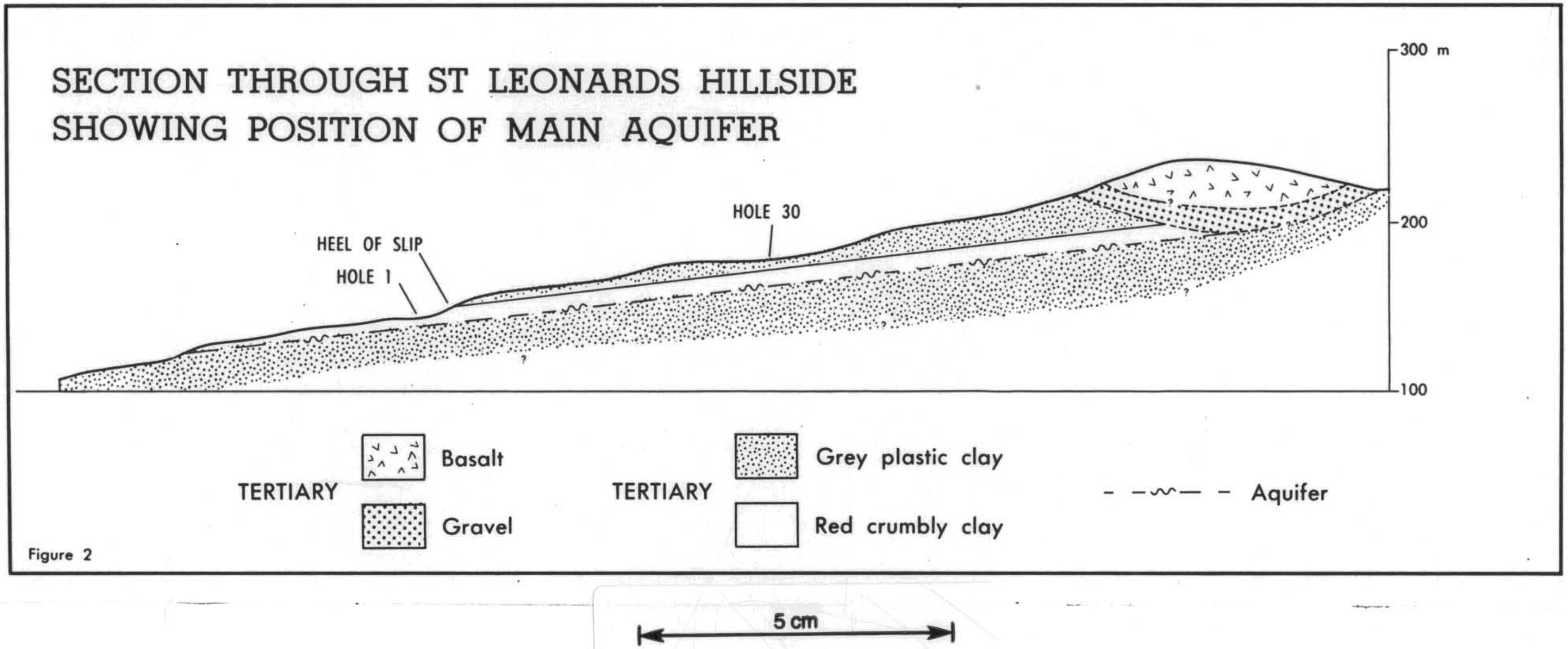
SECTION THROUGH ST LEONARDS HILLSIDE
SHOWING POSITION OF MAIN AQUIFER
HOLE 30
HEEL OF SLIP
HOLE 1
300 m
200
100
Basalt
TERTIARY
Gravel
Grey plastic clay
TERTIARY
Red crumbly clay
Aquifer
5 cm

Figure 2

In general shallow aquifers are under peak pressure at the time of, and soon after, prolonged rainfall. Deep aquifers vary as to their critical period, but it is usually considerably longer than the maximum rainfall period, and occurs in the months of November and December.

ST LEONARDS LANDSLIP [EQ173107]

The present active landslip is a reactivation of the toe of one of the many old landslips which mantle the St Leonards hillside. These old landslips are large rotational slips, but their age is unknown. The geological situation (fig. 2) of gravel and basalt overlying Tertiary sediments is commonly associated with large-scale instability, as springs at the base of the gravel help to feed water into the underlying clay.

The aquifers

Two thin aquifers were encountered during drilling.

Upper aquifer. This is located 2.5-3.5 m below the surface. Water entered through fissures near the top of the blue-grey clay, or in the base of the cover of brown clay which is derived from the weathering of basalt talus. It is monitored by Holes 7, 14, 15.

Hole 13 (adjacent to Hole 7) and Hole 14 were siphoned out to well below aquifer level, and their recharge rates measured (fig. 4, 5). Plotting the results on linear graph paper shows that aquifer depth for both holes 13 and 14 is 3 m. Hole 13 made 4520 *l*/day and Hole 14 made 4750 *l*/day.

Hole 13 was siphoned so as to maintain a reduced head of 1.5 m. Within one hour the radius of influence affected other holes so that one metre away the water level had dropped 130 mm, and 3 m away the level had dropped by 25 mm.

The lower aquifer is located at, or near the base of the red-brown sandy clay. Hole 30 is located at the base of a large topographic flat area 450 m uphill from the present slip, and intersects the aquifer at 8.8 m. Hole 1 is adjacent to the slip and intersected the aquifer at about 7 m. From these, and from other bores which were destroyed by slip movement, it is evident that the aquifer dips downslope and underlies the present hill surface in such a way that it probably forms the basal failure surface for both the present, and the old slips. Piezometric contours have been drawn for the active slip area (Knights and Matthews, 1977). The contours have a downhill slope, thus indicating a downhill flow direction.

Results of piezometric monitoring (fig. 6)

Hole 7. Situated on a flat area above the slip.

Water was encountered at a depth of 3 m. Response to rainfall was rapid; during winter the response time is less than one day. The maximum head was 2.04 m with a total fluctuation in head of 2.04 m. Short term fluctuation in head was 0.51 m over two weeks.

Holes 14 and 15. Situated on sloping ground above the slip.

Water intersected at 3 m in Hole 14, and at 2.7 m in Hole 15. Response to rainfall was rapid during the winter. However after extended dry weather the aquifer becomes completely dry and there is a delay period of several weeks between rainfall and the development of pressure in the aquifer.

37–5

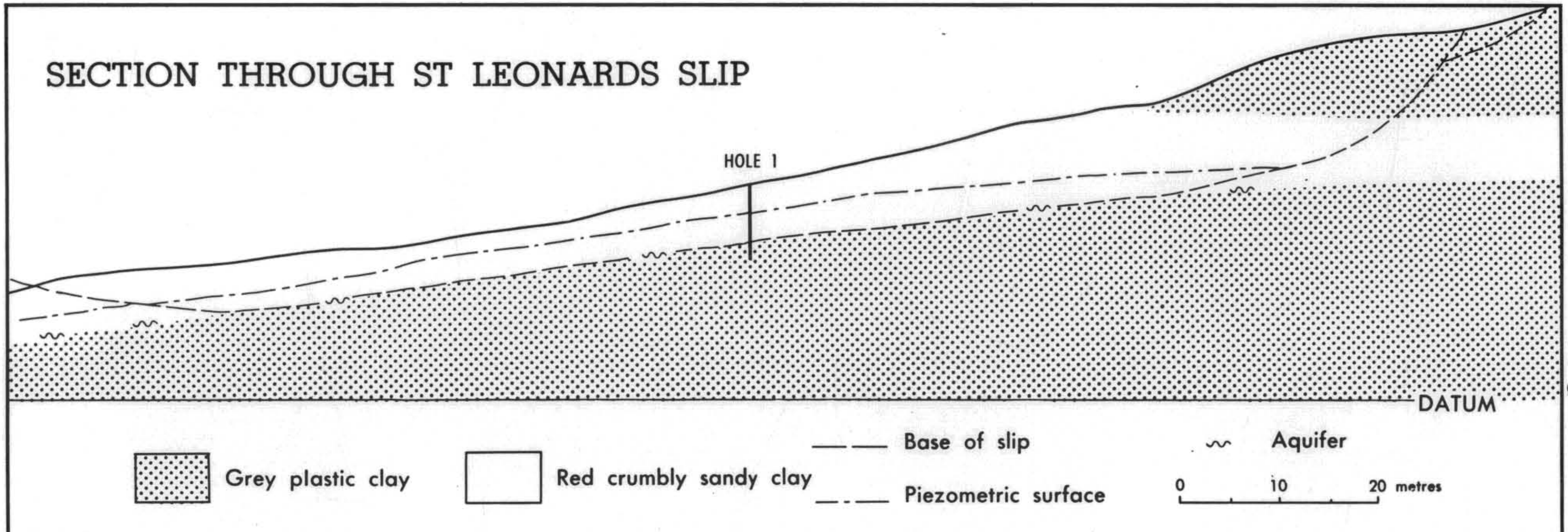

Figure 3

5 cm

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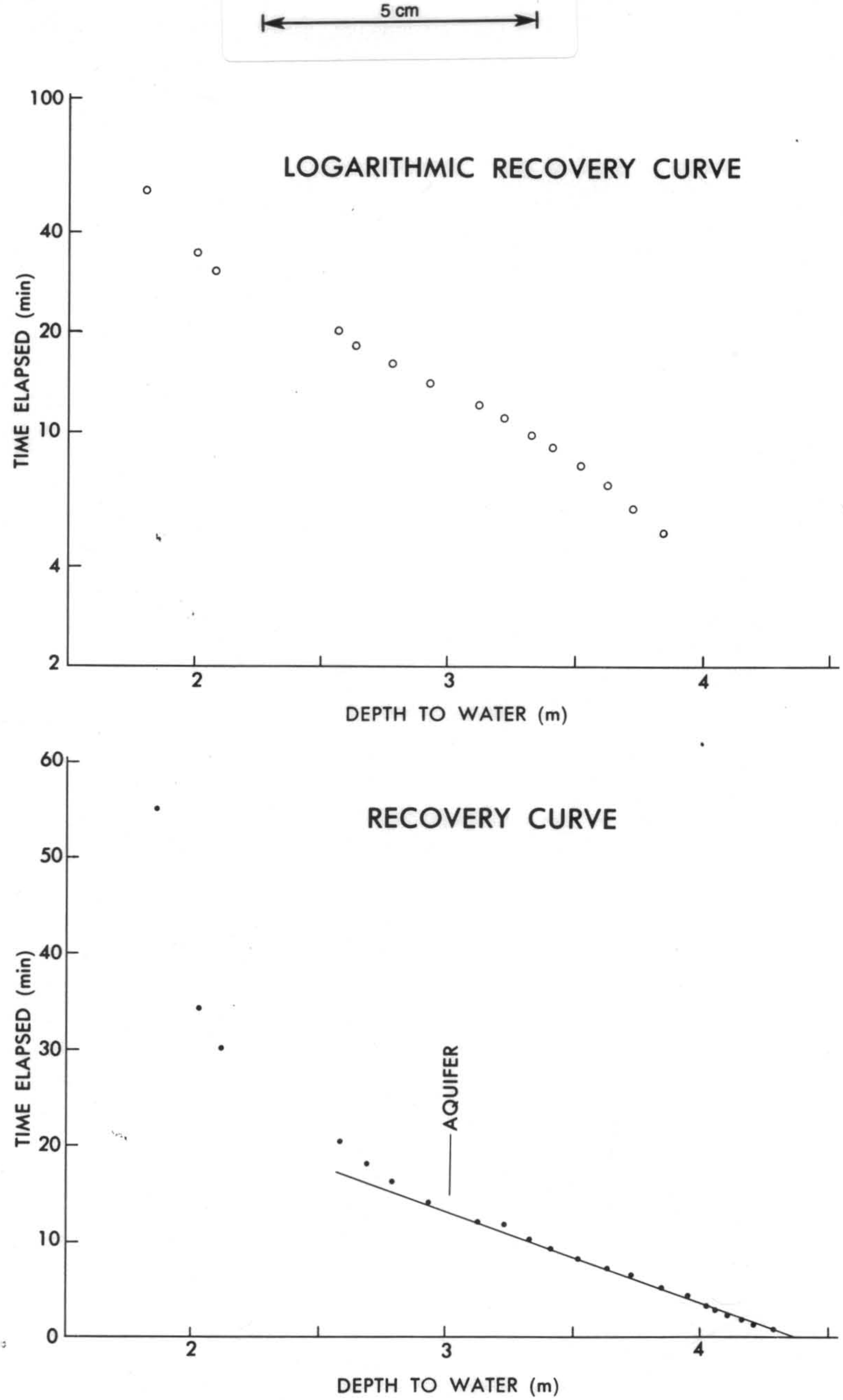


Figure 4. *Recovery curves, St Leonards bore hole 13.*

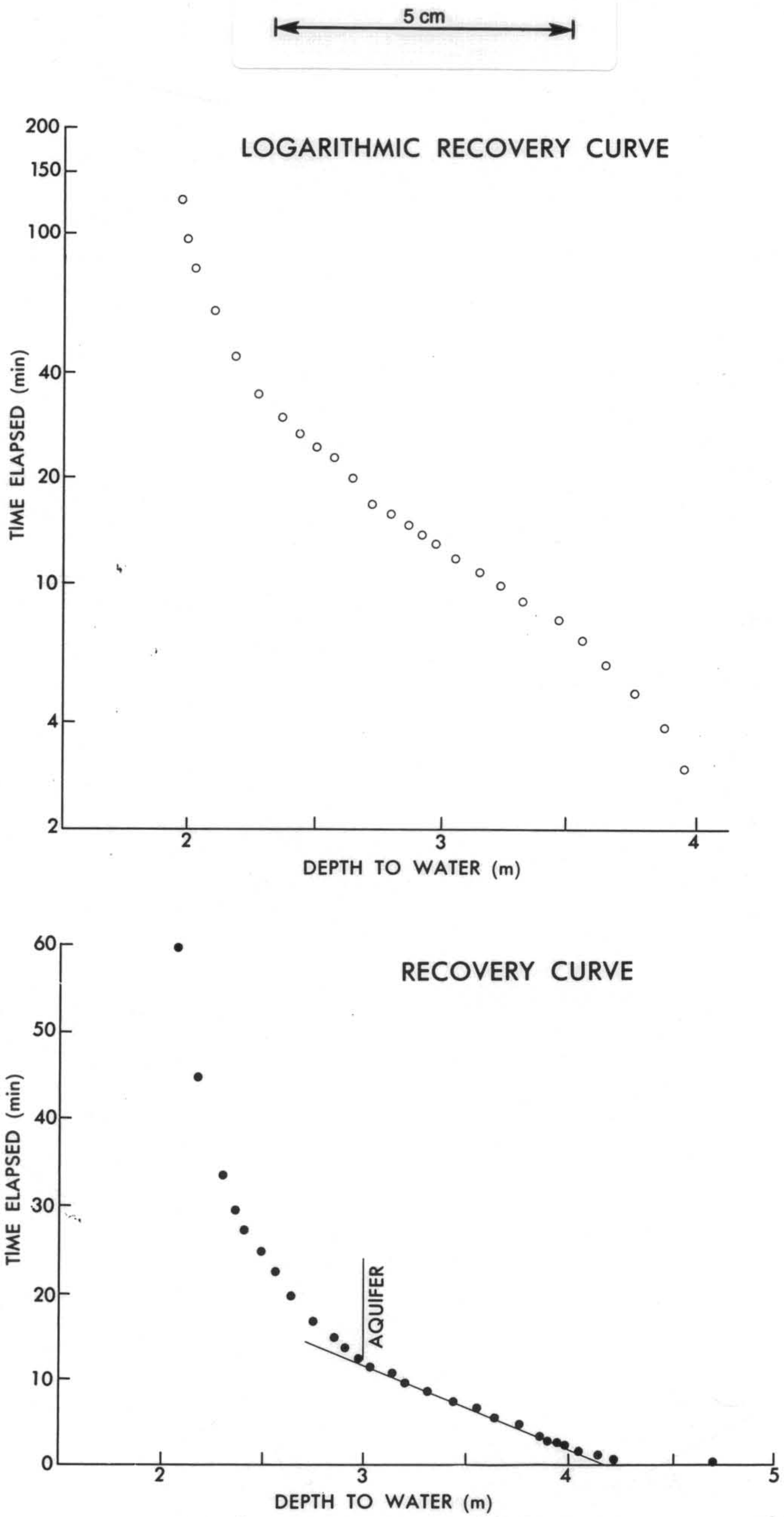


Figure 5. *Recovery curves, St Leonards bore hole 14.*

Hole 14. Maximum head 1.9 m.

Total fluctuation in head 1.9 m, short term fluctuation one metre over two weeks.

Hole 15. Maximum head 1.57 m.

Total fluctuation in head 1.57 m, short term fluctuation 1.27 m over two weeks.

Hole 1. Adjacent to slip, intersecting the lower aquifer (fig. 2, 3).

Water was encountered at a depth of about 7 m. Response to rainfall was delayed, with a lag time before rise in piezometric pressure of 13-25 weeks and a lag time for decrease in pressure of about 13 weeks. The lag time of 25 weeks occurred after the very dry summer of 1976 when there would have been a large water deficit along the drainage path before a pressurised part of the aquifer was reached.

The maximum head was 3 m in November and December. Total fluctuation in head 1.88 m. Maximum short term fluctuation was 0.635 m over two weeks.

Hole 30. 450 m upslope of Hole 1, intersecting the same aquifer (fig. 2).

Water was encountered at a depth of about 8.8-9 m.

After dry periods water in the aquifer near this hole is not under pressure. When the water level in the bore hole falls below aquifer level, the monitored changes merely indicate the amount of water seeping into the hole from the aquifer, relative to the amount escaping from the hole by its inherent permeability. As the depth of this part of the aquifer is only known approximately, it is not known when it begins to develop pressure. Therefore the lag time for increase in piezometric pressure, and the maximum head cannot be estimated.

Lag time for a decrease in head is about 6 weeks.

McEWANS ROAD LANDSLIP [EQ022228]

This West Tamar site lies in an area where numerous old landslips mantle the hillside, and have produced the characteristic hummocky topography. The site is underlain by Tertiary sediments and lies at the foot of a basalt-capped hill in the toe area of an old slip. At present there is no large active slip, but stability analysis and high pore pressures indicate that the stability is tenuous. Minor slip movement occurs at the base of the section, on Rosevears Drive (fig. 7).

The aquifers

Pressure water was encountered in Holes 4 and 6, at what is considered to be a basal slip plane along which there has been movement in the not too distant past. This aquifer is probably the same as the one encountered in Hole 5. Hole 8 was drilled into a fissure 7 m deep which is filled with saturated gravel and clay.

Piezometric pressure varies little throughout the seasons, with the relatively larger variations occurring upslope.

37-9

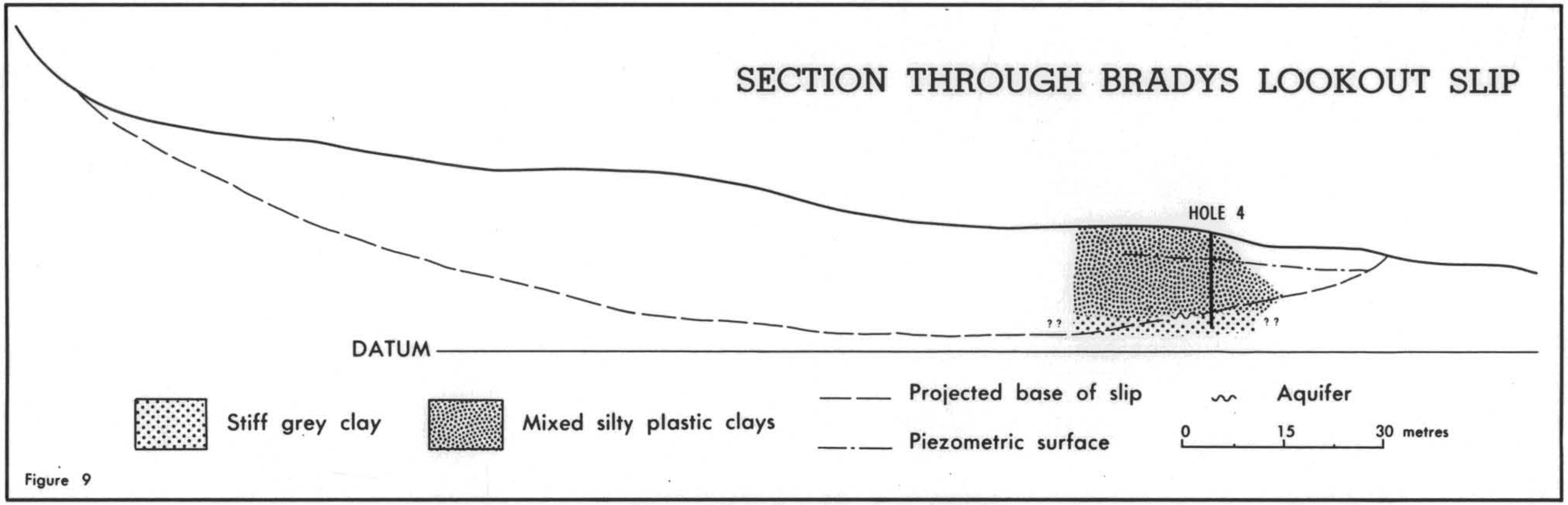


Figure 9

5 cm

Results of piezometric monitoring (fig. 8)

Hole 4

The minor aquifer was encountered at a depth of 2.7 m.

The major aquifer was intersected between 6 m and 9 m. For these 3 m the ground is very soft and in some places semi-liquid.

Response to rainfall is slow (about 8 weeks).

The maximum head was 5.18 m with a total fluctuation in head of 0.55 m. Short term fluctuation in head was 0.216 m over 1.5 weeks.

Hole 6

The aquifer was intersected between 7.3 and 8.2 m.

Response to rainfall was slow (about 10 weeks in 1975).

The maximum head was 4.27 m. Total fluctuation in head: 0.825 m, maximum short term fluctuation 0.345 m over one week.

Hole 5

The aquifer was encountered at a depth of 7.3 m.

Response to rainfall was slow (about 10 weeks, 20 weeks in 1975). The maximum head was 2.2 m. Total fluctuation in head: 1.02 m, maximum short term fluctuation 0.22 m over one week.

LANDSLIP NEAR BRADYS LOOKOUT [DQ993242]

This large landslip affects the West Tamar Highway south of Bradys Lookout (fig. 9). The active area of about 180 000 m^2 is a reactivation of part of a dormant older structure. The hill is underlain by Tertiary sediments and capped by a thin layer of basanitic dolerite which crops out at the top of the deep heel scar. Deeply weathered talus overlies the Tertiary sediments on the slopes (Knights, 1976*b*).

The aquifers

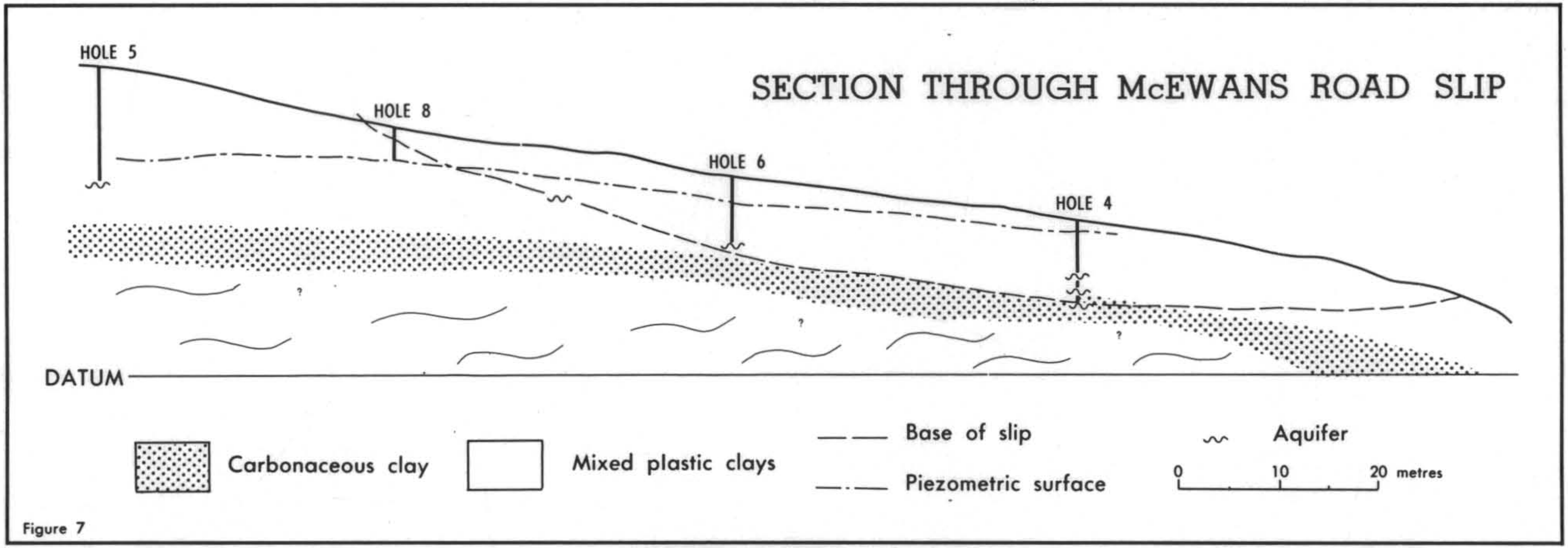
A minor aquifer occurs at a depth of 4 m. The main aquifer, containing pressure water, was intersected in very soft clay located beneath a hard calcareous band at a depth of 11 m and is about 1.5 m thick.

The lag time for the rise of piezometric pressure after rainfall is shorter than the lag time for the fall in pressure after rainfall has lessened. In 1975/1976 the delay time was about 13 weeks for the rise in pressure and 21 weeks for the fall in pressure.

Results of piezometric monitoring (fig. 8)

Hole 4

A minor aquifer was encountered at a depth of 4 m. The major aquifer was encountered between 11 m and 12.5 m. Response to rainfall was slow (about 13 weeks in 1975). The maximum head was 9.5 m with a total fluctuation in head of 1.3 m.


SECTION THROUGH McEWANS ROAD SLIP
HOLE 5
HOLE 8
HOLE 6
HOLE 4
DATUM
Carbonaceous clay
Mixed plastic clays
Base of slip
Piezometric surface
Aquifer
0
10
20 metres
Figure 7

5 cm

37-11

DEVIOT LANDSLIP [DQ944348]

The slip is situated on an 11° slope near the Tamar foreshore (fig.11, 12), in ground composed of Tertiary sediments, overlain by a discontinuous mantle of basalt talus. Upslope, and behind the road, water issues from the base of a basalt layer, and the water is trapped behind the road, probably supplying much of the shallow water in the landslip (Knights, 1976*a*).

Although the slip is only 3 m in depth, bore holes were augered to a maximum of 10 m.

The aquifers

Water was found in soft ground between the surface and 3 m, and also in a deep aquifer at 9.8 m.

Holes 1 and 9 encountered only the shallow aquifer. Fluctuations of water level in Hole 1 show rapid response to rainfall, but in Hole 9 there is some delay indicating an unconfined downslope flow. A large water deficit following a dry period in late 1976 caused a long lag time.

Hole 5 encountered only the deep aquifer. Piezometric levels recorded from this hole show small fluctuations which do not correlate strongly with the seasons. As the piezometric surface is 1-2 m below sea level these fluctuations may be due to variations in tidal pressure. The salinity of the water is 4600 ppm measured electrically.

Holes 3, 4 and 8 encountered both the shallow water and the deep aquifer. Profiles of their changes in water level are similar to that of Hole 9, indicating that the deep aquifer is of low permeability, and that water levels in these holes is controlled by fluctuations in the supply of shallow water.

Results of piezometric monitoring (fig. 10)

Hole 1. Situated on a flat bench above the landslip.

Water was intercepted between the surface and 1.7 m.

Response to rainfall is rapid.

The maximum head was 1.27 m.

The total fluctuation in head was 1.14 m.

Hole 9

Water was intercepted between the surface and 2.7 m.

Response to rainfall was slightly delayed but there was more than 6 weeks after drought.

The maximum head was 2.42 m.

The total fluctuation in head was 2.42 m.

Hole 5

Water was encountered at 10 m in a layer of clayey sand which was 1.9 m thick.

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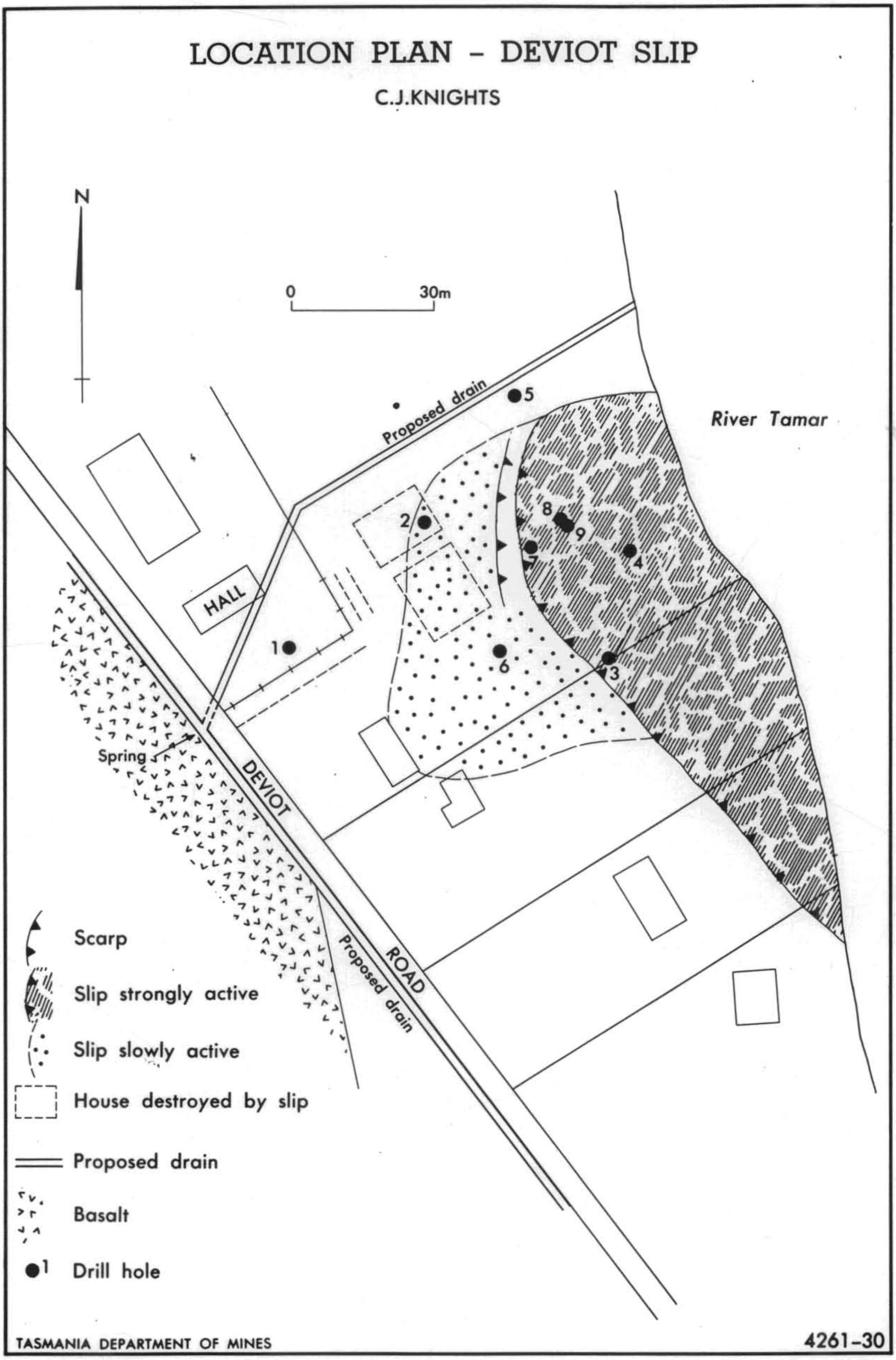

Figure 11.

5 cm

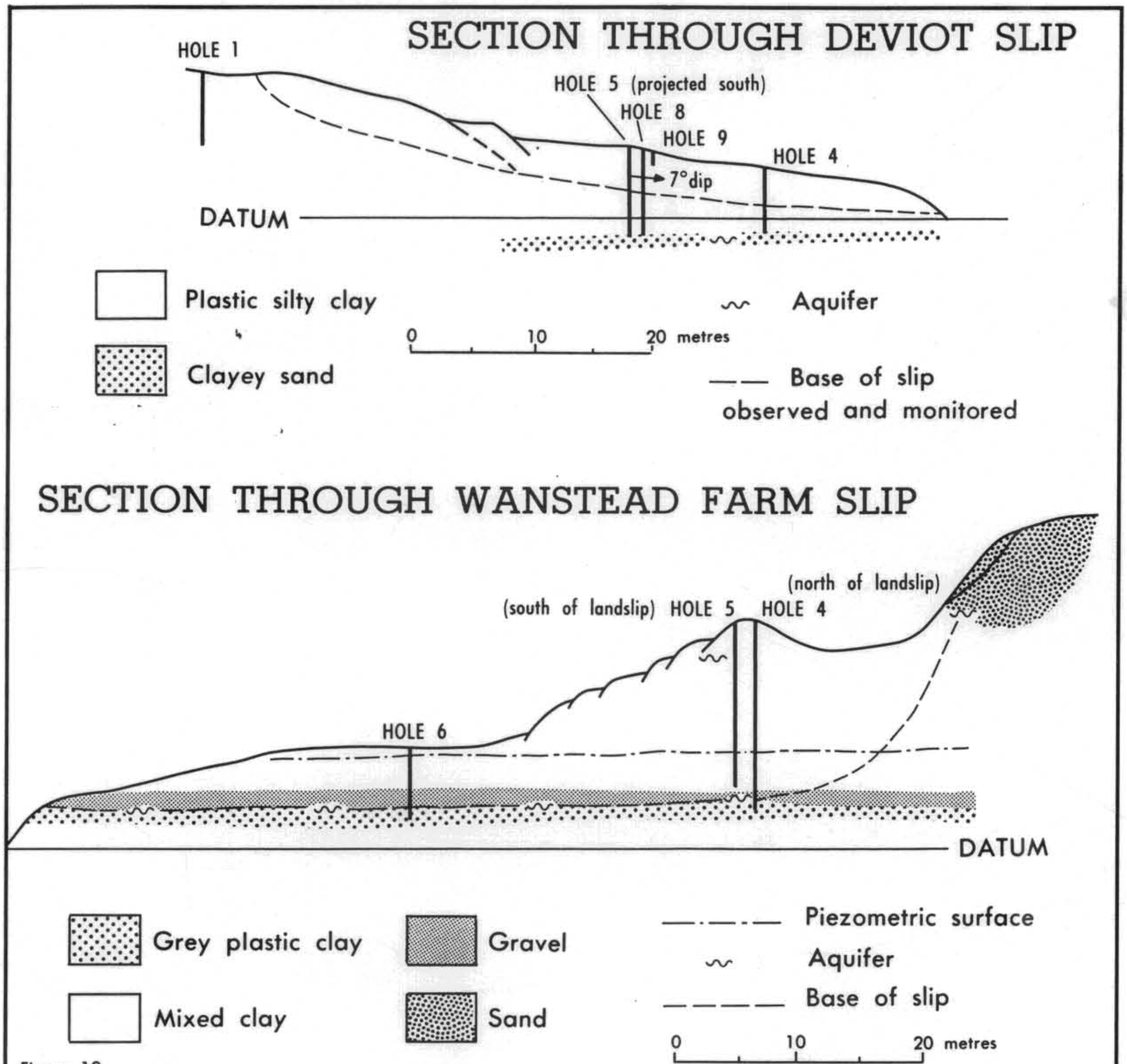

Figure 12

5 cm

Response to seasonal rainfall fluctuations is slight.

The maximum head was 3 m.

The total fluctuation in head was 0.51 m.

Hole 3

Water was intercepted from the surface to 1.8 m, and at 10.5 m.

Response to rainfall: fall time 1-3 weeks.

The aquifer head cannot be assessed.

Hole 4

Water was intercepted from surface to 1.8 m and at 9.4 m.

Response to rainfall: fall time 1-3 weeks.

The aquifer head cannot be assessed.

Hole 8

Water was intercepted from the surface to 2.7 m and at 8.2 m.

Response to rainfall is rapid for the fall time.

The aquifer head cannot be assessed.

Hole 6

Water entered the hole from the surface to 1.8 m.

A pressure head was never recorded.

WANSTEAD FARM LANDSLIP [EQ157089]

The slip lies on the side of a flat-topped hill formed of Tertiary sediments, overlain by Quaternary quartz gravel and sand. Numerous dormant and active slips occur on the hillside. The landslip investigated covers about 5000 m^2 and is on an overall slope of 14.5°. It has been very active throughout the monitored period. A section through the landslip is shown in Figure 12.

The aquifers

Three aquifers were encountered during the investigation. The highest, at the base of the Quaternary gravel and sand has formed a pond at the heel of the slip. Overflow from this pond produces a stream which runs downhill across major cracks and fissures on the southern edge of the slip, to contribute rapidly to groundwater within the slip itself.

A second, more minor aquifer was located in Hole 5 in undisturbed ground north of the slip about 2.5 m below the surface. This was tested by siphoning out the water in the hole and measuring its rate of recharge (fig. 13). During the first nine minutes of siphoning the aquifer yielded 6.8 *l*/min, but then the yield rapidly decreased during recharge. Whilst the water level in the hole was below the aquifer the yield was approximately 0.18 *l*/min. It is evident from these results that Hole 5 intersected a

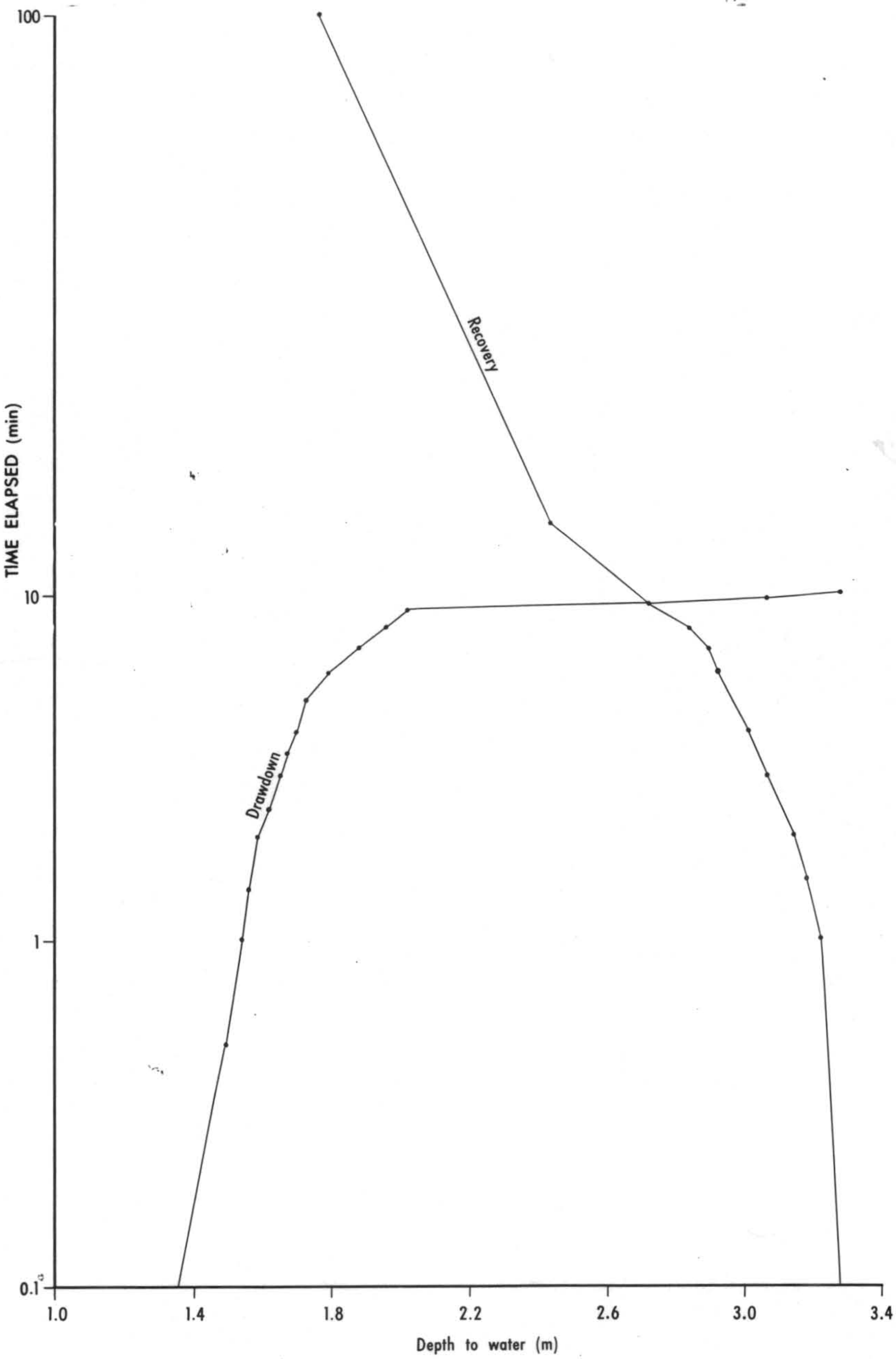

Figure 13. *Drawdown and recovery curves, Wanstead Farm bore hole 5.*

5 cm

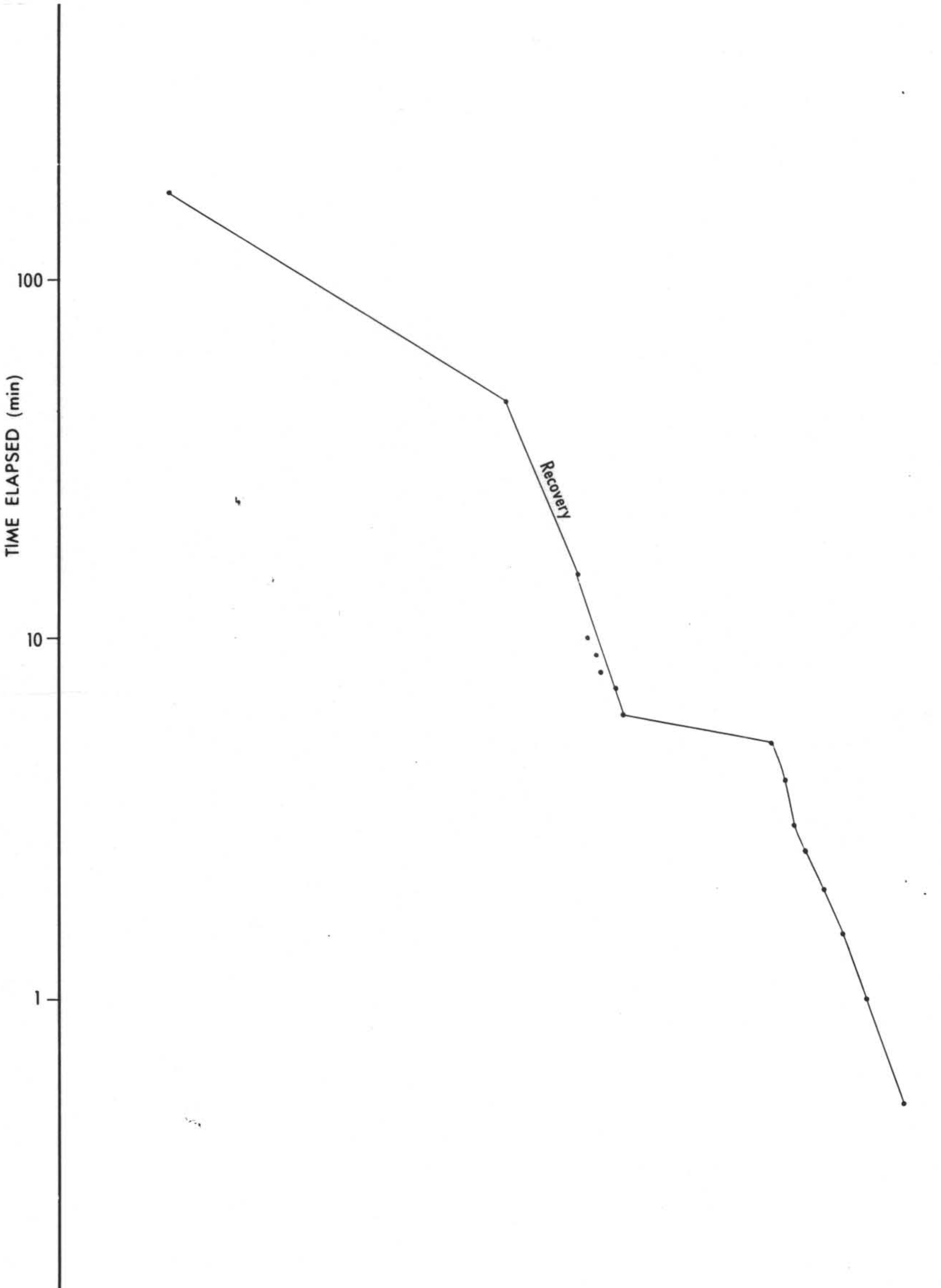

Figure 14. *Recovery curve, Wanstead Farm bore hole 6.*

5 cm

permeable lens which stores water, but is surrounded by less permeable material. Analysis of the water indicated 1005 ppm of total dissolved solids. This is a low figure for Tamar Tertiary sediments and indicates that the water has not travelled far in these materials.

The lower sandy aquifer was intersected between 11 and 12.8 m in Hole 4 which is undisturbed ground north of the slip. It was also intersected between 2.3 and 4.6 m in Hole 6 in the active toe of the slip. Analyses indicate 2100 ppm of total dissolved solids in water from Hole 6 and 5090 ppm in water from Hole 4. These samples were taken during a dry period. Hole 6 was siphoned out, and the rate of recovery recorded (fig. 13). Steps in the graph indicate surges of water into the hole.

Results of piezometric monitoring (fig. 8)

Hole 5

Water was encountered at 2.5 m below surface.

Response to rainfall is rapid.

The maximum head was 1.9 m.

The total fluctuation in head was 1.52 m (short term fluctuation 1.02 m).

Hole 6

The aquifer is sand and lies between 2.3 and 4.3 m below surface.

Response to rainfall is rapid.

The maximum head was 2.3 m.

The total fluctuation in head was 2.16 m (short term fluctuation 1.65 m).

Hole 4

The same aquifer as Hole 6, depth below surface 11-12.8 m.

Response to rainfall is rapid.

The maximum head was 3.69 m.

The total fluctuation was 2.28 m (short term fluctuation 1.39 m).

Water pressure in the sandy aquifer responds rapidly to rainfall, and must be in close pressure connection with the surface. However, the relatively high salinity of water from Hole 4, and lower salinity of water from Hole 6 indicates that actual water flow from the surface into the aquifer does not affect Hole 4 to any great extent. This situation can be explained by the large fissures which cross the slip. If these fissures extend into the aquifer, then when the fissures fill with water there will be rapid pressure response throughout the aquifer. Actual water flow will take place more slowly depending upon aquifer permeability and the general direction of water flow.

In Hole 4 water levels for 1975 peaked at 0.85 m above the 1974 level. This occurred after extensive slip movement which may have blocked aquifer outlets.

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REFERENCES

KNIGHTS, C.J. 1976*a*. Investigation of a landslip at Deviot. *Unpubl.Rep.Dep.Mines Tasm.* 1976/61.

KNIGHTS, C.J. 1976*b*. Investigation of a large landslip near Bradys Lookout, West Tamar. *Unpubl.Rep.Dep.Mines Tasm.* 1976/64

KNIGHTS, C.J.; MATTHEWS, W.L. 1976. A landslip study in Tertiary sediments, northern Tasmania. *Bull.int.Ass.engng Geol.* 14:17-22

KNIGHTS, C.J.; MATTHEWS, W.L. 1977. Investigation of a landslip at St Leonards. *Tech.Rep.Dep.Mines Tasm.* 20:174-218

[13 September 1977]

Table 1. PIEZOMETRIC MEASUREMENTS AT ST LEONARDS LANDSLIP, HOLES 1, 7, 14, 15, 30. DEPTHS FROM SURFACE IN METRES.

Date	1	7	14	15	30
11.07.1973		1.68	2.36		
12.07.1973		1.65	2.08		
25.07.1973		1.50	1.91	2.18	
26.07.1973		1.42	1.42		
6.08.1973		1.35	1.22	1.78	
8.08.1973		1.35	1.12	1.60	
25.09.1973		1.52	1.98	2.41	
24.05.1974		3.20			
3.06.1974		3.25	2.97	2.95	
7.06.1974		3.15	2.87	2.82	
4.07.1974		2.16	2.24	2.46	
10.07.1974		1.70	1.93	2.13	
22.07.1974		1.40	1.19	1.27	
1.08.1974		1.40	1.22	1.47	
6.08.1974		1.37	1.52	1.78	
14.08.1974		1.37	1.52	1.83	
27.08.1974		1.30	1.70	2.11	
12.09.1974		1.57	1.98	2.36	
26.09.1974		1.30	1.50	1.78	
4.10.1974		1.55	1.93	2.29	8.74
11.10.1974	4.37	1.65	2.06	2.39	
20.10.1974	3.89	1.63	2.08	2.44	8.69
31.10.1974	3.76	1.96	2.24	2.36	
13.11.1974	3.73	2.31	2.31		
20.11.1974	3.73	2.49	2.44	2.54	8.86
28.11.1974	3.86	2.44	2.59		
12.12.1974	3.76				
3.01.1975	3.78	2.57	2.51	2.54	
14.01.1975	3.91	2.54			
15.01.1975	3.91	2.57			
17.01.1975	3.86	2.59			
20.01.1975	3.91	2.59			
23.01.1975	3.94	2.69			
24.01.1975	3.94	2.69	2.62	2.59	
28.01.1975	4.01	2.72			
29.01.1975	4.04	2.74		2.64	
31.01.1975	4.04	2.77			
4.02.1975	4.06	2.82	2.77	2.51	9.17
10.02.1975	4.13	2.88			
12.02.1975	4.08	2.86			
14.02.1975	4.17	2.92			
17.02.1975	4.22	2.92			
19.02.1975	4.22	2.93			
21.02.1975		3.15			
24.02.1975		3.02	3.14	2.84	9.05
25.02.1975	4.29	2.97			
27.02.1975	4.32	3.00		4.32	
6.03.1975	4.39	3.02		4.39	
10.03.1975	4.45	3.05		4.45	
11.03.1975		3.05	3.00	2.87	
12.03.1975	4.45	3.06			
19.03.1975	4.50	2.74	2.87	2.72	9.50
21.03.1975	4.56	2.82	2.79	2.72	9.55
22.03.1975	4.57	2.82	2.82	2.72	9.55

Table 1. PIEZOMETRIC MEASUREMENTS AT ST LEONARDS LANDSLIP, HOLES 1, 7, 14, 15, 30. DEPTHS FROM SURFACE IN METRES. (continued)

Date	1	7	14	15	30
26.03.1975	4.62	3.15	2.79	2.79	9.55
2.04.1975	4.67	3.06			
4.04.1975	4.70	2.95			
8.04.1975	4.75	2.92			
9.04.1975	4.75	3.07	2.74		
15.04.1975	4.88	2.74	2.79	2.74	9.58
2.05.1975	5.09	2.54	2.24	2.34	
15.05.1975	5.08	2.21	2.36		
22.05.1975	5.05	2.87	2.82	2.67	9.68
11.06.1975	5.26		2.03	2.39	9.70
1.07.1975	5.33	1.37	2.03	2.13	9.50
15.07.1975	5.13	1.40	1.19	1.17	9.53
1.08.1975	5.19	1.37	1.28	1.50	9.37
8.08.1975	5.08	1.36	1.27	1.59	9.26
27.08.1975	4.67	1.02	1.27		9.07
4.09.1975	4.52	1.30			
9.09.1975	4.37	1.55	1.98	2.29	8.86
13.09.1975	4.29				8.78
19.09.1975	4.14	1.23	1.10?	1.63	8.85
25.09.1975	4.14	1.40	1.93	2.41	8.79
3.10.1975	4.18	1.98	1.92	2.44	8.92
10.10.1975	3.89	1.96	1.80	2.31	8.79
20.10.1975	3.87	2.18	2.11	2.41	8.80
29.10.1975	3.81	2.46	2.41	2.46	8.72
12.11.1975	3.78	2.36	2.39		8.86
17.11.1975	3.81	2.57	2.54		9.25
20.11.1975	3.73				
29.11.1975	3.84	2.36		2.44	9.04
10.12.1975	3.78	2.62	2.57	2.62	9.04
24.12.1975	3.92	2.84	3.00	2.62	9.17
2.01.1976	3.96	2.92	2.97	2.64	
19.01.1976	4.07	3.12	3.37	2.72	
9.02.1976	4.43	3.13	3.89	2.82	
27.02.1976	4.52	3.18	4.96	2.90	9.58
5.03.1976	4.57	3.17	4.91	2.90	9.35
26.03.1976	4.83	3.20	5.15	2.83	9.57
8.04.1976	4.99	3.23	5.23	2.85	9.62
23.04.1976	5.11	3.27	5.31	2.90	9.65
27.05.1976	5.19	2.70	dry	dry	9.70
24.06.1976	5.29	2.81	4.11	2.95	9.76
5.07.1976	5.35	2.44	3.08	3.00	9.77
16.07.1976	5.39	2.69	2.84	3.02	9.76
7.09.1976	5.44	2.44	2.34	2.54	9.78
17.09.1976	5.49	2.44	2.34	2.39	9.86
15.10.1976		2.97		2.97	9.97
29.10.1976	5.54	3.07		3.07	10.04
7.12.1976	5.45	2.60	2.60	1.45	9.70
17.12.1976	5.30	2.10	2.30	1.50	9.30
7.01.1977	5.30	2.20	2.30	1.60	9.53

Depths to water entry in metres:

Hole 1	*7*	*14*	*15*	*30*
∿6.7	3.0	3.0	2.7	∿9.0

Horizontal holes were drilled. On 17 September 1976 five of the lower holes flowed steadily. The water contained 1700 ppm TDS, measured with a salinity meter.

Table 2. PIEZOMETRIC MEASUREMENTS AT McEWANS ROAD LANDSLIP, HOLES 4, 5, 6. DEPTHS FROM SURFACE IN METRES.

Date	4	5	6
14.08.1974	0.91	5.72	3.43
28.08.1974		5.51	3.30
12.09.1974		5.54	3.33
20.10.1974		5.33	3.05
10.11.1974	1.17	5.21	3.25
20.11.1974	1.17	5.31	3.25
28.11.1974	1.14	5.26	3.35
10.12.1974	1.17	5.26	3.25
2.01.1975	1.17	5.35	3.38
24.01.1975	1.27	5.47	3.48
29.01.1975	1.14	5.41	3.38
4.02.1975	1.27	5.49	3.53
24.02.1975		5.64	3.67
11.03.1975	1.42	5.82	3.71
19.03.1975	1.30	5.64	3.58
21.03.1975	1.21	5.66	3.58
22.03.1975	1.24	5.66	3.58
26.03.1975	1.24	5.69	3.61
9.04.1975	1.30	5.79	
17.04.1975	1.32	5.79	3.68
6.05.1975		5.84	3.66
11.06.1975	1.19	5.89	3.61
27.06.1975	1.30	5.89	3.68
1.07.1975	1.12	5.94	2.87
8.08.1975	0.99	5.56	3.33
28.08.1975	1.27	5.31	3.23
3.09.1975	0.97	5.41	3.23
13.09.1975	1.05	5.33	3.29
19.09.1975	0.94	5.25	3.14
25.09.1975	1.02	5.33	3.29
3.10.1975		5.44	3.40
10.10.1975	1.04	5.25	3.05
29.10.1975	1.16	5.18	3.25
12.11.1975	1.09	5.18	
29.11.1975	1.22	5.21	3.28
2.01.1976	1.24	5.19	3.38
27.02.1976	1.40	5.59	3.58
5.03.1976	1.42	5.56	3.58
26.03.1976	1.42	5.73	3.75
8.04.1976	1.38	5.59	3.77
23.04.1976	1.43	5.85	3.82
24.05.1976	1.40	5.88	3.75
24.06.1976	1.49	6.05	3.87
5.07.1976	1.46	6.05	3.82
16.07.1976	1.49	6.10	3.87
17.09.1976	1.32	6.10	3.66
1.10.1976	1.81	5.97	3.67
15.10.1976	1.27	5.97	3.57
29.10.1976	1.37	5.97	
6.12.1976	1.40	6.00	
17.12.1976	1.34	6.10	
7.01.1977	1.48	6.14	

Table 3. PIEZOMETRIC MEASUREMENTS AT BRADYS LOOKOUT LANDSLIP, HOLE 4. DEPTHS FROM SURFACE IN METRES.

Date	4	Date		4
3.10.1975	3.79	5.07.1976		4.90
29.10.1975	3.55	16.07.1976	Slight pipe closure at 8.99 m	4.50
19.11.1975	3.50	7.09.1976		4.43
2.01.1976	3.60	1.10.1976		4.37
26.01.1976	3.73	15.10.1976		4.50
27.02.1976	4.19	6.12.1976		4.80
5.03.1976	4.13	17.12.1976		4.40
8.04.1976	4.46	7.01.1977		4.40
23.04.1976	4.82	14.04.1977		5.24
24.06.1976	4.84			

Table 4. PIEZOMETRIC MEASUREMENTS AT DEVIOT LANDSLIP, HOLES 1, 3, 4, 5, 6, 8, 9. DEPTHS FROM SURFACE IN METRES (see fig. 14).

Date	1	3	4	5	6	8	9
10.07.1974				6.40			
31.07.1974				6.32			
14.08.1974				6.40	3.05		
3.10.1974				6.38	3.63		
20.10.1974				6.40	4.55	0.97	0.61
28.10.1974		0.91	2.13	6.40	4.57		
10.11.1974		1.09	2.16	6.26	4.32	1.12	1.07
3.01.1975		1.42	2.24	6.15	4.70	1.14	0.94
29.01.1975		1.83	2.46			1.57	1.37
4.02.1975		2.06		6.20	4.98	1.45	
24.02.1975		2.49	2.64	6.45?	5.38	2.03	1.85
11.03.1975					5.46	2.26	2.11
19.03.1975			2.29	6.12	5.26	2.29	1.93
22.03.1975			2.62	6.10	5.18	2.31	2.13
6.05.1975		1.60	2.79	6.15	5.08	2.21	2.03
11.06.1975		0.94	2.64	6.22	3.84		0.71
8.08.1975		0.89	2.21	6.25	3.78	0.58	0.46
28.08.1975	3.15	0.61		5.99	1.93	0.30	0.08
3.09.1975	0.33	0.69	1.98			0.55	0.58
9.09.1975	0.58	0.69	1.80	6.05	closed by	0.51	0.33
23.09.1975	0.61		2.03	6.27	movement	0.71	0.41
3.10.1975	1.04	1.22	2.36	6.32		0.97	0.69
29.10.1975	1.09	1.09	2.29	6.17		0.91	
20.12.1975	1.12	1.09	2.34	6.27		1.02	0.61
2.01.1976	1.32	1.04	2.39	6.45		1.22	0.94
19.01.1976		1.50	3.53	6.17		1.57	1.09
27.02.1976	1.55	2.84	closed by	6.34		2.70	2.39
5.03.1976	1.54	2.77	movement	6.37		2.70	2.31
26.03.1976	1.56	2.95		6.34		2.92	2.50
23.04.1976	1.49	3.05		6.34		3.87	2.62
26.05.1976	0.58	3.45		6.30		4.32	2.51
24.06.1976	1.19	2.65		6.41		4.49	4.46?
7.07.1976	0.46	1.78		6.41		4.31	2.47
7.09.1976	0.84	1.02		6.50		2.16	0.71
1.10.1976	1.31	1.27		6.47		2.11	0.70
15.10.1976	0.42	1.11		6.53		1.87	0.57
29.10.1976	0.97	1.37		6.57		1.97	0.80

Table 5. *PIEZOMETRIC MEASUREMENTS AT WANSTEAD FARM LANDSLIP, HOLES 4, 5, 6. DEPTHS FROM SURFACE IN METRES.*

Date	4	5	6
26.06.1973			1.37
28.06.1973			1.37
11.07.1973	8.69	1.17	1.27
28.07.1973	8.67	1.16	0.99
8.08.1973	8.38	0.99	0.30
4.09.1973	8.23	0.91	0.30
3.06.1974	8.76	1.71	
7.06.1974	8.74	1.68	
4.07.1974	8.43	1.63	1.83
22.07.1974		0.71	0.30
1.08.1974	8.33	1.09	0.30
13.08.1974	8.33	0.91	0.74
11.09.1974	8.43	0.94	0.61
26.09.1974	8.28	0.75	0.33
3.10.1974	8.36	0.94	0.94
11.10.1974	8.26	1.19	0.51
20.10.1974	8.23	0.86	0.71
21.10.1974	8.23	0.89	0.99
13.11.1974	8.26	0.89	1.04
20.11.1974	8.33	0.91	1.14
28.11.1974	8.23	0.99	1.07
9.12.1974	8.26	1.09	1.19
12.12.1974	8.26	0.97	1.14
17.12.1974	8.28	0.94	1.24
2.01.1975	8.33	0.97	1.27
24.01.1975	8.38	1.09	1.40
29.01.1975	8.48	1.21	1.53
6.02.1975	8.46	0.94	1.30
24.02.1975	8.53	1.33	1.78
11.03.1975	8.56	1.32	1.83
19.03.1975	8.26	1.17	1.57
20.03.1975	8.41	1.14	1.21
21.03.1975	8.43	1.17	1.14
26.03.1975	8.53	1.47	1.85
9.04.1975	8.61	1.07	1.83
15.04.1975	8.64	1.14	1.88
10.05.1975	8.64	1.19	1.63
2.06.1975	8.59	1.50	0.56
11.06.1975	8.74	1.17	1.68
1.08.1975	8.24	1.00	0.25
8.08.1975	8.51	1.17	0.34
28.08.1975	7.37	1.12	0.00
4.09.1975	7.80		
19.09.1975	7.94	1.19	0.00
3.10.1975	8.36	1.64	0.70
10.10.1975	7.98	1.40	0.00
20.10.1975	8.13	1.59	0.66
12.11.1975	8.13	1.60	0.56
17.11.1975	8.23	1.65	0.79
29.11.1975	8.14	1.73	0.61
24.12.1975	7.99	1.80	1.02
2.01.1976	8.10	1.83	1.00
19.01.1976	8.16	1.95	1.13
9.02.1976	8.26	2.01	1.52

Table 5. PIEZOMETRIC MEASUREMENTS AT WANSTEAD FARM LANDSLIP, HOLES 4, 5, 6. DEPTHS FROM SURFACE IN METRES. (continued)

Date	4	5	6
27.02.1976	8.36	2.08	1.25
5.03.1976	8.36	2.08	1.76
26.03.197	8.43	2.12	1.98
8.04.1976	8.53	2.12	1.67
23.04.1976	8.51	2.09	2.06
24.05.1976	8.20	1.99	0.91
24.06.1976	8.64	2.05	2.09
5.07.1976	8.67	2.06	1.89
16.07.1976	8.71	2.11	2.13
17.09.1976	8.76	2.08	0.58
15.10.1976	8.87	2.17	1.77
29.10.1976	8.87	2.17	1.80
5.11.1976	8.81	2.17	0.80
6.12.1976	9.76	2.10	
17.12.1976	9.63	2.00	5.40
7.01.1977	9.00	2.30	1.70

APPENDIX 1

Logs of bore holes

ST LEONARDS

Hole	*Depth (m)*	*Description*
1, 1A	0-1.8	Grey-brown fairly plastic clay, small quartz fragments.
	1.8-4.6	Grey-brown clay, weathered basalt fragments, limonite-cemented silt towards bottom. Small fragments of plastic clay.
	4.6-6.7	Light brown sandy silty material, very fragmental, limonite-cemented areas, perhaps some carbonate.
	6.7-10.9	Light blue-grey plastic clay.
7	0-0.9	Stiff brown plastic clay.
	0.9-1.8	As above with basalt fragments.
	1.8-2.7	As above, becoming damper and loose-structured.
	2.7-3.0	Base of basalt clay, loose yellow clay.
	3.0-3.6	Stiff grey, plastic clay.
	Water encountered at 3 m.	
14	0-1.8	Orange-brown crumbly clay and basalt fragments.
	1.8-2.7	Crumbly grey clay with yellow patches overlying soft crumbly yellow clay.
	2.7-3.8	Yellow soft crumbly clay overlying wet gravelly material.
	3.8-4.6	Stiff grey clay, very plastic, sticks to the auger.
	Water encountered at 3 m.	
15	0-1.8	Brown soil and weathered boulders.
	1.8-2.7	Grey silty clay with crumbly texture.
	2.7	Grey and yellow clay with a crumbly texture. Patchy, ranges from very soft and wet, to stiff.
	2.7-3.6	Very soft, no auger sample.
	3.6-4.6	Stiff grey clay.
	4.6-5.5	Stiff yellow and grey plastic clay. Rather crumbly, small ironstone fragments.
	5.5-7.3	Stiff grey plastic clay.
	7.3	Very stiff, grey, homogeneous clay.
	Water encountered at 2.7 m.	
30	0-4.6	Rounded quartz gravel and sand mixed with clay, hard and dry.
	4.6-6.0	Dry feldspathic sand.
	6.0-8.5	Dry orange sandy clay.
	8.5-9.0	Wet sandy clay.
	9.0-11.8	Grey plastic clay.
	Water encountered at about 9 m, rose to 8.65 m after the winter rains.	

BRADYS LOOKOUT

Hole 2 (Diamond)	*Depth below surface (m)*	*Hole 4 (Auger)*
	0	
Dark brown clay and gravel.		Fill.
	1	Soft greenish fawn clay with occasional fragment of ironstone.
Very soft pale fawn clay.		— — —
	2	
— — —		Soft wet greenish fawn clay with fragments of ironstone.
	3	
Soft, wet, pale fawn clay with ironstone fragments.	4	— — —
		Water entry. Tougher orange and green clay.
— — —	5	— — — Hard band — — —
Fragments of pink mudstone, 20% core recovery.		
— — —	6	Tough orange and fawn clay with ironstone fragments.
Medium soft fawn coloured silty clay with grey veins. 20% core recovery.	7	— — —
— — —	8	
Stiff, fawn, silty clay with grey clay veins. 75% core recovery.	9	Medium-stiff augering, with little sample recovery. Orange and grey clay.
— — —	10	
Stiff fawn silty clay with calcareous dendritic veining. 20% core recovery.	11	— — — Hard band — — — Pressure water — — —
— — —	12	Very soft drilling
Very soft fawn and grey plastic clay.		— — —
— — —	13	Tough dark grey clay, alternating hard and soft drilling at about one metre intervals.
Hard grey mudstone.		
— — —	14	
Hard grey mudstone.		
— — —	15	

McEWANS ROAD

Hole	*Depth (m)*	*Description*
4, 4′		Collar elevation: 11.30 m
	0-0.9	Plastic fawn and red clay.
	0.3-1.8	Grey and orange clay with ironstone pieces.
	1.8-2.7	Firm, rather fragmented grey and orange clay.
	2.7-3.6	As above, some red crumbly clay and some soft damp red-brown clay.
	3.6-4.5	Stiff grey clay mixed with softer brown clay.
	4.5-5.5	Stiff blue clay.
	5.7-6.4	Clay with sandy laminae (with water). Water rose overnight to 1.3 m below surface.
	6.4-7.3	Soft clay, orange and grey (mainly the former).
	7.3-8.2	Very soft black carbonaceous clay, with gritty lignite pieces.
5		Collar elevation 22.25 m
	0-1.8	Mottled orange and grey, silty, fissured clay.
	1.8-4.5	Friable clay, dry, grey and yellow, some very plastic.
	4.5-5.4	Less friable red clay.
	6.3-7.2	Fragmented silty clay. Some firm grey, some softer red-brown.
	6.3-7.2	Fawn crumbly clay, water.
	7.2-8.2	As above.
	8.2-9.8	Very plastic grey clay with some harder orange oxidised clay. Much ironstone in gravel sized fragments.
6		Collar elevation 14.02 m
	0-0.9	Fairly stiff red-brown plastic clay with ironstone fragments.
	0.9-1.8	Fragmented, soft, red, grey and orange mottled clay.
	1.8-2.7	Soft orange silty clay, with grey flecks.
	2.7-3.6	As above but paler.
	3.6-4.5	Soft, fawn silty clay, with a consistency of soft plasticine.
	4.5-5.5	Moderately stiff orange silty clay with ironstone fragments 1.3 cm in diameter.
	5.5-6.4	Silty orange crumbly clay with nodules of stiff grey plastic clay.
	6.4-7.3	Orange and grey fragmental clay. A soft patch felt when drilling.
	7.3-8.2	Soft red clay with nodules of stiff grey clay.
	8.2-9.2	Water. Stiff grey clay with gritty ironstone fragments.
6′	9.2-11	Clay becomes dark and carbonaceous.

DEVIOT

Hole	*Depth (m)*	*Description*
1	0-0.9	Wet, sandy, dirty grey clay.
	0.9-1.8	Dry silty, red-brown clay, crumbly texture.
	1.8-2.7	Moist, plastic clay, crumbly texture. Brown, ranging to orange and grey. Tough sandy band.
	2.7-3.7	Stiff, plastic and fissured clay. Orange-brown and grey.
	3.7-4.6	Stiff, plastic and fissured clay. Orange-brown and grey.
	4.6-5.5	Stiff clay. Orange and grey.
	5.5-6.4	Stiff clay. Orange and grey becoming more grey with shiny slip surfaces probably caused by drilling.
	6.4-7.3	Softish clay, grey and brown.
	7.3-8.2	Softish clay, grey and brown, easily squashed in the fingers. Nodules of hematite surrounded by limonite about 2 cm in diameter.
	8.2-9.1	As above, orange colour. Small limonite gravel.
	9.1-10.0	After a break in drilling, as above. Very soft.
	10.0-11.0	As above.
	11.0-11.9	Dark chocolate-brown clay, stiff and shiny.
	Water enters hole near surface and possibly at 7.3 m	
2	0-1.8	Crumbly clay, grey and yellow-brown in fine layers.
	1.8-2.7	Stiff plastic clay with polished fissures, grey and yellow.
	3.7-4.6	Stiff clay, flaky texture, yellow-brown and grey.
	4.6-5.5	As above.
	5.5-6.4	Stiff plastic clay, flaky texture. Grey, sticks to the augers.
	6.4-7.3	Stiff plastic clay, brown and grey. Does not adhere to the augers.
	7.3-8.2	As above.
	8.2-9.1	As above. Softer and more plastic towards the end of the run.
	9.1-10.0	As above.
	Water enters hole near surface.	
3	0-0.6	Wet brown clay.
	0.6-0.9	Damp clayey sand.
	0.9-1.8	Damp clayey sand.
	1.8-2.7	Silty plastic clay, light brown, fragmented.
	2.7-4.6	As above, light grey and brown.
	4.6-5.5	Dry, tough clay, fragmented brown and grey.
	5.5-6.4	As above, brown.
	6.4-7.3	As above, grey and brown.
	7.3-10.0	Clay with silty laminae, ironstone gravel throughout. Dark grey-brown colour.
	10.0-11.0	Silty clay passing into wet, fine-grained sand. Hard band below the sand which the drill could not penetrate. Pressure water.
	Water (salinity ∿4500 ppm) enters hole near surface and at 10.5 m.	
3-4	0-0.9	Brown pebbly clay.
	0.9-2.7	Light brown clay, occasional pebbles.
	2.7-4.5	Light grey-brown plastic clay.
	4.5-6.2	Brown plastic clay, fragmental.
	6.2-7.2	Dark grey-brown clay.
	7.2-10.0	Darkish grey brown silty plastic clay.

Hole	Depth (m)	Description
4	0-0.9	Grey clay in pellets. Some sandy areas.
	0.9-1.8	Iron-stained grey clay with pellets.
	1.8-2.7	Brown clay with pellets and silty grey clay, medium stiff. Some fissure surfaces.
	2.7-3.7	Flaky plastic clay with fissure surfaces, light grey with pink streaks.
	3.7-4.6	As above but more brown in colour.
	4.6-5.5	Brown, rather fragmental plastic clay and limonite. Possible fossil mussel horizon.
	5.5-6.4	As above, more plastic.
	6.4-9.4	Stiff silty clay, dark grey-brown colour. Fossils at 6.4-7.3 m.
	9.4-11.3	Fine sand, little return. Water rose to about 8.2 m.
	11.3-11.9	Fine sandy clay and angular fragments of carbonate.
	Water (salinity ∿5000 ppm) enters near surface and at 9.4 m.	
5	0-0.4	Basalt soil and boulders.
	0.4-0.9	Fairly stiff plastic silty clay, light brown and grey.
	0.9-1.8	Medium stiff, plastic, grey silty clay.
	1.8-2.7	Fragmental clay, light grey-brown.
	2.7-3.7	Plastic clay, brown-grey.
	3.7-4.6	As above. Also with some flaky pink clay.
	4.6-5.5	Plastic, brown-grey clay.
	5.5-10.0	Stiff silty clay. Dark grey-brown colour.
	10.0-11.9	Fine, even-grained, clayey sand with pyrite nodules and limonite fragments. Pressure water.
	11.9-	Hard band.
	Water (salinity ∿4600 ppm) enters hole at 10 m.	
6	0-0.9	Soft brown clay and basalt boulders.
	0.9-1.8	Soft, crumbly greenish clay and sand. Water.
	1.8-2.7	Fairly stiff blue-grey and brown fissured clay.
	2.7-3.7	As above. Brown and more crumbly.
	3.7-4.6	Stiff, brown, fragmental clay.
	4.6-5.5	Brown and purple clay. Very plastic and flaky.
	5.5-6.4	Grey plastic clay.
	6.4-8.2	Poor sample recovery. Very plastic shiny brown clay which sticks to the augers.
	Water enters hole near surface.	
7	0-0.9	Very soft wet, brown sandy clay.
	0.9-1.8	As above. Water.
	1.8-2.7	Clay with fine limonite sand. Grey and orange soft patches.
	2.7-3.7	Stiff orange-brown fissured clay.
	3.7-4.6	No sample recovered.
	4.6-5.5	Very stiff plastic grey and fawn clay with ironstone sand and gravel.
	5.5-6.4	No sample.
	6.4-7.3	As above. Fissured clay with ironstone fragments. Softer.
	7.3-8.2	No sample.
	8.2-9.1	Very plastic clay with sand-size ironstone. Grey and fawn, becoming more pink and softer.
	9.1-11.9	Poor recovery. A mixture of very stiff brown and dark grey clay, fawn clay, soft patches, ironstone.
	11.9-12.8	Very stiff dark grey clay and pyrite nodules. Fossil mussels. Sand. Pressure water.
	Water enters near surface and at 12.8 m.	

Hole	Depth (m)	Description
8	0-1.8	Very soft, wet, sandy clay.
	1.8-2.7	Soft orange and grey clay with hard orange pellets and ironstone fragments. Water.
	2.7-3.7	As above, but firmer.
	3.7-4.6	As above, firm.
	4.6-5.5	Very tough orange clay and limonite with hematite band.
	5.5-6.4	Orange and grey clay and ironstone. Sand.
	6.4-9.1	No recovery. Fragments on augers are dark grey, stiff, plastic clay. Sand.
	8.2-9.1	Very soft drilling. Pressure water.
	Water enters	hole near surface and at 8.2 m.
9	0-1.8	Very soft, wet, sandy clay.
	1.8-2.7	Soft orange and grey clay with hard orange pellets and ironstone fragments. Water.
	2.7-3.7	As above. Firmer.
		WANSTEAD FARM
4	0-0.9	Surface soil, sand and grey clay.
	0.9-1.8	Grey clay with wood fragments carbonacous clay, medium-soft and plastic.
	1.8-2.7	Grey clay with brown, iron staining, medium-soft and plastic.
	2.7-6.0	Grey and grey brown silty, fissured clay with lignite fragments.
	6.0-9.2	Crumbly brown clay with minor red, iron staining.
	9.2-10.9	Brown silty clay, passing into brown, sandy clay.
	10.9-11.3	Quartz sandy clay.
	11.3-12.8	Sand and clayey sand, lignite. Water present.
5	0-1.8	Brown soil over clayey sand.
	1.8-2.7	Grey carbonaceous clay with lignite fragments, medium-soft. Water present.
	2.7-5.5	Medium-soft, grey, fissured clay (also sand, which may have come in from above)
	5.5-8.2	Iron-stained grey clay.
	8.2-10.9	Reddish fragmental clay, a little moisture, some sandy material.
	10.9-12.8	(From a nearby bore, 5A) sandy red-brown clay.
6	0-1.8	Very soft sandy clay, orange brown colour.
	1.8-2.1	Damp clayey sand, orange brown colour.
	2.1-2.3	As above, very wet.
	2.3-3.6	Completely wet and sloppy sand. A sample tube pushed right through it.
	3.6-3.9	As above, but more clay present.
	3.9-4.3	Moist clayey sand.
	4.3-4.6	Stiff grey plastic clay.

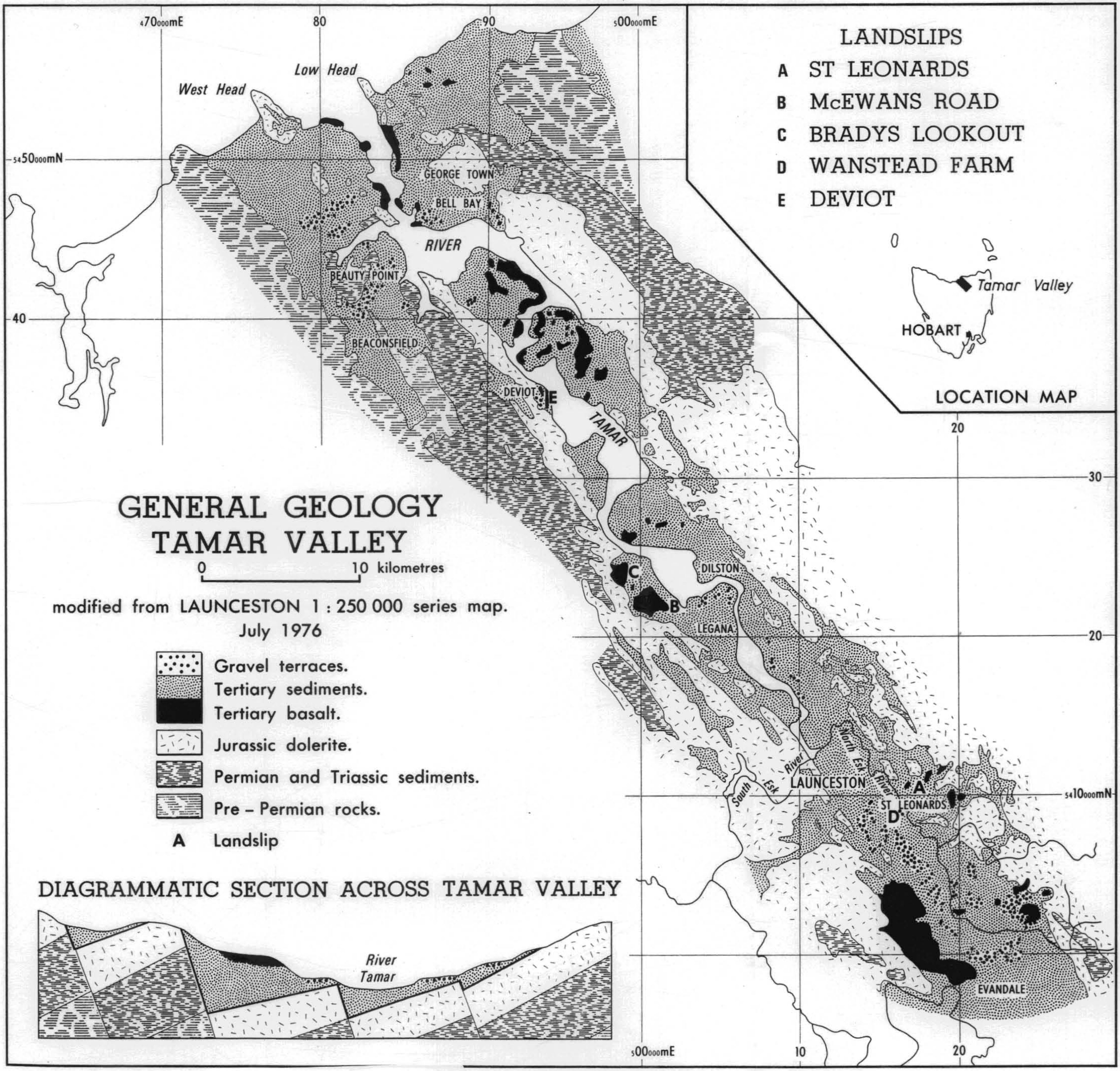

Figure 1 4409

5 cm

ST LEONARDS LANDSLIP
PIEZOMETRIC LEVELS COMPARED WITH RAINFALL VALUES

GEOLOGIST: C. J. KNIGHTS

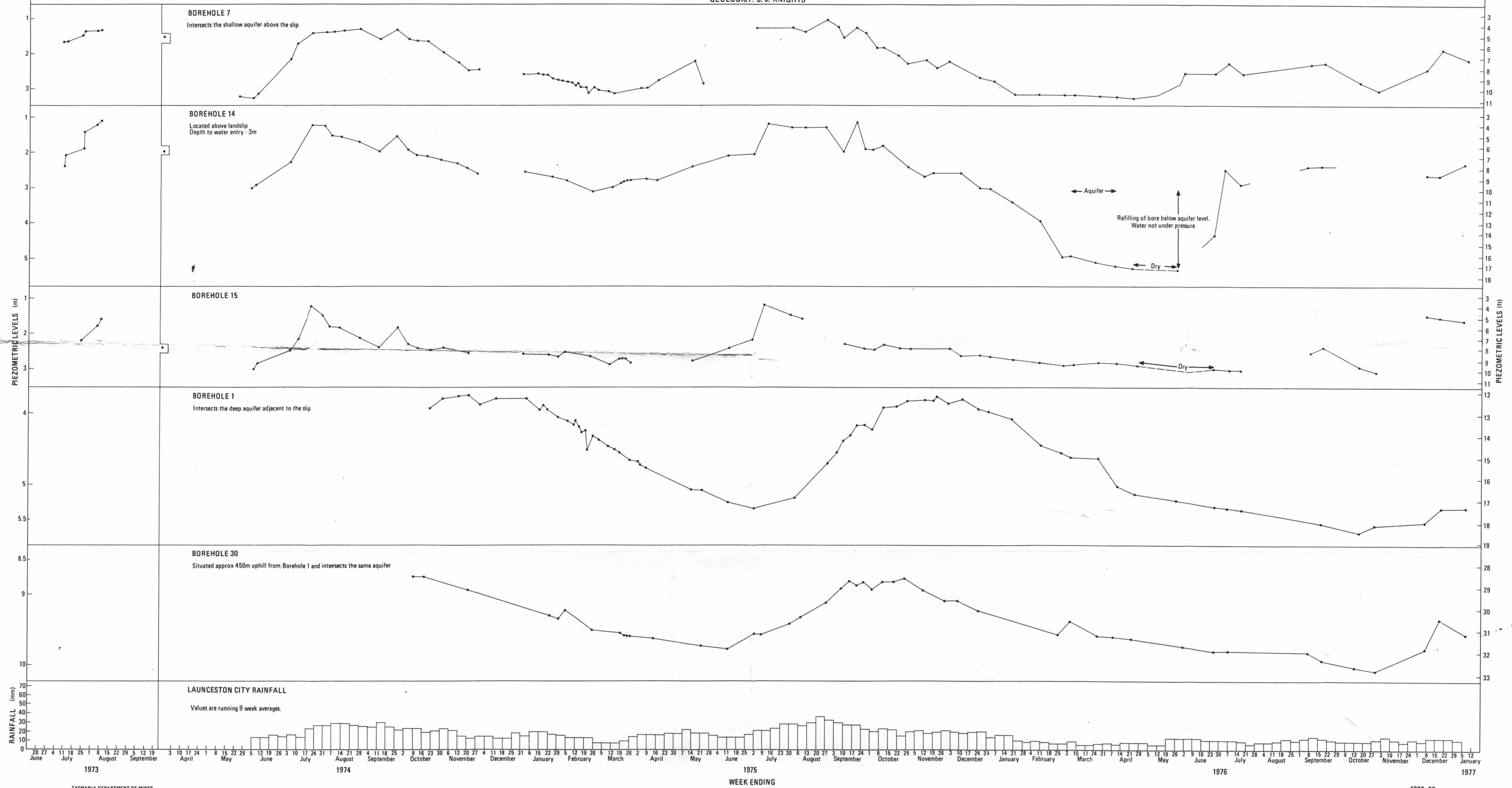

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Figure 6

TAMAR VALLEY LANDSLIPS
PIEZOMETRIC LEVELS COMPARED WITH RAINFALL VALUES

GEOLOGIST: C. J. KNIGHTS

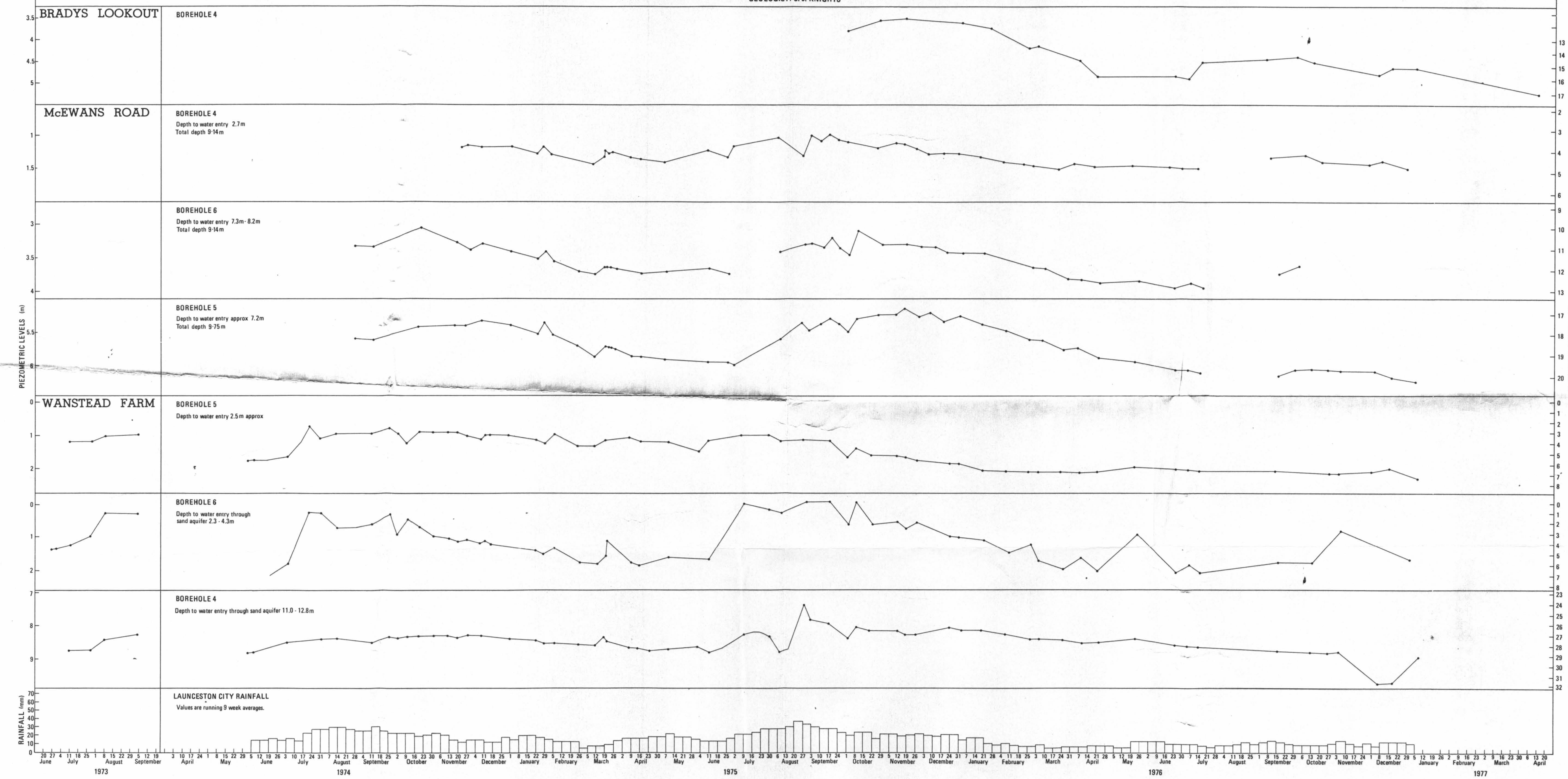

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Figure 8

5 cm

DEVIOT LANDSLIP
PIEZOMETRIC LEVELS COMPARED WITH RAINFALL VALUES
GEOLOGIST: C. J. KNIGHTS

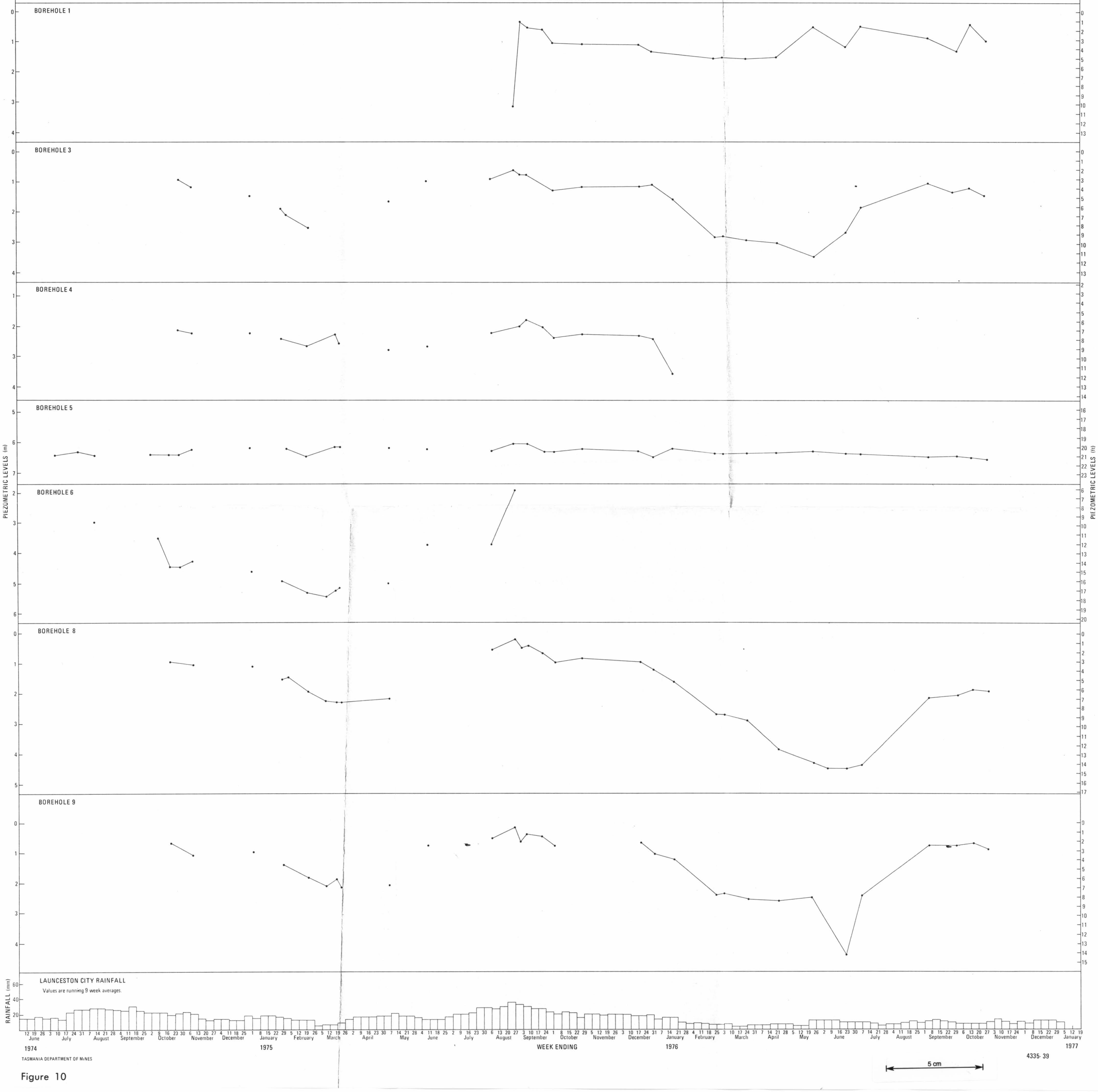

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Figure 10