UR1986_70

1986/70. A difficult house site on steep land underlain by Permian mudstone at Powers Road, Lilydale: A case study

W. R. Moore

Abstract

This steep, 4.6 ha block, is situated on the lower slopes of Mt Arthur and has few stable house sites. The house site chosen is at the break of slope at the foot of a long steep slope in excess of 20°. The slope in front of the site is 16°, increasing to 23°. Outcrops of mudstone of Lower Permian age occur on the access track. Landslides are common in the Lilydale area on these cleared mudstone slopes. Trenching, followed by two auger drill holes (one at the house site, the other 20 m downslope) showed 3.6 m and 4.5 m of clay present. The clay is firm to hard, of low to high plasticity range, and is medium expansive. When shear box tested, it gave an angle of friction of 32° and effective cohesion of 0.6 kPa. Slope stability analyses of a planar failure and two slip circle failures of the upper half and total slope all showed the slope to be sensitive to failure when saturated, and failure planes are shallow. These analyses supported the field evidence. The site was recommended only for a house in which the foundations were tied into the hard bedded mudstone. Particular care is required for drainage and preferably with some reforestation of the cleared area of the block.

INTRODUCTION

Buchanan's block is situated at the eastern end of Powers Road, three kilometres south of Lilydale village [EQ187298]. The block is located on the steep lower slopes of Mt Arthur and rises in elevation some 90 metres from 260 to 350 metres. This elevation results in a magnificent scenic outlook, looking northward across and along the Lilydale valley.

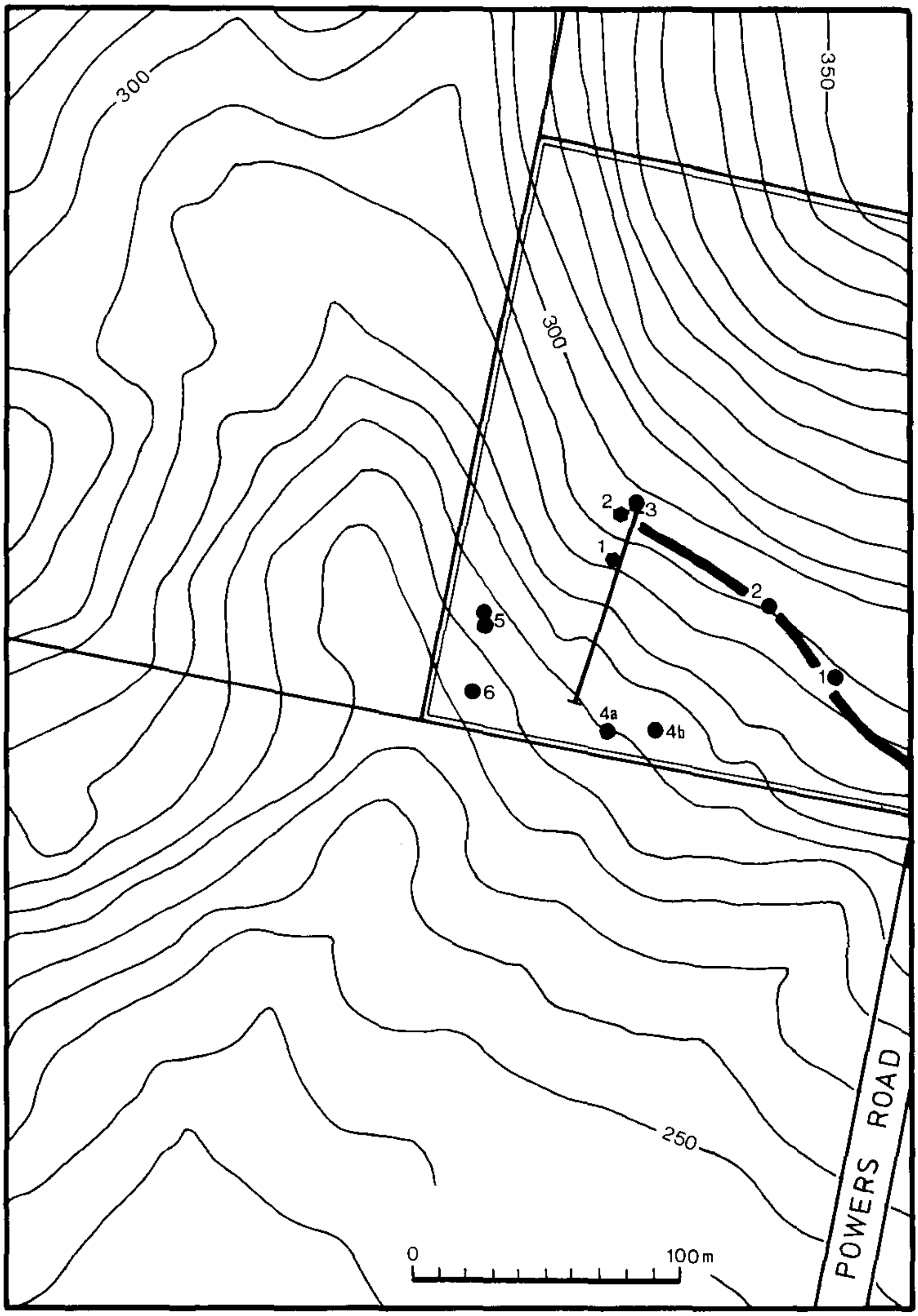
Access to the block is by an old logging track off Powers Road. This track runs north-east across half of the block, following the contour level, before climbing up the slope into the bush (fig. 1). Most of the block is bush covered, with only the lower slopes below the logging track cleared of trees. Formerly pasture, this area is now mostly covered with bracken and scrub.

Most of the slopes on the block are very steep (in excess of 20°) and the slopes above the logging track are considered too steep for any house sites. Consequently even though the block is large (4.6 ha), the area suitable for building is restricted.

Outcrops of friable, massive, blue-grey mudstone of Permian age occur along the track. The mudstone weathers to a yellow clay. A soft moist or wet zone often develops at the base of the clay, at the interface between the clay and weathered bedrock. It is on this interface that the shallow translational landslides occur which are ubiquitous on the slopes around Lilydale, especially where the bush has been cleared.

PREVIOUS INSPECTIONS

During mid 1985, Buchanan's block was inspected several times with Mr D. Baker, Senior Building and Health Inspector of the Lilydale Municipal Council. Slope stability reports were written for two prospective buyers,



Boundary of block

Cross-section line, slope analysis

●3 Proposed house site

Drill hole

Figure 1. *Buchanan's block at Powers Road, Lilydale, showing positions of drill holes and proposed house sites.*

5 cm

Messrs Trapp and Hawes (Appendix 1). Of the three sites preferred by these buyers, all required subsurface investigation including trenching, probably followed by some drilling. At the completion of the investigation there was no assurance that their preferred sites could be recommended to the council. As a result of the extra cost of investigation and the uncertainty of the outcome, both buyers decided not to purchase the block.

Faced with these difficulties in selling the block, and believing there were ample suitable building sites for conventional houses on the block, the then owners (Buchanan's) requested an on-site inspection by D. Baker, the author, and themselves.

Seven sites were inspected on 11 November 1985; the locations are given on Figure 1. Of these, Sites 5a and 5b were rejected immediately by D. Baker because the overflow from the septic tank was likely to pollute the stream. Of the remaining sites, with the exception of Site 1, all had slope stability and/or drainage problems, and required subsurface investigations (Appendix 2).

Robnik's purchased the block on the day of this inspection and are reported to have not been made aware of the stability problems, nor the previous site inspections. As they proposed to build a pole house, and the site they preferred was the same as that of the previous prospective buyer (Mr Trapp), they were informed by the council that they would be required to undertake the recommendations of the previous site inspection report (Appendix 2).

SUBSURFACE INVESTIGATION

Trenching

On 3 July 1986 D. Baker and the writer inspected a foundation trench and septic tank inspection pits at Site 3. The trench was approximately 1.5 m deep and was located on the northern side of the track at the estimated position for the downslope poles of the proposed house. This trench exposed moist, massive, but firm yellow clay, beneath a brown surface clay. The clay was plastic with no soft zones, pebble horizons, or fragments of mudstone exposed. No bedding was visible in clay at the bottom of the trench even though the trench was close to the slightly weathered, poorly bedded grey-yellow mudstone outcrops on the bank side of the track.

This trench, and those dug previously by Mr Trapp, showed that a thick clay layer was present on the lower slope below the track. This clay was possibly the top layer of a talus mantle overlying mudstone. The thickness of the talus above bedrock could be considerable at this site.

It was then recommended that drilling be required at Site 3 in order to establish the thickness of the clay and depth to the slightly weathered mudstone.

Auger Drilling (Appendix 2)

Two auger holes were drilled on 6 August using the light, trailer-mounted Triefus rig. Hole 1 was drilled 20 m downslope from the track and Hole 2 was drilled at the proposed house site.

In Hole 1, 4.5 m of clay was drilled before refusal depth was reached. Hard, extremely weathered mudstone was thought to be present below 3.3 m in this hole, although no bedding was definitely found. Some small pebbles of mudstone were recovered between 0.7 m and 1.5 m depth.

In Hole 2, at the house site, a similar clay sequence was drilled but refusal depth was 3.6 m. At 2.6 m depth a thin gravel or coarse pebble layer in clay was present. The drill had difficulty penetrating this layer. From the drilling machine movement, the pebbles appeared large but none were recovered. Below this layer the drilling was hard and slow with some evidence of bedding present in the fragments, indicating that weathered mudstone is probably *in situ* at 2.6 m depth at the house site.

No soft or moist zones were encountered in the clay in either hole, and neither hole made any water. Clay samples were taken at regular intervals and tested in the Department of Mines Soil Laboratory.

SOIL LABORATORY RESULTS (Table 1)

The moisture content of the clay was low, but higher than anticipated from field testing. The moisture content showed a slight decline in depth; in Hole 1 declining from 28% to 24%, and Hole 2 from 29% to 22%. The clay in the gravel layer of Hole 2 is better drained, with a low (17%) moisture content.

The clay, when tested, showed a medium plasticity and, when plotted, is in the low to high range of the International System of Soil Classification. The highest plastic index of the samples tested was 24, with a liquid limit of 50 (fig. 2).

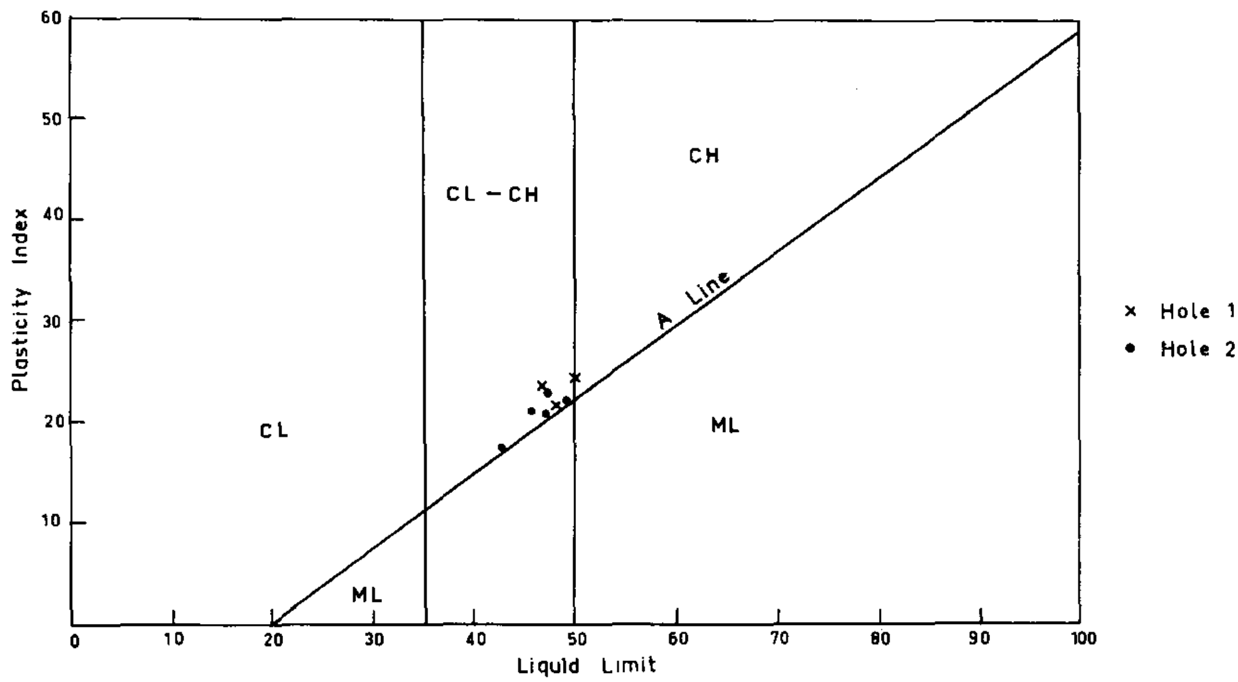


Figure 2. *Clay classification diagram, with samples of clay from Holes 1 and 2 marked.*

5 cm

Table 1 *SOIL TESTING RESULTS*

Hole	Sample	Depth (m)	Moisture content (%)	Plastic limit	Liquid limit	Plastic Index	Linear Shrinkage (%)	X R D Analysis — Clay fraction (%) Illite	Kaolinite	Montmorillonite	Goethite	Total Quartz
1	1	0.6	27	NOT	TESTED		-	-	-	-	-	-
	2	1.5	28	26	50	24	11	60-65	20-25	10-15	-	15-20
	3	2.4	28	24	47	23	10	55-60	20-25	15-20	-	20-25
	4	3.3	26	NOT	TESTED		-	-	-	-	-	-
	5	4.2	25	27	48	21	-	65-70	15-20	10-15	-	20-25
	6	4.5	24	NOT	TESTED		-	-	-	-	-	-
2	1	0.6	29	27	49	22	11	45-50	20-25	15-20	5-10	20-25
	2	1.5	27	26	47	21	10	-	-	-	-	-
	3	2.4	25	25	46	21	9	50-55	25-30	10-15	0-5	20-25
	4	2.6	17	NON-PLASTIC NOT TESTED				-	-	-	-	-
	5	3.3	24	24	47	23	10	-	-	-	-	-
	6	3.6	22	26	43	17	9	75-80	5-10	10-15	-	20-25

Sample 2 Hole 2 - Angle of friction 32°, effective cohesion 0.6 kPa

Soil testing by R.N. Woolley, Department of Mines, Hobart

The clay is expansive, with 9-11% linear shrinkages measured. The XRD analysis showed the composition of the clay to be dominantly of the illite clay family, comprising 45-80% of the total composition of the samples tested. Kaolinite comprises the second major component of the clay but expansive montmorillonite was present, in significant amounts (varying from 10-20%) in all the samples tested. The quartz component of all the samples tested was high, forming 15-25% of the total composition of the samples.

The medium plasticity, combined with the high quartz component, is thought to be reflected in the high angle of friction of 32° for the clay sample shear box tested. The effective cohesion value of 0.6 kPa is very low and is considered to be an unreliable value.

LANDSLIDE TYPES IN LILYDALE

The tested properties of the Lilydale clay derived from the weathering of the Lower Permian mudstone are noticeably different to the properties of clay from the Launceston Beds of Tertiary age of the Tamar Valley. The plasticity is much lower (fig. 2) and the angle of friction is higher and cohesion lower.

The difference in properties is thought to be reflected in the type of recent slope failure in the Lilydale area. The failures are shallow slides affecting only part of the slopes, and of a limited size. The failures appear to occur on a moist clay layer at the interface of the hard, slightly weathered mudstone and the overlying clay. Failures are particularly numerous in the steeper bush-cleared area of Lilydale and appear to be translational planar slides. Other failures, which are thought to be shallow slip-circle failures, occur in wet areas at the head of small valleys, causing valley collapse structures. The large slips at Lilydale, affecting most of the slope, appear to be old, now stable structures with some reactivation by small parasitic slides. In the following stability analyses an attempt is made to model these three types of failures.

SLOPE STABILITY ANALYSIS

Using the shear box results, three back-slope analyses were calculated. One analysis was for a planar slide of infinite length with a slope of 16° (Morgernstern and Sangrey, 1978). The other two analyses were slip circle analyses - one for the whole slope from the house site to the break in slope at 275 m level; and the other for the top half of this slope (fig. 1).

PLANAR SLIDE ANALYSES (Table 2)

The potential failure surface for these analyses was taken at three metres depth. This was the interface depth between the massive yellow clay and the extremely weathered mudstone in Hole 2, downslope from the house site. With the slab totally saturated (pore pressure ru = 0.45), and with cohesion values of 0 and 0.6 kPa, the slab was close to failure. The factors of safety were 1.12 and 1.16. With a more realistic pore pressure value of 0.25, the factors of safety increased to 1.59 and 1.63. When the slab was completely drained (pore pressure 0.0), the factors of safety were 2.18 and 2.22.

The method of failure for most of the shallow Lilydale landslides appears to be planar, but the depth of the failure plane is frequently very shallow

Table 2. PLANAR SLIDE FAILURE ANALYSIS

Factor of safety	Degree of saturation Pore Pressure (ru)	Effective cohesion (kPa)
1.118	Totally saturated ru = 0.45	0.0
1.157	Totally saturated ru = 0.45	0.6
1.589	Wet ru = 0.25	0.0
1.629	Wet ru = 0.25	0.6
1.943	Moist ru = 0.1	0.0
1.982	Moist ru = 0.1	0.6
2.179	Dry ru = 0.0	0.0
2.221	Dry ru = 0.0	0.6

Given: Angle of friction 32°
Infinite length of slope
Depth of failure surface 3 m
Density of material 19 kN/m^3
Slope angle 16°

(from 1.0 to 1.5 m). Because a deeper failure plane of three metres was used, these calculated factors of safety are thought to be conservative, although they do highlight the importance of drainage at this site even with clay having such high angles of friction as 32°.

SLIP CIRCLE ANALYSES

Calculation of both the total slope and the partial slope back analyses used a Texas Instruments T59 calculator, based on a programme for Bishops Simplified Stability Analysis (Moon, 1984). In all of these calculations the shear box angle of friction of 32° was retained, and the effective cohesion value of 0.6 kPa was used in all the partial slope analyses. The effective cohesion was raised to 3 kPa in some of the total slope analyses but the effect on the factor of safety was minimal.

Total slope slip circle analyses (Table 3)

Various slip circle potential failure planes were used in these analyses, with the maximum depth ranging from twelve to four metres. With deep failure planes of eight and twelve metres, and with the slope saturated (pore pressure ru = 0.45) and cohesion at 0.6 and 3.0 kPa, the slope was at point of failure with a factor of safety at 1.0. At an eight metre depth of failure with the slope moist (ru = 0.1), the factor of safety increased to 1.7, and when completely drained and dry (ru = 0.0) it increased to 1.9.

With shallow failure planes at maximum depths of four and six metres, the slope, when fully saturated, failed with a calculated factor of safety at 0.9. In the shallower failure of 4.0 m when very wet (ru = 0.3), the slope was close to failure (1.2), increasing gradually to only 1.8 when completely dry.

To the writer, these analyses support the field evidence that the Lower Permian age mudstone is very sensitive to failure in the Lilydale area. Though the large failures, that these analyses model, do occur in the Lilydale/Karoola area, these types of landslides are considered to be old structures and probably occurred in wetter climatic conditions than the present day.

Table 3. SLIP CIRCLE ANALYSIS, TOTAL SLOPE

Slope angle 16° - 23°
Height = 25 m
Length = 70 m

Given: Tested angle of friction 32°
Density of material 19 kN/m³
Tested effective cohesion 0.6 kPa
Number of slices used in analysis = 7

Factor of safety	Degree of saturation Pore pressure (ru)	Effective cohesion (kPa)
Yc circle = 75 m, maximum depth of failure plane = 12 m		
1.004	Saturated 0.45	0.6
1.05	Saturated 0.45	3.0
Yc circle = 100 m, maximum depth of failure plane = 8 m		
1.005	Saturated 0.45	3.0
1.71	Moist 0.1	3.0
1.92	Dry 0.0	3.0
1.67	Moist 0.1	0.6
Yc circle = 150 m, maximum depth of failure plane = 6 m		
0.91	Saturated 0.45	0.6
Yc circle = 200 m, maximum depth of failure plane = 4 m (approx.)		
0.90	Saturated 0.45	0.6
1.19	Very wet 0.3	0.6
1.38	Wet 0.3	0.6
1.59	Moist 0.1	0.6
1.79	Dry 0.0	0.6

Partial slope slip circle analyses (Table 4)

In an attempt to model the smaller slides that so commonly occur in the mudstones in the Lilydale district, less than half the slope in front of the proposed house site was used. Three slip circle failure planes were used with maximum depths of less than four, four, and seven metres. The same angle of friction (32° from soil laboratory testing) and cohesion value (0.6 kPa) were used.

These analyses showed that the smaller slope was marginally more stable than the total slope when the potential failure planes were at the same depth. With a failure plane at 7.6 m depth for a partial slope when fully saturated, the factor of safety was 1.2 compared with 1.0 for an eight metre deep failure plane for the total slope when fully saturated. When the pore pressure is reduced to a moisture level of 0.1 for the partial slope, the factor of safety was 2.07 for the partial slope compared with 1.71 for the total slope.

Table 4. Slip circle analysis, upper section of slope

Partial slope
Slope angle 16° (mainly)
Height = 11.2 m
Length = 35 m

Given: Tested angle of friction 32°
Density of material 19 kN/m³
Tested effective cohesion 0.6 kPa
Number of slices used in analysis = 7

Factor of safety	Degree of saturation Pore pressure (ru)	Effective cohesion (kPa)
Yc circle = 27 m, maximum depth of failure plane = 7.6 m		
1.20	Saturated	0.45
2.07	Moist	0.1
Yc circle = 50 m, maximum depth of failure plane = 4.5 m		
1.15	Saturated	0.45
1.49	Very wet	0.3
1.74	Wet	0.2
1.96	Moist	0.1
2.21	Dry	0.0
Yc circle = 100 m, maximum depth of failure plane less than 4 m		
1.10	Saturated	0.45
1.42	Very wet	0.3
1.66	Wet	0.2
1.88	Moist	0.1
2.11	Dry	0.0

With a shallow failure plane at a maximum depth of 4.5 m for the partial slope, the factor of safety was 1.15 when fully saturated, increasing to 2.21 when the slope was dry. This compares with a factor of safety of 0.9 for the fully saturated total slope and 1.79 for a dry total slope.

The slip circle analysis results for a failure plane of less than four metres maximum depth are comparable with those of the planar slide analysis of three metres depth. The shallow slip circle analyses gave a factor of safety when fully saturated of 1.10 compared with 1.16 for a planar slide analysis. When the two slopes are dry, the slip circle analysis gives a factor of safety of 2.11, which is similar to that of a planar slide with a factor of safety of 2.22.

These combined models of a shallow slab and slip circle failures for the top half of the slope at Site 3 are probably the more realistic and indicative of any future failure at this site, particularly as two auger holes drilled on the site bottomed on weathered mudstone. As weathered mudstone crops out on the track immediately behind the site, the bedrock profile will most likely be stepped and irregular. Given a bedrock profile of that shape, with variable and sudden changes in the thickness of the overlying clay, small shallow planar or slip circle failures are considered to be the most likely landslides to occur at the site. Any such small slide occurring in the future at the front of the house would probably not destroy the house if it was piled into bedrock.

INVESTIGATION RESULTS

(1) In the Lilydale area, slope failures are common in Permian age mudstone on similar slopes to those of Buchanan's block, as for example at Station and Doaks Roads. These failures appear to have occurred after the bush has been cleared, and are mainly shallow slides that occur on the valley sides or at the head of a valley, causing valley collapse structures. The latter are frequently associated with wet, poorly drained areas.

(2) There is evidence for such localised failures occurring on Buchanan's block at some of the previously investigated house sites (Hawes site b, Appendix 1).

(3) Trenching and drilling show that there is an adequate thickness of clay present on the slope in front of Site 3 for slope failure to occur.

(4) No soft or moist zones were seen in either of the two auger holes and neither hole made water.

(5) The drill is thought to have bottomed on the unweathered mudstone but no rock fragments were recovered on the auger bit to confirm this conclusion. Therefore, there is a slight possibility that the clay sequence is deeper and the drill was stopped in a hard pan layer in both holes.

(6) Such a hard pan layer is likely to act as a moisture barrier within the clay and thus would limit the depth of potential landslides at the site.

(7) The laboratory results show the clay to be plastic and expansive, and with a constantly high quartz content. The shear box test gave a high angle of friction of 32°. This result reflects the medium plasticity and high quartz content of the clay. The effective cohesion is very low (0.6 kPa), and this laboratory result is considered to be conservative.

(8) The three stability models confirm the field evidence that the slope below Site 3 is sensitive to slope failure and that effective drainage is important for the future stability of the slope. The models also show that failures are possible in the Lilydale clay despite the high angle of friction of 32°.

(9) A major failure of the total slope is theoretically possible, given that the whole slope becomes totally saturated. This model becomes more pertinent if the clay underlying this slope is thicker than the writer interpreted from the drilling results; that is the drilling was stopped not on mudstone bedrock or a hard pan, but on a gravel or some other permeable layer which is then underlain by further clay.

This analysis of the total slope models the old landslides at Karoola, Second River Valley, and north of Doaks Road. These large structures now appear to be stable and are thought to have failed in a wetter climate than exists at the present time.

(10) Both the planar slide analysis and slip circle analyses of part of the slope in front of Site 3 indicate that the slope is very close to failure when saturated. Only when the slope is totally drained and dry does the factor of safety exceed 2.0. These two sets of analyses are thought to model closely the recent shallow failures in the mudstone at Lilydale, and show why such landslides are common in this area.

(11) The reason why this slope has not failed to date is that it is located on a spur overlooking the small incised stream valley to the north. Consequently, it is well drained, as indicated by the lack of moist or wet zones in the two drill holes on the site.

(12) A further contributing factor to the slopes stability is that the clay-mudstone interface is probably irregular and stepped as a result of the coarse bedding of the mudstone.

CONCLUSIONS

(1) The field inspections, subsurface investigation, and stability analyses all indicate that there is a definite risk of landslides occurring at Site 3. This is equally true of all the other sites inspected along the logging access track. Even at Site 1, the safest site from the slope stability aspect, there is a slight potential risk, this being from a rock fall occurring on the steep bush-covered slope behind the flat area and boulders damaging any future house.

(2) The landslide risk is enhanced by the amount of water present in the ground on the slope in front of Site 3. The degree of saturation affects the slope stability more than any other factor tested. The clay at Site 3 is unlikely to fail when it is dry or moist. It is only when it is very wet and the slope becomes saturated that failure will occur. Site 3 appears to be naturally well drained because of its location. This fact alone makes the risk at Site 3 acceptable to the writer.

(3) Any failure at Site 3 is more likely to be downslope from the actual house site, because the clay is thicker downslope. Rock crops out immediately behind the house site and the risk of landslide at the site on the track is considered to be small. If a landslide does occur immediately downslope from the proposed house, only the head scarp area is likely to affect the house. If the building is piled into the bedded mudstone rock, there is a possible chance of the house surviving such movements.

(4) The danger of a rock fall occurring behind the house at Site 3 on the steep bushed slope exists, but it is no greater than for the other sites along the track. It will have to be accepted as a minor possibility if the bush on this steep slope is retained.

(5) Of the alternative sites on the lower area of the block, Sites 4a and 4b, because of their lack of views, and the extra cost of roading, cannot be considered as serious alternatives to Site 3.

Even though the views from Site 1 are better than these two lower sites, the close proximity of the neighbour's house is a serious detraction. This site, understandably, will only be acceptable to the Robniks as a feasible alternative if the risk of a slope failure at Site 3 is so great that it is unacceptable. The subsurface investigation and slope analyses do not indicate that the risk is so high. They would appear acceptable to the writer if the following recommendations are implemented and followed over time.

RECOMMENDATIONS

(1) Site 3 cannot be recommended for a house with conventional foundations. The foundations for the site will have to be piers dug or drilled down to the hard bedded mudstone at least 2.5 m deep, as indicated from the drilling on the site. The owner must be convinced that all the piers on which the poles for the house will be situated are into this rock. As the owner was informed verbally, if he has any doubts determining the correct material, an inspection of the foundation holes should be requested from the engineering geology section of the Mines Department. Water must not be allowed to run down the poles and collect on the surface and infiltrate down the pier sockets. A light concrete apron beneath the house would be advantageous in keeping this area dry.

(2) Strictly on slope stability considerations, Site 1 is the preferred site by the writer. It has a lower landslide risk and would be suitable for a house with conventional foundations.

(3) Any cutting into the high slope at the back of the house should be kept to a minimum at Site 3. This high slope should remain covered by trees.

(4) The septic tank overflow and evaporation drains must be located away from the slope in front of the house and located as indicated previously on site by the Launceston City Health Inspector, Mr D. Baker.

(5) The site should be well drained. Any drains should lead away from the slope in front of the house and be kept well maintained. They should be inspected regularly.

(6) The lower slopes should be planted in as many shrubs and trees as possible.

(7) Any swimming pool should be the above ground type so that any leakage is immediately visible.

(8) The access track drains should be adequate to remove any run-off from the slope behind the house.

(9) No further subdivision should be contemplated on this block.

REFERENCES

MOON, A. T. 1984. Bishop's simplified slope stability analysis with a Hewlett-Packard 41C calculator. *Unpubl. Rep. Dep. Mines Tasm.* 1984/51.

MORGENSTERN, N. R.; SANGREY, D. A. 1976. Methods of stability analysis, *in:* SCHUSTER, R. L.; KRIZEK, R. J. (ed.). Landslides. Analysis and control. 155-171. *Special Report Transportation Research Board, National Research Council.* 176.

[18 December 1986]

APPENDIX 1

Letter from W. R. Moore to Mr Steven Tapp

PROPOSED HOUSE SITE - POWERS ROAD, LILYDALE

As requested in your letter of 10 April this proposed site was visited by Mr Moore on 18 April and again on 7 May with Mr David Baker, Building Inspector for the Lilydale Municipality, Mr B. Weldon, Engineering Geologist and yourself.

The house site chosen is on a steep section of a logging track that climbs from the end of Powers Road in a N.E. direction. The site is on a corner of this track and the slope of the bank above the track is 20° and 18° below. On the road bank near the site is a good outcrop of the blue-grey mottled siltstone of Permian age. On the lower slopes below the road, in the shallow inspection pits, the rocks were a grey-white silt (ML) with low plasticity. The depth of weathering is unknown in the siltstone.

With such a steep slope a conventional house is not possible because the cut into bank to form a flat site would require a very high bank. Such a bank would fail without a large retaining wall.

Mr Tapp intends to build a type of pole house which will require little to no cutting into the bank. With such a steep slope, these poles, or foundations for them would be required to be founded into unweathered rock. This requires the depth of weathering be known.

Obviously this is going to be a difficult site and will require extra cost for investigation and for the design of the foundations etc. by a structural engineer.

The first stage of the investigation requires at least two backhoe trenches to be dug along the front of the house. These trenches would be required to be examined by an engineering geologist as they were being dug. If the unweathered rock is not reached, a small drill would be required to drill at least two holes to find the depth to unweathered rock.

There are other less steep sites down the track, and one area of flat ground next to the existing house of Livingston's which would require no investigation.

[3 June 1985]

Letter from W. R. Moore to Mr Steven Tapp

In reply to your letter received at this office on 20 June in which you request a detailed landslide zoning of a 10 acre section of Buchanan's property. This is a difficult project and could be costly to undertake with any degree of accuracy.

On the largest scale topographical map of the area available, the 1:25 000 Lands and Survey series, the extension of Powers Road to Livingston's homestead and the logging track, the location of your preferred house site, are not shown. If detail zoning is required they would have to be surveyed so that they could be plotted accurately on the enclosed map.

In the Lilydale area, any slope above ten degrees and underlain by mudstone of Permian age is classified as a potential landslide risk. On the available scale of the enclosed map a potential landslide classification would cover most of the ten acres you wish to acquire. It should be noted that an investigation is frequently only a site inspection and does not necessarily involve subsurface investigation as recommended at your preferred site. This is the difference between your site and the alternative house site and Livingston's homestead. The homestead is still in a potential landslide area, because the amount of low sloping land on which the homestead is situated is very limited. Steep slopes are also present behind and in front of the homestead and it is thought to be underlain by mudstone. It has a risk of landslide failure but this risk is smaller than your preferred site in Mr Moore's opinion, as previously explained.

[1 July 1985]

Letter from W. R. Moore to Mr and Mrs Hawes

BUCHANAN'S BLOCK, POWERS ROAD, LILYDALE

As requested by your letter of 24 September this letter confirms in writing the results of an on site visit by Messrs Baker and Moore on 1 October 1985.

This block has been previously visited by Messrs Baker and Moore for a house site - higher on the logging track to the site preferred by yourselves. Buchanan's block is difficult, although 10 acres in size - most of it is steep bushland underlain by Permian mudstone. There are very few areas suitable for a house site. The only site in which no subsurface investigation would be required is that on the western boundary adjoining the neighbours existing house. This site is generally not acceptable because people who wish to build in the country do not want to live so close to their neighbours.

Two areas were discussed on 1 October:

(a) The site on the end of the spur covered with a thick grove of large tea-trees is difficult. At this site the proposal to flatten all these trees by a bulldozer and cutting into the top of the spur to build a house site is likely to create problems. Slope failure and severe erosion could occur before the new trees and shrubs grow around the house on the cleared slopes. Slope failures are so common in Lilydale when the bush is removed and erosion appears almost inevitable on the steep Permian mudstone slopes as for example along Doaks and Station Road. A selective replacement of the tightly spaced tea-trees to make a house site would be difficult.

(b) The other site on the N.E. slope above the head of a very shallow valley also has problems. Nearby is a damp seepage area which drains down into this small valley. The proposed house site is very close to a break in slope below which valley headward slumping appears to have occurred.

As stated by Mr Baker, with a house sited in this position the only place to put your septic tank overflow drains is on this unstable ground. Further excess water in an already moist area would add to its instability. The danger of reactivating this area is that headward extension of the slumping may reach your house. A repositioning of your site to the S.E. side of this shallow drainage area which allows the house to be placed further back from the break in slope in the area suggested by Mr Baker is preferred.

If you intend to proceed with any of these sites a backhoe pit is recommended. This allows subsurface material to be adequately examined and tested. This information will be required to design the foundations for your house suitable for these sites.

[18 October 1985]

APPENDIX 2

Letter from W. R. Moore to The Town Clerk, City of Launceston

BUCHANAN'S BLOCK, POWERS ROAD, LILYDALE

This letter confirms the discussion on the five proposed house sites inspected by yourself and Mr Moore with Mr and Mrs Buchanan on 11 November. A copy of Mr Buchanan's site plan is enclosed.

From previous inspections you are aware that Mr Moore considers this block a very difficult area for finding a house site. The steep hill area comprising Permian mudstone behind the access track is considered unsuitable for conventional houses. Of the five sites visited only two would require no further subsurface investigation trenching. A summary of the discussions dealing with slope stability of the five sites is given for your records.

Site 1

This is a low sloping, almost flat site, close to Powers Road. On this site no subsurface investigation would be required for slope stability. The area should be drained and any septic tank overflow and household sullage should be kept off the site. The toe area of the steep Permian mudstone slope behind this site should not be excavated. Any tree cutting on this slope should be kept to a minimum.

Site 2

This site is on a narrow spur ridge covered with Paperbark Tea Trees. The actual site area is narrow and it may be preferable for the house foundations to be in the underlying mudstone. This will depend on the depth of the soil and subsoil layer and if there is a clay layer present between this regolith cover and the underlying mudstone rock. Above this impervious clay is a wet or moist zone. It is on this clay interface where the shallow slides frequently occur in the Lilydale area when trees are removed.

Drainage and septic tank overflow should be removed off this site. The removal of the tea trees should be selective as far as can be achieved. Any ridge top levelling should be kept to a minimum. Planning to bulldoze the ridge and lowering its level and widening the flat area by pushing the fill on the sides of the spur is considered very dangerous. Slope failures have occurred nearby and with further loading by the fill, parasitic slides are likely to develop. This may also reactivate the nearby old slide. Excavating into the slope behind the logging track would also create stability problems.

Site 3

This site is at the foot of a high slope. It is bordered by an incised narrow tributary stream valley. Though the area is larger than site 2 it is still restricted. For similar reasons to site 2 a subsurface trench would be required at this site. Excavating into the foot of the steep slope is also not recommended.

Septic tank overflow and household drainage would have to be removed off the site and the stream is the convenient place for stability reasons but this conflicts with health regulations.

Site 4A and 4B

These sites are situated down on the block near its western boundary. Site 4A is on a low sloping well-drained flat and is unlikely to have any stability problems. Particularly if a house is sited upslope at the east end of the flat. 4B is slightly higher than 4A. The slope is steeper and the flat area is less extensive. This site appears not to be as well drained as site 4A. A subsurface investigation is thought to be prudent at this site in order to see if there is a well developed clay layer present at this site.

Septic tank drainage is a problem of both these sites. If the septic tank overflow is pumped uphill above the sites particularly 4B and increases the amount of groundwater above the clay interface between the soil and underlying mudstone, this would increase the areas potential instability.

A copy of this letter has been forwarded to the Buchanan's who have informed Mr Moore that they have resold the block.

[22 November 1985]

TASMANIA DEPARTMENT OF MINES

18/20

EXPLANATION SHEET FOR ENGINEERING LOGS

Borehole and excavation log

Penetration

Water

Notes - samples and tests

U50	Undisturbed sample 50mm diameter.
D	Disturbed sample.
N	Standard penetrometer blow count for 300mm.
N *	SPT + sample.

Material classification

Based on Unified Soil Classification System.

In Graphic Log materials are represented by clear contrasting symbols consistent for each project.

Moisture content

D	Dry, looks and feel dry.
M	Moist, no free water on hand when remoulding.
W	Wet, free water on hand when remoulding.
LL	Liquid limit.
PL	Plastic limit.
PI	Plasticity Index.

eg. M > PL - Moist, moisture content greater then the plastic limit.

Consistency

		hand penetrometer (kPa)
VS	Very soft.	< 25
S	Soft.	25 - 50
F	Firm.	50 - 100
St	Stiff.	100 - 200
VSt	Very stiff.	200 - 400
H	Hard.	> 400
Fb	Friable.	

Notes: X on log is test result
— is range of results.

Density index

		%
VL	Very loose.	0 - 15
L	Loose.	15 - 35
MD	Medium dense.	35 - 65
D	Dense.	65 - 85
VD	Very Dense	85 - 100

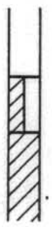
Cored borehole log

Case - lift


Casing used.


Barrel withdrawn.

Fluid loss



Lugeons

Lugeon units (μL) are a measure of rock mass permeability. For a 46 to 74mm diameter borehole 1 Lugeon is defined as a rate of loss of 1 litre per metre per minute. 1 Lugeon is roughly equivalent to a permeability of 1×10^{-4} mm/sec.

Graphic log

Weathering

Fr	Fresh.
SW	Slightly weathered.
HW	Highly weathered.
EW	Extremely weathered.

Strength

		point load strength index $I_{s(50)}$ (MPa)
EL	Extremely low.	< 0·03
VL	Very low.	0·03 - 0·1
L	Low.	0·1 - 0·3
M	Medium.	0·3 - 1
H	High	1 - 3
VH	Very high.	3 - 10
EH	Extremely high.	> 10

Note: X on log is test result.

Significant defects

Significant defects shown graphically.

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – BOREHOLE

borehole no. 1

sheet 1 of 1

19/20

project Proposed house site Buchanans Block

location Powers Road, 20 m north of old Logging Track at end of road.

co-ordinates	5185-54300	drill type	Triefus	hole commenced	6 August 1986
		drill method	Auger	hole completed	6 August 1986
R.L.	240 m (approx.)			drilled by	B. Cox
inclination	Vertical	drill fluid	None	logged by	W.R. Moore
bearing	--			checked by	R.C. Donaldson

notes samples, tests	depth (m)	classification symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency density index	structure, geology
S1		CH	Clay - yellow-brown, highly plastic	M < Pl	F	Clay
	1.0	Cl	Clay - yellow with some small mudstone pebbles. Permian pebbles 10% Clay - yellow, medium plasticity		St	
S2, S3	2.0	CH	Clay - yellow, medium plasticity	M Pl	V St	
S4, S5, S6	3.0, 4.0		Clay - grey-yellow, medium plasticity	D	H	Extremely weathered mudstone

support: None; water: None

Drill refused at 4.5 m. Too hard. Bedrock or very hard layer struck.

N.B. All samples disturbed.

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – BOREHOLE

borehole no. 2
sheet 1 of 1

29/20

project	Proposed House Site Buchanan's Block	location	Powers Road on side of Old Logging Track at end of road
co-ordinates	5185-54300	drill type	Triefus
		drill method	Auger
R.L.	245m	hole commenced	6 August'86
inclination	Vertical	hole completed	6 August'86
bearing	–	drilled by	B. Cox
drill fluid	None	logged by	W.R. Moore
		checked by	R.C. Donaldson

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
	None	None				CL-CH	Clay Brown, Medium plasticity	M	F		Clay
			S1	1.0			Clay Yellow, Medium plasticity	M < Pl	St		
			S2	2.0					V St		
			S3			GC	Clay with gravel. Clay - low plasticity, yellow. Gravel - no pebbles returned.	D	H		Gravel in mudstone
			S4	3.0		CL-CH	Clay - yellow, medium plasticity	D	H		Extremely weathered mudstone
			S5								
			S6				Drill refusal at 3.6 m. Hard layer or bedrock struck.				

N.B. All samples disturbed.

5 cm