1985/64. Slope stability of Watchorn's Estate at Brickmakers Point, Deviot

W.R. Moore

Abstract

The amalgamation of two blocks in Deviot was authorised by the local council, provided a house site could be found on the larger of the two blocks. This block slopes down from a ridge which is capped by sand and gravel, as exposed in old gravel pits. The slope on the block is 10°-12° but three well-developed benches occur on its southern section. These benches appear to be old landslide features.

Trenches were dug on each of these benches by a backhoe. On the upper bench, the interface between the overlying gravel and underlying clay dips towards the back of the bench. The clay was fissured and shear polished. These sediments are considered to belong to the Launceston Beds of Tertiary age and are highly plastic, with high linear shrinkages and a low angle of friction. The tilting on the interface and fissuring of the clay indicate that this bench was formed by slope failure.

Laterised and iron-cemented gravels were encountered in the trenches on the lower two benches. These gravels could not be penetrated by the light backhoe. The cementing is thought to be caused by water table fluctuation and precipitation at the gravel and presumed clay interface, occurring after the benches formed. This indicates that these benches are very old and have been stable for a long period of time. House sites are possible on all three benches but the preferred site is the lower bench. The lot was rezoned as an old landslide area (Zone 4) with certain building recommendations to be followed.

INTRODUCTION

A proposal to amalgamate Lots 1 and 32 from E.B. Watchorn's Estate at Brickmakers Point, Deviot [DQ932359] (fig. 1) was suggested to the Beaconsfield Municipal Council by C.J. Cohen and Associates, Surveyors and Town Planners, Launceston. Some of the larger lot (Lot 1) is in a Zone III (potential landslide) area (fig. 1), and in 1982 the Deviot Road failed approximately 300 metres south-east of the proposed subdivision. The Beaconsfield Council gave approval for the subdivision, provided that the Department of Mines could find a suitable house site on Lot 1.

C.J. Cohen and Associates are acting for Mr and Mrs C.H. Wilkin, who wish to purchase both blocks and amalgamate the titles. The Wilkins wish to build a house on Lot 1 in the Zone III landslide area, along the ESE boundary of the block. They have no plans for any further subdivision. The amalgamation of the two blocks permits access to the large lot through the small Lot 32. This block fronts onto Deviot Road and is poorly drained and marshy. Building approval on such a small block is not likely to be obtained until Deviot is sewered. A septic tank approval is unlikely to be granted because of the difficulty of having a house with a septic tank and retaining overflow drainage on such a small area. The Wilkins hope to build a mud brick home with bricks manufactured from clay occurring on Lot 1.

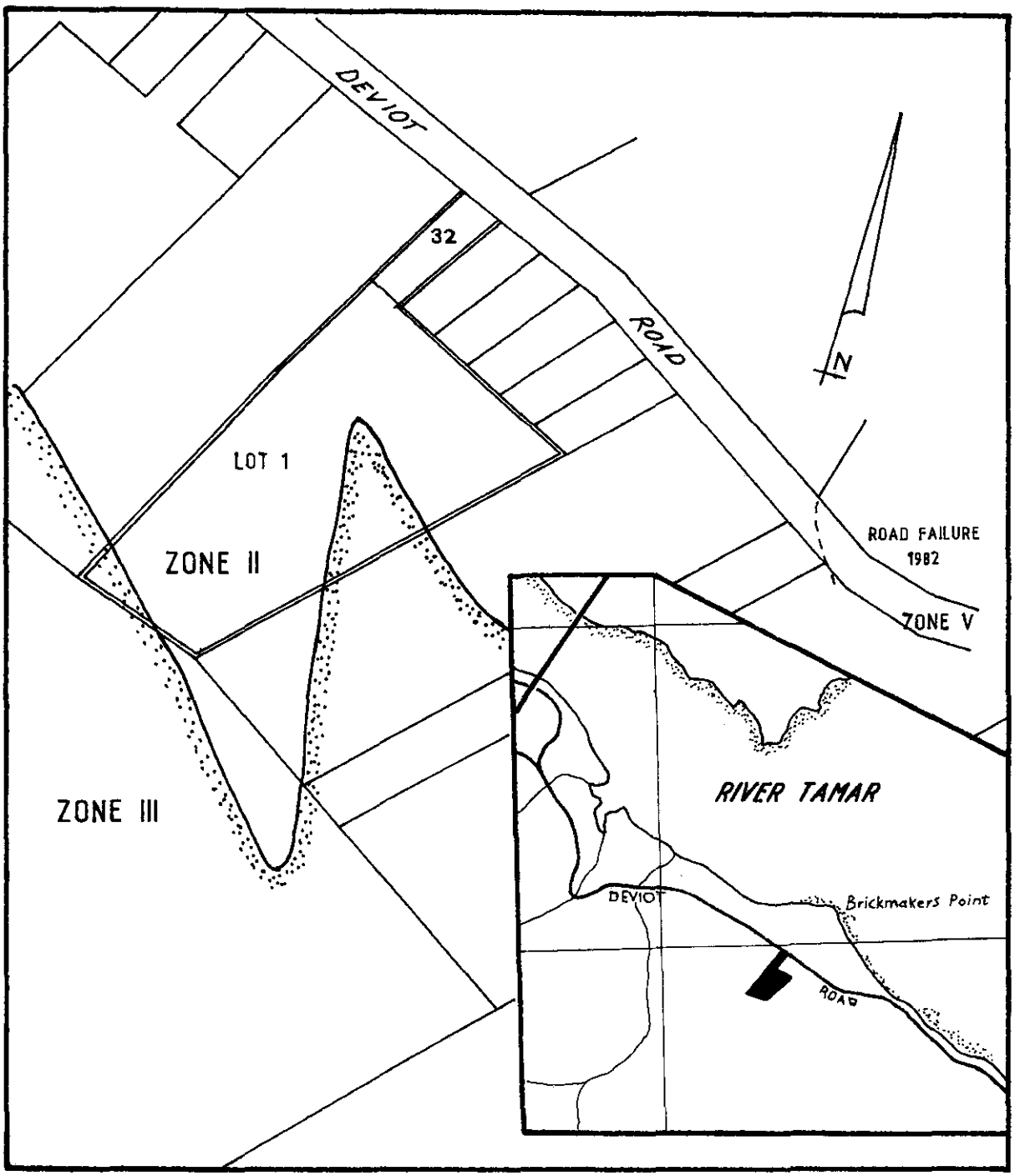

Figure 1. *Location of investigation area. Former landslip zones as marked.*

INVESTIGATION

The blocks were located and briefly examined on 1 October 1985. Lot 1 is bush covered and the boundaries were difficult to locate. As the location where the Wilkins proposed to build was not known, little could be achieved in this visit. On 17 October Mrs Wilkins showed the writer their proposed house site and a possible alternative site. The morphology of the area was mapped (fig. 2) and subsurface investigation requested, requiring trenches on each bench.

One trench was dug on each of the three benches on 13 November, using a light crawler type of backhoe. The actual trench site on each bench was chosen by Mr Wilkin as his preferred house site. The position and logs of these trenches are given in Figure 2 and Appendix 1. Clay samples collected from these trenches were tested in the soil laboratory for moisture content, Atterberg limits, and linear shrinkage. X-ray diffractograms were done to determine the clay composition and percentage of quartz in the total sample. The clay sample with the highest plastic index was shear box tested for its angle of friction and effective cohesion.

SLOPE MORPHOLOGY

The small block (Lot 32) adjoining Deviot Road has no slope stability problems, with a low slope of 2° fronting the road and increasing to 4° at the rear of the block. The block is relatively flat and wet and there may even be a spring in the large area of blackberries in the middle of the block.

Lot 1 has a complex slope, particularly along the south-east boundary, where three well-developed benches with bench slopes of 3°-5° and fore slopes of 12° occur. Each bench has a well defined change of slope (fig. 2). Only the widest of these three benches (the middle bench) continues through to the vehicle track that follows the block's north-west boundary, the other two benches pinching out. The construction of this access track to the gravel pits along the ridge has considerably modified the landscape in this area.

The origin of these benches is not obvious. Similar benches occur along the same ridge one kilometre south at Lawrences (Moore, 1983) where highly fissured clay was found beneath surface sand and gravel. Here the benches were thought to be formed by old landslides. At Lawrences it was recommended that houses could be built on these terraces, if certain precautions were taken and closer subdivision did not occur.

SURFACE GEOLOGY

The only surface exposures in the area are white quartz sand and gravel (SG) in the old pits along the ridge. Similar sand and gravel occurs on the high bench, all of which is now thought by Mr Wilkin to be in Lot 1. The soils on the lower slope of Lot 1 are grey silty sand (SH) and silt with sand (ML). Dark grey silt (MH) soils are present on Lot 32.

No rock outcrops were found on either lots. The dolerite contact shown on the Beaconsfield geological map (Gee and Legge, 1971) as climbing to the gravel pit ridge occurs north of these blocks. Poor outcrops of deeply weathered basalt occur at Brickmakers Point, but no basalt outcrops or boulders were seen on either lot.

The two lots are thought to comprise a strip of Tertiary sediments

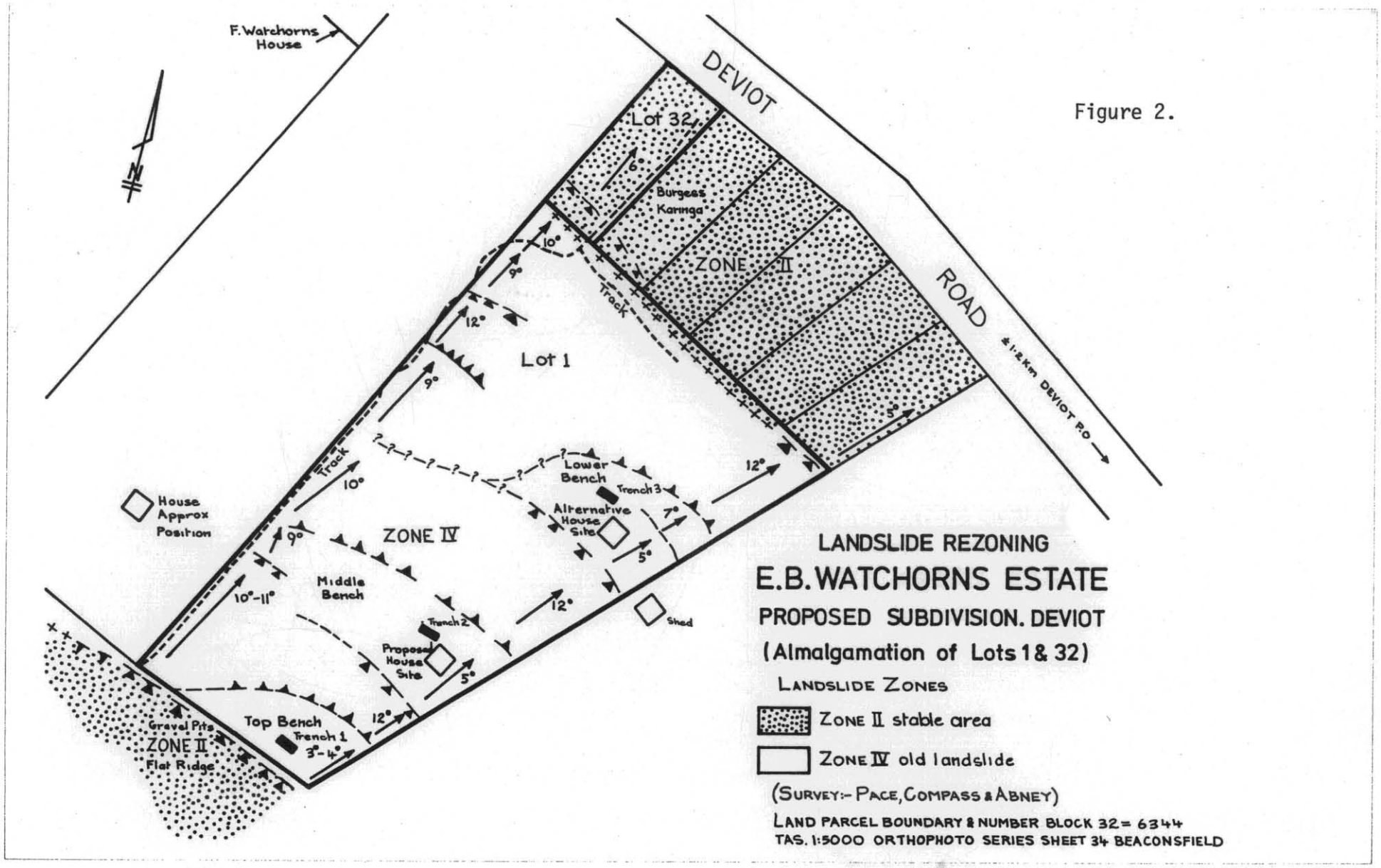

Figure 2.

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underlying the Cainozoic gravels of the ridge and between the dolerite of the Batmans Bridge area and the basalt at Brickmakers Point (Gee and Legge, 1971).

SUBSURFACE GEOLOGY

The engineering log of each hole is given in Appendix 1, and the location of the trenches is shown in Figure 2.

Trench 1

This trench was dug on the highest bench immediately inside the boundary of Lot 1. The trench exposed the gravel and sand that crop out along the ridge in the old gravel pits. The gravel in the trench thickens by one metre towards the back of the bench. The underlying black and organic clay also had a dip on the interface towards the back of the bench as shown on the log.

Below this organic clay layer was a grey-red and grey clay with bauxitic and limonite nodules at the base of the trench. The clay belonged to the Launceston Beds of Tertiary age (Longman, 1966). All the clay exposed was fissured, with polished faces on the fissures. No slickensides were seen. Four samples from this trench were collected for soil testing.

The tilting of the gravel and organic clay layer and the fissuring of the clay indicate to the writer that the top bench was formed by slope failure, and if the other two benches are underlain by fissured clay they were also formed by slope failure.

Trenches 2 and 3

Two extra trenches were dug to see if any clay was present on the two lower benches. Unfortunately, cemented gravel horizons which the back-hoe could not penetrate were encountered in both these trenches. The depth to the cemented gravel was 0.9 m in Trench 2 and 0.7 m in Trench 3 (Appendix 1).

Beneath the silty soil in Trench 2 was a soft orange clay with some sand and ironstone nodules. This irregular clay layer was above the cemented sand and gravel horizon. The clay was very soft, dry and highly plastic, and from field examination appeared dispersive. This type of clay is not normally associated with the Launceston Beds.

In Trench 3 was a very hard, black-brown laterised gravel with pebbles up to 40 mm but averaging 10-20 mm. It appears to be lithologically similar to the gravel and fine gravel (grit) and sand seen in the abandoned gravel pits, except for its iron cementing.

The cementing of the gravel is thought to be the result of a fluctuating water table producing localised precipitated iron pans in the gravel at the interface between the gravel and the clay. Similar iron pans were seen at Lawrences Subdivision, one kilometre to the south (Moore, 1983).

SOIL TESTING (Table 1)

The clay samples are all highly plastic and have high linear shrinkages. The four samples collected from Trench 1 all had higher moisture contents than the sample collected from Trench 2. This moisture content difference is marked in samples from comparable depths (43% compared

with 29%). This probably reflects the better drainage on the middle bench due to the cemented subsurface gravel layer. The plastic indices of the four clay samples from Trench 1 are all higher than the sample from Trench 2, although their composition appears similar.

The clay in Trench 1 is the grey and red mottled clay of the Launceston Beds of Tertiary age, which occur throughout the Tamar Valley. In contrast, the clay above the gravel in Trench 2 was lithologically different in appearance and is considered to be a younger, possibly reworked clay of the Launceston Beds.

Shear box testing showed the clay of Trench 1 to have an angle of friction (ϕ) of 16° and a cohesion of 4.9 kPa. These low results indicate the clay has failed.

SLOPE STABILITY OF THE THREE BENCHES

From their surface morphology, the three benches on Lot 1 appear to be old landscape features. If they are the result of landslides, as thought by the writer, then they were old failures. The cemented gravel underlying the sandy and silty surface soil in Trenches 2 and 3 is thought to be the result of water table fluctuations which have produced localised precipitated iron pans at the interface between the porous gravel and impermeable clay. The time required for these iron pans to develop after failure occurred would make the bench formation very old.

Once developed, the cemented gravels (particularly if underlying most of the benches) would cause the formation of perched water tables in the overlying sandy and silty soil, allowing for better drainage of the benches. The iron pans will also protect the underlying clay from the seasonal moisture fluctuations which appear to increase the clay plasticity. Both of these factors should increase the stability of the lower two benches.

If the iron-cemented gravel is not underlain by clay which has failed, but the benches are old river terraces, the laterised surfaces produced on dolerite or even basalt would have cemented the overlying river terrace gravel. If this is the mode of origin of the two lower benches no stability problem exists on them.

The lower bench is preferred as a house site to the middle bench. The layer of clay above the gravel in Trench 2 appears dispersive and the laterite gravels in Trench 2 did not appear as well developed compared to those exposed in Trench 3.

LANDSLIDE ZONING

The landslide zoning plan submitted by C.J. Cohen (fig. 1) was taken from the Department of Mines Tamar Valley Regional Landslide map. It is difficult to reconcile this zoning with the existing landscape morphology and geology. The zoning appears more related to the Batman Bridge dolerite contact area, approximately 100 m to the north in the vicinity of block number 6017.

After the surface examination, most of the slope on Lot 1 was mapped as a Zone III (potential landslide) area. From the subsurface investigation, the exposures in Trench 1 on the high bench indicated this bench was formed by slope failure. It is also presumed that the lower benches were also formed by slope failure, as they are thought to be underlain by clay.

Therefore, by definition, these three benches and intervening slopes are old landslide areas and must be classified as Zone IV.

This change in the landslide zone classification has not altered the stability of the area. In fact the subsurface investigation indicates that the stability may have improved on the lower two benches after failure.

CONCLUSIONS

(1) The subsurface investigation indicates that the high bench has been formed by slope failure and is a Zone IV landslide area (fig. 2).

(2) If clay of the Launceston Beds underlies the surface soil and cemented gravel exposed in Trenches 2 and 3 on the middle and lower benches, these benches were also probably formed by landslides. These benches therefore become Zone IV (old landslide) areas (fig. 2).

(3) As the backhoe was too light to penetrate the gravel, the slope failure on the lower and middle benches has not been proved. These gravels, particularly the laterised gravel in Trench 3, would be difficult to penetrate and probably would require expensive diamond drilling. This expense is not justified for a single house site on such a large block.

(4) If no clay is present beneath the gravel and it is underlain by basalt or dolerite, the other two rock types occurring in this area, little to no risk of slope failure exists. If the lower two benches were not produced by old landslides, they are combined structural and river terrace landscape features.

(5) Because of the morphology of the three benches and the presence of iron pans under the gravel of the lower benches, these benches are considered very old landslide failures. They have been stable for a long time since slope failure occurred.

(6) Because of possible better drainage by the development of these hard pans, the stability of the lower benches may have improved over time.

(7) On all three benches the risk of reactivating the old landslides by placing one house on them is considered minimal. This conclusion presupposes that septic tank overflow and other drainage is designed and sited to remove all excess water off the bench on which the house is sited, that both systems are maintained over time, and that the stability of the slope is maintained by keeping the existing trees or planting suitable shrubs or replacement trees.

(8) The lowest bench appears to be the most stable of the three benches. This presumes that all three benches are underlain by fissured clay and that the hard iron pan exposed in Trench 3 is extensive and not an isolated lens. It has been recommended to Mr Wilkin that he build his house on this lower bench. The lower bench is preferred to the middle bench because of the clay exposed in Trench 2 between the surface soil and underlying cemented gravel.

(9) Lot 32 has no slope stability problems.

RECOMMENDATIONS

(1) House sites are avilable on the proposed large Lot 1. Therefore the amalgamation of Lots 1 and 32 is recommended.

(2) The most stable house site is considered to be on the low bench near Trench 3. The house foundations should be dug to the lateritic gravel surface exposed in this trench.

(3) No further subdivision be contemplated of this proposed amalgamated lot until Deviot becomes fully sewered.

(4) Careful consideration be given to the siting of the septic tank, or more particularly its overflow or evaporation drains. This excess water should be taken off the bench area where the house is sited, preferably northwards from the house site.

(5) As most of Lot 1 is now considered to be a Zone IV (old landslide) area, adherence to the 1978 Building Regulations Division 5, is recommended.

(6) The usual precautions recommended on such a sensitive slope such as above the ground swimming pool, frequent inspections and maintenance of any drains, no overwatering of the lawns and gardens etc., have already been stressed to Mr Wilkin.

(7) Mr Wilkin proposes to use clay found on Lot 1 to make mud bricks for his proposed house. In view of the high linear shrinkage found in the laboratory tests on these clays, an experimental batch should be made and tested for cracking over a period of time.

REFERENCES

GEE, R.D.; LEGGE, P.J. 1971. Geological atlas 1 mile series. Zone 7 Sheet 30 (8215N). Beaconsfield. *Department of Mines, Tasmania*.

LONGMAN, M.J. 1966. One mile geological map series. K/55-7-39. Launceston. *Explan.Rep.geol.Surv.Tasm*.

MOORE, W.R. 1983. Slope stability and subsurface investigation of a subdivision at Deviot. *Unpubl.Rep.Dep.Mines Tasm*. 1983/42.

[16 December 1985]

Table 1. RESULTS OF SOIL TESTING

Location	Sample no.	Depth (m)	Moisture content (%)	Plastic limit	Liquid limit	Plastic index	Linear shrinkage	XRD (Fines only)	Quartz (%)
Trench 1 Top Bench	1	0.6	39	41	120	79	24	Kaolinite 90-95% Montmorillonite 0-5%	1.6
	2	0.8	34	43	119	76	22	Kaolinite 90-95% Montmorillonite 0-5%	1.5
	3	1.7	37	40	129	89	22	Kaolinite 95-100%	1.7
	4	2.4	41	47	134	87	26	Kaolinite 95-100%	1.8
Trench 2 Middle Bench	1	1.0	29	31	100	69	22	Kaolinite 95-100%	2

Soil testing by P. Terry, Department of Mines, Hobart

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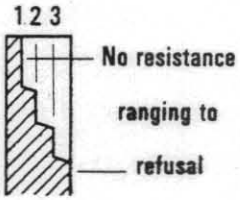
EXPLANATION SHEET FOR ENGINEERING LOGS

Borehole and excavation log

Penetration



Water

22 Jan, 80 Water level on date shown.

Water inflow.

Water outflow.

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

No loss

50% loss

100% 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

No core.

Rock substances represented by clear, contrasting symbols consistent for each project.

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.

Joint.

Sheared zone.

Crushed seam.

Infill seam.

Extremely weathered seam.

5 cm

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ENGINEERING LOG – EXCAVATION

excavation no. 1

sheet 1 of 1

project: C.H. Wilkin, house site investigation

location: Brickmaker Point, Deviot, West Tamar

co-ordinates: DQ931360

R.L.: 30 m

excavation dimensions: 1 x 3 x 2.5 m

exposure type: Trench

equipment: Crawler type of backhoe

operator:

pit commenced: 13.11.85

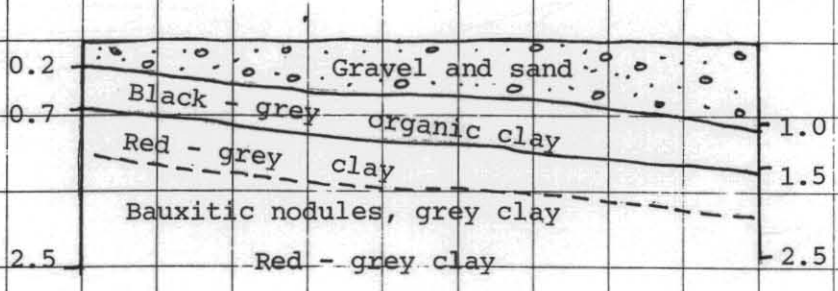
pit completed: 13.11.85

logged by: W.R.M.

checked by: R.C.D.

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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
			S1				SG	*Gravel and sand:* Gravel quartz pebbles +2 mm angular. Sand, med-coarse, poorly graded.	D	L		Quaternary terrace sand & gravel
			S2		1.0		CH	*Clay:* grey-black, highly plastic, sheared, organic - roots	M	St		Sheared
	None	None	S3		2.0		CH	*Clay:* grey-red - highly plastic, sheared ↓ changes to grey ↓ red-grey - bauxitic and limonite layer and nodules	M	St		Clay of Launceston Beds
			S4					Capacity of backhoe reached.				

sketch



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5 cm

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ENGINEERING LOG – EXCAVATION

excavation no. 2

sheet 1 of 1

project C.H. Wilkin, house site investigation

location Brickmaker Point, Deviot, West Tamar

co-ordinates DQ931360

R.L. 27 m approx.

excavation dimensions 1 x 3 x 1.2 m

exposure type Trench

equipment Crawler type of backhoe

operator

pit commenced 13.11.85

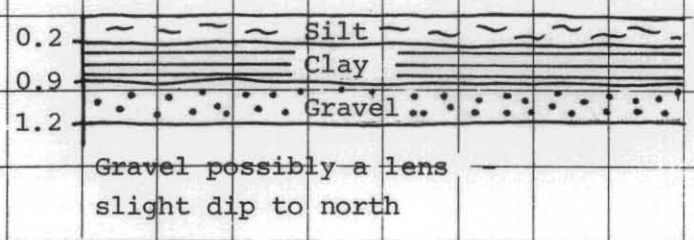
pit completed 13.11.85

logged by W.R.M.

checked by R.C.D.

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
						ML	*Silt with sand, and pebbles:* Silt, grey organic. Sand fine graded. Pebbles quartz	D	L		Soil
				0.5		CH	*Clay:* Orange-yellow, highly plastic. Sand >10%. Some ironstone nodules. Clay appears dispersive	D	F		Clay
	None	None	S1	1.0		GP	*Gravel:* Fine (coarse grit) with some sand. Cemented at base of trench	D	VD		Gravel
				1.5			Backhoe could not penetrate				

sketch



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5 cm

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ENGINEERING LOG – EXCAVATION

excavation no. 3

sheet 1 of 1

project C.H. Wilkin, house site investigation

location Brickmaker Point, Deviot, West Tamar

co-ordinates DQ931360

R.L. 25 m approx.

excavation dimensions 1 x 3 x 1.2 m

exposure type Trench

equipment Crawler type of backhoe

operator

pit commenced 13.11.85

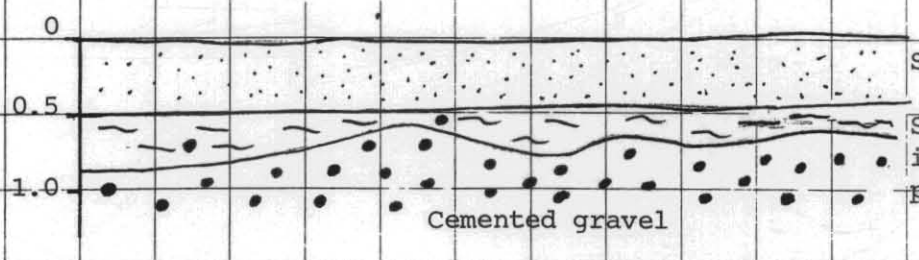
pit completed 13.11.85

logged by W.R.M.

checked by R.C.D.

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		0.5		SM	*Silty sand:* Grey, fine, graded (well-sorted). Organic, much root material.	D	L		Sandy soil
						CL	*Silty clay:* With large pebbles and cemented nodule - irregular lens	D	St		Silty clay
				1.0		GP	*Gravel:* Fine, iron cemented. Poorly graded sand grains, grit and pebble +10 mm	D	VD		Iron cemented gravel
							Backhoe stopped by the cemented gravel				

sketch



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