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TASMANIA DEVELOPMENT AND RESOURCES

Mineral Resources Tasmania

REPORT 1993/37

Investigation of a landslide at Pegema Place, Norwood

by W. L. Matthews

Abstract

Landslide movement has taken place in fill deposited on a slope at the end of Pegema Place, Norwood. Nine auger holes were drilled in the area and samples were collected from each hole. Atterberg Limits were determined on a number of samples, with X-ray diffraction being used for mineral determination. Strength testing was done on two samples from one hole. Tree planting around the slopes surrounding the valley should be used in combination with drainage measures to help stabilise the area.

INTRODUCTION

Investigations have been undertaken around a landslide at the end of Pegema Place, Norwood [EQ153088], at the request of the Launceston City Council. This investigation involved the auger drilling of nine holes to a maximum depth of 8.8 m, collection of samples for testing, and installation of piezometers to measure standing water levels.

The landslide movement has taken place in fill deposited on a slope and infilling a small valley towards the top of the main slope down to Jinglers Creek. The movement was first noticed after the placement of the fill and has involved the natural material occurring adjacent to the fill. The landslide has disrupted a stormwater pipe that was installed down the valley before the placement of the fill. This disruption has obviously allowed water from the broken pipe to move through the soil, which has had an adverse effect on the stability of the area.

The area where the slide has taken place is underlain by Tertiary age sediments. In the Launceston area these sediments are generally made up of clay, silty clay, sandy clay and sand bands. They are expected to be at least several tens of metres thick in many parts of Launceston and may attain considerable thicknesses. Thin layers of gravelly and sandy material on the flatter land at the top of the slope probably represent old terrace deposits.

The area has been zoned Class 4 and Class 2 on the landslide zone map of the Tamar Valley. The sloping land surrounding the landslide had signs of old landslides at the time of the survey of landslide risk prior to 1974. There are indications that recent small-scale movements in nearby areas have taken place since that survey (at least one on each side of the valley and about half way down the slope). There are also signs of large old landslides on the slope; these are represented by benches.

DRILLING

Brief descriptions of the auger holes are attached (Appendix 1), while graphic logs are included as appendix 3. The approximate hole locations are marked on Figure 1.

The holes were drilled in three lines around the slope, with two holes drilled on each line on the north side of the valley and one hole on the south side.

Clay and clayey silt are present in all holes but some holes contain thicker zones of more sandy material (e.g. holes 1, 3, 4 and 9). It has not been possible to link particular beds between holes, as it is likely that both the sandy beds and clayey beds lens out laterally. This has been further complicated by landslide movements which would have caused displacement of beds from their original position.

SAMPLE TESTING

Three to five samples were collected from each hole, being usually chosen to represent the major variations in lithology. Atterberg Limits were determined on a number of samples, with X-ray diffraction being used for mineral determination. Strength testing was done on two samples from the clayey zones of one hole. These samples were selected because clay or similar horizons are most likely to cause stability problems.

The Atterberg Limits determinations (Table 1) show high plasticity index values, with linear shrinkage values in the high range.

Whole-sample and clay fraction X-ray analyses (Table 2) show that the dominant mineral in the material tested is kaolin, although smectite makes up a significant proportion of the clay-size material. As is usually the case with most clay-rich Tertiary sediments, there is a significant component of quartz in the whole-sample analysis.

The residual factors for strength (Table 3) were determined. As various parts of the area have been subject to movement, residual strength measurements are regarded as the most appropriate.

The values of the Atterberg Limits, mineral composition and strength are consistent with unstable conditions on

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Figure 1
Approximate locations of auger holes, Pegema Place

5 cm

Table 1
Atterberg Limits of selected samples

Hole No	Depth (m)	LL	PL	LS	Kaol (%)	Smec (%)	Goeth (%)
2	3.7–4	103	30	23	75	20	5
2	5.5–6.1	107	30	23	75	15	10
1	3.4	89	28	20			
3	7.3–7.6	118	32	23			

Table 2
Whole sample X-ray determinations

Hole No.	Depth (m)	Qtz (%)	Kaol (%)	Smec (%)	Goeth (%)	Mica (%)	Gibbs (%)
2	3.7–4	25	55	10	5	2	2
2	5.5–6.1	20	60	10	5	5	-
1	3.4	25	55	15	2	2	-
3	7.3–7.6	25	60	10	5	-	-

Table 3
Strength tests

Hole No	Depth	$\phi'r$	C'r
2	3.7–4.0	12	2 kPa
2	5.5–6.1	10	2 kPa

Qtz = quartz, Kaol = kaolinite, Smec = smectite, Goeth = goethite, Gibbs = gibbsite. (Determinations by R. N. Woolley, Mineral Resources Tasmania)

Table 4
Water Level Information

Hole No	Depth (m)	5/3/93	10/3/93	1/4/93	29/4/93	3/6/93
1	8.85	0.85	0.87	0.95	0.78	0.15
2	8.30	0.45	0.55	0.40	0.15	0.10
3	8.21	+0.1	+0.10	+0.15	+0.30	+0.40
4	8.40	2.85	2.92	3.05	3.35	3.3
5	8.87	3.95**	4.81	5.05	5.13	5.10
6	8.65	6.47*	6.34	6.55	6.63	6.63
7	8.80	2.45*	2.28	2.30	3.43	2.45
8	8.80	1.17*	1.36	1.43	1.40	1.11
9	≈7.5		3.02*	0.45	0.45	0.5

* Drilled that day
** Drilled the day before

sloping land and are largely comparable with values found in other similar areas in Launceston, and particularly to those tests undertaken on nearby slopes.

WATER LEVEL MEASUREMENTS

It was apparent from surface inspection that water levels would be close to the surface at most locations on the lower slopes because seepages are relatively common, particularly on the north side of the valley. Piezometers installed in each of the nine auger holes were measured a number of times after installation (Table 4). Although the weather had not been particularly wet since their installation, the water level was quite close to the surface in the lower two lines. Even Hole 4 in the upper line had a relatively high standing water level, considering the holes location.

The water in most, if not all, of the bore holes appears to be at least partially confined, i.e. the water level has risen above the zone where it was apparently encountered on drilling. It is often difficult when drilling to accurately determine the level where the material is saturated because clay sediments release water very slowly and a hole will sometimes be dry on completion (i.e. no water) but makes water over a period (e.g. Hole 2).

STABILITY

The indications of large old landslides on the nearby slopes, together with the smaller recently active landslides that have occurred naturally on the lower slopes, demonstrates the general instability of the area. The recent slide at the end of Pegema Place shows how alterations to slope conditions can have an adverse effect on stability and cause additional problems. There is little doubt that the placement of the fill on the top of slope has had a significant effect on the formation of the movement that has taken place in the last four years and which caused the disruption to the stormwater pipe.

Because of the possibility of further movement on the landslide under particularly adverse conditions, some measures should be undertaken to aid in stabilising the area. Examination of the general area shows that seepages are very common at a number of locations on the slope. Installing drainage systems into these will have a stabilising effect. In addition the planting of trees over the slope on and surrounding the landslide will have a positive influence on stability.

Stability analyses (Appendix 2) were calculated by B. D. Weldon of Mineral Resources Tasmania for two segments of the slope from the end of Pegema Place to the flood plain around Jinglers Creek at the foot of the slope. Analyses have also been undertaken for the whole slope.

For the upper segment of the slope, where the slide has taken place in the fill and involved the natural material, a theoretical slip surface of up to 10 m below the ground surface has been considered. This is probably deeper than that at which the movement has actually taken place but no definite depth to the movement is known. Using the strength factors measured for material in Hole 2 (and assuming similar material occurs within the slide mass), a range of factor of safety values has been calculated for various pore pressures. From borehole information, it is known that the slide mass is virtually fully saturated on the lower slope (Ru or pore pressure about 0.5) while in the heel zone the value will be lower. Few of the factor of safety values are more than one. In most such calculations, it is usual to consider values of 1.3 or less as indicating questionable stability.

Similar stability calculations for the lower slope provide some factor of safety values greater than 1.3 but these are for when the pore pressure values are low. When pore pressure is high, as is indicated by bore hole information, safety factors of about unity or less are indicated. In this case a theoretical slide surface of up to 7 m deep has been considered.

The slide surface considered for the whole slope is up to 15 m deep, and only one factor of safety value of greater than 1.3 was obtained.

The larger older landslides probably moved on surfaces of the kind of depths indicated above. The smaller, naturally occurring landslides on the lower slopes appear relatively shallow (perhaps 2–3 m deep), although the slide involving the fill on the upper slope is expected to be much deeper. The analyses assume uniform conditions along the slip surface (i.e. similar material, uniform strength factors and pore pressures), and this is almost certainly not the case; there will be lateral variations. However the analyses show that the slope has potential for instability taking this information alone. Field inspection makes this conclusion obvious. The stability analyses also show how a reduction in pore pressure values have an influence on stability, i.e. drainage to lower the water table will have a stabilising influence.

REMEDIAL MEASURES

The risk of further landslide movements in the area is regarded as high and some measures should be taken to reduce that risk. If movement on the present landslide continues, support for the material upslope will be removed and subsequent movements could involve some of the flatter land behind the slope. If a number of such movements took place, houses could eventually be endangered.

Drainage and tree planting are measures that should be undertaken to improve stability conditions. The effect of lowering the water table (or pore pressure) can be seen from the stability analyses. Planting of trees has the effect of withdrawing moisture from the soil and the addition of overall strength to the soil by way of their root structure.

Strong seepages are present at a number of locations around the slopes near the landslide, and bore hole information shows the water table is close to the surface in all of the six lower bores. Drainage of the seepages and a general lowering of the water table in these areas is recommended. Water from the seepages may need collection in a herringbone system for effective drainage. A drainage system that lowered the water table by two metres or more could make a significant improvement to the stability of the area. The largest seepage zones are on the northern side of the valley but drainage of the southern side should also be considered.

Areas of internal drainage, where water can pond, should also be drained. There is one such area just below the heel of the slide on the north side of the valley.

Horizontal drains (established by drilling) into the slope and extending under the flatter land on which the houses are situated are a possible option if further extensive movements take place. No obvious water-bearing targets were encountered by the drilling, although any horizontal hole that is drilled into zones below the water table should have an effect. The drainage of the lower slopes should be undertaken first. If this is successful, the need for the horizontal drains may not arise.

Surface water should be prevented from running down the slope below Pegema Place and into the tension cracks at the heel of the slide. A small drain or bund may be effective in achieving this. An attempt should be made to reduce infiltration into the slide mass by filling the tension cracks with clay, providing that this can be done with minimal disturbance to the land surface.

An extensive tree planting program around the small valley and surrounding land is recommended. Species that are likely to have the greatest effect are recommended (Table 5).

CONCLUSIONS

Surface examination of the area shows that recent and old landslide movements have taken place under natural conditions. The placement of fill on the top of the slope is thought to have had a significant influence on the formation of the slide in the upper part of the slope which disrupted the stormwater pipe.

Measures to improve the stability of the area are recommended because further movement could involve some of the flatter land on top of the slope. Progressive failures on the slope could eventually affect the properties and perhaps the houses directly behind the present landslide.

The measures recommended are:

- drainage of the seepages using relatively deep drains so that groundwater levels (pore pressures) are considerably lowered;
- Surface water should be prevented, as far as possible, from running down the slope from the end of Pegema Place and entering tension cracks formed at the heel of the slide. Some effort should be taken to fill in the tension cracks with clayey material but this should be undertaken with minimal disturbance.
- Horizontal drains (using bore holes) may need to be considered if significant movement takes place after the establishment of the surface drainage.
- Tree planting around the slopes surrounding the valley should be used in combination with the drainage measures to help stabilise the area.
- Care should be taken when establishing drainage systems, as redirection of surface water for short periods could have an adverse affect on stability. The work should be doone in drier periods, if possible, in order to avoid this.

[20 December 1993]

Table 5

Plant list for landslide conditions

	Wet in winter, dry in summer	Permanently boggy	Permanently wet and ponded	Water absorbing	Common name	Plant size
Acacia	dealbata	-	-	-	Silver Wattle	tall shrub
	floribunda	floribunda	-	-	Gossamer Wattle	shrub
	longifolia	-	-	-	-	shrub
	retinodes	-	-	-	-	shrub
	verticillata	verticillata	-	-	Prickly Mimosa	tall shrub
Bauera	-	rubioides	-	-	-	shrub
Banksia	marginata	-	-	-	Honeysuckle	tall shrub
Callistemon	pallidus	pallidus	-	pallidus	Lemon Bottlebrush	shrub
Eucalyptus	camaldulensis	camaldulensis	-	-	River Red Gum	tree
	globulus	globulus	-	globulus	Blue Gum	tree
	kitsoniana	kitsoniana	-	kitsoniana	Black Gum	tree
	ovata	ovata	ovata	ovata	Cabbage Gum	tree
	pauciflora	-	-	-	-	tree
	perriniana	-	-	-	-	tree
	pulchella	-	-	-	White Peppermint	tree
	risdonii	-	-	-	Risdon Peppermint	tree
	tenuiramis	tenuiramis	-	-	Silver Peppermint	tree
Hakea	sericea	sericea	-	-	Silky Hakea	shrub
Leptospermum	lanigerum	lanigerum	lanigerum	-	Woolly Tea Tree	shrub
	scoparium	scoparium	-	-	Manuka	shrub
Melaleuca	armillaris	armillaris	armillaris	armillaris	Bracelet Honey Myrtle	shrub
	ericifolia	ericifolia	ericifolia	ericifolia	Swamp Paperbark	tall shrub
	-	gibbosa	-	gibbosa	-	shrub
	-	squamea	squamea	squamea	-	shrub
	-	squarrosa	squarrosa	squarrosa	Scented Paperbark	shrub
Sprengelia	-	incarnata	incarnata	-	-	shrub
	-	sprengelioides	-	-	-	shrub
Pinus	radiata	-	-	-	Monterey Pine	tree
Populus	-	alba	alba	-	Silver Poplar	tree

APPENDIX 1

Logs of drill holes, Pegema Place

Hole 1

Depth (m)	*Description*
0 – 0.3	Dark brown sandy silty soil
0.3 – 0.6	Grey brown sandy clay
0.6 – 1.5	Light brown and grey mottled sandy clay, plastic, moist
1.5 – 3.1	Light brown silty (to fine sandy) clay, soft
3.1 – 3.4	Grey and brown silty clay, becoming more sandy
3.4 – 3.7	Brown plastic clay
3.7 – 5.2	Brown silty and fine sandy clay
5.2 – 7.0	Brown sandy silty clay
7.0 – 8.2	As above with reddish clay seams
8.2 – 8.8	Reddish plastic clay

Water struck at about 7.3 m.

Hole 2

Depth (m)	*Description*
0 – 0.3	Dark grey sandy soil
0.3 – 1.5	Brown and grey mottled silty and sand clay
1.5 – 2.4	As above, moist
2.4 – 3.4	Light brown silty clay, a little mottling becoming finer grained
3.4 – 4.3	Slightly lighter brown clay, plastic, some silt
4.3 – 6.7	Reddish and brown, some grey, mottled clay (slightly silty) plastic.
6.7 – 8.8	Darker reddish brown clay, plastic moist, little obvious silt

No water in hole on completion.

Hole 3

Depth (m)	*Description*
0 – 0.3	Black silty clay soil
0.3 – 0.6	Grey clayey gravel/grit (fragments up to 5 mm in diameter), wet
0.6 – 1.5	Brown and grey mottled plastic clay, moist
1.5 – 3.4	Brown clayey sandy silt, becoming lighter in colour with depth, grey clay layers
3.4 – 5.2	Light brown wet clayey sandy silt interspersed with red and grey mottled sandy silty clay
5.2 – 7.0	Brown sandy clayey silt, some layers of grey plastic clay at end
7.0 – 8.8	Grey and brown plastic clay, reddish sandy silty clay at end.

Water came into hole at about 2.8 m.

Hole 4

Depth (m)	*Description*
0 – 1.2	Sandy silty clay, dry (fill)
1.2 – 1.5	Brown sandy clay, plastic
1.5 – 1.8	Brown clay, some gravel fragments
1.8 – 3.7	Mid brown sandy silty clay, moist
3.7 – 8.8	Brownish and grey sandy silty clay (very wet on augers)

Water probably entered hole at 3.7–4.3 m.

Hole 5

Depth (m)	*Description*
0 – 0.9	Brown silty gravelly clay, dry
0.9 – 1.5	Brown clayey silt, plastic, moist
1.5 – 3.4	Darker brown clay with wet pieces of plastic to 2.1–2.4 m — fill to this depth at least
3.4 – 5.2	Grey and brown plastic clay
5.2 – 6.1	Brown plastic clay and bands of clayey sand. Hard band at about 6.2 m gravelly on return — limonite band?
6.1 – 7.0	Blue plastic clay
7.0 – 8.2	Light brown and grey clayey sand, wet
8.2 – 8.8	Mainly grey sand

Material in wet condition from about 1.5 m to base.

Hole 6

Depth (m)	*Description*
0 – 0.9	Light grey brown silt, gravelly at top
0.9 – 1.5	Mid brown sandy silty clay, plastic and moist
1.5 – 3.4	As above with occasional small gravel fragments up to 3 mm across
3.4 – 3.7	As above
3.7 – 4.3	Light grey silty clay, plastic, some sand
4.3 – 5.9	Light grey-brown silty clay, plastic, some sand
5.9 – 7.0	Light brown plastic silty clay, moist
7.0 – 7.6	As above
7.6 – 8.2	Brownish grey sand, sandy clay with water
8.2 – 8.8	Mid brown and grey clayey sand and sandy clay

Water came in from sand near base of hole.

Hole 7

Depth (m)	*Description*
0 – 0.6	Brown silty sand, dry
0.6 – 1.2	Lighter brown silty sand, clay hard and dry
1.2 – 1.5	Light brown and grey mottled silty sandy clay, plastic, some moisture
1.5 – 3.4	Mid brown sandy silty clay, moist
3.4 – 4.3	Mid brown and grey mottled silty sandy clay (less sand than above) moist
4.3 – 5.3	Light brown silty clay, moist
5.3 – 7.0	Grey clayey sand, wet, hard bands at 5.3 m, 6.7 m
7.0 – 8.8	Grey more clayey sand (clay content increased), sandy clay, some rock fragments from 7.0–7.10 m

Water coming into hole from 6.7 m or perhaps 5.3 m.

Hole 8

Depth (m)	*Description*
0 – 0.6	Gravelly clayey silt soil, dry, rounded quartz up to 50 mm across
0.6 – 1.5	Brown silty clay (low silt content), moist
1.5 – 3.7	Mid brown grey silty clay — silt content increased from above (fragmented clay)
3.7 – 5.3	Brown sandy clay, clayey sand (wet)
5.3 – 7.6	Brown and grey plastic clay, minor silt content
7.6 – 8.8	Reddish and brown sandy silty clay interbedded with grey clay

Hole 9

Depth (m)	*Description*
0 – 1.2	Clayey silt, gravelly, dry
1.2 – 1.5	Reddish brown sandy silty clay, plastic, moist
1.5 – 3.4	Brown sandy silty clay, becoming more moist and wetter with depth
3.4 – 7.3	No direct return, brown sandy silty clay
7.3 – 7.9	As above at beginning with brown clay-rich beds towards end (plastic)

Difficulty in installing PVC pipe — blockage at 4.0 m on two occasions (iron oxide seam).

APPENDIX 2

Stability analysis calculations

Site: Pegema Place, Launceston — upper segment

End points:

X lhs	97.5
Y lhs	32
X rhs	167.5
Y rhs	49

Number of slices	14
Density (kN/m^3)	19
Cohesion (kPa)	2
Friction (degrees)	12
Pore pressure ratio	0.5
Y circle (m)	105

Calculated Factor of Safety 0.691

Slice	*Y(I)*
1	33.0
2	34.0
3	36.0
4	37.5
5	38.5
6	39.5
7	40.5
8	41.0
9	41.5
10	42.0
11	42.5
12	43.5
13	45.0
14	48.0
15	

Density	*c'r*	*φ'r*	*Ru*	*Radius*	*FS*
19	2	10	0	105	1.110
19	2	10	0.1	105	1.006
19	2	10	0.2	105	0.902
19	2	10	0.3	105	0.799
19	2	10	0.4	105	0.695
19	2	10	0.5	105	0.591
19	2	12	0	105	1.316
19	2	12	0.1	105	1.192
19	2	12	0.2	105	1.066
19	2	12	0.3	105	0.941
19	2	12	0.4	105	0.816
19	2	12	0.5	105	0.691

Site: Pegema Place, Launceston — lower slope

End points:

X lhs	20
Y lhs	22
X rhs	65
Y rhs	28.5

Number of slices	9
Density (kN/m^3)	19
Cohesion (kPa)	2
Friction (degrees)	12
Pore pressure ratio	0.5
Y circle (m)	60

Calculated Factor of Safety 0.917

Slice	*Y(I)*
1	22.0
2	22.5
3	23.0
4	24.0
5	25.0
6	26.0
7	26.5
8	27.5
9	28.0
10	
11	
12	
13	
14	
15	

Density	*c'r*	*φ'r*	*Ru*	*Radius*	*FS*
19	2	10	0.5	50	0.818
19	2	10	0.5	55	0.799
19	2	10	0.5	60	0.792
19	2	10	0.5	65	0.793
19	2	10	0.5	70	0.799
19	2	10	0	60	1.428
19	2	10	0.1	60	1.300
19	2	10	0.2	60	1.173
19	2	10	0.3	60	1.046
19	2	10	0.4	60	0.918
19	2	10	0.5	60	0.791
19	2	12	0	60	1.684
19	2	12	0.1	60	1.531
19	2	12	0.2	60	1.377
19	2	12	0.3	60	1.224
19	2	12	0.4	60	1.070
19	2	12	0.5	60	0.917

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Site: Pegema Place, Launceston — long slope

End points:

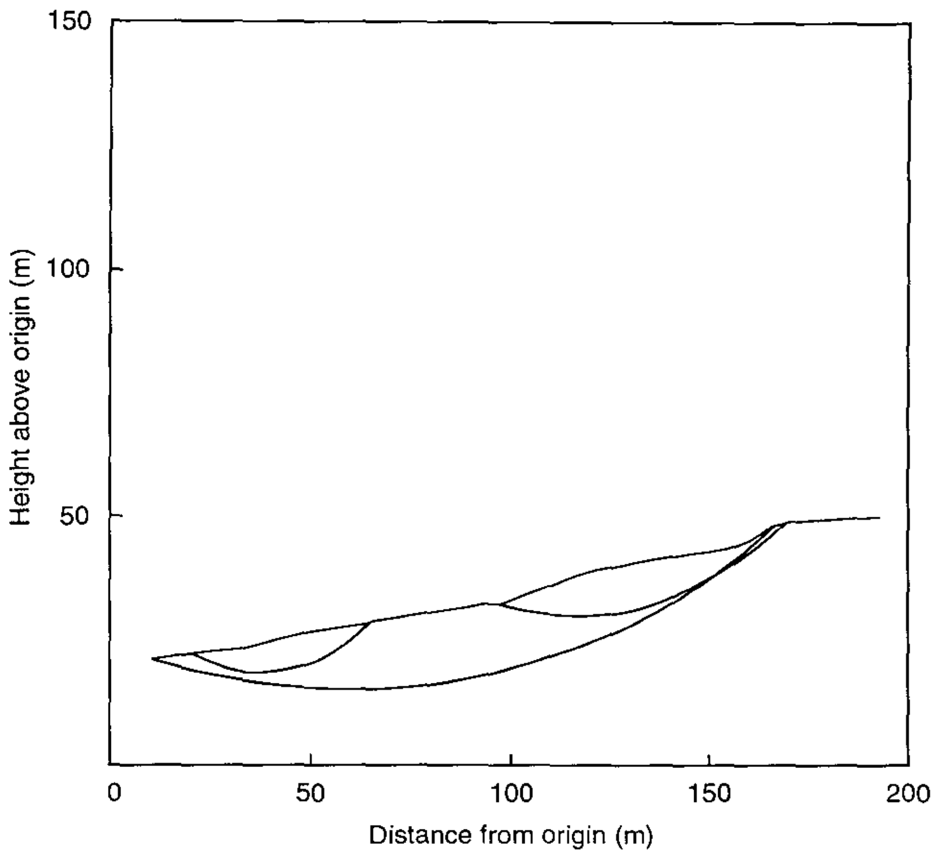
X lhs	10
Y lhs	21
X rhs	170
Y rhs	49

Number of slices	16
Density (kN/m^3)	19
Cohesion (kPa)	2
Friction (degrees)	12
Pore pressure ratio	0.5
Y circle (m)	210

Factor of Safety	0.716
Calculated Factor of Safety	0.716

Slice	*Y(I)*
1	21.5
2	22.0
3	23.0
4	25.5
5	27.0
6	28.5
7	29.5
8	30.5
9	32.0
10	34.5
11	37.5
12	39.5
13	41.0
14	42.0
15	43.5
16	47.5

Density	*c'r*	*ϕ'r*	*Ru*	*Radius*	*FS*
19	2	10	0.5	100	0.727
19	2	10	0.5	150	0.627
19	2	10	0.5	175	0.612
19	2	10	0.5	200	0.607
19	2	10	0.5	210	0.606
19	2	10	0.5	220	0.606
19	2	10	0.5	230	0.607
19	2	10	0.5	240	0.609
19	2	10	0.5	250	0.611
19	2	10	0	210	1.171
19	2	10	0.1	210	1.058
19	2	10	0.2	210	0.945
19	2	10	0.3	210	0.832
19	2	10	0.4	210	0.719
19	2	10	0.5	210	0.606
19	2	12	0	210	1.398
19	2	12	0.1	210	1.261
19	2	12	0.2	210	1.125
19	2	12	0.3	210	0.989
19	2	12	0.4	210	0.852
19	2	12	0.5	210	0.716



Stability analysis Pegema Place

5 cm

APPENDIX 3

Logs of auger holes, Pegema Place

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 1

sheet of

project PEGEMA PLACE location LAUNCESTON

co-ordinates

R.L.

inclination Vertical

bearing

drill type Triefus

drill method Auger

drill fluid —

hole commenced 10/2/93

hole completed 10/2/93

drilled by B COX

logged by L. MATTHEWS

checked by

depth (m)	graphic log	classification symbol	material	moisture condition	consistency density index	structure, geology
		SM	Sandy silt, dark brown	D	VS	Topsoil
		SC	Sandy clay, grey brown	M	F	Launceston Beds
1		CH	Sandy clay, light brown and grey plastic, moist	M	F	Launceston Beds Tertiary sediment
2			Silty clay, some fine sand light brown	M / W	S	"
3			Silty clay, grey and brown, sandy at end	M	F	"
			Clay, brown, plastic	M	F	"
4			Silty and sandy clay (sand fine) brown	M	F	"
5–6			Sandy silty clay, brown	M	F	"
7–8			Sandy silty clay, brown, some reddish clay seams.	M	F / S	"
			Clay, reddish.	M	F	"
9			END OF HOLE			

notes, samples, tests: D – (Alt) (XRD) (at approx. 3.5–4 m)

support: Cased with PVC, gravel packed; Slotted pipe

water: 11/5/3/93

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TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 2

sheet of

project PEGEMA PLACE LANDSLIDE location LAUNCESTON

co-ordinates

R.L.

inclination Vertical

bearing

drill type Triefus

drill method Auger

drill fluid

hole commenced 10/2/93

hole completed 11/2/93

drilled by B Cosc

logged by L. Matthews

checked by

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
	50 mm slotted PVC to bottom, gravel packed	5/3/93					SW	Sand, dark grey	D	S		Topsoil
					1		CL-CH	Silty and sandy clay, brown and grey	D-M	F		Launceston Beds Tertiary sediments
					2		CL-CH	Silty and sandy clay brown and grey, moist	M	F-S		"
					3		CH	Silty clay, light brown a little mottling, becoming finer.	M	F-S		"
			U (Att) (XRD) (Strength)		4		CH	Clay, some silt lighter brown, plastic	M	F-S		"
			U Att XRD (Strength)		5, 6		CH	Clay, reddish, brown and grey mottled, a little silt, plastic	M	F-S		"
					7, 8		CH	Clay, reddish brown and some grey (darker than above) plastic.	M	F-S		"
					9			END OF HOLE				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 3

sheet of

project PEGEMA PLACE LANDSLIDE location LAUNCESTON

co-ordinates

R.L.

inclination Vertical

bearing

drill type Triefus

drill method Auger

drill fluid

hole commenced 11/2/93

hole completed 11/2/93

drilled by B Cox

logged by L. Matthews

checked by

support: 50 mm slotted PVC pipe, gravel packed

water: artesian

depth (metres)	notes samples, tests	classification symbol	material	moisture condition	consistency density index	structure, geology
		OH	Silty clay, black	W	S	Topsoil
		GC	Clayey gravel to grit	W	S	Lag gravel?
1		CH	clay, brown and grey, plastic	M	S / F	Launceston Beds Tertiary Sediments
2–3		CL	Clayey sandy silt, brown, some grey layers.	M / W	S / F	"
4–5		ML / CL	Clayey sandy silt light brown interspersed with red and grey sandy silty clay.	M / W	S / F	"
6–7		ML / CH	Sandy clayey silt, brown plastic	M / W	S / F	"
7–8	D (Att) (XRD)	CH	Clay grey and brown, reddish sandy silty clay at end.	M	F	"
9			END OF HOLE			

13/18

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – BOREHOLE

5 cm

borehole no. 4

sheet of

project PEGEMA PLACE LANDSLIDE location LAUNCESTON

co-ordinates

R.L.

inclination Vertical

bearing

drill type Triefus

drill method Auger

drill fluid

hole commenced 11/2/92

hole completed 11/2/92

drilled by B. Cox

logged by L. Matthews

checked by

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
	50 mm slotted PVC, gravel packed	5/3/93			0–1.5		ML	Sandy silty clay	D	F		fill
							CH	Sandy clay, brown, plastic	M	F		Launceston Beds
							CH GC	Clay with gravel fragments	M	F		"
		11			2		ML	Sandy silty clay, mid brown	M	F		Launceston Beds Tertiary sediments
					4–8		ML	Sandy silty clay, brownish and grey.	W	F / S		"
					9			END OF HOLE				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 5

sheet of

14/18

project PEGEMA PLACE LANDSLIDE   location LAUNCESTON

co-ordinates

R.L.

inclination Vertical

bearing

drill type Triefus

drill method Auger

drill fluid

hole commenced 4/3/93

hole completed 4/3/93

drilled by B Cox

logged by L. Matthews

checked by

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
	50 mm slotted PVC gravel packed	10/3/93			0–1		GC	Silty gravelly clay, brown	D	S		Fill
					1		CH	Clayey silt, brown, plastic	M	F		Fill
					2–3		ML / CH	Clayey silt, darker brown, pieces of plastic to 2.4 m	W	S		Fill —?— ?—?
					4–5		CH	Clay, grey and brown plastic.	W	S		Launceston Beds Tertiary sediments
					6		CH / SC	Clay with bands of clayey sand, brown, gravelly band at 6.4 m (hard)	W	S		"
					7		CH	Clay, blue plastic	W	S		"
					8		SC	Clayey sand, light brown and grey	W	S		"
							SM	Sand, grey	W	S		"
					9			END OF HOLE				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 6

sheet of

project PEGEMA PLACE LANDSLIDE location LAUNCESTON

co-ordinates

R.L.

inclination Vertical

bearing

drill type Triefus

drill method Auger

drill fluid

hole commenced 5/3/93

hole completed 5/3/93

drilled by B Cox

logged by L. Matthews

checked by

depth (metres)	water	classification symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency density index	structure, geology
0–0.9		ML / GM	Silt, gravelly at top, light grey brown	D	S	Soil + fill
0.9–1.9		CH	Sandy silty clay, mid brown, plastic	M	F	Launceston Beds Tertiary Sediments
1.9–3.9		CH	As above, occasional gravel fragments up to 3 mm across.	M	F	"
3.9–4.8		CH	Silty clay, light grey, plastic	M	F	"
4.8–6.1	10/3/93	CH	Silty clay some sand, light grey brown, plastic	M	F	"
6.1–7.8		CH	Silty clay, light brown. plastic	M	F	"
7.8–8.3		SM SC	Sand, sandy clay, brown-ish.	W	S	"
8.3–8.9		SC	Clayey sand and sandy clay, mid brown and grey	W	S	"
9						

hand penetrometer kPa 25 50 100 200 400

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TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 7

sheet of

project PEGEMA PLACE LANDSLIDE location LAUNCESTON

co-ordinates

R.L.

inclination Vertical

bearing

drill type Triefus

drill method Auger

drill fluid

hole commenced 5/3/93

hole completed 5/3/93

drilled by B Cox

logged by L. Matthews

checked by

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
	50 mm slotted PVC casing gravel packed	10/3/93				SM	Silty sand, brown	D	S		Soil
				1		SM SC	Silty sand and clay, lighter brown	D	F		Launceston Beds
						CH	Silty sandy clay, light brown and grey, plastic	M			"
				2, 3		CH - CL	Sandy silty clay, mid brown	M	F		Launceston Beds Tertiary sediments
				4			Silty sandy clay, brown and grey (sand decreasing)	M	F		"
		2		5			Silty clay, light brown	W	F - S		"
				6		SC	Clayey sand, hard bands at 5.3 and 6.7 m, grey	W	F - (H)		"
				7, 8		SC	Clayey sand, grey, clay content increased from above, sandy clay bands some rock fragments from 7–7.10 m	W	S		"
				9			END OF HOLE				

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TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 8

sheet of

project PEGEMA PLACE LANDSLIDE location LAUNCESTON

co-ordinates

R.L.

inclination Vertical

bearing

drill type Trielfus

drill method auger

drill fluid

hole commenced 5/3/93

hole completed 5/3/93

drilled by B Cox

logged by L. Matthews

checked by

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
	50 mm PVC slotted, gravel packed	10/3/93				ML	Clayey silt, quartz gravel pieces up to 5cm, rounded	D	S		Soil
				1		CH	Silty clay (silt minor) brown	M	F		Launceston Beds Tertiary Sediments
				2, 3		CH	Silty clay, mid brown grey (increased silt content)	M	F		"
				4, 5		SC	Sandy clay, clayey sand, brown	W	S - F		"
				6, 7		CH	Clay, minor silt content brown and grey, plastic	M - W	S - F		"
				8		SC	Sandy silty clay, reddish and brown, interbedded with grey clay	M - W	S - F		"
				9							

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 9 | sheet of | 18/18

project PEGEMA PLACE LANDSLIDE location LAUNCESTON

co-ordinates
R.L.
inclination Vertical
bearing

drill type Triefus
drill method auger
drill fluid

hole commenced 5/3/93
hole completed 10/3/93
drilled by B Cox
logged by L. Matthews
checked by

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
	50 mm slotted PVC pipe gravel packed	1/4/93		0–1.2		ML	clayey silt, gravelly	D	S-F		Soil Launceston beds Tertiary sediments
				1.2–1.5		CH	Sandy silty clay, reddish brown plastic	M	F		"
				1.5–3.4		SC-CL	Sandy silty clay, brown	M / W	F		"
				3.4–7.4		SC-CL	Sandy silty clay (no return to surface while drilling this section) brown	W	F-H		"
				7.4–8.0		CH CL	As above with clay rich beds towards end, brown.		F		"