UR1980-22

1980/22. The stability of a building allotment at Orana Place, Riverside

D.J. Sloane

Abstract

An area of land adjacent to Orana Place, Riverside, is underlain by one metre of dark brown silty sand (SM) which overlies at least two metres of yellow-brown and brown clay with reddish brown and grey mottled high plasticity clay (CH). The clay has high Atterberg Limits and low residual values of cohesion (C') and internal friction (ϕ') above a depth of two metres, with low Atterberg Limits and higher C' and ϕ' values below two metres depth.

Stability analysis indicates that the allotment is unstable in the long term and of marginal stability in the short term.

Comments are made as to the validity of parameters used and recommendations are made as to further testing required before the allotment will be approved for development.

INTRODUCTION

At the request of Mr G. Walters of Riverside stability investigations have been conducted on an allotment adjacent to Orana Place, Riverside, on three separate occasions. A visual site inspection was conducted during 1977, followed by the drilling of two auger holes which confirmed the presence of clay to a depth of at least four metres. Two additional auger holes were drilled in 1979 to enable samples to be taken for the determination of clay properties and subsequent stability analysis. The conclusion of these investigations is that the stability of the allotment is marginal, and the advice of a qualified geotechnical engineer will be required to design foundations and test clay properties for any building sited on Lot 1. This Department would consider the engineers advice and evidence before approval was granted. This report summarises the information available to date.

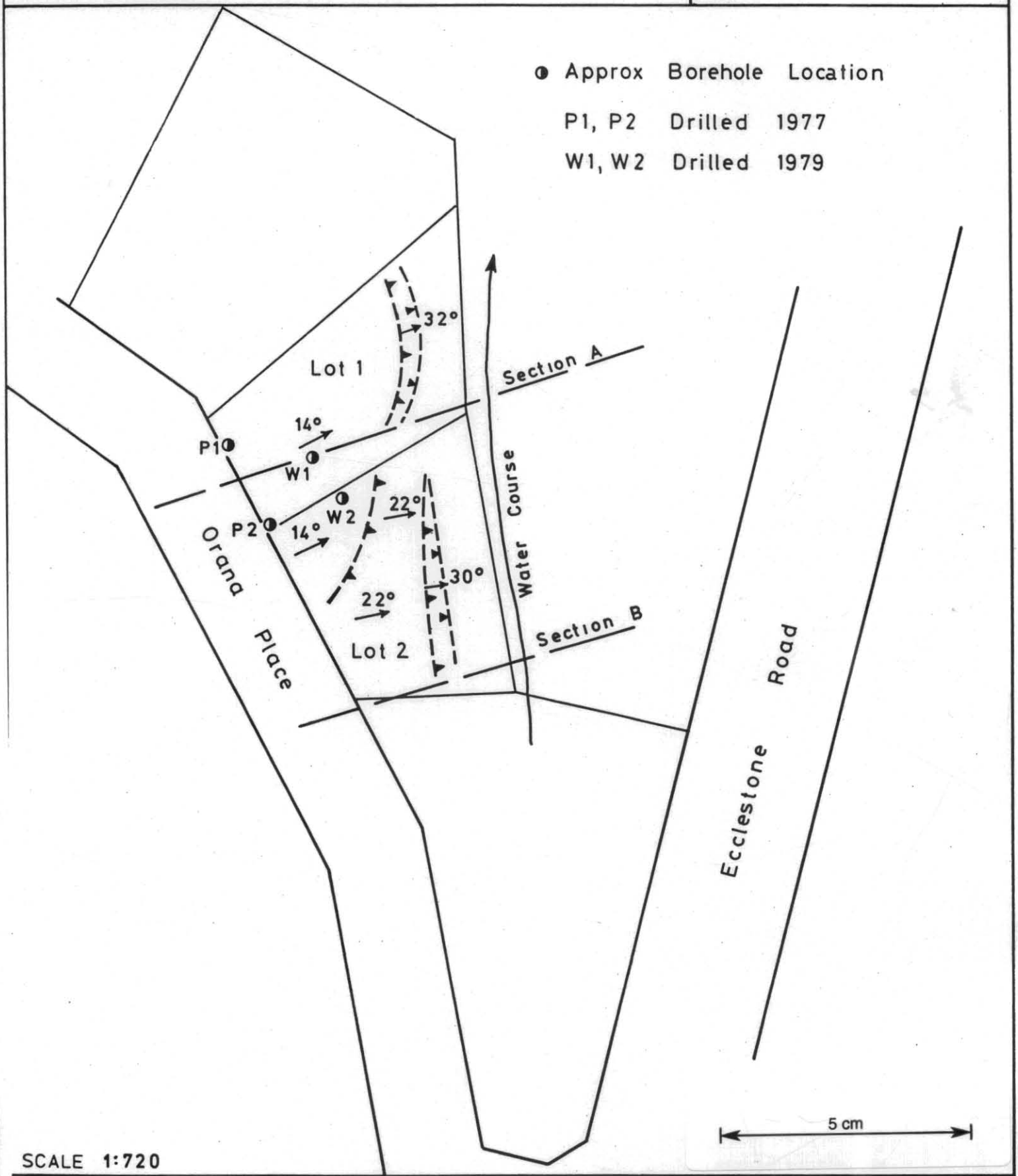
TOPOGRAPHY

The morphology of the allotment is indicated on the sketch map (fig. 1). The area is steeply sloping with regional slopes between 14° and 25° (fig. 2). Locally slopes up to 32° are present, adjacent to the small watercourse at the base of the slope. Steep (32°) fill slopes are present on the upper side of the allotment adjacent to Orana Place. To the east of the hill-slope is an old terrace level associated with the River Tamar and to the west is an undulating plateau region. The regional slope has been formed along a major NNW - SSE trending fault scarp, with the harder intrusive rocks underlying the plateau region and the softer sediments underlying the old terrace area to the east.

GEOLOGY

The geological map of the area (Longman, 1964) indicates that the area under investigation is underlain by Tertiary sediments, but lies close to the boundary of a Jurassic dolerite body to the west. The Tertiary sediments are composed of clay, sand and gravel. It is these sediments which are prone to landslip, especially where they underlie steep slopes along the sides of, and within the Tamar graben.

LOCATION ORANA PLACE	SUBURB RIVERSIDE	GEOLOGIST D.J. Sloane
OWNER G. Walters	TOWN	DATE



SCALE 1:720

LEGEND

20° Slope angle and direction

Change of slope - downslope side indicated

Change of slope - upslope side indicated

Area in which building advised

" " " septic tank "

Figure 1.

AUGER DRILLING

Detailed logs of the two three metre deep auger holes drilled in 1979 have been included as Appendix 1. In summary, a dark brown sandy silt (SM) extends from the ground surface to a depth of 0.8 m. This material is largely part of the A_1 soil horizon, with some fill. Between 0.6 and 2.0 m in depth is a high plasticity brown clay with reddish brown and yellow-brown mottles (CH). Below two metres and to a depth of at least three metres is a high plasticity yellow-brown clay with reddish brown and grey mottled clay containing some medium quartz sand and some ironstone concretions to 20 mm diameter. Fissuring is present to a depth of at least three metres with gleying(?) occurring along these fissures at three metres depth. There is also some evidence of relict dolerite textures in samples taken, indicating that the original deposit may have contained some dolerite boulders which have become completely weathered.

CLAY ANALYSIS - GEOMECHANICAL PROPERTIES

The clay properties determined from auger hole W1 are summarised below:

Sample type	Depth (m)	Moisture content (%) Shear box	Natural	L.L.	P.L.	P.I.	L.S.	ϕ'	C'(kPa)
Disturbed	1.85	48.6	40.9	160.9	34.0	126.9	24	11°	23
Disturbed	2.78	43.7						22°	13.6
Undisturbed	3.0	32.2		74.2	30.4	43.8	14	26.5°	13.6

The sample taken from a depth of two metres had a much higher clay content (visual estimation) than the samples from around 3.0 m in depth. The lower samples had a higher medium quartz sand content and were slightly indurated by iron oxides in mottled patches. It appears that a change in sediment properties occurs at a depth of about two metres in auger hole W1, although this is based on the complete analysis of only two samples. The measured clay properties correspond, especially from a depth of two metres, with properties obtained from clay sampled at 48 Orana Place and in the St Anthony's School area of Fort Street. These localities lie along the same regional slope as the area discussed here.

Vane shear results

Only peak vane shear values were obtained. At a depth of two metres they varied from 100 kPa to 85 kPa. These are generally lower than those measured elsewhere in the Tamar region, but correspond with values measured at St Anthony's School (Sloane, 1979).

STABILITY ANALYSIS

Slab failure

From the geometry of the slope, failure is likely to occur within two to three metres of the ground surface. For slab failure analysis the slope is considered to be an infinite 14° slope composed of homogeneous materials. A residual value of ϕ' of 11° and C' of 13.6 kPa has been considered for the purpose of the stability calculations. Long term stability conditions necessitate the consideration that cohesion is zero, which produces a safety factor of 0.35 for totally saturated conditions and 0.78 for completely dry conditions. If a two metre thick slab is considered, approximately 13% of

C'_r in the fully dry situation and 40% in the totally saturated condition is required to produce a safety factor of 1.0, or marginal stability. These values increase to 20% and 60% respectively for a three metre thick slab.

If full cohesion is considered for the short-term, then drainage for a three metre thick slab must be provided to a depth of about 1.5 m to produce a short-term factor of safety of 1.6. The allotment is therefore considered unstable in the long-term and marginally unstable in the short term.

Slip circle analysis

For this analysis Cousins (1978) stability charts have been used, assuming $\phi'_r = 11°$ and $C'_r = 13.6$ kPa, and considering the slope as a simple embankment failure problem with a height of four metres and a 32° slope.

Assuming fully saturated conditions and $C'_r = 13.6$ kPa, a safety factor of 1.4 is obtained, close to that obtained (1.5) for a three metre thick slab failure. For conditions where half the slip mass is drained, a safety factor of 1.6 is obtained, also close to that obtained for the semi-drained three metre slab failure. This value is again marginal if a safety factor of 1.6 is taken for first time failure. For the long term, if cohesion is considered to be nearly zero (*i.e.* 1 kPa), a safety factor of 0.3 is obtained for fully saturated conditions, again closely corresponding to that obtained for the three metre thick slab failure analysis.

CONCLUSION

In summary, the allotment is considered unstable in the long term. In the short term, and using the C'_r and ϕ'_r values obtained in the laboratory, the slope must be drained to a depth of at least 1.5 m to produce a safety factor of 1.6 against first time failure. Drainage to a greater depth would be required to increase this value above 1.6.

The area considered in the analysis is shown in Figure 2 (section A B), using what are considered to be the better slope conditions to be found on the proposed subdivision. ϕ'_r and C'_r, as measured in the laboratory from slow shear box testing, have been used in the calculations. Recent evidence suggests that these values may not be as conservative as may appear and actual residual values may be much lower.

The allotment is considered unstable in the long term and of marginal stability in the short term, and thus previous conclusions reached in 1979 can only be repeated. Any further investigation should concentrate on stability analysis improvement, especially in obtaining further values of cohesion and angle of internal friction from depths of two to three metres. At least three values should be obtained from a depth of about two metres to check on the consistency of these values. The values used in this report have been determined by the Department of Mines testing facilities and it is advised that a different testing laboratory should be used in further investigations to cross-check the values of these parameters.

This Department will co-operate with any geotechnical engineer conducting further investigations on this area.

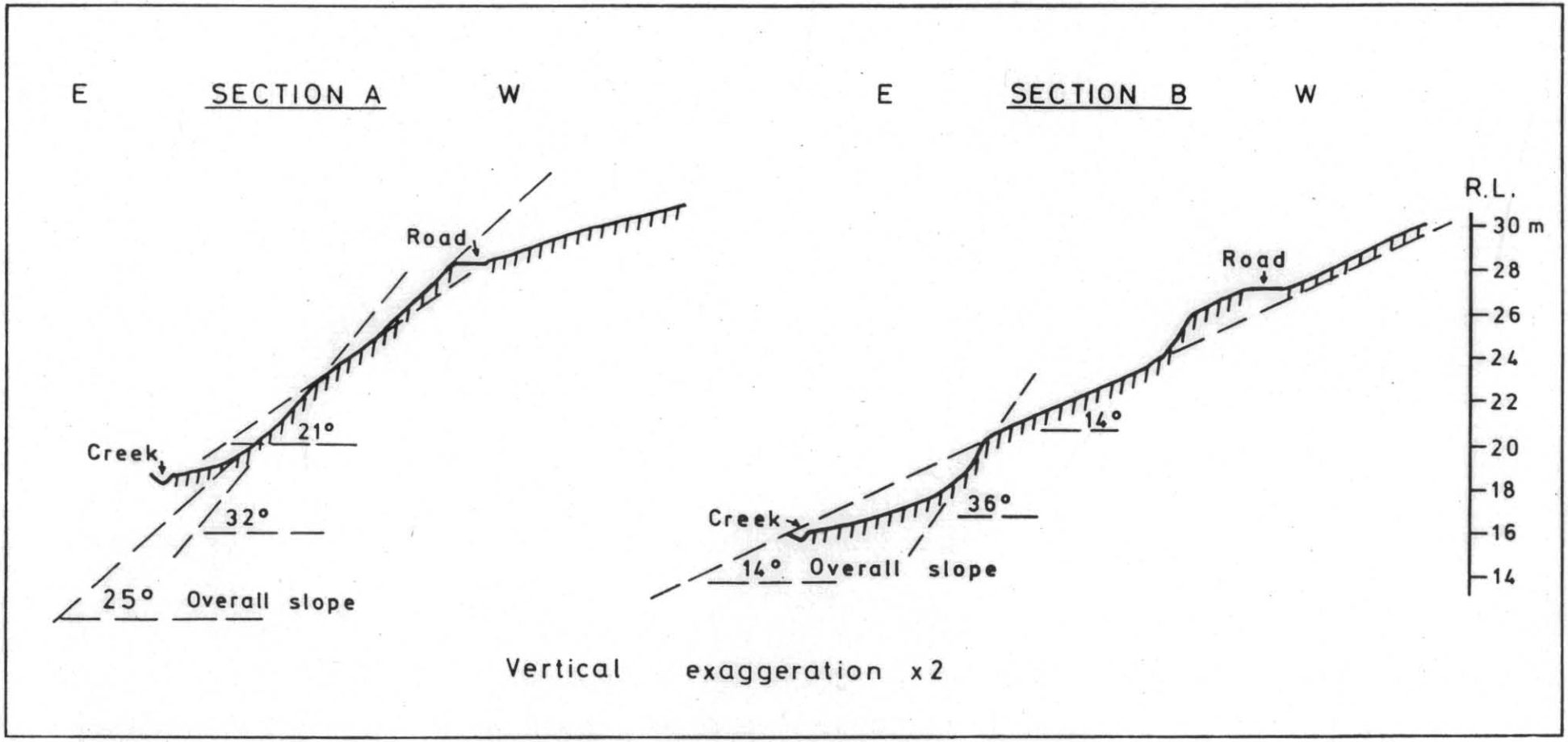


Figure 2. *Sections across proposed subdivision, Orana Place, Riverside*

5 cm

REFERENCES

COUSINS, B.F. 1978. Stability charts for simple earth slopes. *J.geotech. engng.Divn.Am.Soc.Civ.Engrs.* 104:268-279.

LONGMAN, M.J. 1964. One mile geological map series. K/55-7-39. Launceston. *Department of Mines, Tasmania.*

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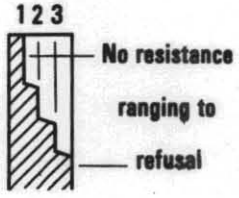
[15 July 1980]

TASMANIA DEPARTMENT OF MINES

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	Undistributed 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 than 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.

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5 cm

borehole no. W 1

sheet 1 of 1

ENGINEERING LOG – BOREHOLE

project G.W. WALTERS location ORANA PLACE, RIVERSIDE

co-ordinates

R.L. ~22 m

inclination 90°

bearing

drill type Proline

drill method Auger

drill fluid

hole commenced 3/79

hole completed

drilled by B. Cox

logged by D.J. Sloane

checked by D.J. Sloane

penetration 1 2 3	support	water	notes samples, tests	feet R.L.	feet depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	SHEAR VANE kPa 25 50 100 200 400	structure, geology
							SM	SANDY SILT; medium - fine sand and silt. Dark brown		S		SOIL A1 HORIZON & FILL
					2		CH	CLAY: High plasticity. Brown with reddish brown mottles. Some concretionary iron particles to 20 mm diameter	M	St	(Peak) 88.6 110.0 (101)	Dessicated and/or fissured Brown clay cutans $\phi = 11^\circ$
			D, MS		6		CH	CLAY: High plasticity. Yellow-brown mottles, some grey. Some concretionary iron particles to 20 mm diameter. Occasional weathered dolerite with relict texture? Some medium quartz sand.	41% M>PL			
					8				M M>PL	St		May be fissured structure with clay cutans along fissures
			U50		10				M>PL			
				END								

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5 cm

borehole no. W 2

sheet 1 of 1

ENGINEERING LOG – BOREHOLE

project G.W. WALTERS

location ORANA PLACE, RIVERSIDE

co-ordinates

R.L. ~22 m

inclination 90°

bearing

drill type Proline

drill method Auger

drill fluid

hole commenced 3/79

hole completed

drilled by B. Cox

logged by D.J. Sloane

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penetration 1 2 3	support	water	notes samples, tests	feet R.L. depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	shear vane kPa 25 50 100 200 400	structure, geology
						SM	SANDY SILT: Medium - fine sand and silt. Dark brown.	M	S		Topsoil & fill
				2		CH	CLAY: High plasticity. Brown with reddish brown and yellow-brown mottles	M	St		
				4							
				6				M> PL		Peak (79-81) 85	
						CH					
				8				M> PL	St		
				10							