Billy's Lookout - Stage 11 Geotechnical Assessment

Fishermans Drive & Pitt Street, Teralba

NEW15P-0070B-AI 29 November 2018



LABORATORY (NSW) PTY LTD

29 November 2018

McCloy Development Management Pty Ltd Suite 2, Ground Floor, 317 Hunter Street NEWCASTLE NSW 2300

Attention: Harry Thomson

Dear Sir

RE: RESIDENTIAL SUBDIVISION – BILLY'S LOOKOUT – STAGE 11 FISHERMANS DRIVE & PITT STREET, TERALBA SITE CLASSIFICATION (LOTS 1101 TO 1117)

Please find enclosed our geotechnical report for Stage 11 of the Billy's Lookout residential subdivision, located at Pitt Street and Fishermans Drive, Teralba.

The report includes recommendations on Site Classification in accordance with AS2870-2011, "Residential Slabs and Footings" for Stage 11 (Lots 1101 to 1117).

If you have any questions regarding this report, please do not hesitate to contact Shannon Kelly or the undersigned.

For and on behalf of Qualtest Laboratory (NSW) Pty Ltd

ken le

Jason Lee Principal Geotechnical Engineer

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Attachments:

Figure Al1:	Site Plan and Approximate Test Locations
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1.0 Introduction

Qualtest Laboratory NSW Pty Ltd (Qualtest) is pleased to present this geotechnical report on behalf of McCloy Development Management Pty Ltd (McCloy), for Stage 11 of the Billy's Lookout residential subdivision, located at Pitt Street and Fishermans Drive, Teralba.

Based on the Brief and Staging Plan Sheet (Ref: GCA Engineering Solutions, Project No. 16653C, Drawing No. C02, Revision 2) provided in an email from McCloy, the development is understood to comprise subdivision into a total of 17 residential lots (Lots 1101 to 1117), as shown on Figure Al1.

The scope of work for the geotechnical investigation included providing Site Classification to AS2870-2011, "Residential Slabs and Footings" for Stage 11 following completion of site regrade works.

This report presents the results of the field work investigations and laboratory testing, and provides recommendations for the scope outlined above.

2.0 Desktop Study

The scope of work has included a review of the following reports completed by Qualtest:

- Level 1 Site Re-Grade Assessment Report 'Proposed Subdivision, Billys Lookout Stage 11, Pitt Street, Teralba' (Ref. No. NEW16P-0109-AB, dated 26/11/2018);
- Geotechnical Assessment Report, 'Proposed Subdivision, Billys Lookout Stage 11, Pitt Street, Teralba' (Report Ref: NEW15P-0070B-AA, dated 16 June 2017); and,
- Site Classification Report Proposed Subdivision, Billys Lookout Stage 8, Fishermans Drive, Teralba, (Report Ref: NEW15P-0070A-AC, dated 17 June 2016).

This report includes a summary of selected results from the previous reports where applicable.

3.0 Field Work

Field work investigations were carried out on 30 October 2018, and comprised of:

- DBYD search of proposed test locations was undertaken to check proposed test locations for the presence of underground services;
- Site walkover to make observations of surface features at the property and in the immediate surrounding area;
- Excavation of 9 test pits (TP1101 to TP1109) using a 2.5 tonne excavator equipped with a 450mm wide bucket. Test pits were terminated at depths of between 1.00m and 2.40m;
- Undisturbed samples (U50 tubes) and small bag samples were taken for subsequent laboratory testing; and,
- Test pits were backfilled with the excavation spoil and compacted using the excavator bucket and tracks.

Investigations were carried out by an experienced Geotechnical Engineer from Qualtest who located the test pits, carried out the testing and sampling, produced field logs of the test pits, and made observations of the site surface conditions.

Engineering logs of the test pits are presented in Appendix A.

Approximate test pit locations are shown on the attached Figure Al1. Test pits were located in the field by handheld GPS and relative to existing site features including topographic features, lot boundaries, existing developments, and trees.

4.0 Site Description

4.1 Site Regrade Works

Site re-grading works were conducted on 2 February 2016 to 1 July 2016, 16 July 2017 to 28 August 2017, and 25 October 2018 to 31 October 2018.

The initial re-grading works consisted of the cutting and filling of residential lots within Stage 11 (Lots 1101 to 1104), and the construction of Pitt Street embankment works between Ch. 900m and 1050m. Subsequent regrading included filling Lots 1105, 1106 and 1112 to 1116, construction of Fisherman's Drive, and associated detention basin.

Further re-grading works were performed between 25 October 2018 and 31 October 2018 within Lots 1101 and 1102, where lots were raised a further 0.6m.

Refer to attached Figure AI1 for approximate limit of lot regrade works for the project.

Prior to filling, re-grade areas were stripped of all topsoil and unsuitable material to expose suitable natural residual foundation profile. Re-grade works then consisted of filling with approved site fill to finish design levels.

Filling was performed using site material won from excavations cut from around the site. The fill material could generally be described as mixtures of Gravelly Sandy CLAY, and Clayey Sandy GRAVEL, of low to medium plasticity, fine to coarse grained sand, and fine to coarse grained gravel.

The approximate depth of fill placed ranged in the order of about 0.1m to 3.6m. The fill was compacted in maximum lifts of 0.3m thickness. Any unsuitable or deleterious material within the fill was removed by hand or mechanical means prior to final compaction of the material.

As the geotechnical testing authority engaged for the project, Qualtest state that the filling performed for the regrade areas (Lots 1101 to 1106, and 1111 to 1116), was carried out to Level 1 criteria as defined in Clause 8.2 – Section 8 of AS3798-2007, 'Guidelines on Earthworks for Commercial and Residential Developments'.

For full details on site regrade works, reference should be made to Qualtest site regrade letter (Ref. No. NEW16P-0109-AB, dated 26/11/2018).

The recommendations of this report are based on the understanding that any existing lot re-grade works are limited to the controlled earthworks works supervised by Qualtest, and placement of low reactivity topsoil material such that total topsoil depths do not exceed 0.4m. Qualtest should be informed without delay if additional earthworks are known to have been carried out.

At the time of the field investigations, relatively large fill stockpiles with heights greater than 0.4m were present on Lots 1108 to 1110, and 1114 to 1116. During a site visit carried out on 26 November 2018, removal of the fill mounds was witnessed and documented Qualtest.

4.2 Surface Conditions

The site comprises Stage 11 of the subdivision known as Billy's Lookout located at Pitt Street and Fishermans Drive, Teralba, as shown on Figure Al1 attached.

The site is located within a region of gently to moderately undulating topography. Ground levels are generally in the range from roughly RL 23m (AHD) at the southern end of the site, falling to roughly RL 10m (AHD) in the northern end of the site. Site slopes generally vary from about 3° to 5° towards the north. Some areas have been roughly levelled by site earthworks.

The site generally comprises undeveloped lots, with concrete block retaining walls and underground service near / at some lot boundaries. Most areas had surface covered with a thin layer of mulch. Several Lots contained fill and/or mulch stockpiles with heights in excess of 0.40m on the day of field work, which have subsequently been removed.

On the day of the investigation, the site was judged to be reasonably well drained primarily by way of downhill surface runoff towards the drainage reserve to the north. Trafficability was judged to be good by way of 4WD vehicle along the existing sealed pavement (Fishermans Drive and Pitt Street). Photographs of the site taken on the day of the site investigations are shown below.



Photograph 1: From near northern corner of Lot 1101, facing southeast.







Photograph 3: From near north boundary of Lot 1114, facing southeast.

Photograph 4: From near north boundary of Lot 1114, facing south.



Photograph 5: From near southern boundary of Lot 1109, facing west.



Photograph 6: From near southern boundary of Lot 1109, facing north.

1101, facing southwest.

Photograph 2: From near northern corner of Lot



Photograph 7: From near southern boundary of Lot 1117, facing west.



Photograph 8: From near southern boundary of Lot 1117, facing north.

4.3 Subsurface Conditions

Reference to the 1:100,000 Newcastle Coalfield Regional Geology Sheet indicates the site to be underlain by the Clifton Subgroup of the Narrabeen Group, and the Moon Island Beach Subgroup of the Newcastle Coal Measures, which are characterised by Conglomerate, Sandstone, Siltstone, Claystone, Tuff and Coal rock types.

Table 1 presents a summary of the typical soil types encountered at test pit locations during the field investigation, divided into representative geotechnical units.

Table 2 contains a summary of the distribution of the above geotechnical units at the test pit locations.

No groundwater levels or water inflows were encountered in the test pits during the limited time that they remained open on the day of the field investigations.

It should be noted that groundwater conditions can vary due to rainfall and other influences including regional groundwater flow, temperature, permeability, recharge areas, surface condition, and subsoil drainage.

Unit	Soil Type	Description
1A	FILL - TOPSOIL	Gravelly Silty SAND, Silty SAND, Clayey SAND – fine to coarse grained, dark grey-brown, fine to medium grained angular to sub- angular gravel, fines of low plasticity, root affected.
		Sandy CLAY – low plasticity, dark grey-brown, fine to coarse grained (mostly fine to medium grained), trace fine to medium grained rounded to sub-rounded gravel.
		With tree mulch on surface in places.
1B	UNCONTROLLED FILL	Sandy CLAY – low to medium plasticity, dark grey, fine to medium grained sand, with small pockets of Gravelly SAND.
		Silty Sandy GRAVEL – fine to medium grained, pale grey-brown, fine to coarse grained (mostly fine to medium grained) sand, fines of low plasticity.
		fine to coarse grained (mostly fine to medium grained) s

TABLE 1 – SUMMARY OF GEOTECHNICAL UNITS AND SOIL TYPES

Unit	Soil Type	Description
1C	CONTROLLED FILL	Gravelly Sandy CLAY, Sandy CLAY – low to medium plasticity, brown to pale grey-brown and pale orange-brown, fine to coarse grained sand, fine to medium grained sub-rounded to sub- angular gravel. Trace cobbles in places.
		Gravelly Clayey SAND, Clayey SAND – fine to medium grained, dark grey-brown, fines of low plasticity, with some fine to medium grained sub-rounded to sub-angular gravel, mulch on top 50mm.
2	TOPSOIL	Silty SAND / Clayey SAND – fine to coarse grained (mostly fine to medium grained), grey to dark grey, fines of low plasticity, with some fine to medium grained sub-angular to sub-rounded gravel in places, root affected.
3	COLLUVIUM / SLOPEWASH	Gravelly Silty SAND / Clayey SAND - fine to medium grained, grey- brown and dark grey, fines of low plasticity, some tree roots in places, fine to medium grained gravel in places.
		Sandy CLAY / Clayey SAND – low plasticity, dark grey to grey- brown, fine to medium grained sand, with some roots in places.
4	RESIDUAL SOIL	Sandy CLAY / Clayey SAND - medium and medium to high plasticity, colour varies with combinations of orange-brown and grey, pale grey, grey, and brown to red, fine to medium grained sand. Typically, of very stiff to hard consistency.
		CLAY / Silty CLAY – high plasticity, mostly pale grey with some red- brown in places.
5	EXTREMELY WEATHERED (XW) ROCK with soil properties	Extremely Weathered Silty Sandstone / Sandstone, breaks down into Silty SAND / Clayey SAND – fine grained, pale grey-white and orange-brown, fines of low to medium plasticity, with highly weathered pockets.
		Extremely Weathered Siltstone, breaks down into Silty CLAY – high plasticity, pale grey to white.
6	HIGHLY WEATHERED (HW) ROCK	Silty SANDSTONE / Sandy SILTSTONE – fine to medium grained, pale grey and orange-brown, estimated low strength, with extremely weathered pockets.
		SANDSTONE - fine to coarse grained, pale grey to white and pale orange, estimated strength of medium to high.
		Pebbly SANDSTONE and Sandy SILTSTONE in places. Extremely to Highly Weathered in places.

Location	Unit 1A	Unit 1B	Unit 1C	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6					
	FILL: Topsoil	Uncontrolled Fill	Controlled Fill	Topsoil	Slopewash / Colluvium	Residual Soil	XW Rock	HW Rock					
				Depth i	n metres (m)								
Current Investigation (Ref: NEW15P-0070B-AI, November 2018)													
TP1101	-	-	0.00 - 2.10	-	-	-	-	-					
TP1102	0.00 - 0.25	-	0.25 - 0.80	-	-	0.80 - 1.30	1.30 - 1.38	1.38 - 1.40*					
TP1103	0.00 - 0.25	-	-	-	-	0.25 - 0.90	-	0.90 - 1.00*					
TP1104	0.00 - 0.25	-	-	-	-	0.25 - 0.85	0.85 - 0.95	0.95 - 1.00*					
TP1105	0.00 - 0.25	_	-	-	-	0.25 - 1.20	-	1.20 - 1.25*					
TP1106	-	_	-	0.00 - 0.20	0.20 - 0.45	0.45 - 1.50	1.50 - 1.75	1.75 - 1.85*					
TP1107	-	0.00 - 0.10	0.10 - 1.20	-	-	1.20 - 1.40	1.40 - 1.55	1.55 - 1.70*					
TP1108	0.00 - 0.20	-	0.20 - 1.20	-	1.20 - 1.40	1.40 - 2.00	-	-					
TP1109	-	-	0.00 - 1.20	-	1.20 - 1.80	1.80 - 2.10	-	-					
Note:	* = Very slow	progress, practic	al refusal or refu	sal of 2.5 tonne	excavator met c	on Highly Weathe	ered Rock.						

TABLE 2 – SUMMARY OF GEOTECHNICAL UNITS ENCOUNTERED AT TEST PIT LOCATIONS

Location	Unit 1A FILL: Topsoil	Unit 1B Uncontrolled Fill	Unit 1C Controlled Fill	Unit 2 Topsoil	Unit 3 Colluvium / Slopewash	Unit 4 Residual Soil	Unit 5 XW Rock	Unit 6 HW Rock		
				Depth i	n metres (m)					
Previous Investigation (Ref: NEW15P-0070B-AA, June 2017)										
TP401	0.00 - 0.20	-	0.20 - 1.00	-	1.00 - 1.20	1.20 - 2.60	-	-		
TP402	0.00 - 0.08	0.08 - 0.70	-	-	-	0.70 - 1.45	-	1.45 - 1.50*		
TP403	-	-	-	0.00 - 0.20	-	0.20 - 0.65	-	0.65 - 0.80*		
TP404	-	-	-	0.00 - 0.14	-	0.14 - 1.10	-	1.10 - 1.15*		
TP405	-	-	-	0.00 - 0.10	0.10 - 0.30	0.30 - 0.80	0.80 - 1.10	1.10 - 1.15*		
Note:	* = Practical	refusal or refusal	of 8 tonne exca	vator met on Hig	ghly Weathered	Rock.				
		Pro	evious Investiga	tion (Ref: NEW15	P-0070A-AC, Jui	ne 2016)				
TP120	-	-	-	0.00 - 0.20	0.20 - 0.75	0.75 - 3.10	-	-		
TP123	-	-	_	0.00 - 0.30	-	0.30 - 1.35	-	1.35 - 1.40*		

Uncontrolled filling was encountered on Lots 1114 to 1116 during the previous investigation in 2017. It is understood that the uncontrolled fill was removed as part of subsequent controlled filling works on an area including those lots, as described in Section 4.1

5.0 Laboratory Testing

Samples collected during the field investigations were returned to our NATA accredited Warabrook Laboratory for testing which comprised of:

- (8 no.) Shrink / Swell test; and,
- (1 no.) Atterberg Limits test.

Proposed Shrink/Swell testing for one of the samples was replaced by an Atterberg Limit classification test due to the friable nature of the site fill.

Results of the laboratory testing are presented in Appendix B, with a summary of the test results presented in Table 3 and Table 4.

The tables also include a summary of laboratory testing information where applicable from the previous Geotechnical Assessments carried out by Qualtest.

Location	Depth (m)	Material Description	I _{ss} (%)								
	Current Investigation (Ref: NEW15P-0070B-AI, November 2018)										
TP1101	TP1101 0.30 - 0.70 FILL: (CI) Gravelly Sandy CLAY 0.6										
TP1102	0.80 - 1.15	Residual: (CH) Sandy CLAY	2.6								
TP1103	0.30 - 0.50	Residual: (CH) Sandy CLAY	2.1								
TP1104	0.40 - 0.65	Residual: (CH) Sandy CLAY	2.2								
TP1105	0.40 - 0.65	Residual: (CH) Sandy CLAY	3.1								
TP1106	0.60 - 0.85	Residual: (CH) Silty CLAY	1.5								
TP1107	0.40 - 0.50	FILL: (CH) Sandy CLAY	4.0								
TP1108	1.40 - 1.60	Residual: (CH) Sandy CLAY	1.8								
	Previous Investigation (Ref: NEW15P-0070B-AA, June 2017)										
TP405 0.60 - 0.70 (CH) Sandy CLAY- Residual 4.3											
Prev	vious Geotechnie	cal Assessment (Ref: NEW15P-0070A-AC, June	2016)								
TP120	TP120 0.90 - 1.20 (CH) Sandy CLAY- Residual 2.1										

TABLE 3 – SUMMARY OF SHRINK/SWELL TESTING RESULTS

Location	Depth (m)	Material Description	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)
		er 2018)				
TP1109	0.30 - 0.40	FILL: (CI) Gravelly Sandy CLAY	36	17	19	6.5
	Previo	ous Investigation (Ref: N	EW15P-0070)B-AA, June	2017)	
TP401	0.40 - 0.60	FILL: (CI) Sandy CLAY	40	17	23	4.5
TP402	0.90 – 1.10	(CH) Sandy CLAY	36	15	21	7.0
TP403	0.30 – 0.65	(CH) Sandy CLAY	67	25	42	12.0
TP404	0.40 - 0.70	(CH) Sandy CLAY	69	24	45	9.0

TABLE 4 – SUMMARY OF ATTERBERG LIMITS TESTING RESULTS

The results of the Shrink/Swell and Atterberg Limits laboratory testing indicate that the residual soils tested from the site generally contain fines of medium to high plasticity, whilst the reblended regrade fill material is generally of low to medium plasticity.

6.0 Site Classification to AS2870-2011

Based on the results of the field work and laboratory testing, and Level 1 site regrade work to AS3798-2007 carried out, residential lots located within the Billy's Lookout subdivision Stage 11, located off Pitt Street and Fishermans Drive, Teralba, as shown on Figure Al1, are classified in their current condition in accordance with AS2870-2011 '*Residential Slabs and Footings*', as shown in Table 5.

	TABLE 5 –	SITE CL	ASSIFICATION		S2870-2011
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Lot Numbers	Site Classification
1107 to 1111 and 1117	M
1101 to 1106, 1112 to 1116	H1

A characteristic free surface movement of 20mm to 40mm is estimated for lots classified as **Class 'M'** in their existing condition.

A characteristic free surface movement of 40mm to 60mm is estimated for lots classified as **Class 'H1'** in their existing condition.

The effects of changes to the soil profile by additional cutting and filling and the effects of past and future trees should be considered in selection of the design value for differential movement.

If site re-grading works involving cutting or filling are performed after the date of this assessment, the classification may change and further advice should be sought.

Final site classification will be dependent on a number of factors, including depth of topsoil, depth of fill and residual soil, reactivity of the natural soil and any fill material placed, and the level of supervision carried out. Re-classification of lots should be confirmed by the geotechnical authority at the time of construction following any site re-grade works.

Footings for the proposed development should be designed and constructed in accordance with the requirements of AS2870-2011.

The classification presented above assumes that:

- All footings are founded in controlled fill (if applicable) or in the residual clayey soils or rock below all non-controlled fill, topsoil material and root zones, and fill under slab panels meets the requirements of AS2870-2011, in particular, the root zone must be removed prior to the placement of fill materials beneath slabs;
- The performance expectations set out in Appendix B of AS2870-2011 are acceptable, and that site foundation maintenance is undertaken to avoid extremes of wetting and drying;
- Footings are to be founded outside of or below all zones of influence resulting from existing or future service trenches;
- The constructional and architectural requirements for reactive clay sites set out in AS2870-2011 are followed;
- Adherence to the detailing requirement outlined in Section 5 of AS2870-2011 'Residential Slabs and Footings' is essential, in particular Section 5.6, 'Additional requirements for Classes M, H1, H2 and E sites' including architectural restrictions, plumbing and drainage requirements; and,
- Site maintenance complies with the provisions of CSIRO Sheet BTF 18, "Foundation Maintenance and Footing Performance: A Homeowner's Guide", a copy of which is attached in Appendix C.

All structural elements on all lots should be supported on footings founded beneath all uncontrolled fill, layers of inadequate bearing capacity, soft/loose, wet or other potentially deleterious material.

If any localised areas of uncontrolled fill of depths greater than 0.4m are encountered during construction, footings should be designed in accordance with engineering principles for Class 'P' sites.

7.0 Limitations

The findings presented in the report and used as the basis for recommendations presented herein were obtained using normal, industry accepted geotechnical design practices and standards. To our knowledge, they represent a reasonable interpretation of the general conditions of the site.

The extent of testing associated with this assessment is limited to discrete test pit locations. It should be noted that subsurface conditions between and away from the test pit locations may be different to those observed during the field work and used as the basis of the recommendations contained in this report.

If subsurface conditions encountered during construction differ from those given in this report, further advice should be sought without delay.

Data and opinions contained within the report may not be used in other contexts or for any other purposes without prior review and agreement by Qualtest. If this report is reproduced, it must be in full.

If you have any further questions regarding this report, please do not hesitate to contact Shannon Kelly or the undersigned.

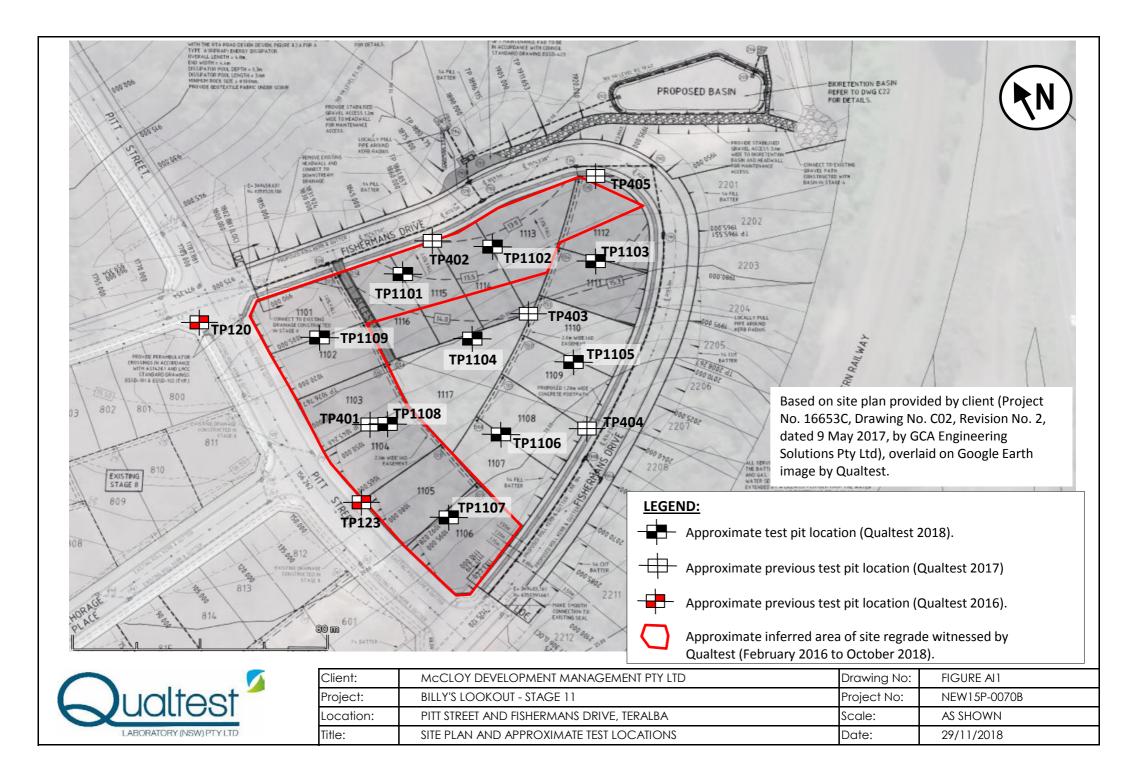
For and on behalf of Qualtest Laboratory (NSW) Pty Ltd.

Re Le.

Jason Lee Principal Geotechnical Engineer

FIGURE AI1:

Site Plan and Approximate Test Locations



APPENDIX A:

Results of Field Investigations



CLIENT: MCCLOY GROUP PTY LTD

PROJECT: BILLYS LOOKOUT SUBDIVISION - STAGE 11 **LOCATION:** FISHERMANS DRIVE, TERALBA TEST PIT NO:

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			-									,												
Drilling and Sampling					Material description and profile information						Fiel	d Test												
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticit characteristics,colour,minor componen		MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additiona observations											
		0.30m		-		CL	FILL: Sandy CLAY - low plasticity, grey-bro medium grained sand, fine grained rounde sub-rounded gravel.		M < W				FILL - CONTROLLED											
		U50 0.70m		- 0. <u>5</u> - -			FILL: Gravelly Sandy CLAY - medium plas brown with some pale grey pale orange-brr red-brown, fine to coarse grained sand, fin coarse grained angular to sub-angular gra some sub-angular cobbles of up to ~200m diameter. Becoming pale grey-brown, no cobbles. Becoming pale brown, with some pale grey orange-brown and red-brown, with some s	own and e to vel, with m in			HP HP HP	420 >600 530 380												
Е	Not Encountered			- 1.0_ -		CI	cobbles of up to ~200mm in diameter. Becoming pale grey-brown, no cobbles.	-	M ~ Wp	VSt - H	HP	480 370												
																- 1. <u>5</u> -			Becoming pale brown, with some pale grey orange-brown and red-brown, with some s cobbles of up to ~200mm in diameter. Becoming grey-brown.	/ pale ub-angular			HP	500 530
				- - 2.0_			Becoming pale grey-brown.																	
				-	~~~~		2.10m Hole Terminated at 2.10 m																	
	Wat (Dat Wat Wat Wat	ter Level te and time sho ter Inflow ter Outflow anges		Notes, Sar U ₅₀ CBR E ASS B Field Test	50mm Bulk s Enviro (Glass Acid S (Plasti Bulk S	Diame ample f nmenta jar, se ulfate \$ c bag, a	ts ter tube sample or CBR testing al sample aled and chilled on site) Soil Sample air expelled, chilled)	S S F F St S VSt V H F Fb F	vncy /ery Soft Soft Stiff /ery Stiff Hard Friable V		<2 25 50 10 20	CS (kPa) 25 5 - 50 0 - 100 00 - 200 00 - 400 400 2005e	Moisture Condition D Dry M Moist W Wet W_p Plastic Limit W_L Liquid Limit											
Gradational or transitional strata Definitive or distict strata change		ansitional strata		PID DCP(x-y) HP	Dynan	nic pen	on detector reading (ppm) etrometer test (test depth interval shown) meter test (UCS kPa)	Density V L MD D VD			oose	n Dense	Density Index 15 - 35% Density Index 35 - 65% Density Index 65 - 85% Density Index 85 - 100%											



CLIENT: MCCLOY GROUP PTY LTD

PROJECT: BILLYS LOOKOUT SUBDIVISION - STAGE 11 **LOCATION:** FISHERMANS DRIVE, TERALBA TEST PIT NO:

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		MENT TYPI IT LENGTH		2.5 TC 2.0 m		EXCA DTH:		SURFACE RL: DATUM:					
	Dri	lling and Sam	npling				Material description and profile informa	tion			Fiel	d Test	
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, pl characteristics,colour,minor comp		MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
				-		CL	FILL-TOPSOIL: Sandy CLAY - low pla grey-brown, fine to coarse grained (m medium grained) sand, trace fine to n rounded to sub-rounded gravel.	ostly fine to	M ~ Wp				FILL - TOPSOIL
	pa			- 0.5_			FILL: Gravelly Sandy CLAY - low to m plasticity, brown to pale orange-brown grained sand, fine to coarse grained a sub-angular gravel, trace sub-angular ~200mm in diameter.	n, fine to coarse angular to	I < Wp	VSt - H	HP HP HP	290 420 380	FILL - CONTROLLED
ш	Not Encountered	0.80m		-			Becoming grey-brown.				HP HP	500 320	RESIDUAL SOIL
5		U50 1.15m		- 1. <u>0</u> -		СН	fine to coarse grained sand, trace roo Becoming pale grey.	ts.	M > w _P	VSt	HP	280	
				-		 SC	1.30m Extremely Weathered Silty Sandstone 1.33m properties; breaks down into Clayey S 1.40m medium grained, pale grey, fines of Ic Iplasticity.	SAND - fine to	D	VD	HP	350	EXTREMELY WEATHERED ROCK HIGHLY WEATHERED
				1. <u>5</u> - - 2.0_			Sity SANDSTONE - fine to medium g grey, estimated low to medium streng Hole Terminated at 1.40 m Very slow progress						
Wa		ter Level			50mm Bulk s	Diame ample f	<u>s</u> ter tube sample or CBR testing il sample	s s	ency Very Soft Soft		<2 25	CS (kPa 25 5 - 50 0 - 100	a) <u>Moisture Condition</u> D Dry M Moist W Wet
	– Wa ata Ch G D	ate and time sh ter Inflow ter Outflow anges Gradational or cansitional stra Definitive or dis trata change	ita	ASS B Field Test PID DCP(x-y) HP	(Glass Acid S (Plasti Bulk S <u>s</u> Photoi Dynan	jar, sea ulfate S c bag, a ample onisatic	aled and chilled on site) soil Sample air expelled, chilled) on detector reading (ppm) strometer test (test depth interval shown) meter test (UCS kPa)	St St VSt V H H	Stiff Very Stiff Hard <u>Friable</u> V L ME D VD	V La D N D	1(2(>/ ery Lo pose	00 - 200 00 - 400 400 Dose n Dense	W _p Plastic Limit W _L Liquid Limit Density Index <15%



CLIENT: MCCLOY GROUP PTY LTD

PROJECT: BILLYS LOOKOUT SUBDIVISION - STAGE 11 **LOCATION:** FISHERMANS DRIVE, TERALBA TEST PIT NO:

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		ient typi T lengti		2.5 TC 2.0 m		EXCA	VATOR 0.5 m	SURFACE R DATUM:	L:				
	Drill	ing and San	npling				Material description and p	profile information			Fiel	d Test	
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL		I: Soil type, plasticity/particle ır,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
				-		SC	FILL-TOPSOIL: Clayey grained (mostly fine to n grey-brown, fines of low medium grained sub-roo	nedium grained) dark	. D - M				FILL - TOPSOIL
	Encountered	0.30m U50		-				to high plasticity, pale brown to medium grained sand.			HP	380	RESIDUAL SOIL
ш	Not Enco	0.50m		0. <u>5</u>		СН			M > W _P	VSt - H	ΗP	420	
				-		CI	0.70m Sandy CLAY / Clayey S brown to pale grey-brow sand. Pockets of Clayey Weathered Silty Sandst 0.90m	AND - medium plasticity, pa n, fine to medium grained / SAND and Extremely one.	le ≥ ≥	н	HP HP		RESIDUAL SOIL / EXTREMELY WEATHERE ROCK
				1.0	<u>, , , , , , , , , , , , , , , , , , , </u>			e to medium grained, pale rown, estimated low to	D				HIGHLY WEATHERED ROCK
	SEND:					nd Tess	Very slow progress	Consi	stency			CS (kPa) Moisture Condition
	t <mark>er</mark> Wat (Dat Wat Wat I Wat I Wat	er Level e and time sł er Inflow er Outflow anges radational or ansitional stra efinitive or dis	nown) ta	U ₅₀ CBR E ASS B <u>Field Test</u> PID DCP(x-y) HP	50mm Bulk s Enviro (Glass Acid S (Plasti Bulk S S Photoi Dynan	Diame ample f onmenta s jar, se Gulfate S c bag, a c bag, a c bag, a conisationis ation	Terr tube sample or CBR testing I sample aled and chilled on site) ioil Sample air expelled, chilled) on detector reading (ppm) etrometer test (test depth interval meter test (UCS kPa)	VS S F St VSt H Fb <u>Densit</u>	Very Soft Soft Firm Stiff Very Stiff Hard Friable		25 25 50 20 20 20 20 20 20 20 20 20 20 20 20 20	25 5 - 50 0 - 100 00 - 200 00 - 400 400 pose	D Dry M Moist W Wet W _p Plastic Limit W _L Liquid Limit Density Index <15%



ENGINEERING LOG - TEST PIT

CLIENT: MCCLOY GROUP PTY LTD

PROJECT: BILLYS LOOKOUT SUBDIVISION - STAGE 11 LOCATION: FISHERMANS DRIVE, TERALBA

TEST PIT NO:

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			ENT TYP		2.5 TC 2.0 m		EXCA		FACE RL: JM:					
		Drilli	ng and San	npling				Material description and profile information				Fiel	d Test	
METHOD		WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticit characteristics,colour,minor componen		MOISTURE	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
					-		CL	FILL-TOPSOIL: Sandy CLAY - low plasticit grey-brown, fine to coarse grained (mostly medium grained) sand, mulch on top 50mr	fine to	D - M				FILL - TOPSOIL
		Not Encountered	<u>0.40m</u>		-			0.25m Sandy CLAY - medium to high plasticity, orange-brown to red-brown with some pale fine to coarse grained sand, trace fine to m grained sub-rounded to sub-angular grave	edium	M > W	VSt	HP	380 520	RESIDUAL SOIL
u	L		U50 0.65m		0.5		СН	Becoming pale grey and pale orange-brow	n.	M ~ Wp	н	HP HP HP	>600 >600 530	
					-		 CI	0.85m Extremely Weathered Silty Sandstone with properties; breaks down into Sandy CLAY	- medium	M < W		HP	>600	EXTREMELY WEATHERED ROCK
10					1.0	· · · · · · ·		 justicity, pale grey, fine to coarse grained trace fine grained rounded gravel. Sitty SANDSTONE - fine to medium graine grey with some pale brown, estimated low strength. Hole Terminated at 1.00 m 		D				HIGHLY WEATHERED
NON-CORED BOREHOLE - TEST PIT TEMPLATE LOGS SHEET.GPJ < <drawingfile>> 28/11/2018 13:37 10.0.000 DatgeLLab and In Stu Too</drawingfile>					-			Practical Refusal						
3:37 10.0.000 Datg					1. <u>5</u>									
File>> 28/11/2018 1					-									
EET.GPJ < <drawing< td=""><td></td><td></td><td></td><td></td><td>2.0</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></drawing<>					2.0									
EMPLATE LOGS SH					-									
HOLE - TEST PIT TE	.EGE Vatei				Notes, Sar U ₅₀			ts ter tube sample	Consister	ncy ery Soft			CS (kPa)	Moisture Condition D Dry
J NON-CORED BORE		Wate (Date Wate Wate	er Level e and time sl er Inflow er Outflow	nown)	CBR E ASS B	Bulk s Enviro (Glass Acid S (Plasti	ample f onmenta s jar, se Sulfate S	or CBR testing al sample aled and chilled on site) Soil Sample air expelled, chilled)	S Sa F Fi St Si VSt Va H H	oft rm tiff ery Stiff ard iable		25 50 10 20	5 - 50 0 - 100 00 - 200 00 - 400 400	$\begin{array}{ll} M & \mbox{Moist} \\ W & \mbox{Wet} \\ W_p & \mbox{Plastic Limit} \\ W_L & \mbox{Liquid Limit} \end{array}$
QTLIB 1.1.GLB Log		Gr - Gr - De	adational or insitional stra efinitive or dis rata change	ita	Field Test PID DCP(x-y) HP	i s Photoi Dynar	ionisatio	on detector reading (ppm) etrometer test (test depth interval shown) ometer test (UCS kPa)	Density	V L MC D VD	Lo M De	ery Lo bose lediun ense ery Do	n Dense	Density Index <15% Density Index 15 - 35% Density Index 35 - 65% Density Index 65 - 85% Density Index 85 - 100%



CLIENT: MCCLOY GROUP PTY LTD

PROJECT: BILLYS LOOKOUT SUBDIVISION - STAGE 11 **LOCATION:** FISHERMANS DRIVE, TERALBA TEST PIT NO:

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		IENT TYPE T LENGTH		2.0 m		IDTH:	VATOR SURI 0.5 m DATU	FACE RL: JM:					
	Drill	ing and Sam	pling			1	Material description and profile information				Fiel	d Test	
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticit characteristics,colour,minor componer		MOISTURE	CONSISTENCY DENSITY	Test Type	Result	Structure and additiona observations
				-		SM	FILL-TOPSOIL: Silty SAND - fine to coarse dark grey-brown, fines of low plasticity, with fine grained angular gravel.	e grained, i some	м				FILL - TOPSOIL
	ered	0.40m		0.5			Sandy CLAY - medium plasticity, orange-b red-brown, fine to coarse grained sand, tra medium grained rounded to sub-rounded o	ce fine to			HP	270	RESIDUAL SOIL
Ш	Not Encountered	U50 0.65m		_		СІ			M > w _P	VSt	ΗP	320	
				_ 1.0_			Becoming pale grey to white, with some fir medium grained rounded to sub-rounded o	e to gravel.	Å _P		ΗP	290	
				-			1.20m	 d, pale	^d M ~ W D		HP	350	
				- - 1.5			grey to white, estimated medium strength. Hole Terminated at 1.25 m Practical Refusal	/					SANDSTONE
				-									
				- 2.0									
				-									
				-									
	Wat (Dat Wat	er Level te and time sho er Inflow er Outflow anges	own)	Notes, Sar U₅o CBR E ASS B	50mm Bulk s Enviro (Glass Acid S (Plasti Bulk S	Diame ample f nmenta jar, se sulfate S	s ter tube sample or CBR testing il sample aled and chilled on site) ioil Sample air expelled, chilled)	S S F F St S VSt V H F	/ery Soft Soft Firm Stiff /ery Stiff Hard Friable		<2 25 50 10 20 >4	CS (kPa 25 5 - 50 0 - 100 00 - 200 00 - 400 400	D Dry M Moist W Wet W _p Plastic Limit W _L Liquid Limit
	tra D	radational or ansitional strata efinitive or dist rata change	a	Field Test PID DCP(x-y) HP	Photoi Dynan	nic pene	on detector reading (ppm) etrometer test (test depth interval shown) meter test (UCS kPa)	<u>Density</u>	V L MC D VD	Lo M De	ery Lo bose ediun ense ery Do	n Dense	Density Index <15% Density Index 15 - 35% Density Index 35 - 65% Density Index 65 - 85% Density Index 85 - 100%



CLIENT: MCCLOY GROUP PTY LTD

PROJECT: BILLYS LOOKOUT SUBDIVISION - STAGE 11 **LOCATION:** FISHERMANS DRIVE, TERALBA TEST PIT NO:

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		MENT TYPI IT LENGTH		2.5 TC 2.0 m		EXCA I DTH :		ACE RL: M:					
	Dril	ling and San	npling				Material description and profile information				Field	d Test	
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity characteristics,colour,minor components		MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
				-		sc	TOPSOIL: Clayey SAND - fine to coarse gra (mostly fine to medium grained), dark grey-t fines of low plasticity, with some fine to medi grained rounded to sub-rounded gravel.	prown.	D - M				TOPSOIL
				-		 CI	0.20m Sandy CLAY - medium plasticity, dark grey t fine to medium grained sand.	 to grey,			HP	>600	COLLUVIUM
		0.60m		0. <u>5</u>			0.45m Silty CLAY - high plasticity, pale grey to white	- <u></u> e.	_		HP	550 >600	RESIDUAL SOIL
	q	U50		-							HP	530	
ш	Encountered	0.85m		-					4		HP HP	580 >600	
	Not E			1. <u>0</u>		СН			M < w _p	Н	HP	>600	
20/11/2010 13:37 10.00000 Dagget Lab and itt Silu 1001				-							ΗP	>600	
1000001 10:000				1. <u>5</u> -		сн	1.50m	perties; , pale	_				EXTREMELY WEATHERED ROCK
JFII6~~ 2011				-	· · _		1.75m SILTSTONE - pale grey to white, estimated strength. Hole Terminated at 1.85 m	low	D			-	HIGHLY WEATHERED ROCK
				- 2. <u>0</u> - -			Very slow progress						
	GEND:			Notes, Sa				Consiste				<u>CS (kPa</u>	
	Wa (Da Wa	ter Level te and time sh ter Inflow ter Outflow anges	hown)	U₅o CBR E ASS B	Bulk s Enviro (Glass Acid s (Plast	ample f onmenta s jar, se Sulfate S	ter tube sample or CBR testing al sample aled and chilled on site) Soil Sample air expelled, chilled)	S S F F St S VSt V H F	/ery Soft Soft Stiff /ery Stiff lard Friable		50 10	- 50 - 100 0 - 200 0 - 400	F
	G tr D	radational or ansitional stra efinitive or dis rata change		Field Test PID DCP(x-y) HP	<u>s</u> Photo Dynai	ionisatio	on detector reading (ppm) etrometer test (test depth interval shown) meter test (UCS kPa)	<u>Density</u>	V L MC D VD	Lo M De	ery Lo bose edium ense ery De	Dense	Density Index <15% Density Index 15 - 35% Density Index 35 - 65% Density Index 65 - 85% Density Index 85 - 100%



CLIENT: MCCLOY GROUP PTY LTD

PROJECT: BILLYS LOOKOUT SUBDIVISION - STAGE 11 **LOCATION:** FISHERMANS DRIVE, TERALBA TEST PIT NO:

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BB

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		IENT TYPI T LENGTH		2.0 m		DTH:		RFACE RL: FUM:					
	Drill	ing and San	npling				Material description and profile information	l			Fiel	d Test	
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasti characteristics,colour,minor compone		MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additiona observations
						GM	FILL: Silty Sandy GRAVEL - fine to medi pale grey-brown, fine to coarse grained (to medium grained) sand, fines of low pla	mostly fine	D				FILL
		0.40m		-		СІ	(to meaium grained) sand, lines of low pla FILL: Gravelly Sandy CLAY - medium pla brown to grey-brown, fine to coarse grain fine to medium grained rounded to sub-re gravel. 0.40m	 sticity, ed sand.	M < W _P		HP	>600	FILL - CONTROLLED
		U50 (0.50m)		- 0.5_ -		сн	 FILL: Sandy CLAY - medium to high plas orange-brown to red-brown with some gr fine to coarse grained (mostly fine to med grained) sand, trace fine to medium grair 0.60m to sub-angular gravel. FILL: Sandy CLAY - medium plasticity, g 	ey-brown, lium ned rounded	-		ΗP	420	
ш	Not Encountered			-		ā	fine to coarse grained sand, with some fi grained sub-angular gravel, trace cobble ~200mm in diameter.	ne to coarse	M ~ WP	Н	HP	>600	
	No			- 1. <u>0</u> -		CI					HP	>600	
				-		CI	1.20m Sandy CLAY - medium plasticity, pale gro fine to coarse grained sand.	ey to grey,	M = M				RESIDUAL SOIL
				1. <u>5</u>		sc	Extremely Weathered Silty Sandstone wi properties; breaks down into Clayey SAN coarse grained (mostly fine to medium g	ID - fine to		VD			EXTREMELY WEATHER
				-	· · · · · · · · · · · · · · · · · · ·		Silty SANDSTONE - fine to medium grain grey, estimated low to medium strength.	 ned, pale					HIGHLY WEATHERED ROCK
				-			Hole Terminated at 1.70 m Practical Refusal						
				- 2. <u>0</u>									
				-									
				-									
LEG	GEND:			Notes, Sa				Consiste				CS (kPa	
	Wat (Dat Wat	er Level e and time sł er Inflow er Outflow	nown)	U ₅₀ CBR E ASS B	Bulk s Enviro (Glass Acid S (Plasti	ample f nmenta jar, se sulfate \$	ter tube sample for CBR testing al sample aled and chilled on site) Soil Sample air expelled, chilled)	S S F F St S VSt V H H	/ery Soft Soft Stiff /ery Stiff Iard Friable		25 50 10 20	25 5 - 50 0 - 100 00 - 200 00 - 400 400	P
<u></u>	tra D	anges radational or ansitional stra efinitive or dis rata change		Field Test PID DCP(x-y) HP	<u>ts</u> Photoi Dynar	onisatio	on detector reading (ppm) etrometer test (test depth interval shown) meter test (UCS kPa)	<u>Density</u>	V L M D VD	L N D	ery Lo bose lediun ense ery D	n Dense	Density Index <15% Density Index 15 - 35% Density Index 15 - 65% Density Index 65 - 85% Density Index 85 - 100%



CLIENT: MCCLOY GROUP PTY LTD

PROJECT: BILLYS LOOKOUT SUBDIVISION - STAGE 11 **LOCATION:** FISHERMANS DRIVE, TERALBA TEST PIT NO:

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NEW15P-0070B

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		MENT TYPE		2.5 TC 2.0 m		EXCA DTH:		SURFACE RL DATUM:	:				
	Dril	ling and Sam	pling				Material description and profile inform	ation			Fiel	d Test	
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, p characteristics,colour,minor com	lasticity/particle ponents	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
	Not Encountered	0.60m D 0.70m U50 1.60m				CI CL CH	FILL-TOPSOIL: Clayey SAND - fine grained, dark grey-brown, fines of lo some fine to medium grained sub-ro sub-angular gravel, mulch on top 50 0.20m FILL: Gravelly Sandy CLAY - mediur brown, fine to coarse grained sand, 1 grained angular to sub-angular grave sandy CLAY / Clayey SAND - low pl grey-brown, fine to coarse grained (r medium grained), with some roots. 1.40m Sandy CLAY - medium to high plasti orange-brown to pale brown with son and pale grey, fine to coarse grained Becoming grey and red-brown to pal 2.00m Hole Terminated at 2.00 m	w plasticity, with unded to mm. 	M > Wp M < Wp M < Wp	H F - St VSt		500 450 >600 490 530 90 180 360 290 310 340	FILL - TOPSOIL FILL - CONTROLLED
	. Wat (Da - Wat ∎ Wat ata Ch ata Ch ata Ch ata Ch tra	ter Level te and time sho ter Inflow ter Outflow anges rradational or ansitional strat efinitive or disti rrata change	a	Notes, Sa U ₅₀ CBR E ASS B Field Test PID DCP(x-y) HP	50mm Bulk s Enviro (Glass Acid S (Plasti Bulk S S Photoi Dynan	Diame ample f nmenta jar, se ulfate \$ c bag, a ample onisationic pen	ts ter tube sample for CBR testing al sample aled and chilled on site) Soil Sample air expelled, chilled) on detector reading (ppm) etrometer test (test depth interval shown) ometer test (UCS kPa)	S F St VSt H	ency Very Soft Soft Firm Stiff Hard Friable V L ME D V V	Vi La D M	<2	n Dense	D Dry M Moist W Wet W _p Plastic Limit W _L Liquid Limit Density Index <15% Density Index 15 - 35%



CLIENT: MCCLOY GROUP PTY LTD

PROJECT: BILLYS LOOKOUT SUBDIVISION - STAGE 11 **LOCATION:** FISHERMANS DRIVE, TERALBA TEST PIT NO:

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BB

30/10/18

TES	ST PI	IENT TYPE T LENGTH		2.0 m		DTH:	VATOR SUR 0.5 m DAT	FACE RL: UM:					
	Drill	ing and Sam	pling				Material description and profile information				Fiel	d Test	
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plastic characteristics,colour,minor component		MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
		0.30m		-		CI	FILL: Gravelly Sandy CLAY - medium plas brown to brown, fine to coarse grained sa coarse grained angular to sub-angular gra	nd, fine to	M ~ Wp	VSt - H	HP HP	500 360	FILL - CONTROLLED
ш	Not Encountered	<u>0.40m</u> , <u>1.00m</u> <u>D</u> <u>1.10m</u> ,		- 0. <u>5</u> - - - 1. <u>0</u>		SC	FILL: Gravelly Clayey SAND - fine to coar pale orange-brown, fines of low to mediun fine to coarse grained sub-angular to ang pockets of cobbles of up to ~200mm diarr	n plasticity, Ilar gravel,	D		-		
				- - 1. <u>5</u> -		CL	1.20m Sandy CLAY / Clayey SAND - low plasticit grey-brown, fine to medium grained sand, roots.		M ~ W	St - VSt	HP HP HP HP	150 230 180 250 210	COLLUVIUM
				2.0		CI	1.80m Sandy CLAY - medium plasticity, grey, find medium grained sand. 2.10m	 e to	M > Wp		HP HP	120 300	RESIDUAL SOIL
<u>Nate</u>	Wat (Dat Wat Wat t <u>a Cha</u>	er Level e and time sho er Inflow er Outflow anges radational or ansitional strat	own)	Notes, Sa U ₅₀ CBR E ASS B Field Test	50mm Bulk s Enviro (Glass Acid S (Plasti Bulk S	Diame ample f nmenta jar, se ulfate S c bag, a ample	Hole Terminated at 2.10 m S ter tube sample or CBR testing I sample aled and chilled on site) ioil Sample air expelled, chilled) on detector reading (ppm)	S S F F St S VSt V H H	Pincy /ery Soft Firm Stiff /ery Stiff Hard Friable V L	V	<2 2 50 10 20	CS (kP 25 5 - 50 0 - 100 00 - 200 00 - 400 400 5005e	D Dry M Moist W Wet W _p Plastic Limit



LOCATION: PITT STREET, TERALBA

PROJECT: PROPOSED SUBDIVISION - STAGE 11

CLIENT: McCLOY DEVELOPMENT MANAGEMENT PTY LTD

TEST PIT NO:

TP401

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NEW15P-0070B

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BE 18-5-17

		ient type: T length:		8 Tonn 2.0 m		vator DTH:		FACE RL: UM:	:				
	Drill	ling and Sampli	ng				Material description and profile information				Fiel	d Test	
METHOD	WATER		RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plastici characteristics,colour,minor componer		MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
						SM	FILL: Gravelly Silty SAND - fine to coarse dark grey, fine to medium grained gravel, a sub-angular, root affected, with tree mulch	angular to	D - M				FILL: TOPSOIL
		0.40m D 0.60m		- - 0.5_ - - -		CL	0.20m surface. FILL: Sandy CLAY - low to medium plastic fine to coarse grained sand, with fine to co grained gravel, sub-rounded to sub-angula	arse	M ~ Wp	н	HP	480 >600	FILL - CONTROLLED
		1.00m		1.0			1.00m Clayey SAND - fine to medium grained, da	 rk grey,			-	-	
	Encountered	D 1.20m		-		SC	fines of low plasticity.		D - M	D			
ш	ot Encor	1.30m		-			Sandy CLAY - medium plasticity, orange-b grey, fine to medium grained sand.	rown and					RESIDUAL SUIL
	Not	D 1.50m		_ 1.5		CI	1.70m			VSt	HP	300	
		<u>2.00m</u>		- - 2.0_			CLAY - high plasticity, pale grey and red-b sandy nodules.	rown, with	M ~ Wp		HP	500	
		D 2.20m		_ _ 		СН				Н	ΗP	550	
							2.60m Hole Terminated at 2.60 m						
				-									
	END:	· · · · · ·		lotes, Sar U ₅₀	-		ter tube sample	VS VS	ncy Very Soft			1 (kPa) 25) Moisture Condition D Dry
	Wat (Dat Wat Wat	er Level e and time show er Inflow er Outflow	(n) A	BR E SS	Bulk s Enviro (Glass Acid S (Plasti	ample f nmenta jar, se ulfate \$ c bag, a	or CBR testing I sample aled and chilled on site) Soil Sample air expelled, chilled)	S F St VSt H	Soft Firm Stiff Very Stiff Hard		25 50 10 20	5 - 50 0 - 100 00 - 200 00 - 400 400	M Moist W Wet W _p Plastic Limit
<u>otra</u>	tra De	i nges radational or ansitional strata efinitive or distict rata change	E	B ield Tests PID DCP(x-y) HP	Photoi Dynan	onisatio	on detector reading (ppm) etrometer test (test depth interval shown) meter test (UCS kPa)	Fb Density	Friable V L MD D	Lo	ery Lo oose lediun	oose n Dense	Density Index <15% Density Index 15 - 35% Density Index 35 - 65% Density Index 65 - 85%



LOCATION: PITT STREET, TERALBA

PROJECT: PROPOSED SUBDIVISION - STAGE 11

CLIENT:

McCLOY DEVELOPMENT MANAGEMENT PTY LTD

TEST PIT NO:

TP402

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Job no: Logged by:

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BE 18-5-17

		ENT TYPE T LENGTI		8 Tonn 2.0 m		avator IDTH:		FACE RL: UM:					
	Dril	ing and San	npling				Material description and profile information				Fiel	d Test	
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticit characteristics,colour,minor componen		MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
					***	SP	FILL: SAND - fine to medium grained, brow		D - M				FILL: TOPSOIL
		0.40m		-		CL	 0.08m to medium grained gravel, angular to sub-a (trace clay. FILL: Sandy CLAY - low to medium plastici grey, fine to medium grained sand, with sm of Gravelly SAND. 0.40m 	/ ity, dark	 ∧ ≥		HP HP HP	>600 100 >600	FILL - UNCONTROLLED
	ountered	D (0.50m)		- 0.5_ -			Gravelly Silty SAND - fine to medium grain grey, fine to medium grained gravel, sub-ar sub-rounded, with tree roots/mulch.	— — — — ∋d, dark ıgular to	М	D			COLLUVIUM / POSSIBLE FILL
ш	Not Encountered	0.90m		-			Sandy CLAY - medium to high plasticity, pa and orange-brown, fine to medium grained	ale grey sand.			HP	210 280	RESIDUAL SOIL
		U50 1.10m		1. <u>0</u>		СН			M > w _P	VSt	HP	280	
				- 1.5			1.45m 1.50m Sandy SILTSTONE - pale grey and orange cestimated low strength, with extremely wea pockets.	-brown, thered	D		-		HIGHLY WEATHERED
				-			Hole Terminated at 1.50 m Practical Excavator Refusal	1					
				2.0									
				-									
				2.5									
				-									
LEC	GEND:			Notes, Sar	nples ar	d Tests	1	Consister	ncy		<u> </u>	CS (kPa	a) Moisture Condition
	t <u>er</u> Wat (Dat Wat	er Level e and time sh er Inflow er Outflow	nown)	U₅₀ CBR E ASS B	50mm Bulk s Enviro (Glass Acid S (Plast	Diame ample f nmenta jar, se Sulfate S	ter tube sample for CBR testing I sample aled and chilled on site) Soil Sample air expelled, chilled)	VS V S S F F St S VSt V H H	/ery Soft Soft Firm Stiff /ery Stiff Hard Friable		<: 2! 50 10 20	25 5 - 50 0 - 100 00 - 200 00 - 400 400	D Dry M Moist W Wet D W _p Plastic Limit
<u>stra</u>	—- tra — Do	nges radational or ansitional stra efinitive or dis rata change		B Field Tests PID DCP(x-y) HP	<u>s</u> Photo Dynar	ionisatio	on detector reading (ppm) etrometer test (test depth interval shown) meter test (UCS kPa)	<u>Density</u>	-nable V L ME D VE	L N D	ery Lo oose lediur ense ery D	n Dense	Density Index <15% Density Index 15 - 35% e Density Index 35 - 65% Density Index 65 - 85% Density Index 85 - 100%



LOCATION: PITT STREET, TERALBA

PROJECT: PROPOSED SUBDIVISION - STAGE 11

CLIENT: McCLOY DEVELOPMENT MANAGEMENT PTY LTD

TEST PIT NO:

TP403

1 OF 1 NEW15P-0070B

JOB NO: LOGGED BY:

PAGE:

DATE:

ΒE 18-5-17

										TE:			18-5-17
		IENT TYPI		8 Tonr 2.0 m		avator ' IDTH :		FACE RL: JM:					
	Dril	ling and Sar	npling				Material description and profile information				Fiel	d Test	
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticit characteristics,colour,minor component		MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additiona observations
				-		SM	Gravelly Silty SAND - fine to medium graine grey, root affected.	ed, dark	D - M				TOPSOIL
Ш	Not Encountered	0.30m U50 0.65m		- - 0.5_ -		 CI	O.20m Sandy CLAY - medium to high plasticity, orange-brown and brown, fine to medium gr sand, with some fine to medium grained gra sub-angular to sub-rounded. O.65m O.65m	avel,	M < w _p	н	HP	>600	RESIDUAL SOIL
				-			SANDSTONE - fine to coarse grained, pale grey-white and pale orange, estimated med high strength, with extremely weathered po Hole Terminated at 0.80 m	lium to	D				HIGHLY WEATHERED ROCK
LEG	END:			1.0		d Test		Consister	ncy			CS (kPa) Moisture Condition
	Wat (Dat Wat Wat Wat	-	hown)	U₅o CBR E ASS B Field Test	Bulk s Enviro (Glass Acid s (Plast Bulk s	sample onmenta s jar, se Sulfate :	ster tube sample for CBR testing al sample saled and chilled on site) Soil Sample air expelled, chilled)	S S F F St S VSt V H H	/ery Soft Soft Firm Stiff /ery Stiff Hard Friable V		25 50 10 20	25 5 - 50 0 - 100 00 - 200 00 - 400 400	P
	tra D	radational or ansitional stra efinitive or dis rata change		PID DCP(x-y) HP	Photo Dynar	nic pen	on detector reading (ppm) etrometer test (test depth interval shown) ometer test (UCS kPa)	Penalt	L ME D VD	Lo M D	oose	n Dense	Density Index 15 - 35%



LOCATION: PITT STREET, TERALBA

PROJECT: PROPOSED SUBDIVISION - STAGE 11

CLIENT:

McCLOY DEVELOPMENT MANAGEMENT PTY LTD

TEST PIT NO:

TP404

1 OF 1 NEW15P-0070B

JOB NO: LOGGED BY:

PAGE:

DATE:

ΒE 18-5-17

	Duill					idth:	0.5 m DATU	JM:					
	Drii	ling and Sam	pling				Material description and profile information				Fiel	d Test	
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity characteristics,colour,minor component		MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
					} }	SM	Silty SAND - fine grained, dark grey, trace f grained gravel, sub-angular, root affected.	ine	D - M				TOPSOIL
ш	Not Encountered	0.40m U50 0.70m		- - - 0.5_ - -		СН	Silty CLAY - medium to high plasticity, pale	grey.	M < W _P	н	HP	>600	RESIDUAL SOIL
				- 1.0_			1.10m				HP	>600	
				-			1.15m Pebbly SANDSTONE - fine to coarse graine grey-white, estimated high strength.	d, pale					HIGHLY WEATHERED
							Refusal						
	Wat (Dat Wat Wat ta Cha	ter Level te and time sh ter Inflow ter Outflow Inges radational or ansitional strat	own) ta	I <u>Notes, Sar</u> U₅₀ CBR E ASS B <u>Field Test</u> PID DCP(x-y)	50mm Bulk s Enviro (Glass Acid S (Plasti Bulk S S Photo	Diame ample f nmenta jar, sea Sulfate S ic bag, a Sample	er tube sample or CBR testing sample led and chilled on site) oil Sample ir expelled, chilled) n detector reading (ppm) trometer test (test depth interval shown)	S F St VSt H	Pency Very Soft Soft Firm Stiff Very Stiff Hard Friable V L ME	V	<2 2 50 10 20 20 20 20 20 20 20 20 20 20 20 20 20	CS (kPa 25 5 - 50 0 - 100 00 - 200 00 - 400 400 Doose m Dense	D Dry M Moist W Wet W _p Plastic Limit W _L Liquid Limit Density Index <15% Density Index 15 - 35%



LOCATION: PITT STREET, TERALBA

PROJECT: PROPOSED SUBDIVISION - STAGE 11

McCLOY DEVELOPMENT MANAGEMENT PTY LTD

TEST PIT NO:

TP405

1 OF 1 NEW15P-0070B

JOB NO: LOGGED BY:

PAGE:

DATE:

ΒE 18-5-17

		ient type T lengti		8 Tonn 2.0 m		idth:		FACE RL: UM:					
	Drill	ling and San	npling				Material description and profile information				Fiel	d Test	
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticit characteristics,colour,minor componen		MOISTURE	CONSISTENCY DENSITY	Test Type	Result	Structure and additiona observations
					<u>}</u>	SM	Silty SAND - fine to medium grained, grey, <u>0.10m</u> medium grained gravel, angular to sub-ang	with fine to ular, root	D - M				TOPSOIL / SLOPE WASH
						SM	Affected. Gravelly Silty SAND - fine to medium graine grey-brown, fine to medium grained gravel,	/ ed, rounded	м	D			COLLUVIUM
	Not Encountered			- 0.5_		— — -	0.30m to sub-rounded	rey-brown sand.	M ^P	VSt	HP	360	RESIDUAL SOIL
ш	Not En	0.60m CBR U50 0.80m					0.80m		ž	VOL	HP HP	360 390	EXTREMELY WEATHER
				1.0		SM	Extremely Weathered SANDSTONE with s properties: excavates as Silty SAND - fine ; pale grey-white and orange-brown, with hig weathered pockets.	grained,	D - M	VD			ROCK
				-	<u></u>		1.15m SANDSTONE - fine to coarse grained, pale grey-white and orange-brown, estimated m high strength.						HIGHLY WEATHERED
				-			Hole Terminated at 1.15 m Practical Excavator Refusal]					
				1.5									
				_									
				-									
				2.0									
				-									
				-									
				_									
				2.5									
				-									
	END:			Notes, San				Consiste				CS (kPa)	
Wati	Wat	er Level e and time sh	nown)	U₅₀ CBR E	Bulk s Envirc	ample to	ter tube sample for CBR testing Il sample aled and chilled on site)	S S F I	Very Soft Soft Firm Stiff		25 50	25 5 - 50 0 - 100 00 - 200	D Dry M Moist W Wet W _p Plastic Limit
	Wat	er Inflow er Outflow		ASS	Acid S (Plast	Sulfate S ic bag, a	Soil Sample air expelled, chilled)	VSt V	Very Stiff Hard		20	00 - 400 400	W _L Liquid Limit
Stra	tra	radational or ansitional stra		B Field Tests PID DCP(x-y)	E Photo		on detector reading (ppm) etrometer test (test depth interval shown)	Fb I Density	Friable V L MD	Lo	ery Lo oose lediun	oose n Dense	Density Index <15% Density Index 15 - 35% Density Index 35 - 65%
		efinitive or dis rata change	uct	HP	-		meter test (UCS kPa)		D VD	D	ense ery De		Density Index 65 - 85% Density Index 85 - 100%

	ENGINEERING LOG - TEST PIT TEST PIT NO:									TP120			
6	Qualtest CLIENT: MCCLOY GROUP PAGE:										1 OF 2		
	PROJECT: PROPOSED SUBDIVISION - STAGES 5 TO 9 JOB NO:										NEW15P-0070A		
	LOCATION: PITT STREET, TERALBA LOGGED BY:									SJK			
	DATE:										13-1-16		
		ENT TYPE T LENGTI		22 toni 3.0 m	22 tonne excavatorSURFACE RL3.0 mWIDTH:1.5 mDATUM:					3.5 m ssum			
	Drill	ing and San	npling				Material description and profile information		F		Fiel	d Test	
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/ characteristics,colour,minor components		MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
						SM	Silty SAND - fine to coarse grained, brown to fines of low plasticity, root affected.	o grey,					TOPSOIL
		<u>0.30m</u>				 -	0.20m Silty Clayey SAND - fine to coarse grained, p brown, fines of low to medium plasticity, som medium grained gravel with gravelly pockets, tree roots.	ne fine to	м				
		CBR 13.0 0.5 0.70m				SC				M to W			
	US0		12. <u>5</u>	 - 1.0			Sandy CLAY - medium plasticity, pale brown orange and pale grey, fine to coarse grained	i to sand.			HP	250	RESIDUAL SOIL
ш	~2L/min inflow from	<u>1.20m</u>	12. <u>0</u>	 _ 1.5					M > w _P	VSt			
			11. <u>5</u>	2.0		CI					-		
			11. <u>0</u>						M < w _p	Н	HP	>600	
						СН	2.80m CLAY - medium to high plasticity, grey with s brown, some fine to medium grained sand, a have some relict rock structure.	ppears to	M ~ W		HP	550	
<u>Wat</u> ▼	Wat (Dat Wat Wat	er Level e and time sh er Inflow er Outflow	nown)	Notes, Sar U ₅₀ CBR E ASS	50mm Bulk s Enviro (Glass Acid S (Plast	n Diame sample onmenta s jar, se Sulfate s ic bag,	eter tube sample for CBR testing al sample ealed and chilled on site) Soil Sample air expelled, chilled)	S So F Fi St Si VSt Vo H Ha	ery Soft oft rm tiff ery Stiff ard		<2 25 50 10 20	<u>CS (kPa</u> 25 5 - 50 0 - 100 00 - 200 00 - 400 400	D Dry M Moist W Wet W _p Plastic Limit
<u>stra</u>	tra De	nges radational or ansitional stra efinitive or dis rata change	al strata PID Photoionisation detector reading (ppm) or distict DCP(x-y) Dynamic penetrometer test (test depth interval shown)				<u>Density</u>	Friable V Very Loose L Loose MD Medium Dens D Dense VD Very Dense			n Dense	Density Index <15% Density Index 15 - 35% Density Index 35 - 65% Density Index 65 - 85% Density Index 85 - 100%	

	ENGINEERING LOG - TEST PIT									TE	ST PI):	TP120	
CLIENT: MCCLOY GROUP PAGE:												2 OF 2		
PROJECT: PROPOSED SUBDIVISION - STAGES 5 TO 9 JOB NO: LOCATION: PITT STREET, TERALBA LOGGED BY:										JO	B NO:			NEW15P-0070A
										:	SJK			
DATE:											13-1-16			
	EQUIPMENT TYPE: 22 tonne excavator SURFACE RL: 13.5 m IEST PIT LENGTH: 3.0 m WIDTH: 1.5 m DATUM: Assumed													
123		ing and Sam		5.0 M	VV	חיטי.	Material description and profi		// / 1:	F	Assum		d Test	
			ping			z					~			
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: So characteristics,colour,m	oil type, plasticity ninor component	//particle s	MOISTURE	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
ш						СН	3.10m				н			
							Hole Terminated at 3.10 m							
			-											
			-											
			10. <u>0</u>	3.5										
			-	-										
			-	_										
			-											
			_	_										
			9. <u>5</u>	4.0										
			_											
			-											
			-											
			-											
			9.0	4.5										
			0.0_											
			-	-										
			-	_										
			-											
			-	-										
			8.5	5.0										
			-	-										
			-	- 1										
			-	-										
			-	- 1										
			8.0	5.5										
			-	-										
			-											
			-											
			_	-										
LEGEND: Notes, Samples and Tests Water U ₅₀ 50mm Diameter tube sample								ery Soft		<'	CS (kPa) 25	D Dry		
Water Level CBR					Bulk sample for CBR testing Environmental sample				S Soft 25 - 50 F Firm 50 - 100					M Moist W Wet
(Date and time shown) (Gla					(Glass	(Glass jar, sealed and chilled on site) Acid Sulfate Soil Sample				St Stiff 100 - 200 VSt Very Stiff 200 - 400			00 - 200	W _p Plastic Limit W _L Liquid Limit
- Water Outflow (Plastic bag, air expelled, chilled)						нн	ard riable			400				
<u>strata</u>	Gradational or Field Tests					Bulk Sample				V		ery Lo	ose	Density Index <15%
		ansitional stra efinitive or dis		PID DCP(x-y)	Photoionisation detector reading (ppm) Dynamic penetrometer test (test depth interval shown)					L ME	D M		n Dense	
		rata change		HP	Hand Penetrometer test (UCS kPa)								Density Index 65 - 85% Density Index 85 - 100%	

ENGINEERING LOG - TEST PIT									TEST PIT NO:):	TP123
CLIENT: MCCLOY GROUP									PA	GE:			1 OF 1
PROJECT: PROPOSED SUBDIVISION - STAGES 5 TO 9								C 9	JO	B NO:	:		NEW15P-0070A
									LO	GGEI) ВХ	:	SJK
									DA	TE:			12-1-16
EQ	EQUIPMENT TYPE: 22 tonne excavator SURFACE RL: 18.5 m												
				3.0 m						Assum			
	Dril	ling and Sar	npling		Material description and profile information				Field Test			d Test	
_					~	NOI				ζ			
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticit characteristics,colour,minor component		MOISTURE	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
					131131	C				ŏ			TOPSOIL
			-				Clayey SAND - fine to coarse grained, dark grey, fines of low to medium plasticity, trace	brown to e of fine					TOPSOIL
						SC	grained gravel, root affected.		М				
			-	-			0.30m						
		0.40	-	-		<u>+</u>	Sandy CLAY - medium to high plasticity, pa						RESIDUAL SOIL
		0.40m	-				white and orange to pale brown, fine to coa grained sand, trace of fine grained subroun	rse ded					
	eq		18.0	0.5			gravel.				HP	160	
	Not Encountered	CBR	-	_						St			
ш	ncor	0.70m											
ш	ot E		-										
	z		-	-		СН			_ × I				
			-						Σ		HP	200	
			17. <u>5</u>	1.0									
			-	_						St /			
										VSt			
			-	-			Becoming weakly cemented.						
			-				1.35m						
					:0:::		1.40m PEBBLY SANDSTONE - fine to coarse grain grey to white and orange to pale brown, fine		М				HIGHLY WEATHERED
			17.0	1.5			medium grained subrounded gravel, estima medium to high strength, few joints.	ted					<u></u>
			_	_			Hole Terminated at 1.40 m]					
							Practical Refusal						
			-	-									
			-										
			-	-									
			16. <u>5</u>	2.0									
			-	-									
			-	-									
			-	-									
			16. <u>0</u>	2.5									
			-										
			-	-									
			-	-									
			-										
	EGEND: Notes Semiles and Tests							0.000			L		
	LEGEND: Notes, Samples and Tests Water U ₅₀ 50mm Diameter						ter tube sample	Consister VS V	i cy ery Soft	:		CS (kPa 25	a) <u>Moisture Condition</u> D Dry
Ţ		ter Level	0	CBR		•	or CBR testing Il sample		oft irm			5 - 50) - 100	M Moist W Wet
	(Date and time shown)				(Glass	s jar, se	aled and chilled on site)	St S	tiff		10	00 - 200) W _p Plastic Limit
▶ Water Inflow ASS Acid Sulfate Soil Sample ✓ Water Outflow (Plastic bag, air expelled, chilled)							ery Stiff ard)0 - 400 100) W _L Liquid Limit		
							Fb F	riable					
Gradational or Field Tests						on detector reading (ppm)	<u>Density</u>	V L		ery Lo oose	ose	Density Index <15% Density Index 15 - 35%	
		ansitional stra efinitive or dis	- I I	DCP(x-y)	y) Dynamic penetrometer test (test depth interval shown)				ME	D N	lediun	n Dense	e Density Index 35 - 65%
	st	rata change		HP	Hand	Penetro	meter test (UCS kPa)		D VD		ense ery De	ense	Density Index 65 - 85% Density Index 85 - 100%
									۷L	v	J. J. J.		2010ty mack 00 - 100 /0

APPENDIX B:

Results of Laboratory Testing



 QUALTEST Laboratory (NSW) Pty Ltd (20708)

 8 Ironbark Close Warabrook NSW 2304

 T:
 02 4968 4468

 F:
 02 4960 9775

 E:
 admin@qualtest.com.au

 W:
 www.qualtest.com.au

 ABN: 98 153 268 896

Shrink Swell Index Report	Report No: SSI:NEW18W-3526S01 Issue No: 1
Client: McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300	Accredited for compliance with ISO/IEC 17025-Testing. The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. Results provided relate only to the items tested or sampled. This report shall not be reproduced except in full.
Principal: Project No.: NEW15P-0070B Project Name: Billys Lookout - Stage 11	WORLD RECORNISED ACCREDITATION
Sample Details	
Sample ID: NEW18W-3526S01	Client Sample ID: -
Fest Request No.: -	Sampling Method: AS1289.1.2.1 cl 6.5
Material: Sandy Clay	Date Sampled: 30/10/2018
Source: On-Site	Date Submitted: 31/10/2018
Specification:No SpecificationProject Location:Teralba, NSWSample Location:TP1101 - (0.3 - 0.7m)Borehole Number:TP1101Borehole Depth (m):0.3 - 0.7	
Swell Test AS 1289.7.1	.1 Shrink Test AS 1289.7.1.1
Swell on Saturation (%): -1.5	Shrink on drying (%): 1.1
Moisture Content before (%): 15.3	Shrinkage Moisture Content (%): 14.3
Moisture Content after (%): 19.0	Est. inert material (%): 10.0
Est. Unc. Comp. Strength before (kPa): 290 Est. Unc. Comp. Strength after (kPa): 200	Crumbling during shrinkage: Nil Cracking during shrinkage: Minor
Shrink Swell Shrinka	age 🔶 Swell
10.0	
2	
ت	
(%)	
ell se	
	- <u> </u>
Esh 🗸	
(%)	
Shrink (%) Esw -2.0 -0.0 -0.0 -0.0 -0.0 -0.0 -0.0 -0.0	
ές - Ξ	
-10.0 +	
0.0 5.0 10.0 15.0 20.0	25.0 30.0 35.0 40.0 45.0 50.0
	Aoisture Content (%)
Shrink Swell Index - Iss (%): 0.6	

Comments



Shrink Swell Index Report Client: McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300 Principal: Project No.: NEW15P-0070B Project Name: Billys Lookout - Stage 11 Sample Details Sample ID: NEW18W-3526S02 Client Sam Fest Request No.: - Sampling I Material: Sandy Clay Date Samp Source: On-Site Date Subm Specification: No Specification Project Location: Teralba, NSW Sample Location: TP1102 - (0.8 - 1.15m)	world Recognised ACCREDITATION P Method: AS1289.1 Dled: 30/10/201	is document are trace soulds provided relate his report shall not be pproved Signato Senior Geotechn ATA Accredited ate of Issue: 20/ .2.1 cl 6.5 8	calibrations and/or n able to Australian/na only to the items tes reproduced except i pry: Adam Dwye ician) Laboratory Nur	measurements included ational standards. isted or sampled. in full.
Suite 1 Level 3, 426 King Street Newcastle West NSW 2300 Principal: Project No.: NEW15P-0070B Project Name: Billys Lookout - Stage 11 Sample Details Sample ID: NEW18W-3526S02 Client Sam Test Request No.: - Sampling I Material: Sandy Clay Date Samp Source: On-Site Date Subm Specification: No Specification Project Location: Teralba, NSW	world Recognised ACCREDITATION P Method: AS1289.1 Dled: 30/10/201	e results of the tests, is document are trace asults provided relate is report shall not be pproved Signato Senior Geotechn ATA Accredited ate of Issue: 20/ .2.1 cl 6.5 8	calibrations and/or n able to Australian/na only to the items tes reproduced except i pry: Adam Dwye ician) Laboratory Nur	measurements included ational standards. isted or sampled. in full.
Project No.: NEW15P-0070B Project Name: Billys Lookout - Stage 11 Sample Details Client Sam Sample ID: NEW18W-3526S02 Client Sam Test Request No.: - Sampling I Material: Sandy Clay Date Samp Source: On-Site Date Subm Specification: No Specification Project Location: Teralba, NSW	mple ID: - Method: AS1289.1 pled: 30/10/201	2.1 cl 6.5	ician) Laboratory Nur	
Project No.: NEW15P-0070B Project Name: Billys Lookout - Stage 11 Sample Details Client Sam sample ID: NEW18W-3526S02 Client Sam est Request No.: - Sampling I Iaterial: Sandy Clay Date Samp source: On-Site Date Subm pecification: No Specification roject Location: Teralba, NSW	mple ID: - Method: AS1289.1 pled: 30/10/201	2.1 cl 6.5	ician) Laboratory Nur	
Sample Details Client Sample ID: NEW18W-3526S02 Client Sample ID: Sest Request No.: - Sandy Clay Date Sample ID: Interial: Sandy Clay Source: On-Site Opecification: No Specification Project Location: Teralba, NSW	mple ID: - Method: AS1289.1 pled: 30/10/201	2.1 cl 6.5	ician) Laboratory Nur	
Client Sample ID: NEW18W-3526S02 Client Sampling I Cest Request No.: - Sampling I Interial: Sandy Clay Date Sampling I Interial: Sandy Clay Date Sampling I Source: On-Site Date Subm Specification: No Specification Teralba, NSW	Method: AS1289.1 bled: 30/10/201	8		
est Request No.:-Sampling Ilaterial:Sandy ClayDate Sampource:On-SiteDate Submpecification:No Specificationroject Location:Teralba, NSW	Method: AS1289.1 bled: 30/10/201	8		
laterial:Sandy ClayDate Sampource:On-SiteDate Submpecification:No Specificationroject Location:Teralba, NSW	bled: 30/10/201	8		
ource: On-Site Date Subm pecification: No Specification roject Location: Teralba, NSW				
pecification: No Specification roject Location: Teralba, NSW	nitted: 31/10/201	8		
roject Location: Teralba, NSW				
-				
ample Location: TP1102 - (0.8 - 1.15m)				
•				
orehole Number: TP1102 orehole Depth (m): 0.8 - 1.15				
well Test AS 1289.7.1.1 Shrink 1	Fest		AS	1289.7.1
	drying (%):	4.5		
	Moisture Content			
	material (%):	1.0		
) during shrinkage: during shrinkage:			
	auring shrinkage.	Nil		
Shrink Swell Shrinkage	Sw ell			
10.0	•••••••••••••••••••••••••••••••••••••••		· · · · · · · · · · · · · · · · · · ·	· · · · ·
-	1	:	1	÷
		:		
Shrink (%) Esh - Swell (%) Esh		:		
	: :		÷	÷
		:	÷	
			:	
S -	; ;	:	:	:
8				
Ĕ	1	:		
ର୍ଚ୍ଚ -	1			1
10.0				
-10.0 +				
0.0 5.0 10.0 15.0 20.0 25.0	30.0 35.0	40.0	45.0	50.0
Moisture Content ((%)			
Shrink Swell Index - Iss (%): 2.6				



Shrink	Swell	Index R	eport					t NO. 331		V-3526S0 Issue No:
Client:	Suite 1 Lev	velopment Mana el 3, 426 King S West NSW 230	street	ty Ltd				Accredited for compliar The results of the tests, his document are trace Results provided relate This report shall not be	calibrations and/or r able to Australian/na only to the items tes	neasurements included i tional standards. ted or sampled.
Principal: Project No.: Project Name:	NEW15P-0 : Billys Look						DITATION	Approved Signato Senior Geotechn NATA Accredited Date of Issue: 20	ician) Laboratory Nur	
ample De	tails									
ample ID:		8W-3526S03			Client Sa	mple ID:	-			
est Request N	No.: -				Sampling	Method:	AS1289.	1.2.1 cl 6.5		
laterial:	Sandy	Clay			Date Sam	pled:	30/10/20	18		
ource:	On-Site	Э			Date Sub	mitted:	31/10/20	18		
pecification:	No Spe	ecification								
roject Locatio	on: Teralba	a, NSW								
ample Locati		3 - (0.3 - 0.5m)								
orehole Num										
orehole Dept	in (m): 0.3 - 0.	.5								
well Test			AS 12	89.7.1.1	Shrink				AS	1289.7.1.
well on Satur	. ,	-0			11	n drying (%	-	3.9		
loisture Conte	-	-	2.7			e Moisture				
loisture Conte		24 24 cefore (kPa): 54	1.6 IN		11	material (g during s	-	5.0 •: Nil		
st. Unc. Com					11	during sh	-	Nil		
hrink Swe		. ,				•	<u> </u>			
	711			Shrinkage	•	Sw ell				
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Shrink (%) Esh - Swell (%) E		0 10.0	15.0		25.0 sture Content		35.0	40.0	45.0	50.0



Shrink Swell Index Report	Report No: SSI:NEW18W-3526S0 Issue No:
Client: McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300	Accredited for compliance with ISO/IEC 17025-Testing. The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards. Results provided relate only to the items tested or sampled. This report shall not be reproduced except in full.
Principal: Project No.: NEW15P-0070B	Approved Signatory: Adam Dwyer
Project Name: Billys Lookout - Stage 11	WORLD RECOGNISED (Senior Geotechnician) ACCREDITATION NATA Accredited Laboratory Number: 18686 Date of Issue: 20/11/2018
ample Details	
ample ID: NEW18W-3526S04	Client Sample ID:
est Request No.: -	Sampling Method: AS1289.1.2.1 cl 6.5
laterial: Sandy Clay	Date Sampled: 30/10/2018
ource: On-Site	Date Submitted: 31/10/2018
pecification: No Specification	
roject Location: Teralba, NSW	
ample Location: TP1104 - (0.4 - 0.65m)	
orehole Number: TP1104 orehole Depth (m): 0.4 - 0.65	
well Test AS 1289.7.1.	1 Shrink Test AS 1289.7.1
well on Saturation (%): -0.3	Shrink on drying (%): 4.0
loisture Content before (%): 26.4	Shrinkage Moisture Content (%): 26.4
loisture Content after (%): 29.3	Est. inert material (%): 10.0
st. Unc. Comp. Strength before (kPa): 480	Crumbling during shrinkage: Nil
st. Unc. Comp. Strength after (kPa): 350	Cracking during shrinkage: Major
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S.0 U(%) UIIINO US (%) UIIINO -5.0 -0	25.0 30.0 35.0 40.0 45.0 50.0 oisture Content (%)



Shrink Swell Index Report	Report No: SSI:NEW18W-3526S05 Issue No: 1
Client: McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300	Accredited for compliance with ISO/IEC 17025-Testing. The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. Results provided relate only to the items tested or sampled. This report shall not be reproduced except in full.
Principal:	
Project No.: NEW15P-0070B	Approved Signatory: Adam Dwyer
Project Name: Billys Lookout - Stage 11	ACCREDITATION (Senior Geotechnician) NATA Accredited Laboratory Number: 18686 Date of Issue: 20/11/2018
Sample Details	
Sample ID: NEW18W-3526S05	Client Sample ID:
Test Request No.: -	Sampling Method: AS1289.1.2.1 cl 6.5
Material: Sandy Clay	Date Sampled: 30/10/2018
Source: On-Site	Date Submitted: 31/10/2018
Specification: No Specification	
Project Location: Teralba, NSW	
Sample Location: TP1105 - (0.4 - 0.65m)	
Borehole Number: TP1105 Borehole Depth (m): 0.4 - 0.65	
Swell Test AS 1289.7.	
Swell on Saturation (%): -1.7	Shrink on drying (%): 5.5
Moisture Content before (%): 30.8	Shrinkage Moisture Content (%): 30.5
Moisture Content after (%): 30.9 Est. Unc. Comp. Strength before (kPa): 290	Est. inert material (%): 1.0 Crumbling during shrinkage: Nil
Est. Unc. Comp. Strength after (kPa): 290	Crumbling during shrinkage: Nil Cracking during shrinkage: Nil
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Shrink (%) Esh -0.0 -0.0 -0.0 -0.0 -0.0 -0.0 -0.0 -0.	
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-10.0	
0.0 5.0 10.0 15.0 20.0	0 25.0 30.0 35.0 40.0 45.0 50.0 Moisture Content (%)
Shrink Swell Index - Iss (%): 3.1	



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Report No: SSI:NEW18W-3526--S06 **Issue No: 1** Shrink Swell Index Report Accredited for compliance with ISO/IEC 17025-Testing. The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. Results provided relate only to the items tested or sampled. Client: McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300 This report shall not be reproduced except in full. ΝΑΤΑ **Principal:** Project No.: NEW15P-0070B Approved Signatory: Dane Cullen Project Name: Billys Lookout - Stage 11 (Senior Geotechnician) WORLD RECOGNISED NATA Accredited Laboratory Number: 18686 Date of Issue: 29/11/2018 Sample Details Sample ID: **Client Sample ID:** NEW18W-3526--S06 Test Request No.: Sampling Method: AS1289.1.2.1 cl 6.5 Material: Sandy Clay **Date Sampled:** 30/10/2018 Source: On-Site **Date Submitted:** 31/10/2018 Specification: No Specification **Project Location:** Teralba, NSW Sample Location: TP1106 - (0.6 - 0.85m) **Borehole Number:** TP1106 Borehole Depth (m): 0.6 - 0.85 AS 1289.7.1.1 AS 1289.7.1.1 Swell Test Shrink Test Swell on Saturation (%): Shrink on drying (%): -0.3 2.8 Shrinkage Moisture Content (%): 23.2 Moisture Content before (%): 23.1 Moisture Content after (%): Est. inert material (%): 25.9 1.0 Est. Unc. Comp. Strength before (kPa): 580 Crumbling during shrinkage: Nil Est. Unc. Comp. Strength after (kPa): 250 Cracking during shrinkage: Nil Shrink Swell -Shrinkage ٠ Sw ell 10.0 Shrink (%) Esh - Swell (%) Esw 50 0.0 -5.0 -10.0 0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0 45.0 50.0 Moisture Content (%) Shrink Swell Index - Iss (%): 1.5



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	ewcastle West NSW	ng Street	ty Ltd			this document are traceable	rations and/or measurements included to Australian/national standards. to the items tested or sampled.
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Sample Detail	S						
Sample ID:	NEW18W-3526S0	7		Client Samp	le ID: -		
est Request No.:	-			Sampling Me	ethod: AS1289.	1.2.1 cl 6.5	
laterial:	Sandy Clay			Date Sample	ed: 30/10/20	18	
Source:	On-Site			Date Submit	ted: 31/10/20	18	
Specification:	No Specification						
Project Location:	Teralba, NSW						
Sample Location:	TP1107 - (0.4 - 0.5n	1)					
Borehole Number	•	-)					
Borehole Depth (n	n): 0.4 - 0.5						
Swell Test		AS 12	89.7.1.1	Shrink Te	bet		AS 1289.7.1.
Swell on Saturation	n (%):	-0.4	00.7.1.1	Shrink on d		7.1	AU 1203.7.1.
Noisture Content		27.7			loisture Content		
Noisture Content		26.6		Est. inert ma		<1%	
Est. Unc. Comp. S	trength before (kPa	: 380			luring shrinkage	: Nil	
Est. Unc. Comp. S	trength after (kPa):	210		Cracking du	ring shrinkage:	Nil	
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Report No: SSI:NEW18W-3526--S08

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	Suite 2	Level 3, 4	26 King S	treet	.,			A t	his document are trac Results provided relate	eable to Australian/na e only to the items tes	ational standards. sted or sampled.
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incipal:									2 (19001	1	
oject No.:		5P-0070B	1						Approved Signat		n
oject Name:	: Billys i	_00KOUT - S	tage 11					DITATION	Senior Geotechi NATA Accredited Date of Issue: 28	d Laboratory Nu	mber: 18686
imple De	tails										
mple ID:		EW18W-352	26S08			Client Sa	=	-			
st Request I	No.: -						g Method:	AS1289.	1.2.1 cl 6.5		
terial:	S	andy Clay				Date San	npled:	30/10/20	18		
urce:	C	n-Site				Date Sub	mitted:	31/10/20	18		
ecification:		o Specificati									
oject Locatio		eralba, NSW									
mple Locati rehole Num		P1108 - (1.4 P118	- 1.6M)								
rehole Dept											
ell on Satur isture Conto isture Conto t. Unc. Com	ent befo ent after p. Stren	re (%): [.] (%): gth before	23 (kPa): 44	.8 3.2 40		Shrink o Shrinkag Est. iner Crumblin	n drying (% je Moisture t material (ng during s j during sh	Content %): hrinkage	<1%		
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Comments

Report re-issued due to amendment of Sample depth



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Report No: MAT:NEW18W-3526--S09 Issue No: 1 **Material Test Report** Accredited for compliance with ISO/IEC 17025-Testing. The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. Results provider letale only to the items tested or sampled. This report shall not be reproduced except in full. McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Client: Newcastle West NSW 2300 ΝΑΤΑ Principal: Cull K Project No.: NEW15P-0070B Approved Signatory: Brent Cullen Project Name: Billys Lookout - Stage 11 WORLD RECOGNISED (Senior Geotechnician) NATA Accredited Laboratory Number: 18686 Date of Issue: 8/11/2018

Sample Details

Sample ID:	NEW18W-3526S09
Sampling Method:	AS1289.1.2.1 cl 6.5
Date Sampled:	30/10/2018
Source:	On-Site
Material:	Sandy Clay
Specification:	No Specification
Project Location:	Teralba, NSW
Sample Location:	TP1109 - (0.3 - 0.4m)
Material:	Sandy Clay
Specification:	No Specification
Project Location:	Teralba, NSW

Test Results

Description	Method	Result	Limits
Sample History	AS 1289.1.1	Air-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	6.5	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	36	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	17	
Plasticity Index (%)	AS 1289.3.3.1	19	

APPENDIX C:

CSIRO Sheet BTF 18

Foundation Maintenance and Footing Performance: A Homeowner's Guide

Foundation Maintenance and Footing Performance: A Homeowner's Guide



BTF 18 replaces Information Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a boglike suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

	GENERAL DEFINITIONS OF SITE CLASSES				
Class	Foundation				
А	Most sand and rock sites with little or no ground movement from moisture changes				
S	Slightly reactive clay sites with only slight ground movement from moisture changes				
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes				
Н	Highly reactive clay sites, which can experience high ground movement from moisture changes				
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes				
A to P	Filled sites				
Р	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise				

Tree root growth

Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- · Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation

Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay

Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage

As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots

In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself

Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures

Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred. The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures

Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.

Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

 Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.

- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing

Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage

In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

Protection of the building perimeter

It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS					
Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category			
Hairline cracks	<0.1 mm	0			
Fine cracks which do not need repair	<1 mm	1			
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2			
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3			
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4			



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

The information in this and other issues in the series was derived from various sources and was believed to be correct when published.

The information is advisory. It is provided in good faith and not claimed to be an exhaustive treatment of the relevant subject.

Further professional advice needs to be obtained before taking any action based on the information provided.

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