Proposed Subdivision
Billy's Lookout - Stage 14
Site Classification

Fishermans Drive, Teralba

NEW15P-0070B-AJ
28 August 2019

Qualtest
LABORATORY (NSW) PTY LTD

GEOTECHNICAL I LABORATORY I EARTHWORKS I QUARRY I CONSTRUCTION MATERIAL TESTING

28 August 2019

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

Attention: Harry Thomson

Dear Sir

RE: PROPOSED SUBDIVISION – BILLY'S LOOKOUT - STAGE 14
FISHERMANS DRIVE, TERALBA
SITE CLASSIFICATION (LOTS 1401 TO 1418)

Please find enclosed our geotechnical report for Stage 14 of the proposed residential subdivision of Billy's Lookout, located at Fishermans Drive, Teralba.

The report provides site classification with respect to reactive soils, in accordance with the requirements of AS2870-2011 '*Residential Slabs and Footings*', for Stage 14 (Lots 1401 to 1418), following the completion of site regrading works.

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

Jason Lee
Principal Geotechnical Engineer

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Attachments:

1.0 Introduction

Qualtest Laboratory NSW Pty Ltd (Qualtest) is pleased to present this geotechnical site classification report on behalf of McCloy Development Management Pty Ltd (McCloy), for Stage 14 of the residential subdivision of Billy's Lookout, located at Fishermans Drive, Teralba.

Based on drawings including staging layout drawing provided, (Ref. Drawing Nos. CO13231.01-DA14-15 and CO13231.01-DA14-60, Issue C, dated 12 July 2018, by Costin Roe Consulting Pty Ltd), Stage 14 is understood to comprise 18 residential lots (Lots 1401 to 1418), as shown on Figure AJ1.

The scope of work for the geotechnical investigation included providing site classification with respect to reactive soils, in accordance with the requirements of AS2870-2011 '*Residential Slabs and Footings*', for Stage 14 following the completion of site regrading 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 Regrade Assessment report, 'Proposed Subdivision, Billy's Lookout – Stage 14, Fishermans Drive, Teralba, (Report Reference: NEW19P-0042-AA, dated 14 August 2019).
- Geotechnical Assessment report, 'Proposed Subdivision, Billy's Lookout – Stages 13, 14 & 15 Fishermans Drive, Teralba, (Report Reference: NEW15P-0070B-AB.Rev1, dated 26 June 2017).

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 14 August 2019 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 10 test pits (TP1401 to TP1410) using a 2.5 tonne rubber tracked excavator equipped with a 0.45m wide toothed bucket, to depths of between 0.80m to 2.10m;
- Bulk disturbed samples, 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 AJ1. Test pits were located in the field with reference to site features including lot boundaries, retaining walls, and constructed pavements.

4.0 Site Description

4.1 Site Regrade Works

Following an initial site visit, stripping assessment and recommendations performed 14 March 2019 (Qualtest ref. NEW19P-0042-SR01, dated 19/03/19), and subsequent site visit and recommendations performed on 26 March 2019 (Qualtest ref. NEW19P-0042-SR02, dated 12/04/2019), initial site re-grading works were conducted between 26 February 2019 and 19 July 2019.

The re-grading works consisted of the cutting and filling of proposed residential lots within Stage 14 of the subdivision (Lot 1401 to 1418).

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

Following a subsequent site visit on 2 August 2019, additional re-grade works were performed within Lot 1408 on the same day. Prior to filling, the proposed re-grade area was stripped of all topsoil and mulch to approved natural profile foundation, generally consisting of weathered Sandstone.

Re-grade works consisted of the placement of a further 0.1m to 0.7m of approved material across the southern half of Lot 1408. 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.

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, of low to medium plasticity, fine to coarse grained sand, with some fine to coarse grained gravel inclusions.

The approximate depth of fill placed ranged in the order of 0.1m to about 3.0m. 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, we state that the filling performed for the regrade areas (Lots 1401 to 1418), 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*'.

Reference should be made to the 'Level 1 Site Re-grade Assessment Report' (Qualtest Ref: NEW19P-0042-AA, dated 14 August 2019) for details of the site regrade works conducted by Qualtest.

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.

4.2 Surface Conditions

The site comprises Stage 14 of the subdivision known as Billy's Lookout, located off Fishermans Drive, Teralba, as shown on Figure AJ1 attached.

The site is bounded to the east by completed stages of the residential subdivision, by undeveloped bushland to the north, by the Main Northern Railway to the south, and by future Stage 15 to the west.

The site is located within a region of gently to moderately undulating topography, on the south to southwest facing mid slopes of a prominent hill formation which rises to the north of the site. Site slopes generally vary from about 2° to 5° over the majority of the site, with some locally steeper batters of up to around 30°. Earthworks on the site have approximately levelled the residential lots, with construction of several retaining walls of up to about 1.40m height.

Ground levels range from about RL 45m (AHD) at the northern part of the site, to about RL 34m (AHD) towards the southern boundary of the site.

The site generally comprises approximately levelled vacant lots, with some blockwork retaining walls to achieve levels. Lots are unvegetated, and most are covered with a roughly 50mm layer of top mulch with access by subdivision roads, which at the time of site investigation were unsealed pavement.

On the day of the investigation which was carried out in a period of fine weather, the majority of the site was judged to be moderately drained primarily by way of surface runoff following the natural and altered topography towards gullies and the southern boundary of the site.

Trafficability was judged to be good by way of 4WD vehicle.

Photographs of the site taken on the day of the site investigations are shown below.

Photograph 1: From northern end of shared boundary of Lots 1401 and 1402, facing southwest.

Photograph 2: From southern shared boundary of Lots 1417 and 1418, facing northeast.

Photograph 3: From near south-western corner of Lot 1404, facing northeast.

Photograph 4: From near south-western corner of Lot 1404, facing southeast.

Photograph 5: From southern boundary of Lot 1406, facing northeast.

Photograph 6: From southern boundary of Lot 1406, facing southeast.

Photograph 7: From southern boundary of Lot 1415, facing northeast.

Photograph 8: From southern boundary of Lot 1415, facing east.

Photograph 9: From near northern boundary Lot 1414, facing southwest.

Photograph 10: From near northern boundary Lot 1414, facing northwest.

Photograph 11: From northern boundary of Lot 1407, facing southeast.

Photograph 12: From northern boundary of Lot 1407, facing southwest.

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, which are characterised by Conglomerate, Sandstone, Siltstone and Claystone 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.

TABLE 1 – SUMMARY OF GEOTECHNICAL UNITS AND SOIL TYPES

Unit	Soil Type	Description
1A	FILL - TOPSOIL	Sandy CLAY / Clayey SAND – low plasticity, dark grey-brown, fine to coarse grained (mostly fine to medium grained) sand, with trace to some fine to medium grained angular gravel, root affected. Including about 50mm thickness of mulch on top.
1B	FILL - CONTROLLED	Gravelly Sandy CLAY / Gravelly Clayey SAND / Sandy GRAVEL – medium plasticity, fine to coarse grained sand (mostly fine to medium grained), fine to coarse grained angular to sub-rounded (mostly fine to medium grained sub-angular) gravel, with some cobbles up to ~200mm in places.
2	TOPSOIL	SAND / Silty SAND / Gravelly Silty SAND – fine to medium or fine to coarse grained, grey to brown, fine to medium grained gravel, sub-angular to sub-rounded, root affected.
3	SLOPEWASH / COLLUVIUM	Silty Clayey SAND / SAND – fine to coarse grained, mostly grey-brown, fines of low plasticity, with fine to medium grained sub-rounded to sub-angular gravel in places; Sandy CLAY – medium to high plasticity, grey-brown, fine to coarse grained sand.
4	RESIDUAL SOIL	Sandy CLAY – medium plasticity and medium to high plasticity, pale grey, orange-brown to red-grey, sand fine to coarse grained, with fine to medium grained sub-rounded gravel in places; Clayey SAND – fine to coarse grained, pale grey and orange-brown, fines of medium plasticity; Silty CLAY – medium to high plasticity, pale grey-brown.
5	EXTREMELY WEATHERED (XW) ROCK with soil properties	Silty SILTSTONE / SANDSTONE / Pebbly SANDSTONE; breaks down into Clayey SAND / SAND – fine to medium grained, pale brown, pale grey-brown and red-brown, with some fine to medium grained gravel in places, with highly weathered pockets in places; SILTSTONE; breaks down into Sandy CLAY / Silty CLAY – medium to high plasticity, pale grey, fine grained sand.
6	HIGHLY WEATHERED (HW) ROCK	Silty SANDSTONE / SANDSTONE / Pebbly SANDSTONE – fine to medium grained, pale brown, pale grey-brown and red-brown, rock strength assessed to vary between low to high strength, with extremely weathered pockets in places. Sandy SILTSTONE – fine to medium grained, pale grey to grey-brown and pale orange-brown, estimated very low to medium strength.

TABLE 2 – SUMMARY OF GEOTECHNICAL UNITS ENCOUNTERED AT EACH TEST PIT LOCATION

Location	Unit 1A Fill - Topsoil	Unit 1B Fill - Controlled	Unit 2 Topsoil	Unit 3 Slopewash / Colluvium	Unit 4 Residual Soil	Unit 5 XW Rock	Unit 6 HW Rock
	Depth in metres (m)						
Current Investigation (NEW15P-0070B-AJ) – After Site Regrade Works							
TP1401	0.00 – 0.30	0.30 – 1.20	-	-	1.20 – 2.00	2.00 – 2.10	-
TP1402	0.00 – 0.10	0.10 – 1.30	-	-	1.30 – 1.90	-	-
TP1403	0.00 – 0.30	0.30 – 2.00	-	-	-	-	-
TP1404	0.00 – 0.40	0.40 – 1.60	-	-	1.60 – 2.00	-	-
TP1405	0.00 – 0.40	0.40 – 1.50	-	-	1.50 – 2.00	-	-
TP1406	0.00 – 0.35	0.35 – 2.00	-	-	-	-	-
TP1407	0.00 – 0.35	0.35 – 1.80	-	-	1.80 – 2.00	-	-
TP1408	0.00 – 0.30	0.30 – 2.00	-	-	-	-	-
TP1409	0.00 – 0.25	-	-	-	0.25 – 0.60	0.60 – 0.75	0.75 – 0.80*
TP1410	0.00 – 0.35	0.35 – 2.00	-	-	-	-	-
Notes:	* = Practical refusal or refusal of excavator met on Highly Weathered Rock ^ = Slow to very slow progress, close to practical excavator refusal.						

TABLE 2 (CONTINUED) – SUMMARY OF GEOTECHNICAL UNITS ENCOUNTERED AT EACH TEST PIT LOCATION

Location	Unit 1A Fill - Topsoil	Unit 1B Fill - Controlled	Unit 2 Topsoil	Unit 3 Slopewash / Colluvium	Unit 4 Residual Soil	Unit 5 XW Rock	Unit 6 HW Rock
	Depth in metres (m)						
Previous Investigation (NEW15P-0070B-AB.Rev1, dated 26 June 2017) – Prior to Site Regrade Works							
TP311	-	-	0.00 – 0.14	0.14 – 0.30	0.30 – 0.40	-	0.40 – 1.30*****
TP312	-	-	0.00 – 0.17	-	0.17 – 1.70	-	1.70 – 1.80*****
TP314	-	-	0.00 – 0.12	0.12 – 0.36	0.40 – 0.49	-	0.36 – 0.40 0.49 – 0.70*
TP315	-	-	0.00 – 0.20	0.20 – 0.75	0.75 – 2.60**^**	-	-
TP316	-	-	0.00 – 0.10	0.10 – 0.24	1.00 – 1.90	0.24 – 1.00	-

Notes: * = Practical refusal or refusal of excavator met on Highly Weathered Rock

^ = Slow to very slow progress, close to practical excavator refusal.

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.

5.0 Laboratory Testing

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

- (9 no.) Shrink / Swell tests.

Results of the laboratory testing are presented in Appendix B, with a summary of the Shrink/Swell test results presented in Table 3.

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

TABLE 3 – SUMMARY OF SHRINK / SWELL TESTING RESULTS

Location	Depth (m)	Material Description	I_{ss} (%)
Current Investigation			
TP1401	0.35 - 0.65	FILL: (CI) Sandy CLAY	0.8
TP1402	1.00 - 1.30	FILL: (CI) Sandy CLAY	1.3
TP1404	0.80 - 1.05	FILL: (CI) Sandy CLAY	1.3
TP1405	0.45 - 0.65	FILL: (CI) Sandy CLAY	1.5
TP1406	1.10 - 1.30	FILL: (CI) Sandy CLAY	1.3
TP1407	0.60 - 0.90	FILL: (CI) Sandy CLAY	1.8
TP1408	0.50 - 0.90	FILL: (CI) Sandy CLAY	1.3
TP1409	0.30 - 0.55	(CI) Sandy CLAY	1.0
TP1410	0.70 - 1.00	FILL: (CI) Sandy CLAY	0.9
Previous Investigation (NEW15P-0070B-AB.Rev1, dated 26 June 2017)			
TP316	1.00 – 1.20	(CH) Silty CLAY	2.5

6.0 Site Classification to AS2870-2011

Based on the results of the field work and laboratory testing, and Level 1 site supervision and testing carried out, residential lots located within Stage 14 of the Billy's Lookout subdivision at Fishermans Drive, Teralba, as shown on Figure AJ1, are classified in their current condition in accordance with AS2870-2011 *'Residential Slabs and Footings'*, as shown in Table 4.

TABLE 4 – SITE CLASSIFICATION TO AS2870-2011

Lot Numbers	Site Classification
1401 to 1418	**H1**

A characteristic free surface movement of 40mm to 60mm is estimated for the 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 cut / fill, reactivity of the natural soil and any fill material placed, depth to rock, 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.

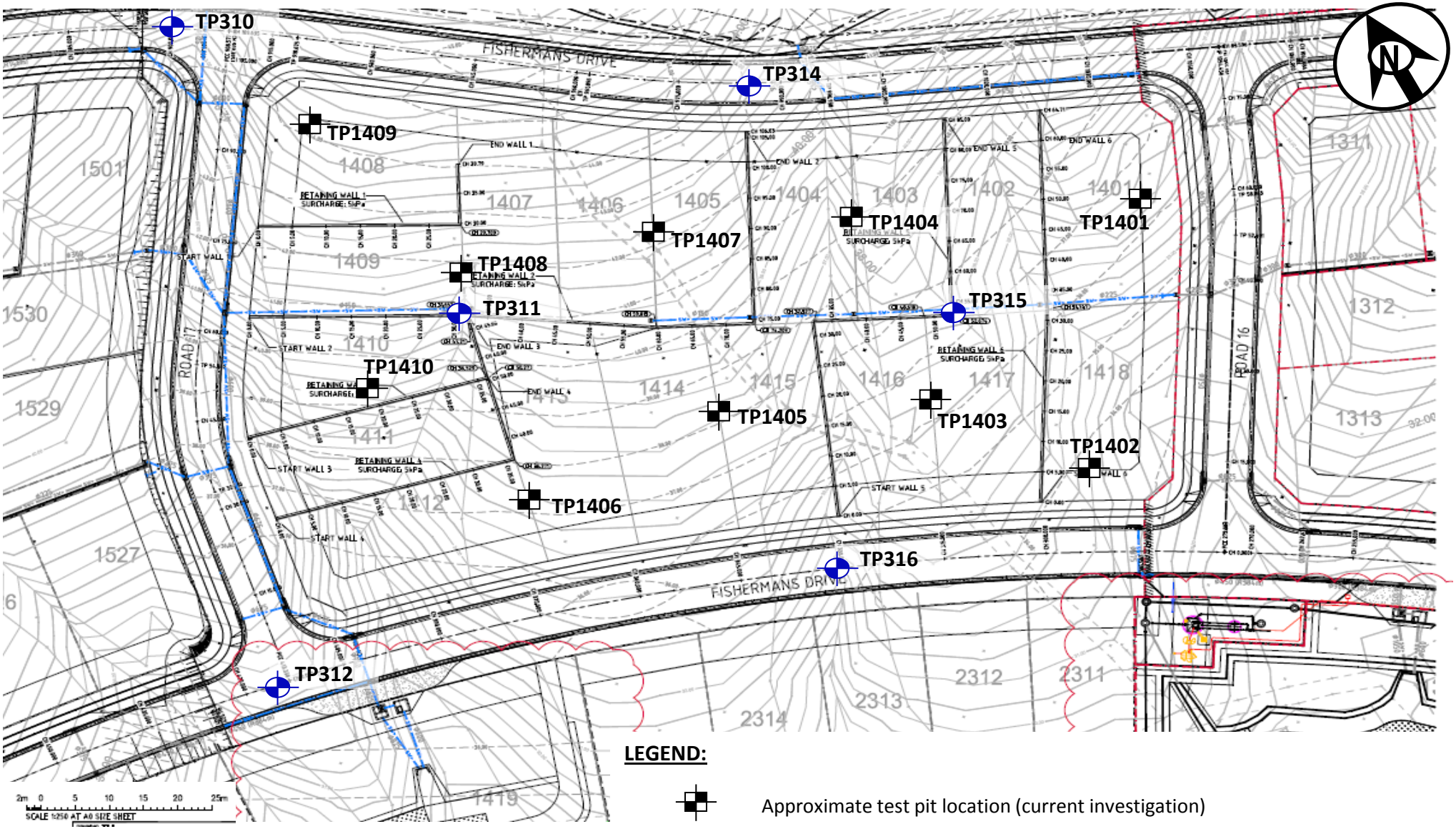
If you have any further questions regarding this report, please do not hesitate to contact Shannon Kelly or the undersigned.

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

Jason Lee
Principal Geotechnical Engineer

FIGURE AJ1:

Site Plan and Approximate Test Locations



LEGEND:

Approximate test pit location (current investigation)

Approximate test pit location (previous investigation)

Based on site plan prepared by Costin Roe Consulting Pty Ltd (Dwg No. C01323.01-DA14-60, Iss. C, dated 12/07/2018)

Qualtest LABORATORY (NSW) PTY LTD

Client:	McCLOY DEVELOPMENT MANAGEMENT PTY LTD	Drawing No:	FIGURE AJ1
Project:	BILLYS LOOKOUT - STAGE 14	Project No:	NEW15P-0070B
Location:	FISHERMANS DRIVE, TERALBA	Scale:	AS SHOWN
Title:	SITE PLAN AND APPROXIMATE TEST LOCATIONS	Date:	26/08/2019

APPENDIX A:

Results of Field Investigations

ENGINEERING LOG - TEST PIT

CLIENT: MCCLOY GROUP PTY LTD
PROJECT: BILLYS LOOKOUT - STAGE 14
LOCATION: FISHERMANS DRIVE, TERALBA

TEST PIT NO: TP1401
PAGE: 1 OF 1
JOB NO: NEW15P-0070B
LOGGED BY: BB
DATE: 14/8/19

EQUIPMENT TYPE: 2.5 TONNE EXCAVATOR
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
SURFACE RL:
DATUM:

Drilling and Sampling					Material description and profile information					Field Test		Structure and additional observations
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	
							MULCH	M				MULCH
							0.10m					
						CL	FILL-TOPSOIL: Sandy CLAY - low to medium plasticity, grey-brown, fine to coarse grained (mostly fine to medium grained) sand, with some fine to medium grained angular to sub-angular gravel.			HP	280	FILL - TOPSOIL
							0.30m					
		0.35m					FILL: Gravelly Sandy CLAY - medium plasticity, pale orange-brown, fine to coarse grained sand, fine to coarse grained (mostly fine to medium grained) angular to sub-angular gravel.					FILL - CONTROLLED
		U50		0.5						HP	350	
		0.65m						M ~ w_P	VSt - H	HP	420	
E	Not Encountered					CI						
										HP	500	
				1.0						HP	380	
							1.20m					
							Clayey SAND / Sandy CLAY - fine to medium grained, pale brown to pale orange-brown, fines of low to medium plasticity, trace fine to medium grained rounded gravel.					RESIDUAL SOIL
				1.5		SC		M	D			
				2.0			2.00m					
						SC	Extremely Weathered Sandstone with soil properties; breaks down into Clayey SAND - fine to medium grained, pale orange-brown, fines of low to medium plasticity.		VD			EXTREMELY WEATHERED ROCK
							2.10m					
							Hole Terminated at 2.10 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

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

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

ENGINEERING LOG - TEST PIT

CLIENT: MCCLOY GROUP PTY LTD
PROJECT: BILLYS LOOKOUT - STAGE 14
LOCATION: FISHERMANS DRIVE, TERALBA

TEST PIT NO: TP1402
PAGE: 1 OF 1
JOB NO: NEW15P-0070B
LOGGED BY: BB
DATE: 14/8/19

EQUIPMENT TYPE: 2.5 TONNE EXCAVATOR
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
SURFACE RL:
DATUM:

Drilling and Sampling					Material description and profile information					Field Test		Structure and additional observations
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	
							0.05m MULCH	M				MULCH
						SM	0.10m FILL: Silty SAND - fine to medium grained, dark grey-brown, fines of low plasticity, root affected.					FILL - TOPSOIL
							FILL: Gravelly Sandy CLAY - low to medium plasticity, grey-brown with some pale grey to white and pale orange-brown, fine to coarse grained (mostly fine to medium grained) sand, fine to coarse grained angular gravel, with some angular cobbles (~15%).			HP	>600	FILL - CONTROLLED
						CL				HP	550	
				0.5						HP	>600	
							0.70m FILL: Sandy CLAY - medium plasticity, pale orange-brown, fine to coarse grained (mostly fine to medium grained) sand, fine to coarse grained angular to sub-angular gravel.			HP	350	
E	Not Encountered	1.00m		1.0		CI		M ~ w_P	H	HP	380	
		U50								HP	320	
		1.30m					1.30m Sandy CLAY - medium plasticity, pale orange-brown, fine to coarse grained (mostly fine to medium grained) sand, trace fine to coarse grained angular gravel.					RESIDUAL SOIL / POSSIBLE FILL
				1.5		CI				HP	350	
										HP	300	
							1.80m					
						CH	Sandy CLAY - medium to high plasticity, grey-brown, fine to coarse grained (mostly fine to medium grained) sand. 1.90m	M > w_P	VSt			RESIDUAL SOIL
				2.0			Hole Terminated at 1.90 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

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

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

ENGINEERING LOG - TEST PIT

CLIENT: MCCLOY GROUP PTY LTD
PROJECT: BILLYS LOOKOUT - STAGE 14
LOCATION: FISHERMANS DRIVE, TERALBA

TEST PIT NO: TP1403
PAGE: 1 OF 1
JOB NO: NEW15P-0070B
LOGGED BY: BB
DATE: 14/8/19

EQUIPMENT TYPE: 2.5 TONNE EXCAVATOR
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
SURFACE RL:
DATUM:

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
							MULCH	M				MULCH
							0.10m					
						CL	FILL-TOPSOIL: Sandy CLAY - low to medium plasticity, dark grey-brown, fine to coarse grained sand, trace sticks.	M ~ w_P				FILL - TOPSOIL
							0.30m					
E	Not Encountered	0.80m D 0.90m		0.5 1.0 1.5 2.0		CI	FILL: Gravelly Sandy CLAY - medium plasticity, dark grey-brown, fine to coarse grained sand, fine to coarse grained (mostly fine to medium grained) angular gravel, with some angular cobbles (~10%).	M < w_P	H	HP	>600	FILL - CONTROLLED
							2.00m					
							Hole Terminated at 2.00 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

ENGINEERING LOG - TEST PIT

CLIENT: MCCLOY GROUP PTY LTD
PROJECT: BILLYS LOOKOUT - STAGE 14
LOCATION: FISHERMANS DRIVE, TERALBA

TEST PIT NO: TP1404
PAGE: 1 OF 1
JOB NO: NEW15P-0070B
LOGGED BY: BB
DATE: 14/8/19

EQUIPMENT TYPE: 2.5 TONNE EXCAVATOR
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
SURFACE RL:
DATUM:

Drilling and Sampling					Material description and profile information					Field Test		Structure and additional observations
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	
							MULCH	M				MULCH
							0.10m					
						CL	FILL-TOPSOIL: Sandy CLAY - low to medium plasticity, dark grey-brown, fine to medium grained sand, with some sticks.					FILL - TOPSOIL
							0.40m					
				0.5			FILL: Sandy CLAY - medium plasticity, dark grey-brown, fine to coarse grained sand, with some fine to coarse grained (mostly fine to medium grained) angular gravel, with some (~10%) angular cobbles.			HP	>600	FILL - CONTROLLED
										HP	480	
		0.80m								HP	550	
E	Not Encountered	U50		1.0		CI		M ~ w_P	H	HP	420	
		1.05m								HP	>600	
										HP	>600	
				1.5								
							1.60m			HP	380	RESIDUAL SOIL
							Sandy CLAY - medium plasticity, pale orange-brown, fine to medium grained sand, trace fine to medium grained angular gravel.					
						CI			VSt	HP	350	
				2.0			2.00m					
							Hole Terminated at 2.00 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

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

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

ENGINEERING LOG - TEST PIT

CLIENT: MCCLOY GROUP PTY LTD
PROJECT: BILLYS LOOKOUT - STAGE 14
LOCATION: FISHERMANS DRIVE, TERALBA

TEST PIT NO: TP1405
PAGE: 1 OF 1
JOB NO: NEW15P-0070B
LOGGED BY: BB
DATE: 14/8/19

EQUIPMENT TYPE: 2.5 TONNE EXCAVATOR
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
SURFACE RL:
DATUM:

Drilling and Sampling					Material description and profile information					Field Test		Structure and additional observations
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	
							0.05m MULCH	M				MULCH
						CL	FILL-TOPSOIL: Sandy CLAY - low to medium plasticity, dark grey-brown, fine to coarse grained (mostly fine to medium grained) sand, with some sticks.	M > w_P				FILL - TOPSOIL
							0.40m			HP	>600	
		0.45m					FILL: Sandy CLAY - medium plasticity, grey-brown, fine to coarse grained sand, with some fine to medium grained angular gravel, trace (<5%) angular cobbles.					FILL - CONTROLLED
		U50		0.5						HP	>600	
		0.65m										
										HP	>600	
										HP	>600	
E	Not Encountered			1.0		CI		M ~ w_P	H	HP	>600	
										HP	>600	
										HP	>600	
				1.5			1.50m					RESIDUAL SOIL
							Sandy CLAY - medium plasticity, orange-brown with some pale grey and red-brown, fine to coarse grained (mostly fine to medium grained) sand, with some fine to coarse grained angular gravel.			HP	>600	
						CI						
										HP	>600	
				2.0			2.00m					
							Hole Terminated at 2.00 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

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

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

ENGINEERING LOG - TEST PIT

CLIENT: MCCLOY GROUP PTY LTD
PROJECT: BILLYS LOOKOUT - STAGE 14
LOCATION: FISHERMANS DRIVE, TERALBA

TEST PIT NO: TP1406
PAGE: 1 OF 1
JOB NO: NEW15P-0070B
LOGGED BY: BB
DATE: 14/8/19

EQUIPMENT TYPE: 2.5 TONNE EXCAVATOR
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
SURFACE RL:
DATUM:

Drilling and Sampling					Material description and profile information					Field Test		Structure and additional observations
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	
							0.05m MULCH	M				MULCH
						CL	FILL-TOPSOIL: Sandy CLAY - low to medium plasticity, dark grey-brown, fine to medium grained sand.					FILL - TOPSOIL
							0.35m					
				0.5			FILL: Gravelly Sandy CLAY - medium plasticity, pale brown, fine to coarse grained sand, fine to coarse grained (mostly fine to medium grained) sub-angular to sub-rounded gravel, trace (<5%) angular cobbles.			HP	>600	FILL - CONTROLLED
										HP	>600	
										HP	>600	
E	Not Encountered			1.0				M ~ w_P		HP	>600	
		1.10m										
		U50				CI			H	HP	>600	
		1.30m										
				1.5						HP	>600	
										HP	>600	
				2.0			2.00m					
							Hole Terminated at 2.00 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

ENGINEERING LOG - TEST PIT

CLIENT: MCCLOY GROUP PTY LTD
PROJECT: BILLYS LOOKOUT - STAGE 14
LOCATION: FISHERMANS DRIVE, TERALBA

TEST PIT NO: TP1407
PAGE: 1 OF 1
JOB NO: NEW15P-0070B
LOGGED BY: BB
DATE: 14/8/19

EQUIPMENT TYPE: 2.5 TONNE EXCAVATOR
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
SURFACE RL:
DATUM:

Drilling and Sampling					Material description and profile information					Field Test		Structure and additional observations
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	
							0.05m MULCH	M				MULCH
						CL	FILL-TOPSOIL: Sandy CLAY - low to medium plasticity, dark grey-brown, fine to medium grained sand, with some sticks.					FILL - TOPSOIL
							0.35m					
				0.5			FILL: Gravelly Sandy CLAY - medium plasticity, pale orange-brown and grey-brown, fine to coarse grained sand, fine to coarse grained angular gravel, with some (~5%) angular cobbles.			HP	>600	FILL - CONTROLLED
		0.60m								HP	>600	
		U50				CI						
		0.90m								HP	>600	
E	Not Encountered			1.0			1.00m			HP	>600	
							FILL: Gravelly Sandy CLAY - medium plasticity, pale orange-brown, fine to coarse grained sand, fine to coarse grained angular gravel, with some (~5%) angular cobbles.	M < w_P	H	HP	>600	
						CI				HP	>600	
				1.5						HP	>600	
							1.80m			HP	>600	
							Sandy CLAY - medium plasticity, pale brown with some pale grey, fine to medium grained sand.					RESIDUAL SOIL
						CI						
				2.0			2.00m					
							Hole Terminated at 2.00 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

ENGINEERING LOG - TEST PIT

CLIENT: MCCLOY GROUP PTY LTD
PROJECT: BILLYS LOOKOUT - STAGE 14
LOCATION: FISHERMANS DRIVE, TERALBA

TEST PIT NO: TP1408
PAGE: 1 OF 1
JOB NO: NEW15P-0070B
LOGGED BY: BB
DATE: 14/8/19

EQUIPMENT TYPE: 2.5 TONNE EXCAVATOR
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
SURFACE RL:
DATUM:

Drilling and Sampling					Material description and profile information					Field Test		Structure and additional observations
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	
						CL	FILL-TOPSOIL: Sandy CLAY - low to medium plasticity, grey-brown, fine to coarse grained (mostly fine to medium grained) sand, trace fine to medium grained sub-angular to sub-rounded gravel, with some sticks.	M < w_P				FILL - TOPSOIL
							0.30m					
							FILL: Sandy CLAY - medium plasticity, dark grey-brown with some orange-brown, fine to coarse grained sand, with some fine to medium grained sub-angular to sub-rounded gravel.					FILL - CONTROLLED
		0.50m		0.5		CI				HP	>600	
		U50								HP	>600	
		0.90m								HP	>600	
							0.90m					
E	Not Encountered			1.0			FILL: Sandy CLAY - medium to high plasticity, pale orange-brown, fine to coarse grained sand, with some fine to coarse grained angular gravel.	M ~ w_P	H	HP	>600	
										HP	>600	
				1.5		CH				HP	>600	
										HP	>600	
										HP	>600	
				2.0			2.00m					
							Hole Terminated at 2.00 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

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

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

ENGINEERING LOG - TEST PIT

CLIENT: MCCLOY GROUP PTY LTD
PROJECT: BILLYS LOOKOUT - STAGE 14
LOCATION: FISHERMANS DRIVE, TERALBA

TEST PIT NO: TP1409
PAGE: 1 OF 1
JOB NO: NEW15P-0070B
LOGGED BY: BB
DATE: 14/8/19

EQUIPMENT TYPE: 2.5 TONNE EXCAVATOR
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
SURFACE RL:
DATUM:

Drilling and Sampling					Material description and profile information					Field Test		
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
						SC	FILL-TOPSOIL: Clayey SAND - fine to medium grained, pale grey-brown, fines of low plasticity, with some sticks.	D				FILL - TOPSOIL
	Not Encountered	0.30m					0.25m					
		U50		0.5		Cl	Sandy CLAY - medium to high plasticity, pale orange-brown to orange-brown, fine to medium grained sand, pockets of Extremely Weathered Sandstone with soil properties.	M ~ w_P	VSt	HP HP HP	380 330 350	RESIDUAL SOIL
		0.55m					0.60m					
						SC	Extremely Weathered Sandstone with soil properties; breaks down into Clayey SAND - fine to medium grained, orange-brown and pale grey to white, fines of low to medium plasticity.	D - M	VD			EXTREMELY WEATHERED ROCK
							0.75m 0.80m SANDSTONE - fine to medium grained, pale orange-brown and pale grey to white, estimated low to medium strength.					HIGHLY WEATHERED ROCK
E				1.0			Hole Terminated at 0.80 m Practical Excavator Refusal					
				1.5								
				2.0								

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

ENGINEERING LOG - TEST PIT

CLIENT: MCCLOY GROUP PTY LTD
PROJECT: BILLYS LOOKOUT - STAGE 14
LOCATION: FISHERMANS DRIVE, TERALBA

TEST PIT NO: TP1410
PAGE: 1 OF 1
JOB NO: NEW15P-0070B
LOGGED BY: BB
DATE: 14/8/19

EQUIPMENT TYPE: 2.5 TONNE EXCAVATOR
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
SURFACE RL:
DATUM:

Drilling and Sampling					Material description and profile information					Field Test		Structure and additional observations
METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	
							0.05m MULCH					MULCH
						SC	FILL-TOPSOIL: Clayey SAND - fine to medium grained, dark grey-brown, fines of low plasticity, with some sticks.	M				FILL - TOPSOIL
							0.35m					
E	Not Encountered	0.70m U50 1.00m		0.5 1.0 1.5 2.0		CI	FILL: Sandy CLAY - medium plasticity, pale orange-brown, fine to coarse grained sand, with some fine to coarse grained (mostly fine to medium grained) angular to sub-angular gravel, trace (<5%) angular cobbles.	M ~ w_P	H	HP	>600	FILL - CONTROLLED
							1.20m FILL: Sandy CLAY - medium plasticity, dark grey-brown, fine to coarse grained sand, with some fine to coarse grained (mostly fine to medium grained) angular to sub-angular gravel, trace (<5%) angular cobbles.			HP	>600	
							2.00m					
							Hole Terminated at 2.00 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample (Glass jar, sealed and chilled on site)
ASS	Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled)
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

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

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

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

Report No: SSI:NEW19W-2801--S01
Issue No: 1

Shrink Swell Index Report

Client:	McCloy Development Management Pty Ltd Suite 2, Ground Floor, 317 Hunter Street Newcastle NSW 2300
Principal:	
Project No.:	NEW15P-0070B
Project Name:	Billy's Lookout - Stage 14

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 27/08/2019

Sample Details

Sample ID:	NEW19W-2801--S01	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Sandy CLAY	**Date Sampled:**	14/08/2019
Source:	On-Site	**Date Submitted:**	15/08/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP1401 - 0.35 to 0.65m		
Borehole Number:	TP1401		
Borehole Depth (m):	0.35 - 0.65		

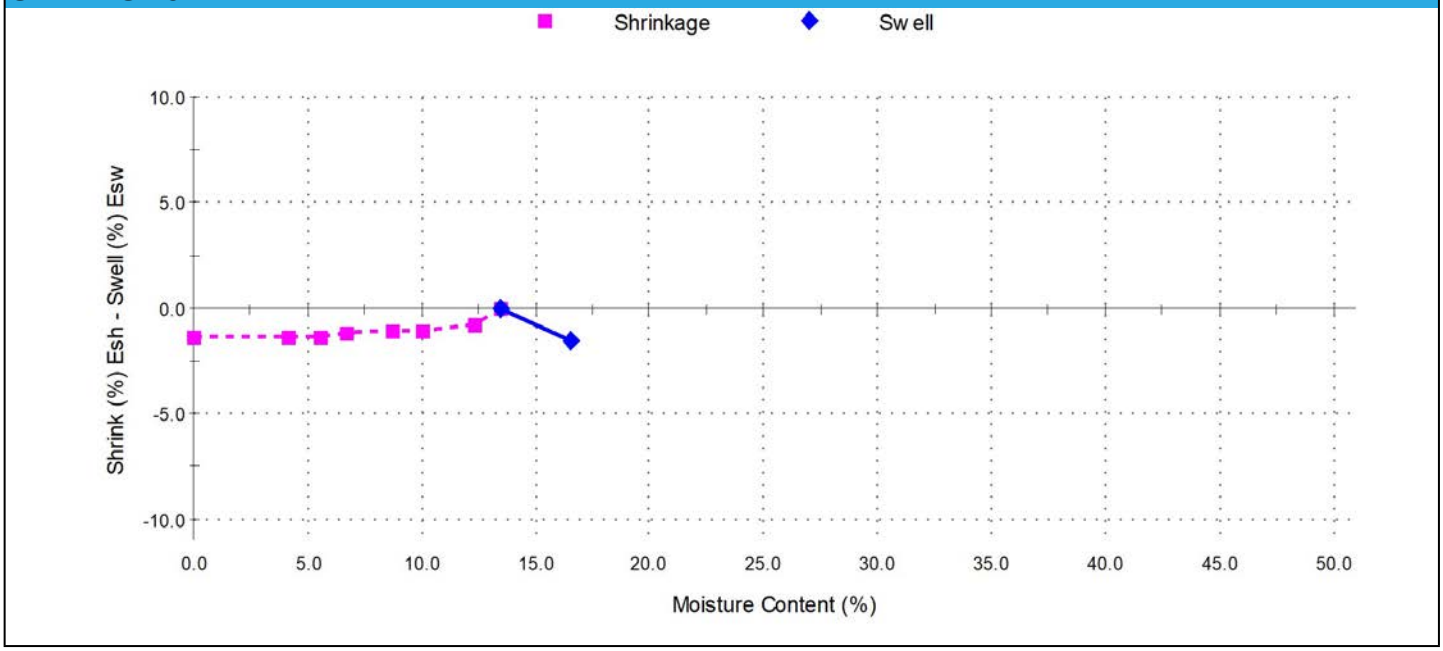
Swell Test — AS 1289.7.1.1

Swell on Saturation (%):	-1.6
Moisture Content before (%):	13.4
Moisture Content after (%):	16.5
Est. Unc. Comp. Strength before (kPa):	390
Est. Unc. Comp. Strength after (kPa):	350

Shrink Test — AS 1289.7.1.1

Shrink on drying (%):	1.4
Shrinkage Moisture Content (%):	13.4
Est. inert material (%):	15.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Moderate

Shrink Swell



Shrink Swell Index - Iss (%): 0.8

Comments

The results outlined above apply to the sample as received

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:NEW19W-2801--S02
Issue No: 2
This report replaces all previous issues of report no 'SSI:NEW19W-2801--S02'.

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Principal:
Project No.: NEW15P-0070B
Project Name: Billy's Lookout - Stage 14

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 27/08/2019

Sample Details

Sample ID:	NEW19W-2801--S02	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Sandy CLAY	**Date Sampled:**	14/08/2019
Source:	On-Site	**Date Submitted:**	15/08/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP1402 - 1.00 to 1.30m		
Borehole Number:	TP1402		
Borehole Depth (m):	1.00 - 1.30		

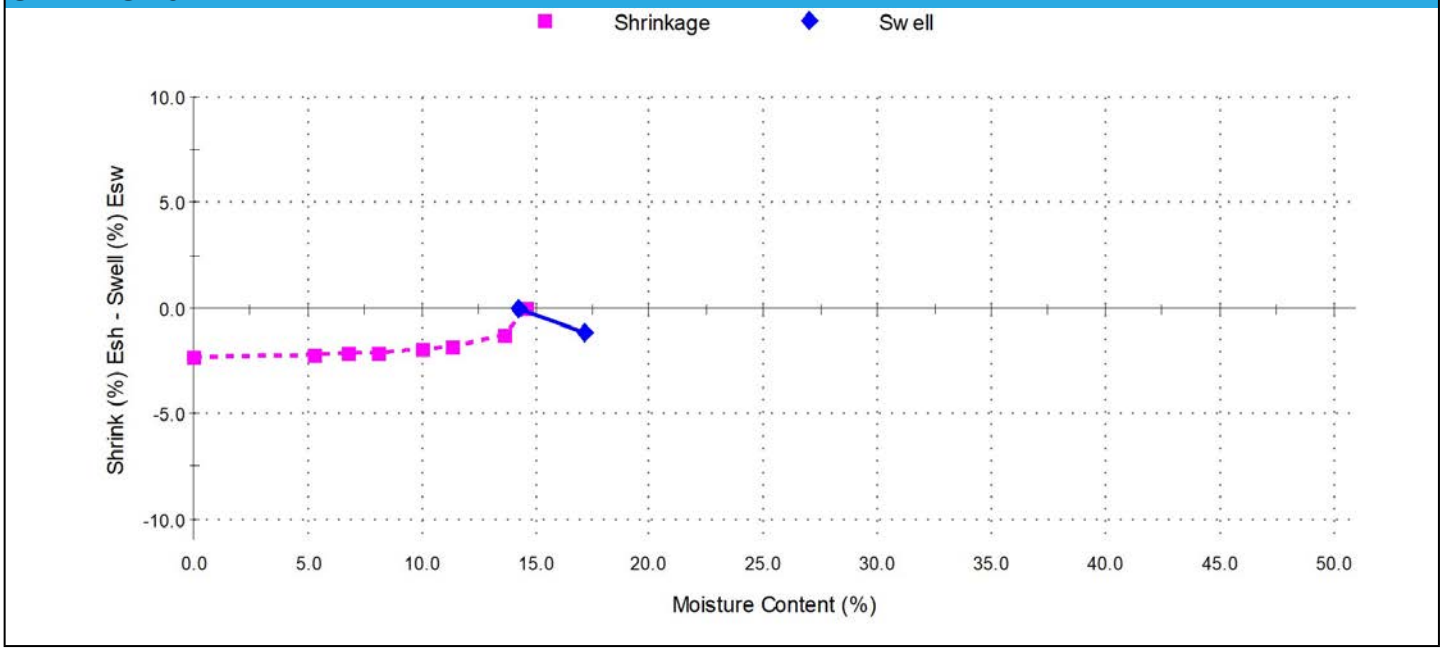
Swell Test — AS 1289.7.1.1

Swell on Saturation (%):	-1.2
Moisture Content before (%):	14.3
Moisture Content after (%):	17.2
Est. Unc. Comp. Strength before (kPa):	370
Est. Unc. Comp. Strength after (kPa):	200

Shrink Test — AS 1289.7.1.1

Shrink on drying (%):	2.3
Shrinkage Moisture Content (%):	14.6
Est. inert material (%):	5.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 1.3

Comments

The results outlined above apply to the sample as received

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Shrink Swell Index Report

Report No: SSI:NEW19W-2801--S03
Issue No: 1

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Principal:
Project No.: NEW15P-0070B
Project Name: Billy's Lookout - Stage 14

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 27/08/2019

Sample Details

Sample ID:	NEW19W-2801--S03	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Sandy CLAY	**Date Sampled:**	14/08/2019
Source:	On-Site	**Date Submitted:**	15/08/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP1404 - 0.80 to 1.05m		
Borehole Number:	TP1404		
Borehole Depth (m):	0.80 - 1.05		

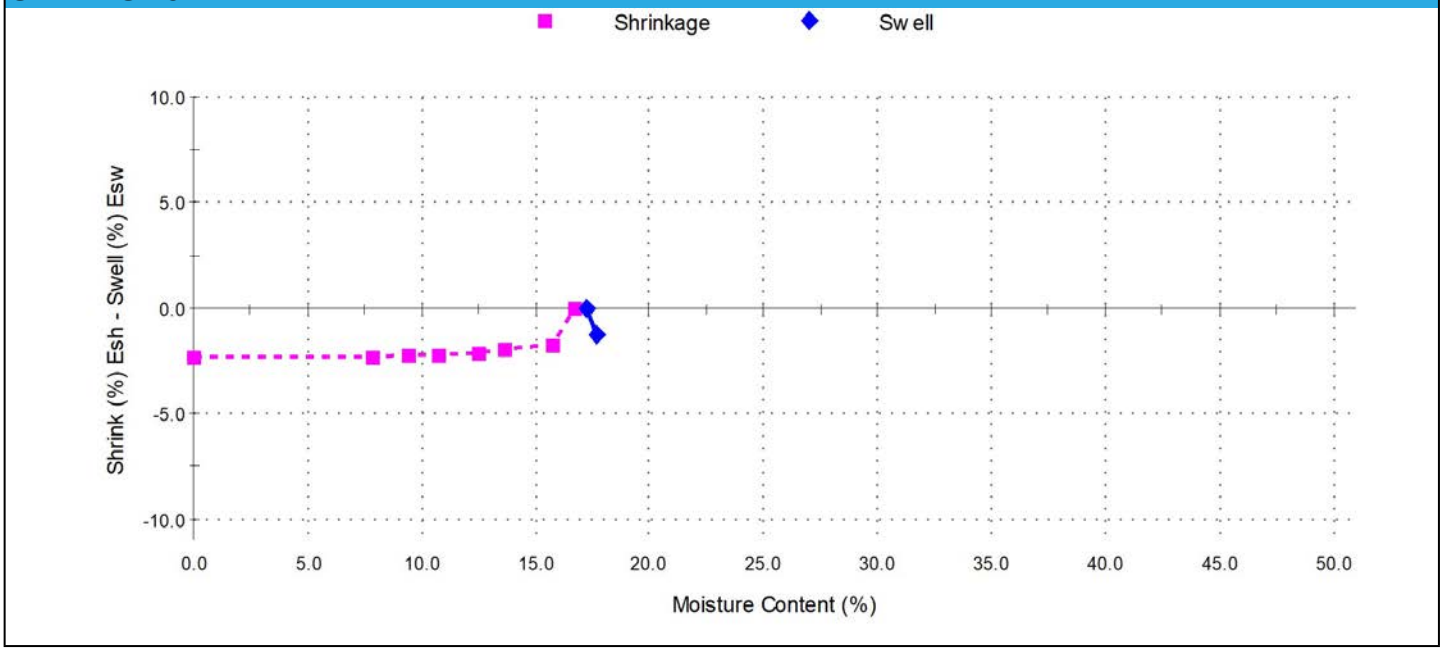
Swell Test — AS 1289.7.1.1

Swell on Saturation (%):	-1.3
Moisture Content before (%):	17.2
Moisture Content after (%):	17.6
Est. Unc. Comp. Strength before (kPa):	420
Est. Unc. Comp. Strength after (kPa):	310

Shrink Test — AS 1289.7.1.1

Shrink on drying (%):	2.3
Shrinkage Moisture Content (%):	16.7
Est. inert material (%):	5.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 1.3

Comments

The results outlined above apply to the sample as received

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Shrink Swell Index Report

Report No: SSI:NEW19W-2801--S04
Issue No: 1

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Principal:
Project No.: NEW15P-0070B
Project Name: Billy's Lookout - Stage 14

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 27/08/2019

Sample Details

Sample ID:	NEW19W-2801--S04	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Sandy CLAY	**Date Sampled:**	14/08/2019
Source:	On-Site	**Date Submitted:**	15/08/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP1405 - 0.45 to 0.65m		
Borehole Number:	TP1405		
Borehole Depth (m):	0.45 - 0.65		

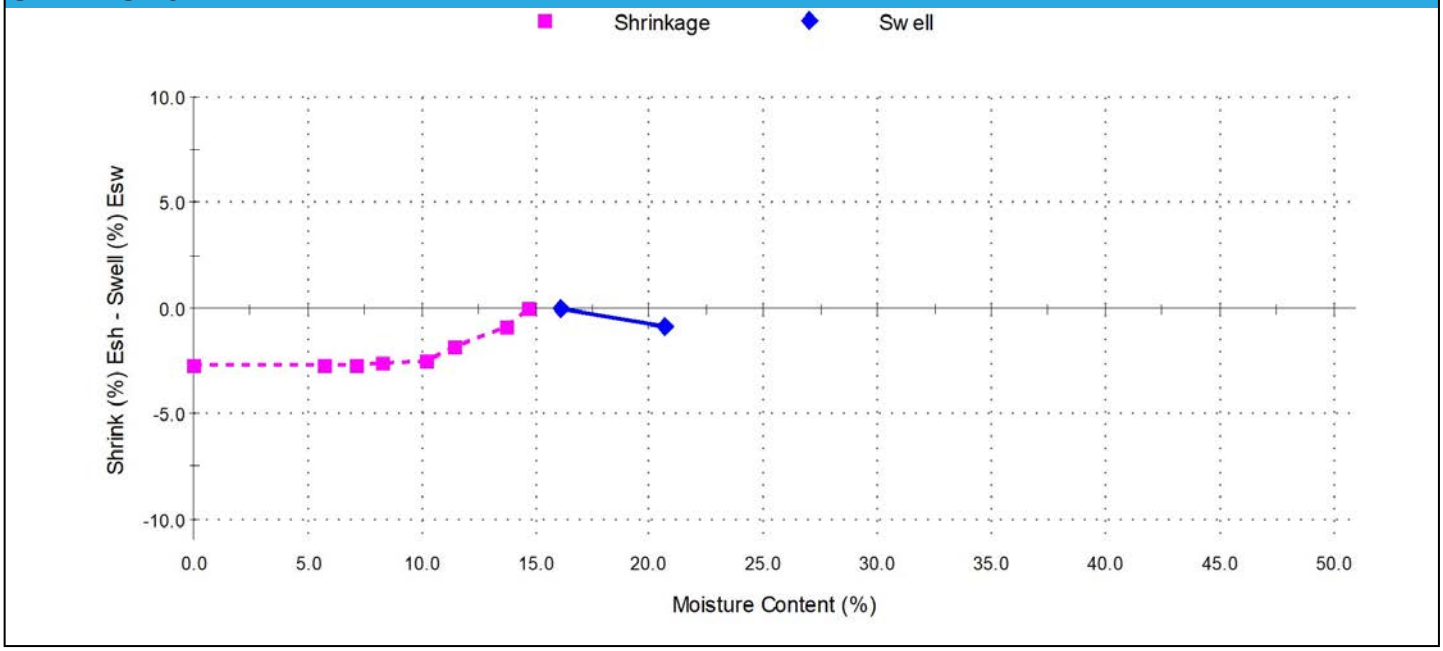
Swell Test — AS 1289.7.1.1

Swell on Saturation (%):	-0.9
Moisture Content before (%):	16.1
Moisture Content after (%):	20.6
Est. Unc. Comp. Strength before (kPa):	> 600
Est. Unc. Comp. Strength after (kPa):	200

Shrink Test — AS 1289.7.1.1

Shrink on drying (%):	2.7
Shrinkage Moisture Content (%):	14.7
Est. inert material (%):	10.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 1.5

Comments

The results outlined above apply to the sample as received

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Shrink Swell Index Report

Report No: SSI:NEW19W-2801--S05
Issue No: 1

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Principal:
Project No.: NEW15P-0070B
Project Name: Billy's Lookout - Stage 14

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 27/08/2019

Sample Details

Sample ID:	NEW19W-2801--S05	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Sandy CLAY	**Date Sampled:**	14/08/2019
Source:	On-Site	**Date Submitted:**	15/08/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP1406 - 1.10 to 1.30m		
Borehole Number:	TP1406		
Borehole Depth (m):	1.10 - 1.30		

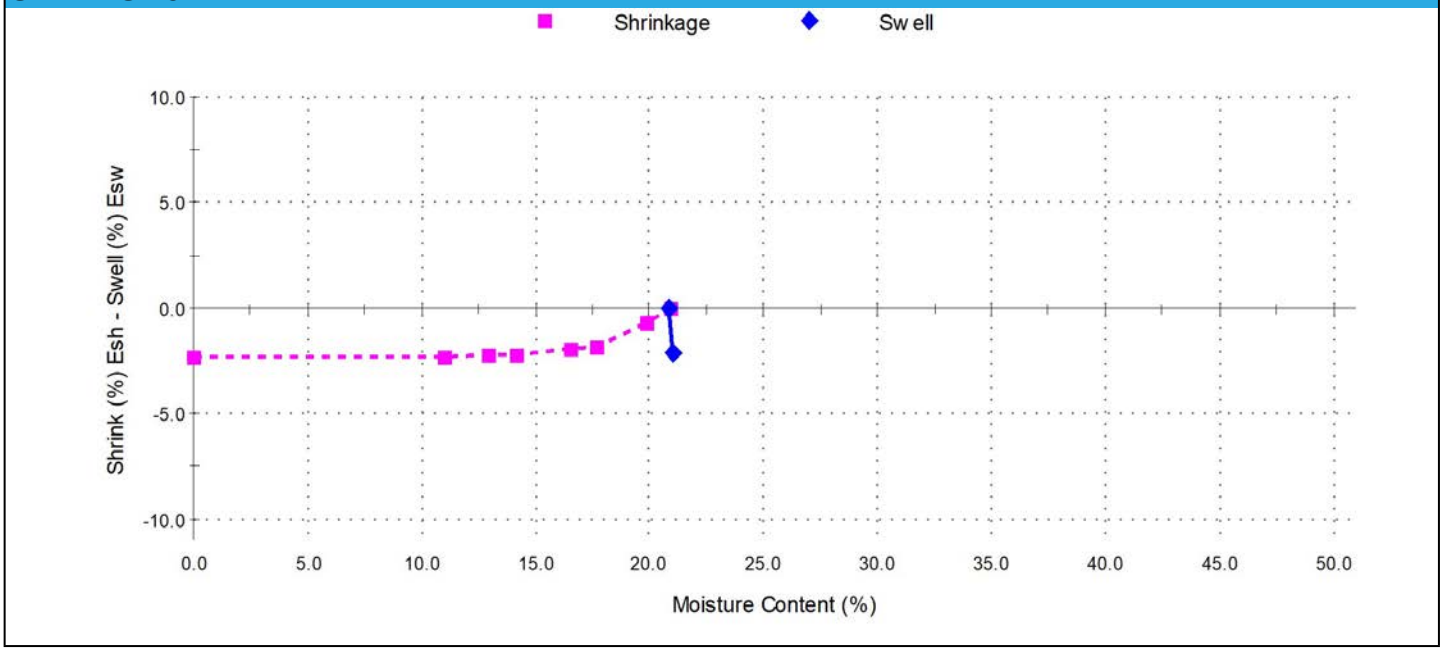
Swell Test — AS 1289.7.1.1

Swell on Saturation (%):	-2.2
Moisture Content before (%):	20.9
Moisture Content after (%):	21.0
Est. Unc. Comp. Strength before (kPa):	> 600
Est. Unc. Comp. Strength after (kPa):	200

Shrink Test — AS 1289.7.1.1

Shrink on drying (%):	2.3
Shrinkage Moisture Content (%):	20.9
Est. inert material (%):	5.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Major

Shrink Swell



Shrink Swell Index - Iss (%): 1.3

Comments

The results outlined above apply to the sample as received

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Report No: SSI:NEW19W-2801--S06
Issue No: 1

Shrink Swell Index Report

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Principal:
Project No.: NEW15P-0070B
Project Name: Billy's Lookout - Stage 14

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 27/08/2019

Sample Details

Sample ID:	NEW19W-2801--S06	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Sandy CLAY	**Date Sampled:**	14/08/2019
Source:	On-Site	**Date Submitted:**	15/08/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP1407 - 0.60 to 0.90m		
Borehole Number:	TP1407		
Borehole Depth (m):	0.60 - 0.90		

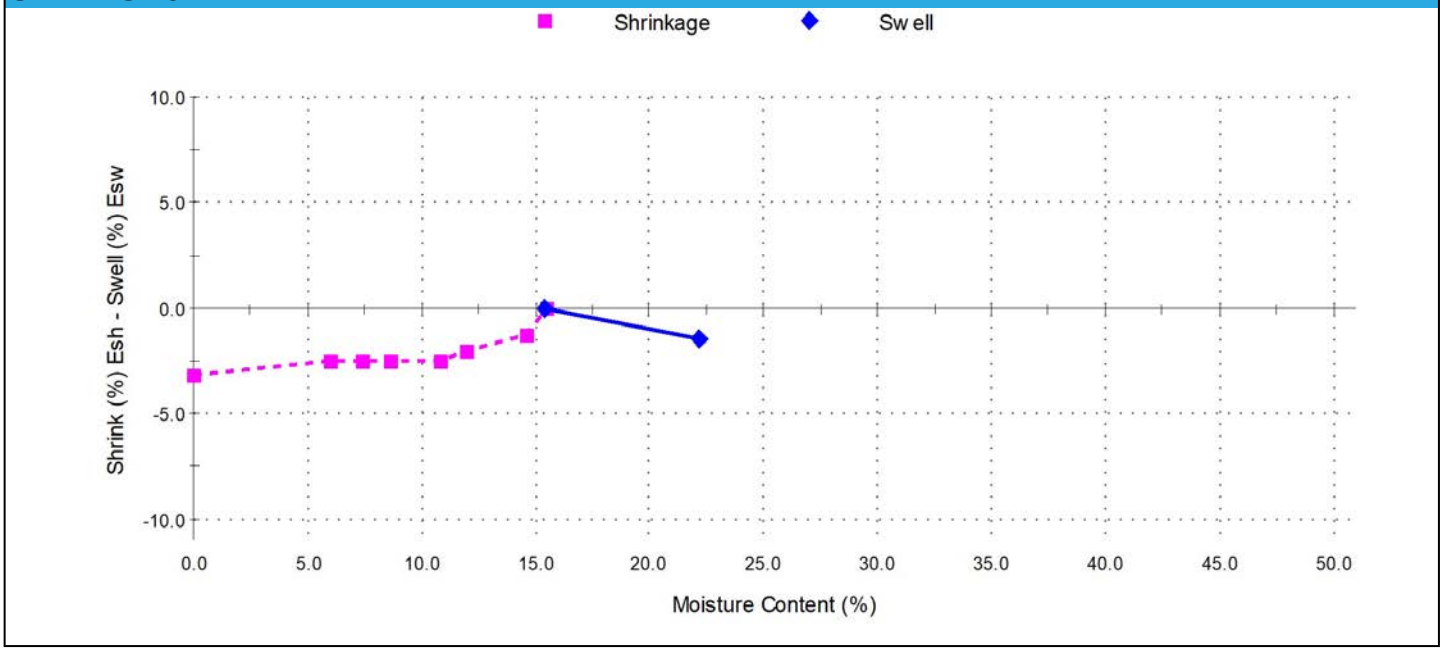
Swell Test — AS 1289.7.1.1

Swell on Saturation (%):	-1.5
Moisture Content before (%):	15.4
Moisture Content after (%):	22.2
Est. Unc. Comp. Strength before (kPa):	> 600
Est. Unc. Comp. Strength after (kPa):	250

Shrink Test — AS 1289.7.1.1

Shrink on drying (%):	3.2
Shrinkage Moisture Content (%):	15.5
Est. inert material (%):	10.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 1.8

Comments

The results outlined above apply to the sample as received

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Report No: SSI:NEW19W-2801--S07
Issue No: 1

Shrink Swell Index Report

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Principal:
Project No.: NEW15P-0070B
Project Name: Billy's Lookout - Stage 14

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 27/08/2019

Sample Details

Sample ID:	NEW19W-2801--S07	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Sandy CLAY	**Date Sampled:**	14/08/2019
Source:	On-Site	**Date Submitted:**	15/08/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP1408 - 0.50 to 0.90m		
Borehole Number:	TP1408		
Borehole Depth (m):	0.50 - 0.90		

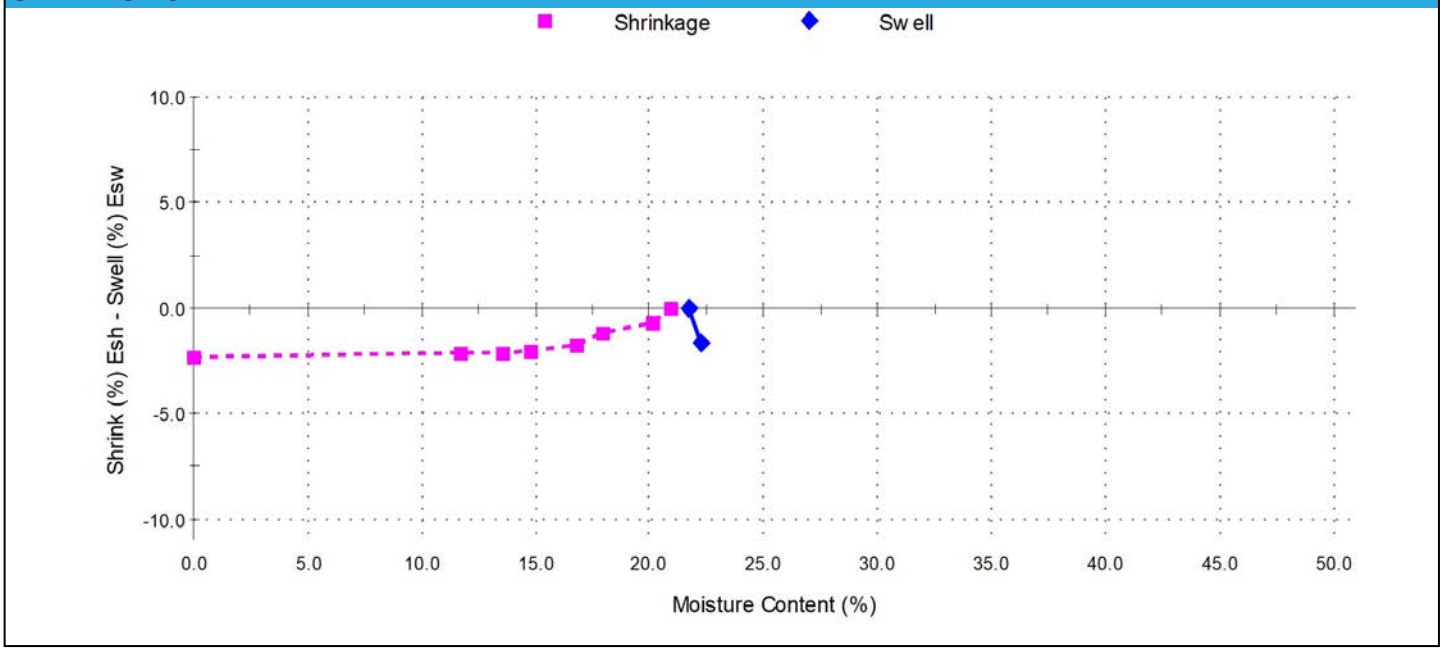
Swell Test — AS 1289.7.1.1

Swell on Saturation (%):	-1.6
Moisture Content before (%):	21.7
Moisture Content after (%):	22.2
Est. Unc. Comp. Strength before (kPa):	250
Est. Unc. Comp. Strength after (kPa):	210

Shrink Test — AS 1289.7.1.1

Shrink on drying (%):	2.3
Shrinkage Moisture Content (%):	20.9
Est. inert material (%):	5.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 1.3

Comments

The results outlined above apply to the sample as received

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Report No: SSI:NEW19W-2801--S08
Issue No: 1

Shrink Swell Index Report

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Principal:
Project No.: NEW15P-0070B
Project Name: Billy's Lookout - Stage 14

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 27/08/2019

Sample Details

Sample ID:	NEW19W-2801--S08	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Sandy CLAY	**Date Sampled:**	14/08/2019
Source:	On-Site	**Date Submitted:**	15/08/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP1409 - 0.30 to 0.55m		
Borehole Number:	TP1409		
Borehole Depth (m):	0.30 - 0.55		

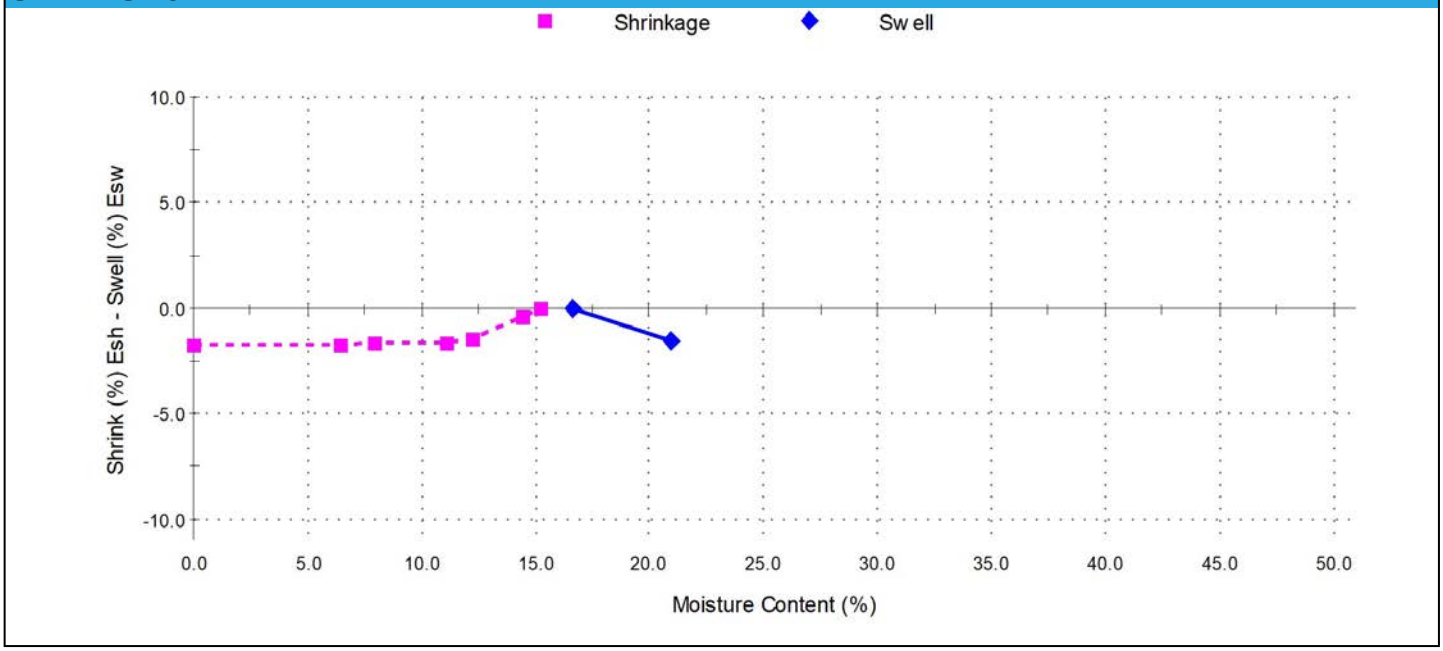
Swell Test — AS 1289.7.1.1

Swell on Saturation (%):	-1.5
Moisture Content before (%):	16.6
Moisture Content after (%):	20.9
Est. Unc. Comp. Strength before (kPa):	250
Est. Unc. Comp. Strength after (kPa):	250

Shrink Test — AS 1289.7.1.1

Shrink on drying (%):	1.7
Shrinkage Moisture Content (%):	15.2
Est. inert material (%):	3.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Moderate

Shrink Swell



Shrink Swell Index - Iss (%): 1.0

Comments

The results outlined above apply to the sample as received

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Shrink Swell Index Report

Report No: SSI:NEW19W-2801--S09
Issue No: 2
This report replaces all previous issues of report no 'SSI:NEW19W-2801--S09'.

Client: McCloy Development Management Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
Newcastle NSW 2300

Principal:
Project No.: NEW15P-0070B
Project Name: Billy's Lookout - Stage 14

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 27/08/2019

Sample Details

Sample ID:	NEW19W-2801--S09	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Sandy CLAY	**Date Sampled:**	14/08/2019
Source:	On-Site	**Date Submitted:**	15/08/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP1410 - 0.70 to 1.00m		
Borehole Number:	TP1410		
Borehole Depth (m):	0.70 - 1.00		

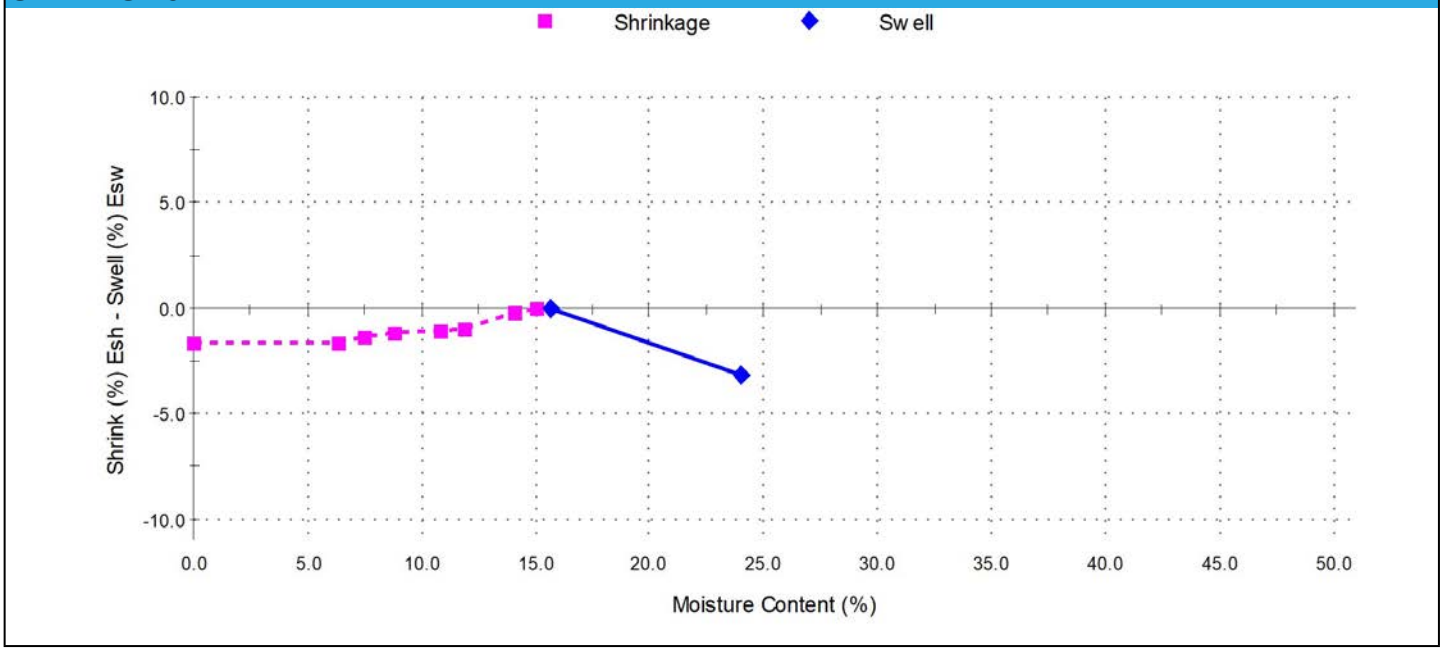
Swell Test — AS 1289.7.1.1

Swell on Saturation (%):	-3.2
Moisture Content before (%):	15.6
Moisture Content after (%):	24.0
Est. Unc. Comp. Strength before (kPa):	> 600
Est. Unc. Comp. Strength after (kPa):	180

Shrink Test — AS 1289.7.1.1

Shrink on drying (%):	1.6
Shrinkage Moisture Content (%):	15.1
Est. inert material (%):	5.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Major

Shrink Swell



Shrink Swell Index - Iss (%): 0.9

Comments

The results outlined above apply to the sample as received

APPENDIX C:

CSIRO Sheet BTF 18

Foundation Maintenance and Footing Performance: A Homeowner's Guide

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

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 bog-like 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
A	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
H	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
P	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.

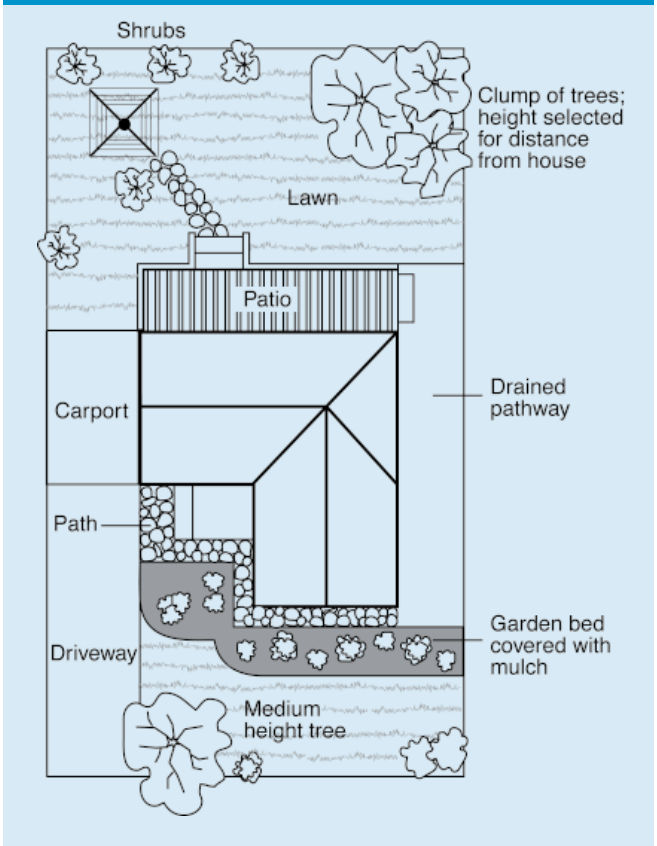
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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

Gardens for a reactive site



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.

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