Proposed Subdivision Billy's Lookout - Stages 10, 16, & 17 Geotechnical Assessment

Outrigger Drive, Teralba

NEW15P-0070F-AA
22 November 2019

Qualtest
LABORATORY (NSW) PTY LTD

GEOTECHNICAL I LABORATORY I EARTHWORKS I QUARRY I CONSTRUCTION MATERIAL TESTING

22 November 2019

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

Attention: Mr Harry Thomson

Dear Sir

RE: PROPOSED SUBDIVISION – BILLY'S LOOKOUT – STAGES 10, 16, & 17
OUTRIGGER DRIVE, TERALBA
GEOTECHNICAL ASSESSMENT

Please find enclosed our Geotechnical Assessment report for the proposed residential subdivision of Billy's Lookout, Stages 10, 16, & 17, to be located at Outrigger Drive, Teralba.

The report includes recommendations on earthworks, pavement design and construction for internal subdivision roads, preliminary site classification in accordance with AS2870-2011, "*Residential Slabs and Footings*", and foundation conditions for proposed retaining wall.

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

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 report on behalf of McCloy Development Management Pty Ltd (McCloy), for the proposed residential subdivision of Billy's Lookout, Stage 10, 16, and 17, to be located at Outrigger Drive, Teralba.

Based on the Brief and Staging Plans Sheet (Ref: High Definition Design Pty Ltd, Project No. HD16, Drawing No. SH3, Revision 4, dated 10/07/2019) provided in an email from McCloy dated 17 September 2019, the proposed development is understood to comprise subdivision into a total of 77 residential lots, (Lots 1 to 44, 1001 to 1017, 1601 to 1607, 1701 to 1706, and 3 unnamed lots, denoted "A", "B", and "C" on Figure AA1), and construction of subdivision road pavements for Outrigger Drive, and Roads 3 to 6, as shown on Figure AA1.

The scope of work for the geotechnical investigation included providing discussion and recommendations on the following:

- Preliminary site classification to AS2870-2011, "*Residential Slabs and Footings*" for residential lots within Stages 10, 16, & 17;
- Pavement design for proposed subdivision roads, including Outrigger Drive;
- Foundation design parameters for piered footings of proposed retaining / sound wall along the rail corridor boundary; and,
- Recommendations for constructability and earthworks guidelines, including the suitability of the site soils for use as fill and fill construction procedures.

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 or others, as noted below:

- Geotechnical Assessment report by Qualtest, 'Proposed Subdivision, Stages 3 & 4 Pitt Street, Teralba, (Report Reference: NEW15P-0070-AA.Rev1, dated 28 August 2015); and,
- Report on Geotechnical Investigation by Cardno Geotech Solutions ('Stage 2 Proposed Subdivision: Pitt Street, Teralba, (Report Reference: CGS1785-006.0, dated 19 December 2014).

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 9 October 2019 and comprised of:

- DBYD search and visual check of 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 17 test pits (TPP01 to TPP17) using a 2.7 tonne excavator equipped with a 450mm wide bucket. Test pits were terminated at depths of between 0.65m and 2.05m;
- 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 AA1. 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 Surface Conditions

The site comprises proposed Stages 10, 16, and 17 of the subdivision known as Billy's Lookout located off Outrigger Drive, Teralba, as shown on Figure AA1 attached.

The site is located within a region of moderately sloping topography, on the footslopes to mid-slopes of a broad hill. Ground levels are generally in the range from roughly RL 40m (AHD) at the north-western corner of the site, falling to roughly RL 15m (AHD) in the south-eastern corner of the site. Site slopes generally vary from about 4° to 15° towards the southeast and east.

The site is typically covered by undeveloped bushland, vegetated by a moderate to dense coverage of mature trees with an undergrowth of native shrubs, bushes and grass cover, with some cleared areas associated with access tracks for subdivision development and services.

An area of filling for temporary access road construction is present on the southern side of the site in the vicinity of the proposed Outrigger Drive alignment (Photographs 7 & 8). A fill mound is present to the north of the temporary access road. The approximate location of this filling is shown on Figure AA1. A relatively small stockpile was located northeast of TPP02 (Photograph 3).

On the day of the investigation, the site was judged to be reasonably well drained by way of surface runoff following the natural topography towards the drainage reserve to the south.

Trafficability was judged to be good by way of 4WD vehicle along the existing access tracks. Photographs of the site taken on the day of the site investigations are shown below.

Photograph 1: From near TPP01, facing northeast.

Photograph 2: From near TPP01, facing southeast.

Photograph 3: From near TPP02, facing east.

Photograph 4: From near TPP02, facing south.

Photograph 5: From near TPP04, facing west.

Photograph 6: Near TPP04, facing north.

Photograph 7: From near TPP05, facing west.

Photograph 8: From near TPP05, facing east.

Photograph 9: From near TPP07, facing southeast.

Photograph 10: From near TPP07, facing southwest.

Photograph 11: Near TPP09 facing southwest.

Photograph 12: From near TPP09 facing west.

Photograph 13: From near TPP14, facing west.

Photograph 14: From near TPP14, facing northwest.

Photograph 15: From near TPP16, facing west.

Photograph 16: From near TPP16, facing northwest.

Photograph 17: From near TPP17, facing west.

Photograph 18: From near TPP17, facing northwest.

4.2 Subsurface Conditions

Reference to the 1:100,000 Newcastle Coalfield Regional Geology Sheet indicates the site to be underlain by the Moon Island Beach Subgroup of the Newcastle Coal Measures, which is characterised by Conglomerate, Sandstone, Siltstone, 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.

TABLE 1 – SUMMARY OF GEOTECHNICAL UNITS AND SOIL TYPES

Unit	Soil Type	Description
1A	FILL – TOPSOIL, MULCH	Silty/Clayey SAND – fine to medium grained, dark grey-brown, fines of low to medium plasticity, root affected. Sandy CLAY – low plasticity, pale grey-brown, fine to medium grained sand, root affected. In the order of 50mm of tree mulch on surface in places.
1B	UNCONTROLLED FILL	Clayey GRAVEL / Clayey Sandy GRAVEL – fine to coarse grained (mostly fine to medium grained) rounded to sub-rounded, pale orange-brown, fine to coarse grained sand, fines of low to medium plasticity. Gravelly CLAY – medium plasticity, dark grey-brown, fine to medium grained rounded to sub-rounded gravel. Silty Sandy GRAVEL – fine to medium grained sub-angular to sub-rounded, pale grey, fine to coarse grained (mostly fine to medium grained) sand, fines of low plasticity.
1C	CONTROLLED FILL	Not encountered during current investigation.
2	TOPSOIL	Silty SAND – mostly fine to medium grained, grey dark grey, with fine to medium grained gravel in places, root affected. Sandy CLAY – low plasticity, pale grey-brown, fine to medium grained sand, root affected.
3	SLOPEWASH / COLLUVIUM	Gravelly Silty SAND / Clayey SAND - fine to medium grained, grey-brown and dark grey, fines of low plasticity, some tree roots and mulch in places, fine to medium grained gravel in places. Sandy CLAY – low plasticity, grey with some pale brown, fine to coarse grained (mostly fine grained) sand, trace fine to medium grained sub-angular to sub-rounded gravel, with some roots. Silty Sandy GRAVEL – fine to medium grained rounded to sub-angular, grey to grey-brown, fine to coarse grained sand, fines of low plasticity.
4	RESIDUAL SOIL	Sandy CLAY - 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, with some fine to medium grained sand, Gravelly Sandy CLAY – medium plasticity, pale brown to pale grey-brown, fine to coarse grained sand, fine to medium grained rounded to sub-rounded.

5	EXTREMELY WEATHERED (XW) ROCK with soil properties	Sandstone; breaks down into Silty SAND – fine grained, pale grey-white an orange-brown, with highly weathered pockets. Silty Sandstone; breaks down into Sandy CLAY – medium plasticity, grey, fine to coarse grained (mostly fine to medium grained sand). Sandstone; breaks down into SAND – fine to medium grained, pale brown to pale orange-brown and pale grey, with some fines of low plasticity. Conglomerate; breaks down into Silty Sandy GRAVEL – fine to coarse grained rounded, pale brown, fine to coarse grained sand, fines of low plasticity.
6	HIGHLY WEATHERED (HW) TO MODERATELY WEATHERED (MW) ROCK	Sandy SILTSTONE – pale grey and orange-brown, estimated low strength, with extremely weathered pockets. SANDSTONE - fine to coarse grained, pale grey to white and pale orange-brown to red-brown, estimated strength of medium to high. Pebbly SANDSTONE and Sandy SILTSTONE in places. Extremely to Highly Weathered in places. CONGLOMERATE – fine to coarse grained, rounded to sub-rounded, pale grey and pale brown, fine to coarse grained sand, estimated medium to high strength.

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

Location	**Unit 1A** **Fill – Topsoil, Mulch**	**Unit 1B** **Uncontrolled Fill**	**Unit 1C** **Controlled Fill**	**Unit 2** **Topsoil**	**Unit 3** **Slopewash / Colluvium**	**Unit 4** **Residual Soil**	**Unit 5** **XW Rock**	**Unit 6** **HW to MW Rock**
	Depth in metres (m)							
Current Investigation								
TPP01	-	-	-	0.00 - 0.15	-	0.15 - 0.60	0.60 - 0.80	0.80 - 0.85*
TPP02	0.00 - 0.10	-	-	-	-	0.10 - 0.60	-	0.60 - 0.65*
TPP03	-	-	-	0.00 - 0.30	-	0.30 - 1.00	-	1.00 - 1.05*
TPP04	-	-	-	0.00 - 0.35	-	0.35 - 1.05	-	1.05 - 1.15*
TPP05	-	0.00 - 0.90	-	-	-	0.90 - 1.90	1.90 - 1.95	-
TPP06	-	0.00 - 0.60	-	-	0.60 - 0.80	0.80 - 1.60	1.60 - 2.05	-
TPP07	-	-	-	0.00 - 0.20	0.20 - 0.40	0.40 - 0.95	0.95 - 1.10	1.10 - 1.15*
TPP08	-	-	-	0.00 - 0.40	-	-	0.40 - 0.70	0.70 - 0.75*
TPP09	-	-	-	0.00 - 0.15	-	0.15 - 0.90	0.90 - 1.85^	-
TPP10	-	-	-	0.00 - 0.20	-	0.20 - 0.80	0.80 - 1.10	1.10 - 1.20*
TPP11	-	-	-	0.00 - 0.20	-	0.20 - 0.80	0.80 - 1.00	1.00 - 1.10*
TPP12	0.00 - 0.15	0.15 - 0.25	-	-	-	0.25 - 0.90	0.90 - 1.10	1.10 - 1.15*
TPP13	-	-	-	0.00 - 0.10	0.10 - 0.20	0.20 - 1.20	1.20 - 1.50	1.50 - 1.60*

Location	**Unit 1A** **Fill – Topsoil, Mulch**	**Unit 1B** **Uncontrolled Fill**	**Unit 1C** **Controlled Fill**	**Unit 2** **Topsoil**	**Unit 3** **Slopewash / Colluvium**	**Unit 4** **Residual Soil**	**Unit 5** **XW Rock**	**Unit 6** **HW to MW Rock**
	Depth in metres (m)							
TPP14	0.00 - 0.40	-	-	-	-	0.40 - 1.60	1.60 - 2.00	-
TPP15	0.00 - 0.05	-	-	0.05 - 0.20	-	0.20 - 1.10	1.10 - 1.65	1.65 - 1.70*
TPP16	0.00 - 0.05	0.05 - 0.20	-	-	-	0.20 - 1.20	1.20 - 1.45	1.45 - 1.55*
TPP17	0.00 - 0.05	-	-	0.05 - 0.15	-	0.15 - 1.00	1.00 - 1.25	1.25 - 1.40*
Note:	* = Practical refusal or refusal of 2.7 tonne excavator met on Highly Weathered Rock.							
Previous Investigation (Ref: NEW15P-0070-AA.Rev1, 28 August 2015)								
TP16	-	-	-	0.00 - 0.10	-	0.10 - 0.50	-	0.50 - 0.60#
TP17	-	-	-	0.00 - 0.20	0.20 - 0.40	0.40 - 2.00	-	2.00 - 2.20
TP18	-	-	-	0.00 - 0.13	0.13 - 0.25	0.25 - 1.30	1.30 - 2.20	-
Note:	# = Practical refusal or refusal of 20 tonne excavator met on Highly Weathered Rock.							
Cardno Geotech Solutions (Ref: CGS1785, 19 December 2014)								
TP206	-	-	-	0.00 - 0.15	-	0.15 - 0.30	0.30 - 1.50#	
Note:	# = Practical refusal or refusal of 20 tonne excavator met on Highly Weathered Rock.							

5.0 Laboratory Testing

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

- (4 no.) Shrink / Swell test;
- (2 no.) Atterberg Limits tests; and,
- (6 no.) California Bearing Ratio (4 day soaked) & Standard Compaction.

Proposed shrink/swell testing for a number of samples were replaced by Atterberg Limits classification tests due to the friable nature of the site soils.

Results of the laboratory testing are presented in Appendix B, with a summary of the test results presented in Table 3, Table 4 and Table 5.

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

TABLE 3 – SUMMARY OF SHRINK/SWELL TESTING RESULTS

Location	Depth (m)	Material Description	I_{ss} (%)
Current Investigation			
TPP03	0.45 - 0.65	(CH) Sandy CLAY	2.9
TPP05	1.00 - 1.20	(CI) Gravelly Sandy CLAY	2.4
TPP10	0.25 - 0.55	(CI) Sandy CLAY	1.8
TPP12	0.30 - 0.50	(CH) Sandy CLAY	3.6
Previous Investigation (Ref: NEW15P-0070-AA, 28 August 2015)			
TP18	0.40 - 0.70	(CI) CLAY / Sandy CLAY	0.9

TABLE 4 – SUMMARY OF ATTERBERG LIMITS TESTING RESULTS

Location	Depth (m)	Material Description	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)
Current Investigation						
TPP01	0.40 - 0.60	(CH) Sandy CLAY	73	26	47	10.5
TPP07	0.70 - 0.80	(CI) Sandy CLAY	32	18	14	5.0
Previous Investigation (Ref: NEW15P-0070-AA, 28 August 2015)						
TP17	0.40 - 0.80	(CL) Sandy CLAY	36	17	19	5.0

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.

TABLE 5 – SUMMARY OF CBR TESTING RESULTS

Location	Sample Depth (m)	Field Moisture Content (%)	Optimum Moisture Content (%)	Relationship of Field MC to OMC (%)	CBR (%)
Current Investigation (Ref: NEW15P-0070B-AB, May 2017)					
TPP01	0.40 – 0.60	20.8	24.0	3.2 DRY	4.0
TPP03	0.45 – 0.65	26.5	26.5	≈ OMC	3.0
TPP07	0.80 – 0.90	10.4	15.0	4.6 DRY	6
TPP08	0.50 – 0.70	7.4	11.0	3.6 DRY	15
TPP09	0.35 – 0.50	17.6	21.0	3.4 DRY	5
TPP12	0.30 – 0.50	19.0	18.5	0.5 WET	3.5
Previous Investigation (Ref: NEW15P-0070-AA, 28 August 2015)					
TP17	0.40 – 0.80	15.1	14.6	0.5 WET	7
TP18	0.40 – 0.70	28.6	23.8	4.8 WET	6
Cardno Geotech Solutions (Ref: CGS1785, 19 December 2014)					
TP206	0.50 – 0.90	11.6	15.5	3.9 DRY	17

6.0 Discussion and Recommendations

6.1 Preliminary Site Classification to AS2870-2011

Based on the results of the field work and laboratory testing carried out, proposed residential lots located within Billy’s Lookout Stages 10, 16, and 17 at Outrigger Drive, Teralba, as shown on Figure AA1, are classified in their current condition in accordance with AS2870-2011 '*Residential Slabs and Footings*', as shown in Table 6.

TABLE 6 – SITE CLASSIFICATION TO AS2870-2011

Stage No.	Lot Numbers	Site Classification
10	1001 to 1013	**M**
	1014 to 1017	**P**
16	1601 to 1607	**M**
17	1702 to 1706	**M**
	1701	**P**
TBC	1 to 44, and A to C	**M**

The classifications in Table 6 are preliminary, based on broadly spaced investigations and limited surface observations, and should be confirmed prior to design of foundations.

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

Proposed Lots 1014 to 1017 and 1701 are classified as **Class 'P'** due to the presence or inferred presence of fill to depths of greater than 0.4m.

The approximate extent of fill mounds observed during the current investigation is shown on Figure AA1. If the depth and extent of fill needs to be known more accurately for planning, design or other purposes, then it should be investigated further.

If the fill mounds are removed, it is likely that these lots could be re-classified. It is envisaged that if removal of material and site regrade is witnessed and documented by the geotechnical authority, then it is likely that these lots may be re-classified as Moderately Reactive, **Class 'M'** in accordance with AS2870-2011.

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.

As a preliminary guide, if the site is filled with site won Unit 4 Residual Soil or similar material (I_{ss} of about 4.0% or less), carried out to 'Level 1' criteria as defined in Clause 8.2 – Section 8, of AS3798-2007, lots are likely to be classified as **Class 'M'** or **Class 'H1'**.

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.

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.

6.2 Foundations

6.2.1 Shallow Footings

Shallow footings founded on stiff or better residual clay, dense or better sand, or approved controlled fill (placed under Level 1 supervision in accordance with AS3798-2007) may be proportioned for a maximum allowable bearing pressure of 100kPa, provided they are founded below any existing uncontrolled fill, topsoil, deleterious material, or very soft to firm material.

Shallow footings founded on very stiff or better residual clay, or approved controlled fill (compacted to a minimum density ratio of 98% Standard Compaction placed under Level 1 supervision in accordance with AS3798-2007) may be proportioned for a maximum allowable bearing pressure of 150kPa, provided they are founded below any existing uncontrolled fill, topsoil, deleterious material, or very soft to firm material.

Shallow footings founded in Highly Weathered Rock (Class V Shale or better) may be proportioned for a maximum allowable bearing pressure of 600kPa.

The recommended allowable bearing pressures assume that elastic settlements will be less than about 1% of least footing width; although, relevant ground movements related to reactive clay would also apply.

6.2.2 Deep Footings

Piled foundation options are expected to include bored piles. Table 7 presents a summary of founding parameters for deep footings (founding depth greater than 3 times maximum footing width) that have been adopted for the relevant materials.

Increased capacity may be achieved in rock of medium strength or better; however, due to the investigations being limited to test pitting rather than rock coring, and potential for low strength layers to be present, it is recommended that the values provided in Table 7 are adopted for Unit 6 rock unless further investigations are carried out to confirm or otherwise the presence of medium strength rock over the depth of proposed pile socket and below the base depth of proposed piles.

TABLE 7 – SUMMARY OF DEEP FOOTING DESIGN PARAMETERS

Soil Description	Serviceability (Allowable) End Bearing Capacity (kPa)	Serviceability (Allowable) Shaft Adhesion (kPa)	Serviceability (Allowable) Lateral Bearing Capacity (kPa)	Ultimate End Bearing Capacity (kPa)	Ultimate Shaft Adhesion (kPa)
Uncontrolled Fill, Topsoil, slopewash	-	-	-	-	-
Unit 4 –Residual Soil (stiff or better)	150	25	50	450	50
Unit 5 - Extremely Weathered Rock	300	25	100	900	50
Unit 6 - Highly Weathered to Fresh Rock (low strength Class V Sandstone or better)	1000	75	500	3000	150

Notes:

1) Ultimate values occur at large settlements (>5% of minimum footing dimensions).
2) The ultimate pile parameters presented should be used in limit state pile design in accordance with Australian Standard AS 2159-2009, *Piling – Design and Installation*.
3) A geotechnical strength reduction factor should be adopted for use with the above ultimate soil and rock parameters. A geotechnical strength reduction factor of 0.45 is recommended based on available information at this stage.
4) Where the founding stratum is underlain by a weaker layer, the pile toe should be located at least three pile diameters above the top of the weaker layer.
5) Piles should be no closer than 2.5 pile diameters apart.
6) It is expected that the settlement of deep footings proportioned as recommended above should be less than about 1% of the effective pile diameter.

The design parameters for rock sockets assume the socket is clean and rough. Sockets should be checked to confirm appropriate cleanliness prior to pouring of concrete.

The base of piles should be cleaned using a suitable bucket to remove spoil, as open flight augers usually cannot remove sufficient spoil to expose the majority of the pile base. A suitably experienced geotechnical engineer should inspect the pile excavations prior to pouring concrete.

Contingency should be made for localised use of casing if collapse of the side walls due to water inflows or granular soils is encountered. If groundwater is encountered, then piles will require dewatering prior to the pouring of concrete or else tremmie methods should be used to ensure concrete can be placed effectively to the base of the pile.

For the proposed retaining / sound wall along the rail corridor boundary, reference should be made to test pits logs TPP14, TPP15, TPP16 & TPP17 for approximate depth to relevant founding materials for Unit 4 (Residual Soil), Unit 5 (Extremely Weathered Rock) or Unit 6 (Highly Weathered to Fresh Rock).

6.2.3 Retaining Wall Design Parameters

All structural retaining walls and all landscaping walls in excess of 1.0m should be designed by an experienced engineer familiar with the site conditions. All retaining walls should be designed for surcharge loading from slopes, structures and other existing/future improvements in the vicinity of the wall. Adequate subsurface and surface drainage should be provided behind all retaining walls.

Retaining walls backfilled with a free draining granular material may be designed for an active earth pressure coefficient (k_a) of 0.33 and a passive earth pressure coefficient (k_p) of 3.0 and a total density of 1.9 t/m^3.

Unit 4 Stiff or better clay and Unit 5 extremely weathered rock material may be designed for an active earth pressure coefficient (k_a) of 0.4 and a passive earth pressure coefficient (k_p) of 2.5 and a total density of 1.9 t/m^3.

Unit 6 highly weathered to slightly weathered rock material may be designed for an active earth pressure coefficient (k_a) of 0.27 and a passive earth pressure coefficient (k_p) of 3.7 and a total density of 2.2 t/m^3.

During progressive placement of fill behind the retaining wall it may displace outwards slightly. An at rest earth pressure coefficient (k_o) should be used instead of an active earth pressure coefficient (K_a) behind the retaining structures for any walls that are relatively rigid and/or propped. A modified at rest earth pressure coefficient (k_o) of 0.5 may be used for walls that can tolerate a small amount of movement (about 0.1% to 0.3% of wall height).

Allowance should be made for in the design of retention measures to resist hydrostatic pressures due to groundwater build-up in addition to earth pressures.

6.3 Pavement Design

6.3.1 Design Subgrade CBR Values

Based on the results of the field work, laboratory testing, and previous experience in the surrounding area, the following design California Bearing Ratio (CBR) values have been adopted for pavement thickness design for the proposed subdivision roads.

TABLE 8 – DESIGN SUBGRADE CBR VALUES

Road Section	Design Subgrade	Design CBR (%)
To Be Confirmed	Residual Clay (in vicinity of TPP03 and TPP12)	3.0
To Be Confirmed	Residual Clay, Controlled Fill (majority of the site)	4.0
To Be Confirmed	Weathered Rock (if encountered at subgrade level)	8

Notes:

1) Design subgrade CBR values should be confirmed at the time of construction by the geotechnical authority for each relevant road section.
2) Fill placed at road subgrade level should be assessed by the geotechnical authority. If the fill is assessed to have CBR different to that of the design CBR, then a revised pavement design will be required for that section.

Based upon discussions with the client it is understood that significant earthworks may be carried out, generally comprising cut from the northern area and fill of the southern area.

Based upon the test results from the site, is anticipated that:

- Design subgrade CBR of 4.0% is likely to apply to the majority of road sections;
- Design subgrade CBR of 3.0% may apply to some road sections including in the vicinity of TPP03 and TPP12 if the residual clay soil forms the subgrade for new pavements;
- Design subgrade CBR of 8% may apply to some road sections in deeper cuts which expose weathered rock provided that the ripped and re-compacted weathered rock is confirmed to have a design CBR $\geq$ 8%;
- An area in the southern part of the site is affected by uncontrolled fill which should be removed, and replaced if necessary, prior to pavement construction.

Where subgrade comprises fill removed and replaced as controlled fill prior to pavement construction, design subgrade CBR would be dependent upon the composition of the fill material.

Subgrade should be prepared in accordance with the site preparation requirements presented in Section 6.5.

If rock subgrade materials are encountered, the rock should be ripped and re-compacted for a minimum depth of 300mm to break-up any preferential drainage paths and provide a dense homogenous surface on which to construct the pavement.

6.3.2 Design Traffic Loadings

The design traffic loading adopted for internal subdivision roads in accordance with Lake Macquarie City Council, Engineering Guidelines to The Development Control Plan, Part 1 – Design Guidelines, December 2013, in terms of equivalent standard axles (ESA's) is as follows:

TABLE 9 – DESIGN TRAFFIC LOADING

Road Section	Classification	Design Traffic (ESA's)
Outrigger Drive & Road Nos. 3 to 6	Local Road – Primary or Secondary	4×10^5

In the event that a different design traffic loading is applicable, then the pavement thickness designs presented in this report should be reviewed.

6.3.3 Flexible Pavement Thickness Design

Flexible pavement thickness design has been based on the procedures outlined in:

- Lake Macquarie Development Control Plan 2014, Part 8 – Subdivision Development, February 2014 – Revision 3;
- Lake Macquarie City Council, Engineering Guidelines to The Development Control Plan, Part 1 – Design Guidelines, December 2013;
- Lake Macquarie City Council, Engineering Guideline Part 1 Design Specification, D2 Pavement Design, September 2003;
- Austroads, "Guide to Pavement Technology, Part 2: Pavement Structural Design"; and,
- Australian Road Research Board, Special Report No. 41 (ARRB-SR41).

Flexible Pavement Thickness Designs are presented in Table 10.

Pavement Material Specification and Compaction Requirements are presented in Table 11.

Select fill or bridging layer should be allowed for beneath the pavement in any areas where poor, wet or saturated subgrade conditions are encountered. This is discussed in Section 6.5.

If rock subgrade materials are encountered, the rock should be ripped and re-compacted for a minimum depth of 300mm to break-up preferential drainage paths and provide a dense homogenous surface on which to construct the pavement. Pavement thickness designs for a ripped and re-compacted rock subgrade based on a design subgrade CBR of 8% is provided.

Pavements should not be constructed on the existing fill. Uncontrolled fill should be removed and replaced as controlled fill.

It is recommended that each construction length be boxed out to the minimum subgrade level required by the relevant pavement thickness design. Prior to pavement construction, the exposed subgrade should be assessed by the geotechnical authority to confirm the pavement thickness requirement for that section.

TABLE 10 – FLEXIBLE PAVEMENT THICKNESS DESIGN SUMMARY – LOCAL ROAD

Road Classification	Local Road – Primary or Secondary		
Subgrade Material	Clay Subgrade (locally lower CBR)	**Clay Subgrade**	Weathered Rock Subgrade
Design Traffic Loading (ESA's)	4 x 10^5	**4 x 10^5**	4 x 10^5
Design Subgrade CBR (%)	3.0	**4.0**	8.0
Wearing Course (mm)	30 - AC10 (Gap Graded)	**30 – AC10 (Gap Graded)**	30 – AC10 (Gap Graded)
Base Course (mm)	150	**150**	150
Subbase (mm)	280	**230**	150
Select Fill (mm)	-	**-**	-
Total Thickness (mm)	460	**410**	330

Notes:

1) A 7mm primer seal should be placed over the base course prior to placement of the asphaltic concrete wearing course.
2) An allowance for subgrade replacement should be anticipated in any areas where poor, wet or saturated subgrade conditions are encountered. As specified by LMCC, '*Where such situations arise, a minimum of 300mm thick select layer shall be provided in addition to the recommended pavement thickness*'.
3) The requirement for, and depth and extent of any subgrade replacement / select filling, should be confirmed by the geotechnical authority at the time of construction.
4) Where rock subgrade materials are encountered, the rock should be ripped and re-compacted for a minimum depth of 300mm to break-up preferential drainage paths and provide a dense homogenous surface on which to construct the pavement.
5) Prior to pavement construction, the exposed subgrade should be assessed by the geotechnical authority to confirm the pavement thickness requirement for that section.
6) Wearing course to be a minimum of 3 times the nominal mix size as specified by LMCC.

TABLE 11 – PAVEMENT MATERIAL SPECIFICATION AND COMPACTION REQUIREMENTS

Pavement Course	Material Specification	Compaction Requirements
Wearing Course (AC)	Lake Macquarie City Council Specification	Lake Macquarie City Council Specification
Base Course	CBR ≥ 80%, PI ≤ 6%	98% Modified (AS1289 5.2.1)
Subbase	CBR ≥ 30%, PI ≤ 12%	95% Modified (AS1289 5.2.1)
Select Fill / Stabilised Subgrade	Select, CBR ≥ 15%, PI ≤ 15%, max particle size 75mm or 2% cement stabilised subbase material or Stabilised Subgrade - lime stabilised with either 3% quicklime or 4% hydrated lime to achieve CBR > 10%	95% Modified (AS1289 5.2.1)
Subgrade (top 300mm)	Minimum CBR = Design CBR	100% Standard (AS1289 5.1.1)
Subgrade / Fill Below	Minimum CBR = Design CBR	95% Standard (AS1289 5.1.1)

Notes:

1) All flexible road pavement materials shall be supplied to comply with requirements of Lake Macquarie City Council's Engineering Construction Guidelines for unbound base and unbound sub base.

2) CBR = California Bearing Ratio, PI = Plasticity Index.

3) Select Fill / Stabilised Subgrade options if required and/or adopted will be dependent on subgrade moisture conditions.

6.3.4 Construction Considerations

Care should also be taken to follow recommended construction practices when constructing new pavement adjacent to existing, including:

- A clean, vertical perpendicular surface at full depth should be cut for both transverse and longitudinal jointing. This will reduce the risk of plating and heaving effects on the pavement;
- Ensuring joints are not in wheel paths;
- Ensuring joints in sub-base / select layers are offset to joints in the base layer;
- Ramping between layers, and at the entry and exit points to the pavement, must be removed at all times. During construction, any temporary access ramps to properties or driveways must also be removed.

6.4 Excavation Conditions and Depth to Rock

The depths of fill, topsoil, colluvium, residual soils and weathered rock, together with depths of practical refusal of the 2.7 tonne excavator where encountered are summarised in Table 2.

In terms of excavation conditions, site materials can generally be divided into:

- Clayey and Granular Soils (Units 1, 2, 3 & 4). It is anticipated that these materials could be excavated by a conventional excavator or backhoe bucket;
- Weathered Rock (Unit 5 & 6). Rippability is dependent on rock strength, depth, degree of weathering and number of defects within the rock mass which can vary significantly.

It is anticipated that the Weathered Rock (Unit 5 & 6) material encountered could be excavated by conventional excavator at least to the depths indicated on the appended test pit logs.

It is expected that material below the depth of excavator bucket refusal will be excavatable by ripping to some greater depth, although this has not been assessed as part of the current investigation.

It is recommended that targeted investigations (e.g. cored boreholes) are carried out if significant excavations are proposed where bedrock depth or excavatability is important to design or construction.

The use of toothed buckets, ripping tines, and/or hydraulic rock hammers may be required if hard bands of weathered rock are encountered or for deep confined excavations such as for service trenches. Higher strength rock or randomly occurring hard bands within the rock mass if encountered, are likely to occur towards the base of deeper cuts.

It is understood that bulk cutting works may be carried out generally on the northern side of the site. Based upon the test pit excavations in these areas, rock depths may be generally in the order of 0.5m to 1.1m in the elevated areas where bulk excavation is most likely.

Based upon this information and our experience during previous stages of the subdivision, preliminary recommendations in the area of major cuttings are as follows:

- The majority of the rock is in the medium to high rock strength range, slightly fractured, with variable fracture spacings.
- Based on the findings it would be expected that in a large bulk excavation such as that proposed, where ripping directions can be adjusted readily to optimise ripping direction relative to fracture orientation, the majority of rock would be excavatable by a medium to large dozer such as a Caterpillar D9 or equivalent equipped with a single ripping tine.
- Isolated beds of high to very high strength rock are likely to be encountered. If these bands are highly fractured, they should still be rippable, but may require additional effort such as impact ripping or a larger dozer.
- It is recommended that an allowance for rock breakers or pre-splitting prior to ripping be made for areas where such hard bands may be encountered.

Groundwater may exist at localised areas of the site such as within the topsoil / colluvium profile, from water perched above the residual clay / bedrock profile, or in areas of former drainage channels. It is possible that slow water inflow may be encountered from such layers, particularly if earthworks are carried out during or following periods of wet weather.

Excavations should be supported by properly designed and constructed retaining walls or else battered at 1V:2H or flatter and protected from erosion.

Temporary excavations should be battered at 1V:1H or flatter in cohesive soils, or 1V:1.5H or flatter in granular soils, and protected from erosion. Steeper excavations may be supported by means of temporary shoring.

Temporary excavations to depths of up to 1.2m in competent compact material with sufficient cohesion, such as clay of stiff consistency or better may be battered vertically, subject to inspection during excavation by the geotechnical authority.

The safe working procedures of Work Cover NSW Excavation work code of practice, dated July 2015 should be followed.

Care should be taken not to disturb or destabilise existing underground services or structures.

6.5 Site Preparation

Site preparation and earthworks suitable for pavement support and site re-grading should consist of:

- Following any bulk excavation to proposed subgrade level, all areas of proposed pavement construction or site re-grading should be stripped to remove all existing uncontrolled fill, vegetation, topsoil, root affected or other potentially deleterious materials;
- Stripping is generally expected to be required to depths of about 0.2m to 0.4m to remove topsoil and root affected material;
- Stripping of greater depths of fill material in addition to topsoil and root affected material is anticipated in areas affected by fill mounds or surface filling. An estimate of the extent of filling to depths of about 0.4m or greater is indicated approximately on Figure AA1.
- Additional stripping may be required in any areas where poor, wet or saturated subgrade conditions are encountered;
- Following stripping, the exposed subgrade should be proof rolled (minimum 10 tonne static roller), to identify any wet or excessively deflecting material. Any such areas should be over excavated and backfilled with an approved select material;
- The moisture content of the subgrade materials and therefore the need for moisture conditioning or over-excavation and replacement, will be largely dependent on pre-existing and prevailing weather conditions at the time of construction;
- Subgrade preparation should be carried out using a tracked excavator equipped with a smooth sided ('gummy') bucket to minimise the risk of over-disturbance of soils;
- Protect the area after subgrade preparation to maintain moisture content as far as practicable. The placement of subbase gravel would normally provide adequate protection;
- Site preparation should include provision of drainage and erosion control as required, as well as sedimentation control measures.

At the time of the field investigations, moisture content for the subgrade material tested varied from 4.6% dry to 0.5% wet of standard Optimum Moisture Content (OMC). It should be anticipated that moisture conditioning of the subgrade may be necessary prior to compaction and placement of pavement materials.

The required time period to prepare the subgrade is likely to be dependent on the prevailing weather conditions at the time of construction.

If over-wet subgrades exist at the time of construction or deleterious materials are encountered at subgrade level, these materials should be over-excavated and be replaced with a minimum depth of 250mm of well graded granular select material with CBR of 15% or greater or a 2% cement stabilised subbase material. The requirement for, and extent of subgrade replacement / select filling, should be confirmed by the geotechnical authority at the time of construction.

If the Lime Stabilisation option was to be considered, further testing would be required to confirm percentage of lime required and that adequate increase in CBR could be achieved following mixing.

6.6 Fill Construction Procedures

Earthworks for pavement construction or support of foundations should consist of the following measures:

- Approved fill beneath pavements should be compacted in layers not exceeding 300mm loose thickness to the compaction requirements provided in Table 11;
- The top 300mm of natural subgrade below pavements or the final 300mm of road subgrade fill should be compacted to provide a subgrade that is within the moisture range of 60% to 90% of Optimum Moisture Content (OMC);
- Site fill beneath structures should be compacted to a minimum density ratio of 98% Standard Compaction within ±2% of OMC in cohesive soils;
- All fill should be supported by properly designed and constructed retaining walls or else battered at 1V:2H or flatter and protected against erosion;
- Where fill is to be placed on slopes in excess of 1V:8H (7°), a prepared surface should be benched or stepped into the natural slope; and,
- Earthworks should be carried out in accordance with the recommendations outlined in AS3798-2007 'Guidelines for Earthworks for Commercial and Residential Developments'.

6.7 Suitability of Site Materials for Re-Use as Fill

The following comments are made with respect to suitability of site materials for re-use as fill:

- Unit 1 - Fill materials may be variable. Some fill material may be suitable for landscaping purposes only due to the presence of roots and organics. If fill material is not affected by roots or other deleterious material, it is generally expected to be suitable for re-use as general fill for engineering purposes. Suitability for re-use should be confirmed prior to, or at the time of construction;
- Unit 2 - Topsoil materials are expected to be suitable for landscaping purposes only;
- Unit 3 - Slopewash / Colluvium may be variable and suitability for re-use should be confirmed at the time of construction;
- Unit 4 - Residual Soils are generally expected to be suitable for re-use as general fill for engineering purposes;
- Unit 5 - Extremely Weathered Rock is generally expected to be suitable for re-use as general fill for engineering purposes; and,
- Unit 6 - Highly Weathered Rock are generally expected to be suitable for re-use as general fill for engineering purposes.

Final selection of fill materials should consider properties such as reactivity which is typically moderate to high for site won Unit 4 Residual Soils, and low for site won Unit 5 Extremely Weathered Rock and Unit 6 Highly Weathered Rock.

The suitability of material for re-use should be assessed and confirmed by the geotechnical authority at the time of construction. The materials may require some moisture conditioning.

6.8 Special Construction Requirements and Site Drainage

The enclosed pavement thickness designs assume the provision of adequate surface and subsurface drainage of the pavement and adjacent areas. As a minimum, it is recommended that subsoil drains be installed:

- Along the high side of roads aligned across site slopes;
- Along both sides of roads aligned down slope.

It is recommended that surface and subsoil drainage be installed in line with the above advice, and in accordance with Lake Macquarie City Council (LMCC) specifications.

Adequate surface and subsurface drainage should be installed and connected to the stormwater disposal system.

Inspection should be carried out by a geotechnical authority during construction to confirm the conditions assumed in this report and in the design.

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 locations. It should be noted that subsurface conditions between and away from the test 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.

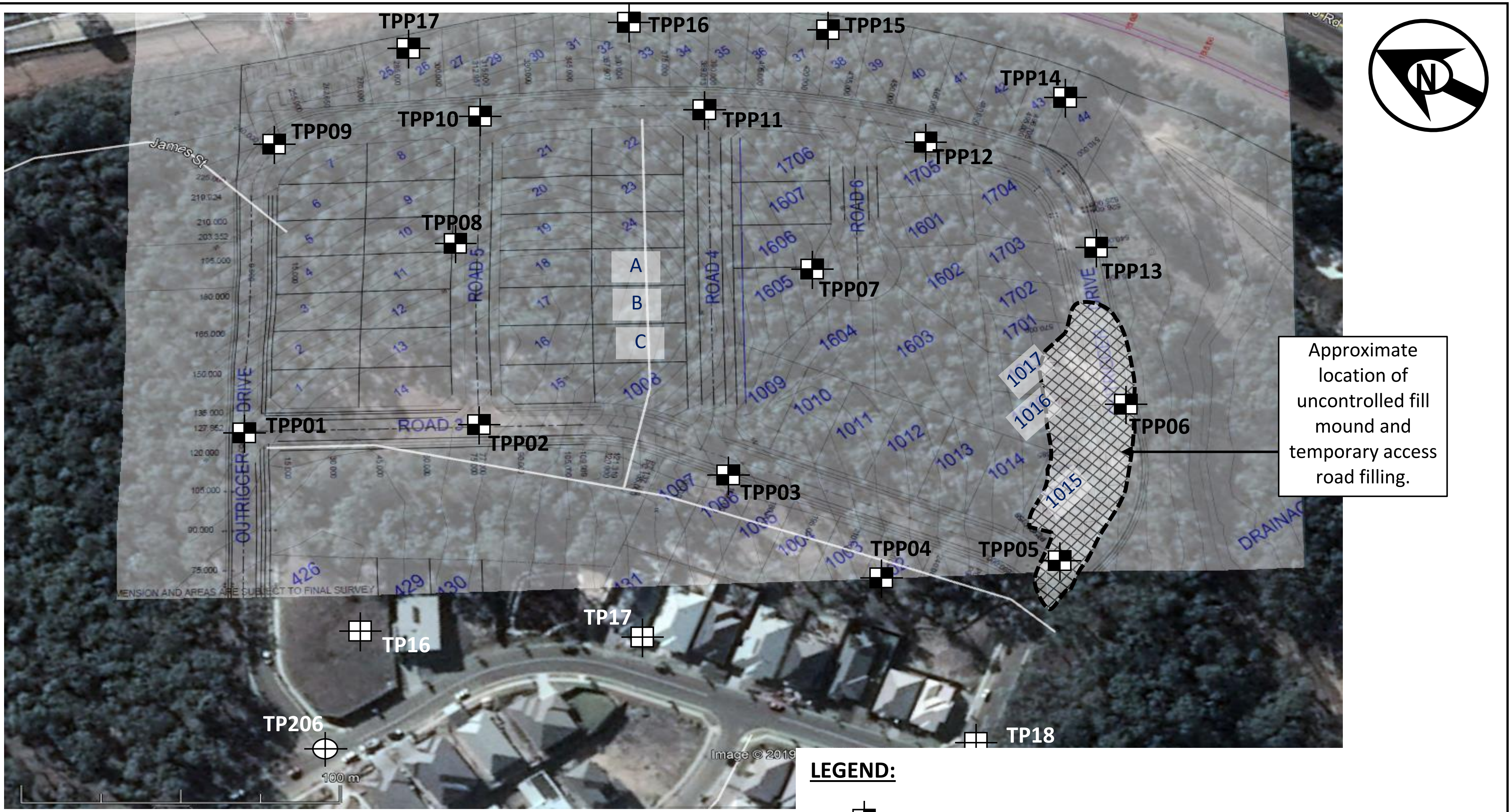
For and on behalf of Qualtest Laboratory (NSW) Pty Ltd.

Jason Lee

Jason Lee
Principal Geotechnical Engineer

FIGURE AA1:

Site Plan and Approximate Test Locations



LEGEND:

⊞	Approximate test pit location (Qualtest, 2019)
⊞	Approximate test pit location (Qualtest, 2015)
⊕	Approximate test pit location (Cardno, 2014)

Based on "Small Lot Housing r4 Option 3" site plan provided by High Definition Design Pty Ltd (Project No. HD16, Dwg No. SH3, Rev. 4, dated 10/07/2019), overlaid approximately on Google Earth image (dated 1/8/2018) by Qualtest.

Qualtest
LABORATORY (NSW) PTY LTD

Client:	MCCLOY GROUP	Drawing No:	FIGURE AA1
Project:	BILLYS LOOKOUT - STAGE 10, 16, & 17	Project No:	NEW15P-0070F
Location:	OUTRIGGER DRIVE, TERALBA	Scale:	AS SHOWN
Title:	SITE PLAN AND APPROXIMATE TEST LOCATIONS	Date:	21/11/2019

APPENDIX A:

Results of Field Investigations

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT:	MCCLOY GROUP	**TEST PIT NO:**	**TPP01**
PROJECT:	BILLYS LOOKOUT - STAGE 10, 16, & 17	**PAGE:**	1 OF 1
LOCATION:	OUTRIGGER DRIVE, TERALBA	**JOB NO:**	NEW15P-0070F
		LOGGED BY:	BB
		DATE:	9/10/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR **SURFACE RL:**
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **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
E	Not Encountered			0.00–0.15m		CL	TOPSOIL: Sandy CLAY - low plasticity, pale grey-brown, fine to medium grained sand, root affected.	M < W_P				TOPSOIL
		0.40m CBR & U50 0.60m		0.15m–0.60m		CH	Sandy CLAY - high plasticity, pale red-brown and pale brown, fine to coarse grained sand, with some fine to medium grained (mostly fine grained) angular gravel, with some roots.		H	HP HP	>600 >600	RESIDUAL SOIL
				0.60m–0.80m		CI	Gravelly Sandy CLAY - medium plasticity, pale brown to pale grey-brown, fine to coarse grained sand, fine to medium grained rounded to sub-rounded gravel.			HP HP	>600 >600	RESIDUAL SOIL / EXTREMELY WEATHERED ROCK
				0.80m–0.85m			CONGLOMERATE - fine to coarse grained, rounded to sub-rounded, pale grey and pale brown, fine to coarse grained sand, estimated medium to high strength.	D				HIGHLY WEATHERED ROCK

Hole Terminated at 0.85 m
Practical Refusal

0.5 1.0 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	

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
PROJECT: BILLYS LOOKOUT - STAGE 10, 16, & 17
LOCATION: OUTRIGGER DRIVE, TERALBA

TEST PIT NO: TPP02
PAGE: 1 OF 1
JOB NO: NEW15P-0070F
LOGGED BY: BB
DATE: 9/10/19

EQUIPMENT TYPE: 2.7 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
E	Not Encountered						0.05m FILL: MULCH	M				FILL - MULCH
						SM	0.10m FILL-TOPSOIL: Silty SAND - fine to medium grained, dark grey-brown, fines of low plasticity.					FILL - TOPSOIL
						CH	CLAY - medium to high plasticity, red-brown to brown, with some fine to medium grained (mostly fine grained) sand.	M ~ W_P	H	HP	>600	RESIDUAL SOIL
							Pale orange-brown and pale grey.			HP	>600	
				0.5			Pale grey.					
							0.60m 0.65m SANDSTONE - fine to medium grained, orange-brown to red-brown and grey, estimated medium strength.	D				HIGHLY WEATHERED ROCK
							Hole Terminated at 0.65 m Practical Refusal					
				1.0								
				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	

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%

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ENGINEERING LOG - TEST PIT

CLIENT:	MCCLOY GROUP	**TEST PIT NO:**	**TPP03**
PROJECT:	BILLYS LOOKOUT - STAGE 10, 16, & 17	**PAGE:**	1 OF 1
LOCATION:	OUTRIGGER DRIVE, TERALBA	**JOB NO:**	NEW15P-0070F
		LOGGED BY:	BB
		DATE:	9/10/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR
SURFACE RL:
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
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	
E	Not Encountered					CL	TOPSOIL: Sandy CLAY - low plasticity, dark grey-brown, fine to medium grained sand, root affected.	D - M				TOPSOIL
		0.45m CBR & U50 0.65m		0.5		CH	0.30m Sandy CLAY - medium to high plasticity, pale grey, fine to coarse grained (mostly fine to medium grained) sand, trace fine to medium grained rounded to sub-rounded gravel, with some roots to 0.65m.	M ~ w_P	VSt - H	HP	350 - 420	RESIDUAL SOIL
									H	HP	450	
										HP	430	
				1.0						HP	>600	
							1.00m 1.05m Pebbly SANDSTONE / CONGLOMERATE - fine to coarse grained, dark grey with some orange-brown, fine to coarse grained (mostly fine to medium grained) rounded gravel, estimated medium strength.	D				HIGHLY WEATHERED ROCK
							Hole Terminated at 1.05 m Practical 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	

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
PROJECT: BILLYS LOOKOUT - STAGE 10, 16, & 17
LOCATION: OUTRIGGER DRIVE, TERALBA

TEST PIT NO: TPP04
PAGE: 1 OF 1
JOB NO: NEW15P-0070F
LOGGED BY: BB
DATE: 9/10/19

EQUIPMENT TYPE: 2.7 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
E	Not Encountered					SM	TOPSOIL: Silty SAND - fine to medium grained, dark grey-brown to grey-brown, fines of low plasticity, root affected.	M				TOPSOIL
				0.35m 0.5		CH	Sandy CLAY - medium to high plasticity, pale brown to pale orange-brown, fine to medium grained sand, with some roots to 0.80m.	M ~ W_P	H	HP HP HP HP	>600 >600 >600 >600	RESIDUAL SOIL
				0.80m 1.0		CI	Sandy CLAY - medium plasticity, pale grey with some pale brown, fine to coarse grained sand, with some fine grained rounded to sub-rounded gravel.			HP HP	>600 >600	
				1.05m			Pebbly SANDSTONE / CONGLOMERATE - fine to coarse grained sand, pale grey and orange-brown, fine to coarse grained (mostly fine grained) rounded gravel, estimated medium strength.	D				HIGHLY WEATHERED ROCK
				1.15m 1.5 2.0			Hole Terminated at 1.15 m Practical Refusal					

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

Qualtest LABORATORY (NSW) PTY LTD

CLIENT: MCCLOY GROUP
PROJECT: BILLYS LOOKOUT - STAGE 10, 16, & 17
LOCATION: OUTRIGGER DRIVE, TERALBA

TEST PIT NO: **TPP05**
PAGE: 1 OF 1
JOB NO: NEW15P-0070F
LOGGED BY: BB
DATE: 9/10/19

EQUIPMENT TYPE: 2.7 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	
E	Not Encountered			0.5		GC	FILL: Clayey Sandy GRAVEL - fine to coarse grained (mostly fine to medium grained) rounded to sub-rounded, pale orange-brown, fine to coarse grained sand, fines of low to medium plasticity.	M				FILL - GRAVEL ACCESS ROAD
				0.80m		CI	FILL: Gravelly CLAY - medium plasticity, dark grey-brown, fine to medium grained rounded to sub-rounded gravel.	M ~ W_P				FILL
		1.00m CBR & U50 1.20m		0.90m 1.0		CI	Gravelly Sandy CLAY - medium plasticity, pale grey and pale orange-brown, fine to coarse grained (mostly fine to medium grained) sand, fine to medium grained (mostly fine grained) rounded to sub-rounded gravel.		H	HP HP	480 520	RESIDUAL SOIL
				1.30m 1.5		CI	Sandy CLAY - medium plasticity, pale grey and pale orange-brown, fine to medium grained sand.	M > W_P	VSt	HP HP	350 380	
								M ~ W_P	H	HP	>600	
				1.90m 1.95m		CI	Extremely Weathered Silty Sandstone with soil properties; breaks down into Sandy CLAY - medium plasticity, grey, fine to coarse grained (mostly fine to medium grained) sand.	D				EXTREMELY WEATHERED ROCK
				2.0			Hole Terminated at 1.95 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

Qualtest LABORATORY (NSW) PTY LTD

CLIENT: MCCLOY GROUP
PROJECT: BILLYS LOOKOUT - STAGE 10, 16, & 17
LOCATION: OUTRIGGER DRIVE, TERALBA

TEST PIT NO: TPP06
PAGE: 1 OF 1
JOB NO: NEW15P-0070F
LOGGED BY: BB
DATE: 9/10/19

EQUIPMENT TYPE: 2.7 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
E	Not Encountered			0.5		GC	FILL: Clayey Sandy GRAVEL - fine to coarse grained (mostly fine to medium grained) angular to sub-angular, pale brown, fine to coarse grained sand, fines of low to medium plasticity.	M				FILL - GRAVEL ACCESS ROAD
				0.60m		CL	Sandy CLAY - low plasticity, grey with some pale brown, fine to coarse grained (mostly fine grained) sand, trace fine to medium grained sub-angular to sub-rounded gravel, with some roots.	M ~ w_P	VSt	HP	350	COLLUVIUM
				0.80m		CI	Sandy CLAY - medium plasticity, orange-brown red-brown and pale grey to grey, fine to medium grained sand, trace fine to medium grained sub-angular gravel.		VSt - H	HP HP HP	340 410 380	RESIDUAL SOIL
				1.0 1.5					H	HP HP HP	420 500 >600	
				1.60m 2.0		CH	Extremely Weathered Silty Sandstone with soil properties; breaks down into Sandy CLAY - medium to high plasticity, red-brown and grey, fine to medium grained sand.	M < w_P				EXTREMELY WEATHERED ROCK / RESIDUAL SOIL
				2.05m			Hole Terminated at 2.05 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
PROJECT: BILLYS LOOKOUT - STAGE 10, 16, & 17
LOCATION: OUTRIGGER DRIVE, TERALBA

TEST PIT NO: TPP07
PAGE: 1 OF 1
JOB NO: NEW15P-0070F
LOGGED BY: BB
DATE: 9/10/19

EQUIPMENT TYPE: 2.7 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)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
E	Not Encountered			0.20m	SM	TOPSOIL: Silty SAND - fine to medium grained, grey-brown, fines of low plasticity, root affected.	D - M				TOPSOIL
				0.40m	CL	Sandy CLAY - low to medium plasticity, grey-brown to dark grey-brown, fine to medium grained (mostly fine grained) sand, with some roots.	M < W_P	H	HP	>600	COLLUVIUM
		0.70m U50 0.80m 0.80m CBR 0.90m		0.5 0.95m	CH	Sandy CLAY - medium to high plasticity, pale brown to brown, fine to medium grained sand. Pockets of Extremely Weathered Sandstone.			HP HP HP HP	>600 >600 >600 >600	RESIDUAL SOIL
				1.0 1.10m	SP	Extremely Weathered Sandstone with soil properties; breaks down into SAND - fine to medium grained, pale brown to pale orange-brown and pale grey, with some fines of low plasticity.	D	VD			EXTREMELY WEATHERED ROCK
				1.15m		SANDSTONE - fine to medium grained, dark grey with some orange-brown, estimated low to medium strength.					HIGHLY WEATHERED ROCK
				1.5 2.0		Hole Terminated at 1.15 m Practical Refusal					

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%

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LABORATORY (NSW) PTY LTD

ENGINEERING LOG - TEST PIT

CLIENT:	MCCLOY GROUP	**TEST PIT NO:**	**TPP08**
PROJECT:	BILLYS LOOKOUT - STAGE 10, 16, & 17	**PAGE:**	1 OF 1
LOCATION:	OUTRIGGER DRIVE, TERALBA	**JOB NO:**	NEW15P-0070F
		LOGGED BY:	BB
		DATE:	9/10/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR
SURFACE RL:
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
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	
E	Not Encountered					SM	TOPSOIL: Silty SAND - fine to coarse grained (mostly fine to medium grained), grey-brown, fines of low plasticity, root affected.	D - M				TOPSOIL
		0.50m CBR 0.70m		0.5		GM	0.40m Extremely Weathered Conglomerate; breaks down into Silty Sandy GRAVEL - fine to coarse grained rounded, pale brown, fine to coarse grained sand, fines of low plasticity, with some roots to 0.55m.		VD			EXTREMELY WEATHERED ROCK
							0.70m 0.75m CONGLOMERATE - fine to coarse grained, rounded to sub-rounded, dark grey with some orange-brown, fine to coarse grained sand, estimated medium to high strength.	D				HIGHLY TO MODERATELY WEATHERED ROCK
				1.0			Hole Terminated at 0.75 m Practical 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	

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%

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ENGINEERING LOG - TEST PIT

CLIENT:	MCCLOY GROUP	**TEST PIT NO:**	**TPP09**
PROJECT:	BILLYS LOOKOUT - STAGE 10, 16, & 17	**PAGE:**	1 OF 1
LOCATION:	OUTRIGGER DRIVE, TERALBA	**JOB NO:**	NEW15P-0070F
		LOGGED BY:	BB
		DATE:	9/10/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR **SURFACE RL:**
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **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
E	Not Encountered					CL	TOPSOIL: Sandy CLAY - low plasticity, grey-brown, fine to medium sand, root affected.	M < W_P				TOPSOIL
		0.35m CBR 0.50m		0.5		CI	0.15m Sandy CLAY - medium plasticity, grey to grey-brown, fine to coarse grained (mostly fine to medium grained) sand, with some roots to 0.50m. Pockets of Highly Weathered Silty SANDSTONE.		H	HP HP HP HP	>600 >600 >600 >600	RESIDUAL SOIL
				1.0 1.5		CI	0.90m Extremely Weathered Silty Sandstone with soil properties; breaks down into Sandy CLAY - medium plasticity, pale grey to pale brown, fine to medium grained sand.					EXTREMELY WEATHERED ROCK
				2.0			1.85m Hole Terminated at 1.85 m Slow progress					

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	**TEST PIT NO:**	**TPP10**
PROJECT:	BILLYS LOOKOUT - STAGE 10, 16, & 17	**PAGE:**	1 OF 1
LOCATION:	OUTRIGGER DRIVE, TERALBA	**JOB NO:**	NEW15P-0070F
		LOGGED BY:	BB
		DATE:	9/10/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR **SURFACE RL:**
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **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
E	Not Encountered					CL	TOPSOIL: Sandy CLAY - low plasticity, pale grey-brown, fine to medium grained sand, root affected.	$M < w_P$				TOPSOIL
		0.25m U50 0.55m		0.5		CI	0.20m Sandy CLAY - medium plasticity, pale brown with some pale orange-brown, fine to coarse grained (mostly fine to medium grained) sand, with some roots to 0.50m.	$M \sim w_P$	H	HP HP HP HP HP HP	>600 >600 >600 >600 >600 >600	RESIDUAL SOIL
				1.0		SP	0.80m Extremely Weathered Sandstone with soil properties; breaks down into SAND - fine to medium grained, brown to pale brown, trace fines of low plasticity.	D	VD			EXTREMELY WEATHERED ROCK
							1.10m SANDSTONE - fine to coarse grained, brown, estimated low strength. 1.20m					HIGHLY WEATHERED ROCK
				1.5 2.0			Hole Terminated at 1.20 m Practical Refusal					

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%

Qualtest
LABORATORY (NSW) PTY LTD

ENGINEERING LOG - TEST PIT

CLIENT: MCCLOY GROUP
PROJECT: BILLYS LOOKOUT - STAGE 10, 16, & 17
LOCATION: OUTRIGGER DRIVE, TERALBA

TEST PIT NO: TPP11
PAGE: 1 OF 1
JOB NO: NEW15P-0070F
LOGGED BY: BB
DATE: 9/10/19

EQUIPMENT TYPE: 2.7 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
E	Not Encountered					SM	TOPSOIL: Silty SAND - fine to medium grained, pale grey, fines of low plasticity, root affected.	D				TOPSOIL
		0.50m CBR 0.70m		0.20m 0.5		CI	Sandy CLAY - medium plasticity, pale brown, fine to medium grained sand, with some roots to 0.70m. Pale orange-brown and pale grey.	$M \sim W_P$	H	HP HP HP HP HP	>600 >600 >600 >600 >600	RESIDUAL SOIL
				0.80m 1.0		CI	Extremely Weathered Sandstone with soil properties; breaks down into Sandy CLAY / Clayey SAND - medium plasticity, orange-brown and pale grey, fine to medium grained sand.	$M < W_P$				EXTREMELY WEATHERED ROCK
				1.00m			SANDSTONE - fine to medium grained, pale orange-brown to orange-brown with some pale grey, estimated low to medium strength.	D				HIGHLY WEATHERED ROCK
				1.10m 1.5 2.0			Hole Terminated at 1.10 m Practical Refusal					

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%

Qualtest LABORATORY (NSW) PTY LTD

ENGINEERING LOG - TEST PIT

CLIENT:	MCCLOY GROUP	**TEST PIT NO:**	**TPP12**
PROJECT:	BILLYS LOOKOUT - STAGE 10, 16, & 17	**PAGE:**	1 OF 1
LOCATION:	OUTRIGGER DRIVE, TERALBA	**JOB NO:**	NEW15P-0070F
		LOGGED BY:	BB
		DATE:	9/10/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR **SURFACE RL:**
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **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
E	Not Encountered					CL	FILL-TOPSOIL: Sandy CLAY - low plasticity, pale grey-brown, fine to medium grained (mostly fine grained) sand, root affected.	$M < W_P$				FILL - TOPSOIL
				0.15m		GM	FILL: Silty Sandy GRAVEL - fine to medium grained sub-angular to sub-rounded, pale grey, fine to coarse grained (mostly fine to medium grained) sand, fines of low plasticity.	D				FILL / POSSIBLE SLOPEWASH
		0.30m CBR & U50 0.50m		0.25m 0.5		CH	Sandy CLAY - medium to high plasticity, pale brown with some orange-brown and grey-brown, fine to medium grained sand, with some roots to 0.50m.	$M \sim W_P$	H	HP HP HP HP HP	>600 >600 >600 >600 >600	RESIDUAL SOIL
				0.90m 1.0		SC	Extremely Weathered Sandstone with soil properties; breaks down into Clayey SAND - fine to medium grained, orange-brown and pale grey with some red-brown, fines of low to medium plasticity.	D	VD			EXTREMELY WEATHERED ROCK
				1.10m 1.15m			SANDSTONE - fine to medium grained, brown to red-brown with some pale grey, estimated low to medium strength.					HIGHLY WEATHERED ROCK
				1.5 2.0			Hole Terminated at 1.15 m Practical Refusal					

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	**TEST PIT NO:**	**TPP13**
PROJECT:	BILLYS LOOKOUT - STAGE 10, 16, & 17	**PAGE:**	1 OF 1
LOCATION:	OUTRIGGER DRIVE, TERALBA	**JOB NO:**	NEW15P-0070F
		LOGGED BY:	BB
		DATE:	9/10/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR
SURFACE RL:
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
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	
E	Not Encountered			0.10m		SM	TOPSOIL: Silty SAND - fine to medium grained, grey-brown, fines of low plasticity, root affected.	D - M				TOPSOIL / POSSIBLE FILL
				0.20m		GM	Silty Sandy GRAVEL - fine to medium grained rounded to sub-angular, grey to grey-brown, fine to coarse grained sand, fines of low plasticity.					SLOPE WASH / POSSIBLE FILL
		0.40m CBR 0.60m		0.5 1.0 1.20m		CH	Sandy CLAY - medium to high plasticity, pale grey and pale orange-brown, fine to coarse grained (mostly fine to medium grained) sand, with some fine to medium grained sub-rounded to sub-angular gravel, with some roots to 0.50m.	M ~ w_P	VSt - H H	HP HP HP HP HP HP HP HP HP	350 380 350 350 430 380 500 >600 >600	RESIDUAL SOIL
				1.5 1.50m		CI	Extremely Weathered Sandstone with soil properties; breaks down into Sandy CLAY / Clayey SAND - medium plasticity, pale orange-brown and pale grey, fine to medium grained sand.					EXTREMELY WEATHERED ROCK
				1.60m			SANDSTONE - fine to medium grained, pale orange-brown to orange-brown and pale grey, estimated low to medium strength.	D				HIGHLY WEATHERED ROCK
				2.0			Hole Terminated at 1.60 m Practical Refusal					

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
PROJECT: BILLYS LOOKOUT - STAGE 10, 16, & 17
LOCATION: OUTRIGGER DRIVE, TERALBA

TEST PIT NO: TPP14
PAGE: 1 OF 1
JOB NO: NEW15P-0070F
LOGGED BY: BB
DATE: 9/10/19

EQUIPMENT TYPE: 2.7 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
E	Not Encountered						FILL: MULCH					FILL - MULCH
				0.10m		SC	FILL-TOPSOIL: Clayey SAND - fine to medium grained, dark brown, low to medium plasticity, root affected.	M				FILL - TOPSOIL
				0.40m 0.5 1.0 1.5		CH	Sandy CLAY - medium to high plasticity, pale brown with some pale grey, fine to medium grained sand, with some fine to medium grained sub-rounded to sub-angular gravel, with some roots to 0.80m.	M ~ W_P	H	HP HP HP HP HP HP HP	>600 >600 >600 >600 >600 >600 >600	RESIDUAL SOIL
				1.60m		SC	Extremely Weathered Sandstone with soil properties; breaks down into Clayey SAND - fine to medium grained, pale brown, fines of low plasticity.	D	VD			EXTREMELY WEATHERED ROCK
				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

Qualtest LABORATORY (NSW) PTY LTD

CLIENT:	MCCLOY GROUP	**TEST PIT NO:**	**TPP15**
PROJECT:	BILLYS LOOKOUT - STAGE 10, 16, & 17	**PAGE:**	1 OF 1
LOCATION:	OUTRIGGER DRIVE, TERALBA	**JOB NO:**	NEW15P-0070F
		LOGGED BY:	BB
		DATE:	9/10/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR **SURFACE RL:**

TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **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
E	Not Encountered						0.05m FILL: MULCH	M				FILL - MULCH
						CL	TOPSOIL: Sandy CLAY - low to medium plasticity, grey to dark grey, fine to medium grained sand.					TOPSOIL
						CI	0.20m Sandy CLAY - medium plasticity, pale brown, fine to medium grained sand, with some roots to 0.80m.	M > W_P	VSt	HP HP HP HP HP HP	250 290 320 350 350 500	RESIDUAL SOIL
				0.5								
				1.0			Pale brown with some orange-brown and pale grey.	M ~ W_P	H	HP HP	>600 >600	
						SC	1.10m Extremely Weathered Sandstone with soil properties; breaks down into Clayey SAND - fine to medium grained, pale grey and orange-brown, fines of low to medium plasticity.	D	VD			EXTREMELY WEATHERED ROCK
				1.5								
							1.65m SANDSTONE - fine to medium grained, pale brown with some pale orange-brown and pale grey, estimated low to medium strength.					HIGHLY WEATHERED ROCK
							1.70m Hole Terminated at 1.70 m Practical Refusal					
				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	

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%

Qualtest
LABORATORY (NSW) PTY LTD

ENGINEERING LOG - TEST PIT

CLIENT: MCCLOY GROUP
PROJECT: BILLYS LOOKOUT - STAGE 10, 16, & 17
LOCATION: OUTRIGGER DRIVE, TERALBA

TEST PIT NO: TPP16
PAGE: 1 OF 1
JOB NO: NEW15P-0070F
LOGGED BY: BB
DATE: 9/10/19

EQUIPMENT TYPE: 2.7 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
E	Not Encountered			0.05m	▩		FILL: MULCH					FILL - MULCH
				0.20m	▩	GC	FILL: Clayey GRAVEL - fine rounded to sub-rounded, grey, fines of low to medium plasticity.	M				FILL
				0.30m	▨	CH	Sandy CLAY - medium to high plasticity, red-brown, fine to coarse grained (mostly fine to medium grained) sand.	M ~ w_P	H	HP	>600	RESIDUAL SOIL
					▨	CI	Sandy CLAY - medium plasticity, pale brown to pale orange-brown, fine to medium grained (mostly fine grained) sand, with some roots to 0.80m.			HP	>600	
				0.5						HP	>600	
										HP	>600	
										HP	>600	
										HP	>600	
				1.0						HP	>600	
				1.20m						HP	>600	
				1.45m	▧	SC	Extremely Weathered Sandstone with soil properties; breaks down into Clayey SAND - fine to medium grained, pale brown, fines of low to medium plasticity.	D	VD			EXTREMELY WEATHERED ROCK
				1.5 1.55m	░		SANDSTONE - fine to medium grained, pale brown and pale grey to white, estimated low to medium strength.					HIGHLY WEATHERED ROCK
							Hole Terminated at 1.55 m Practical Refusal					
				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	

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%

Qualtest
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ENGINEERING LOG - TEST PIT

CLIENT:	MCCLOY GROUP	**TEST PIT NO:**	**TPP17**
PROJECT:	BILLYS LOOKOUT - STAGE 10, 16, & 17	**PAGE:**	1 OF 1
LOCATION:	OUTRIGGER DRIVE, TERALBA	**JOB NO:**	NEW15P-0070F
		LOGGED BY:	BB
		DATE:	9/10/19

EQUIPMENT TYPE: 2.7 TONNE EXCAVATOR
SURFACE RL:
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
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	
E	Not Encountered						FILL: MULCH 0.05m	M				FILL - MULCH
						CL	TOPSOIL: Sandy CLAY - low to medium plasticity, dark grey, fine to coarse grained (mostly fine to medium grained) sand, trace fine to medium grained sub-rounded to sub-angular gravel. 0.15m	M > W_P				TOPSOIL
						CI	Sandy CLAY - medium plasticity, pale brown trace grey, fine to medium grained sand.	M ~ W_P	VSt - H	HP	380 - 420	RESIDUAL SOIL
									H	HP	450	
										HP	490	
				0.5						HP	>600	
							Pale brown with some pale orange-brown.			HP	>600	
										HP	>600	
										HP	>600	
				1.0			1.00m			HP	>600	
						SC	Extremely Weathered Sandstone with soil properties; breaks down into Clayey SAND - fine to medium grained, pale brown and pale orange-brown with some pale grey, fines of low plasticity. 1.25m	D	VD			EXTREMELY WEATHERED ROCK
							SANDSTONE - fine to coarse grained (mostly fine to medium grained), pale brown, estimated low to medium strength. 1.40m					HIGHLY WEATHERED ROCK
							Hole Terminated at 1.40 m Practical 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	

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%

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: MAT:NEW19W-3457--S01
Issue No: 1

Material Test Report

Client:	McCloy Development Management Pty Ltd Suite 2, Ground Floor, 317 Hunter Street Newcastle NSW 2300
Principal:	
Project No.:	NEW15P-0070F
Project Name:	Billy's Lookout - Stages 10, 16 & 17

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.

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 28/10/2019

Sample Details

Sample ID:	NEW19W-3457--S01
Sampling Method:	Sampled by Engineering Department
Date Sampled:	09/10/2019
Source:	On-Site
Material:	Sandy CLAY
Specification:	No Specification
Project Location:	Teralba, NSW
Sample Location:	TP01 - 0.40 to 0.60m

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	10.5	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	73	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	26	
Plasticity Index (%)	AS 1289.3.3.1	47	

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

Report No: MAT:NEW19W-3457--S04
Issue No: 1

Material Test Report

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

Principal:
Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 10, 16 & 17

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 28/10/2019

Sample Details

Sample ID:	NEW19W-3457--S04
Sampling Method:	Sampled by Engineering Department
Date Sampled:	09/10/2019
Source:	On-Site
Material:	Sandy CLAY
Specification:	No Specification
Project Location:	Teralba, NSW
Sample Location:	TP07 - 0.70 to 0.80m

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	5.0	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	32	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	18	
Plasticity Index (%)	AS 1289.3.3.1	14	

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

Report No: SSI:NEW19W-3457--S02
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-0070F
Project Name:	Billy's Lookout - Stages 10, 16 & 17

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 18/10/2019

Sample Details

Sample ID:	NEW19W-3457--S02	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Sandy CLAY	**Date Sampled:**	9/10/2019
Source:	On-Site	**Date Submitted:**	10/10/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP03 - 0.45 to 0.65m		
Borehole Number:	TP03		
Borehole Depth (m):	0.45 - 0.65		

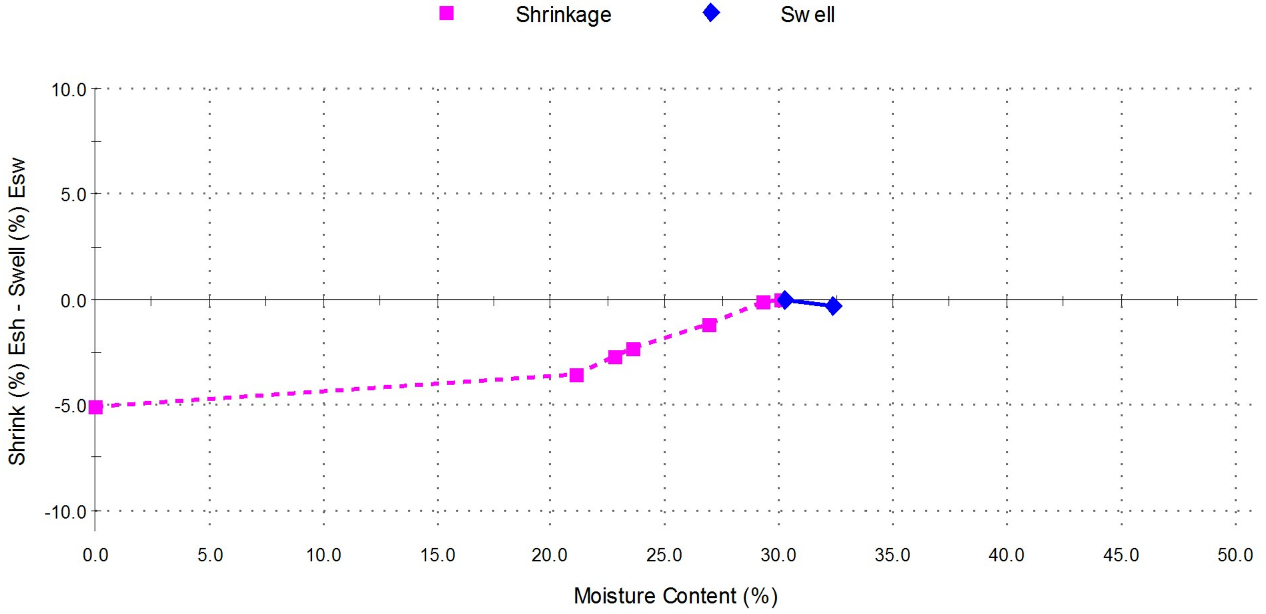
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.3
Moisture Content before (%):	30.3
Moisture Content after (%):	32.4
Est. Unc. Comp. Strength before (kPa):	190
Est. Unc. Comp. Strength after (kPa):	100

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	5.1
Shrinkage Moisture Content (%):	30.1
Est. inert material (%):	5.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Moderate

Shrink Swell



Shrink Swell Index - Iss (%): 2.9

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-3457--S03
Issue No: 1

Client:	McCloy Development Management Pty Ltd Suite 2, Ground Floor, 317 Hunter Street Newcastle NSW 2300
Principal:	
Project No.:	NEW15P-0070F
Project Name:	Billy's Lookout - Stages 10, 16 & 17

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 16/10/2019

Sample Details

Sample ID:	NEW19W-3457--S03	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Gravelly Sandy CLAY	**Date Sampled:**	9/10/2019
Source:	On-Site	**Date Submitted:**	10/10/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP05 - 1.00 to 1.20m		
Borehole Number:	TP05		
Borehole Depth (m):	1.00 - 1.20		

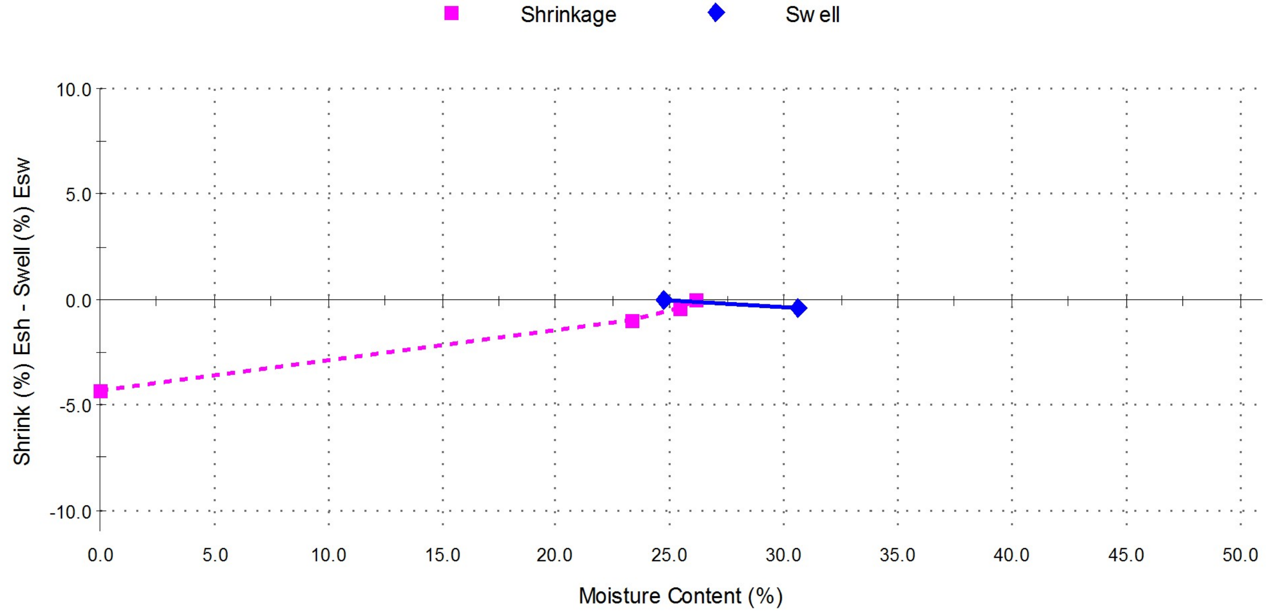
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.4
Moisture Content before (%):	24.7
Moisture Content after (%):	30.6
Est. Unc. Comp. Strength before (kPa):	320
Est. Unc. Comp. Strength after (kPa):	190

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	4.3
Shrinkage Moisture Content (%):	26.1
Est. inert material (%):	10.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 2.4

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-3457--S05
Issue No: 1

Client:	McCloy Development Management Pty Ltd Suite 2, Ground Floor, 317 Hunter Street Newcastle NSW 2300
Principal:	
Project No.:	NEW15P-0070F
Project Name:	Billy's Lookout - Stages 10, 16 & 17

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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.
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NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 18/10/2019

Sample Details

Sample ID:	NEW19W-3457--S05	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Sandy CLAY	**Date Sampled:**	9/10/2019
Source:	On-Site	**Date Submitted:**	10/10/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP10 - 0.25 to 0.55m		
Borehole Number:	TP10		
Borehole Depth (m):	0.25 - 0.55		

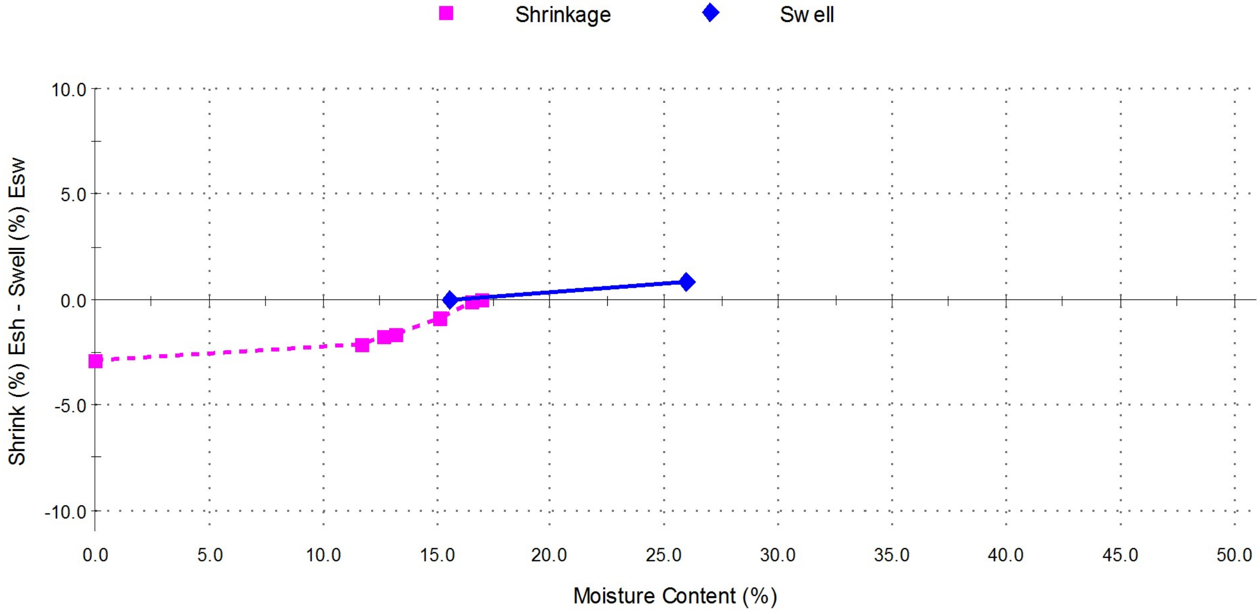
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	0.8
Moisture Content before (%):	15.5
Moisture Content after (%):	25.9
Est. Unc. Comp. Strength before (kPa):	> 600
Est. Unc. Comp. Strength after (kPa):	190

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	2.9
Shrinkage Moisture Content (%):	17.0
Est. inert material (%):	5.0
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-3457--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-0070F
Project Name:	Billy's Lookout - Stages 10, 16 & 17

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 25/10/2019

Sample Details

Sample ID:	NEW19W-3457--S06	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	Sampled by Engineering Department
Material:	Sandy CLAY	**Date Sampled:**	9/10/2019
Source:	On-Site	**Date Submitted:**	10/10/2019
Specification:	No Specification		
Project Location:	Teralba, NSW		
Sample Location:	TP12 - 0.30 to 0.50m		
Borehole Number:	TP12		
Borehole Depth (m):	0.30 - 0.50		

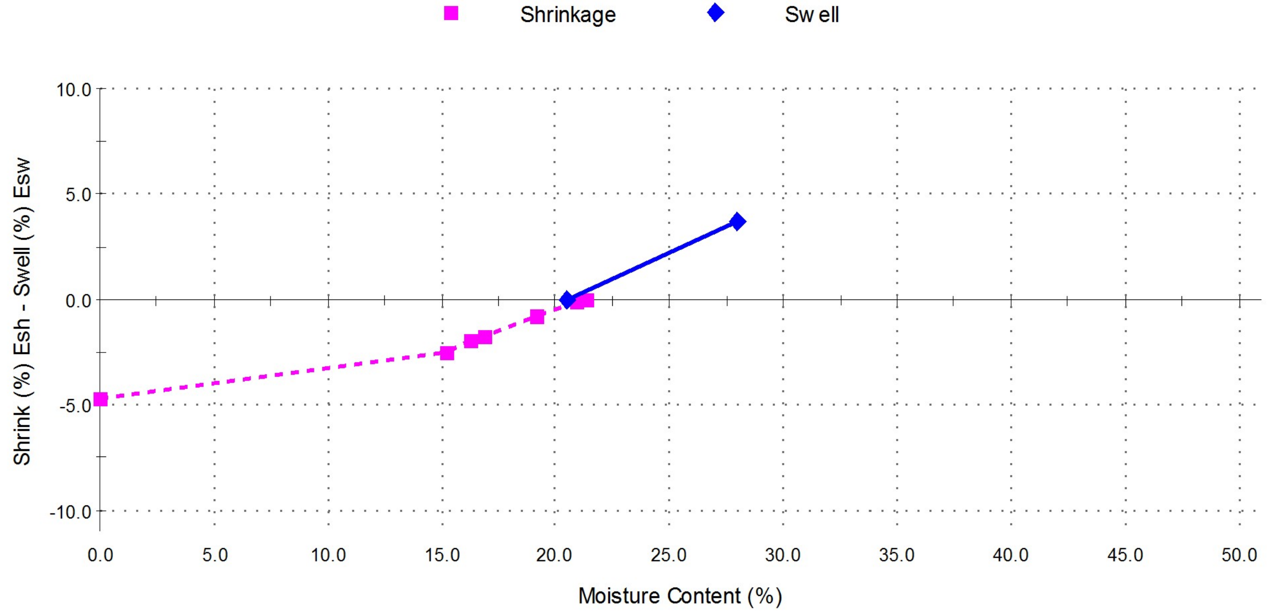
Swell Test — AS 1289.7.1.1

Swell on Saturation (%):	3.7
Moisture Content before (%):	20.5
Moisture Content after (%):	27.9
Est. Unc. Comp. Strength before (kPa):	580
Est. Unc. Comp. Strength after (kPa):	110

Shrink Test — AS 1289.7.1.1

Shrink on drying (%):	4.7
Shrinkage Moisture Content (%):	21.4
Est. inert material (%):	5.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Nil

Shrink Swell



Shrink Swell Index - Iss (%): 3.6

Comments

The results outlined above apply to the sample as received

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ABN: 98 153 268 896

Report No: CBR:NEW19W-3485--S01
Issue No: 1

California Bearing Ratio Test Report

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

Principal:
Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 10, 16 & 17

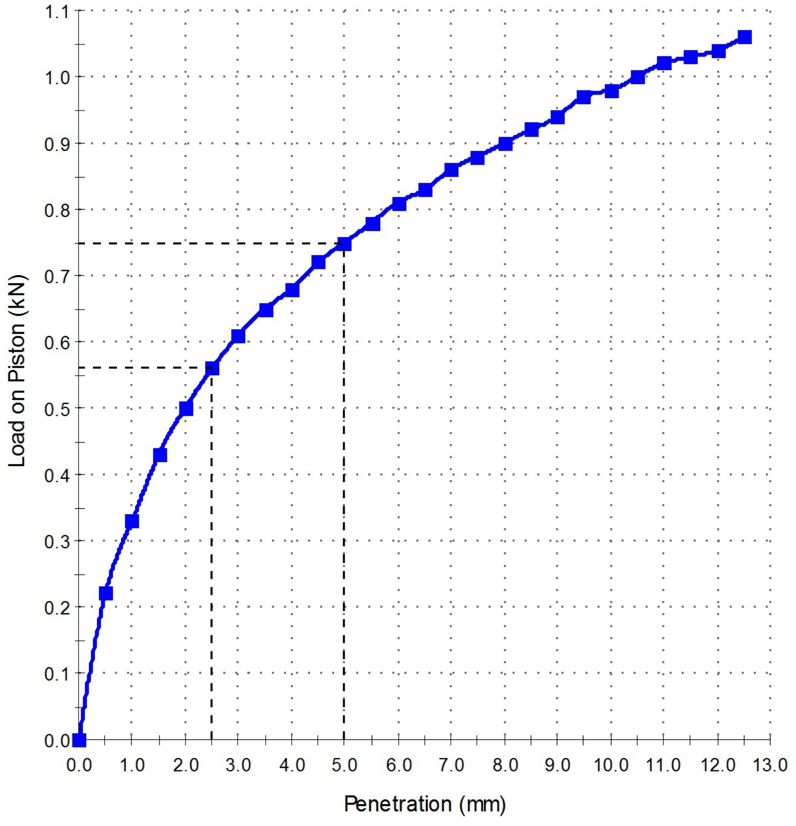
NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 22/10/2019

Sample Details

Sample ID: NEW19W-3485--S01
Date Sampled: 9/10/2019
Sampling Method: Sampled by Engineering Department
Specification: No Specification
Source: On-Site
Location: TP01 - 0.40 to 0.60m
Material: Sandy CLAY
Project Location: Teralba, NSW

Load vs Penetration



Test Results

AS 1289.6.1.1 - 2014

CBR At 2.5mm (%):	**4.0**
Maximum Dry Density (t/m³):	1.54
Optimum Moisture Content (%):	24.0
Dry Density before Soaking (t/m³):	1.54
Density Ratio before Soaking (%):	100.0
Moisture Content before Soaking (%):	23.6
Moisture Ratio before Soaking (%):	99.5
Dry Density after Soaking (t/m³):	1.52
Density Ratio after Soaking (%):	99.0
Swell (%):	1.5
Moisture Content of Top 30mm (%):	30.2
Moisture Content of Remaining Depth (%):	27.2
Compactive Effort:	Standard AS 1289.5.1.1
Surcharge Mass (kg):	9.00
Period of Soaking (Days):	4
Oversize Material:	Excluded
Oversize Material (%):	2
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Moisture Content	AS 1289.2.1.1
Field Moisture Content (%):	20.8
Curing Time (hrs) :	120

Comments

Method of establishing plasticity level: Visual Assessment
The results outlined above apply to the sample as received

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Report No: CBR:NEW19W-3485--S02
Issue No: 1

California Bearing Ratio Test Report

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

Principal:
Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 10, 16 & 17

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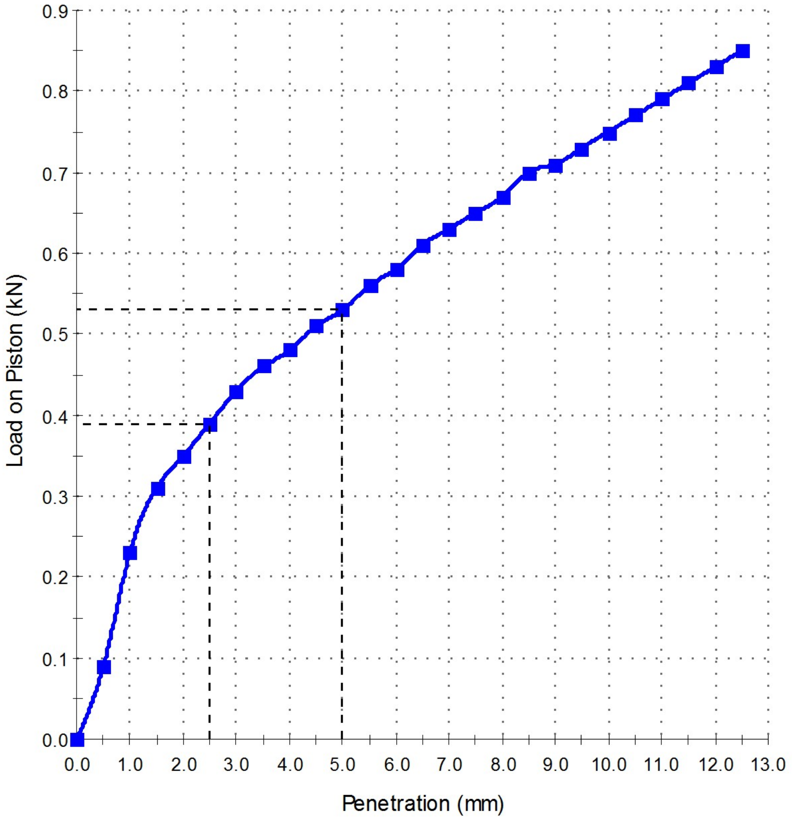
Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 23/10/2019

Sample Details

Sample ID:	NEW19W-3485--S02	**Date Sampled:**	9/10/2019
Sampling Method:	Sampled by Engineering Department		
Specification:	No Specification	**Source:**	On-Site
Location:	TP03 - 0.45 to 0.65m	**Material:**	Sandy CLAY
Project Location:	Teralba, NSW		

Load vs Penetration



Test Results

AS 1289.6.1.1 - 2014

CBR At 2.5mm (%):	**3.0**
Maximum Dry Density (t/m³):	1.52
Optimum Moisture Content (%):	26.5
Dry Density before Soaking (t/m³):	1.52
Density Ratio before Soaking (%):	100.0
Moisture Content before Soaking (%):	26.4
Moisture Ratio before Soaking (%):	100.0
Dry Density after Soaking (t/m³):	1.49
Density Ratio after Soaking (%):	98.0
Swell (%):	2.0
Moisture Content of Top 30mm (%):	33.1
Moisture Content of Remaining Depth (%):	26.5
Compactive Effort:	Standard AS 1289.5.1.1
Surcharge Mass (kg):	9.00
Period of Soaking (Days):	4
Oversize Material (%):	0
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Moisture Content	AS 1289.2.1.1
Field Moisture Content (%):	26.5
Curing Time (hrs) :	120

Comments

Method of establishing plasticity level: Visual Assessment
The results outlined above apply to the sample as received

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Report No: CBR:NEW19W-3485--S03
Issue No: 1

California Bearing Ratio Test Report

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

Principal:
Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 10, 16 & 17

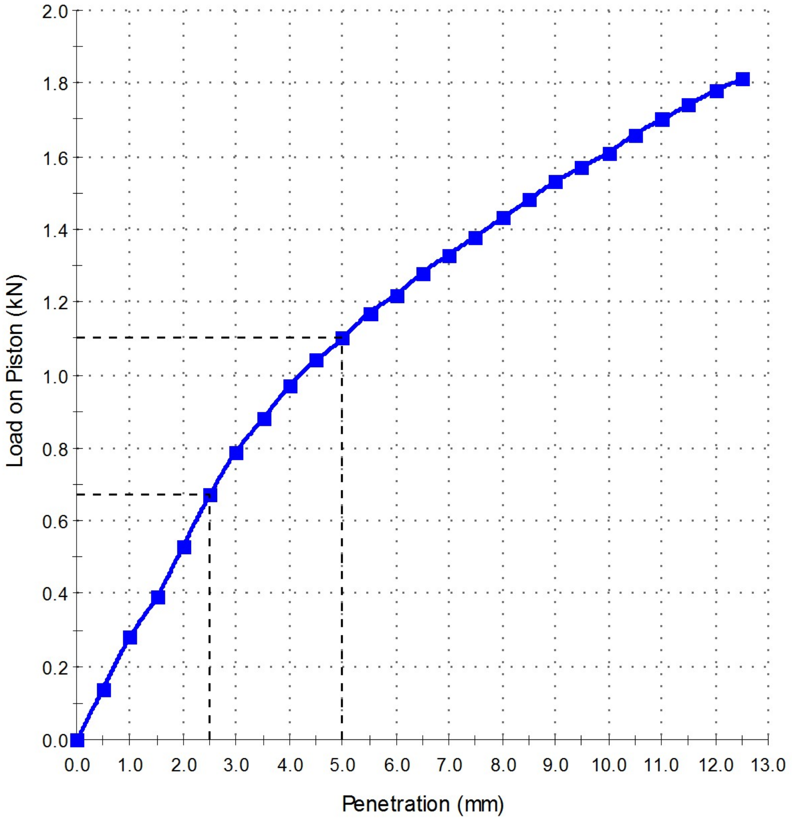
NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 22/10/2019

Sample Details

Sample ID: NEW19W-3485--S03
Date Sampled: 9/10/2019
Sampling Method: Sampled by Engineering Department
Specification: No Specification
Source: On-Site
Location: TP07 - 0.80 to 0.90m
Material: Sandy CLAY
Project Location: Teralba, NSW

Load vs Penetration



Test Results

AS 1289.6.1.1 - 2014

CBR At 5.0mm (%):	**6**
Maximum Dry Density (t/m³):	1.77
Optimum Moisture Content (%):	15.0
Dry Density before Soaking (t/m³):	1.76
Density Ratio before Soaking (%):	99.5
Moisture Content before Soaking (%):	15.0
Moisture Ratio before Soaking (%):	100.0
Dry Density after Soaking (t/m³):	1.75
Density Ratio after Soaking (%):	99.0
Swell (%):	0.5
Moisture Content of Top 30mm (%):	23.5
Moisture Content of Remaining Depth (%):	17.0
Compactive Effort:	Standard AS 1289.5.1.1
Surcharge Mass (kg):	9.00
Period of Soaking (Days):	4
Oversize Material (%):	0
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Moisture Content	AS 1289.2.1.1
Field Moisture Content (%):	10.4
Curing Time (hrs) :	120

Comments

Method of establishing plasticity level: Visual Assessment
The results outlined above apply to the sample as received

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Report No: CBR:NEW19W-3485--S04
Issue No: 1

California Bearing Ratio Test Report

Client:	McCloy Development Management Pty Ltd Suite 2, Ground Floor, 317 Hunter Street Newcastle NSW 2300
Principal:	
Project No.:	NEW15P-0070F
Project Name:	Billy's Lookout - Stages 10, 16 & 17

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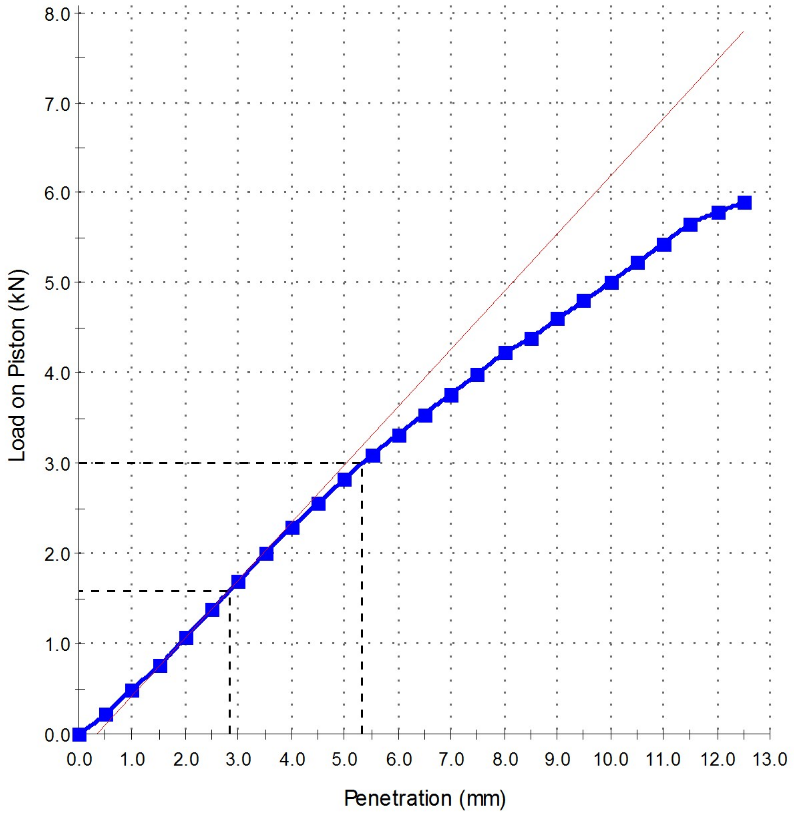
Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 22/10/2019

Sample Details

Sample ID:	NEW19W-3485--S04	**Date Sampled:**	9/10/2019
Sampling Method:	Sampled by Engineering Department		
Specification:	No Specification	**Source:**	On-Site
Location:	TP08 - 0.50 to 0.70m	**Material:**	Silty Sandy GRAVEL
Project Location:	Teralba, NSW		

Load vs Penetration



Test Results

AS 1289.6.1.1 - 2014

CBR At 5.0mm (%):	**15**
Maximum Dry Density (t/m³):	1.98
Optimum Moisture Content (%):	11.0
Dry Density before Soaking (t/m³):	1.97
Density Ratio before Soaking (%):	99.5
Moisture Content before Soaking (%):	11.4
Moisture Ratio before Soaking (%):	102.0
Dry Density after Soaking (t/m³):	1.97
Density Ratio after Soaking (%):	99.5
Swell (%):	0.0
Moisture Content of Top 30mm (%):	13.3
Moisture Content of Remaining Depth (%):	11.7
Compactive Effort:	Standard AS 1289.5.1.1
Surcharge Mass (kg):	9.00
Period of Soaking (Days):	4
Oversize Material:	Excluded
Oversize Material (%):	2
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Moisture Content	AS 1289.2.1.1
Field Moisture Content (%):	7.4
Curing Time (hrs) :	120

Comments

Method of establishing plasticity level: Visual Assessment
The results outlined above apply to the sample as received

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Report No: CBR:NEW19W-3485--S05
Issue No: 1

California Bearing Ratio Test Report

Client:	McCloy Development Management Pty Ltd Suite 2, Ground Floor, 317 Hunter Street Newcastle NSW 2300
Principal:	
Project No.:	NEW15P-0070F
Project Name:	Billy's Lookout - Stages 10, 16 & 17

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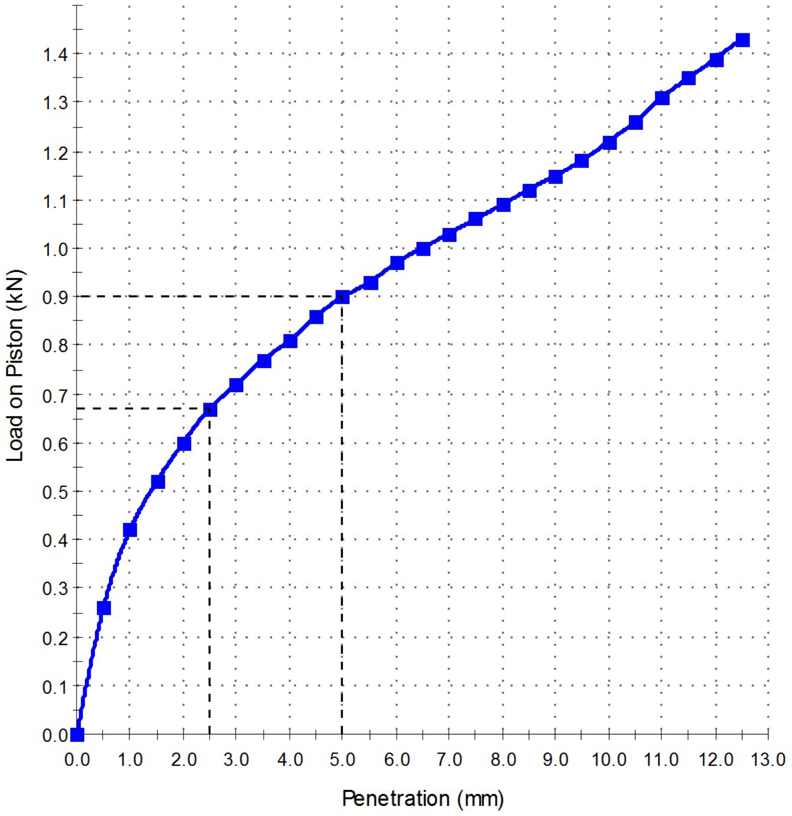
NATA Accredited Laboratory Number: 18686
Date of Issue: 23/10/2019

Sample Details

Sample ID:	NEW19W-3485--S05	**Date Sampled:**	9/10/2019
Sampling Method:	Sampled by Engineering Department		
Specification:	No Specification	**Source:**	On-Site
Location:	TP09 - 0.35 to 0.50m	**Material:**	Sandy CLAY
Project Location:	Teralba, NSW		

Load vs Penetration



Test Results

AS 1289.6.1.1 - 2014

CBR At 2.5mm (%):	**5**
Maximum Dry Density (t/m³):	1.60
Optimum Moisture Content (%):	21.0
Dry Density before Soaking (t/m³):	1.60
Density Ratio before Soaking (%):	100.0
Moisture Content before Soaking (%):	21.0
Moisture Ratio before Soaking (%):	99.5
Dry Density after Soaking (t/m³):	1.58
Density Ratio after Soaking (%):	98.5
Swell (%):	1.5
Moisture Content of Top 30mm (%):	27.8
Moisture Content of Remaining Depth (%):	21.6
Compactive Effort:	Standard AS 1289.5.1.1
Surcharge Mass (kg):	9.00
Period of Soaking (Days):	4
Oversize Material (%):	0
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Moisture Content	AS 1289.2.1.1
Field Moisture Content (%):	17.6
Curing Time (hrs) :	120

Comments

Method of establishing plasticity level: Visual Assessment
The results outlined above apply to the sample as received

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Report No: CBR:NEW19W-3485--S06
Issue No: 1

California Bearing Ratio Test Report

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

Principal:
Project No.: NEW15P-0070F
Project Name: Billy's Lookout - Stages 10, 16 & 17

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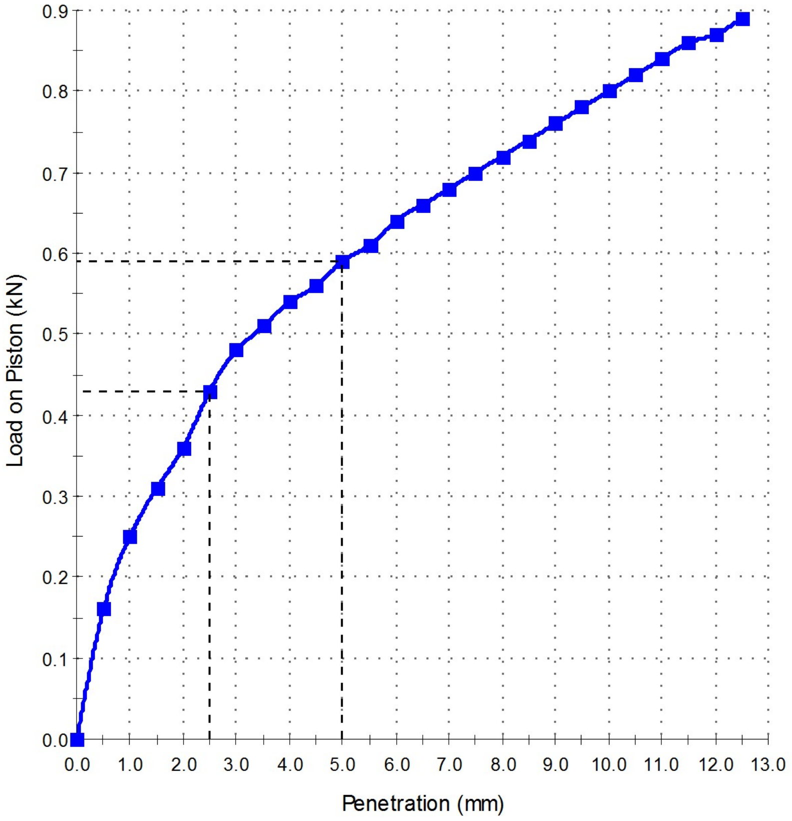
Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 22/10/2019

Sample Details

Sample ID: NEW19W-3485--S06
Date Sampled: 9/10/2019
Sampling Method: Sampled by Engineering Department
Specification: No Specification
Source: On-Site
Location: TP12 - 0.30 to 0.50m
Material: Sandy CLAY
Project Location: Teralba, NSW

Load vs Penetration



Test Results

AS 1289.6.1.1 - 2014

CBR At 2.5mm (%):	**3.5**
Maximum Dry Density (t/m³):	1.72
Optimum Moisture Content (%):	18.5
Dry Density before Soaking (t/m³):	1.72
Density Ratio before Soaking (%):	100.0
Moisture Content before Soaking (%):	18.9
Moisture Ratio before Soaking (%):	101.5
Dry Density after Soaking (t/m³):	1.70
Density Ratio after Soaking (%):	99.0
Swell (%):	1.0
Moisture Content of Top 30mm (%):	23.1
Moisture Content of Remaining Depth (%):	19.6
Compactive Effort:	Standard AS 1289.5.1.1
Surcharge Mass (kg):	9.00
Period of Soaking (Days):	4
Oversize Material (%):	0
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Moisture Content	AS 1289.2.1.1
Field Moisture Content (%):	19.0
Curing Time (hrs) :	120

Comments

Method of establishing plasticity level: Visual Assessment
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.

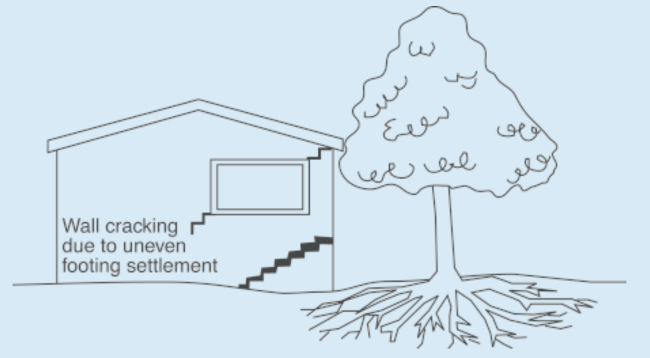
Seasonal swelling/shrinkage in clay

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.

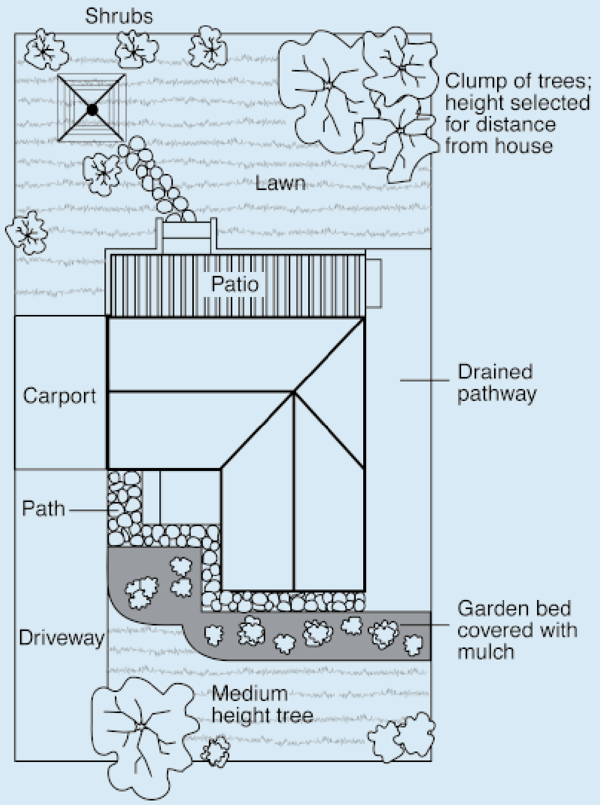
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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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