Proposed Seniors' Living Development
The Bower Stage 6
Preliminary Geotechnical Assessment

Western Road, Medowie

NEW15P-0033D-AD
9 November 2018

Qualtest
LABORATORY (NSW) PTY LTD

GEOTECHNICAL I LABORATORY I EARTHWORKS I QUARRY I CONSTRUCTION MATERIAL TESTING

9 November 2018

McCloy Development Management
Suite 1, Level 3, 426 King Street
NEWCASTLE WEST NSW 2302

Attention: Mr James Goode

Dear James,

RE: PROPOSED SENIOR'S LIVING DEVELOPMENT – THE BOWER STAGE 6
WESTERN ROAD, MEDOWIE
PRELIMINARY GEOTECHNICAL ASSESSMENT

Please find enclosed our Preliminary Geotechnical Assessment report for the proposed seniors living development located off Western Road, Medowie NSW. It is understood this Preliminary Geotechnical Assessment will be submitted as part of a Development Application to Port Stephens Council for the proposed development.

This report includes results of previous investigations by Qualtest at the subject site and provides preliminary geotechnical recommendations for urban development including risk of slope instability and associated geotechnical constraints, preliminary site classification in accordance with AS2870-2011, "*Residential Slabs and Footings*", pavement design and construction for subdivision roads, and earthworks.

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

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

Jason Lee
Principal Geotechnical Engineer

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Attachments:

1.0 Introduction

Qualtest Laboratory NSW Pty Ltd (Qualtest) is pleased to present this Preliminary Geotechnical Assessment report on behalf of McCloy Development Management (McCloy), for the proposed Seniors Living Development to be located within The Bower subdivision at Western Road, Medowie. It is understood this Geotechnical Assessment will be submitted as part of a Development Application to Port Stephens Council for the proposed development.

Previous Geotechnical Assessments have been carried out on broader areas of 'The Bower' subdivision, which included the subject site. Reports have been prepared by Douglas Partners (DP Report Ref: Project No. 39519.01, 3 September 2009), which included results of a previous investigation at the site carried out by DP in 1986, and by Qualtest Laboratory NSW Pty Ltd (Qualtest Report Ref. NEW15P-0033-AA, dated 25 May 2015).

This report has been prepared to assess the current site conditions and confirm or otherwise that the findings from those previous assessments are still relevant.

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

- Site capability assessment - Assessing the suitability of the site for urban development from a geotechnical perspective, including risk of slope instability and associated geotechnical constraints;
- Pavement design and construction to Port Stephens Council specifications;
- Preliminary site classification to AS2870-2011, "*Residential Slabs and Footings*";
- Excavation conditions and depth to rock;
- The suitability of the site soils for use as fill and fill construction procedures;
- Special requirements for construction procedures and or site drainage.

This report presents the results of the field work investigations and laboratory testing based upon a desktop study of previous investigations carried out by Qualtest at the site, and provides recommendations for the scope outlined above.

2.0 Desktop Study

The site conditions have been assessed based upon a review of the following reports completed by Qualtest:

- Preliminary Geotechnical Assessment report, 'Proposed Subdivision, Boundary Road, Medowie, (Report Reference: NEW15P-0033-AA, dated 25 May 2015);
- Geotechnical Assessment report, 'Proposed Subdivision, Stages 1, 2 & 3, Boundary Road, Medowie, (Report Reference: NEW15P-0033-AC.Rev1, dated 25 August 2016);
- Site Classification report, 'The Bower, Stage 1, Boundary Road, Medowie, (Report Reference: NEW15P-0033-AE, dated 31 May 2017);
- Preliminary Geotechnical Assessment report, 'Proposed Subdivision, The Bower Stages 3, 4, 5 & 6, Boundary Road, Medowie, (Report Reference: NEW15P-0033B-AA, dated 30 November 2017);
- Preliminary Geotechnical Assessment report, 'Proposed Subdivision, The Bower Stages 7 to 11, Boundary Road, Medowie, (Report Reference: NEW18P-0102-AA, dated 15 August 2018);

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

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

Approximate test pit locations are shown on the attached Figure AD1.

Reference should be made to the reports outlined above for further details.

3.0 Site Description

3.1 Surface Conditions

The site is located to the east of Western Road within The Bower residential development area. The site is bounded to the south by existing Stage 1 of The Bower, to the west by Western Road and proposed Stage 11, to the north by proposed Stage 11, and to east by Stage 5 which is under construction. The site and area of the proposed future stage 11 generally comprises disused farmland and bushland. The site location is shown in the attached Figure AD1.

The site is situated in an area of gently undulating topography, on the mid slopes of a local hill formation with low relief. Natural surface slopes are typically in the order of about 1° to 2° towards the northeast. Some temporary stockpiles and filled access tracks are present on the site.

Selected photographs of the site taken during November 2018 are shown below.

Photograph 1: Facing west from south-eastern corner of site.

Photograph 2: Facing north from south-eastern corner of site.

Photograph 3: Facing north from south-western corner of site.

Photograph 4: Facing east from south-western corner of site.

Photograph 5: Facing northeast from western side of site.

Photograph 6: Facing east from western side of site.

Photograph 7: Facing east from north-western corner of site.

Photograph 8: Facing south from north-western corner of site.

Photograph 9: Facing south from north-eastern corner of site.

Photograph 10: Facing west from north-eastern corner of site.

3.2 Subsurface Conditions

Reference to the 1:100,000 Newcastle Coalfield Regional Geology Sheet 9231 indicates the site to be underlain by the Permian Aged Tomago Coal Measures, which are characterised by Siltstone, Sandstone, Coal, Tuff and Claystone rock types.

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

TABLE 1 – SUMMARY OF GEOTECHNICAL UNITS AND SOIL TYPES

Unit	Soil Type	Description
1A	FILL - TOPSOIL	Not observed within the previous test pits on the subject site.
1B	CONTROLLED FILL	Not observed within the previous test pits on the subject site.
1C	UNCONTROLLED FILL	Silty SAND – fine to medium grained, grey-brown, with fine to medium grained sub-angular gravel, root affected.
2	TOPSOIL	Silty SAND, Sandy CLAY – fine to medium grained, low to medium plasticity, dark brown to grey, root affected.
3	SLOPEWASH / COLLUVIUM	Silty SAND – fine grained, grey, fines of low plasticity, with fine to medium grained charcoal fragments. Sandy CLAY – medium / medium to high plasticity, pale brown, dark grey-brown, fine grained sand, with trace to some fine to medium grained gravel, some roots in places.
4	RESIDUAL SOIL	CLAY, Sandy CLAY – medium plasticity to high plasticity, varying colours including brown and grey, orange-brown to red-brown, grey to pale brown, fine to medium grained sand / trace to some fine to medium grained gravel in places.
5	EXTREMELY WEATHERED (XW) ROCK (with soil properties)	Extremely to Highly Weathered Sandy SILTSTONE, excavated as Sandy GRAVEL - fine to coarse grained, angular to sub-angular, with some cobbles.
6	HIGHLY WEATHERED (HW) ROCK	Sandy SILTSTONE, SILTSTONE – pale grey to grey some orange-brown, sand mostly fine grained, estimated strength ranging from low to high. Generally fractured or semi-fractured. SHALE – pale grey/grey and orange-brown, estimated medium to high strength, highly fractured becoming less fractured.

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

The test pits were carried out as part of geotechnical investigations conducted for various stages of the subdivision between April 2015 and May 2018; therefore, conditions may have changed at some locations following the previous investigations.

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

Location	Unit 1A Fill: Topsoil	Unit 1B Controlled Fill	Unit 1C Uncontrolled Fill	Unit 2 Topsoil	Unit 3 Slopewash / Colluvium	Unit 4 Residual Soil	Unit 5 XW Rock	Unit 6 HW Rock
	Depth (m)							
TPQ01	-	-	-	0.00 - 0.20	-	0.20 - 1.50	-	1.50 - 2.10
TPQ02	-	-	-	0.00 - 0.25	-	0.25 - 2.20	-	-
TPQ21	-	-	-	0.00 - 0.30	0.30 - 0.60	0.60 - 1.90	-	-
TPQ22	-	-	-	0.00 - 0.25	-	0.25 - 2.00	-	-
TP101	0.00 - 0.07	0.07 - 0.40	-	-	-	0.40 - 2.00	-	-
TP102			-	0.00 - 0.10	-	0.10 - 1.70	-	1.70 - 2.10**^**
TP103			-	0.00 - 0.24	-	0.24 - 1.60	-	1.60 - 2.10**^**
TP104			-	0.00 - 0.16	-	0.16 - 1.00	-	1.00 - 1.40**^**
TP105			-	0.00 - 0.25	-	0.25 - 2.00	-	-
TP501	-	-	-	0.00 - 0.03	0.03 - 0.35	0.35 - 2.10	-	-
TP502	-	-	-	0.00 - 0.20	-	0.20 - 0.80	-	0.80 - 1.40**^**
TP503	-	-	-	0.00 - 0.03	0.03 - 0.30	0.30 - 2.00	-	-
TP603	-	-	-	0.00 - 0.02	0.02 - 0.15	0.15 - 2.00	-	-
TP604	-	-	-	0.00 - 0.05	0.05 - 0.35	0.35 - 2.20**^**	-	-
TP605	-	-	-	0.00 - 0.05	0.05 - 0.15	0.15 - 2.00	-	2.00 - 2.10
TP9-01	-	-	-	0.00 - 0.20	-	0.20 - 1.00	-	1.00 - 1.10*****
TP11-01	-	-	-	0.00 - 0.30	-	0.30 - 1.90	-	-
TP11-02	-	-	-	0.00 - 0.20	-	0.20 - 1.90	-	-
TP11-03	-	-	-	0.00 - 0.20	0.20 - 0.35	0.35 - 1.10	1.10 - 1.50**^**	-
Notes:	***** = Refusal or Practical refusal of excavator met on Highly Weathered Rock. **^** = Slow to very slow progress, close to practical refusal of excavator.							

Minor groundwater inflow was observed at test pit TP11-03 at a depth of 0.20m. No groundwater levels or inflows were encountered in the other test pits during the limited time that they remained open on the days 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.

4.0 Laboratory Testing

Laboratory testing carried out on samples collected during the previous field investigations from the test pit locations summarised included in Section 3.2 included:

- (9 no.) California Bearing Ratio (4 day soaked) & Standard Compaction;
- (15 no.) Shrink / Swell tests;
- (1 no.) Atterberg Limits test;

Results of the laboratory testing are presented in Appendix B, with a summary of the CBR, Atterberg Limits, and Shrink/Swell test results presented in Table 3, Table 4, and Table 5, respectively.

TABLE 3 – SUMMARY OF CBR TESTING RESULTS

Location	Sample Depth (m)	Field Moisture Content (%)	Optimum Moisture Content (%)	Relationship of Field MC to OMC (%)	CBR (%)
TP-Q01	0.40 – 0.70	40.7	32.7	8.0 wet	3.0
TP-Q22	0.30 – 0.50	21.2	22.3	1.1 dry	12
TP502	0.40 - 0.60	29.6	27.7	1.9 wet	4.5
TP503	0.60 - 0.80	31.1	32.5	1.4 dry	8
TP604	0.50 - 0.80	27.3	29.2	1.9 dry	4.5
TP605	0.40 - 0.60	28.6	31.1	2.5 dry	10
TP09-01	0.60 – 0.70	38.7	34.5	4.2 wet	7
TP11-01	0.40 – 0.60	24.8	22.5	2.3 wet	7
TP11-02	0.50 – 0.65	27.7	26.0	1.7 wet	7
TP11-03	0.40 – 0.55	46.3	26.5	19.8 wet	1.5

TABLE 4 – SUMMARY OF ATTERBERG LIMITS TESTING RESULTS

Location	Depth (m)	Material Description	Liquid Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)
TP101	1.00 – 1.40	(CH) CLAY	70	46	11.0

TABLE 5 – SUMMARY OF SHRINK / SWELL TESTING RESULTS

Location	Depth (m)	Material Description	I_{ss} (%)
TP-Q01	0.70 - 0.90	(CH) CLAY	4.9
TP102	0.70 – 0.85	(CH) CLAY	3.7
TP103	1.30 – 1.70	(CH) CLAY	4.9
TP104	0.50 – 0.64	(CH) CLAY	4.2
TP105	1.00 – 1.40	(CH) CLAY	3.9
TP501	0.40 - 0.55	(CH) CLAY	3.6
TP502	0.40 - 0.60	(CH) CLAY	3.9
TP503	0.60 - 0.80	(CH) CLAY	2.6
TP603	0.90 - 1.25	(CH) CLAY	3.6
TP604	0.50 - 0.80	(CH) CLAY	5.1
TP605	0.40 – 0.55	(CH) CLAY	3.2
TP09-01	0.60 – 0.70	(CH) CLAY	4.8
TP11-01	0.80 – 1.00	(CH) CLAY	2.4
TP11-02	0.50 – 0.65	(CH) CLAY	2.1
TP11-03	0.40 – 0.55	(CH) CLAY	4.8

The results of laboratory shrink / swell tests indicate that the residual clays at the site are generally highly reactive.

5.0 Discussion and Recommendations

5.1 General

Preliminary geotechnical assessment was previously carried out for the broader subdivision area by Qualtest (Ref. NEW15P-0033-AA, dated 25 May 2015). Review of a previous Preliminary Geotechnical Assessment report (Douglas Partners Report Ref: Project No. 39519.01, 3 September 2009) was carried out as part of the preliminary geotechnical assessment by Qualtest.

The subsurface profiles encountered during those previous investigations at the site are judged to be in general agreement with the results of the subsequent investigations.

Based upon shrink/swell testing carried out, lots in their natural condition not altered by cutting or filling are generally classified as Class 'H1'. Based upon previous experience on adjoining stages, most lots are expected become Class 'H2' if altered by controlled filling.

There is potential for some areas to become Class 'E' following earthworks if the engineering measures recommended in Section 5.2, plus any further advice from the geotechnical authority during construction are not complied with.

Some areas affected by fill stockpiles are classified as Class 'P' in their current condition. It is anticipated these areas will be reclassified as either Class 'H1' or Class 'H2' following supervised earthworks in accordance with the geotechnical authority recommendations.

Laboratory CBR results are mostly equal to or greater than 3.5%, but local areas of equal to or less than 3.0% may exist within the subject site. Subgrade Soils were generally wet of optimum moisture content, therefore are likely to require drying back or treatment with lime prior to pavement construction.

The site is considered suitable for the proposed development from a geotechnical viewpoint provided that development is carried out in accordance with sound engineering principles and good hillside practice, and with respect to the constraints and recommendations of this report.

5.2 Preliminary Site Classification to AS2870-2011

Based on the results of the field work and laboratory testing, the site of the proposed seniors living development within The Bower Stage 6, Western Road, Medowie as shown in the attached Figures AD1 and AD2 is mostly classified in the current condition in accordance with AS2870-2011 '*Residential Slabs and Footings*', as **Class 'H1'**.

Areas with temporary fill stockpiles and depths of fill and topsoil which exceed 0.40m are classified as **Class 'P'.** It is envisaged that these lots will be re-classified following earthworks carried out under geotechnical supervision (including removal of fill).

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 residual soil, weathered rock or similar material, 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 'H2'**, or potentially Class 'H1' or Class 'E' in some cases.

With engineering input and measures such as providing a sufficiently thick topsoil layer, **minimum topsoil depth of 0.2m comprising very low to non-reactive soil, and using fill with Iss of less than 4.0% in the upper 0.5m**, it is envisaged that site classification of **Class 'H2'** (or better) could be achievable in most cases. However, this would need to be confirmed at the time of bulk earthworks once the type of fill and level of filling is confirmed.

Final site classification will be dependent on the type of fill and 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.

5.3 Preliminary Pavement Design

5.3.1 Design Subgrade CBR Value

Subgrade CBR test results from the previous investigations within and close to the subject site ranged from 1.5% to 12%, with eight of the ten samples tested having CBR results of greater than range 3.0%.

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 preliminary pavement thickness design for the proposed subdivision roads.

TABLE 6 – DESIGN SUBGRADE CBR VALUES

Road Section	Design Subgrade	Design CBR (%)
Clay Subgrade	Unit 1B & 4	3.5
Clay Subgrade (Select Subgrade Required)	Unit 1B & 4	≤ 3.0
Weathered Rock Subgrade	Unit 5 & 6	8

It is assessed that the majority of roads would have a design subgrade value of CBR = 3.5%.

Localised areas of poor, wet or saturated subgrade conditions may be encountered with design CBR ≤ 3.0%, as encountered at test pit location TPQ01 and TP11-03. For a design subgrade value of CBR ≤ 3.0%, a select layer is required to provide additional depth of cover over the low CBR subgrade. Alternatively subgrades may be lime stabilised (likely to be with either 3% quicklime or 4% hydrated lime). Laboratory lime stabilisation trials should be carried out to confirm suitability and liming rates if lime stabilisation is proposed.

A select layer option has also been provided for subgrade conditions with design CBR = 3.5%, to reduce overlying basecourse and subbase layer thicknesses where applicable.

Pavement thickness designs for a rock subgrade have also been included, provided that the ripped and re-compacted weathered rock is confirmed to have a design CBR = 8%.

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. Apart from possibly localised short lengths, it is considered unlikely that rock subgrades will be encountered unless relatively deep cuttings occur for proposed roads.

Pavements should not be constructed on the existing fill. Design subgrade CBR adopted for areas with existing fill have been based on the CBR of the natural clay subgrades in the vicinity of those areas on the basis that the fill is removed and replaced as controlled fill.

Fill placed at road subgrade level should be assessed by a geotechnical authority. If the fill is assessed to have a CBR different to that of the design CBR, then a revised pavement design will be required for that section.

Prior to pavement construction, the exposed subgrade should be assessed by the geotechnical authority to confirm the design subgrade CBR and subsequent pavement thickness design requirement for that section.

5.3.2 Design Traffic Loadings

For the purposes of flexible pavement design, design traffic loadings have been adopted in accordance with Port Stephens Council specifications for subdivision roads in terms of equivalent standard axles (ESA's) as outlined in Table 7.

TABLE 7 – DESIGN TRAFFIC LOADING

Road Classification	Potential Dwellings Serviced	Road	Design Traffic (ESA's)
Local Street	200	Internal Roads TBC	1×10^6
Access Street	30	Internal Roads TBC	1×10^5

In the event that different design traffic design loadings are applicable, then the pavement thickness designs presented in this report should be revised.

5.3.3 Flexible Pavement Thickness Design

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

- Port Stephens Council – Infrastructure Specification, D2, Pavement Design;
- Australian Road Research Board, Special Report No. 41 (ARRB-SR41);
- Austroads, "Guide to Pavement Technology, Part 2: Pavement Structural Design".

Flexible Pavement Thickness Designs are presented in Table 8 to Table 11.

Pavement Material Specification and Compaction Requirements are presented in Table 12.

Pavement Variation Note:

For 'Access Street' road classifications, depth of basecourse has been increased to 150mm at the request of the client, due to construction practicalities when tying in with depth of kerb and gutter construction (i.e. total depth of 180mm for asphalt and basecourse layers). The subbase layer thickness has been reduced by the equivalent amount.

Varying basecourse and subbase depths is not an issue from a geotechnical design perspective provided the minimum basecourse layer thickness and total pavement thickness design requirements are satisfied.

The subbase layer should extend a minimum of 150mm behind the rear face of any kerbing and/or guttering.

TABLE 8 – FLEXIBLE PAVEMENT THICKNESS DESIGN SUMMARY

(RESIDUAL CLAY SUBGRADE - DESIGN CBR = 3.5%)

Road Classification	Access Street	Local Street
Design Traffic Loading (ESA's)	1 x 10^5	1 x 10^6
Subgrade Material	Residual Clay	Residual Clay
Design Subgrade CBR (%)	3.5	3.5
Wearing Course (mm)	30 AC	40 AC
Base Course (mm)	150	140
Subbase (mm)	200	300
Select Fill (mm)	-	-
Total Thickness (mm)	380	480

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 and/or bridging layers should be anticipated where road pavements cross gullies and in any areas where poor, wet or saturated subgrade conditions are encountered.
3) The requirement for, and extent of any subgrade replacement / select filling, should be confirmed by the geotechnical authority at the time of construction.
4) Prior to pavement construction, the exposed subgrade should be assessed by the geotechnical authority to confirm the pavement thickness requirement for that section.
5) Where 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.

TABLE 9 – FLEXIBLE PAVEMENT THICKNESS DESIGN SUMMARY

(SELECT OPTION, RESIDUAL CLAY SUBGRADE - DESIGN CBR = 3.5%)

Road Classification	Access Street	Local Street
Design Traffic Loading (ESA's)	1×10^5	1×10^6
Subgrade Material	Select Subgrade	Select Subgrade
Design Subgrade CBR (%)	3.5	3.5
Wearing Course (mm)	30 AC	40 AC
Base Course (mm)	150	140
Subbase (mm)	120	140
Select Fill (mm)	300*	300*
Total Thickness (mm)	600	620

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 and/or bridging layers should be anticipated where road pavements cross gullies and in any areas where poor, wet or saturated subgrade conditions are encountered.
3) The requirement for, and extent of any subgrade replacement / select filling, should be confirmed by the geotechnical authority at the time of construction.
4) Prior to pavement construction, the exposed subgrade should be assessed by the geotechnical authority to confirm the pavement thickness requirement for that section.
5) * Select fill or Stabilised Subgrade – Approved select fill or lime stabilised with either 3% quicklime or 4% hydrated lime.
6) Where 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.

TABLE 10 – FLEXIBLE PAVEMENT THICKNESS DESIGN SUMMARY

(SELECT OPTION, RESIDUAL CLAY SUBGRADE, DESIGN CBR ≤ 3.0%)

Road Classification	Access Street	Local Street
Design Traffic Loading (ESA's)	1×10^5	1×10^6
Subgrade Material	Select Subgrade	Select Subgrade
Design Subgrade CBR (%)	≤ 3.0	≤ 3.0
Wearing Course (mm)	30 AC	40 AC
Base Course (mm)	150	140
Subbase (mm)	120	140
Select Fill (mm)	300*	300*
Total Thickness (mm)	600	620

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 and/or bridging layers should be anticipated where road pavements cross gullies and in any areas where poor, wet or saturated subgrade conditions are encountered.
3) The requirement for, and extent of any subgrade replacement / select filling, should be confirmed by the geotechnical authority at the time of construction.
4) Prior to pavement construction, the exposed subgrade should be assessed by the geotechnical authority to confirm the pavement thickness requirement for that section.
5) * Select fill or Stabilised Subgrade – Approved select fill or lime stabilised with either 3% quicklime or 4% hydrated lime.
6) Where 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.

TABLE 11 – FLEXIBLE PAVEMENT THICKNESS DESIGN SUMMARY

(WEATHERED ROCK SUBGRADE, DESIGN CBR = 8%)

Road Classification	Access Street	Local Street
Design Traffic Loading (ESA's)	1 x 10^5	1 x 10^6
Subgrade Material	Rock Subgrade	Rock Subgrade
Design Subgrade CBR (%)	8	8
Wearing Course (mm)	30 AC	40 AC
Base Course (mm)	150	140
Subbase (mm)	120	140
Select Fill (mm)	0	0
Total Thickness (mm)	300	320

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 and/or bridging layers should be anticipated where road pavements cross gullies and in any areas where poor, wet or saturated subgrade conditions are encountered.
3) The requirement for, and extent of any subgrade replacement / select filling, should be confirmed by the geotechnical authority at the time of construction.
4) Prior to pavement construction, the exposed subgrade should be assessed by the geotechnical authority to confirm the pavement thickness requirement for that section.
5) * Select fill or Stabilised Subgrade – Approved select fill or lime stabilised with either 3% quicklime or 4% hydrated lime.
6) Where 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.

TABLE 12 – PAVEMENT MATERIAL SPECIFICATION AND COMPACTION REQUIREMENTS

Pavement Course	Material Specification	Compaction Requirements
Wearing Course (AC)	Port Stephens Council Spec.	Port Stephens Council Spec.
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 *	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 = Refer Design	100% Standard (AS1289 5.1.1)
Subgrade / Fill Below	Minimum CBR = Refer Design	95% Standard (AS1289 5.1.1)

Notes:

1) All flexible road pavement materials shall be supplied to comply with requirements of Port Stephens Council, Specification 242, Flexible Pavements, for unbound base and unbound sub base.
2) CBR = California Bearing Ratio, PI = Plasticity Index.
3) * Select Fill adopted will be dependent on subgrade moisture conditions.

A select fill or bridging layer should be allowed for beneath the pavement in any areas where poor, wet or saturated subgrade conditions are encountered.

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.

5.3.4 Construction Considerations

Care should 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.

5.4 Excavation Conditions

The depths of fill, topsoil, slopewash, colluvium, residual soils and weathered rock, together with depths of slow progress or refusal of the excavator where encountered, are summarised in Section 3.2.

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

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

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

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

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 recommended that targeted investigations are carried out if significant excavations are proposed where bedrock depth or excavatability is important to design or construction.

There is potential for groundwater to exist at localised areas of the site such as within the topsoil profile, from water perched above the residual clay / bedrock profile. 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, or in the vicinity of farm dams and gullies when water is present. If groundwater is encountered, it is generally expected to be manageable by de-watering by sump and pump methods.

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.

5.5 Site Preparation

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

- Following 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 0.3m to remove topsoil and root affected material. In the vicinity of existing filled areas, additional stripping is likely to be required to remove / replace existing fill;
- Additional stripping may be required in any areas where poor, wet or saturated subgrade conditions are encountered. It is likely that excavation of over-wet material will be required in areas of existing dams and watercourses prior to placement of fill;
- 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.

The test results indicate that the subgrade soils are likely to have a propensity to soften relatively quickly with moisture ingress; therefore, it is particularly important that care be taken to ensure that the subgrade is not exposed to wet conditions.

At the time of the previous field investigations conducted by Qualtest, moisture content for the clay subgrade material tested varied from 19.8% wet to 2.5% dry of standard Optimum Moisture Content (OMC).

The significant variations in moisture conditions encountered during the investigation is a likely result of the weather conditions encountered during and preceding the work, and local drainage conditions at the test locations.

It should therefore be anticipated that some moisture conditioning and drying back of the subgrade is likely to 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 fill materials are encountered at subgrade level, these materials should be over-excavated and be replaced with a minimum depth of 300mm of well graded granular select material with CBR of greater than 15%, or a 2% cement stabilised subbase material. The selection of select material where required will be dependent on moisture condition of subgrades at the time of construction.

Areas such as dams and watercourses may be particularly wet to depths which may not be practicable to over-excavate down to a suitable base for compaction of proposed fill. It is recommended that a bridging layer comprising free draining granular select wrapped in geofabric and geogrid be allowed for in such areas. The thickness and extent of the free draining granular select material requirement should be confirmed at the time of construction.

5.6 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 Section 5.2.3;
- 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 residential structures should be compacted to a minimum density ratio of 95% 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;
- Earthworks should be carried out in accordance with the recommendations outlined in AS3798-2007 '*Guidelines for Earthworks for Commercial and Residential Developments*'.

5.7 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. The surface fill material may be suitable for landscaping purposes only due to the presence of roots. 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 may be suitable for re-use as general fill for engineering purposes except where root affected. These materials may require some moisture conditioning;
- Unit 3 Colluvium, Unit 4 Residual Soils, Unit 5 Extremely Weathered Rock and Unit 6 Highly Weathered Rock are generally expected to be suitable for re-use as general fill for engineering purposes. These materials may require some moisture conditioning.

Final selection of fill materials should consider properties such as reactivity which is typically high for site won Unit 4 Residual Soils.

The suitability of material for re-use should be assessed and confirmed by the geotechnical authority at the time of construction.

5.8 Slope Stability and Recommended Geotechnical Constraints

The risk of slope instability has been assessed from the observed site conditions using methods consistent with those presented in the Australian Geomechanics Society (AGS) publication "*Practice Note Guidelines for Landslide Risk Management, 2007*". Based on those methods, the risks to property associated with slope instability on the subject area have been assessed using the terms presented in AGS 2007, *Landslide Risk Assessment Qualitative Terminology for Use in Assessing Risk to Property*, extracts of which are attached in Appendix D.

The report provides an assessment of the risk of slope instability on the proposed development area. The report also recommends some geotechnical constraints for the site development in light of the slope instability assessment. The assessed risk to the proposed development is based on the geotechnical constraints and recommendations provided in this report being implemented. The onus is on the owner, potential owner, or interested party to decide whether the assessed level of risk is acceptable taking into account the likely consequences of the risk and the recommended geotechnical constraints.

Based on the site features discussed in this report, in particular the gently undulating topography, and no obvious evidence of slope instability observed during the investigations, proposed residential development of the site is assessed as having a "Low" risk of slope instability.

It would be normal practice in the Port Stephens local government area for development to proceed on a site with a risk level classification of Low.

Development should be carried out in accordance with sound engineering principles and good hillside practice (as set out in Appendix D), and the geotechnical constraints outlined in this report.

There are no particular geotechnical constraints on the type of structures provided they are founded on footings designed and constructed in accordance with AS2870, '*Residential Slabs and Footings*'.

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

Excavations should be designed for surcharge loading from slopes, retaining walls, structures and other improvements in the vicinity of the excavation.

Care should be taken not to disturb or destabilise existing underground services or structures. Excavations should remain outside a 1V:2H projection from the base of any structural footings.

The depth of unsupported fill on the site should preferably not exceed 1.5m and should be battered at 1V:2H or flatter and protected against erosion. All fill greater than 1.5m deep should preferably be supported by engineer designed retaining walls.

6.0 Limitations

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

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

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

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

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

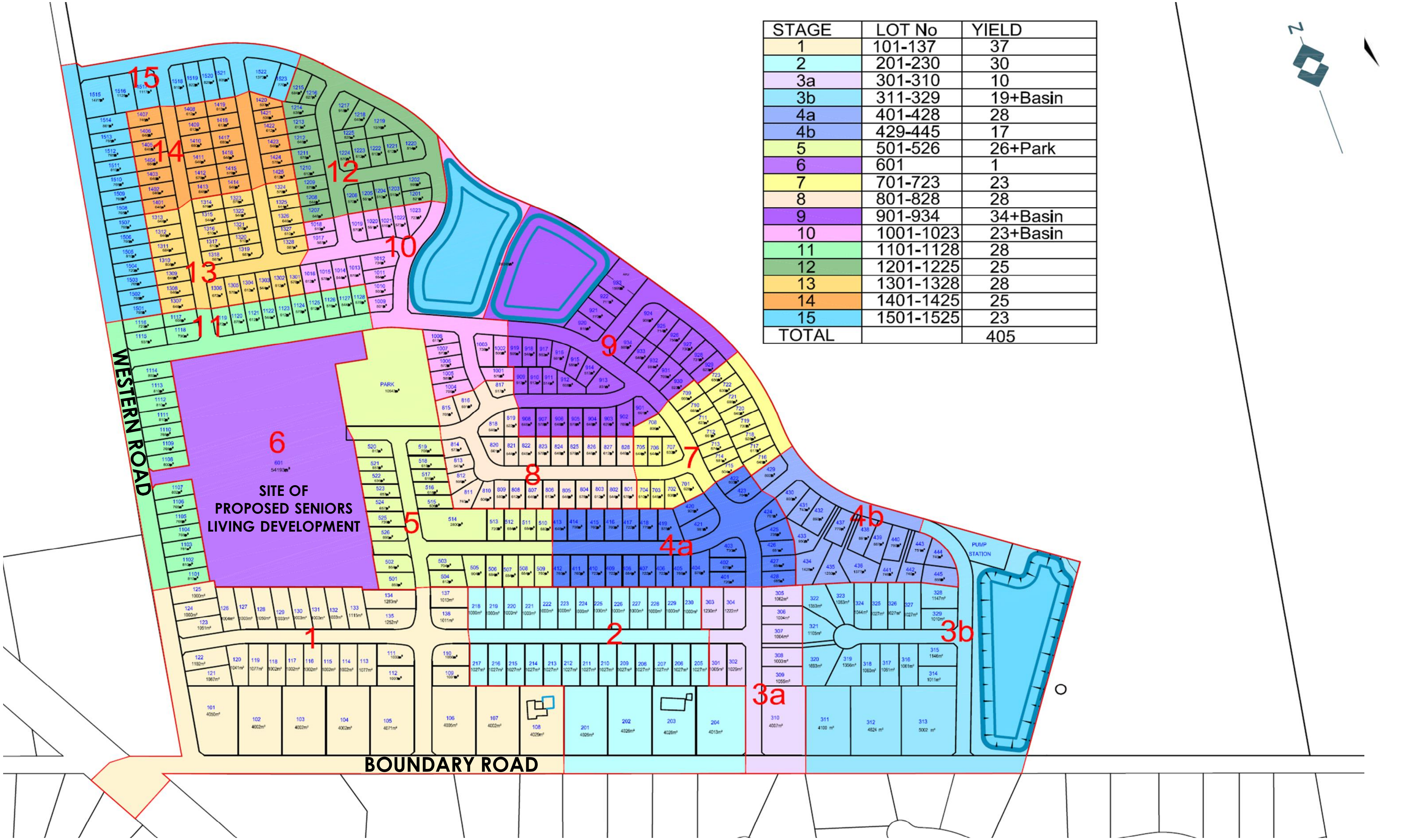
For and on behalf of Qualtest Laboratory (NSW) Pty Ltd.

Jason Lee
Principal Geotechnical Engineer

FIGURES

Figure AD1 – Site Location Plan

Figure AD2 – Approximate Test Pit Locations

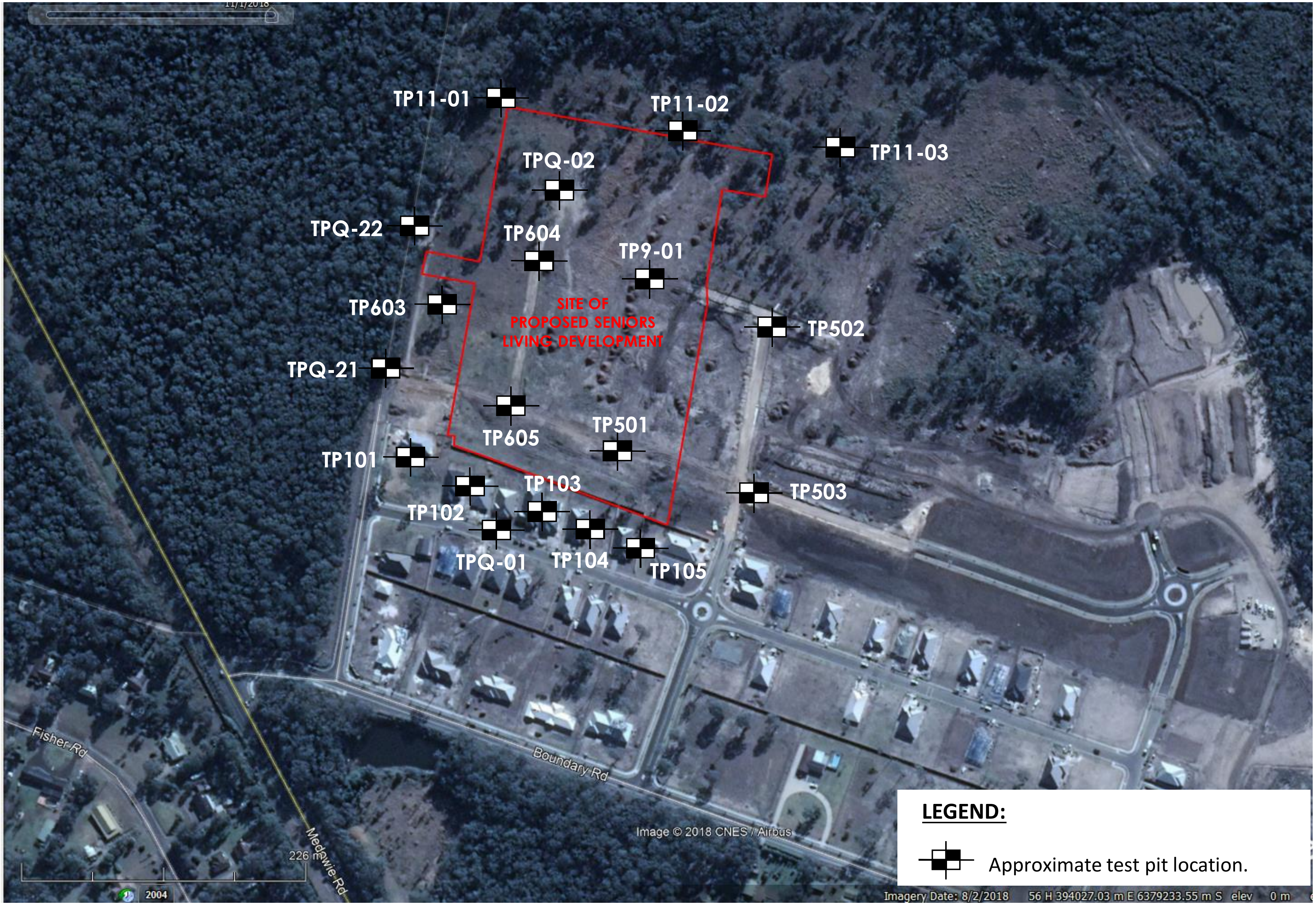


STAGE	LOT No	YIELD
1	101-137	37
2	201-230	30
3a	301-310	10
3b	311-329	19+Basin
4a	401-428	28
4b	429-445	17
5	501-526	26+Park
6	601	1
7	701-723	23
8	801-828	28
9	901-934	34+Basin
10	1001-1023	23+Basin
11	1101-1128	28
12	1201-1225	25
13	1301-1328	28
14	1401-1425	25
15	1501-1525	23
TOTAL		405

Based on concept drawing provided by client (ref. Project HD3, Drawing No. HD04, Rev. 25S3, 13.06.18).

Qualtest LABORATORY (NSW) PTY LTD

Client:	MCCLOY GROUP	Drawing No:	FIGURE AD1
Project:	PROPOSED SENIORS LIVING DEVELOPMENT - THE BOWER STAGE 6	Project No:	NEW15P-0033D
Location:	WESTERN ROAD, MEDOWIE	Scale:	AS SHOWN
Title:	SITE LOCATION PLAN	Date:	7 NOVEMBER 2018



Based on Google Earth image.

Qualtest LABORATORY (NSW) PTY LTD

Client:	MCCLOY MEDOWIE	Drawing No:	FIGURE AD2
Project:	PROPOSED SENIORS LIVING DEVELOPMENT - THE BOWER STAGE 6	Project No:	NEW15P-0033D
Location:	WESTERN ROAD, MEDOWIE	Scale:	AS SHOWN
Title:	APPROXIMATE TEST PIT LOCATIONS	Date:	7 NOVEMBER 2018

APPENDIX A:

Results of Field Investigations

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT:	MCCLOY MEDOWIE	**TEST PIT NO:**	**TP-Q01**
PROJECT:	PROPOSED SUBDIVISION	**PAGE:**	1 OF 1
		JOB NO:	NEW15P-0033
		LOGGED BY:	SJK
LOCATION:	BOUNDARY ROAD, MEDOWIE	**DATE:**	14/4/15

EQUIPMENT TYPE:	Backhoe - JCB3CX			**SURFACE RL:**
TEST PIT LENGTH:	2.5 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
BH	Not Encountered			0.00 – 0.20m		CL	Sandy CLAY - low plasticity, dark brown, fine to medium grained sand, root affected.	M < W_P				TOPSOIL
		0.40m – 0.70m CBR		0.20m		CH	CLAY - medium to high plasticity, pale brown and grey, some fine to medium grained sand, trace of fine to medium grained subrounded gravel.	M > W_P	VSt	HP	300	RESIDUAL SOIL
		0.70m – 0.90m U50		0.5			Pale grey with red to brown and orange.			HP	240	
				1.0						HP	240	
										HP	260	
							With gravelly pockets - fine to medium grained, angular.					
				1.50m			SILTSTONE - pale grey to white with orange and brown to red, fractured, estimated low to medium strength.	M				HIGHLY WEATHERED ROCK
				2.0 – 2.10m								
				2.10m – 2.5			Hole Terminated at 2.10 m					

LEGEND:

Water

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

Strata Changes

- — — Gradational or transitional strata
- —— Definitive or distict strata change

Notes, Samples and Tests

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

Field Tests

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

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

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 MEDOWIE	TEST PIT NO:	TP-Q02
PROJECT:	PROPOSED SUBDIVISION	PAGE:	1 OF 1
		JOB NO:	NEW15P-0033
		LOGGED BY:	SJK
LOCATION:	BOUNDARY ROAD, MEDOWIE	DATE:	14/4/15

EQUIPMENT TYPE:	Backhoe - JCB3CX	SURFACE RL:	
TEST PIT LENGTH:	2.5 m WIDTH: 0.5 m	DATUM:	

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
BH	Not Encountered			0.00–0.25m		CL	Sandy CLAY - low plasticity, dark brown, fine to medium grained sand, root affected.	$M \sim W_P$		HP	100	TOPSOIL
				0.25–0.60m		CI	CLAY - medium plasticity, pale brown and grey, some fine to medium grained sand, trace of fine to medium grained subrounded gravel, some tree roots.	$M > W_P$	St / VSt	HP	200	RESIDUAL SOIL
		0.60m U50 0.80m		0.60–2.20m		CH	CLAY - medium to high plasticity, grey with brown to red, some fine to medium grained sand, trace of fine to medium grained subrounded gravel.		VSt	HP	250	
										HP	220	
							Some gravelly pockets.			HP	220	
										HP	200	
				2.20m			Hole Terminated at 2.20 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 MEDOWIE PTY LTD	**TEST PIT NO:**	**TP-Q21**
PROJECT:	PROPOSED SUBDIVISION	**PAGE:**	1 OF 1
		JOB NO:	NEW15P-0033
		LOGGED BY:	SJK
LOCATION:	BOUNDARY ROAD, MEDOWIE	**DATE:**	23/11/15

EQUIPMENT TYPE: 5t Excavator (Eurocomach) **SURFACE RL:**
TEST PIT LENGTH: 1.5 m **WIDTH:** 0.3 m **DATUM:**

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			0.00–0.30m	SM	Gravelly Silty SAND - mostly fine grained, pale brown to grey, fines of low plasticity, fine to medium grained subrounded gravel, heavily root affected.	D - M				TOPSOIL
				0.30–0.60m	CI	Sandy CLAY / CLAY - medium plasticity, pale brown, sand mostly fine grained, trace of fine to medium grained subrounded gravel, some tree roots.	$M \sim W_P$	VSt	HP	270	COLLUVIUM 0.50: Access track surface level.
				0.60–1.90m	CH	CLAY - high plasticity, pale brown to pale grey and brown to red, trace of fine to medium grained sand, trace of fine to medium grained subrounded gravel, some tree roots. Brown to red, pale grey and pale brown.	$M < W_P$	H	HP	>600	RESIDUAL SOIL / COLLUVIUM
				1.90m		Hole Terminated at 1.90 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

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

Moisture Condition

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

Density

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

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT: MCCLOY MEDOWIE PTY LTD
PROJECT: PROPOSED SUBDIVISION
LOCATION: BOUNDARY ROAD, MEDOWIE

TEST PIT NO: TP-Q22
PAGE: 1 OF 1
JOB NO: NEW15P-0033
LOGGED BY: SJK
DATE: 23/11/15

EQUIPMENT TYPE: 5t Excavator (Eurocomach)
TEST PIT LENGTH: 1.5 m **WIDTH:** 0.3 m
SURFACE RL:
DATUM:

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			0.25m		CL	Silty Sandy CLAY - low to medium plasticity, brown to grey and pale brown, fine to medium grained sand, root affected. (not present on adjacent access track)	M < W_P				TOPSOIL / COLLUVIUM
		0.30m CBR 0.50m		0.5, 1.0, 1.5, 2.00m		CH	CLAY - high plasticity, pale brown to orange and pale grey, trace of fine to medium grained sand, some tree roots. Grey with brown to red and some pale brown to orange.	M < W_P	H	HP	>600	RESIDUAL SOIL
										HP	400	
								M > W_P	VSt	HP	280	
										HP	250	
				2.5			Hole Terminated at 2.00 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

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

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

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

ENGINEERING LOG - TEST PIT

CLIENT: McCLOY DEVELOPMENT MANAGEMENT
PROJECT: THE BOWER - STAGE 1
LOCATION: BOUNDARY ROAD, MEDOWIE

TEST PIT NO: TP101
PAGE: 1 OF 1
JOB NO: NEW15P-0033
LOGGED BY: BE
DATE: 3/5/17

EQUIPMENT TYPE: 4 TONNE EXCAVATOR
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
SURFACE RL:
DATUM:

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			0.07m	SM	FILL: Silty SAND - fine to medium grained, grey-brown, with fine to medium grained gravel, sub-angular, root affected.	M				FILL - TOPSOIL
				0.40m	CL	FILL: Sandy CLAY - low plasticity, grey-brown, fine grained sand, with fine gravel, sub-angular to angular.	M < W_P	H	HP	>600	CONTROLLED FILL
				0.5; 0.60m	CI	Sandy CLAY - medium plasticity, brown to orange-brown and grey, fine sand, trace tree roots.	M ~ W_P	VSt	HP	250	RESIDUAL SOIL
		1.00m U50 1.40m		1.0; 1.5; 2.0; 2.00m	CH	CLAY - high plasticity, grey and red-brown.	M > W_P	VSt	HP; HP	340; 370	
						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 DEVELOPMENT MANAGEMENT	**TEST PIT NO:**	**TP102**
PROJECT:	THE BOWER - STAGE 1	**PAGE:**	1 OF 1
LOCATION:	BOUNDARY ROAD, MEDOWIE	**JOB NO:**	NEW15P-0033
		LOGGED BY:	BE
		DATE:	3/5/17

EQUIPMENT TYPE: 4 TONNE EXCAVATOR **SURFACE RL:**
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **DATUM:**

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			0.00–0.10m	SM	Silty SAND - fine to medium grained, with tree mulch, root affected.	M				TOPSOIL
				0.10–0.30m	CH	CLAY - medium to high plasticity, brown to orange, some fine grained sand.	M > W_P	VSt	HP	300	RESIDUAL SOIL
				0.30–1.70m	CH	CLAY - high plasticity, grey, with some orange to red-brown.	M > W_P	H	HP	450	
									HP	350	
		0.70m U50 0.85m						VSt	HP	300	
									HP	310	
									HP	310	
				1.70–2.10m		Sandy SILTSTONE - pale grey-white with some orange to red-brown, moderately fractured, estimated medium strength, with some thin clay bands.	D - M				HIGHLY WEATHERED ROCK
						Hole Terminated at 2.10 m Very 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

Qualtest LABORATORY (NSW) PTY LTD

CLIENT:	McCLOY DEVELOPMENT MANAGEMENT	**TEST PIT NO:**	**TP103**
PROJECT:	THE BOWER - STAGE 1	**PAGE:**	1 OF 1
LOCATION:	BOUNDARY ROAD, MEDOWIE	**JOB NO:**	NEW15P-0033
		LOGGED BY:	BE
		DATE:	3/5/17

EQUIPMENT TYPE: 4 TONNE EXCAVATOR **SURFACE RL:**

TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **DATUM:**

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			0.08m		SM	Silty SAND - fine to medium grained, dark brown, with clay, root affected.	M				TOPSOIL
				0.24m		CL	Sandy CLAY - low plasticity, dark grey, fine grained sand.	M > Wp	St	HP	180	TOPSOIL / SLOPE WASH
		0.90m U50 1.15m		1.20m		CH	CLAY - medium to high plasticity, grey to brown and orange, with some fine grained sand.	M > Wp	VSt	HP HP HP	300 320 220	RESIDUAL SOIL
		1.30m U50 1.70m		1.60m		CH	CLAY - high plasticity, pale grey with some orange.	M > Wp	VSt	HP HP	210 250	
				2.10m			Sandy SILTSTONE - pale grey with some orange, estimated medium strength.	D - M				HIGHLY WEATHERED ROCK
							Hole Terminated at 2.10 m Very 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

Qualtest LABORATORY (NSW) PTY LTD

CLIENT: McCLOY DEVELOPMENT MANAGEMENT		**TEST PIT NO:**	**TP104**
PROJECT: THE BOWER - STAGE 1		**PAGE:**	1 OF 1
LOCATION: BOUNDARY ROAD, MEDOWIE		**JOB NO:**	NEW15P-0033
		LOGGED BY:	BE
		DATE:	3/5/17

EQUIPMENT TYPE: 4 TONNE EXCAVATOR **SURFACE RL:**
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **DATUM:**

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			0.16m	SM	Silty SAND - fine to medium grained, grey-brown, with some fine grained gravel, sub-angular to angular, root affected.	M				TOPSOIL
					CH	CLAY - high plasticity, pale grey with some pale orange-brown and red-brown.	M > W_P	VSt	HP	300	RESIDUAL SOIL
									HP	220	
		0.50m U50 0.64m		0.5					HP	210	
									HP	240	
								St	HP	210	
									HP	180	
									HP	160	
				1.00m					HP	150	
				1.40m		Sandy SILTSTONE - pale grey-white with some orange to red-brown, moderately fractured, estimated medium strength, with some thin clay bands.	D				HIGHLY WEATHERED ROCK
				1.5		Hole Terminated at 1.40 m Very slow progress					
				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

Qualtest LABORATORY (NSW) PTY LTD

CLIENT:	McCLOY DEVELOPMENT MANAGEMENT	**TEST PIT NO:**	**TP105**
PROJECT:	THE BOWER - STAGE 1	**PAGE:**	1 OF 1
LOCATION:	BOUNDARY ROAD, MEDOWIE	**JOB NO:**	NEW15P-0033
		LOGGED BY:	BE
		DATE:	3/5/17

EQUIPMENT TYPE: 4 TONNE EXCAVATOR **SURFACE RL:**
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **DATUM:**

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			0.08m		SM	Silty SAND - fine to medium grained, dark brown, with clay, root affected.	M				TOPSOIL
				0.25m		CL	Sandy CLAY - low plasticity, dark grey, fine grained sand.	M < W_P	St	HP	150	
		0.60m U50 0.80m		0.70m		CH	CLAY - medium to high plasticity, grey to brown and orange, with some fine grained sand.	M > W_P	St	HP / HP	160 / 140	RESIDUAL SOIL
		1.00m U50 1.40m		2.00m		CH	CLAY - high plasticity, pale grey with some orange.	M > W_P	St	HP / HP / HP	140 / 160 / 160	
							Hole Terminated at 2.00 m					

Depth scale: 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

Qualtest LABORATORY (NSW) PTY LTD

CLIENT: McCLOY DEVELOPMENT MANAGEMENT
PROJECT: THE BOWER STAGES 3, 4, 5 & 6
LOCATION: BOUNDARY ROAD, MEDOWIE

TEST PIT NO: TP501
PAGE: 1 OF 1
JOB NO: NEW15P-0033B
LOGGED BY: BE
DATE: 12-10-17

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

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			0.03m	SM	TOPSOIL: Silty SAND - fine to medium grained, dark brown, fines of low plasticity.	D				TOPSOIL / POSSIBLE FILL
				0.30m	SM	Silty SAND - fine grained, grey, fines of low plasticity.	D				SLOPE WASH / POSSIBLE FILL
				0.35m	CL	Sandy CLAY - low plasticity, grey, fine grained sand, with some Silt.	M < W_p	H	HP	>600	COLLUVIUM / POSSIBLE FILL
		0.40m U50 0.55m		1.00m	CH	CLAY - high plasticity, grey to dark brown with some orange-brown, some fine grained sand. Trace SANDSTONE cobbles.	M < W_p	VSt	HP HP HP HP	210 330 390 330	RESIDUAL SOIL 0.6M: REFUSAL ON NORTHERN SIDE OF TEST PIT ON SANDSTONE POCKET.
				2.10m	CH	CLAY - high plasticity, grey with red-brown.	M > W_p	St	HP HP HP HP HP	200 190 180 180 180	
						Hole Terminated at 2.10 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

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

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 DEVELOPMENT MANAGEMENT	**TEST PIT NO:**	**TP502**
PROJECT:	THE BOWER STAGES 3, 4, 5 & 6	**PAGE:**	1 OF 1
LOCATION:	BOUNDARY ROAD, MEDOWIE	**JOB NO:**	NEW15P-0033B
		LOGGED BY:	BE
		DATE:	12-10-17

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

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 brown, fines of low plasticity, root affected.	M				TOPSOIL
		0.40m CBR U50 0.60m		0.20m – 0.5		CH	CLAY - high plasticity, brown with orange-brown to red-brown, with some fine to medium grained sand. With some pockets of Highly Weathered SHALE.	M > W_p	St - VSt	HP HP HP HP	190 220 210 180	RESIDUAL SOIL
		0.90m CBR 1.10m		0.80m – 1.0			SHALE - pale grey with some orange-brown to red-brown, estimated medium to high strength, highly fractured.	D - M				HIGHLY WEATHERED ROCK
				1.40m			Hole Terminated at 1.40 m Slow progress					
				1.5								
				2.0								
				2.5								

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 DEVELOPMENT MANAGEMENT	TEST PIT NO:	TP503
PROJECT:	THE BOWER STAGES 3, 4, 5 & 6	PAGE:	1 OF 1
LOCATION:	BOUNDARY ROAD, MEDOWIE	JOB NO:	NEW15P-0033B
		LOGGED BY:	BE
		DATE:	12-10-17

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

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			0.03m	SM	TOPSOIL: Silty SAND - fine to medium grained, grey-brown, fines of low plasticity, root affected.					TOPSOIL
				0.30m	SM	Silty SAND - fine grained, grey, fines of low plasticity.	D	MD - D			SLOPE WASH
					CH	CLAY - medium to high plasticity, grey to brown and orange-brown to red-brown.	M ~ W_P	H	HP	>600	RESIDUAL SOIL
		0.60m CBR U50 0.80m		0.5					HP	>600	
				1.0		Becoming grey and red-brown.			HP	>600	
									HP	>600	
							M > W_P	VSt	HP	460	
									HP	330	
				1.5					HP	340	
				2.00m					HP	330	
						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

TEST PIT NO: TP603
PAGE: 1 OF 1
JOB NO: NEW15P-0033B
LOGGED BY: BE
DATE: 12-10-17

CLIENT: McCLOY DEVELOPMENT MANAGEMENT
PROJECT: THE BOWER STAGES 3, 4, 5 & 6
LOCATION: BOUNDARY ROAD, MEDOWIE

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

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			0.02m	SM	TOPSOIL: Silty SAND - fine to medium grained, dark brown, fines of low plasticity, root affected.	M				TOPSOIL
				0.15m	SM	Silty SAND - fine grained, grey, fines of low plasticity.	D	MD - D			SLOPE WASH
					CH	CLAY - high plasticity, grey and red-brown, with some fine to medium grained sand. Tree roots to 0.30m depth.	M ~ W_P	H	HP	>600	RESIDUAL SOIL
				0.5					HP	450	
									HP	350	
		0.90m				Becoming pale grey with pale orange to red-brown.	M > W_P	VSt			
		U50		1.0							
		1.25m							HP	310	
				1.5							
				2.00m					HP	280 - 330	
				2.0		Hole Terminated at 2.00 m					
				2.5							

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 DEVELOPMENT MANAGEMENT
PROJECT: THE BOWER STAGES 3, 4, 5 & 6
LOCATION: BOUNDARY ROAD, MEDOWIE

TEST PIT NO: TP604
PAGE: 1 OF 1
JOB NO: NEW15P-0033B
LOGGED BY: BE
DATE: 12-10-17

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

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	Field Test: Test Type	Field Test: Result	Structure and additional observations
E	Not Encountered			0.05m		SM	TOPSOIL: Silty SAND - fine to medium grained, dark brown, fines of low plasticity, root affected.					TOPSOIL
				0.35m		SM	Silty SAND - fine grained, grey, fines of low plasticity.	D				SLOPE WASH
		0.50m CBR U50 0.80m		0.5		CH	CLAY - high plasticity, pale brown to red-brown, with some fine to medium grained sand.	M ~ W_P	H	HP HP	>600 550	RESIDUAL SOIL
							Becoming grey, red-brown and pale orange-brown.	M > W_P	VSt	HP HP	380 350	
				1.0			Becoming pale grey and pale orange-brown.			HP	310	
				1.5			With red-brown sandy nodules.			HP	270 - 300	
				2.0			With pockets of Extremely Weathered SHALE.					
				2.20m			Hole Terminated at 2.20 m Slow progress					
				2.5								

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 DEVELOPMENT MANAGEMENT
PROJECT: THE BOWER STAGES 3, 4, 5 & 6
LOCATION: BOUNDARY ROAD, MEDOWIE

TEST PIT NO: TP605
PAGE: 1 OF 1
JOB NO: NEW15P-0033B
LOGGED BY: BE
DATE: 12-10-17

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

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			0.05m	SM	TOPSOIL: Silty SAND - fine to medium grained, dark brown, fines of low plasticity, root affected.	D - M				TOPSOIL
				0.15m	SM	Silty SAND - fine grained, grey, fines of low plasticity.	D	MD - D			SLOPE WASH
		0.40m–0.55m U50; CBR 0.40m–0.60m; 0.70m–0.84m U50		0.5	CH	CLAY - high plasticity, grey and red-brown, with some fine to medium grained sand. Tree roots to 0.20m depth.	$M \sim w_P$	H	HP	>600	RESIDUAL SOIL
						Becoming red-brown and grey.			HP	480	
							$M > w_P$	VSt	HP	380	
									HP	310	
				1.0					HP	280	
				1.5					HP	260	
		1.60m–1.80m D				Becoming pale grey with some pale orange with red-brown sandy nodules.			HP	180	
						With pockets of Extremely Weathered SHALE.					
		2.00m–2.10m D		2.00m		SHALE - pale grey with some orange-brown to red-brown, estimated medium to high strength, highly fractured.	D				HIGHLY WEATHERED ROCK
				2.10m		Hole Terminated at 2.10 m					
				2.5							

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 DEVELOPMENT MANAGEMENT
PROJECT: THE BOWER - STAGES 7 TO 11
LOCATION: BOUNDARY ROAD, MEDOWIE NSW

TEST PIT NO: TP09-01
PAGE: 1 OF 1
JOB NO: NEW18P-0102
LOGGED BY: BE
DATE: 22-5-18

EQUIPMENT TYPE: 3.5 TONNE EXCAVATOR
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m
SURFACE RL:
DATUM:

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	Field Test: Test Type	Field Test: Result	Structure and additional observations
E	Not Encountered			0.00–0.20m		CL	TOPSOIL: Sandy CLAY - low plasticity, grey, fine grained sand, root affected.	M > W_P				TOPSOIL/ SLOPEWASH
		0.30m–0.40m D		0.20–0.50m		CI	Sandy CLAY - medium plasticity, brown to dark brown and grey, fine grained sand.		VSt	HP HP	280 260	RESIDUAL SOIL
		0.60m–0.70m CBR & U50		0.50–1.00m		CH	CLAY - high plasticity, grey with some brown.			HP HP HP	260 300 360	REFUSAL ON HIGHLY WEATHERED ROCK AT 0.7M AT NORTHERN END OF TEST PIT.
				1.00–1.10m			Sandy SILTSTONE - fine grained, grey to pale grey and orange, estimated medium to high strength, fractured.	D				HIGHLY WEATHERED ROCK
							Hole Terminated at 1.10 m 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 DEVELOPMENT MANAGEMENT	TEST PIT NO:	**TP11-01**
PROJECT:	THE BOWER - STAGES 7 TO 11	PAGE:	1 OF 1
LOCATION:	BOUNDARY ROAD, MEDOWIE NSW	JOB NO:	NEW18P-0102
		LOGGED BY:	BE
		DATE:	22-5-18

EQUIPMENT TYPE: 3.5 TONNE EXCAVATOR **SURFACE RL:**
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **DATUM:**

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	Field Test: Test Type	Field Test: Result	Structure and additional observations
E	Not Encountered			0.0 – 0.30m		CL	TOPSOIL: Sandy CLAY - low to medium plasticity, grey, fine grained sand, root affected.	M > W_P				TOPSOIL
		0.40m – 0.60m CBR & U50		0.30m – 1.90m		CH	CLAY - medium to high plasticity, grey-brown and brown.		VSt	HP	200	RESIDUAL SOIL
							Becoming grey and red-brown.			HP	320	
		0.80m – 1.00m CBR & U50								HP	340	
										HP	280 - 340	
				1.90m			Hole Terminated at 1.90 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

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

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

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

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT:	McCLOY DEVELOPMENT MANAGEMENT	**TEST PIT NO:**	**TP11-02**
PROJECT:	THE BOWER - STAGES 7 TO 11	**PAGE:**	1 OF 1
LOCATION:	BOUNDARY ROAD, MEDOWIE NSW	**JOB NO:**	NEW18P-0102
		LOGGED BY:	BE
		DATE:	22-5-18

EQUIPMENT TYPE: 3.5 TONNE EXCAVATOR **SURFACE RL:**
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **DATUM:**

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			0.00–0.20m	CL	TOPSOIL: Sandy CLAY - low to medium plasticity, grey, fine grained sand, trace fine grained angular gravel, root affected.	M > W_P				TOPSOIL
		0.30m CBR 0.50m		0.20m	CH	CLAY - medium to high plasticity, grey-brown and brown.		VSt	HP HP	280 290	RESIDUAL SOIL
		0.50m CBR & U50 0.65m		0.5		With orange-brown and red-brown.			HP HP HP HP	280 310 250 200	
				1.0		Becoming grey with some brown to orange-brown.		St	HP HP HP	180 160 160	
				1.70m	GC	Clayey Sandy GRAVEL - fine to coarse grained angular to sub-angular, grey and brown, fine to coarse grained sand, fines of medium plasticity.	D	VD			RESIDUAL SOIL / EXTREMELY WEATHERED ROCK
				1.90m		Hole Terminated at 1.90 m					

LEGEND:

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

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

Notes, Samples and Tests

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

Field Tests

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

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

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

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

ENGINEERING LOG - TEST PIT

Qualtest LABORATORY (NSW) PTY LTD

CLIENT:	McCLOY DEVELOPMENT MANAGEMENT	**TEST PIT NO:**	**TP11-03**
PROJECT:	THE BOWER - STAGES 7 TO 11	**PAGE:**	1 OF 1
LOCATION:	BOUNDARY ROAD, MEDOWIE NSW	**JOB NO:**	NEW18P-0102
		LOGGED BY:	BE
		DATE:	22-5-18

EQUIPMENT TYPE: 3.5 TONNE EXCAVATOR **SURFACE RL:**
TEST PIT LENGTH: 2.0 m **WIDTH:** 0.5 m **DATUM:**

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					CL	TOPSOIL: Sandy CLAY - low to medium plasticity, dark brown, fine grained sand, root affected.	M > W_P				TOPSOIL
	~1L/min			0.20m	CH	CLAY - medium to high plasticity, dark grey-brown and brown, trace fine to medium grained angular to sub-angular gravel, trace fine grained sand.		St	HP HP	160 160	COLLUVIUM MINOR INFLOW AT 0.2M.
		0.40m CBR & U50 0.55m		0.35m	CH	CLAY - high plasticity, grey-brown and brown.			HP HP	140 140	RESIDUAL SOIL
		0.80m U50 0.95m		0.5		Becoming grey with some brown.			HP	150	
				1.10m		Sandy SILTSTONE - fine grained, orange to dark brown and pale grey, estimated medium strength, highly fractured. Excavated as Sandy GRAVEL - fine to coarse grained angular to sub-angular, with some cobbles.	D				EXTREMELY TO HIGHLY WEATHERED ROCK
				1.50m		Hole Terminated at 1.50 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%

QT LIB 1.1.GLB Log NON-CORED BOREHOLE - TEST PIT NEW18P-0102-22-5-18.GPJ <<DrawingFile>> 09-08-2018 11:56 10.0.000 Datgel Lab and In Situ Tool

APPENDIX B:

Results of Laboratory Testing

QUALTEST Laboratory (NSW) Pty Ltd
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

California Bearing Ratio Test Report

Report No: CBR:NEW15W-0818--S01
Issue No: 1

Client:	McCloy Medowie Suite 1 Level 3, 426 King Street Newcastle NSW 2300
Principal:	
Project No.:	NEW15P-0033
Project Name:	Proposed Subdivision - Boundary Road, Medowie

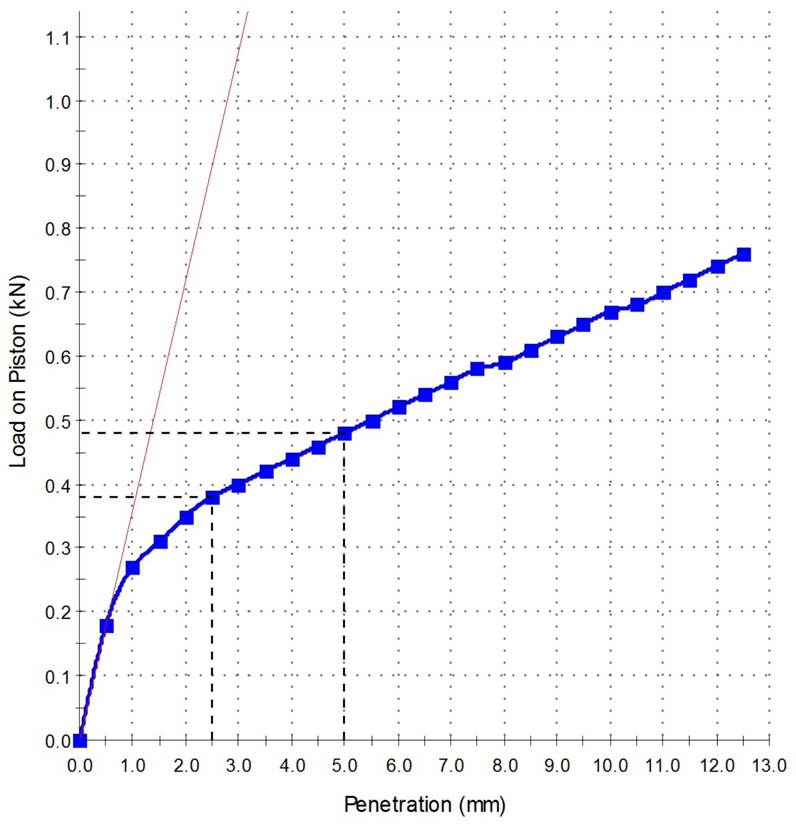
Accredited for compliance with ISO/IEC 17025
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number18686
Date of Issue: 27/04/2015

Sample Details

Sample ID:	NEW15W-0818--S01		
Client ID:	-		
Date Sampled:	14/04/2015		
Sampling Method:	AS1289.1.2.1 cl 6.5		
Specification:	No Specification	Source:	On-Site Insitu
Location:	TP-Q01 (0.40-0.70m)	Material:	TP-Q01 (0.40-0.70m)
Date Tested:	25/04/2015		

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR At 2.5mm (%):	3.0
Maximum Dry Density (t/m³):	1.32
Optimum Moisture Content (%):	32.7
Dry Density before Soaking (t/m³):	1.32
Density Ratio before Soaking (%):	100
Moisture Content before Soaking (%):	32.5
Moisture Ratio before Soaking (%):	99
Dry Density after Soaking (t/m³):	1.26
Density Ratio after Soaking (%):	95
Swell (%):	5.0
Moisture Content of Top 30mm (%):	47.6
Moisture Content of Remaining Depth (%):	36.8
Compactive Effort:	Standard
Surcharge Mass (kg):	9.00
Period of Soaking (Days):	4
Oversize Material (%):	0.0

Moisture Content

Field Moisture Content (%):	40.7

Comments

Moisture Content Method Performed as Per AS1289.2.1.1.

QUALTEST Laboratory (NSW) Pty Ltd (20708)
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ABN: 98 153 268 896

California Bearing Ratio Test Report

Report No: CBR:NEW15W-2564--S05
Issue No: 1

Client:	McCloy Medowie Pty Ltd Suite 1 Level 3, 426 King Street Newcastle NSW 2300
Principal:	
Project No.:	NEW15P-0033
Project Name:	Proposed Subdivision - Boundary Road, Medowie

Accredited for compliance with ISO/IEC 17025
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards

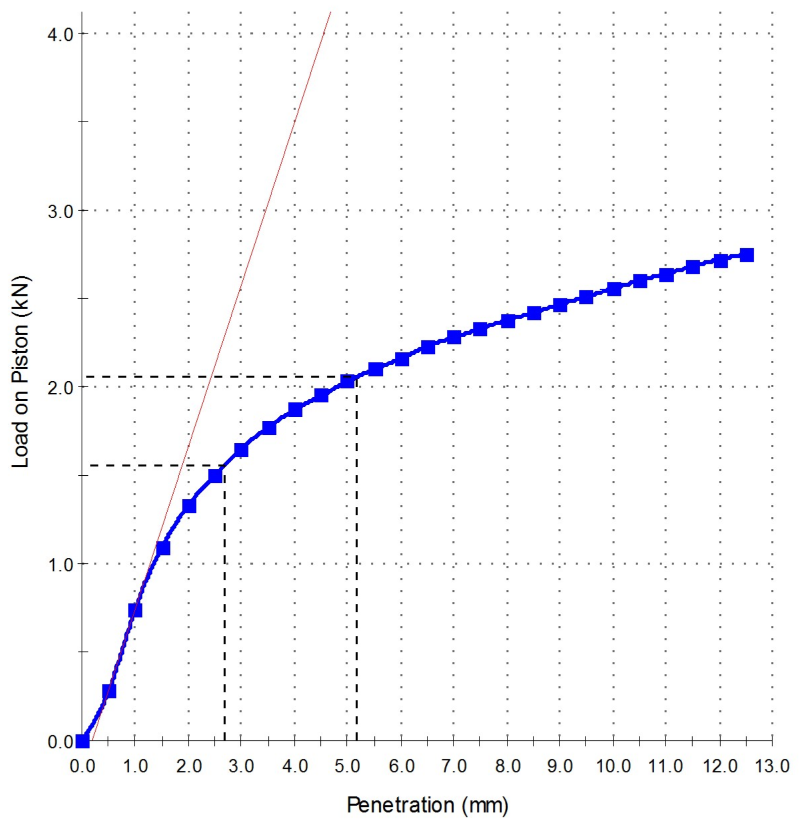
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 2/12/2015

Sample Details

Sample ID:	NEW15W-2564--S05		
Client ID:	-		
Lot No.:	-		
Test Request No.:	-		
Date Sampled:	23/11/2015		
Sampling Method:	AS1289.1.2.1 cl 6.4b		
Specification:	No Specification	Source:	On-Site
Location:	TPQ22 - (0.3 - 0.5m)	Material:	Clay
Date Tested:	27/11/2015		

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR At 2.5mm (%):	12
Maximum Dry Density (t/m³):	1.61
Optimum Moisture Content (%):	22.3
Dry Density before Soaking (t/m³):	1.62
Density Ratio before Soaking (%):	100
Moisture Content before Soaking (%):	22.3
Moisture Ratio before Soaking (%):	100
Dry Density after Soaking (t/m³):	1.62
Density Ratio after Soaking (%):	100
Swell (%):	0.5
Moisture Content of Top 30mm (%):	25.6
Moisture Content of Remaining Depth (%):	22.6
Compactive Effort:	Standard
Surcharge Mass (kg):	9.00
Period of Soaking (Days):	4
Oversize Material (%):	0.0

Moisture Content

Field Moisture Content (%):	21.2

Comments

Moisture Content Method Performed as Per AS1289.2.1.1.

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ABN: 98 153 268 896

California Bearing Ratio Test Report

Report No: CBR:NEW17W-4760--S07
Issue No: 1

Client: McCloy Development Management Pty Ltd
Suite 1 Level 3, 426 King Street
Newcastle West NSW 2300

Principal:
Project No.: NEW15P-0033B
Project Name: The Bower Stages 3, 4, 5 & 6

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

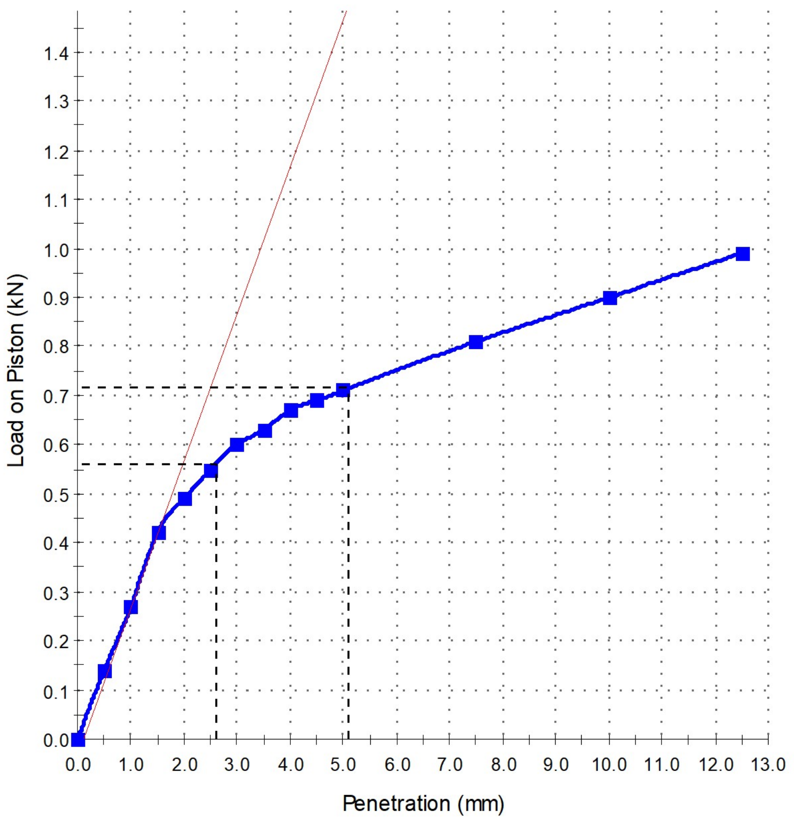
Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 6/11/2017

WORLD RECOGNISED ACCREDITATION

Sample Details

Sample ID:	NEW17W-4760--S07	Date Sampled:	12/10/2017
Sampling Method:	AS1289.1.2.1 cl 6.5		
Specification:	No Specification	Source:	On-Site
Location:	TP502 - 0.40 to 0.60m	Material:	Sandy CLAY
Project Location:	Boundary Road, Medowie, NSW		

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR At 2.5mm (%):	4.5
Maximum Dry Density (t/m³):	1.46
Optimum Moisture Content (%):	27.7
Dry Density before Soaking (t/m³):	1.47
Density Ratio before Soaking (%):	100
Moisture Content before Soaking (%):	27.4
Moisture Ratio before Soaking (%):	99
Dry Density after Soaking (t/m³):	1.43
Density Ratio after Soaking (%):	98
Swell (%):	2.5
Moisture Content of Top 30mm (%):	32.4
Moisture Content of Remaining Depth (%):	30.9
Compactive Effort:	Standard
Surcharge Mass (kg):	9.00
Period of Soaking (Days):	4
Oversize Material (%):	0.0

Moisture Content

Field Moisture Content (%):	29.6

Comments

Moisture Content Method Performed as Per AS1289.2.1.1.
Laboratory Density Ratio (LDR): 100.5% Laboratory Moisture Ratio (LMR): 99.0%
Method of establishing plasticity level: Visual Assessment
Sample curing time: 48 hrs

QUALTEST Laboratory (NSW) Pty Ltd (20708)
8 Ironbark Close Warabrook NSW 2304
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ABN: 98 153 268 896

California Bearing Ratio Test Report

Report No: CBR:NEW17W-4760--S08
Issue No: 1

Client:	McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW15P-0033B
Project Name:	The Bower Stages 3, 4, 5 & 6

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

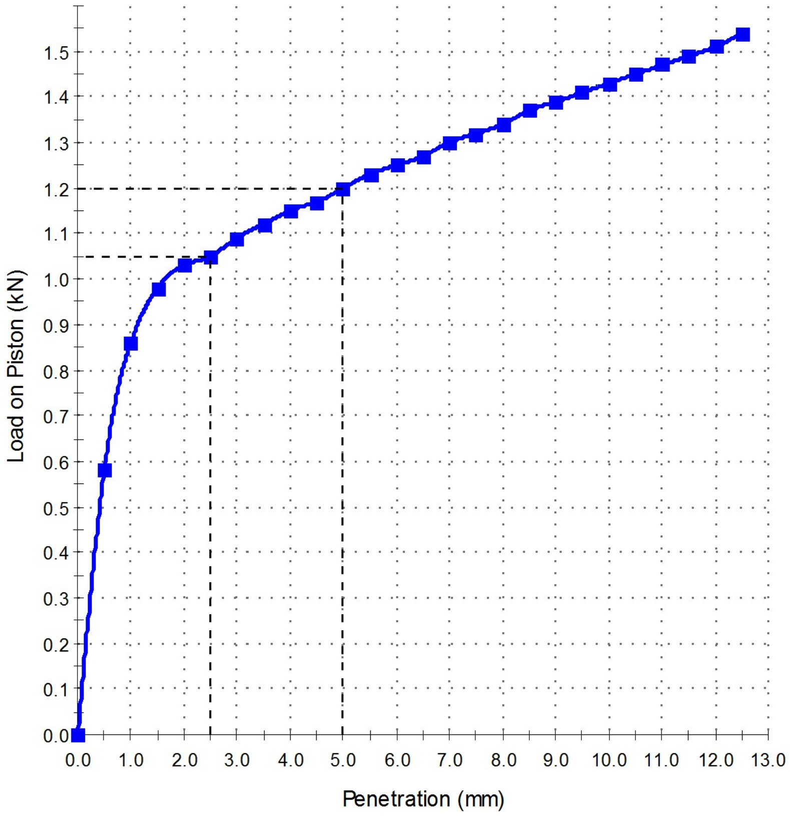
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Brent Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 31/10/2017

Sample Details

Sample ID:	NEW17W-4760--S08	Date Sampled:	12/10/2017
Sampling Method:	AS1289.1.2.1 cl 6.5		
Specification:	No Specification	Source:	On-Site
Location:	TP503 - 0.60 to 0.80m	Material:	Sandy CLAY
Project Location:	Boundary Road, Medowie, NSW		

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR At 2.5mm (%):	8
Maximum Dry Density (t/m³):	1.37
Optimum Moisture Content (%):	32.5
Dry Density before Soaking (t/m³):	1.37
Density Ratio before Soaking (%):	99
Moisture Content before Soaking (%):	33.0
Moisture Ratio before Soaking (%):	102
Dry Density after Soaking (t/m³):	1.36
Density Ratio after Soaking (%):	99
Swell (%):	0.5
Moisture Content of Top 30mm (%):	38.4
Moisture Content of Remaining Depth (%):	35.0
Compactive Effort:	Standard
Surcharge Mass (kg):	9.00
Period of Soaking (Days):	4
Oversize Material (%):	0.0

Moisture Content

Field Moisture Content (%):	31.1

Comments

Laboratory Density Ratio (LDR): 99.5% Laboratory Moisture Ratio (LMR): 101.5%
Method of establishing plasticity level: Visual Assessment
Moisture Content Method Performed as Per AS1289.2.1.1.
Sample curing time: 48 hrs

QUALTEST Laboratory (NSW) Pty Ltd (20708)
8 Ironbark Close Warabrook NSW 2304
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ABN: 98 153 268 896

California Bearing Ratio Test Report

Report No: CBR:NEW17W-4760--S09
Issue No: 2
This report replaces all previous issues of report no 'CBR:NEW17W-4760--S09'.

Client:	McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW15P-0033B
Project Name:	The Bower Stages 3, 4, 5 & 6

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

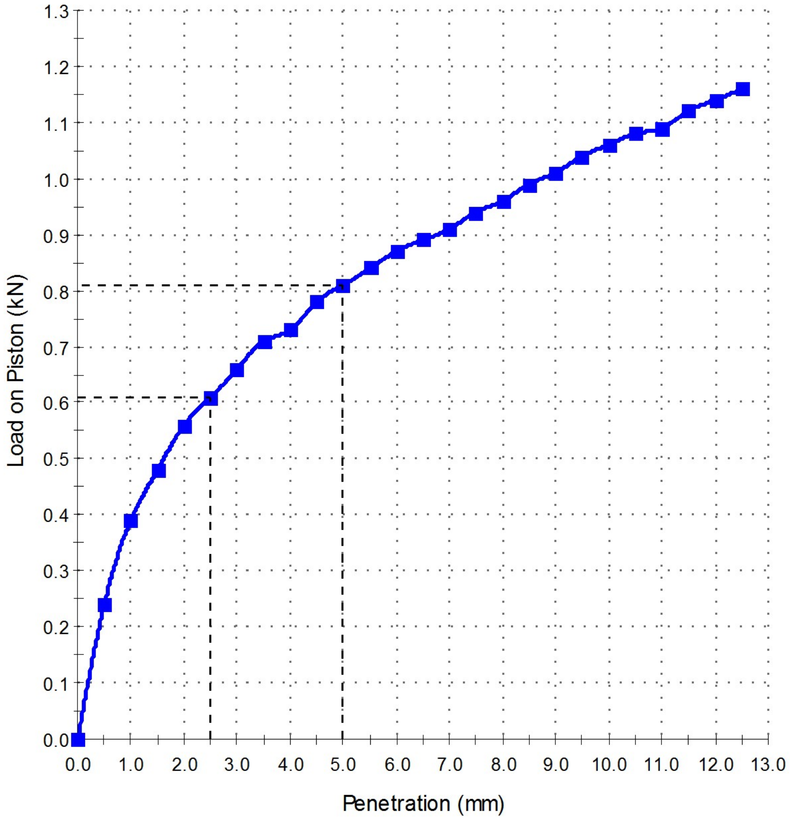
NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Glen Richardson
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 28/11/2017

Sample Details

Sample ID:	NEW17W-4760--S09	Date Sampled:	12/10/2017
Sampling Method:	AS1289.1.2.1 cl 6.5		
Specification:	No Specification	Source:	On-Site
Location:	TP604 - 0.50 to 0.80m	Material:	Sandy CLAY
Project Location:	Boundary Road, Medowie, NSW		

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR At 2.5mm (%):	4.5
Maximum Dry Density (t/m³):	1.44
Optimum Moisture Content (%):	29.2
Dry Density before Soaking (t/m³):	1.44
Density Ratio before Soaking (%):	100
Moisture Content before Soaking (%):	29.5
Moisture Ratio before Soaking (%):	101
Dry Density after Soaking (t/m³):	1.41
Density Ratio after Soaking (%):	97
Swell (%):	2.5
Moisture Content of Top 30mm (%):	37.5
Moisture Content of Remaining Depth (%):	30.6
Compactive Effort:	Standard
Surcharge Mass (kg):	9.00
Period of Soaking (Days):	4
Oversize Material (%):	0.0

Moisture Content

Field Moisture Content (%):	27.3

Comments

Laboratory Density Ratio (LDR): 100.0% Laboratory Moisture Ratio (LMR): 101.0%
Method of establishing plasticity level: Visual Assessment
Moisture Content Method Performed as Per AS1289.2.1.1.
Sample curing time: 48 hrs

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California Bearing Ratio Test Report

Report No: CBR:NEW18W-1675--S06
Issue No: 1

Client:	McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW18P-0102
Project Name:	The Bower Stages 7, 8, 9, 10 & 11

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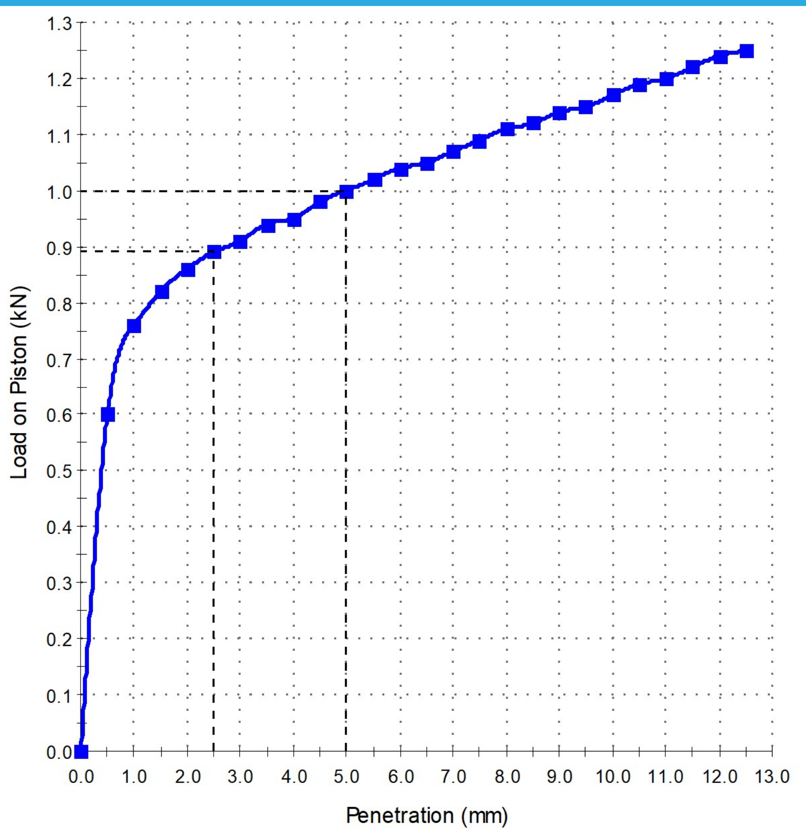
NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 14/06/2018

Sample Details

Sample ID:	NEW18W-1675--S06	**Date Sampled:**	22/05/2018
Sampling Method:	AS1289.1.2.1 cl 6.4b		
Specification:	No Specification	**Source:**	On-Site
Location:	TP901 - (0.6 - 0.7m)	**Material:**	Clay
Project Location:	Boundary Road, Medowie, NSW		

Load vs Penetration



Test Results

AS 1289.6.1.1 - 2014

CBR At 2.5mm (%):	**7**
Maximum Dry Density (t/m³):	1.33
Optimum Moisture Content (%):	34.5
Dry Density before Soaking (t/m³):	1.32
Density Ratio before Soaking (%):	100.0
Moisture Content before Soaking (%):	35.3
Moisture Ratio before Soaking (%):	102.5
Dry Density after Soaking (t/m³):	1.30
Density Ratio after Soaking (%):	98.0
Swell (%):	1.5
Moisture Content of Top 30mm (%):	42.8
Moisture Content of Remaining Depth (%):	36.6
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
Field Moisture Content (%):	38.7
Curing Time (hrs) :	48

Comments

Method of establishing plasticity level: Visual Assessment

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California Bearing Ratio Test Report

Report No: CBR:NEW17W-4760--S10
Issue No: 2
This report replaces all previous issues of report no 'CBR:NEW17W-4760--S10'.

Client:	McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW15P-0033B
Project Name:	The Bower Stages 3, 4, 5 & 6

Accredited for compliance with ISO/IEC 17025 - Testing
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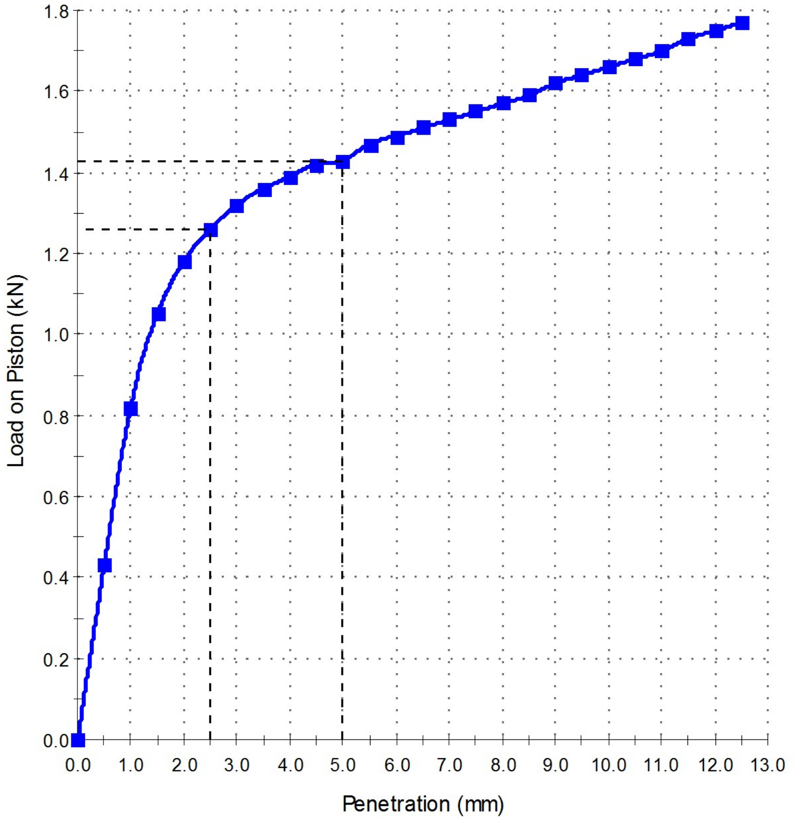
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Glen Richardson
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 28/11/2017

Sample Details

Sample ID:	NEW17W-4760--S10	Date Sampled:	12/10/2017
Sampling Method:	AS1289.1.2.1 cl 6.5		
Specification:	No Specification	Source:	On-Site
Location:	TP605 - 0.40 to 0.60m	Material:	Sandy CLAY
Project Location:	Boundary Road, Medowie, NSW		

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR At 2.5mm (%):	10
Maximum Dry Density (t/m³):	1.30
Optimum Moisture Content (%):	31.1
Dry Density before Soaking (t/m³):	1.31
Density Ratio before Soaking (%):	100
Moisture Content before Soaking (%):	31.3
Moisture Ratio before Soaking (%):	101
Dry Density after Soaking (t/m³):	1.30
Density Ratio after Soaking (%):	100
Swell (%):	0.0
Moisture Content of Top 30mm (%):	35.3
Moisture Content of Remaining Depth (%):	33.4
Compactive Effort:	Standard
Surcharge Mass (kg):	9.00
Period of Soaking (Days):	4
Oversize Material (%):	0.0

Moisture Content

Field Moisture Content (%):	28.6

Comments

Laboratory Density Ratio (LDR): 100.5% Laboratory Moisture Ratio (LMR): 101.0%
Method of establishing plasticity level: Visual Assessment
Moisture Content Method Performed as Per AS1289.2.1.1.
Sample curing time: 48 hrs

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Report No: CBR:NEW18W-1675--S10
Issue No: 1

California Bearing Ratio Test Report

Client: McCloy Development Management Pty Ltd
Suite 1 Level 3, 426 King Street
Newcastle West NSW 2300

Principal:
Project No.: NEW18P-0102
Project Name: The Bower Stages 7, 8, 9, 10 & 11

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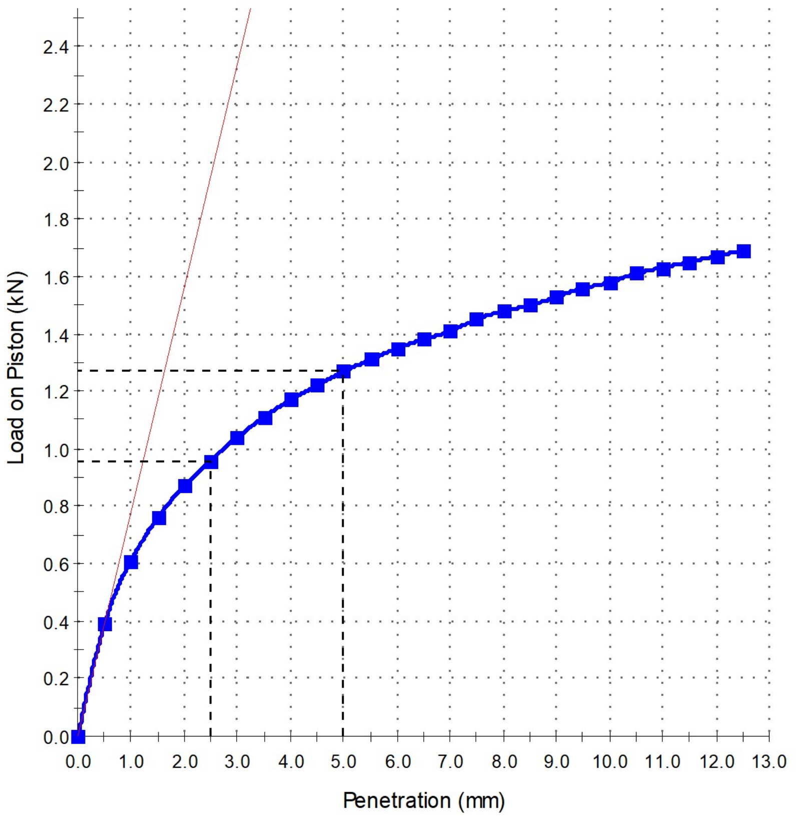
Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 14/06/2018

Sample Details

Sample ID:	NEW18W-1675--S10	**Date Sampled:**	22/05/2018
Sampling Method:	AS1289.1.2.1 cl 6.4b		
Specification:	No Specification	**Source:**	On-Site
Location:	TP11-01 - (0.4 - 0.6m)	**Material:**	Clay
Project Location:	Boundary Road, Medowie, NSW		

Load vs Penetration



Test Results

AS 1289.6.1.1 - 2014

CBR At 2.5mm (%):	**7**
Maximum Dry Density (t/m³):	1.61
Optimum Moisture Content (%):	22.5
Dry Density before Soaking (t/m³):	1.61
Density Ratio before Soaking (%):	100.0
Moisture Content before Soaking (%):	22.6
Moisture Ratio before Soaking (%):	101.0
Dry Density after Soaking (t/m³):	1.61
Density Ratio after Soaking (%):	100.5
Swell (%):	-0.5
Moisture Content of Top 30mm (%):	26.1
Moisture Content of Remaining Depth (%):	22.8
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
Field Moisture Content (%):	24.8
Curing Time (hrs) :	48

Comments

Method of establishing plasticity level: Visual Assessment

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Report No: CBR:NEW18W-1675--S11
Issue No: 1

California Bearing Ratio Test Report

Client:	McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW18P-0102
Project Name:	The Bower Stages 7, 8, 9, 10 & 11

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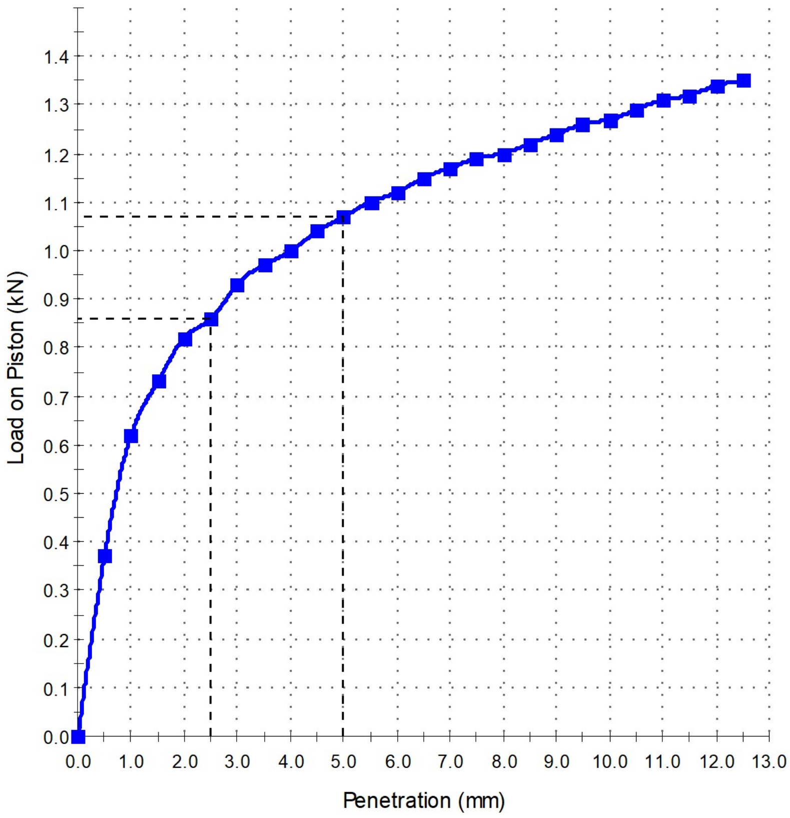
Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 14/06/2018

Sample Details

Sample ID:	NEW18W-1675--S11	**Date Sampled:**	22/05/2018
Sampling Method:	AS1289.1.2.1 cl 6.4b		
Specification:	No Specification	**Source:**	On-Site
Location:	TP11-02 - (0.5 - 0.65m)	**Material:**	Clay
Project Location:	Boundary Road, Medowie, NSW		

Load vs Penetration



Test Results

AS 1289.6.1.1 - 2014

CBR At 2.5mm (%):	**7**
Maximum Dry Density (t/m³):	1.53
Optimum Moisture Content (%):	26.0
Dry Density before Soaking (t/m³):	1.53
Density Ratio before Soaking (%):	100.0
Moisture Content before Soaking (%):	26.1
Moisture Ratio before Soaking (%):	101.0
Dry Density after Soaking (t/m³):	1.53
Density Ratio after Soaking (%):	100.0
Swell (%):	0.0
Moisture Content of Top 30mm (%):	28.9
Moisture Content of Remaining Depth (%):	27.3
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
Field Moisture Content (%):	27.7
Curing Time (hrs) :	48

Comments

Method of establishing plasticity level: Visual Assessment

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California Bearing Ratio Test Report

Report No: CBR:NEW18W-1675--S12
Issue No: 1

Client:	McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW18P-0102
Project Name:	The Bower Stages 7, 8, 9, 10 & 11

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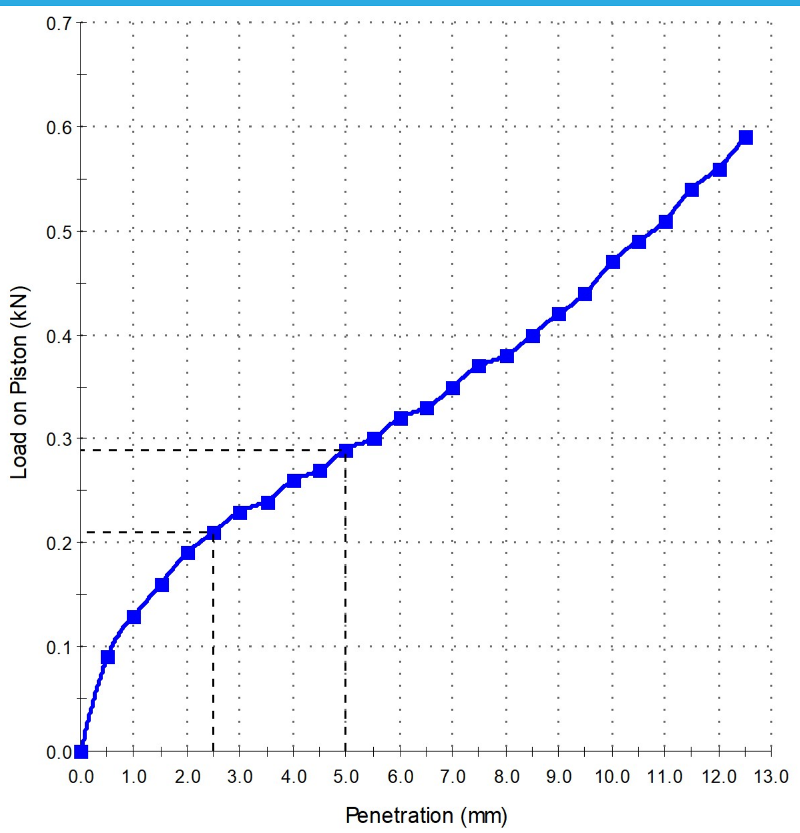
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Dane Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 14/06/2018

Sample Details

Sample ID:	NEW18W-1675--S12	**Date Sampled:**	22/05/2018
Sampling Method:	AS1289.1.2.1 cl 6.4b		
Specification:	No Specification	**Source:**	On-Site
Location:	TP11-03 - (0.4 - 0.55m)	**Material:**	Clay
Project Location:	Boundary Road, Medowie, NSW		

Load vs Penetration



Test Results

AS 1289.6.1.1 - 2014

CBR At 2.5mm (%):	**1.5**
Maximum Dry Density (t/m³):	1.51
Optimum Moisture Content (%):	26.5
Dry Density before Soaking (t/m³):	1.51
Density Ratio before Soaking (%):	100.5
Moisture Content before Soaking (%):	26.0
Moisture Ratio before Soaking (%):	97.5
Dry Density after Soaking (t/m³):	1.47
Density Ratio after Soaking (%):	97.5
Swell (%):	3.0
Moisture Content of Top 30mm (%):	46.4
Moisture Content of Remaining Depth (%):	28.4
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
Field Moisture Content (%):	46.3
Curing Time (hrs) :	48

Comments

Method of establishing plasticity level: Visual Assessment

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Report No: MAT:NEW17W-1684--S01
Issue No: 1

Material Test Report

Client:	McCloy Development Management Suite 1 Level 3, 426 King Street Newcastle NSW 2300
Principal:	
Project No.:	NEW15P-0033
Project Name:	The Bower Subdivision - Stage 1

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WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 16/05/2017

Sample Details

Sample ID:	NEW17W-1684--S01
Sampling Method:	AS1289.1.2.1 cl 6.5
Date Sampled:	03/05/2017
Source:	On-Site
Material:	Clay
Specification:	No Specification
Project Location:	Boundary Road, Medowie, NSW
Sample Location:	TP101 - (1.0 - 1.4m)

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	11.0	
Mould Length (mm)		250	
Crumbling		No	
Curling		No	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	70	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	24	
Plasticity Index (%)	AS 1289.3.3.1	46	

Comments

N/A

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Shrink Swell Index Report

Report No: SSI:NEW15W-0817--S01
Issue No: 1

Client:	McCloy Medowie Suite 1 Level 3, 426 King Street Newcastle NSW 2300
Principal:	
Project No.:	NEW15P-0033
Project Name:	Proposed Subdivision - Boundary Road, Medowie

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Approved Signatory: Alan Cullen
(Principal Geotechnician)
NATA Accredited Laboratory Number18686
Date of Issue: 23/04/2015

Sample Details

Sample ID:	NEW15W-0817--S01	Client Sample ID:	
Test Request No.:	-	Sampling Method:	AS1289.1.2.1 cl 6.5
Material:	TP-Q01 (0.70-0.90m)	Date Sampled:	14/04/2015
Source:	On-Site Insitu	Date Submitted:	16/04/2015
Specification:	No Specification		
Project Location:	Medowie, NSW		
Sample Location:	TP-Q01 (0.70-0.90m)		
Borehole Number:	TP-Q01		
Borehole Depth (m):	0.7 To 0.9		

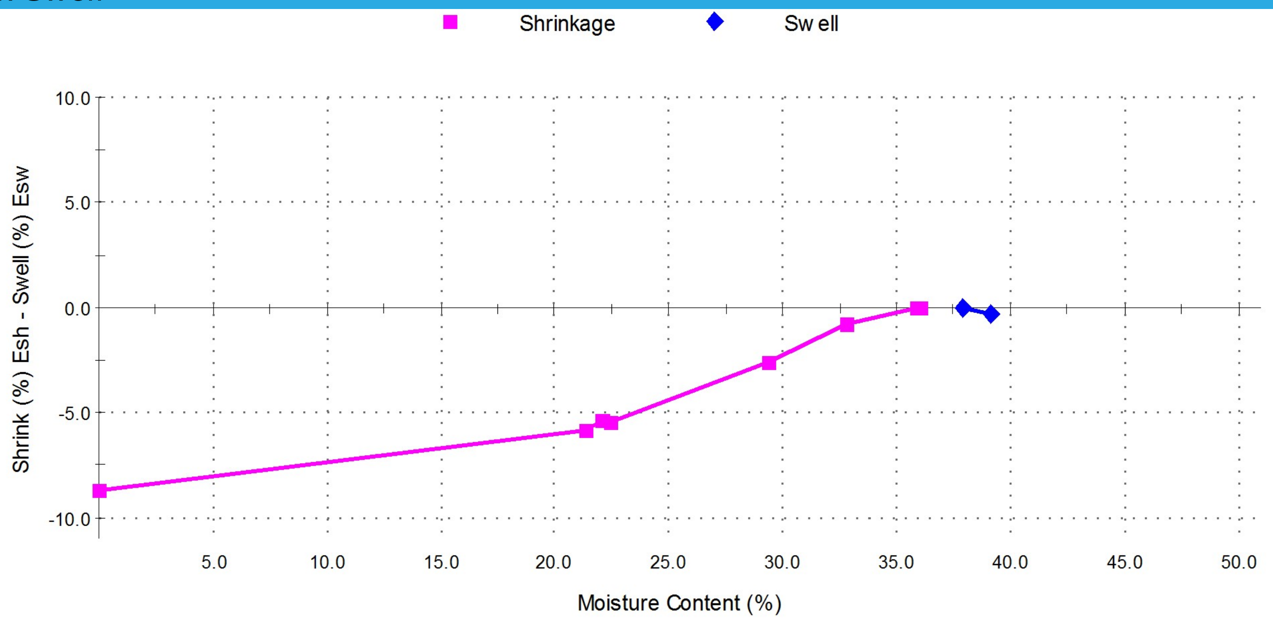
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.3
Moisture Content before (%):	37.9
Moisture Content after (%):	39.2
Est. Unc. Comp. Strength before (kPa):	300
Est. Unc. Comp. Strength after (kPa):	220

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	8.7
Shrinkage Moisture Content (%):	36.1
Est. inert material (%):	0%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Nil

Shrink Swell



Shrink Swell Index - Iss (%): 4.9

Comments

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Report No: SSI:NEW17W-1684--S02
Issue No: 1

Shrink Swell Index Report

Client:	McCloy Development Management Suite 1 Level 3, 426 King Street Newcastle NSW 2300
Principal:	
Project No.:	NEW15P-0033
Project Name:	The Bower Subdivision - Stage 1

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Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 16/05/2017

Sample Details

Sample ID:	NEW17W-1684--S02	Client Sample ID:	-
Test Request No.:	-	Sampling Method:	AS1289.1.2.1 cl 6.5
Material:	Clay	Date Sampled:	3/05/2017
Source:	On-Site	Date Submitted:	5/05/2017
Specification:	No Specification		
Project Location:	Boundary Road, Medowie, NSW		
Sample Location:	TP102 - (0.7 - 0.85m)		
Borehole Number:	TP102		
Borehole Depth (m):	0.7 - 0.85		

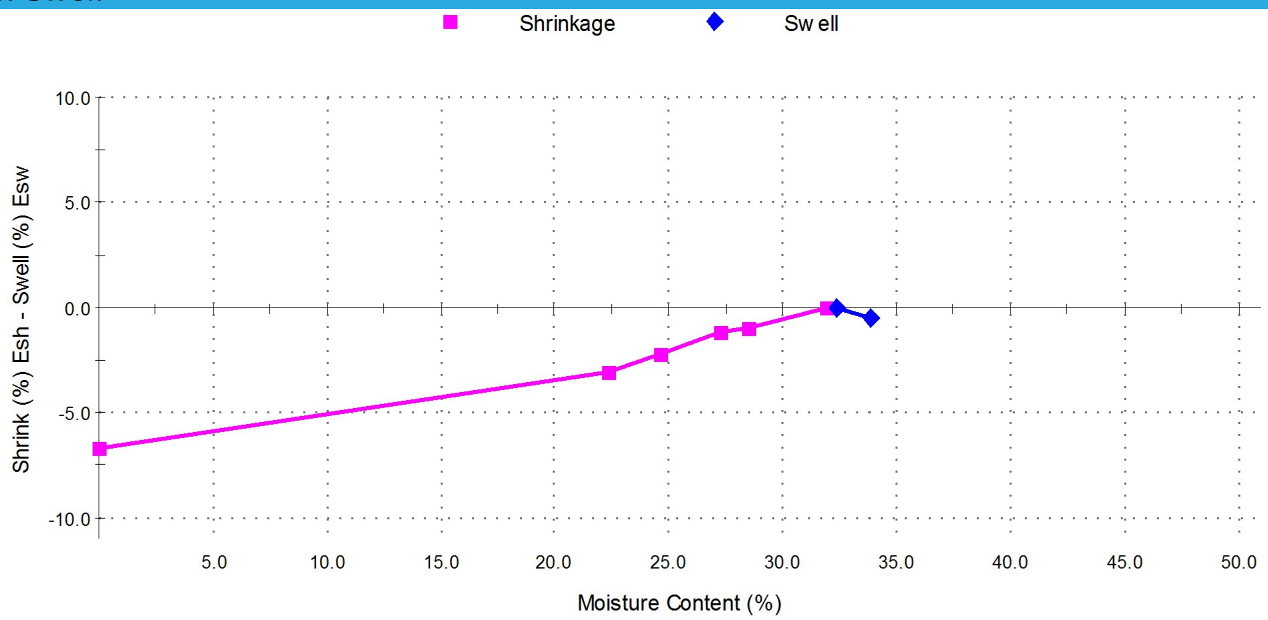
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.5
Moisture Content before (%):	32.4
Moisture Content after (%):	33.9
Est. Unc. Comp. Strength before (kPa):	280
Est. Unc. Comp. Strength after (kPa):	280

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	6.7
Shrinkage Moisture Content (%):	31.9
Est. inert material (%):	1.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 3.7

Comments

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Report No: SSI:NEW17W-1684--S03
Issue No: 1

Shrink Swell Index Report

Client:	McCloy Development Management Suite 1 Level 3, 426 King Street Newcastle NSW 2300
Principal:	
Project No.:	NEW15P-0033
Project Name:	The Bower Subdivision - Stage 1

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WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 16/05/2017

Sample Details

Sample ID:	NEW17W-1684--S03	Client Sample ID:	-
Test Request No.:	-	Sampling Method:	AS1289.1.2.1 cl 6.5
Material:	Clay	Date Sampled:	3/05/2017
Source:	On-Site	Date Submitted:	5/05/2017
Specification:	No Specification		
Project Location:	Boundary Road, Medowie, NSW		
Sample Location:	TP103 - (1.3 - 1.7m)		
Borehole Number:	TP103		
Borehole Depth (m):	1.3 - 1.7		

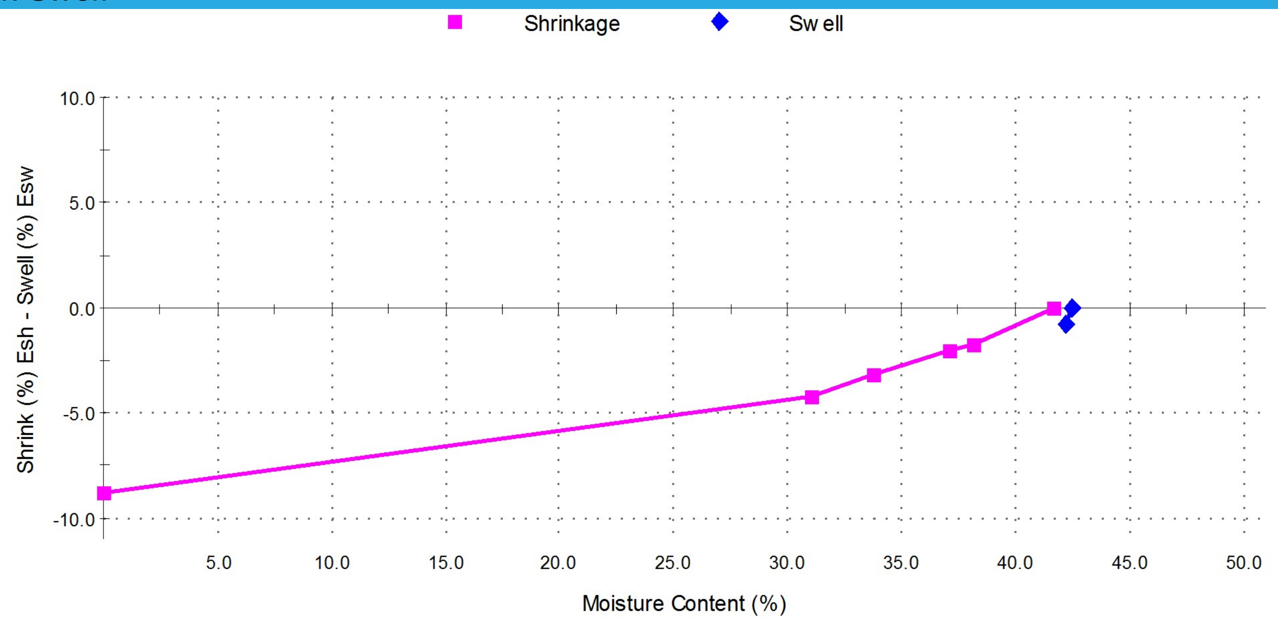
Swell Test — AS 1289.7.1.1

Swell on Saturation (%):	-0.8
Moisture Content before (%):	42.5
Moisture Content after (%):	42.2
Est. Unc. Comp. Strength before (kPa):	270
Est. Unc. Comp. Strength after (kPa):	270

Shrink Test — AS 1289.7.1.1

Shrink on drying (%):	8.8
Shrinkage Moisture Content (%):	41.7
Est. inert material (%):	2.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Nil

Shrink Swell



Shrink Swell Index - Iss (%): 4.9

Comments

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Shrink Swell Index Report

Report No: SSI:NEW17W-1684--S04
Issue No: 1

Client:	McCloy Development Management Suite 1 Level 3, 426 King Street Newcastle NSW 2300
Principal:	
Project No.:	NEW15P-0033
Project Name:	The Bower Subdivision - Stage 1

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WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 16/05/2017

Sample Details

Sample ID:	NEW17W-1684--S04	Client Sample ID:	-
Test Request No.:	-	Sampling Method:	AS1289.1.2.1 cl 6.5
Material:	Clay	Date Sampled:	3/05/2017
Source:	On-Site	Date Submitted:	5/05/2017
Specification:	No Specification		
Project Location:	Boundary Road, Medowie, NSW		
Sample Location:	TP104 - (0.5 - 0.64m)		
Borehole Number:	TP104		
Borehole Depth (m):	0.5 - 0.64		

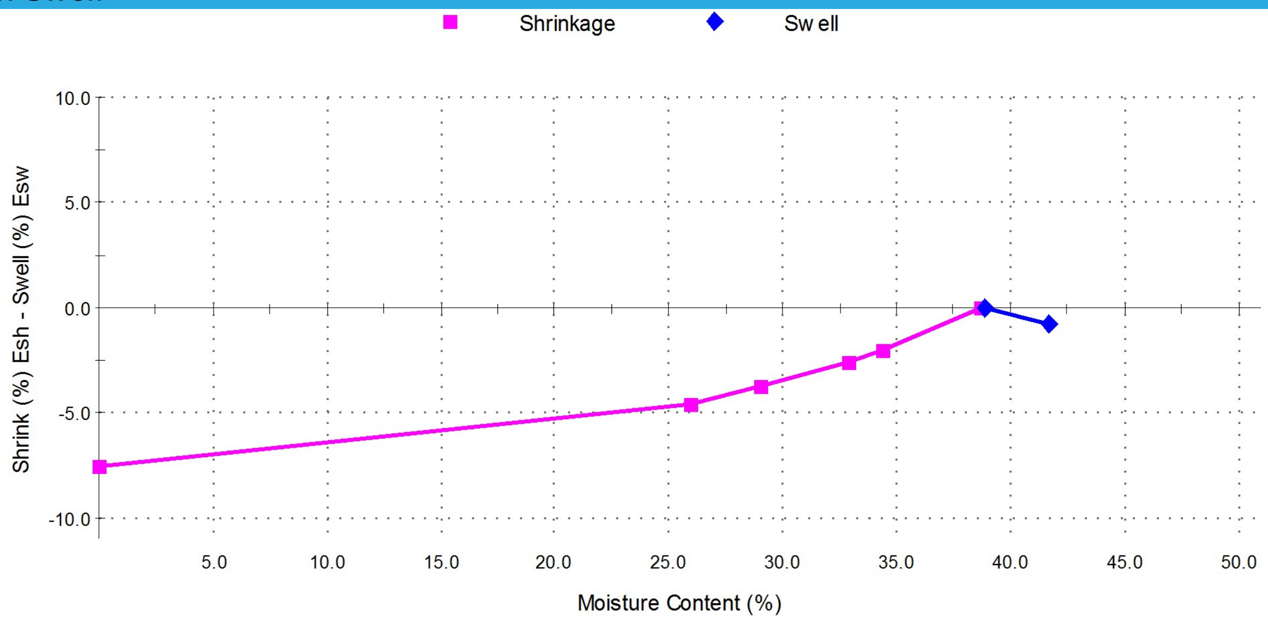
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.8
Moisture Content before (%):	38.9
Moisture Content after (%):	41.7
Est. Unc. Comp. Strength before (kPa):	230
Est. Unc. Comp. Strength after (kPa):	210

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	7.6
Shrinkage Moisture Content (%):	38.7
Est. inert material (%):	2.5
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	MInor

Shrink Swell



Shrink Swell Index - Iss (%): 4.2

Comments

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W: www.qualtest.com.au
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Report No: SSI:NEW17W-1684--S05
Issue No: 1

Shrink Swell Index Report

Client:	McCloy Development Management Suite 1 Level 3, 426 King Street Newcastle NSW 2300
Principal:	
Project No.:	NEW15P-0033
Project Name:	The Bower Subdivision - Stage 1

Accredited for compliance with ISO/IEC 17025
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 16/05/2017

Sample Details

Sample ID:	NEW17W-1684--S05	Client Sample ID:	-
Test Request No.:	-	Sampling Method:	AS1289.1.2.1 cl 6.5
Material:	Clay	Date Sampled:	3/05/2017
Source:	On-Site	Date Submitted:	5/05/2017
Specification:	No Specification		
Project Location:	Boundary Road, Medowie, NSW		
Sample Location:	TP105 - (1.0 - 1.4m)		
Borehole Number:	TP105		
Borehole Depth (m):	1.0 - 1.4		

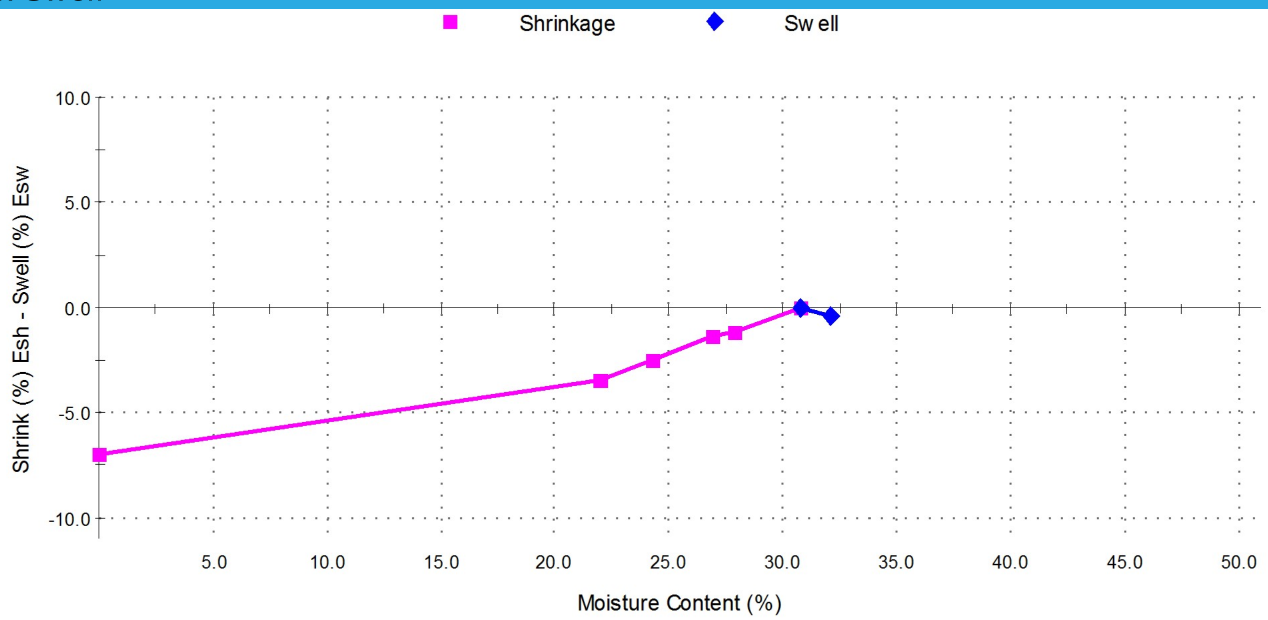
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.4
Moisture Content before (%):	30.8
Moisture Content after (%):	32.1
Est. Unc. Comp. Strength before (kPa):	190
Est. Unc. Comp. Strength after (kPa):	190

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	7.0
Shrinkage Moisture Content (%):	30.8
Est. inert material (%):	1.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Nil

Shrink Swell



Shrink Swell Index - Iss (%): 3.9

Comments

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Shrink Swell Index Report

Report No: SSI:NEW17W-4770--S12
Issue No: 1

Client:	McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW15P-0033B
Project Name:	The Bower Stages 3, 4, 5 & 6

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NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 27/10/2017

Sample Details

Sample ID:	NEW17W-4770--S12	Client Sample ID:	-
Test Request No.:	-	Sampling Method:	AS1289.1.2.1 cl 6.5.4
Material:	Sandy Clay	Date Sampled:	13/10/2017
Source:	On-Site	Date Submitted:	17/10/2017
Specification:	No Specification		
Project Location:	Boundary Road, Medowie, NSW		
Sample Location:	TP501 - (0.4 - 0.55m)		
Borehole Number:	TP501		
Borehole Depth (m):	0.4 - 0.55		

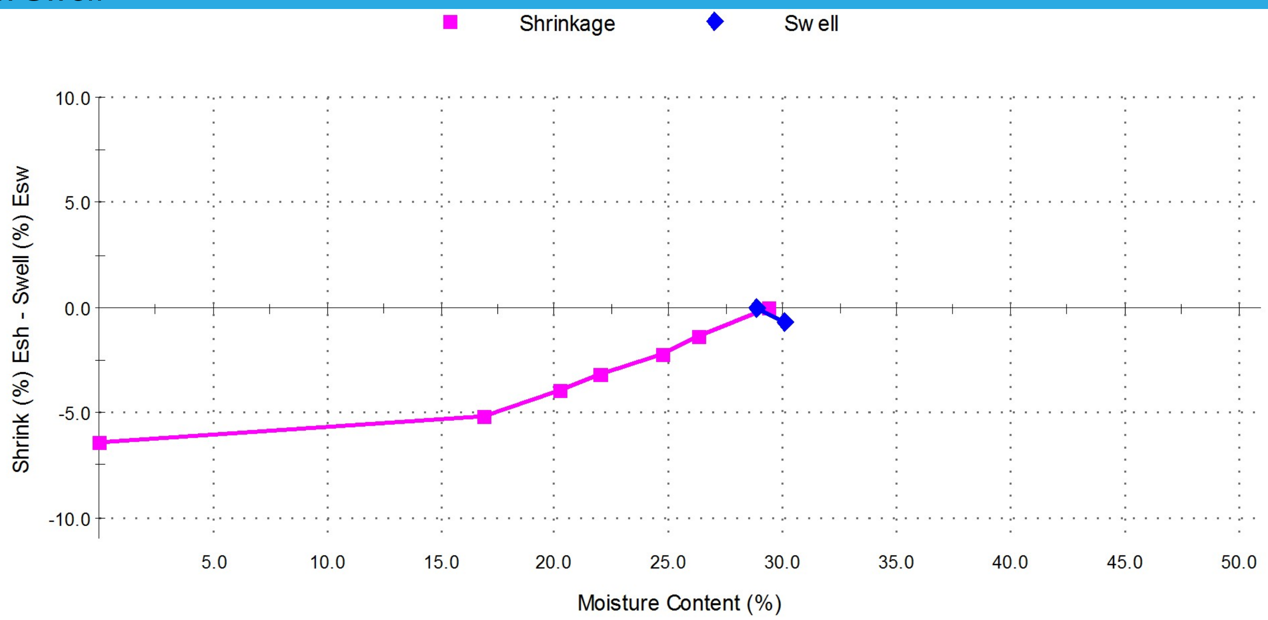
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.7
Moisture Content before (%):	28.8
Moisture Content after (%):	30.1
Est. Unc. Comp. Strength before (kPa):	> 600
Est. Unc. Comp. Strength after (kPa):	330

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	6.4
Shrinkage Moisture Content (%):	29.4
Est. inert material (%):	3.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 3.6

Comments

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Shrink Swell Index Report

Report No: SSI:NEW17W-4770--S13
Issue No: 1

Client:	McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW15P-0033B
Project Name:	The Bower Stages 3, 4, 5 & 6

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WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 27/10/2017

Sample Details

Sample ID:	NEW17W-4770--S13	Client Sample ID:	-
Test Request No.:	-	Sampling Method:	AS1289.1.2.1 cl 6.5.4
Material:	Sandy Clay	Date Sampled:	13/10/2017
Source:	On-Site	Date Submitted:	17/10/2017
Specification:	No Specification		
Project Location:	Boundary Road, Medowie, NSW		
Sample Location:	TP502 - (0.4 - 0.6m)		
Borehole Number:	TP502		
Borehole Depth (m):	0.4 - 0.6		

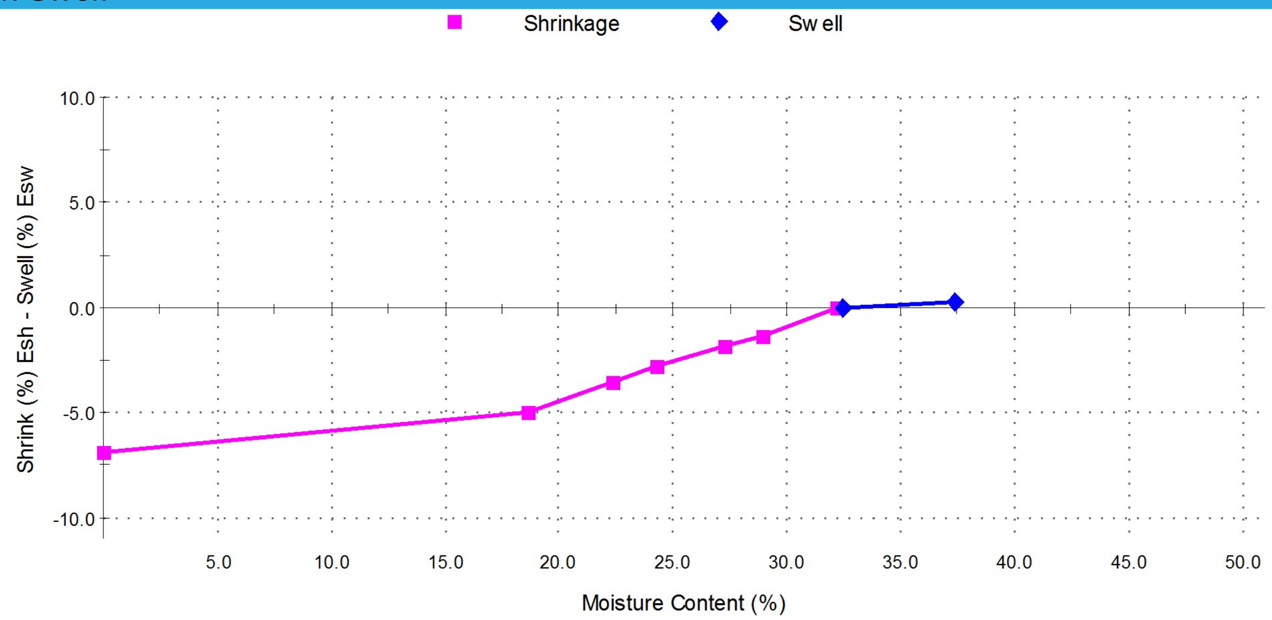
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	0.3
Moisture Content before (%):	32.4
Moisture Content after (%):	37.4
Est. Unc. Comp. Strength before (kPa):	220
Est. Unc. Comp. Strength after (kPa):	180

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	6.9
Shrinkage Moisture Content (%):	32.2
Est. inert material (%):	5.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Major

Shrink Swell



Shrink Swell Index - Iss (%): 3.9

Comments

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Report No: SSI:NEW17W-4770--S14
Issue No: 1

Shrink Swell Index Report

Client:	McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW15P-0033B
Project Name:	The Bower Stages 3, 4, 5 & 6

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WORLD RECOGNISED ACCREDITATION

Approved Signatory: Adam Dwyer
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 27/10/2017

Sample Details

Sample ID:	NEW17W-4770--S14	Client Sample ID:	-
Test Request No.:	-	Sampling Method:	AS1289.1.2.1 cl 6.5.4
Material:	Sandy Clay	Date Sampled:	13/10/2017
Source:	On-Site	Date Submitted:	17/10/2017
Specification:	No Specification		
Project Location:	Boundary Road, Medowie, NSW		
Sample Location:	TP503 - (0.6 - 0.8m)		
Borehole Number:	TP503		
Borehole Depth (m):	0.6 - 0.8		

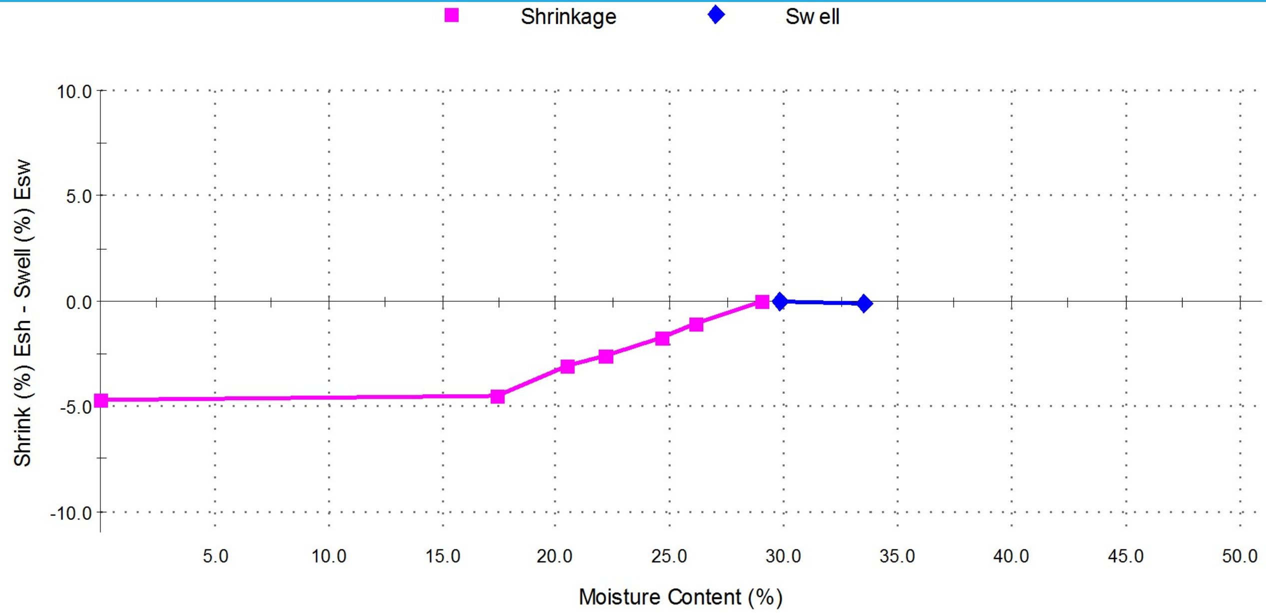
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.2
Moisture Content before (%):	29.8
Moisture Content after (%):	33.5
Est. Unc. Comp. Strength before (kPa):	> 600
Est. Unc. Comp. Strength after (kPa):	340

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	4.7
Shrinkage Moisture Content (%):	29.0
Est. inert material (%):	2.0
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Major

Shrink Swell



Shrink Swell Index - Iss (%): 2.6

Comments

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Shrink Swell Index Report

Report No: SSI:NEW17W-4770--S16
Issue No: 2
This report replaces all previous issues of report no 'SSI:NEW17W-4770--S16'.

Client:	McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW15P-0033B
Project Name:	The Bower Stages 3, 4, 5 & 6

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WORLD RECOGNISED ACCREDITATION

Approved Signatory: Glen Richardson
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 28/11/2017

Sample Details

Sample ID:	NEW17W-4770--S16	Client Sample ID:	-
Test Request No.:	-	Sampling Method:	AS1289.1.2.1 cl 6.5.4
Material:	Sandy Clay	Date Sampled:	13/10/2017
Source:	On-Site	Date Submitted:	17/10/2017
Specification:	No Specification		
Project Location:	Boundary Road, Medowie, NSW		
Sample Location:	TP603 - (0.9 - 1.25m)		
Borehole Number:	TP603		
Borehole Depth (m):	0.9 - 1.25		

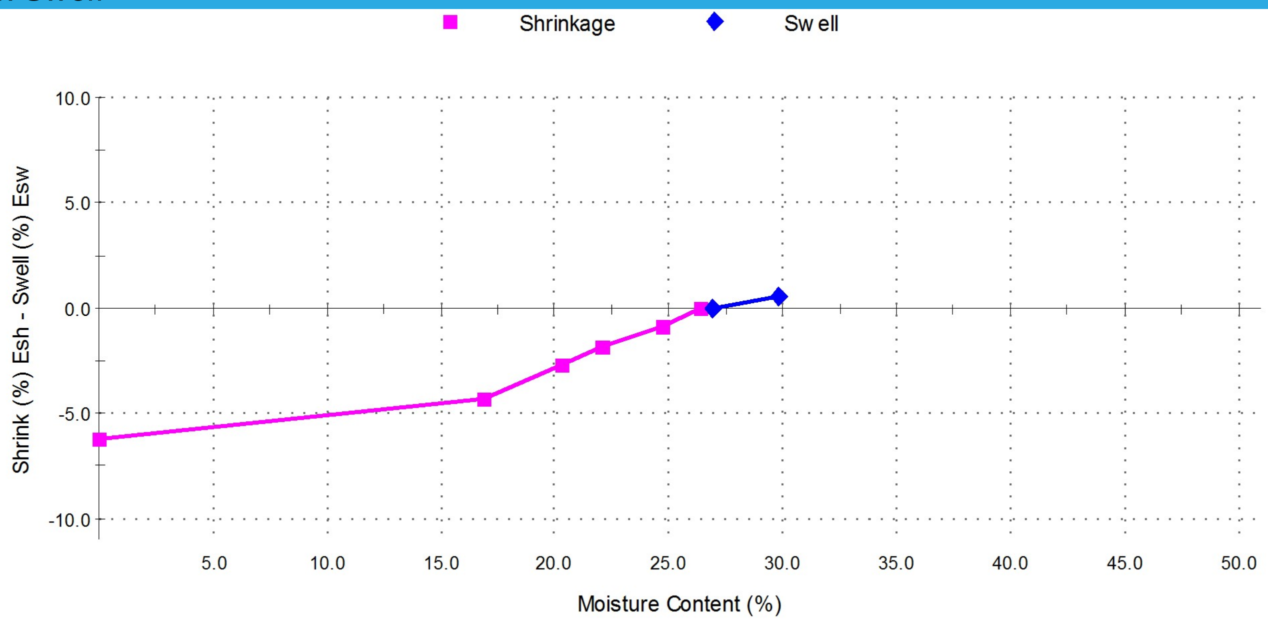
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	0.5
Moisture Content before (%):	26.9
Moisture Content after (%):	29.9
Est. Unc. Comp. Strength before (kPa):	420
Est. Unc. Comp. Strength after (kPa):	210

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	6.2
Shrinkage Moisture Content (%):	26.4
Est. inert material (%):	< 1
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 3.6

Comments

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Shrink Swell Index Report

Report No: SSI:NEW17W-4770--S17
Issue No: 2
This report replaces all previous issues of report no 'SSI:NEW17W-4770--S17'.

Client:	McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW15P-0033B
Project Name:	The Bower Stages 3, 4, 5 & 6

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WORLD RECOGNISED ACCREDITATION

Approved Signatory: Glen Richardson
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 28/11/2017

Sample Details

Sample ID:	NEW17W-4770--S17	Client Sample ID:	-
Test Request No.:		Sampling Method:	AS1289.1.2.1 cl 6.5.4
Material:	Sandy Clay	Date Sampled:	13/10/2017
Source:	On-Site	Date Submitted:	17/10/2017
Specification:	No Specification		
Project Location:	Boundary Road, Medowie, NSW		
Sample Location:	TP604 - (0.5 - 0.8m)		
Borehole Number:	TP604		
Borehole Depth (m):	0.5 - 0.8		

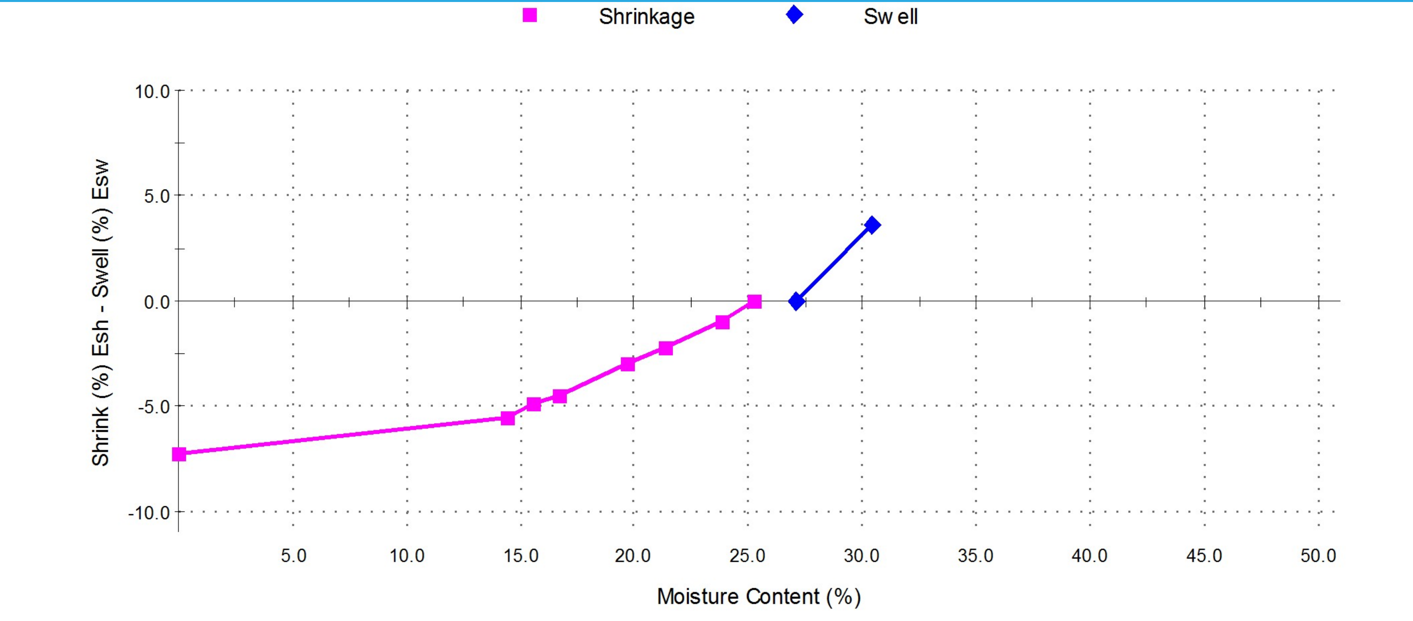
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	3.6
Moisture Content before (%):	27.1
Moisture Content after (%):	30.4
Est. Unc. Comp. Strength before (kPa):	550
Est. Unc. Comp. Strength after (kPa):	220

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	7.3
Shrinkage Moisture Content (%):	25.2
Est. inert material (%):	<1%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Nil

Shrink Swell



Shrink Swell Index - Iss (%): 5.1

Comments

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Shrink Swell Index Report

Report No: SSI:NEW17W-4770--S18
Issue No: 2
This report replaces all previous issues of report no 'SSI:NEW17W-4770--S18'.

Client: McCloy Development Management Pty Ltd
Suite 1 Level 3, 426 King Street
Newcastle West NSW 2300

Principal:
Project No.: NEW15P-0033B
Project Name: The Bower Stages 3, 4, 5 & 6

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NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Glen Richardson
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 28/11/2017

Sample Details

Sample ID:	NEW17W-4770--S18	Client Sample ID:	-
Test Request No.:		Sampling Method:	AS1289.1.2.1 cl 6.5.4
Material:	Sandy Clay	Date Sampled:	13/10/2017
Source:	On-Site	Date Submitted:	17/10/2017
Specification:	No Specification		
Project Location:	Boundary Road, Medowie, NSW		
Sample Location:	TP605 - (0.4 - 0.55m)		
Borehole Number:	TP605		
Borehole Depth (m):	0.4 - 0.55		

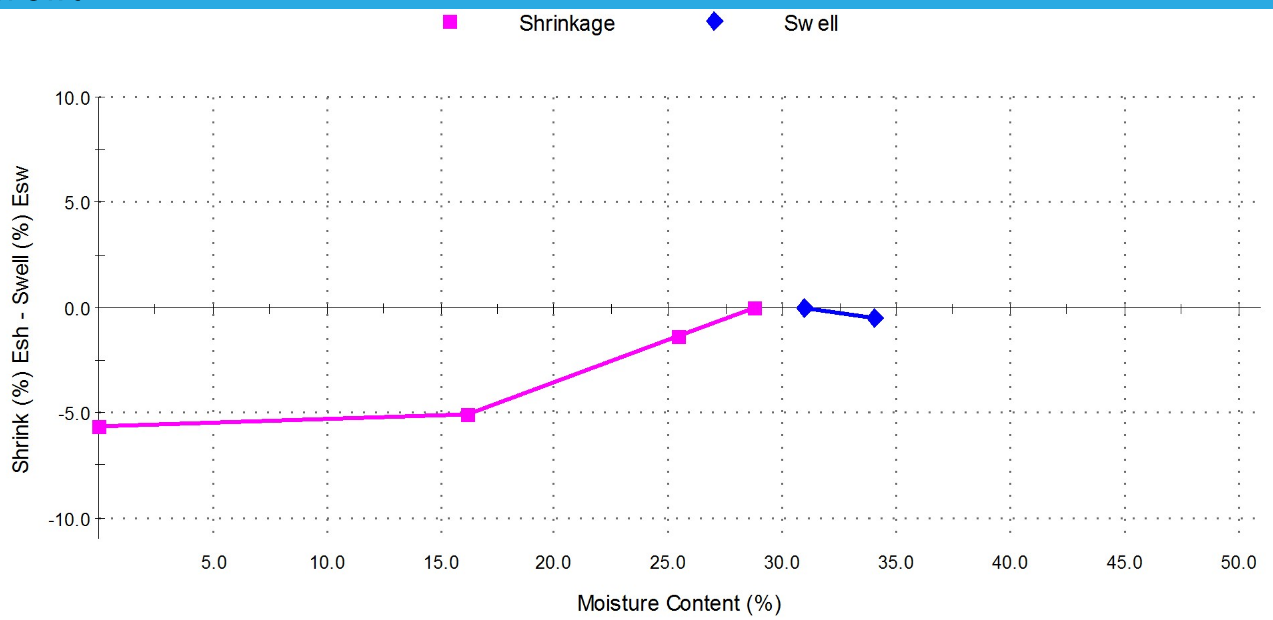
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.5
Moisture Content before (%):	31.0
Moisture Content after (%):	34.1
Est. Unc. Comp. Strength before (kPa):	>600
Est. Unc. Comp. Strength after (kPa):	440

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	5.7
Shrinkage Moisture Content (%):	28.8
Est. inert material (%):	<1%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Moderate

Shrink Swell



Shrink Swell Index - Iss (%): 3.2

Comments

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Shrink Swell Index Report

Report No: SSI:NEW18W-1655--S06
Issue No: 1

Client:	McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW18P-0102
Project Name:	The Bower Stages 7, 8, 9, 10 & 11

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NATA
WORLD RECOGNISED ACCREDITATION

B. Cullen
Approved Signatory: Brent Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 5/06/2018

Sample Details

Sample ID:	NEW18W-1655--S06	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	AS1289.1.2.1 cl 6.4b
Material:	Clay	**Date Sampled:**	22/05/2018
Source:	On Site	**Date Submitted:**	30/05/2018
Specification:	No Specification		
Project Location:	Boundary Road, Medowie, NSW		
Sample Location:	TP901 - (0.6 - 0.7m)		
Borehole Number:	TP901		
Borehole Depth (m):	0.6 - 0.7		

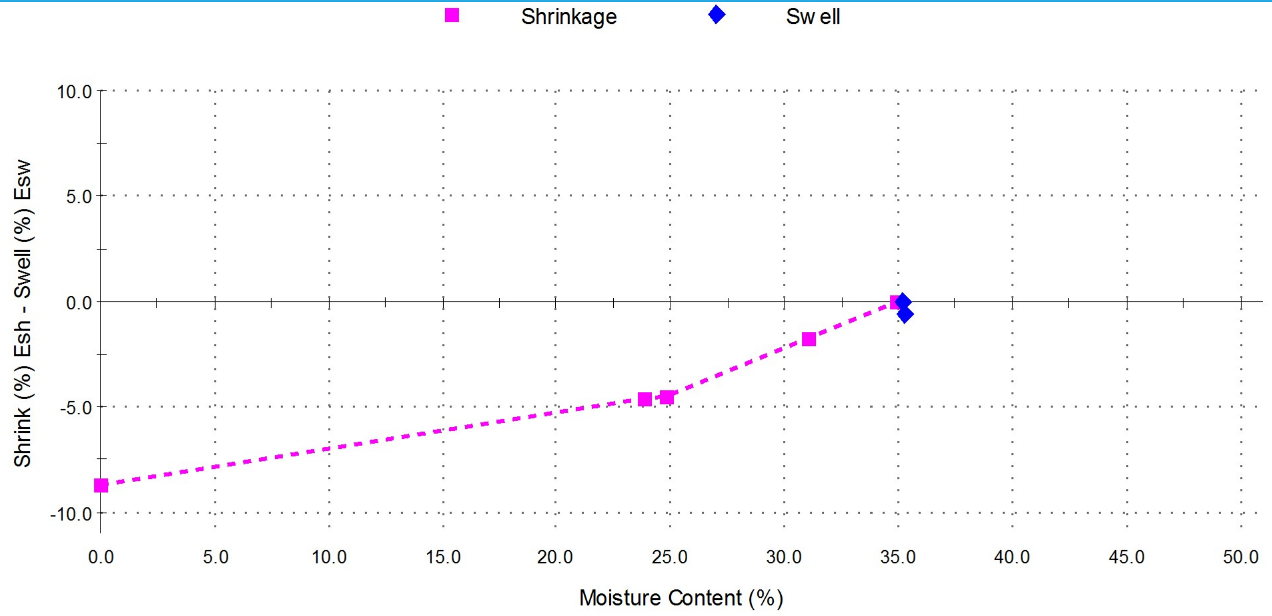
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.6
Moisture Content before (%):	35.1
Moisture Content after (%):	35.2
Est. Unc. Comp. Strength before (kPa):	200
Est. Unc. Comp. Strength after (kPa):	140

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	8.7
Shrinkage Moisture Content (%):	34.9
Est. inert material (%):	Nil
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Nil

Shrink Swell



Shrink Swell Index - Iss (%): 4.8

Comments

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Report No: SSI:NEW18W-1655--S10
Issue No: 1

Shrink Swell Index Report

Client:	McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW18P-0102
Project Name:	The Bower Stages 7, 8, 9, 10 & 11

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Approved Signatory: Brent Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 5/06/2018

Sample Details

Sample ID:	NEW18W-1655--S10	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	AS1289.1.2.1 cl 6.4b
Material:	Clay	**Date Sampled:**	22/05/2018
Source:	On Site	**Date Submitted:**	30/05/2018
Specification:	No Specification		
Project Location:	Boundary Road, Medowie, NSW		
Sample Location:	TP11-01 - (0.8 - 1.0m)		
Borehole Number:	TP11-01		
Borehole Depth (m):	0.8 - 1.0		

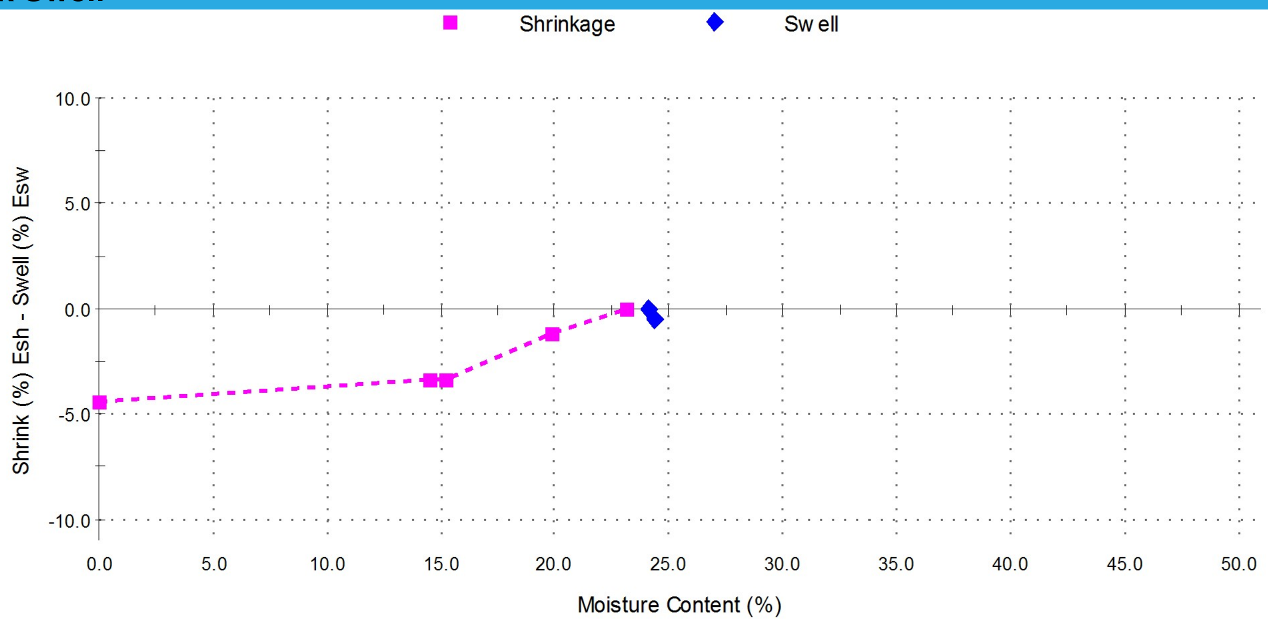
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.5
Moisture Content before (%):	24.1
Moisture Content after (%):	24.3
Est. Unc. Comp. Strength before (kPa):	380
Est. Unc. Comp. Strength after (kPa):	360

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	4.4
Shrinkage Moisture Content (%):	23.1
Est. inert material (%):	Nil
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 2.4

Comments

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Report No: SSI:NEW18W-1655--S11
Issue No: 1

Shrink Swell Index Report

Client: McCloy Development Management Pty Ltd
Suite 1 Level 3, 426 King Street
Newcastle West NSW 2300

Principal:
Project No.: NEW18P-0102
Project Name: The Bower Stages 7, 8, 9, 10 & 11

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NATA
WORLD RECOGNISED ACCREDITATION

B. Cullen
Approved Signatory: Brent Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 5/06/2018

Sample Details

Sample ID:	NEW18W-1655--S11	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	AS1289.1.2.1 cl 6.4b
Material:	Clay	**Date Sampled:**	22/05/2018
Source:	On Site	**Date Submitted:**	30/05/2018
Specification:	No Specification		
Project Location:	Boundary Road, Medowie, NSW		
Sample Location:	TP11-02 - (0.5 - 0.65m)		
Borehole Number:	TP11-02		
Borehole Depth (m):	0.5 - 0.65		

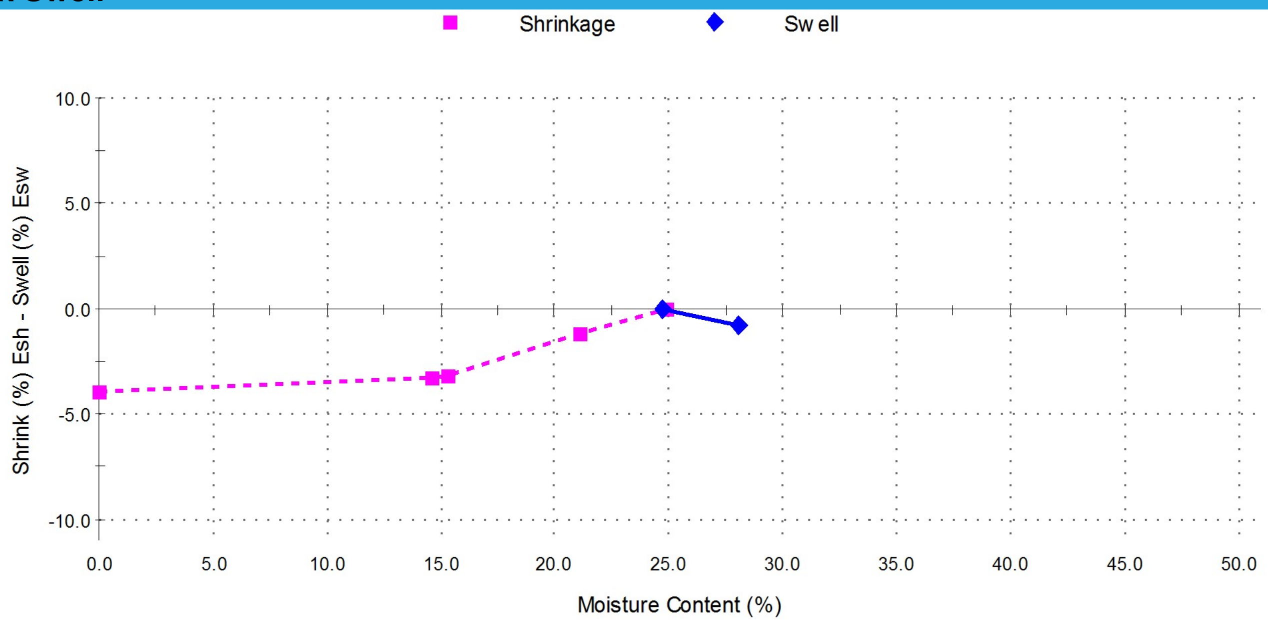
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.8
Moisture Content before (%):	24.7
Moisture Content after (%):	28.1
Est. Unc. Comp. Strength before (kPa):	260
Est. Unc. Comp. Strength after (kPa):	170

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	3.9
Shrinkage Moisture Content (%):	24.9
Est. inert material (%):	2%
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Major

Shrink Swell



Shrink Swell Index - Iss (%): 2.1

Comments

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Shrink Swell Index Report

Report No: SSI:NEW18W-1655--S12
Issue No: 1

Client:	McCloy Development Management Pty Ltd Suite 1 Level 3, 426 King Street Newcastle West NSW 2300
Principal:	
Project No.:	NEW18P-0102
Project Name:	The Bower Stages 7, 8, 9, 10 & 11

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NATA
WORLD RECOGNISED ACCREDITATION

B. Cullen
Approved Signatory: Brent Cullen
(Senior Geotechnician)
NATA Accredited Laboratory Number: 18686
Date of Issue: 5/06/2018

Sample Details

Sample ID:	NEW18W-1655--S12	**Client Sample ID:**	-
Test Request No.:	-	**Sampling Method:**	AS1289.1.2.1 cl 6.4b
Material:	Clay	**Date Sampled:**	22/05/2018
Source:	On Site	**Date Submitted:**	30/05/2018
Specification:	No Specification		
Project Location:	Boundary Road, Medowie, NSW		
Sample Location:	TP11-03 - (0.4 - 0.55m)		
Borehole Number:	TP11-03		
Borehole Depth (m):	0.4 - 0.55		

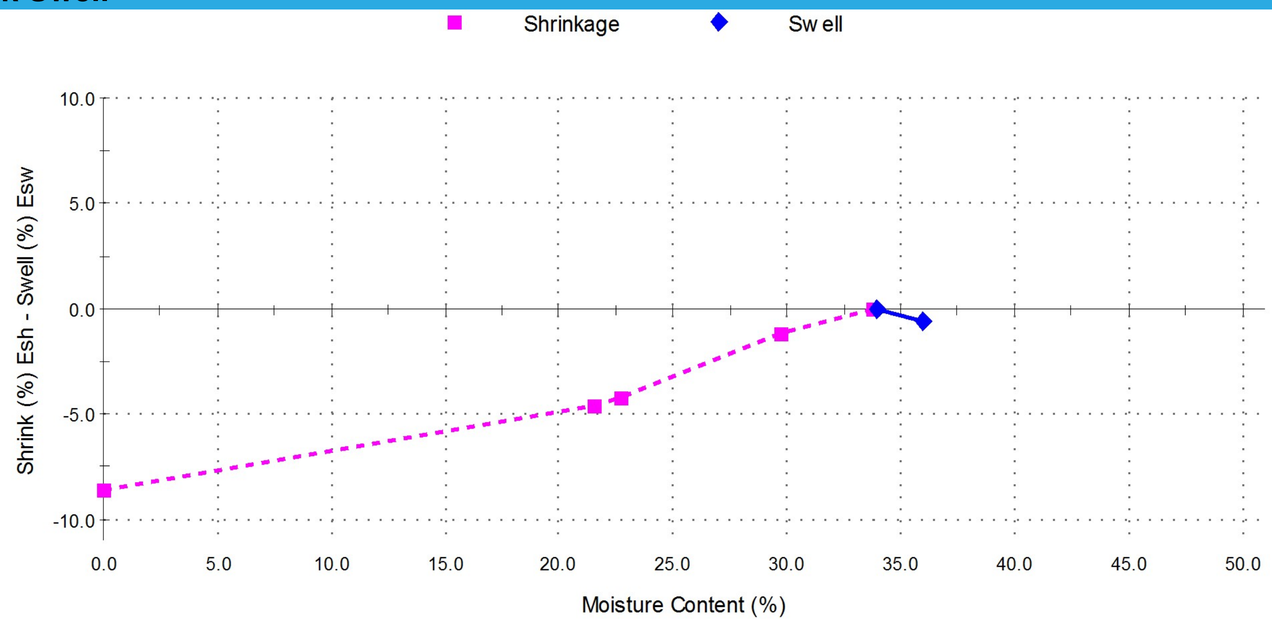
Swell Test AS 1289.7.1.1

Swell on Saturation (%):	-0.6
Moisture Content before (%):	34.0
Moisture Content after (%):	36.0
Est. Unc. Comp. Strength before (kPa):	70
Est. Unc. Comp. Strength after (kPa):	60

Shrink Test AS 1289.7.1.1

Shrink on drying (%):	8.6
Shrinkage Moisture Content (%):	33.7
Est. inert material (%):	Nil
Crumbling during shrinkage:	Nil
Cracking during shrinkage:	Minor

Shrink Swell



Shrink Swell Index - Iss (%): 4.8

Comments

APPENDIX C:

CSIRO Sheet BTF 18

Foundation Maintenance and Footing Performance: A Homeowner's Guide

Foundation Maintenance and Footing Performance: A Homeowner's Guide

BTF 18 replaces Information Sheet 10/91

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

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

Soil Types

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

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

Causes of Movement

Settlement due to construction

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

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

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

Erosion

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

Saturation

This is particularly a problem in clay soils. Saturation creates a 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).

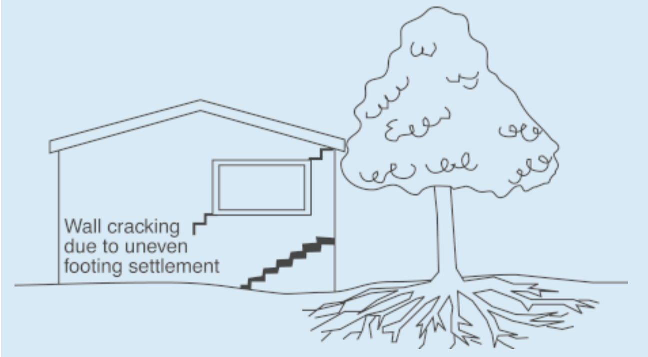
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

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.

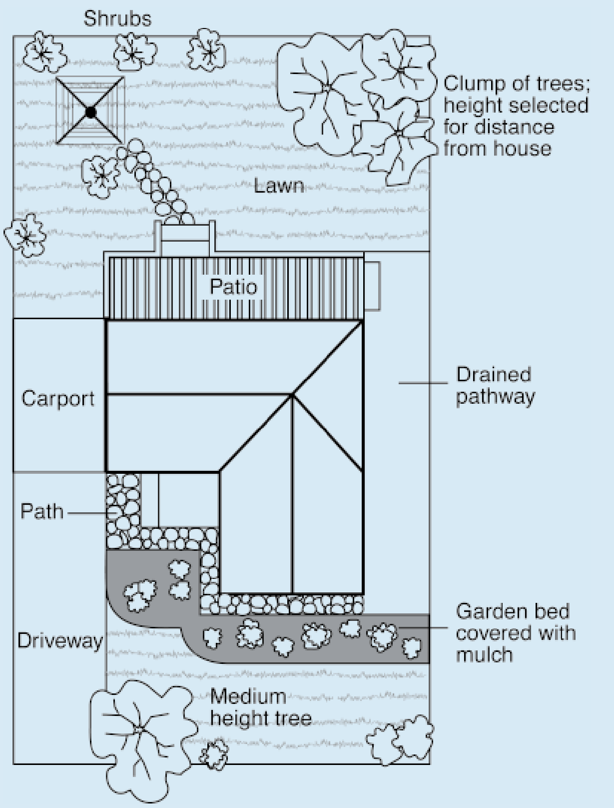
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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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APPENDIX D:

Selected Excerpts from AGS 2007 - Practice Note Guidelines for Landslide Risk Management

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		**Implied Indicative Landslide Recurrence Interval**		**Description**	**Descriptor**	**Level**
Indicative Value	**Notional Boundary**					
10^{-1}	5×10^{-2}	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	5×10^{-3}	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	5×10^{-4}	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	5×10^{-5}	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	5×10^{-6}	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		**Description**	**Descriptor**	**Level**
Indicative Value	**Notional Boundary**			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	**1: CATASTROPHIC 200%**	**2: MAJOR 60%**	**3: MEDIUM 20%**	**4: MINOR 5%**	**5: INSIGNIFICANT 0.5%**
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or **L** (5)
B - LIKELY	10^{-2}	VH	VH	H	M	**L**
C - POSSIBLE	10^{-3}	VH	H	M	M	**VL**
D - UNLIKELY	10^{-4}	H	M	**L**	**L**	**VL**
E - RARE	10^{-5}	M	**L**	**L**	**VL**	**VL**
F - BARELY CREDIBLE	10^{-6}	**L**	**VL**	**VL**	**VL**	**VL**

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.

(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

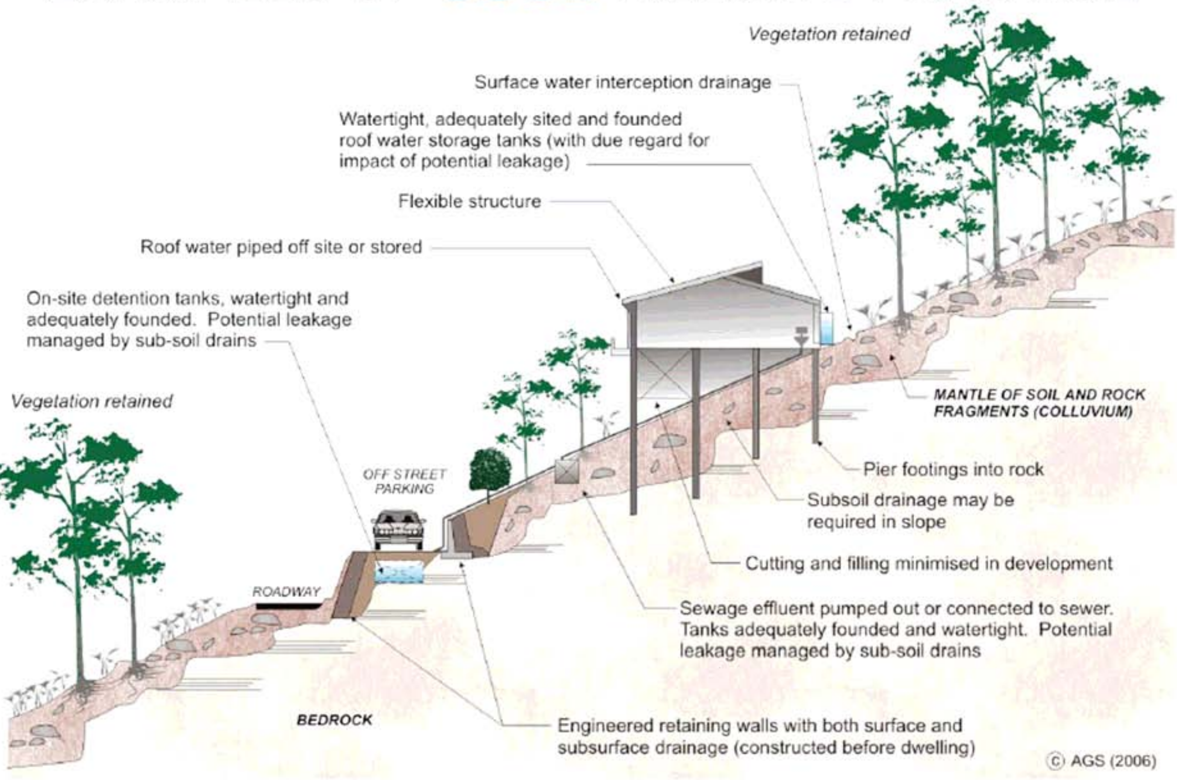
Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	POOR ENGINEERING PRACTICE
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminatory bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	

EXAMPLES OF GOOD HILLSIDE PRACTICE



EXAMPLES OF POOR HILLSIDE PRACTICE